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A prediction model of Consumer's willingness to fly in autonomous air taxis

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ABSTRACT

As companies begin to consider new alternatives to urban transportation and urban air mobility, one method under investigation is autonomous air taxis. Literature indicates that people, in general, have positive attitudes towards innovation and new technology. However, complex factors determine their willingness and speed in acceptance. The objective of this study was to examine which factors significantly forecast consumer willingness to fly in autonomous air taxis. A quantitative methodology and non-experimental design were accomplished using 510 participants to develop the regression equation and assess model fit. Six significant predictors of consumer willingness to fly in autonomous air taxis were found: familiarity, value, fun factor, wariness of new technology, fear and happiness. Three additional analyses were assessed using an independent sample of participants, revealing strong model fit. Few previous studies have provided a quantitative assessment of which factors significantly predict consumer willingness to fly in autonomous air taxis. The study contributes to the body of knowledge by identifying six significant factors which account for over 76% of the variance. These findings may help the industry, manufacturers and regulators identify the types of individuals most willing to try this new form of transportation and provide more information on the type of consumer most likely to buy in to this new form of transportation.

1. Introduction

Many major urban cities suffer from high traffic congestion, especially during peak periods and rush hours before and after the workday. A limiting factor toward traffic management is the roadway network and system to move individuals into, out of, and around the urbanized area. Automobiles, buses, trains and subways are some platforms that currently exist; however, some cities offer more alternatives than others. Previous research has indicated that the densely populated urban and city environment provides a higher likelihood of willingness to accept new innovative technology such as driverless cars (Liljamo et al., 2018; Rogers, 2003). A relatively underutilized aspect of urban transportation would be to use the sky, although this space is currently restricted primarily to helicopter traffic which usually is cost-prohibitive for most individuals. However, the announcement of a new form of transportation may provide a more viable alternative to those who live in urban areas.

Volocopter announced in 2018 their intention to deploy autonomous air taxis for testing in Singapore in the second half of 2019 (Holt, 2018). These aircraft would be primarily two-to-four-seat autonomous aircraft that would serve as an air taxi service in urbanized areas. This technology offers the potential to revamp the urban transportation market. However, an existing gap in the literature exists surrounding whether or not consumers would actually fly in an autonomous air taxi. Therefore, the objective of this study is to identify the type of passenger who may be willing to ride on an autonomous air taxi. The study was conducted in two stages. The first stage was designed to generate a prediction equation and the second to provide validation and ensure model fit. By showing model fit, we can be confident that the regression equation is not only a descriptive model of the previous data, but also a predictive model of future data. In the following sections, we discuss the literature on autonomous air taxis, previous research on consumer perceptions toward highly automated vehicles, and the influence of emotions on the decision-making process.

1.1. Autonomous air taxis

Wickens and Hollands (2000) defined automation as the use of a machine or system to complete a task that would otherwise be completed by humans. As a result of this definition, it is possible for automation to have many varying levels associated with it. Something as basic as a hand tool that gets some form of additional support could be a

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low level of automation to something as complex as a modern commercial airliner which contains many automated systems, some even with the capabilities of having automation land the aircraft. Autonomous air taxis are proposed fill a large sector of what is being labeled Urban Air Mobility (UAM).

UAM is defined as "the system that enables on-demand, highly automated, passenger or cargo-carrying air transportation services within and around a metropolitan environment" (Lascara et al., 2018, p. 5). The use of autonomous air taxis could be diverse. They could be used to transport people around urban and suburban areas, for sightseeing, or for delivering supplies. The possible capabilities and change to the transportation landscape are having traditional aviation companies such as Boeing, Airbus, and Bell Helicopters developing aircraft, but also new entrants to the industry such as Uber and Terrafugia (Lascara et al., 2018). As automation continues to proliferate, a new concept of mobility-as-a-service is being discussed where consumers would purchase multi-modal support options (Simpson et al., 2019), of which autonomous air taxis may fill a void.

However, while technology and engineering advances continue to move autonomous air taxis from design to demonstration flights, a major challenge is promoting consumer trust and confidence in the use of these aircraft. In other words, ensuring consumer buy-in. As part of the National Aeronautics and Space Administration's (NASA) Urban Air Mobility Grand Challenge on the advancement of UAM, promoting confidence and fostering community-wide learning are key focal points of the development of UAM (NASA, 2019). Booz Allen Hamilton (2018) also cite public perception as a long term, non-technical constraint on the growth of UAM. Therefore, it is vital for research such as this study to be completed which examines consumer's thoughts on the use and deployment of autonomous air taxis and the broader concept of UAM.

1.2. The type of consumer who is likely to adopt autonomous air taxis

Several highly developed and accepted theories have been considered the benchmark for understanding technology acceptance by customers (Ajzen, 1991; Beck and Ajzen, 1991; Davis, 1989; Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975; Rogers, 2003; Venkatesh and Davis, 1996; Venkatesh, 2000; Venkatesh and Davis, 2000). These theories provide useful models and frameworks that have given researchers a greater understanding of the complexities of consumer's perceptions and decisions and acceptance of technology (Kaur and Rampersad, 2018; Leicht et al., 2018; Molnar et al., 2018).

Widely used in studies in the computer industry, emerging autonomous car, and disruptive technology industries, these theories include: the Theory of Planned Behavior (TPB) (Ajzen, 1991; Beck and Ajzen, 1991) the Technology Acceptance Model (TAM) (Davis, 1989), the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975), the Innovation Diffusion Model (IDM) (Rogers, 2003), and the Unified Theory Of Acceptance And Use Of Technology (UTAUT) (Venkatesh and Davis, 1996; Venkatesh, 2000; Venkatesh and Davis, 2000).

Each of the theoretical frameworks implies a unique lens in which to focus on a particular phenomenon. Over time the models and frameworks have evolved and been modified to further explore complex aspects of acceptance, adoption, and willingness to use various technologies. One of those modifications resulted in the development of TAM from limitations of TPB and TRA, including the crucial element of *trust* as an enabler of acceptance (Choi and Ji, 2015; Ghazizadeh et al., 2012; Pavlou, 2003; Xu, Zhang, Min, Wang, Zhao & Liu, 2018).

1.2.1. Trust in the technology

Trust in the technology is the central theme of technology acceptance by customer's and their willingness to use it, (Lee and Moray, 1992; Molnar et al., 2018; Parasuraman and Riley, 1997; Verberne et al., 2012). Molnar et al. (2018) also highlighted that customers who have some level control, or some activity of interaction with the technology, in this case an autonomous vehicle, may affect [increase] the level of trust and acceptance of the automated vehicle.

Trust is a complex multi-layered process and humans take time to process uncertainty, therefore acceptance and willingness may be supported by factors that encourage and enable trust (Ghazizadeh, Lee, & Boyle, 2012; Molnar et al., 2018). Trust is a significant factor in acceptance and has shown to be a critical predictor in willingness to ride in autonomous vehicles, while these are affected through mediating effects such as risk perception (Choi and Ji, 2015; Ghazizadeh et al., 2012; Pavlou, 2003).

1.2.2. Potential consumers of autonomous air taxis

Potential consumers of autonomous air taxis are those with more of a propensity to accept and adopt the technology that they perceived implies a direct reward or benefit to them (Rogers, 2003). For example, those who are likely successful professionals living in highly congested cities where the commute to work or meetings means frustration, lost productivity, and time away from family, friends or valuable personal time (Rogers, 2003; Uber Elevate, 2016). In line with identifying the most likely demographic of potential customers of autonomous air taxis, Rogers (2003) divides consumers into five groups. These groups are: (a). The *innovators,* those who are likely to have a high willingness to ride in an autonomous air taxi; (b) *Early adopters*, who will follow the innovators who have gone first and proven it is safe; (c) *Early majority;* (d) L*ate majority,* and finally (e) L*aggards* who represent those least willing to ride or adopt the new technology.

Research using the TAM model have indicated a considerable difference between the customers categorized as *innovators* compared to those who fall into the *laggards* category. Innovators show a higher level of intrinsic motivation towards curiosity and computer playfulness, perceiving the technology benefits and ease of use compared to those of the laggards (Davis, 1989; Venkatesh, 2000). Coincidently, research has also indicated that consumers who fit into the category of innovators are usually successful, intelligent people [men] who reside and or work in high density cities (Liljamo et al., 2018; Rogers, 2003; Uber Elevate, 2016). These potential consumers are more likely to recognize benefits from utilizing an autonomous air taxi service (Liljamo et al., 2018). Previous studies have examined passenger willingness to fly in autonomous passenger airliners. Vance and Malik (2015) found that approximately 1/3 of the population would be willing to fly, and Winter et al. (2015) found that willingness to fly decreased from two human pilots operating on-board to autonomously operated.

1.2.3. Consumer adoption and critical mass

Rogers (2003) states that once 'a few' innovators adopt a new disruptive technology; other early adopters inevitably follow. This builds momentum for the required 'critical mass' needed to support larger widespread acceptance of the technology in question. However, it is imperative that industry leaders understand that the triggers to support widespread adoption of autonomous vehicles may be psychological, rather than technological (Shariff et al., 2017). Strategies to support the psychological needs of the first consumers, the innovators and early adopters, if successful, will facilitate the more wide-spread adoption and 'buy-in' by the later majority that will follow them. This prior research demonstrates the value of the current study to examine which factors predict consumer's willingness to fly in autonomous air taxis. While acceptance of technology has demonstrated a significant influence on consumers, the affective domain, or emotions, has also been shown to significantly influence the decision-making process related to willingness.

1.3. Emotions as a part of decision-making

Emotions or the affective domain has been demonstrated to play a function in making decisions, particularly if decisions are made with limited information and in a short period of time (Bechara, 2004; Sayegh et al., 2004; Schwarz, 2000). The concept of autonomous air taxis is still rather novel. Most passengers are probably unfamiliar with the high level of automation that currently exists within commercial airliners, and thus, they may have an emotional response to the thought of flying on board a fully autonomous aerial taxi. Affect has been shown to be a significant variable, both as a mediator and predictor variable in prior studies related many constructs and including automated transportation in aircraft and ground-based vehicles (Baker and Cameron, 1996; Campbell, 2007; Rice et al., 2015; Winter et al., 2014). Affect will be measured within the context of this study using these expressions published by Ekman and Friesen (1971), thus allowing specific emotions to be identified as possible predictors.

1.3.1. Universal facial expressions

Ekman and Friesen (1971) identified six universal facial expressions depicted in Fig. 1. The expressions depicted are anger, disgust, fear, happiness, sadness, and surprise. Through their studies, findings demonstrated that these six facial expressions were identifiable to persons from all ethnicities, cultures, languages, and backgrounds. The findings also replicated when using participants who had minimal contact with western society. The use of images was a beneficial approach in the current study for two reasons. First, it minimized any priming by the researchers as the specific emotion did not have to be named, such as asking a participant how happy or sad they felt. By presenting the facial expression image to participants, they were able to respond to the image with minimal influence from the instrument or researchers to minimize threats to internal validity. Second, instead of using an overall measure of affect, the expressions allowed for each of the specific six emotions to be included as a predictor variable to identify a more focused measure of which emotion(s) were significantly contributing to the model. This adds value to the findings as it is more helpful interpreting the results if the specific emotion(s) that serve as significant predictors in the model is known compared to simply using a general affect measure. Additional details on the use of the facial expressions is provided in the following section.

2. Methods

2.1. Participants

Five hundred and ten participants from the United States were collected for the study. In order to conduct the analysis, the overall data set was randomly divided into two separate samples, one for developing the equation in stage 1 and the other to examine model fit in stage 2. The data set for stage 1 had 259 participants. An initial data analysis of these cases results in 11 cases being removed due to missing or incomplete data and 5 cases removed due to high leverage values (greater than 0.2), all other assumptions were verified as met. Therefore, stage 1 used 243 participants with an average age of 36.42 ($SD = 12.12$) years old. One hundred and forty-one participants identified as male, 100 as female, and 1 participant failed to report their gender. Participants in stage 1 reported an average annual income of \$46,993 ($SD =$ \$35,248, $MDN =$ \$40,000). Approximately, 84% were Caucasian, 5% African, 5% Hispanic, and 6% Asian. Approximately 30% had at least a high school education, 53% held a four-year college degree, and 17% had post-graduate degrees. The stage 2 data set had 251 participants. An initial data analysis resulted in the removal of 8 cases due to missing or incomplete data. All other assumptions for regression were met. Therefore, stage 2 used 243 participants (108 females) to conduct the model fit. Participants in stage 2 reported an average age of 37.22 ($SD =$ 12.26) years old, with one participant failing to report their age. Participants in stage 2 reported an average annual income of \$49,171 ($SD =$ \$70,431, $MDN =$ \$40,000). Approximately, 80% were Caucasian, 5% African, 7% Hispanic, 5% Asian, 1% Indian, and 2% Other. Approximately 32% had at least a high school education, 52% held a four-year college degree, and 16% had post-graduate degrees. A comparison between the two stages was conducted to further verify group equivalency after conducting the randomized split. No significant differences were found between the two stages of participants based on an assessment of age or willingness to fly ratings (all p's $> .40$).

All participants were enlisted using Amazon's ® Mechanical Turk ® (MTurk). This platform offers a pool of users willing to complete assignments for compensation. Prior studies have demonstrated that data collected via MTurk is as reliable as traditional research laboratory data (Buhrmester et al., 2011; Germine et al., 2012; Rice et al., 2017). In order to use MTurk, the researchers, called Requesters, create an account with the platform. To recruit participants, requesters create a posting which is displayed to MTurk participants, called Workers. Within the posting, the researchers provide a brief description of the task, identify the number of needed participants, set compensation amounts, and provide a link to the electronic instrument. The electronic instrument used for the current study was Google Forms ®. The software tool G*Power determined the a-priori minimum sample size. Using the parameters of an estimated medium effect size of 0.15, alpha level of significance 0.05, power 0.95, and 16 predictors required a minimum of 204 participants for each stage. This requirement was exceeded with 243 participants in each stage.

2.2. Materials and stimuli

The study used 16 potential predictors: five scales which measured level of complexity, familiarity, value, fun factor, wariness of new technology, as they related to autonomous air taxis; six emotional facial expressions of anger, disgust, fear, happiness, sadness, and surprise; age, gender, ethnicity, education level, and income. The dependent variable for each stage was willingness to fly.

Participants completed an online consent form that they signed agreeing to participate in the study. After verifying they were at least 18 years old, they were presented with instructions, and the subsequent information on autonomous air taxis: "*An autonomous air taxi is a robotic vehicle that is designed to travel between short haul destinations (30 min or less) without a human operator. They usually have 2–4 seats for passengers, and there are no flight controls in the cabin. Reference:* https://www.volocopter.com/en/." Following this, participants completed five valid

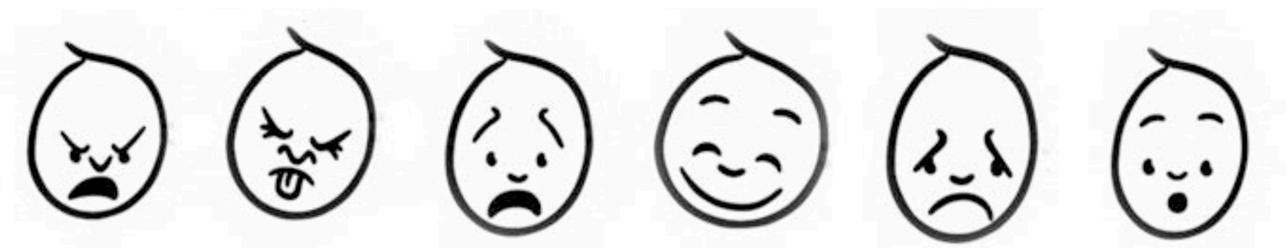

Fig. 1. Six emotions from Ekman and Friesen (1971) work are represented here with images. These images were re-validated in a separate pilot study. They represent anger, disgust, fear, happiness, sadness, and surprise.

scales relating to their familiarity, complexity, value, fun factor, and wariness of new technology toward autonomous air taxis. These five scales are depicted in Appendix A.

Next, the following hypothetical scenario was shown to participants, *"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. The ride is about 30 min long."* Participants were then asked to report their emotional responses using images of facial expressions based on the six universal facial expressions (Ekman and Friesen, 1971). Along with the images, participants rated how strongly they felt like the image shown. A numerical scale was provided for each of the six facial expressions that ranged from "*I do not feel this way at all*" (1) to "*Extremely feel this way*" (10). The order of the facial expressions was randomized on the page to prevent order effects, and the facial expressions used are depicted in Fig. 1. This was followed by participants rating their willingness to fly using a 7-statement valid scale developed by (Rice et al., 2020) and found in Appendix B. Following this, participants provided demographic data such as gender, ethnicity, age, education level, annual income (in USD), and country of birth. Lastly, participants were debriefed and dismissed. MTurk was used to provide compensation to participants.

2.3. Valid scales used as predictors in this study

The current study utilized 5 previously validated measures which provided values of a participant's perception of complexity, rating of familiarity, perceived value, perceived fun factor, and wariness of new technology (Rice and Winter 2019), and each scale was measured using 5-point anchors from strongly disagree to strongly agree. Slight adjustments were made to these scales for their use with autonomous air taxis. As a result of this modification, scale validation metrics were assessed prior to data analysis and are provided in Table 1, and the statements of each scale is provided in Appendix A.

2.3.1. Willingness to fly scale

The dependent variable in this study was willingness to fly (Rice et al., 2020). The willingness to fly scale was designed to measure a participant's rating of their willingness to fly on-board an autonomous air taxi. The seven-item Likert scale was rated on a five-point scale from strongly disagree (−2) to strongly agree (2). Due to the high internal consistency of the scale, the seven items were averaged into one score per participant prior to data analysis. The validation metrics are provided in Table 1, and a copy of the scale is provided in Appendix B. In order to meet the assumptions of conducting ordinary least squares regression (OLS), an analysis of the distribution of standardized residuals for the dependent variable revealed an approximately normal distribution, thus meeting the assumption of normality for OLS regression. The histogram with approximate normal curve is shown in Appendix C.

Table 1
Summary of scale metrics used as in the study.

Scale	Items	Variance	Cronbach's Alpha	Guttman's Split-Half
Complexity	5	.69	.89	.90
Familiarity	5	.79	.93	.89
Value	5	.77	.93	.90
Fun Factor	5	.79	.93	.89
Wariness of New Tech.	5	.71	.90	.87
Willingness to Fly	7	.84	.97	.94

Notes: All scales were validated using a principal components analysis, varimax rotation, and loaded onto one factor. Items on the first five scales were modified from their original validation in Rice and Winter (2019) to be used with autonomous air taxis.

2.4. Design and purpose of the study

The objective of this study was to create and validate a statistical model to predict which types of factors would influence a consumer's willingness to fly in an autonomous air taxi. The study used a quantitative non-experimental design conducted in two stages. In stage 1, a sample of participants responded to a scenario where they rated their willingness to fly in an autonomous air taxi. Backward stepwise regression was used in stage 1 with 243 participants to conduct the exploratory analysis to develop the regression equation. In stage 2, a separate sample of 243 participants assessed model fit. Through the use of three statistical assessments, model fit of the equation was performed and evaluated. The study was approved by the research institution's ethic review board, and each researcher held current certificates from the Collaborative Institutional Training Initiative (CITI) on proper treatment of human participants.

3. Results

Data analyses were conducted in two stages to first develop the regression equation and then to test model fit to determine factors that predict a participant's willingness to fly in an autonomous air taxi.

3.1. Stage 1 – regression equation development

A backward stepwise regression using ordinary least squares was completed using 243 participants recruited from MTurk. The following regression equation was produced:

$$Y = -0.903 + 0.201X_1 + 0.178X_2 + 0.120X_3 - 0.115X_4 - 0.044X_5 + 0.181X_6$$

Where Y is predicted willingness to fly, and X_1, X_2, X_3, X_4, X_5, and X_6 are familiarity, value, fun factor, wariness of new technology, fear, and happiness, respectively. The predictors indicate that participants who reported higher familiarity, value, fun factor, and happiness toward autonomous air taxis were more willing to fly while wariness and fear detracted from a participant's willingness to fly. A statistical summary of the significant predictors is found in Table 2. The model accounted for 76.3% (75.7% adjusted) of the variance in the dependent variable, and it was significant, $F(6, 235) = 126.16$, $p < .001$. Table 3 provides a summary of these statistics.

3.2. Stage 2 – model fit

Stage 2 was used to assess model fit of the equation developed in stage 1. A separate sample of 243 participants from MTurk were used in stage 2. The model fit was tested using three analyzes, specifically, *t*-tests and correlations between predicted and actual willingness to fly scores, and cross validated R^2.

First, the model fit was examined by using a *t*-test between the predicted willingness to fly scores of stage 2 data calculated using the stage 1 regression equation and the actual willingness to fly scores reported in stage 2. An independent samples *t*-test found no significant differences between the predicted stage 2 scores ($M = -0.08$, $SD = 1.03$) and the

Table 2
Summary of regression weights for variables predicting willingness to fly from stage 1 (N = 243).

Variable	*M(SD)*	*B*	*SE*	*t*	Sig.	VIF
Constant	–	-.903	.185	−4.89	<.001	–
Familiarity	-.78 (1.10)	.201	.039	5.17	<.001	1.35
Value	.63 (0.95)	.178	.069	2.56	.011	3.19
Fun Factor	.53 (1.09)	.120	.067	1.79	.074	3.91
Wariness of New Tech.	-.17 (1.04)	-.115	.042	−2.75	.006	1.38
Fear	5.19 (3.37)	-.044	.016	−2.79	.006	2.10
Happiness	5.76 (3.00)	.181	.020	9.04	<.001	2.65

Table 3
Summary stage 1 model (N = 243).

R^2	Adjusted R^2	df	F	Sig.
.763	.757	6, 235	126.16	<.001

actual stage 2 scores ($M = -0.12$, $SD = 1.21$), $t(484) = -0.412$, $p = .681$. Since the predicted scores do not significantly vary from actual scores, it appears the original equation is a valid model to predict willingness to fly in autonomous air taxis.

Second, a Pearson's correlation was conducted between the predicted stage 2 willingness to fly scores and actual stage 2 willingness to fly scores. The data suggest a statistically significant relationship exists, $r(241) = 0.857$, $p < .001$. The significance of this cross-validity coefficient provides further evidence of model fit.

In the final step, cross validated R^2 was used to test model fit. The cross validated $R'^2 = 1 - (1 - R^2)[(n + k)/(n - k)]$, where R^2 is the overall R^2 from the stage 1 model, n is the sample size of the stage 1 sample, and k is the degrees of freedom. The analysis revealed an $R'^2 = 0.751$, and this suggests how well the preliminary model would apply to other samples from the population. Based on the closeness of the overall R^2 and the cross validated R'^2, the presence of model fit is supported. A summary of the model fit statistics is provided in Table 4.

4. Discussion

The goal of the current study was to determine which factors predict the kind of consumer who is willing to fly on autonomous air taxis. As many major cities around the world suffer from traffic congestion, especially during high use periods, industries are examining the development of urban air mobility (UAM). UAM would take advantage of an area of space underutilized by most metropolitan areas, specifically the skies above them (Lascara et al., 2018). Currently, helicopters are the only method of transportation available to be deployed for urban air mobility, but these aircraft are usually cost prohibitive, except for a very slim margin of the population.

As automation and technology increase, the concept of UAM is proposed to expand within the next decade through the development of primarily autonomous, 2–4 seat aircraft (Booz Allen Hamilton, 2018; NASA, 2019). These aircraft may be powered through electric or hybrid means, with the goal of a price point achievable for a wider margin of the population. Manufacturers, such as Boeing (LeBeau, 2019) and Airbus (Hawkins, 2018), have already completed their first flight tests of autonomous air taxis, and Volocopter is already planning to complete testing in Singapore during the second half of 2019 (Holt, 2018). UAM is proposed to provide transportation of people both around urban areas and between urban and suburban areas, along with other uses such as package delivery, tourist activities, and assistance during events such as natural disasters.

The current study examined 16 possible predictors to determine a consumer's willingness to fly in autonomous air taxis. These factors included a series of scales to assessing a participant's perceptions of value, fun, and familiarity, and pictorial representations of the six universal facial expressions to assess affective predictors. Lastly, some basic demographic factors were collected. The data identified six factors were found to be significant: familiarity, value, fun factor, happiness, wariness of new technology, and fear. These significant factors will likely play a role in those consumers who serve as the innovators and early adopters of this new technology (Rogers, 2003).

Familiarity, value, fun factor, and happiness were all positively related to willingness to fly meaning that as ratings for those predictors increased, so did a participant's willingness to fly. As a person becomes more familiar with a topic, there are fewer unknowns and fewer gaps in knowledge which they have to fill. As a result, participants are more likely to make decisions cognitively rather than emotionally (Bechara, 2004; Sayegh et al., 2004; Schwarz, 2000). Similarly, as their perception of value increased so did their willingness to fly. Autonomous air taxis have the potential to revolutionize the urban transportation landscape and further the concept of mobility-as-a-service (Simpson et al., 2019). For individuals who typically spend hours commuting in a car or other common forms of urban transportation, such as a train or a subway, the use of an air taxi could provide a time savings in a daily commute. This could result in more productive time at work or more valuable time at home. These factors may also be related to concepts expressed through the earlier technology acceptance models of benefits and ease of use (Davis, 1989; Venkatesh, 2000). For consumers who identify familiarity and value, it is likely that they will also see the overall benefits from use of this new technological transportation means. Additionally, as companies develop these vehicles, these findings suggest there may be value in promoting the concepts to consumers to increase their familiarity and perceived value of the vehicles as the findings indicate this should result in an increased willingness to fly.

Additionally, as a participant's perception of fun and feelings of happiness increased, so did their willingness to fly. For those individuals who perceive fun in the experience of autonomous air taxis, it is understandable that they would have a high level of willingness to fly. Similarly, emotions have been shown to be a strong predictor of behavior (Babin and Attaway, 2000; Winter et al., 2018), especially in times when new information is presented to participants. Therefore, those consumers who felt happiness toward the concept of autonomous air taxis also had higher levels of willingness to fly. For manufacturers and companies designing urban air mobility vehicles, consideration should be given to the user experience to encourage a positive affective experience.

The last two significant predictors had negative relationships with willingness to fly. In other words, as values for wariness of new technology and fear increased, this resulted in a decrease in participant's willingness to fly. Autonomous air taxis present a completely new form of transportation (NASA, 2019), especially being operated fully autonomously. For consumers who are wary of technological advancements, it is understandable that they may have lower willingness to fly ratings until the technology has a chance to be demonstrated safely for a period of time. Similarly, for participants who experience fear at the thought of autonomous air taxis, there is an unwillingness to fly. Fear can be a powerful and instinctive driver in humans, especially for things that are unknown to us, and it is not surprising to see this emotional factor as a significant predictor (Schwarz, 200). NASA (2019) provides recognition of this possibility in their challenge to build consumer confidence in the urban air mobility concept while also advancing the technological and engineering aspects. While peripherally related, a prior study (Anania et al., 2018) found that consumer's opinions could be significantly increased if positive information were presented on autonomous cars or significantly decreased if presented negative information. As the development of autonomous air taxis continues, there is a clear need for the industry and manufacturers to provide educational content to consumers on the benefits, safety, and efficiency of urban air mobility to increase their chances of buy-in and usage. In other words, focus should not only be on the engineering and technological aspects of these vehicles, but also on the user experience.

Table 4
Model Fit using Actual Vs Predicted Scores (Stage 2).

	t-Test			Correlation		Cross-Validated R^2
	t	df	Sig.	r	Sig.	
Actual vs. Predicted Scores	−0.412	484	.681	.871	<0.001	.751

4.1. Practical applications

The findings from the study provide some valuable practical applications. As the technology and engineering of autonomous air taxis continues to develop, these results highlight a prediction equation to identify a consumer's willingness to fly. The results could help companies and governments identify the types of consumers to select for their initial use cases and demonstrations. The data suggests those individuals who are familiar and perceive value, fun, and happiness from the use of autonomous air taxis will be more likely to use it. Key individuals would also not be wary of new technology or fearful of the thoughts related to autonomous air taxis. Additionally, manufacturers of these devices should promote emphasis on building consumer confidence and familiarity with this new form of technological transportation. As these individuals adopt the use of autonomous air taxis, then the word of mouth relation of their experiences to others may work to further encourage consumer confidence and trust in the use and deployment of this technology. While the technology and engineering may be possible, developing the consumer buy-in, usage, and support for its deployment will be an essential aspect of the success of autonomous air taxis. The findings from this study can help through identifying passengers with high levels of willingness to fly and the key factors which relate to willingness to fly.

4.2. Limitations

This study was bound by a few limitations. First, the use of a non-probability sample from MTurk restricts the generalizability of the study. While MTurk data has been demonstrated to be as good as normal laboratory data, the results may not generalize beyond populations of individuals who register and complete tasks on these types of platforms. Additionally, the cross-sectional data collection only provides the attitudes of consumers at a single point in time. Additional research should work to replicate the findings longitudinally and with replications of other populations. The study was also limited in the selection of possible predictor variables. While the selection was grounded in the literature and prior research, there remain other factors that explain the variance in willingness to fly in autonomous air taxis and future studies should work to identify and update the model.

5. Conclusions

The purpose of the current study was to create and validate a statistical model to predict the type of early adopter consumer who would be willing to fly on autonomous air taxis. Using 510 participants through two stages, a significant statistical model was created and validated. In stage one, 16 predictors were assessed as to whether they were significant predictors of willingness to fly in autonomous air taxis. Six predictors were found to be significant: familiarity, value, fun factor, wariness of new technology, fear and happiness. Stage two was used to conduct the model fit. Three independent measures suggested strong model fit. These findings may be able to compliment the technology and engineering development of autonomous air taxis through helping build the consumer trust and confidence in these devices, along with identify the target individuals for early adoption. The findings suggest there is value is providing information to consumers to increase their familiarity and perceived value toward autonomous air taxis. Information that relates to positive affect and reduces wariness of new technology should help increase willingness to fly. Lastly, a focus on the user experience, in addition to the engineering and technological design aspects, would be valuable efforts to encourage consumer buy-in and the success of urban air mobility.

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Declaration of competing interest

None.

Appendix A

Perception of Complexity Scale

Please respond to each of the following statement:

1. The automation that controls autonomous air taxis is very complex.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
2. I do not understand the automation that controls autonomous air taxis.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
3. It is difficult to know how the automation that controls autonomous air taxis works.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
4. I have no idea what the automation that controls autonomous air taxis is doing.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5. It is a mystery to me how the automation that controls autonomous air taxis operates.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Familiarity Scale

Please respond to each of the following statement:

1. I am familiar with autonomous air taxis.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
2. I have a lot of knowledge about autonomous air taxis.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
3. I have read a lot about autonomous air taxis.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
4. Autonomous air taxis have been of interest to me for awhile.				

(*continued on next page*)

(*continued*)

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5. I know more about autonomous air taxis than the average person.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Value Scale

Please respond to each of the following statement:

1. An autonomous air taxis is something that would be beneficial to me.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
2. Autonomous air taxis would be something valuable for me to use.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
3. I think autonomous air taxi technology is useful.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
4. There would be value in using an autonomous air taxi.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5. If autonomous air taxis were available, I think it would be beneficial to own one.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Fun Factor Scale

Please respond to each of the following statement:

1. I like the idea of autonomous air taxis.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
2. I think it would be fun to ride in an autonomous air taxi.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
3. I am interested in trying out an autonomous air taxi.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
4. I think it would be cool to have an autonomous air taxi.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5. I've always wanted to ride in an autonomous air taxi.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Wariness of New Technology Scale

Please respond to each of the following statement:

1. In general, I am wary of new technology.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
2. New technology scares me.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
3. New technology is not as safe as it should be.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
4. I tend to fear new technology until it is proven to be safe.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5. New technology is likely to be dangerous.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Appendix B

Willingness to Fly Scale (Rice et al., 2020)

Please respond to each of the following statement:

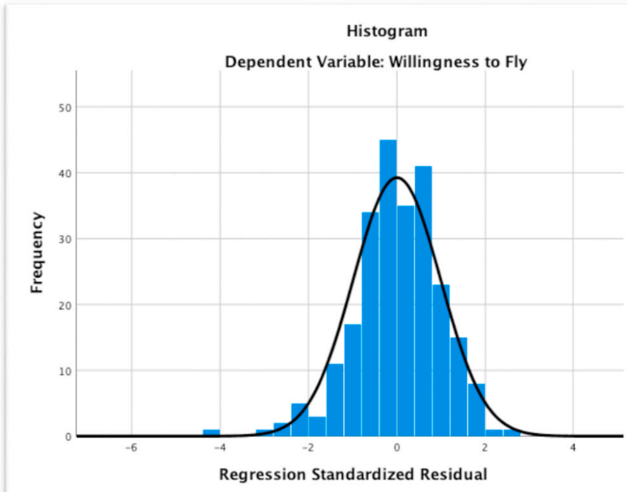
1. I would be willing to fly in this situation.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
2. I would be comfortable flying in this situation.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
3. I would have no problem flying in this situation.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
4. I would be happy to fly in this situation.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5. I would feel safe flying in this situation.				

(*continued on next page*)

(*continued*)

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
6. I have no fear of flying in this situation.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree
7. I feel confident flying in this situation.				
Strongly disagree	Disagree	Neutral	Agree	Strongly agree

Appendix C. Histogram of Standardized Residuals for Willingness to Fly



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