Collegiate Aviation Review International

Volume 38 | Issue 1 Peer-Reviewed Article #5

2-18-2020

How Weather, Terrain, Flight Time, and Population Density Affect Consumer Willingness to Fly in Autonomous Air Taxis

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Background: Many studies have investigated passengers' willingness to fly (WTF) or ride in autonomous aircraft and vehicles. With the emergence of urban air mobility, it is important to consider consumer perceptions of autonomous air taxis and passengers' willingness to fly in various conditions. Therefore, the purpose of this study was to determine what external factors may influence consumers' willingness to fly on autonomous air taxis in various weather conditions, terrain, flight time, and population densities. Methods: Across two studies, 782 participants were presented with a definition of autonomous air taxis. Then a hypothetical scenario involving an air taxi that included four variables: rain versus no rain (Weather), 5-minute flight versus 30-minute flight (Flight Time), over land or water (Terrain), and over urban or rural areas (Population Density). Results: The data from the study suggest that both United States and Indian passengers were more willing to fly in good weather conditions versus rainy weather, over land versus over water, and on short flights versus longer flights. Conclusions: As urban air mobility becomes more well-known, it is important to understand consumer opinions and educate them on emerging technology. This, in turn, can aid industries in developing marketing strategies to help increase awareness of new technologies in the future.

Recommended Citation:
Ragbir, N.K., Rice, S., Winter, S.R., Choy, E.C., & Milner, M.N. (2020). How Weather, Terrain, Flight Time, and Population Density Affect Consumer Willingness to Fly in Autonomous Air Taxis. *Collegiate Aviation Review International*, 38(1), 69-87. Retrieved from http://ojs.library.okstate.edu/osu/index.php/CARI/article/view/7962/7350

Prior research has extensively examined consumers' perceptions and how certain perceptions can influence their willingness to fly in autonomous vehicles (Asgari & Jin, 2019; Haddad, Chaniotakis, Straubinger, Plötner, & Antoniou, 2020; Hughes, Rice, Trafimow, & Clayton, 2009; Mehta, Rice, & Winter, 2014; Mehta, Rice, Winter, & Eudy, 2017; Ragbir, Baugh, Rice, & Winter, 2018; Rice, Kraemer,Winter, Mehta, & Dunbar, 2014; Rice, Winter, Mehta, & Ragbir, 2019; Rice & Winter, 2015). However, research on external factors and their impact on the adoption of autonomous vehicles for urban air mobility (UAM) is limited. Traffic congestion on the ground can be extremely high in many urban areas, and there is a lot of airspaces available to alleviate this congestion. Since transportation is most effective when it can assist the masses, it is important to know in what conditions consumers are most likely to adopt and use UAM. Thus, the purpose of this study aims to determine consumers' willingness to fly in autonomous air taxis in varying weather, flight time, terrain, and population density conditions. This study will also consider consumers' cultural differences between India and the United States and how that may affect individual responses to the adoption and use of UAM in varying conditions.

Urban Air Mobility

Urban air mobility (UAM) refers to transportation systems, mainly within urban areas, that move people by air (Thipphavong et al., 2018). This system is intended to reduce traffic congestion by creating more avenues for public transportation. There are various barriers to the successful implementation of UAM. First, the technology and infrastructure need to be reliable and accessible to the public (Risen, 2018). For example, for an electric vehicle with vertical takeoff and landing (VTOL), like a helicopter, to provide transportation in urban areas, it needs to have a robust battery and designated landing pads. Another important barrier is the expense as emerging technology and infrastructure are quite costly throughout the developmental process (Risen, 2018). Therefore, it is imperative to optimize costs while upholding safety to create a transportation system that can truly assist the public and reduce congestion.

Another important barrier to consider is the public's likelihood of adoption of UAM. Haddad et al. (2020) studied factors that can affect adoption, like the 1989 Technology Acceptance Model by Davis, Bagozzi, and Warshaw. The results indicated that the key factors associated with the adoption are safety, trip cost, trip duration, and service reliability. Analyses of socio-demographic factors indicated that females were much less interested in UAM adoption by expressing lower trust, lower perceived usefulness, and greater concerns for safety and security (Haddad et al., 2020). Tackling these barriers is key for future researchers and designers, as resolving them could lead to a higher potential for UAM adoption. While technology is advancing for all autonomous vehicles, it is ideal that autonomous cars are available to the masses first as this adoption and growing familiarity will assist with autonomous aircraft in the future.

Moreover, Unmanned Aerial Systems, or better known as drones, also play a role in understanding the public's adoption of autonomous technology. Drones do not have a human pilot onboard; however, a pilot is operating the aircraft by remote control (Clothier, Greer, Greer, & Mehta, 2015). As drones began to gain popularity, some citizens expressed apprehensions regarding drone operations. One study explored a predictive approach to understand what factors predicted an individual's privacy concerns of drones (Marte et al., 2018). The results of the study suggested that seven factors predicted these concerns, some of which was the importance of privacy, attitudes towards drones, and safety in the neighborhood (Marte et al., 2018). The Federal Aviation Administration issued new regulations beginning in 2020 regarding recreational drone flying in the U.S. Some regulations include flying below 400 feet, not flying in controlled airspaces such as around airports, and no flying in airspaces where a flight is prohibited (Federal Aviation Administration [FAA], 2020).

Cultural Considerations

The study of human behavior is complex because there are so many variables and influences involved. This study strives to further understand human behavior and decision-making by accounting for nationality and perceptions of various flight conditions. Determining how nationality can play a role typically involves cultural influences. Culture is difficult to define because its influences on society and individuals are mostly invisible (Hofstede, 1984). Helmreich defines culture as "shared norms, values, and practices associated with a nation, organization, or profession" (2000, p. 134). It is extremely important to consider cultural differences across nations because of the limits to generalizability. What may be common practice or belief in one culture may even be unheard of in another culture. For example, an individual's willingness to trust others may be influenced by cultural background, and therefore, cannot be generalized to individuals that do not share a similar culture (Hofstede, 1980).

In this study, the participants were either from the United States or Indian. Participants from both countries are important to the aviation market because millions fly each year in India and close to a billion fly in the United States (Carrerio, n.d.; Bureau of Transportation Statistics, 2019). One key cultural difference between these nations is the value of individualism in the United States versus collectivism in India. Markus and Kitayama (1991) concluded that collectivist cultures have an interdependent view of the self. Individuals are taught to trust without question and to take others' interests into higher regard than their own (Wu & Jang, 2008; Rice et al., 2014). Collectivist cultures also have a preference for a closely-knit social framework, where individuals can rely on nurturing from relatives and others within the in-group in exchange for unquestioning loyalty (Hofstede, 1980).

Conversely, individualistic cultures place preference for a more relaxed social framework, where individuals care for themselves and their immediate families only (Hofstede, 1980, 1984). Those of individualistic cultures are also more autonomous and independent from their in-groups, as they prioritize personal goals over group goals (Triandis, 2002). It is common for individualists to behave based on their attitudes, as opposed to aligning behaviors to mimic those of the in-groups.

To further solidify the cultural differences between India and the United States, on Hofstede's Cultural Values by Nation Index comparing individualistic and collectivist dimensions, India scored a 48 out of 100. This score indicates that culture is mainly collectivist with some individualistic characteristics (Hofstede, 1980, 1984). The United States scored the highest value at 91 out of 100, which suggests a strong individualistic culture. For this study, the differences in cultures will play a role in the participant's willingness to fly in autonomous vehicles.

Willingness to Fly on Autonomous Aircraft

Automation is the capability for technology to select data, transform information, make decisions, and control processes (Hughes et al., 2009). To improve human performance, automation is commonly utilized in the field of aviation, which includes aircraft take off, piloting, and landing. An autonomous aircraft does not require a pilot and can fulfill all operation procedures required to fly an aircraft safely such as interaction with air traffic controllers and national airspace (Ragbir et al., 2018). On the other hand, drones or unmanned aerial systems are operated by a pilot who is controlling the aircraft through a remote control device, though one similarity between autonomous aircrafts and drones is there is no human pilot directly onboard the aircraft.

However, the successful adoption of automation in commercial aircraft relies heavily on consumer opinions. These opinions pertained to risk, knowledge, price, trust, and reliability (Hughes et al., 2009). Pilots must be comfortable working with associated risks and be knowledgeable with more complex technologies should problems arise. Passengers prefer that the price is affordable, but not so inexpensive that quality is compromised. Lastly, both pilots and passengers need to be able to trust the automation to work reliably. While these opinions may seem reasonable and workable, it is not uncommon for individuals to exercise the *affect heuristic*, which is unconsciously and immediately assessing an object as good or bad based on feeling, regardless of actual risk or benefit (Hughes et al., 2009). In a 2009 study by Hughes and colleagues, participants almost always preferred the human pilot over the automated pilot, both functioning at 99% reliability when accounting for the price, trust, confidence and emergency. Therefore, it is likely that automation technology needs to overachieve in commonly used areas to combat negative affect heuristic and improve consumer opinions.

In addition to ensuring overachievement, it is important to develop familiarity either by interactions, experiences, or pure learning because trust is developed "within the set of familiarity" (Mehta, Rice, & Winter, 2014). For example, consumers are very trusting in the use of cruise control because they are familiar with the functional parameters from experience. In a 2014 study by Mehta and colleagues, participants, varying from novice to expert in aviation, ranked their familiarity and reliability with numerous automated aircraft devices (e.g., airspeed indicator, autopilot, anti-ice controls, etc.). The results indicated a strong correlation between familiarity with device and perceived reliability (Mehta et al., 2014). Even though the average consumer will have minimal aviation experience, it is worth developing familiarity through in-flight pamphlets and other learning materials. Repeated exposure will help consumers develop more trust in automation.

When striving towards more exposure and familiarity, it is important to know the consumer, as well, and be able to account for cultural norms. In a 2014 study by Rice and colleagues, results indicated that Indians and participants from the U.S. were more comfortable, trusting, and willing to fly with a human pilot than an automated aircraft. However, Indian participants were more forgiving when it came to automated and remote-controlled (RC) aircrafts in comfort, trust, and willingness than American participants (Rice et al., 2014). These results are further supported in a study by Ragbir et al. (2018) where willingness to fly in an autonomous aircraft accounted for nationality, weather, wind, and distance. Across the board, Indians were much more willing to fly in an autonomous aircraft, as almost every American participant responded negatively across all conditions. These results are likely due to differences in societal norms rooted in collectivism or individualism of Indians and Americans, respectively. It is uncommon within collective cultures, like Indians, to challenge the status quo or push boundaries. Therefore, to conform with others, Indian participants are likely to be moderates, as opposed to extremists.

Winter et al. (2015) expanded on the research by focusing on cockpit configurations (e.g., one or two pilots onboard and/or one or two pilots in a remote-control ground station with no autonomy). Both Indian and participants from the U.S preferred having a traditional cockpit, where both pilots are onboard. However, both groups of participants were slightly more in favor of the aircraft that were operated by remote-control to delivered cargo, as opposed to passengers (Winter et al., 2015). While the preference was not significant, this could be a starting point to teach the usefulness and reliability of automation in aviation. In 2017, a study by Mehta and colleagues expanded on cockpit configurations to account for gender. Indian male participants were less willing to fly when two female pilots were onboard, but still preferred all human pilot configurations over autopilot. Even though Indian participants are generally more in favor of automation in aviation than Americans, it is still important to properly familiarize Indians and Americans with the technology, likely with different learning methodologies, so that they are informed consumers.

While there may be cultural perspective differences in the use of automation in aviation, there are emotions that are more congruent across all individuals and less dependent on culture. In 2015, Rice and Winter conducted a study utilizing emotions as a mediator for pilot configurations and the willingness to fly. All participants in the study experienced more negatively associated emotions when presented with autopilot configurations, including anger, disgust, fear, sadness, and surprise. The only clear positive emotion, happiness, was expressed significantly in favor of human pilots. There was also a correlation between emotions and the willingness to fly. Participants that expressed a negative affect for autopilot were not willing to fly, whereas participants that had expressed a positive affect for human pilots were also more willing to fly (Rice & Winter, 2015). These correlated emotions are also consistent with Rice, Winter, Deaton, and Cremer (2016) regarding system-wide trust (SWT) loss. Participants that were more likely to feel negative about aircraft automation failures (e.g., unnecessary deployed oxygen masks) also lost trust in the other automated systems that did not fail (e.g., autopilot system, landing gear, seat video monitor). While SWT loss and negative perceptions are likely to be consistently correlated, it is important to address and reassure consumers that not all components within the aircraft are entirely linked or interconnected. As mentioned previously, familiarity and experience with autonomous aviation and its processes can assist with building and earning trust.

While there may be disparities in willingness to fly in autonomous aircraft, consumers do acknowledge the advantages, as well. In the qualitative portion of Ragbir and colleague's (2018) study, participants mentioned that autonomous aircrafts would have *less human error* as there are *no emotions involved*. Participants also mentioned that the autopilot would not fatigue like a human pilot, and there may be *cheaper flight costs* (Ragbir et al., 2018). Individuals who buy into the advantages of autonomous aircrafts would likely be more willing to fly in the future. Rice et al. (2019) conducted a study to determine if there are predictors of individuals who are more willing to fly and may be early adopters to the technology. The seven significant predictors were familiarity, fun factor, wariness of new technology, fear, happiness, age, and education level. It is reasonable that individuals with more knowledge in aviation and autonomous technology are more willing to fly as the opportunities become available. Those same individuals may feel happiness or perceive emerging technology as fun since they have a better idea of how aircraft worked traditionally (Rice et al., 2019). It is important not only to identify these individuals that are more likely to support and be willing to fly in autonomous aircraft but also to consider their input on improvements to better the technology for the masses.

Willingness to Ride in Autonomous Cars

Similar to aviation, autonomous technology intends to reduce human error and fatigue when in an automotive vehicle. However, differing media portrayals can have an impact on the potential consumers' perspectives on willingness to ride. Anania et al. (2018) conducted a study determining the effects of information regarding driverless vehicles and whether nationality or gender can affect the consumer's willingness to ride. Firstly, there were correlations where individuals were more willing to ride after hearing positive information and less willing to ride after hearing negative information. These results made clear the importance of seeking information from various sources to get a better understanding of the technology and a more accurate perspective of advantages and disadvantages to autonomous cars. Similar to findings within autonomous aircraft, Indian participants were also more willing to ride in driverless cars than American participants. Gender had less consistent correlations as Indian females reported the highest willingness to ride scores, but American females reported the lowest willingness to ride scores (Anania et al., 2018).

Further research by Rice and Winter (2019) demonstrated that females were less willing to ride compared to males, and that effect was mostly mediated by fear and anger. These emotional responses may be due to perceptions of complexity in the technology, a lack of fun factor, and less familiarity with technology. The study results also demonstrated a significant effect for age, where older participants were less willing to ride compared to younger participants. These results supported previous findings by Winter and colleagues in 2018. They had applied an affective perspective to consumer use of driverless ambulances. Both genders preferred having a human as the driver of an emergency medical service vehicle (Winter et al., 2018). Similar to results by Rice and Winter (2019), females were less willing to ride in driverless ambulances, and this result was mostly mediated by anger.

Similar to literature from autonomous aircraft, there will always be consumers that are not willing to ride in driverless cars. However, as technology continues to advance and become more accessible, it is important to identify those who are willing to ride and become early adopters. A study by Asgari and Jin (2019) utilized attitudinal factors as mediators for consumers who are willing to adopt or pay for autonomous vehicles. The four most prominent factors were the *joy of driving*, *mode choice reasoning*, *trust*, and *technology savviness* (Asgari & Jin, 2019). Participants that enjoyed driving were less willing to adopt and pay for autonomous vehicles. However, participants that were technologically savvy were much more willing to adopt the use of autonomous vehicles. *Mode choice reasoning* referred to individuals that factored in the costs and benefits of a driverless vehicle, and were only willing to pay for automated features if it would save time and cost, be more convenient, reduce stress, improve quality of life, or produce some other benefit (Asgari & Jin, 2019). Lastly, individuals with low trust were more likely to pay for automated features as they would provide more privacy and protection compared to public transit or other shared mobility options (Asgari & Jin, 2019). Knowing where consumers are hesitant or excited about autonomous vehicles is one of the best courses of action toward developing technology that can be utilized by the masses.

Current Study

Prior research has shown that consumers are more willing to fly in vehicles that are manned by humans versus fully autonomous vehicles (Anania et al., 2018; Hughes et al., 2009; Mehta et al., 2014; Rice et al., 2014; Rice et al., 2019; Rice & Winter, 2015; Winter et al., 2015). However, there are emerging consumers that are willing to be early adopters of autonomous vehicles, and they share similar interests and factors. Indian consumers tend to be more willing to fly or ride on autonomous vehicles than American consumers (Rice et al., 2014). Familiarity with technology and emotions are also mediators for consumers interested and willing to fly or ride in autonomous aircraft or vehicles (Mehta et al., 2014; Rice & Winter, 2015; Rice & Winter, 2019). This study will expand on previous research by determining which external factors may affect consumers in their willingness to fly in an autonomous aircraft designed for UAM in various weather, flight time, and environmental conditions. The following research question drove this study:

> RQ: Do weather, terrain, flight time, and population density affect consumer willingness to fly in autonomous air taxis?
>
> We hypothesized the following:
>
> Ha1: Participants would be more willing to fly in an air taxi in good weather versus rainy weather.
> Ha2: Participants would be more willing to fly in an air taxi over dry land versus over water.
> Ha3: Participants would be more willing to fly in an air taxi for shorter flights versus longer flights.
> Ha4: Participants would be more willing to fly in an air taxi over rural areas versus urban areas.

Study 1 – Methods

Study 1 investigated which external factors may affect consumers in their willingness to fly in an autonomous aircraft designed for UAM in various weather, flight time, and environmental conditions. Study 1 used American participants only. Both studies utilized a within-participants experimental design where all participants were responding to all conditions. Each participant was presented with a randomly ordered set of scenarios to avoid order effects.

Participants

Four hundred and ninety-six (261 females) people took part in the study. All participants were located in the United States. The mean age was 37.77 years old (*SD* = 11.54). Participants were recruited from Amazon's Mechanical Turk, which is an online portal where participants receive monetary compensation for completing human intelligence tasks. Data from this site have been shown to have high reliability, similar to what is found in experimental labs (Buhrmester, Kwang, & Gosling, 2011; Germine et al., 2012; Rice, Winter, Doherty & Milner, 2017).

Materials and Stimuli and Procedure

Participants first read and signed an electronic informed consent, and then, they were given instructions. Participants were presented with a definition of autonomous air taxis, and followed by a hypothetical scenario involving an air taxi. Specifically, they were told:

> *Imagine a situation where you have no other option of getting across a major city except to ride in an autonomous air taxi. This aircraft has no human pilot and is fully automated. There are no flight controls, and no way for anyone inside to take over control*.

Afterward, they were asked how willing or unwilling they would be to ride in the air taxi under a variety of conditions that were divided into four experimental independent variables: rain versus no rain (Weather), 5-minute flight versus 30-minute flight (Flight Time), over land or water (Terrain), and over urban or rural terrain (Population Density). Each of these conditions was crossed with all other conditions for a total of 16 conditions. Participants responded to the *willingness to fly scale* (WTF) (Rice et al., 2020) with seven possible responses from extremely unwilling to fly (-3) to extremely willing to fly (+3) with a zero neutral option. A description of the scale can be found in Appendix A.

They were then asked basic demographics questions and allowed to elaborate, if they wished, with open-ended questions. Finally, participants were debriefed, compensated, and dismissed.

Ethics

This research followed the ethical protocol for human participants' research with oversight from the Institutional Review Board. All researchers have current CITI certificates, and all participants were provided with consent forms.

Study 1 – Results

Figures 1 and 2 present the results from Study 1 for both the 30-minute flight time and the 5-minute flight time. A four-way analysis of variance using Weather, Flight Time, Terrain and PopDensity as the main factors revealed significant main effects of Weather, $F(1, 468) = 148.24$, p < .001, *partial eta-squared* = .24, of Flight Time, $F(1, 468) = 148.46$, $p < .001$, *partial eta-squared* = .24, and of Terrain, $F(1, 468) = 46.31$, $p < .001$, *partial eta-squared* = .09. There was a significant interaction between Weather and Terrain, $F(1, 468) = 4.01$, $p = .046$, *partial eta-squared* = .01. There was no significant interactions between Urban and Rural (PopDensity) areas $F(1, 468) = 0.45$, $p = .502$, *partial eta-squared* = .001.

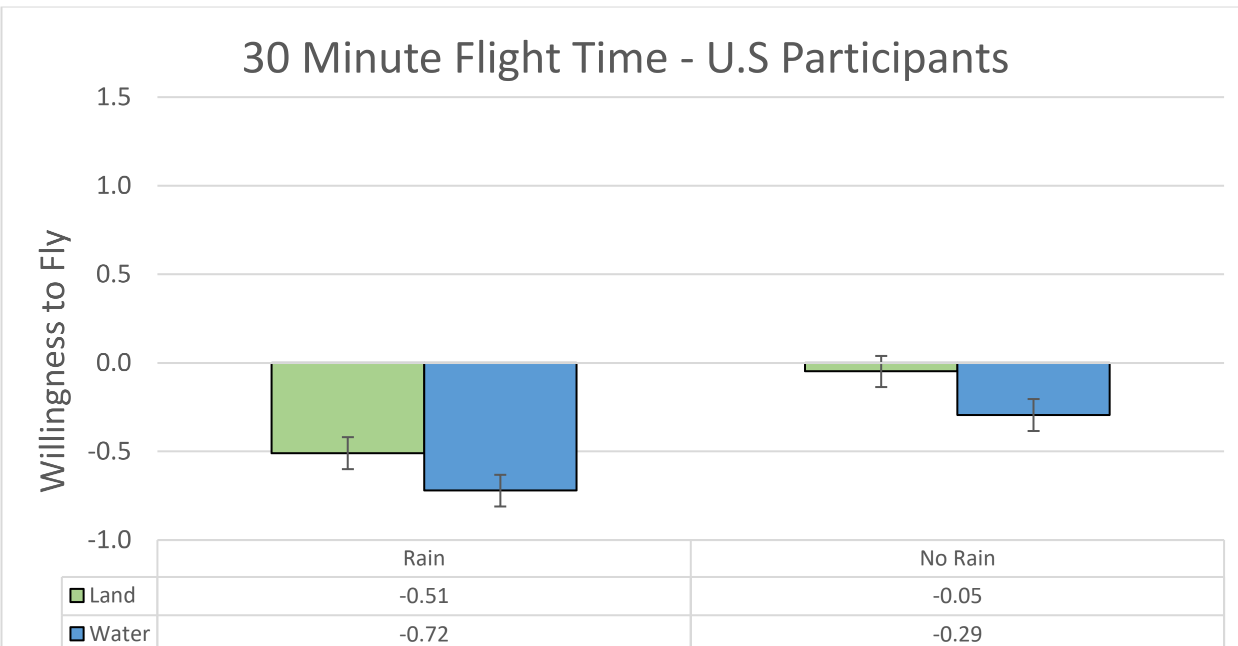


Figure 1. United States participant data on the 30 minute flight time. Standard error bars are included.

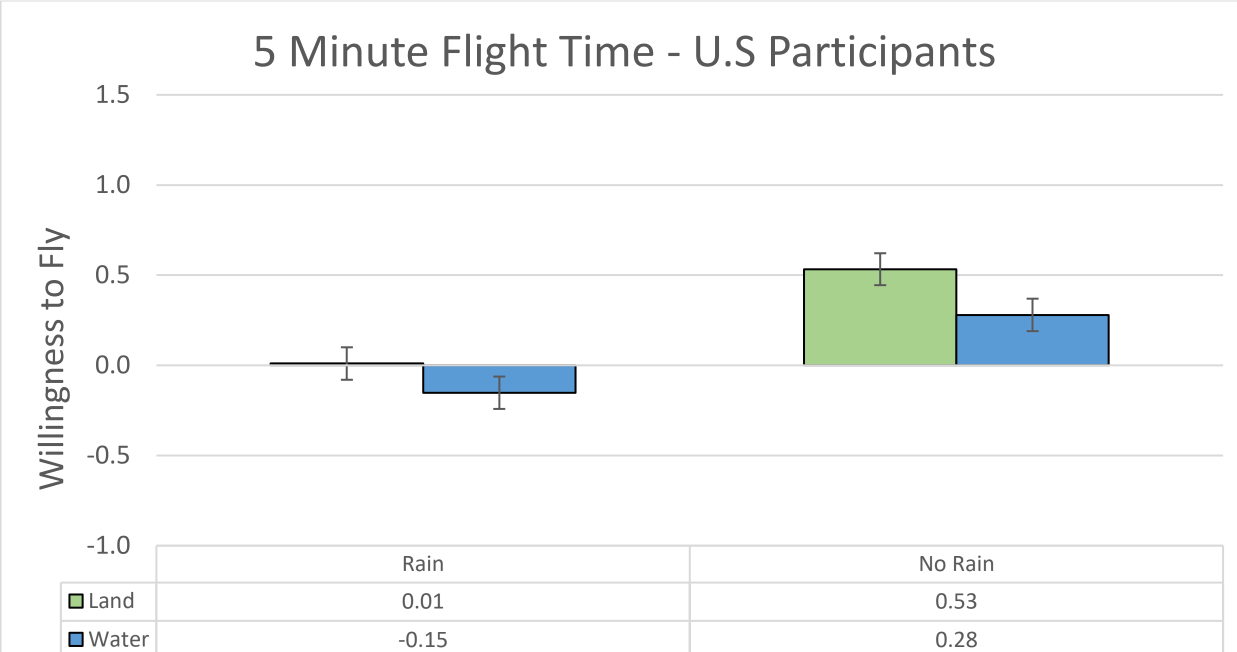


Figure 2. United States participant data on the five minute flight time. Standard error bars are included.

Study 1 – Discussion

Participants were more willing to fly in the air taxi when the weather was clear, if the flight was short, and if they were flying over dry land. The data revealed no significant differences between flying over urban or rural areas. There was a weather by terrain interaction, but it was barely significant, and the graphs do not reveal a practical interaction that is necessary to discuss in detail.

Study 2 – Introduction

Study 1 revealed that participants were more willing to fly in certain situations. Specifically, this included very short flights, in good weather, and over land. However, it has been well documented that Americans tend to be more negative about using advanced technologies compared to their Indian counterparts (Mehta et al., 2017; Ragbir et al., 2018; Rice et al., 2019). The purpose of Study 2 was to replicate the findings from Study 1 using a sample from India. We hypothesized the following:

Ha1: Participants would be more willing to fly in an air taxi in good weather versus rainy weather.
Ha2: Participants would be more willing to fly in an air taxi over dry land versus over water.
Ha3: Participants would be more willing to fly in an air taxi for shorter flights versus longer flights.
Ha4: Participants would be more willing to fly in an air taxi over rural areas versus urban areas.

Study 2 – Methods

Participants

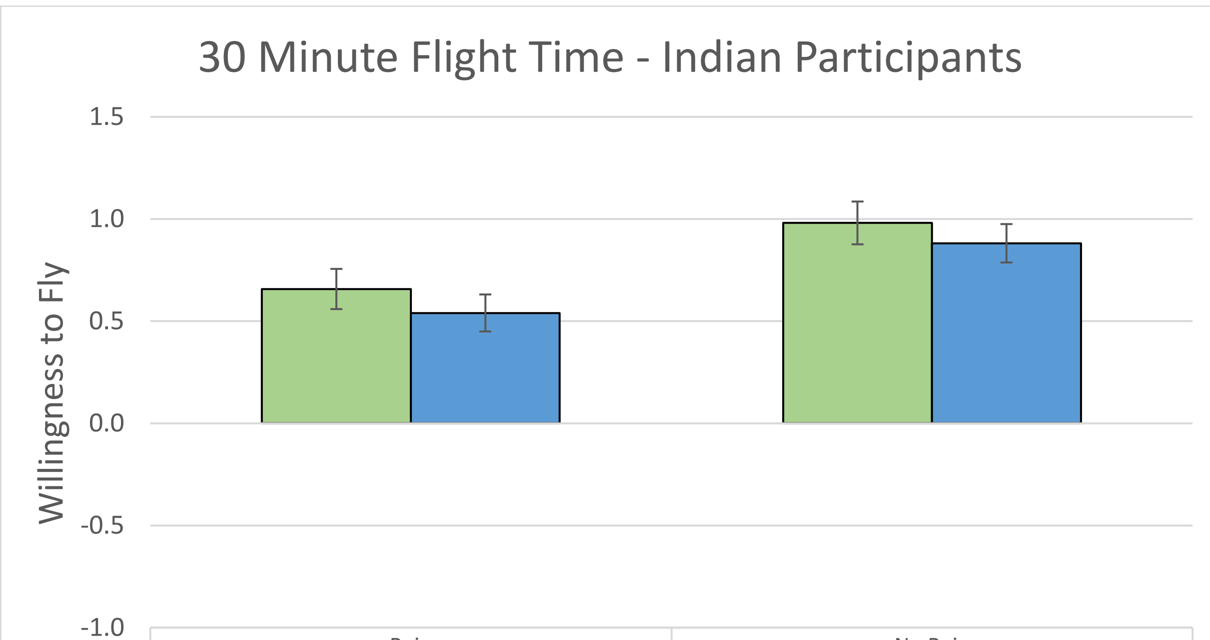
Two hundred and eighty-six (73 females) people took part in this study. All participants were located in India. The mean age was 31.29 (*SD* = 7.45). Participants were again recruited from Amazon's Mechanical Turk.

Materials and Stimuli and Procedure

Study 2 was identical to Study 1 with one exception: participants were located in India rather than from the United States.

Study 2 – Results

Figures 3 and 4 present the results from Study 2 for both the 30-minute flight time and the 5-minute flight time. A four-way analysis of variance using Weather, Flight Time, Terrain and PopDensity as the main factors revealed significant main effects of Weather, $F(1, 262) = 27.13$, $p < .001$, *partial eta-squared* = .09, of Flight Time, $F(1, 262) = 30.92$, $p < .001$, *partial eta-squared* = .11, and of Terrain, $F(1, 262) = 10.63$, $p = .001$, *partial eta-squared* = .04. There was no significant interactions between Urban and Rural (PopDensity) areas $F(1, 262) = .383$, $p = .537$, *partial eta-squared* = .001.



	Rain	No Rain
Land	0.66	0.98
Water	0.54	0.88

Figure 3. Indian participant data on the 30 minute flight time. Standard error bars are included.

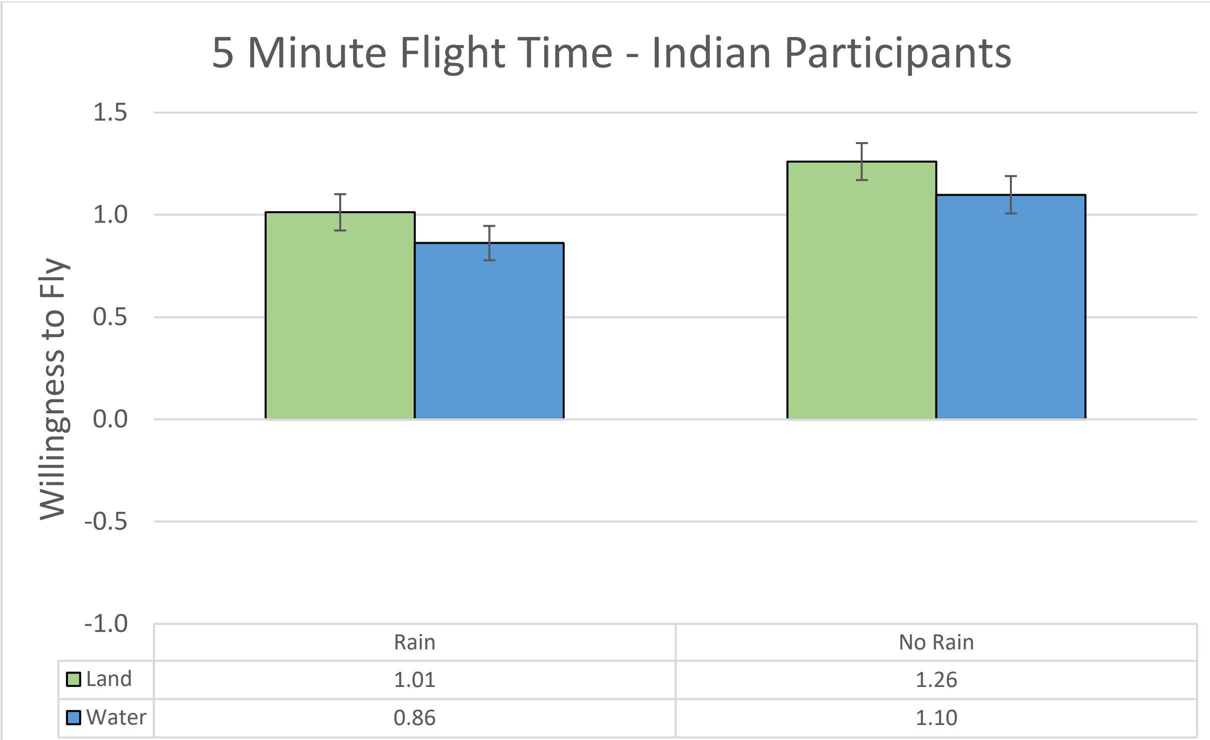


Figure 4. Indian participant data on the five minute flight time. Standard error bars are included.

Study 2 – Discussion

The data from Study 2 are both similar and different from Study 1. Replicating Study 1, participants were more willing to fly in the air taxi when the weather was clear if the flight was short, and if they were flying over dry land. However, when comparing the data from Figures 3 and 4 to Figures 1 and 2, Indians reported much higher WTF ratings compared to their American counterparts. This phenomenon has been seen in previous studies about willingness to use advanced technologies, and we discuss this in more detail in the General Discussion.

General Discussion

Many studies have investigated passengers' willingness to fly or ride in autonomous aircraft and vehicles (Anania et al., 2018; Ragbir et al., 2018; Rice et al., 2014; Rice & Winter, 2019; Vance & Malik, 2015). Though, with the emergence of urban air mobility, it is important to consider consumer perceptions of autonomous air taxis and passengers' WTF in various conditions. Therefore, the purpose of this study was to determine what external factors may influence consumers' WTF on autonomous air taxis in various weather, flight time, terrain, and population density conditions.

The authors first hypothesized that participants would be more willing to fly in an air taxi in good weather compared to rainy weather. The data from both studies supported this hypothesis. In study 1, American participants were less willing to fly in inclement weather. Similarly, in the second study, Indian participants were also less willing to fly in the rain. Chen, Zhao, Liu, Ren, and Liu (2019) investigated how a driver's perceived risk changed while driving a car under different adverse weather conditions by using a driving simulation. The authors highlighted that a driver's perceived risk was highest during rainy and heavy fog conditions. This uncertainty of risk could potentially transfer to aircraft, as well as autonomous systems. Another recent study found that both participants from the U.S and India were less willing to fly in autonomous aircraft if it was raining. The results also showed a significant difference in Indian participants displaying a more willingness to fly in autonomous aircrafts overall (Ragbir et al., 2018).

The second hypothesis stated that participants would be more willing to fly in an air taxi for short amounts of time compared to long amounts of time. The data from both studies supported the hypothesis. In study 1, Americans participants were more willing to fly in the autonomous air taxi for five minutes as opposed to 30 minutes. In study 2, Indian participants displayed analogous results, illustrating more positivity towards flying for five minutes in the air taxi rather than 30 minutes. One possibility for these results could be the consumers' familiarity with the development of urban air mobility, and in turn, autonomous air taxis. Passengers can have the perception that the longer lengths of time traveling in new modes of transportation could offer more possibilities for issues.

The third hypothesis stated that participants would be more willing to fly in an air taxi over dry land compared to over water. The data from both studies supported this hypothesis. In study 1, American participants were more willing to fly over land than water. In study 2, Indian participants reflected the same attitudes. Perhaps, participants felt flying over water would result in the additional danger of drowning if the vehicle was unable to land safely. Another possible reason for these results could be access to emergency response resources if a vehicle were to go down on land as opposed to water.

The final hypothesis stated that participants would be more willing to fly in an air taxi over rural areas compared to over urban areas. The data from both studies showed that population density was not a factor. In study 1, there was no significant difference between flying over rural or urban areas for American participates. Similarly, in study 2, there was no significant difference in population densities for Indian participants.

Lastly, we note that there may be some differences between Indians and Americans. Prior research has shown that Indians tend to be more accepting of new technologies compared to their American counterparts, and this data certainly does not dispel that notion. However, the authors did not conduct statistical analyses on these differences because they are not confident that they have captured identical samples from each country that would be conducive to making this comparison. The participants from the United States are probably closer to the average American, while the participants from India are probably more educated and wealthy than the average Indian. Having access to the internet and being able to work online via MTurk is probably more of a luxury reserved for the higher class in India. Thus, we worry that we might be comparing a smaller subset of the Indian population to a more general subset of United States participants.

Practical Applications

The findings from the study provide some meaningful, practical applications, especially as aerial taxi manufacturers and companies continue extensive development of vehicles intending to deploy urban air mobility devices within the next few years. First, the data indicate that passengers are more willing to fly when the weather is good. This finding is important, but it also presents some challenges. While the finding that passengers are more willing to fly in good weather is perhaps intuitive, for air taxi operations to be successful, there will likely need to maintain a level of reliability equal to or better than traditional ground-based vehicle, such as a car. If aerial taxi flights have to cancel frequently for the weather, this could deter passengers from seeking to use this service.

Another practical outcome of the study relates to the routing of flights. Passengers indicated greater willingness to be over dry land as opposed to water. This factor could present some challenges, as some initial discussions related to urban air mobility routings have considered taking flights over waterways to avoid the congestion of downtown metropolitan areas as well as noise abatement concerns. While passengers may be willing to fly over lakes or ponds, flights over extended waterways may be a deterrent to some passengers. As a result, operators should give consideration not only to the most logical flight path routings of these initial flights, but also the concerns of the passengers who will be flying onboard.

Limitations

Some limitations bound the current studies. First, a convenience sample was used, which provides restrictions on the generalizability of the findings. The sample was drawn from an online repository of participants, Amazon's MTurk, and it was limited to only two countries. Data for the study was conducted cross-sectionally so the findings indicate consumer preference at one point in time. As additional testing continues and becomes more common, it is possible, and likely, that consumers' views will shift based on the outcomes of these trials.

Conclusion

The purpose of this study was to determine what external factors may influence consumers' WTF on autonomous air taxis in various weather, flight time, terrain, and population density conditions. The data from the study suggested that both American and Indian passengers were more willing to fly in good weather conditions (i.e., no rain, no wind), over land, and on short flights consisting of about five minutes. The results of the study also suggest that Indian and American participants were not concerned if they were flying over rural or urban areas. As urban air mobility becomes more well-known, with several years of a solid safety record, it could be possible that passengers may become more willing to fly in adverse conditions. These results are valuable in understanding how to reach consumers and educate them on emerging technology. This, in turn, can aid industries in developing marketing strategies to help increase awareness of new technologies in the future.

Future Research

As revealed, several studies have explored differences between participants from the United States and India and their willingness to fly in autonomous aircraft. Prior research has also captured their attitudes regarding new technology. Future studies should identify whether these differences are reflected in autonomous air taxis as well. Other studies could potentially investigate whether age, income, and residence influence the results from participants in the U.S. Also, many countries have expressed an interest or are actively engaging in urban air mobility testing, future research should expand the sample from this study to see if the findings replicate across broader populations. Therefore, conducting frequent replication studies over time will provide valuable insights into the trends of consumer willingness to fly onboard urban air mobility devices.

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Appendix A – Willingness to Fly Scale (Rice et al., 2015; Rice et al., 2020)

1) I would be happy to fly in this situation

Strongly Disagree Disagree NeutralAgree Strongly Agree

2) I would be willing to fly in this situation

Strongly Disagree Disagree NeutralAgree Strongly Agree

3) I have no fears of flying in this situation

Strongly Disagree Disagree NeutralAgree Strongly Agree

4) I would be comfortable flying in this situation

Strongly Disagree Disagree NeutralAgree Strongly Agree

5) I would have no problem flying in this situation

Strongly Disagree Disagree NeutralAgree Strongly Agree

6) I feel confident flying in this situation

Strongly Disagree Disagree NeutralAgree Strongly Agree

7) I would feel safe flying in this situation

Strongly Disagree Disagree NeutralAgree Strongly Agree