Consumers’ Level of Trust in Using an Automated Train, Aircraft, or Vehicle as a Transportation Means

by

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Abstract

Title: Consumers’ Level of Trust in using an Automated Train, Aircraft, or Vehicle as a Transportation Means

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Automation is a growing technology within most industries. It is expected that automated systems may replace human functions in the near future. The purpose of this study was to determine whether factors such as: type of passenger, type of transportation, and type of operating system have an effect on consumers’ level of trust when it comes to automation in terms of transportation. In order to accomplish this task, an experimental study was conducted with 735 participants who were recruited via Amazon’s ® Mechanical Turk ®.

The study provided participants with a questionnaire where they were presented with different scenarios such as either they themselves, their offspring, or their neighbor would board a human or automated train, aircraft, and a ground vehicle. After each given scenario, participants were asked to rate their level of trust, which was measured in a 7-point Likert Type scale with values ranging from extremely distrust to extremely trust with a neutral option. After this, participants were asked to describe why they did or did not trust the presented scenario. This
helped examine their level of trust, and the increase and decrease of trust levels within each one of the eighteen conditions.

Findings of this study showed that participants’ level of trust was affected by factors such as type of passenger, type of transportation, and type of operating system. Results of the analysis showed that there was not a statistically significant interaction between type of passenger, type of transportation, and type of operating system, yet a statistically significant interaction was found between type of passenger and type of operating system, and type of transportation and type of operating system. In other words, participants level of trust varied depending on whether the scenario involved trains and human operated systems, or trains and automated systems, and whether participants were on-board themselves, or their offspring, or their neighbor under controlled systems or automated systems. Results indicated that participants trusted more scenarios involving trains and human operated systems, while trusting the least scenarios related to trains and automated systems (no human interaction). Overall, it was found that participants were more trusting of the controlled systems, and least trusting of the automated systems in general.
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DEDICATION

This thesis work is dedicated to the person who given the circumstances, has taught me that the man who falls and rises is even greater than he who has not fallen. I dedicate my hard work and every effort to my grandfather Jose Miguel Patin. I am grateful for every teaching you have left me, not knowing that you have. For giving me an example of the importance of working hard for the things you want to achieve, and above all for giving the word “perseverance” a meaning in my life.
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Chapter 1

Introduction

Problem Statement

As technology has advanced, it has facilitated the development of new systems in automation that can potentially replace human responsibilities. It has become evident that people have different perspectives and thoughts when it comes to automation in terms of transportation. Whether it is given to culture, gender, or age, an individual’s level of trust to board an automated train, aircraft, vehicle, differs within each type of transportation. This brings up to question whether individuals trust the usage of automated vehicles is actually greater than using automated trains or aircraft, and whether this difference in level of trust is a result of an individual’s personological characteristics. It is likely consumers will need to trust automation in order to be willing to use it; therefore, issues rise when the technology advances faster than consumers’ trust in the automation. This study mainly aims to further evaluate individuals’ level of trust in autonomous operating systems.
Purpose Statement

Automation has been in high demand among many industries. It is known for reducing the possibility or human error, as well as facilitating operations involving human interaction. Studies have shown that individuals rely upon this growing technology differently (Lee & See, 2004; Rice et al., 2014). The purpose of this study is to determine whether factors such as: type of transportation, type of operating system, and type of passenger have an effect on consumers’ level of trust when it comes to automation in transportation. The experiment will be conducted through a convenience sampling method with 735 randomly assigned participants recruited via Amazon’s © Mechanical Turk ©.

Operational Definitions

In order to provide readers with a better understanding of the concept of this study, the following terms are operationally defined as follows:

Consumers

In the context of this study, consumers are defined as males and females in the United States who are over the age of 18 (Foster, 2015).

Type of Transportation

For the analysis of this study, type of transportation is defined as aircraft, train or vehicle (Comtois, Rodrigue, and Slack, 1998).

Type of Operating System
Type of operating system in this experiment is defined as autonomous operating system (does not involve human interaction) and human operated system (involves human interaction) (Ellis, 2015).

_Type of Passenger_

Type of passenger in this study refers to the participant himself/herself, their offspring, and their neighbor (Culp, 2016).

_Trust_

Trust is commonly associated with the reliability upon other individuals. In the context of this particular study, trust will refer to subjects’ scores on the Likert-type scale of the questionnaire given (Jamieson, 2004) (see Appendix A).

**Research Questions and Hypotheses**

The study will propose the following research questions and hypotheses:

**Research Questions (RQ)**

RQ1: How does consumer’s trust vary based on the type of vehicle?
RQ2: How does consumer trust vary based on operating condition?
RQ3: How does consumer trust change based on who is on-board the automated vehicle?
RQ4: Is there an interaction between the independent variables?
Hypotheses

Null Hypothesis 1

$H_{01}$: There is no significant difference between consumers’ trust to use automated aircraft, vehicles, trains as transportation mean.

Alternative Hypothesis 1

$H_{A1}$: There is a significant difference between consumers’ willingness to use automated aircraft, vehicles, trains as transportation mean.

Null Hypothesis 2

$H_{02}$: There is no significant difference in consumers’ level of trust on regards to human operated systems and autonomous operating systems.

Alternative Hypothesis 2

$H_{A2}$: There is a significant difference in consumers’ level of trust on regards to human operated systems and autonomous operating systems.

Null Hypothesis 3

$H_{03}$: There is no significant difference in consumers’ level of trust to use an automated transportation mean depending on whom on-board.

Alternative Hypothesis 3

$H_{A3}$: There is a significant difference in consumers’ level of trust to use an automated transportation mean depending on whom on-board.

Null Hypothesis 4

$H_{04}$: There is no interaction between the independent variables.
Alternative Hypothesis 4

H₄: There is an interaction between the independent variables.

Significance of the Study

Automation has been a prevalent topic among the research community. Reliance on automation has been found to affect its acceptance within industries such as transportation (Riley, 1996). Studies have focused on how the context in which automation is used has an influence over automation performance, and how its characteristics along with cognitive processes affect trust (Lee & See, 2004). Other research has shown that individuals are drawn towards using devices that they trust more often. Likewise, levels of human comfort, trust, and willingness to use automated technology have been factors considered within research involving trust and automation. This study aims to explore how trust in automation is affected by multiple factors. A better understanding of how trust can be affected in automation can potentially lead to an evaluation of automation growth. Some studies have focused on further investigating passenger’s trust in human operated system versus autonomous autopilot systems, as well as how trust is affected within varying cultures.

The greater demand of automation justifies the need for an evaluation of the factors that affect consumers’ level of trust when it comes to the use of this growing technology. The significance of this study lies in the attempt to determine the factors that affect the usage of automation within the transportation industry.
The growth in this technology has led to the development of devices and machines that do not require human interaction eventually leading to replacement.

**Assumptions and Limitations**

**Assumptions**

In order to obtain relevant findings in any given research study assumptions have to be made. Throughout this section assumptions of this particular study will be outlined.

To begin it is assumed that participants will provide straight and honest answers. It is also expected that even though individuals will receive a compensation for their participation answers will reflect the subject’s truthful emotions. Every effort will be made to ensure that data collection and analyses procedures are conducted correctly.

This study is designed in hopes that its results will provide a clearer understanding of the important role trust plays when it comes to automation in terms of transportation. The study is designed so its results can be generalizable to general populations such as the United States population, all individuals in the country who can legally board/use an automated aircraft, train, or vehicle as a transportation mean.

**Limitations**

Limitations are considered to be potential weaknesses in a study, which are out of the researcher’s control. The primary limitation to this study is the data collection method, and the instrument itself. Participants will be recruited via
Amazon’s ® Mechanical Turk ® and then presented with the instrument created through SurveyMonkey ® providing the researcher as much control as having on-site live participants. Even though this service facilitates a convenience sampling method, it does offer participants with compensation. However, a prior study conducted by Buhrmester, Kwang, and Gosling (2011) ensures reliability among this data collection service. Data collected through Amazon’s ® Mechanical Turk ® is known to be as valid as normal laboratory data.

Even though statistics and figures have shown airline transportation to be the safest way of travel nowadays, there is still a large amount of our population that are terrified at the simple thought of an aircraft. Therefore, it is possible that individuals who have a “fear of flight might let their emotions affect the input of their data. Other limitations include the collection of data at one point in time, instead of longitudinally. In addition, participants are basing their personal opinions off of a hypothetical scenario instead of a real-life behavioral choice. Also, another limitation to this study is the cross-sectional administration. In other words, data is only collected one time; therefore participants’ views are collected in one point in time only.

**Summary**

Technological advances have led to the development of new systems that have provided humans with support in daily tasks. Automation has been among the significant advances in technology. Reliance in this technology has been found to
be affected by different factors. This particular study aims to evaluate some of the factors that have an effect on consumers’ level of trust when using automation in terms of transportation.
Chapter 2- Literature Review

Introduction

Whether it is due to the type of operating system (human/autonomous), or even who is to board (yourself/offspring/neighbor), consumers’ level of trust is expected to vary within different transportation methods. In general, trust is known to have a broad concept. It is essential to understand the important role trust plays in means of transportation; therefore, arriving to a definition of this term that appropriately suits the context of this study is fundamental. In terms of automation, the concept of trust has been found to be divided into two different aspects: (1) interpersonal trust, and (2) trust in machines. In the same way, different trust related theories such as system-wide trust, component-specific trust, and organizational trust theory potentially allow predictions to be made on regards to trust and reliability.

Defining Trust

Trust in general is considered to be a result of emotions, thought of as a psychological frame of mind. Trust is known for being interpreted in many different ways. Due to the great variety of fields, several definitions of trust have been established and accepted within the research community. In hopes of understanding the role trust plays in the interaction between automation and humans, several researchers define trust as follows: “the expectancy held by an individual that the word promise or written communication of another can be relied
upon” (Rotter, 1967, p. 651) or “trust can be defined as the attitude that an agent will help achieve an individual’s goals in a situation characterized by uncertainty and vulnerability” (Lee & See, 2004, p. 51). The definition that best suits the context of this study, is “willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that party” (Davis, Mayer, & Schoorman, 1995, p. 712), which according to Rousseau, Sitkin, Burt, and Camerer (1998) is the most accepted definition of trust within the research community, and identifies vulnerability as a basic element. It is imperative to understand that the responsibility of building trust falls over the trustor. This definition established by Mayer, Davis, & Schoorman (1995) best defines trust in terms of this specific study, since participants are exposed (through scenarios) to becoming vulnerable to and rely on decisions made by pilots controlling an aircraft, an engineer conducting a train, a driver conducting vehicle, or an autonomous operating system itself conducting all three transportation means, either one to transport them from one destination to another with the expectation of a safe arrival.

A study conducted by Lee and See (2004) concluded that trust does have an influence on how and to what extent people rely on automation, yet does not determine reliance itself. Wright (2010) suggested that trust is different from reliance or any other possible case in which someone asks for something strongly expecting that this will be done due to the different attitude taken by the trustor. In
the same way, Wright (2010) argued that the trustor takes Holton’s “participant stance” and that this is responsible for distinguishing trust from reliance. The participant stance is known to be an attitude that is adopted by the trustor towards the trustee (Holton, 1994). However, Rempel et al. (1985) reported that trust will be less fragile when it is based on an understanding of the agent’s motive’s compared to basing trust on the reliability of the agent’s performance.

Due to the fact that trust and trustworthiness are concepts that have been often mistaken for one another because of their similarity in meaning, it is important to understand the difference between the two. Ben-Ner and Halldorsoon (2010) defined trust as person “B” being believed by person “A” in the process of their cooperation; meaning that person “B” as a trustee will not respond spitefully toward person “A”, not receiving any benefits from cooperation when person “A” is faced a loss situation. In other words, it is considered that individuals believe that others are credible and responsible for is done, or what might have happened.

In the same way, Ben-Ner and Halldorsoon (2010) established that trustworthiness validates that individual “B” acts a positive and favorably attitude toward demands and expectations of individual “A”; adding that the more individual “B” returns to individual “A”, the better trustworthiness they have.

On the other hand, Becerra (2008) defined trustworthiness as a characteristic of the trustee, while trust is the trustor’s willingness to engage in risky behavior that originates from the trustor’s vulnerability to the trustee’s behavior, also indicating that trustworthiness is the scale of trust. Becerra (2008)
added by explaining that the main difference between trust and trustworthiness is that they both have their own particular dimensions. Such trust dimensions include: goodwill trust, predictability trust, and competence trust. Likewise, Mayer (1995) identified the three dimensions of trustworthiness as integrity, benevolence, and competence.

As mentioned before, studies show that trust and trustworthiness are two different conceptions, yet a relationship can be established between them. In the same way, it has been recognized that trust and trustworthiness have different extents, though dimensions of trustworthiness are consistent with trust dimensions. It is important to understand that trust itself varies within individuals. According to Slovic (1993) after trust is gained and lost, it is possible that it might never be recovered. A study conducted by Schweitzer et al. (2006) aimed to examine the effects of untrustworthy behavior from deception, and described the interaction between deception and apologies in regaining trust. Results of this study identified a complex relationship between promises and trust recovery. It was found that “a promise helped initial trust recovery, yet long-term, trustworthy actions were as effective as trustworthy actions accompanied by a promise” (Schweitzer et al., p.6, 2006). Therefore, it is also concluded that a promise can be considered a sign of intention to change behavior.

**Trust Related-Theories**

Additionally, trust theories have been used in order to make predictions of any possible existing difference between the factors that might be affected by trust.
For instance, Rice and Geels (2013) used system-wide trust theories in order to make predictions about the dependence on four diagnostic aids. The system-wide trust theory mainly establishes the fact that if one component of the system fails, it will consequently affect a person’s trust in other areas as well. The study conducted by Rice and Geels (2013) showed that when a perfectly reliable aid was presented together with an unreliable aid, participants leaned more towards treating the two aids as a single unit (system-wide trust theory), rather than as different units with different reliabilities, then explaining the component-specific trust theory. This specific study, increased the number of aids, manipulated the amount of information and feedback given to participants, and used a single-task paradigm instead of a dual-task paradigm to reconsider the hypothetical issue (Rice & Geels, 2013). Findings of the study conducted by Rice and Geels (2013) included that while providing information and feedback were beneficial to overall performance, dependence measures specified that system-wide trust approaches were noticeable and prevalent across almost all of the manipulations.

Likewise, a study conducted by Keller and Rice (2009), evaluated how the trust of the operator is affected by the presence of multiple aids. It uses a component-specific trust theory in order to predict that operators will differentially place their trust in automated aids that differ in reliability. The component-specific trust theory establishes that trust will be affected by one specific component of the entire system and will not trickle out into the rest of the system. In this same study, a system-wide theory predicted that operators would handle multiple defective aids
as one system, and merge their trust across aids notwithstanding differences in the aids’ reliability (Keller & Rice, 2009). Results reported that a system-wide trust theory best predicted the findings. Keller and Rice (2009) reported that operators compiled their trust through both aids, having the same behaviors towards reliable and unreliable aids.

Previously mentioned studies by (Keller & Rice, 2009; Rice & Geels, 2010) can potentially provide possible explanations for the varying levels of trust in this particular experiment. For instance, making reference to the system-wide trust theory, if oxygen masks suddenly came down during a flight, yet the captain immediately informs passengers that this was a system failure and there was no current active threat, this might affect consumers level of trust when it comes to considering this transportation method in the future expecting issues in the system as a whole. On the other hand, component-specific trust theory provides an alternative explanation. If the system controlling oxygen masks fails, that does not necessarily mean the whole aircraft fleet will experience a failure.

On the other hand, the concept of organizational trust theory can potentially be used in several different ways. Starnes et al. (2005) explain how trust in any system relies on an organization as a whole. For instance, they use as an example how individuals rely on United Parcel Service (UPS) to deliver their products in a timely manner. If the product is not delivered on the expected date, this affects trusty and reliability on the organization as a whole, then questioning the company’s integrity. Starnes et al. (2005) describe organizational trust as
intraorganizational trust, a term that is used in many different ways by different researchers. Some focus on the relationship between employees and supervisors, while others focus more on the relationship between employees and senior leaders.

Previously mentioned theories (Keller & Rice, 2009; Rice & Geels, 2010; Starnes et al., 2005) have been used to address studies conducted on trust and automation, and have found that trust is affected by many different factors. In the context of this study, the theory that can potentially addresses why and how differences occur within trust and factors such as type of transportation, type of passenger, and type of operating system, is the organizational trust theory.

**Automation**

Technological advances have resulted in the strong development of automated operating systems. Automation and its importance have been greatly stressed given the series of advantages it provides to a variety of fields. For example, automation advantages include less opportunity for human error, reduction of time production, enhancement of production volumes, as well as reduction in employee expenses, among others.

The primary focus in terms of research is to understand the concept of automation. The definition of automation that best suits the context of this study is: “the execution by a machine agent (usually a computer) of a function that was previously carried out by a human” (Parasuraman & Riley, 1997, p.230).

Automation is most certainly known for easing tasks and general aspects of our daily lives. Even though the belief of human replacement by automation has been
Parasuraman and Riley (1997) argued that automation does not substitute human activity, instead it changes the nature of the work humans do, considering individuals “consumers of automation”.

Individuals constantly fail to rely on autonomous operating systems, yet overreliance has also shown to be an issue. For instance, the excess of reliance in automation was considered to be a contributing factor in an accident occurred in Ohio in 1994 (Parasuraman & Riley, 1997). The National Transportation Safety Board (1994) reported an accident in which a pilot did not trust his own control skills over the aircraft, and instead constantly tended to strongly rely on automatic pilot during flight at night, low-visibility approaches did not monitor the aircraft’s speed during final approach in a snowstorm at night, and unexpectedly crashed short of the runway.

On the other hand, scenarios also show that individuals are not willing to trust automation more than humans. A study conducted by Rice et al. (2014) consisted of presenting scenarios to participants from different cultures, in which an aircraft was either operated by a human pilot, an auto-pilot, or by a human in a ground station using a remote control system. Results of this study showed that US participants leaned more towards flights operated by human pilots, and had much more negative reactions towards automated operating systems compared to Indian participants (Rice et al., 2014). In the same way, Riley (1996) reported that participants of this study preferred manual operations over automated operating
systems even though automated system could have turned out to be more beneficial.

Automation consists of different levels. The four stages of automation include: information synthesis, analysis, decision and action selection, and implementation (Parasuraman, et al., 2000). Stage 1 includes obtaining various information sources, as well as sensory processing, preprocessing of data, and selective attention. In the same way, Stage 2 included the control over information in working memory and cognitive operations such as incorporation, diagnosis, and interference, occurring prior to the point of decision. Stage 3 involves decisions based on the specific cognitive processing, while Stage 4 requires an actin consistent with the decision making process (Parasuraman et al., 2008).

Automation is greatly known for its numerous advantages, such as the ability to multitask, and humans becoming less prone to making mistakes; nevertheless, it is also known to come along with complexity. Individuals believe that automation is an increasing issue itself. Norman (1990) proposed in his research that the problem was not the presence of automation, yet the inappropriate design of it. It is thought that procedures under normal operating conditions are conducted properly, however once humans must control the overall conduct of the task, inadequate feedback and interaction with the system is expected; therefore, it is believed that when required task conditions exceed machine performance, improper feedback leads to troubles in human operation (Norman, 1990).
Consequently, Norman (1990) suggested that the possible solution to this would be the revision and development of appropriate designs. Automated operating systems have silently but surely found their way into many fields such as aviation, motor vehicle operations, and marine procedures, among others. Lee and See (2004) detailed the belief of how this technology can potentially extend human performance while also improving safety, nonetheless numerous accidents and incidents describes otherwise.

The interaction between humans and automated operating systems is crucial. Parasuraman and Riley (1997) use the terms misuse and disuse of automation in order to describe weak relationships between humans and automation. It is known as misuse when individuals fail to have a complete proper understanding of automation, and tend to over rely on it as a consequence. In contrast, disuse refers to the lack of acceptance by individuals of automated operating systems. A study conducted by Singh et al. (1993) reported misuse amongst operators that were carrying on with monitoring procedures. In addition, this behavior was considered to be “a psychological state characterized by a low index of suspicion” (Wiener, 1981, p.117).

**Human Reliance vs. Machine Reliance**

Human-human reliance is considered to be the primary concept of trust (Lyons & Stokes, 2011). It can be concluded that greater trust in an individual lead to a greater possibility of reliance. Lyons and Stokes (2011) reported how research has demonstrated the association of trust with greater reliance on others as
characterized by greater risk taking behaviors (Colquitt et al., 2007; Fuller, Mayer, & Serva, 2005), greater support of performance management systems (Mayer & Davis, 1999), improved information sharing (Staples & Webster, 2008), and greater willingness to make sacrifices for team purposes (Cress, Hesse, & Kimmerle, 2007; Dirks, 1999).

Trust is considered to be essential in human-automation reliance decision (Cohen et al., 1998; Lee & Moray, 1992; Moray et al., 2000). Automation has had a growing presence in our daily lives. Lyons and Strokes (2011) shared that due to the relative predictability of automation, predisposed perspectives on the systems, and existence of non-supporting information, individuals will most likely opt to rely less on non-familiar humans.

**Type of Transportation**

Catastrophic events that occurred in the aviation industry have led to question whether there is a need of pilots in order to complete a flight. It is believed that advances in technology are making pilots less necessary in the field, since commercial aviation is significantly automated nowadays. Weyer (2015) conducted a study, which aimed towards investigating whether pilots had confidence in human-automation collaboration, including cases in which automated systems acted autonomously. Results of this study reported that confidence in hybrid collaboration was fairly high, mostly depending on perceived symmetry of humans
and automation and perceived change of competencies and role distribution (Weyer, 2015).

On the other hand, a study conducted by Winter et al. (2014) focused on examining perceptions of different cockpit configurations, as well as exploring cultural differences between Indian and American individuals. Participants were provided different scenarios in which the aircraft was piloted by two pilots in the cockpit, one pilot in the cockpit and one pilot in a ground facility using remote controls, and two pilots in a cockpit using remote controls. Results of this study show that participants were opposed to having two pilots on the ground controlling the aircraft with remote controls (Winter et al., 2014).

In the same way, a study led by Mehta (2014) sought to determine whether a contagion effect from automation to humans existed. The study presented different scenarios to participants where a) automated aid failed during a commercial flight, and b) no automation failure. After presented with these scenarios, participants were expected to rate their levels of trust in different individuals of a commercial flight system (Mehta, 2014). Results of the mentioned study reported how trust rating had a statistically significant decline when comparing the failure condition to the non-failure/control condition (Mehta, 2014, p.53). In addition, studies conducted by Geels-Blair, Rice, and Schwark (2013), Keller and Rice (2010), Rice and Geels (2010) showed that when one automated device is unreliable, trust in other devices is affected as well.
Cogan (1997) reported that after testing an automated Buick LeSabre driving on a highway, which was controlled by a global positioning satellite system, it was proven that automated cars could completely function without the input of a human. The test consisted of a set of orange cones, which delimited the course, and participants were in two different scenarios: a) blindfolded and b) eyes open but hands off ride. According to Cogan (1997) what will keep traffic flowing in the future is automating control of cars in special lanes, as well as enabling vehicles function safely at high speeds in heavy traffic flow.

Likewise, Le Vine et al. (2015) addressed the impacts of automated cars on traffic flow at signalized intersections. Researchers developed and used a deterministic simulation model of the kinematics of automated cars at a signalized intersection line, when proceeding forward from a standing queue at the beginning of a signal phase. Each vehicle practiced an operation consistent with the “Assured Clear Distance Ahead” criteria, which essentially suggested that each vehicle limits its speed and space from the vehicle ahead regardless of its independent action, in order to avoid any potential accidents or incidents (Le Vine et al., 2015). Le Vine et al. (2015) found the following: “the time required to process a standing queue of ten vehicles was decreased by 25% compared to human operated vehicle; the standard queue discharge model for human operated cars does not directly transfer to queue discharge of automated vehicles; a wet roadway surface may result in the increase in capacity at signalized intersections; a specific form of vehicle communications that allows all automated vehicles in the stationary queue to begin
moving simultaneously at the beginning of a signal phase provides relatively minor increases in capacity in this analysis; and in recognition of uncertainty regarding the value of each operational parameter, researchers identified (via scenario analysis, calculation of arc elasticities, and Monte-Carlo methods) the relative sensitivity of overall traffic flow efficiency to the value of each operational parameter” (p.35).

Other research has been conducted in which vehicles operate independently under adaptive cruise control, and results of a particular study showed that 25% penetration rate of vehicles that were operating under Adaptive Cruise Control (ACC), which according to Howard (2013) is an intelligent form of autonomous cruise control that aims to keep pace with the vehicle in front, eliminated congestion from a condition that existed from human operating conditions (Kesting et al. 2008). The driver is expected to set a maximum speed while the radar sensor is sensible to traffic movements, instructing the car to stay within 2-5 seconds away from the vehicle ahead (Howard, 2013). In addition, autonomous vehicles are expected to reduce accident rates.

On the other hand, since trains have been designed to travel in a same direction, it is expected that this would be the industry with more acceptance regarding automation. The main concern when it comes to rail carriers and automated operating systems is the possible obstruction by an individual or object and the ability to stop the train in time. According to a report published by the
Office of Technology Assessment (1976) the first automated operated subway went into service in New York in 1961. This report was submitted as an assessment of the technology of automated train control in rail rapid transit systems (Office of Technology Assessment, 1976). Through this report, it is explained that automation does not necessarily refer to the solemn operation of automated systems without human involvement in operating or monitoring the device. In contrast, the concept explains that machines perform a significant amount of the functions, yet still slightly relying on humans as an operational component.

Due to technological advances the amount of professionals needed in order to operate trains has been significantly reduced through time. However, the reliance concerns have brought issues on the application of such technology. According to the International Association of Public Transport (UITP) by the end of 2013, there were 48 completely autonomous public metro systems in 32 countries, not including private light rail systems. Individuals to rely on a human aboard some of these systems, yet he only provides emergency support in case the automatic system fails.

Franzen (2015) explained how a law established in 2008, most of the US rail industry is expected to implement a semi-automated system known as Positive Train Control (PTC) as this year comes to an end. “PTC uses communication-based/processor-based train control technology that provides a system capable of reliably and functionally preventing train-to-train collisions, overspeed derailments,
incursions into established work zone limits, and the movement of a train through a main line switch in the wrong position” (U.S Department of Transportation, Railroad Administration, 2008).

Peter (2015) reported how Positive Train Control (PTC) would have helped prevent the Amtrak 188 accident, which carried 238 passengers from Washington, DC to New York. The engineer lost situational awareness and the National Transportation Safety Board (2016) determined that PTC could have prevented this accident. Likewise, Peter (2015) stated how the Hoboken accident where a transit commuter train from New Jersey crashed into the Hoboken Terminal where passengers were a high traffic foot was waiting at the platform, could have also been prevented with the prior implementation of the PTC system. Therefore, it can be noted that in these specific cases, automated systems are being trusted more than humans. When it comes to the completion of tasks, human intervention is most likely expected to lead to human error while autonomous operating systems reduce this possibility.

**Individualism vs. Collectivism**

Hofstede and Bond (1984) defined individualism as a situation where individuals were only concerned about themselves, and close family members, while collectivism was defined as a situation in which people feel they belong to larger groups or collectives who are expected to care for them in exchange of loyalty. G. Hofstede and G.J. Hofstede (2005) describe key differences between
collectivist and individualist societies through examples within schools and workplace such as students only speaking in class when selected by group being a collectivist perspective, whereas from an individualist perspective students are expected to individually speak and participate in class. In the same way G. Hofstede and G.J. Hofstede (2005) also explain how the individualist perspective encourages the word “I”, while the collectivist perspective usually avoids it.

Darwish and Huber (2003) assessed individualism and collectivism in two different groups of male and female students from Egypt and Germany. Results of this study found the effect that cultural background had on individualist vs. collectivist orientations in both cultures for males and females. The population had higher individualist scores in Germany, while in Egypt collectivist scores were higher (Darwish & Huber, 2003).

In addition, Gheorghiu et al. (2009) tested Yamagishi’s emancipation theory of trust across 31 nations. According to Yamagishi, his emancipation theory differs from other approaches since it “emphasizes the relationship-extension role of trust in addition to the relationship consolidation role of trust, the role that previous approaches have traditionally focused on” (Yamagishi, 2011, p.37). The study conducted by Gheorghiu et al. (2009) focused on examining the relationship between individualism/collectivism and generalized social trust across 31 European nations that participated in the European social survey. The mentioned study used multilevel regression analysis and provided the first practical investigation of the
effects of cultural norms of individualism/collectivism on generalized social trust while accounting for individuals’ own cultural orientations within the same analysis. Results showed strong support for Yamagishi, Toshio and Midori Yamagishi (1994) emancipation theory of trust, showing a significant and positive relationship between individualism/collectivism and generalized social trust (Gheorghiu et al., 2009).

Culture plays an important role when it comes to perception of trust in automated operating systems. According to Yerdon et al. (2016) collectivist and individualistic culture characteristics such as prioritizing society, family, and work, as well as only sharing responsibilities of the primacy of the individual were found to be essential in the perception and potential success of automated technologies. In the same way, Yerdon et al. (2016) explained how manufacturers must focus on building based on cultural variances such as individualistic, and collectivistic levels in the use of the systems, in order to create the highest trust, safety, and lowest error and accident rate for the implementation of new systems.

Likewise, Yerdon et al. (2016) distributed a survey in order gather information on regards to drivers’ attitudes towards automated vehicles. Results reported that overall drivers have positive views towards autonomously operated vehicles. Participants were provided different scenarios with different levels of autonomy (0-4) 0 being “no-automation”, and 4 being “full self-driving” automation. Individuals from the U.S. were mostly driven towards the potential
safety benefits automated vehicles could provide, yet concerned about costs. On the other hand, people from the UK showed a positive attitude towards automation, however were concerned about riding in levels of autonomy 3 (limited self-driving automation/ enabling the driver to cede control of all critical functions involving safety under certain traffic conditions) and level 4 (full self-driving automation), as well as Indian participants. In contrast, individuals from Netherlands expect to have autonomous operating systems commercially available between 2025 and 2045, while China relies on a high percentage of knowledge on self-driving vehicles. Japanese individuals showed neutral opinion, though were willing to pay the least for the technology.

Summary

It is important to understand that automation is only expected to grow. It is evident that trust, reliance, and usage of the system are expected to vary due to multiple aspects. As it has been presented, it can be said that culture as well as organizational features can potentially influence perception on automated devices. In some circumstances, consumers have been admitted to be more willing to trust autonomous operating systems over human operated systems, since this leaves a very slight margin of possible human error like it was the case of the Amtrak 188 train accident. In the same way, the development of trust related theories such as system-wide trust, component-specific, and organizational theories have aimed to provide explanations regarding the varying levels of trust when it comes to
acceptance of automation within the different transportation means. In the context of this study, the theory that can potentially explain these varying levels would be the organizational theory, which aims towards relying on organizations such as airlines, rail carriers, and vehicle manufacturers as a whole when it comes to transportation.
Chapter 3 – Methodology

Chapter Overview

In this chapter, the organization and procedures of this particular study are discussed. The chapter will include essential information on regards to the construct of this study. The research will be conducted in order to examine consumers’ level of trust in using an automated aircraft, vehicle, or train as a transportation mean.

The chapter will be dedicated to describe the methods and procedures used in order to obtain specific data. It will include information regarding the population, sample size, and eligibility of the same. Information of how data will be collected (instrumentation), analyzed, and interpreted will also be provided throughout this chapter. In the same way, the chapter will cover type of research design and methodology, as well as a detailed description data processing and arrival to conclusions. A proper address in the research design, data collection, and data analysis will strongly justify the credibility and validity of the research.

Research Design

This study will utilize a true-experimental design to establish a cause and effect relationship. It uses a quantitative methodology with a between-participants factorial design and a convenience sampling technique. The study is considered to be an experimental study, since (1) it manipulates the independent variables (observed and measured in the dependent variable) and (2) has a random
assignment of sample. For these purposes, Amazon’s ® Mechanical Turk ®
(MTurk) will be used in order to collect data from all participants.

For this particular study, the primary design is a factorial design with three
independent variables in different levels: (a) type of passenger (three levels), (b)
type of transportation (three levels), and (c) type of operator (two levels), and one
dependent variable (a) trust. ANOVA will be used to measure for any significant
interactions or main effects. This test allows the comparison of two or more groups
at the same time in order to determine whether there is an existing relationship.
Likewise, a post hoc test will be conducted in order to confirm where the
differences within variables occurred. This test consists in the overview of data
once the experiment has finished. The study will use a between-groups design
given that each participant will only be subjected to a single scenario. This design
will allow the simultaneous testing of all three independent variables and their
different levels.

To begin, participants will be asked to sign an electronic consent form.
Through a questionnaire, participants will be presented with different scenarios
such as either they themselves, their offspring, or their neighbor would board an
automated train, aircraft, and vehicle, and a human operated aircraft, train, and
vehicle. After each given scenario, participants are asked specify their trust in every
one, this will help examine their level of trust. Responses were given by using a 7-
point likert-type scale. Rating of this scale will be measured from Extremely
Distrust (-3) to Extremely Trust (+3), with a neither option of 0. Hartley (2014)
explained how scale items are normally rated from low to high with the negative pole on the left leaving the positive one on the right. In the same way, Hartley (2014) reports how common it is to have negatively worded items, forcing participants to reverse their thinking, and how this brings along difficulties such as writing equivalent items in a positive and negative way, difficulty in reverse thinking, the possibility of the obtaining different scores on positive and negative forms of the same exact item. Following this rating, participants will be asked to describe why they do or they do not trust the presented scenario. By the end of each questionnaire, participants will be expected to provide information regarding their personological factors such as gender, age, and nationality.

Sample and Location

Population

The target population of this study is randomly selected individuals over 18 years of age from the United States. This study aims to generalize results and findings from the sample to the United States population. In the context of setting, the accessible population is known as transportation consumers participating through Amazon’s ® MTurk service via Internet. Amazon’s ® Mechanical Turk ® service has grown to become a popular tool used among researchers who aim to conduct online experiments. With the help of this service provided by Amazon ®, any individual with Internet access can recruit participants for a study. It provides researchers with immediate accessibility to a group of individuals who can serve as participants in a research study, assisting in the data collection process. A study
conducted by Buhrmester, Kwang, and Gosling (2011) provides insight on the
contributions of Amazon’s ® MTurk service to the research community. Findings
of this particular study indicate that participants from this service were slightly
more demographically diverse than other Internet samples, and found to be more
diverse than American college samples. In addition, findings of this study suggest
that data obtained through this service is as reliable as data obtained through
traditional methods (Burhmester et al., 2011). As transportation and automation
have significantly grown through time, and are becoming matter of growing
knowledge within populations worldwide, findings of this study are expected to be
generalized. In view of the quality that can be obtained from data collected through
this service, it can be concluded that data gathered can be as reliable as other data
collection settings.

Sample

The sample of this research study references consumers of the
transportation industry in general. Participants will be recruited via Amazon’s ®
Mechanical Turk®, and are monetarily compensated for their participation by
completing questionnaires. A representative sample of the population requires 735
participants to complete one survey each. Even though the sampling method for
this study is convenience sampling, this does not limit the participation of
individuals who have never boarded an operating aircraft, train, and/or vehicle.
This sampling method will help provide the number of responses necessary for a
valid and reliable representation.
Power Analysis

To establish a proper sample size for this research study, a power analysis will be conducted using G*Power 3.0.10 software program. This analysis is considered to be a formal procedure conducted in order to determine the appropriate sample size for a specific study giving the minimum of subjects needed. In order to conduct this priori power analysis, parameters such as: an effect size of .15, power (beta) of .8, and an alpha level of significance .05. This analysis will help reduce the possibility of any potential false-negative result. Because of the different factors that affect and individual’s level of trust, I will conduct an experiment with 735 participants (approximately 38 in each condition) in order to determine whether these factors have an effect on consumers’ level of trust when it comes to using an automated aircraft, vehicle, or train as a transportation mean.

Variables

Independent Variables

In this research study there are three independent variables with different levels each. The first independent variable is Type of Passenger with three different levels being: a) Yourself, b) Offspring, and c) Neighbor. The second independent variable to this study is Type of Transportation with three levels: a) Train, b) Aircraft, and c) Vehicle. Lastly, the third independent variable is the Type of Operating system including two different levels: a) human operated system and b) autonomous operating system. The scale of measurement of all three independent variables in
this experiment is identified as nominal, since the study mostly aims to categorize
the data without establishing any particular order.

**Dependent Variables**

This particular experiment involves a single dependent variable. The
dependent variable of this study is Trust. The study relies on subjects’ scores on the
Likert-type scale of the survey (Appendix A) in order to measure the dependent
variable. The scale of measurement on the dependent variable of this study is
ordinal. Responses of items are ordered ranging from extremely distrust to
extremely trust. This type of measurement scale allows the comparison of the
degree to which two participants hold the dependent variable, making it possible to
distinguish whether one person has more or less trust than another in a specific
scenario.

**Research Instrumentation**

**Instrumentation**

For the purpose of this study, a survey questionnaire will be created as the
main instrument to collect data. The questionnaire will be created using
SurveyMonkey ®, and presented to participants through Amazon’s ® Mechanical
Turk ®. Every participant will be provided with one of the following scenarios, and
then asked to rate their level of trust in it:

1. “Imagine you are traveling from one major city to another on a train
   operated by a human. Rate your level of trust.”
2. “Imagine your child is traveling between the same cities in a train operated by a human. Rate your level of trust.”

3. “Imagine your neighbor is traveling between the same cities in a train operated by a human. Rate your level of trust.”

4. “Imagine you are traveling from one major city to another on a train completely operated by an automated operating system (no human interference). Rate your level of trust.”

5. “Imagine your child is traveling between the same cities on a train completely operated by an automated operating system (no human interference). Rate your level of trust.”

6. “Imagine your neighbor is traveling between the same cities on a train completely operated by an automated operating system (no human interference). Rate your level of trust.”

7. “Imagine you are traveling from one major city to another on an aircraft operated by a human. Rate your level of trust.”

8. “Imagine your child is traveling between the same cities on an aircraft operated by a human. Rate your level of trust.”

9. “Imagine your neighbor is traveling between the same cities on an aircraft operated by a human. Rate your level of trust.”

10. “Imagine you are traveling from one major city to another on an aircraft completely operated by an autonomous operating system (no human interference). Rate your level of trust.”
11. “Imagine your child is traveling from one major city to another on an 
aircraft completely operated by an autonomous operating system (no 
human interference). Rate your level of trust.”

12. “Imagine your neighbor traveling from one major city to another on an 
aircraft completely operated by an autonomous operating system (no 
human interference). Rate your level of trust.”

13. “Imagine you are traveling from one major city to another on a vehicle 
operated by a human. Rate your level of trust.”

14. “Imagine your child is traveling from one major city to another on a vehicle 
operated by a human. Rate your level of trust.”

15. “Imagine your neighbor is traveling from one major city to another on a 
vehicle operated by a human. Rate your level of.”

16. “Imagine you are traveling from one major city to another on a vehicle 
completely operated by an autonomous operating system (no human 
interference). Rate your level of trust.”

17. “Imagine your child is traveling from one major city to another on a vehicle 
completely operated by an autonomous operating system (no human 
interference). Rate your level of trust.”

18. “Imagine your neighbor is traveling from one major city to another on a 
vehicle completely operated by an autonomous operating system (no human 
interference). Rate your level of trust.”
Following each scenario, participants are asked to rate their trust level of trust based on varying departure hours allowing the examination of the relationship between the variables. By using a seven point likert-scale within the questionnaire variables can be measured. In the same way, after rating their level of trust, participants will be asked to describe why they do or do not trust the presented scenario.

Conducting this research study within the previously mentioned parameters allows to employ a between-subjects design. The experiment considers a between-subjects design, since randomly selected groups will be subjected to a different item. Each participant will be presented with a questionnaire including a single scenario, along with the request of demographics such as: gender, age, and ethnicity. A copy of the full instrument is found in Appendix A.

Data Analysis

Data gathered from questionnaires are processed using Microsoft Excel Software, and organized in graphic charts. The main purpose of data analysis is to determine whether the independent variables: a) Type of Transportation, b) Type of Passenger, and c) Type of Operating System have a significant effect on the dependent variable: a) Trust. Statistical analyses will be conducted within the research study using IBM SPSS Software including: a 3-way factorial analysis of variance (ANOVA) to compare groups to determine whether there is a relationship between them and/or
an interaction, and a Post Hoc test to confirm where the possible differences occurs. After obtaining results, the hypotheses can be tested. Results of these tests will allow to test the following hypotheses:

1) H0: There will not be a significant difference between consumers’ trust to use automated aircrafts, vehicles, trains as transportation mean.
   H1: There will be a significant difference between consumers’ willingness to use automated aircrafts, vehicles, trains as transportation mean.

2) H0: There will not be a significant difference in consumers’ level of trust on regards to human operated systems, and autonomous operating systems.
   H1: There will be a significant difference in consumers’ level of trust on regards to human operated systems, and autonomous operating systems.

3) H0: There will not be a significant difference in consumers’ level of trust to use an automated transportation mean depending on whom on-board.
   H1: There will be a significant difference in consumers’ level of trust to use an automated transportation mean depending on whom on-board.

4) H0: There is no interaction between the independent variables.
   H1: There is an interaction between the independent variables.

Interpretations of these results will determine relevance to the following research questions:

1) How does consumer’s trust vary based on the type of vehicle?

2) How does consumer trust vary based on operating condition?
3) How does consumer trust change based on who is on-board the automated vehicle?

4) Is there an interaction between the type of transportation, type of passenger, and type of operating system?

Participants’ Eligibility

Subjects’ recruited via Amazon’s ® Mechanical Turk ® to participate in this study must be over 18 years of age. Sample selection method being convenience sampling does not allow control over the participant’s previous experience with any one of the transportation means mentioned.

Participants’ Privacy

The research utilizes a survey created by SurveyMonkey ® as the instrument to collect data. This survey does not request private information, and it is not mandatory to be completed. Therefore, participation in this experiment is voluntary, anonymous, and protects information provided meaning it is completely confidential, and these parameters will be rigorously followed in order to protect participants’ privacy at its maximum extent.

Legal and Ethical Concerns

Risks in the conduction of this particular study are not expected towards subjects’ participating in the experiment to be greater than normal daily activities. Participants will be assessed through a survey created through SurveyMonkey ®,
and available in Amazon’s® Mechanical Turk® where participants will be randomly selected to participate without concerns regarding physical, psychological, social, or legal risks. Participation in the study is voluntary, and they may opt out at any time with no penalty. A copy of IRB exemption is located in Appendix B.

Summary

Overall, this chapter aims to provide detailed information regarding the methodology of the experimental research being conducted. It provides essential information of the research methodology, design, and approach used. In the same way, the target population is defined, as well as describes the technique used to select the sample, and recruitment details. In addition, the chapter describes the creation of the instrumentation tool, its internal consistency, and the means used to create the same. Likewise, it lists the various tests being conducted to obtain specific results. Lastly, information regarding participants eligibility, protection, and legal and ethical concerns are specified.
Chapter 4

Overview

In previous sections, the need for the study was stated and thoroughly explained. In chapter three, the organizations and procedures of this study were described. The chapter included information regarding the construct of the study. In this particular chapter (chapter four), the researcher will analyze the data collected. The researcher textually presents the results through this section with the aid of graphs. With the analysis tool IBM SPSS Statistics Software, the researcher will present both descriptive and inferential statistics in this chapter.

General Design

The study utilized a true-experimental design in order to establish a cause and effect relationship. It uses a quantitative methodology with a between-participants factorial design. The independent variables were: Type of Transportation with three different levels being: a) Train, b) Aircraft, c) Vehicle; Type of Passenger with three levels being: a) yourself, b) offspring, c) neighbor; and lastly, Type of operating System with two levels: a) human, and b) autonomous. In addition, this particular experiment involves a single dependent variable: Trust. As mentioned in previous chapter, analysis such as three way ANOVA and Post Hoc Test, were performed in order to determine whether factors such as type of transportation, type of passenger, and type of operating system have an effect on consumers’ level of trust when it comes to automation in terms of transportation.
Research Tool

The primary research tool of this study was a survey questionnaire. As previously described, the survey was created utilizing SurveyMonkey ®, as participants were recruited via Amazon’s ® Mechanical Turk ®. In addition, there were eighteen versions of the questionnaire outlining the eighteen different conditions. Conditions were rated utilizing a seven point Likert-type scale ranging from Extremely Distrust (-3) to Extremely Trust (+3), while each participant was asked to rate their level of trust in the following eighteen different scenarios as presented in table 1:

Table 1
Summary of Scenarios Provided to Participants

<table>
<thead>
<tr>
<th></th>
<th>Yourself</th>
<th>Offspring</th>
<th>Neighbor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train</td>
<td>Train</td>
<td>Train</td>
<td>Train</td>
</tr>
<tr>
<td>Aircraft</td>
<td>Aircraft</td>
<td>Aircraft</td>
<td>Aircraft</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Vehicle</td>
<td>Vehicle</td>
<td>Vehicle</td>
</tr>
<tr>
<td><strong>Automated</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Train</td>
<td>Train</td>
<td>Train</td>
<td>Train</td>
</tr>
<tr>
<td>Aircraft</td>
<td>Aircraft</td>
<td>Aircraft</td>
<td>Aircraft</td>
</tr>
<tr>
<td>Vehicle</td>
<td>Vehicle</td>
<td>Vehicle</td>
<td>Vehicle</td>
</tr>
</tbody>
</table>

*Note: 18 Conditions*
Data Analysis

Descriptive Statistics

This research sampled the population in eighteen different groups including the eighteen different scenarios. Each condition had a sample size of at least N=38, not greater than (N=43) per condition. The total sample size of the experiment was (N=735), of which (N=331) were female participants, and (N=404) were males.

There were 40 participants in the “Yourself/ Train/ Human” condition, the mean age was 38.4 (SD=10.42). There were 41 participants in the second condition “Offspring/ Train/ Human”; the mean age was 33.17 (SD=9.05). There were 40 participants in the third condition “Neighbor/ Train/ Human”; the mean age was 34.95 (SD=11.21). For the fourth condition “Yourself/ Train/ Automated”, there were 41 participants; the mean age was 38.53 (SD=13.25). In the fifth condition “Offspring/ Train/ Automated” there were 38 participants; the mean age was 33.81 (SD=10.36). For the sixth condition “Neighbor/ Train/ Automated”, there were 41 participants; the mean age was 34.75 (SD=8.82). There were 41 participants in the seventh condition “Yourself/ Aircraft/ Human”; the mean age was 37.56 (SD=10.87). In the eighth condition “Offspring/ Aircraft/ Human”, there were 40 participants; the mean age was 36.47 (SD=11.30). In the same way, for the ninth condition “Neighbor/ Aircraft/ Human”, there were 43 participants; the mean age was 35.06 (SD=11.59). The tenth condition “Yourself/ Aircraft/ Automated” had
45 participants; the mean age was 40.42 ($SD=12.34$). There were 41 participants in the eleventh condition “Offspring/ Aircraft/ Automated”; the mean age was 34 ($SD=8.43$). In the twelfth condition “Neighbor/ Aircraft/ Automated” there were 45 participants; the mean age was 38.97 ($SD=13.97$). The thirteenth condition “Yourself/ Vehicle/ Human” had 40 participants; the mean age was 37.9 ($SD=13.25$). There were 40 participants in the fourteenth condition “Offspring/ Vehicle/ Human” ; the mean age was 38.3 ($SD=10.20$). In the fifteenth condition “Neighbor/ Vehicle/ Human” there were 40 participants; the mean age was 37.52 ($SD=15.01$). The sixteenth condition “Yourself/ Vehicle/ Automated” there were 40 participants; the mean age was 38.27 ($SD=12.53$). There were 40 participants in the seventeenth condition “Offspring/ Vehicle/ Automated”; the mean age was 36.4 ($SD=12.09$). Lastly, for the eighteenth condition “Neighbor/ Vehicle/ Automated” there were 39 participants; the mean age was 37.30 ($SD=13.08$).

Overall, the mean age of all 18 conditions was 36.60 ($SD=11.73$). All previously mentioned values are displayed below in a table as Table 2.
Table 2
Summary of Participants Age

<table>
<thead>
<tr>
<th></th>
<th>Yourself</th>
<th>Offspring</th>
<th>Neighbor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
<td>$M$ (SD)</td>
</tr>
<tr>
<td>Human</td>
<td>Train</td>
<td>38.4 (10.42)</td>
<td>33.17 (9.05)</td>
</tr>
<tr>
<td></td>
<td>Aircraft</td>
<td>37.56 (10.87)</td>
<td>36.47 (11.3)</td>
</tr>
<tr>
<td></td>
<td>Vehicle</td>
<td>37.9 (13.25)</td>
<td>38.3 (10.2)</td>
</tr>
<tr>
<td>Automated</td>
<td>Train</td>
<td>38.53 (13.25)</td>
<td>33.81 (10.36)</td>
</tr>
<tr>
<td></td>
<td>Aircraft</td>
<td>40.42 (12.34)</td>
<td>34 (8.43)</td>
</tr>
<tr>
<td></td>
<td>Vehicle</td>
<td>38.27 (12.53)</td>
<td>36.4 (12.09)</td>
</tr>
</tbody>
</table>

Note: N = 735.

Participants of this study were Americans, yet there were a variety of ethnicities within. Overall, 78.64% of the participants were Caucasian, 6.94% were from African Descent, 4.76% were from Hispanic Descent, 8.44% were Asian, and 1.22% claimed to be from other ethnicities as displayed below in Figure 1.

Figure 1: Ethnicity data for participants in all eighteen conditions
Trust Data

In the “Yourself/ Train/ Human” condition the trust results had a mean score of 2.00 ($SD=0.95$). In the “Offspring/ Train/ Human” condition, trust results had a mean score of 1.00 ($SD=1.68$). For the “Neighbor/ Train/ Human” condition, trust results had a mean score of 2.23 ($SD=0.84$). In the same way, for the “Yourself/ Train/ Automated” condition, trust results had a mean score of -1.53 ($SD=1.41$). In the “Offspring/ Train/ Automated” condition, trust results had a mean score of -1.29 ($SD=1.36$). The “Neighbor/ Train/ Automated” condition had trust results with a mean score of -0.64 ($SD=1.81$). In the “Yourself/ Aircraft/ Human” condition, trust results showed a mean score of 2.03 ($SD=0.70$). In the “Offspring/ Aircraft/ Human” condition, trust results had a mean score of 1.05 ($SD=1.52$). In addition, in the “Neighbor/ Aircraft/ Human” condition, trust results revealed a mean score of 1.85 ($SD=1.12$). In the “Yourself/ Aircraft/ Automated” condition, trust results had a mean score of 0.05 ($SD=1.90$). For the “Offspring/ Aircraft/ Automated” condition, there was a mean score for trust results of -0.21 ($SD=1.79$). The “Neighbor/ Aircraft/ Automated” condition, showed trust results with a mean score of -0.76 ($SD=1.67$). On the other hand, the “Yourself/ Vehicle/ Human” condition, had trust results with a mean score of 1.73 ($SD=1.01$). In the “Offspring/ Vehicle/ Human” condition, trust results had a mean score of 0.93 ($SD=1.37$). The “Neighbor/ Vehicle Human” condition had trust results with a mean score of 1.58 ($SD=1.30$). In the “Yourself/ Vehicle/ Automated” condition, trust results showed a mean score of -0.68 ($SD=1.93$). In the case of the “Offspring/
Vehicle/Automated” condition, trust results had a mean score of -0.65 (SD = 1.90). Lastly, in the “Neighbor/ Vehicle/ Automated condition” trust results showed a mean score of -0.31 (SD = 1.59). Values are displayed in Table 3 and Figure 2 below.

Table 3
Summary of Participants Trust Results

<table>
<thead>
<tr>
<th></th>
<th>Yourself</th>
<th>Offspring</th>
<th>Neighbor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
</tr>
<tr>
<td><strong>Human</strong></td>
<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
</tr>
<tr>
<td>Train</td>
<td>2 (0.95)</td>
<td>1 (1.68)</td>
<td>2.23 (0.84)</td>
</tr>
<tr>
<td>Aircraft</td>
<td>2.03 (0.70)</td>
<td>1.05 (1.52)</td>
<td>1.85 (1.12)</td>
</tr>
<tr>
<td>Vehicle</td>
<td>1.73 (1.01)</td>
<td>0.93 (1.37)</td>
<td>1.58 (1.30)</td>
</tr>
<tr>
<td><strong>Automated</strong></td>
<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
<td><strong>M (SD)</strong></td>
</tr>
<tr>
<td>Train</td>
<td>-1.53 (1.41)</td>
<td>-1.29 (1.36)</td>
<td>-0.64 (1.81)</td>
</tr>
<tr>
<td>Aircraft</td>
<td>0.05 (1.90)</td>
<td>-0.21 (1.79)</td>
<td>0.76 (1.67)</td>
</tr>
<tr>
<td>Vehicle</td>
<td>-0.68 (1.93)</td>
<td>-0.65 (1.90)</td>
<td>-0.31 (1.59)</td>
</tr>
</tbody>
</table>

*Note: N = 735.*
Assumptions of ANOVA

In this particular study, there are four ANOVA assumptions after data collection. The first assumption of this study was about existing outliers in the dataset. Outliers are data points that are significantly high or low and caused by data that has been contaminated or unusual cases. According Laerd (2015), there are three reasons for finding outliers within data: (1) data entry errors, (2) measurement errors, and (3) genuinely unusual values. The analysis conducted revealed that there were a total of 34 outliers. After revising the data, it was concluded that there were no data entry errors and no measurement errors;
therefore, the values were genuinely unusual, and even though they are not ideal in a statistical perspective, they are not to be rejected as invalid, therefore, the assumption was met. The second assumption is independence of cases; this assumption was analyzed for all eighteen conditions. For this, participants were randomly assigned to conditions and surveys were made available to subjects with time gaps. The third assumption was regarding normal distribution. This assumption was checked, and according to results from the Kolmogorov-Smirnov and Shapiro Wilk test in SPSS, it was found that values were not equal to the normal curve. Values were significant, \( p < .05 \), therefore, trust scores are not normally distributed. Lastly, the fourth assumption, the assumption of homogeneity of variances was violated, as assessed by Levene’s test for equality of variances, \( p < 0.001 \). While these two assumptions were violated, the ANOVA statistical test was still utilized, since according to Ito (1980) ANOVA is considered to be a robust test, defining this test to be unaffected by changes in extraneous factors not under testing. Furthermore, there is not a non-parametric statistic equivalent to a three-way ANOVA. The violation of these assumptions is identified in the Limitations section in the following chapter.

**Analysis of Variance (ANOVA)**

In order to examine the effect of the independent variables (type of passenger, type of transportation, type of operating system) on the single dependent variable (trust) this research uses a three way ANOVA. Three way ANOVA is conducted using trust data in order to determine whether there are statistical
differences between type of passenger, type of transportation, and type of operating system as well as interactions in the data.

Results showed three significant main effects: Type of Passenger, $F(2,717) = 16.750$, $p < 0.001$, partial-$\eta$ squared $= 0.045$, Type of Transportation $F(2,717) = 12.039$, $p < 0.001$, partial-$\eta$ squared $= 0.032$, and Type of Operating System $F(1,717) = 367.585$, $p < 0.001$, partial-$\eta$ squared $= 0.339$.

However, these main effects were qualified by some significant interactions. It was found that there was a statistically significant interaction between type of passenger and type of operating system, $F(2,717) = 6.432$, $p = 0.002$, partial-$\eta$ squared $= 0.018$, and there was a statistically significant interaction between type of transportation and type of operating system interaction, $F(2, 717) = 15.479$, $p < 0.001$, partial-$\eta$ squared $= 0.041$. Interactions are displayed in Figures 4 and 5 below:
Figure 4: Statistically significant interaction between independent variables: Type of Passenger and Type of Operating System.

Figure 5: Statistically significant interaction independent variables: Type of transportation and Type of Operating System.
There was no statistically significant three way interaction between type of passenger, type of transportation, and type of operating system, $F(4,717) = 0.391, p = 0.815$, partial-eta squared = 0.002, nor was there a statistically significant type of passenger and type of transportation interaction, $F(4,717) = 0.806, p = 0.521$, partial-eta squared = 0.004.

A three-way ANOVA was conducted in order to determine the effects of type of passenger, type of transportation, and type of operating system on trust. In post hoc tests conducted, significant differences were found in the type of passenger variable between “yourself” and “offspring”, “yourself” and “neighbor”, and “offspring” and “neighbor”, in the type of transportation between “train” and aircraft, and “aircraft” and “vehicle”. Nevertheless, a post hoc test was not needed for the independent variable “type of operating system” since this variable only has two levels (human and automated).

**Summary**

As mentioned in previous chapters, this study aims to determine whether factors such as type of transportation, type of passenger, and type of operating system have an effect on consumers’ level of trust when it comes to automation in terms of transportation, and this is obtained through a three-way ANOVA conducted. Results suggest that participants level of trust is higher towards trains, human operated systems, and scenarios involving their neighbors, while their trust levels are at its lowest when it comes to themselves boarding, trains, and automated systems. In the same way, results show there is a significant effect on the
dependent variable “Trust” depending on the independent variables “type of passenger” and “type of operating system”, and “type of transportation” and “type of operating system”.
Chapter 5

Overview

The purpose of this study was to determine whether factors such as: type of transportation, type of operating system, and type of passenger have an effect on consumers’ level of trust when it comes to automation in transportation. This study focused on determining whether type of transportation, type of operating system, or type of passenger had an influence on consumers’ level of trust under eighteen different conditions.

The study used 735 participants (332 females/ 403 males) from the United States. The study relied on a between-subjects design, since randomly selected groups were subjected to a different condition. Each participant was presented with a questionnaire including a single scenario, along with the request of demographics such as: gender, age, and ethnicity. Participants were presented with different scenarios such as either they themselves, their offspring, or their neighbor would board an automated aircraft, train, and vehicle, and a human operated aircraft, train, and vehicle. After each participant was given scenario to rate their level of trust, then they were asked to describe why they did or did not trust the scenario. This helped examine their level of trust. Responses were given by using a 7-point likert-type scale. Rating of this scale will be measured from Extremely Distrust (-3) to Extremely Trust (+3), with a neutral option of 0.
This study utilized a true-experimental design to establish a cause and effect relationship. The study was considered to be an experimental study, since (1) it manipulates the independent variables (observed and measured in the dependent variable) and (2) has a random assignment of the sample. The primary design was a factorial design with three independent variables in different levels: (a) type of transportation (three levels), (b) type of operator (two levels), and (c) type of passenger (three levels), and one dependent variable (a) trust. ANOVA was used in order to measure for any significant interactions or main effects. This test allowed the comparison of two or more groups at the same time and determined significant relationships. Likewise, a post hoc test was conducted in order to confirm where the differences within variables occurred.

The hypotheses of this study were:

**Null Hypothesis 1**

H$_{01}$: There is no significant difference between consumers’ trust to use automated trains, aircraft, vehicles as transportation mean.

**Alternative Hypothesis 1**

H$_{A1}$: There is a significant difference between consumers’ willingness to use automated trains, aircraft, vehicles as transportation means.

**Null Hypothesis 2**

H$_{02}$: There is no significant difference in consumers’ level of trust on regards to human operated systems and autonomous operating systems.
Alternative Hypothesis 2

\( H_{A2} \): There is a significant difference in consumers’ level of trust on regards to human operated systems and autonomous operating systems.

Null Hypothesis 3

\( H_{03} \): There is no significant difference in consumers’ level of trust to use an automated transportation mean depending on whom on-board.

Alternative Hypothesis 3

\( H_{A3} \): There is a significant difference in consumers’ level of trust to use an automated transportation mean depending on whom on-board.

Null Hypothesis 4

\( H_{04} \): There is no interaction between the independent variables.

\( H_{A4} \): There is an interaction between the independent variables.

Summary of Findings

This study aimed to determine whether factors such as: type of transportation, type of operating system, and type of passenger have an effect on consumers’ level of trust when it comes to automation in transportation. The study collected trust results from 735 participants who were randomly provided with a single condition from eighteen different possible scenarios, and these results were explained in detail in chapter 4.

Results of this study showed that the level of trust among participants varied depending on a relationship between type of passenger and type of operating system, and type of transportation and type of operating system. It was found that
participants were more trusting of the human operated systems, and least trusting of the automated systems in general. Variations in trust levels can be due to many different factors that are that will be further discussed.

**Discussion**

Results were reported and explained in detail in previous chapters, yet it is important to interpret these findings. Since automation is a growing technology, research regarding the matter is only expected to continue its development as well. The purpose of this study was to observe whether factors such as type of passenger, type of transportation, and type of operating system had an influence when it come to consumers’ trust level. The study predicted that there would be a significant difference between consumers’ level of trust when using automated aircraft, vehicles, and trains as transportation means than when those means were operated by humans, and results of the data analysis generally supported these hypotheses. Trust results significantly varied among conditions depending on type of operating system and type of passenger, and type of operating system and type of transportation, specifically in automated conditions.

The first hypothesis predicted that there would be a significant difference between consumers’ willingness to use automated trains, aircraft, and vehicles as transportation means. Results of data analysis supported this hypothesis, by showing that there was a statistically significant main effect of “type of transportation”. Participants’ level of trust was affected by the type of transportation in each condition. Trust ratings overall decreased in the three types
of transportation (Trains, Aircraft, Vehicles), especially when related to automated systems. This result was consistent with a previous study conducted by Winter et al. (2014), which focused on examining perceptions of different cockpit configurations, as well as exploring cultural differences between Indian and American individuals. Results of this study showed that participants were opposed to having two pilots on ground controlling the aircraft with remote controls.

From an open ended question provided to participants requesting them to describe why they did or did not trust given scenario, it can be concluded that like participants from the study conducted by Winter et al. (2014), participants from this study are not comfortable utilizing trains, aircraft, or vehicles without a human on-board operating them. Participants expressed that if there is no trained human on board, there would be no way of interference in case of an emergency; consequently the significant difference in trust levels between the two operating systems can also be accounted to this.

The second hypothesis expected that there would be a significant difference in consumers’ level of trust on regards to human operated systems and autonomous operating systems. Findings of this study supported this hypothesis, since results showed there was a statistically significant main effect on “type of operating system”. Levels of trust from participants of this study were higher in conditions involving human systems. This result can be considered consistent with research conducted by Lyons and Stokes (2011). According to Lyons and Strokes (2011), due to the relative predictability of automation, predisposed perspectives on the
system, and the current existence of non-supporting information, individuals will less likely rely on automated systems. The decrease in trust ratings within automated systems can be accounted to the fact that there is uncertainty and a great amount of negative information when it comes to these systems, and this might have led participants to predisposition, which consequently have affected their levels of trust on non-human systems.

The third hypothesis stated that there would be a significant difference in consumers’ level of trust to use an automated mean depending on whom-on-board. According results from this study, both type of operating system and type of passenger have statistically significant main effects. Findings showed that participants’ levels of trust were the lowest when conditions involved automated systems and offspring, and the highest in scenarios involving neighbors. These results can be accounted to the individualistic perspective. For instance, Hofstede and Bond (1984) define the concept of “individualism” as a situation where individuals are only concerned about themselves and close family members. Therefore, the concept of “Individualism” may offer possible explanation of these results, and it is possible that participants identified with the individualistic perspective. As a result, they are more concerned about themselves and their offspring compared to the concern for their neighbors.

Lastly, the fourth hypothesis of this study predicted that there would be some interactions between independent variables. Results of the study partially supported this hypothesis. There was no statistically significant interaction between
type of passenger, type of transportation, and type of operating system. Instead, results did show an interaction between type of passenger and type of operating system, and type of transportation and type of operating system. A study conducted by Mehta (2014), which held common concepts with this study, performed a three-way ANOVA in its “Trust” data, and there was a main effect found between variables.

In general, participants of this study were more trusting of a condition involving trains and human systems, and least trusting of a condition involving trains and automated systems. Since, trains have been designed to travel in the same direction, it was expected that this would be the industry with more acceptance of automated systems. A report published by the Office of Technology Assessment (1976) explains that automation does not necessarily refer to the operation of automated systems without human involvement in monitoring the device, slightly relying on humans as an operational component, which potentially explains the low values of trust rating in this study; given the fact that the main concern when it comes to rail carriers and automated systems is the possible obstruction by an individual or object and the ability to stop the train in time in case of an emergency.

Significant main effects were found of the independent variables: type of passenger, type of transportation, type of operating system and trust when it comes to transportation. United States manufacturers such as General Motors (GM) “Buick”, have been developing new technology and have been leaning more
towards automated systems, and further research involving participants from other countries can provide a different perspective in terms of identifying whether culture may have a significant effect on consumers’ level of trust in automation. As reported by Cogan (1997) after testing an automated Buick LeSabre driving on a highway controlled by a global positioning satellite system (GPS), it was proven that automated cars could completely function without the input of a human, and this can lead to the potential growth of automation in the transportation industry. This study can potentially evaluate whether consumers’ trust this new technology within the specific type of transportation, and through this manufacturers can be able to evaluate whether the investment in the new technology will be beneficial or not.

Overall, participants were more trusting of the controlled system (human) in relationship with both type of passenger and type of transportation. When it comes to the automated system and type of passenger, participants were more trusting of the scenario when it was a “Neighbor” on board, and least trusting with an “Offspring” on board. When it comes to the automated system and type of transportation, participants were most trusting of “Aircraft” conditions, and least trusting of “Train” conditions when related to automated systems. An open ended question asking participants to describe why they do or do not trust the given scenario can potentially provide support to these results. In the case of the automated system and type of passenger, participants expressed in “Neighbor” conditions, that this was their neighbors choice, and they were not being affected
by it; this can also be related to “individualistic” and “collectivist” concepts provided in a study conducted by Yerdon et al. (2016). According to Yerdon et al. (2016) individualistic and collectivist characteristics such as prioritizing society, family, and work, as well as only sharing responsibilities of the primacy of the individual were found to be essential in terms of perception and potential success of automated technologies. The increase in trust in conditions involving automated systems and “Neighbors” may potentially be accounted to the fact that participants do not feel affected by or face consequences because of their neighbor’s choice, meaning they may not rely on a collectivist perspective; instead, they might hold an individualistic perspective where they feel they can be affected if it were themselves or an offspring on board. From this, it can be concluded that individualistic and collectivist concepts may have a significant influence when it comes to automated systems’ growth.

**Practical Implications**

Results of this study showed that factors such as type of passenger, type of transportation, and type of operating system, do affect the consumers’ level of trust in terms of transportation. This information is important for the transportation industry, since automation is currently a growing popular topic. For instance, there have been many tests and research conducted in automated vehicles, therefore vehicle brands might need to do future research in order to learn whether these factors have an influence on consumers’ level of trust.
This study benefits manufacturers that are contemplating whether the investment in a new technology such as automation is feasible or not. This study provides an evaluation on consumers’ levels of trust, and this can help determine how acceptant the society is of such technology.

**Limitations**

The main limitation of this study was the violation of ANOVA assumptions. As detailed in chapter 4, normality and homogeneity assumptions were violated. Another limitation to this study was the data collection method, and the instrument itself. Participants will be recruited via Amazon’s ® Mechanical Turk ® and then presented with the instrument created through SurveyMonkey ® providing the researcher as much control as having on-site live participants. Even though this service facilitates a convenience sampling method, it does offer participants with compensation. However, other research conducted ensured that data collected through Amazon’s ® Mechanical Turk ® is known to be as valid as normal laboratory data (Buhrmester, Kwang, and Gosling, 2011).

**Recommendation for Future Research**

As technology advances and developments are being implemented in several industries, automation can only be expected to grow. From this research it can be noted that there are different perspectives and thoughts when it comes to automation in terms of transportation.
The current research evaluated three factors that could have an effect on consumers’ level of trust: type of passenger, type of transportation, and type of operating system. The study produced noteworthy results, yet this study’s methodology can be replicated with a greater sample size and the involvement of other independent variables such as time of the day and culture, also encouraging the participation of subjects from other countries.

Conclusion

This study aimed to determine whether factors such as: type of transportation, type of operating system, and type of passenger have an effect on consumers’ level of trust when it comes to automation in transportation. After collecting data from 735 participants from the United States, the study found that consumers’ trust is influenced depending on type of transportation, type of passenger, and type of operating system. This research can potentially lead to future investigation in the different branches of the transportation industry. The study benefits transportation service providers that are contemplating the reliability of automated systems in terms of transportation.
References


Washington, D.C.


Appendix A - Measuring Trust

1. Are you at least 18 years of age?
□ Yes
□ No

Instructions:

You will be presented with a scenario and you will then be asked some questions about that scenario. Following that, you will be asked some demographics questions. The data collection process is anonymous and your responses will remain confidential.

The questions portion of the survey contains 5 questions. We expect that it will take you 2-3 minutes to answer all the questions.

2. Please rate your level of trust given the presented scenario:

Scenarios:

1. “Imagine you are traveling from one major city to another on a train operated by a human. Rate your level of trust.”

2. “Imagine your child is traveling between the same cities in a train operated by a human. Rate your level of trust.”

3. “Imagine your neighbor is traveling between the same cities in a train operated by a human. Rate your level of trust.”

4. “Imagine you are traveling from one major city to another on a train completely operated by an automated operating system (no human interference). Rate your level of trust.”
5. "Imagine your child is traveling between the same cities on a train completely operated by an automated operating system (no human interference). Rate your level of trust."

6. "Imagine your neighbor is traveling between the same cities on a train completely operated by an automated operating system (no human interference). Rate your level of trust."

7. "Imagine you are traveling from one major city to another on an aircraft operated by a human. Rate your level of trust."

8. "Imagine your child is traveling between the same cities on an aircraft operated by a human. Rate your level of trust."

9. "Imagine your neighbor is traveling between the same cities on an aircraft operated by a human. Rate your level of trust."

10. "Imagine you are traveling from one major city to another on an aircraft completely operated by an autonomous operating system (no human interference). Rate your level of trust."

11. "Imagine your child is traveling from one major city to another on an aircraft completely operated by an autonomous operating system (no human interference). Rate your level of trust."

12. "Imagine your neighbor traveling from one major city to another on an aircraft completely operated by an autonomous operating system (no human interference). Rate your level of trust."
13. “Imagine you are traveling from one major city to another on a vehicle operated by a human. Rate your level of trust.”

14. “Imagine your child is traveling from one major city to another on a vehicle operated by a human. Rate your level of trust.”

15. “Imagine your neighbor is traveling from one major city to another on a vehicle operated by a human. Rate your level of.”

16. “Imagine you are traveling from one major city to another on a vehicle completely operated by an autonomous operating system (no human interference). Rate your level of trust.”

17. “Imagine your child is traveling from one major city to another on a vehicle completely operated by an autonomous operating system (no human interference). Rate your level of trust.”

18. “Imagine your neighbor is traveling from one major city to another on a vehicle completely operated by an autonomous operating system (no human interference). Rate your level of trust.”

3. Please describe why you would, or would not trust the given scenario.

4. Gender:
   
   □ Male
   
   □ Female

5. What is your age?
6. **What is your ethnicity?**

- □ Caucasian
- □ African descent (e.g. African American)
- □ Hispanic descent (e.g. Latin America)
- □ Asian descent
- □ Other…

7. **Please input your initials followed by your age. For example, if your name is John Smith and you are 23 years old, then you would put: JS23**
Appendix B- IRB Exempt Letter

Notice of Exempt Review Status
Certificate of Clearance for Human Participants Research

Principal Investigator: Vivalda A. Patin
Date: January 9, 2017
IRB Number: 17-008
Study Title: Consumers’ Level of Trust in Using an Automated Aircraft, Vehicle, or Train as a Transportation Means

Your research protocol was reviewed and approved by the IRB Chairperson. Per federal regulations, 45 CFR 46.101, your study has been determined to be minimal risk for human subjects and exempt from 45 CFR 46 federal regulations and further IRB review or renewal unless you change the protocol or add the use of participant identifiers.

All data, which may include signed consent form documents, must be retained in a secure location for a minimum of three years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained on a password-protected computer if electronic information is used. Access to data is limited to authorized individuals listed as key study personnel.

The category for which exempt status has been determined for this protocol is as follows:

2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior so long as confidentiality is maintained.
   a. Information is recorded in such a manner that the subject cannot be identified, directly or through identifiers linked to the participant and/or
   b. Subject’s responses, if known outside the research would not reasonably place the subject at risk of criminal or civil liability or be damaging to the subject’s financial standing, employability, or reputation.