Examining the Relationship between Familiarity and Reliability of Automation in the Cockpit

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Abstract

This study sought to determine the correlation between familiarity and perceptions of reliability, as associated to specific aviation-related automated devices. Participants' experience levels ranged from non-pilots to novice pilots to certified flight instructors. It was hypothesized that familiarity has a direct correlation with ratings of reliability for various aviation-related automated devices and that the correlation across devices for each participant would be positive. The researchers expected to find a difference in the familiarity-reliability relationship as a function of experience. Findings showed that there was a significant positive correlation between familiarity and reliability for every single automated device. A positive correlation across automated devices for 87% of the participants was also found. Interestingly, the study did not find any relationship between experience and the familiarity-reliability relationship.

Introduction

Automation has become a part of our everyday lives. The general public has grown accustomed to a great number of automated applications, from cruise control to automatic transmissions. Within aviation, pilots are becoming more accustomed to glass panel displays, autopilots, and Global Positioning System (GPS) navigation as a part of everyday flying. People tend to have blind faith that certain components will reliably perform the tasks expected of them. However, they may be less trusting of other aids and devices. The current study sought to determine the correlation between personal experiences and history (i.e. familiarity) with an automated device and ratings of the same device's perceived reliability. The research team predicted that the participants' rating of reliability would have a direct relationship with their trust in that particular aid, device, or system, showing the relationship between familiarity and reliability. The study included 181 participants with different levels of aviation experience, ranging from non-pilots to Certified Flight Instructors. The non-pilots were deemed to have aviation experience by virtue of their ground training and college level education in the non-flight aspects of the aviation industry. The participants were asked to rate their familiarity and perceived reliability for a number of different aviation related automated devices and aids.

Humans' trust in automation has been widely researched, and what the implications of the same could mean throughout the industry. Additionally, familiarity has also been seen as a predictor of trust between humans and within interpersonal interactions (Jian, Bisantz, & Drury, 2000). This study is unique in that it works to enhance the industry's understanding of trust and familiarity by attempting to find a correlation as it relates to multiple automated aids. This study aims to understand the extent to which familiarity with an automated device increases or decreases a person's perception of the system's reliability. There may be, of course, certain exceptions showing negative correlations between familiarity and perceived reliability. These exceptions may result from a participant's negative experiences with a specific automated aid or device. Trust is defined in social psychology as the predictability of another person (Deutsch, 1958; Eckel & Wilson, 2004; Ergeneli, Saglam, & Metin, 2007); research has also shown that this concept can likewise be applied toward automation (Parasuraman & Riley, 1997; Reeves & Nass, 1996; Rice, 2009). Once trust in an item or person is affected or lost, it is an extremely powerful psychological occurrence; it can be very difficult to overcome, even over an extended period of time. In certain cases, once trust is lost, it may never be regained (Slovic, 1993). In these cases, increased familiarity and exposure to a device operating accurately may take years of effort to regain lost trust.

The following sections outline the industry's research on trust in automation, familiarity between human operators and how familiarity can be used as a predictor of perceived reliability in automation. This will clearly outline the necessity for the current study and allow for a discussion of the much larger implications that this study could have on the aviation industry as a whole.

Automation

Automation is defined by Wickens and Hollands (2000) as a mechanical or electrical task or accomplishment of work that otherwise would need to be accomplished by a human operator. Parasuraman, Sheridan, and Wickens (2000) identify four stages of automation: synthesis, diagnosis, response selection, and response execution functions. Automated aids can assist a human in times of high workload, or perform a task that a person is not suited to perform accurately and precisely, and can often replace the human from these tasks (Rice & Geels, 2010). The next step in understanding automation fully is to determine the extent to which human beings rely on automation to perform accurately and consistently. Research demonstrates that the acceptance and perceived reliability that a person places in an automated system can be affected by that individuals' trust in the system (Sheridan, 1998).

Unfortunately, automation is not always accurate, and like any system, has the propensity to fail. It is for this reason that people may be wary of completely trusting automation, and a cautious attitude toward automation is perfectly healthy. Automation can fail to catch potentially hazardous situations (misses), or issue alerts for events that did not actually occur (false alarms). Both failures have been shown to negatively affect an operator's trust in the system (Geels-Blair, Rice, & Schwark, 2013; Parasuraman & Riley, 1997; Rice, 2009; Rice & Geels, 2010). Repeated failures of an automated system could lead us to explore the possibility that continued exposure to such events could create a psychological tendency to have less perceived reliability in that particular automated system. Conversely, repeated exposure to a system that performs accurately and efficiently on a constant basis, it may, either falsely or accurately, increase the operator's sense of reliability in the system.

Familiarity with Humans

Previous studies have greatly researched several different facets of trust in automation (Gefen, 2000; Gulati, 1995; Larzelere & Huston, 1980; Lee & Moray, 1994; Luhmann, 1979; Luhmann, 2000; Minsky, 2003; Muir & Moray, 1996; Sheridan, 1988), and several works have documented the different relationships between humans, and how trust affects the same. Familiarity has been defined as a complex understanding frequently based on prior interactions, experiences, and learning of others (Luhmann, 1979). Luhmann (2000) clearly warns against confusing the concepts of familiarity and trust. He explains that familiarity is an unavoidable occurrence, but trust has to be earned within this set of familiarity. Changes within the natural set of occurrences are bound to take place, and these changes may not necessarily affect our familiarity with a system or human being, but they will affect our trust (Luhmann, 2000). Gefen (2000) researched the relationship between familiarity and trust in the context of e-commerce, which found that even though trust and familiarity are different, familiarity does affect trust. Minsky (2003) differentiates between two types of trust, namely familiarity based trust, and reliability based trust, which infers that familiarity based trust is based on personal familiarity. Interpersonal relationship studies, within the business realm, have been researched, and it has been noted that people are more likely to build alliances and trust business partners with whom they have prior ties. Familiarity leads to laxer practices as firms build confidence in their partners, which is the direct display of their trust in the other set of human counterparts (Gulati, 1995). Larzelere and Huston (1980) measure trust in terms of benevolence and honesty between partners. From their studies, they were able to determine that several factors affected the measure of trust, some of which included predictability, reliability, and dependability. Studies prior to the current research (Lee & Moray, 1994; Muir & Moray, 1996) took the opportunity to apply these measures of trust to determine if they were similar for an operator's trust in automated systems. They developed an additive trust model that included six components: predictability, dependability, faith, competence, responsibility, and reliability. It has also been noted that possible factors in trust include reliability, robustness, familiarity, understandability, explication of intention, usefulness, and dependence (Sheridan, 1988). Trust is therefore crucial in the overall role of familiarity and the connection between trust, familiarity and reliability is the key to this researchers' observations. Trust could therefore be categorized as the emotional and psychological construct that aids in the development of familiarity, thus affecting the individual's perceptions of reliability.

Familiarity with Equipment

Numerous studies have researched the connection between trust and automation, as well as the relationship between human operators and their use of automation within the scope of their required tasks (Dzindolet, Peterson, Pomranky, Pierce, & Beck, 2003; Jian, Bisantz, & Drury, 2000). Jian, Bisantz, and Drury (2000) saw the need to be able to effectively measure a human operator's trust in automation and their effective use through an empirically determined scale. Trust is an extremely powerful psychological occurrence. Interestingly, once people are informed as to why automation might fail or make errors, their trust and reliance in the automation is renewed, even though the increase is unwarranted (Dzindolet et al., 2003).

Novice versus Experts

The differences between novices and experts from several fields have been researched greatly to measure their variations, including those relating to aspects of aviation (Li, Baker, Lamb, Grabowski, & Rebok, 2002; Kasarskis, Stehwien, Hickox, Aretz, & Wickens, 2001; Rowe & Wright, 2001; Thomson, Önkal, Avcioğlu, & Goodwin, 2004). It has been found that since aircraft mechanical reliability has improved over the decades, the causes of accidents have shifted heavily onto the pilots, and this is where pilot experience becomes a factor. In today's aviation environment, with so many mechanical enhancements and automated features available to a pilot, approximately 70-80% of accidents, regardless of experience, occur due to human error (Li, Baker, Lamb, Grabowski, & Rebok, 2002). It was found that expert pilots were more adept to identifying low risk situations, while novice pilots are more likely to overestimate the potential for a hazardous situation (Thomson, Önkal, Avcioğlu, & Goodwin, 2004). Thomson, Önkal, Avcioğlu, and Goodwin (2004) also go on to state that experts are customarily thought to have characteristics and knowledge that allow them to better perform relevant task than novices. Interestingly, Rowe and Wright (2001) aim to show that there is very little evidence to support the generally accepted concepts that experts judge risks differently, and are more veridical than novices. As experience (measured in terms of flight hours) relates to flying skills, expert pilots were found to have more active scan patterns than novice pilots. This finding translates into better, more consistent and more efficient flying skills as they relate to airspeed maintenance and landing performance (Kasarskis, Stehwien, Hickox, Aretz, & Wickens, 2001). Within the vast array of research conducted on the differences between novices and experts in several fields and situations, no prior studies discuss the differences of the two groups as they relate to familiarity and reliability in automation.

An important part of this current study lies in the fact that a varied sample of participants from different levels of aviation experience was used to collect this data. The range of knowledge and experience varied from non-pilots, to novice pilots beginning their aviation education, all the way up to seasoned flight instructors with several thousands of hours of flight experience. The inclusion of non-pilots was to serve as benchmark for lack of flight experience and give the perspective of a person unfamiliar with instruments and automation in the cockpit. This is important to the study, as the researchers were able to gauge the variations from several different levels of experience to see if they all behave in a similar manner universally. This may have major implications in the findings, as it could suggest how level of experience influences one's view toward automation reliability.

Current Study

Previously studies have paved the path in the research of trust relating to automation, and the manner in which familiarity between human beings affects trust. The current study goes into depth to examine the familiarity of human operators and non-operators with automation, which is something that has yet to be conducted within this field of research, and may have significant promise for future research. The survey asks participants to rate their familiarity with a range of automated aids and devices, as well as their feelings of reliability in those same devices. If familiarity with automation is found to have a significant correlation with peoples' concept of reliability in the automation, it can be hypothesized that trust in automation has a direct relation to one's familiarity with the same. This would mean that the more familiar the participant is with an automated system, the higher the rated reliability will be from the participant. Our hypotheses were as follows:

1) It was predicted that the between-participants correlation between familiarity and reliability would be positive. It was expected this would exist across all participant levels and that this would apply to all automated devices.
2) It was predicted that the within-participants correlation between familiarity and reliability would be positive. It was expected this would exist across all participant levels as well.
3) It was predicted that there would be a noted difference in the correlational analysis of the familiarity-reliability relationship as a function of experience as measured by flight hours.

Method

Participants. 181 persons (19 females) participated in the study. The mean age was 21.17 (*SD* = 4.46). The data was collected from college students and university professionals associated with an aviation college at the subject university. There are eleven different subsets of data that were collected from participants in different aviation related college courses (see Table 1). All participants were members of the subject university's College of Aeronautics as either students or flight instructors.

Materials and Recruitment. The study was completed using paper surveys that were administered to participants; seven randomized versions of the instrument were created to reduce order effects. To recruit participants, members of the research team solicited volunteers from various level courses within the College of Aeronautics from introductory students with minimal or no flight experience to university flight instructors. A listing of sections surveyed can be found in Table 2. The items listed are described as automation, and the argument of the definition of automation is extensive. The items are a wide range of instruments, aids, and devices, and have been specifically chosen to be the best representation of items used in the cockpit that would serve the purpose of the study. Participants were informed that completion of the survey was optional and separate from any course requirements, and no compensation was provided to participants for survey completion.

Table 1

Data as a Function of Coursework

	Between	Within	N
Introduction to Aviation Human Factors	.41	.37	30
Aeronautics 1 (Section 1)	.43	.41	24
Aeronautics 1 (Section 2)	.20	.31	17
Aeronautics 1 (Section 3)	.27	.45	18
Aeronautics 2 (Section 1)	.35	.42	16
Aeronautics 3 (Section 1)	.41	.49	11
Aeronautics 3 (Section 2)	.47	.58	11
Aeronautics 4 (Section 1)	.32	.56	8
Advanced Aircraft Systems (Section 1)	.38	.24	9
Advanced Aircraft Systems (Section 2)	.13	.50	7
Certified Flight Instructors	.23	.33	23

Procedure. After obtaining institutional review board (IRB) approval, participants were instructed that the survey instrument was designed to gather information on their familiarity and perceived reliability of 33 aircraft components (see Table 2). These items were selected as a mixture of commonly used instruments on board general aviation aircraft as well as complex automated systems found on larger commercial airliners. The researchers instructed participants to review each instrument and then rate their familiarly, from -3 (extremely unfamiliar) to 3 (extremely familiar), and reliability, from -3 (extremely unreliable) to 3 (extremely reliable) using the Likert scale. The order of the two ratings was counter-balanced, and participants were instructed not to go back once they had provided answers. Following this, basic demographic information was sought from participants, along with number of flight hours (as an indicator of experience), following which they were dismissed from the room.

Design. A correlational design was employed for this study including between and within subjects analyses.

Results

Out of the 181 total participants, 169 provided viable data. The most common reason for dropping a participant's (11) data were due to a failure to input responses. One additional participant was dropped due to a failure to provide demographic data. All analyses used a two-tailed analysis per the non-directional hypotheses.

The mean familiarity score was 1.01 (*SD* = 1.05) on a scale from -3 (extremely unfamiliar) to 3 (extremely familiar). The mean reliability score was 1.40 (*SD* = 0.45) on a scale from -3 (extremely unreliable) to 3 (extremely reliable).

Table 2

Between-Participant Correlations for Each Automated Device

Type of Device	Correlation
Air Data Computer	0.54
Airspeed Indicator	0.41
Altimeter	0.34
Anti-Ice Controls	0.36
Attitude Indicator	0.39
Attitude, Heading, and Reference System	0.44
Autopilot	0.42
Brakes	0.36
Cabin Pressurization System	0.19
Communication Radio	0.20
Crew Alerting System	0.43
Engine Indication	0.45
Flight Management System	0.24
GPS	0.30
Heading Indicator	0.25
Heads Up Display	0.34
Inclinometer	0.48
Inertial Guidance System	0.15
Lights	0.31
Magnetic Compass	0.22
Mode Control Panel	0.36
Multi-Function Display	0.49
Navigational System	0.43
Oxygen Controls	0.32
Primary Flight Display	0.46
Rudder Pedals	0.44
Servo Actuator	0.32
Throttle Levers	0.50
Traffic Collision Avoidance System	0.36
Turn and Bank Indicator	0.40
Vertical Speed Indicator	0.42
Yaw Rate Sensor	0.34
Yoke	0.54

The overall between-participant correlations for all participants ranged from .15 (p = .05) to .54 ($p < .001$), with a mean score of .37, $p < .001$. These values can be found in Table 1. The overall between-participant correlations for Non-US participants ranged from -.78 ($p < .001$) to .89 ($p < .001$), with a mean score of .34, $p = .01$. The overall between-participant correlations for US participants ranged from -.64 ($p < .001$) to .91 ($p < .001$), with a mean score of .42, $p = .01$. The overall between-participant correlations for female participants ranged from -.56 ($p = .01$) to .77 ($p < .001$), with a mean score of .34, $p = .15$. The overall between-participant correlations for male participants ranged from -.78 ($p < .001$) to .91 ($p < .001$), with a mean score of .39, $p < .001$.

The overall within-participant correlations ranged from -.78 ($p < .001$) to .91 ($p < .001$), with a mean score of .40, $p = .02$. 147 out of 169 participants had positive correlations (Binomial probability $P(x=147)$, $p < .001$).

There was no significant correlation between flight time and the within-participants consistency coefficient, $r = -.05$, indicating that there was no relationship between level of expertise and the familiarity-reliability relationship. There was no significant correlation between age and the within-participants consistency coefficient, $r = -.08$, indicating that there was no relationship between age and the familiarity-reliability relationship.

Table 2 presents the data by course/section. As can be seen in the table, every course/section followed the same pattern as the overall data. The between-participant correlations for the courses/sections ranged from .13 to .47, with a mean score of .37. The within-participant correlations for the courses/sections ranged from .24 to .58, with a mean score of .40.

Discussion

The purpose of the study was to further analyze the relationship between familiarity and reliability (a construct related to trust). Prior research has indicated that there may be a positive correlation between the two variables; however, it has not been pursued in the field of aviation to the degree that would allow for strong generalizations. In the current study, aviation students (from non-flight up to certified flight instructors) in the College of Aeronautics at the subject university were given a list of 33 common automated devices in the cockpit and asked to rate how familiar they were with the devices, and how reliable they felt the devices to be. In general, the research team predicted a positive correlation between familiarity and reliability across all devices and participants. The findings are discussed here.

The first hypothesis was that the between-participants correlation between familiarity and reliability would be positive. It was expected that this would exist across all participant levels, and that this would apply to all automated devices. The findings supported this hypothesis; in fact, the between-participants analyses showed that there was a significant positive correlation between familiarity and reliability for every single automated device.

While it is possible that this relationship might not exist for some other automated devices, the current data provide strong evidence towards a possible future generalizable positive relationship between the two variables. Furthermore, this relationship exists across all levels of coursework and experience in the Aeronautics program.

The second hypothesis predicted that the within-participants correlation across automated devices for each participant would be positive. This was the case for 87% of the participants. These results indicate that the positive within-participants correlation between familiarity and reliability exists for the vast majority of participants in the study. These results are surprising, given that human attitudes and behavior tend to have a large amount of variance. To have 87% of participants agree about a particular relationship between variables allows us to not only generalize the effects across automated devices, but also across the general population of Aeronautics students at the subject university. The sample population is a mix of pilots and non-pilots with a specific purpose of understanding the relationship and the differences in the relationship as a function of experience or lack thereof with aviation systems.

The third hypothesis was that the relationship between flight hours (experience), and the within-participants consistency coefficient would show that more experienced pilots would have a stronger familiarity-reliability relationship. The data did not support this hypothesis. Instead, the results indicate that there was no significant relationship between level of experience and the familiarity-reliability relationship. Thus, the correlation between familiarity and reliability appears to be constant across all levels of experience up to certified flight instructor. It is also important to note that none of the other demographics collected correlated with this familiarity-reliability relationship.

Practical Implications

The findings of this study offer some practical implications. First, it is clear that designers of automated systems must take into account the operator's familiarity with the device before assuming high-perceived reliability in the system. It is already known that more opaque automated systems (Wickens & Holland, 2000) result in lowered trust in the system. Designers need to create automated systems that are transparent and easy to become familiar with. Training should focus on helping the operator to become familiar with the device, including understanding the algorithms behind the automation.

Most automated devices fail eventually, and sometimes frequently. Operators need to have an understanding of why the devices fail, so that when a device does operate inaccurately, there is not a total loss of trust due to ignorance of the reason behind the failure. Learning why a device fails is a way of becoming more familiar with it; therefore, even though an individual is becoming more familiar with a faulty device, they might still perceive it as being more reliable. This has been shown through prior research (Dzindolet et al., 2003), and an example in the aviation industry in the Traffic Collision Avoidance System (TCAS). All pilots know that the TCAS frequently produces false alarms; however, most pilots still value the system and the regulations still requires compliance because it saves lives.

Another interesting finding was the lack of relationship between experience (as measured by flight hours) and the familiarity/reliability relationship. The relationship appears to be robust across the sample, at least within this study. None of the other demographic variables collected in this study were shown to have a relationship with familiarity/reliability either. This may indicate that there is some other variable or factors that influence how operators determine familiarity and perceived reliability within a system. Further research should seek to examine for other predictors that could influence the relationship between familiarity and reliability. The likely line of research would include studies that seek to determine the quantity of familiarity needed to produce the quality of reliability to meet industry best practices.

Limitations and Recommendations for Future Research

The current study has certain limitations common to studies of this nature. First, the correlations found in the study do not prove causation. It is possible that other confounding variables may be interacting with the two variables measured and causing a misunderstanding of the data. Further research should focus on experimentally testing these findings while controlling for possible confounds in order to provide causal inferences.

A second limitation is demographics of the participants; they were all from the same aviation program at the subject university, therefore it is possible that many had similar forms of training and experiences. They were fairly young; mean age was about 21 years old. All the participants come from a Part 141 school. Future studies should include participants from other schools (including Part 61), different age groups, and potentially includes commercial pilots, and not just students with commercial flight ratings. Most of the participants were male; a function of the demographics of the aviation program. The researchers were unable to find gender differences because of this, and thus further research should include more females in order to make gender comparisons.

A third limitation that prevented us from making meaningful comparisons between the different courses was the unequal number of participants in the courses. Introduction to Aviation Human Factors had 30 participants, while Aeronautics 4 had only eight. The researchers hope that future research will allow for sampling a higher number of advanced students compared to what the research team was able to deliver here.

Conclusions

The purpose of this study was to determine the relationship between familiarity and reliability using an aviation related sample from a small to medium sized university in the southern part of the United States. The findings of the study indicate significant, positive correlations between familiarity and reliability for both the between and within participants conditions. Interestingly, the study did not find any relationship between experience (as measured by flight time) and the familiarity/reliability relationship, which seems to indicate that this relationship is robust across all levels of experience. Additionally, none of the other demographic variables collected correlated with the familiarity/reliability relationship. This highlights the need for continued research on this topic to enhance the understanding of the relationship between familiarity and reliability within an aviation related field.

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