Transportation Research Part A 185 (2024) 104122

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Ready for take-off? The dual role of affective and cognitive evaluations in the adoption of Urban Air Mobility services

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ARTICLE INFO

Keywords:
Urban Air Mobility
Technology adoption
Automation
Artificial intelligence
Emotions
Virtual reality

ABSTRACT

Technological advancements have led to the development of aerial vehicle concepts for passenger transportation, termed "Urban Air Mobility." Related services could provide more efficient and flexible travel options. However, as flight modes will shift to autonomous operations in the near future, a deeper understanding of consumer perceptions and adoption intentions related to this AI-enabled service will be crucial to its success. Building on dual-process theory, we examine the influence of affective and cognitive considerations in the formation of adoption intentions of autonomous passenger drones. Using Virtual Reality (VR), we manipulate the presence of a pilot onboard the vehicle to assess the influence of human supervision on subsequent adoption intentions using structural equation modeling. In two experimental studies, we show that affective responses exert a stronger influence on adoption intentions than cognitive considerations. Results indicate that some form of human supervision will be crucial to trust formation, especially for risk-averse consumers.

1. Introduction

Smart, autonomous technologies are on the rise and are increasingly changing the way we use and experience services (Bagozzi et al., 2022). In particular, autonomous mobility services promise to provide consumers with more efficient and convenient travel options (Al Haddad et al., 2020), thus having the potential to significantly improve the mobility of various groups of consumers. However, we still have no clear understanding of consumer responses to automated transport technologies and the factors that influence consumers' adoption thereof, despite the general interest in individual acceptance of new technologies (Hess et al., 2014).

In recent years, technological advancements have led to the development of autonomous aerial vehicle concepts for passenger services, often termed "Urban Air Mobility" (UAM) (Garrow et al., 2021). UAM describes the extension of urban traffic by including the airspace above a city as a transport route for medical goods, packages, or passenger transportation, using so-called "electrical vertical take-off and landing" (eVTOL) aircraft or drones (Straubinger et al., 2020). In the context of passenger transportation, such drones—often referred to as "air taxis"—offer significant advantages compared to existing alternatives: By flying over busy roads and avoiding traffic jams, they can reach urban destinations more quickly, thus significantly reducing travel time (Brauchle et al., 2019). The introduction of UAM services is expected to offer safer, more reliable, more flexible, and environmentally friendly transportation, all while reducing the strain on urban transport networks (Brauchle et al., 2019). First autonomous flights have already taken place, and commercial passenger services using eVTOL are expected to enter into service within the next two years (Volocopter, 2022), with a

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https://doi.org/10.1016/j.tra.2024.104122
Received 10 February 2023; Received in revised form 21 April 2024; Accepted 24 May 2024
Available online 31 May 2024

global market potential estimated to be as large as $310 billion USD by 2035 (Goyal et al., 2021). However, next to technological, infrastructure, and regulatory aspects, consumer adoption of this technology and related transport services is still among the central challenges (Straubinger et al., 2020). Thus, a better understanding of the factors that facilitate or impede consumer uptake of such automated mobility services is needed (Davenport et al., 2020).

Although it is expected that regulations will require onboard pilots when UAM services are initially introduced, a transition to remotely controlled and, ultimately, fully autonomous operations appears inevitable for economic reasons (cf. Thipphavong et al., 2018) and is aspired by industry leaders (e.g., Volocopter, 2021; Riedel, 2021). However, while autonomous operations are desirable from an economic standpoint (Pelli and Riedel, 2020), consumer confidence and trust in the use of unmanned aircraft remain unclear (Winter et al., 2020). Currently, little is known about the specific determinants that play a role in the formation of perceptions and adoption intentions of UAM services. Previous research on the determinants of consumers' adoption intentions of automated technologies has mostly focused on functional attributes of the technology and cognitive evaluations made by consumers (e.g., Al Haddad et al., 2020; Johnson et al., 2022). More recently, there has been an increasing awareness of the crucial role of emotions and affective responses in shaping consumers' willingness to use automated technologies and services (e.g., Filieri et al., 2022; Osburg et al., 2022). However, the relative importance of affective responses compared to cognitive considerations such as safety and benefit perceptions has not yet been investigated (Valor et al., 2022), especially in autonomous mobility services. To address this gap in the literature, our study aims to answer the following research questions:

1. How does a switch from flights under human supervision to fully autonomous operations affect consumers' trust and subsequent adoption intentions of UAM services?
2. What is the relative importance of affective and cognitive evaluations in the formation of adoption intentions of UAM services?

To answer these questions, we take a novel approach and conduct two experimental studies using a VR simulation of a flight in an autonomous passenger drone, thus providing participants with a vivid impression of the flight experience before evaluating factors related to the adoption and usage of UAM services. In our investigation, we specifically focus on the effect of automation (vs. human supervision) on trust as well as the dual role of affective and cognitive considerations in adoption intentions.

In doing so, we make several important contributions to the literature on consumer adoption of automated transport technologies and related services. First, we advance scholarly understanding of the factors influencing the adoption of future UAM services, thereby contributing to the fields of consumer behavior, technology acceptance, and transportation research. It has been argued that established, predominantly utilitarian models, such as the Technology Acceptance Model (TAM), do not fully encompass the characteristics of advanced AI-enabled technologies and services (Fernandes and Oliveira, 2021). Therefore, we develop and examine a context-specific model of determinants of technology adoption, which places a particular focus on the relative impact of affective and cognitive responses in the formation of adoption intentions, thus taking a more holistic perspective on consumer perceptions of autonomous UAM services.

Second, our research adds to the growing literature on the importance of affect in consumer judgment and decision-making (Bagozzi, 2007; Lerner et al., 2015). Building on established dual-process theories, we shed light on the relative importance of affective responses and cognitive considerations in the context of new technology adoption, specifically in the context of automated mobility services. In particular, our findings indicate that affective responses exert a stronger influence on consumers' willingness to use autonomous passenger drones than considerations of benefits and safety perceptions. Thus, we contribute to a deeper understanding of emotions as a psychological mechanism enabling or impeding automated service adoption, following previous calls for research on the emotional dimension of technology adoption decisions (Bagozzi et al., 2022; Valor et al., 2022).

Third, we make two methodological contributions to research on consumers' interactions with autonomous technologies and services. First, as passenger drones have not entered into service yet, previous research has relied mostly on surveys providing respondents with hypothetical scenarios about the technology under study (Harb et al., 2021). In contrast, we employ a highly immersive VR simulation, ensuring a more lifelike experience for study participants and significantly increasing the external validity of our study (Hoggenmueller et al., 2021). As previous studies have typically determined consumer preferences based on survey data or choice models (e.g., Osburg et al., 2022; Molesworth and Koo, 2016), we seek to provide causal evidence for the effect of human supervision on trust using an experimental setup instead. Second, by manipulating the presence of human supervision, we can more precisely show the potential impact of the anticipated transition to autonomous drone operations on consumer trust and subsequent evaluations of UAM services.

Finally, our research provides guidance on successfully implementing automated passenger drones and related services. Our findings suggest that some form of human supervision may be necessary to instill confidence and trust in potential users of UAM. Hence, providers are advised to explore the potential of remote modes of human supervision to foster trust and willingness to use automated services. To this end, service providers should consider measures and design elements to ensure social support at all times during the flight and provide passengers with a sense of social presence, even when no human pilot is onboard the aircraft. Additionally, while achieving and maintaining the perception that autonomous UAM services are a safe and reliable alternative to current modes of transport will be an essential step in fostering usage intentions (Chancey and Politowicz, 2020; Hogreve and Janotta, 2021), the results of our research suggest that service providers must understand and address the emotional dimension of flying to ensure the future market success of their offerings. Given the critical role of perceived enjoyment in both the formation of usage intentions and the willingness to pay for UAM services, providers need to carefully consider the user experience in piloted, remote-piloted, and autonomous passenger drones and focus on creating positive affective experiences on future flights (Winter et al., 2020).

The paper is structured as follows: First, the theoretical background and identified research gaps are outlined, considering extant research on the adoption of automated technologies, the relevance of trust in this context, and the dual role of cognitive and affective responses to technologies. Based on this review of existing literature, we derive our hypotheses and research model. Next, we describe our empirical approach and methodology, followed by our data analysis procedure and results for both empirical studies. Finally, we discuss the main findings from our studies and their theoretical implications, followed by a discussion of relevant implications for industrial stakeholders and policymakers. The paper concludes with a discussion of potential directions for future research.

2. Relevant literature and conceptual framework

2.1. Adoption of automated technologies

Determinants of the adoption of emergent technologies are typically studied using theoretical models of consumer behavior, such as the TAM (Davis et al., 1989; Blut et al., 2021b), the Unified Theory of Acceptance and Use of Technology (UTAUT, Venkatesh et al., 2003) or variations thereof.[1] In essence, such models are based on the assumption that consumers' intentions to use a new technology are mainly driven by perceptions of usefulness and ease of use (Davis, 1989). However, with the focus on automation as a new topic of interest in research, researchers have argued that traditional acceptance models may be insufficient to explain consumer decision-making in the context of more complex technologies (Bagozzi, 2007) and, thus, are less suited for examining the adoption of automated technologies, which have unique characteristics that need to be addressed accordingly (Gursoy et al., 2019; Lu et al., 2019).

Early technology acceptance models were developed to explain usage decisions related to non-intelligent technologies (Gursoy et al., 2019). However, as autonomous functioning is a constituent characteristic of AI-enabled automated technologies and services, they do not require users to learn how to operate them, rendering considerations about ease of use obsolete (Gursoy et al., 2019; Lu et al., 2019). Additionally, as the use of automated technologies and services implies delegating control to a machine, researchers have emphasized the importance of trust in human–technology interactions, especially when automation is involved (Blut et al., 2021b; Fernandes and Oliveira, 2021). Therefore, modified acceptance models geared toward AI-enabled technologies consider trust as a critical factor in determining adoption intentions and usage (Ghazizadeh et al., 2012; Wirtz et al., 2018). Finally, while early research on technology adoption mainly focused on functional attributes, it has recently been suggested that consumers' intention to adopt automated technologies and services does not depend solely on functional attributes and cognitive evaluations; it is also driven by emotional or even social aspects of the offering as well as individual characteristics of consumers (Bagozzi et al., 2022; Wirtz et al., 2018). Thus, it seems warranted to consider not only cognitive evaluations but also trust as well as affective responses when examining the determinants of consumers' adoption intentions related to autonomous passenger drones to ensure a more balanced consideration of the cognitive and affective aspects of acceptance formation (Shi et al., 2021).

2.2. Fostering trust through human supervision

Trust has been shown to be a significant predictor of consumers' willingness to use automated technologies, such as AI-based recommendation systems (Shi et al., 2021) or intelligent voice assistants (Pitardi and Marriott, 2021). Similarly, in the context of automated transport services, trust has been recognized as one of the main determinants of adoption intentions (e.g., Choi and Ji, 2015; Zhang et al., 2019). Research suggests that consumers' evaluations and, ultimately, intentions to adopt autonomous transport services such as passenger drones may be affected by the type of human supervision provided—in-vehicle (i.e., an onboard pilot), remote (i.e., a ground-based security operator), or no supervision (i.e., fully autonomous flight) (Chancey and Politowicz, 2020). Studies indicate that consumers view automated operations less favorably than flights involving human supervision and, if presented with a choice between a conventionally piloted aircraft and autonomous operations without human supervision on board, would choose the former (Hughes et al., 2009; Molesworth and Koo, 2016). More specifically, previous studies in the context of commercial aviation show that consumers' attitudes towards aerial vehicles are significantly more positive when a human pilot is still present onboard, as opposed to a fully autonomous cockpit (e.g., Mehta et al., 2017). These findings are echoed in research focusing on autonomous ground vehicles, showing that consumers are less willing to ride in autonomous buses than human-supervised buses (Anania et al., 2018; Winter et al., 2018). In the context of shared autonomous mobility, study respondents have expressed concerns about the absence of staff onboard the vehicle, especially at night (Piao et al., 2016).

Despite these concerns, ensuring human supervision for each individual passenger drone is a major cost factor (Pelli and Riedel, 2020). Thus, it has been argued that a transition to remotely supervised or even fully autonomous operations will be inevitable in the long run (Chancey and Politowicz, 2020; Thipphavong et al., 2018). However, consumer confidence and trust in using autonomous passenger drones remain uncertain (Winter et al., 2020). It is essential to understand how the autonomous operation of passenger drones will influence consumers' trust as well as their subsequent evaluations and adoption intentions of related services to inform adequate design decisions regarding future services.

2.3. Dual path models of attitude formation

Consumers base their judgments of new technology "not only on what they think about it but also on what they feel about it" (Slovic

[1] This paper does not aim to comprehensively discuss all possible theories and influence factors previously employed in technology acceptance research. For a comprehensive overview, we refer to the review of Jing et al. (2020).

et al., 2002, p. 333). In consumer psychology, this duality in attitude formation, consumer judgment, and decision-making has been explained using dual-process models (e.g., Chaiken, 1987; Kahneman, 2003; Petty and Cacioppo, 1986; Smith and DeCoster, 2000). Dual-process models distinguish two systems or modes of thinking and information processing: one characterized by automatic, fast, and non-conscious thinking and decision-making, and the other allowing for more effortful, controlled, and conscious thinking and decision-making (Chaiken and Trope, 1999; Samson and Voyer, 2012). The former has been described as associative and experiential, generating intuitive responses to stimuli, which are typically affective in nature (Slovic et al., 2002; Smith and DeCoster, 2000). In contrast, the second system is described as reflective and analytical, enabling information processing and subsequent decision-making based on knowledge and learned rules (Slovic et al., 2002; Smith and DeCoster, 2000). Regarding the sequence of these two types of responses, there seem to be different schools of thought in research. Some authors hypothesize that intuitive, affective responses occur more rapidly and automatically and, thus, subsequently influence cognitive evaluation and decision-making (e.g., Zajonc, 1980; Merk and Pönitzsch, 2017), while other authors assume the opposite sequence of effects (e.g., Kim et al., 2020). Contrary to this sequential school of thought, Smith and DeCoster (2000) posit that "the two processing modes generally operate simultaneously rather than as alternatives or in sequence."

When evaluating new technologies, consumers employ both analytical and intuitive processing (Midden and Huijts, 2009). In the context of technology adoption, it has been suggested that the associative, experiential system may be represented by an affective pathway to acceptance formation. In contrast, the analytic system is reflected in a cognitive pathway, comprising analytic judgments of aspects such as benefits, safety, or risks related to technology usage (e.g., Merk and Pönitzsch, 2017; Midden and Huijts, 2009). Indeed, affective and cognitive considerations have been shown to be influential in attitude formation and acceptance decisions for a variety of technologies (e.g., Liu et al., 2019; Merk and Pönitzsch, 2017; Shi et al., 2021). While these studies concur that both affective responses and cognitive evaluations play a role in the formation of attitudes and acceptance toward a new technology, the results are not conclusive when it comes to the relative importance of both paths, with some studies assuming a dominant role of the affective path (e.g., Liu et al., 2019; Merk and Pönitzsch, 2017) and others indicating a stronger influence of cognitive evaluations (e.g., Kim et al., 2020).

However, no research has considered the critical role of affective evaluations in adoption intentions related to autonomous passenger drones. By integrating previous findings, we posit that the formation of behavioral intentions in the context of UAM services is guided by both affective and cognitive considerations, which play a dual role in the formation of adoption intentions and are firmly grounded in trust. Additionally, by manipulating the presence of human supervision, we examine the potential impact of the shift from accompanied flights to fully autonomous passenger drone operations expected in the future on subsequent adoption intentions.

2.4. Hypothesis development

2.4.1. Influence of human supervision on trust

Trust plays a critical role in human–technology interactions, especially when automation is involved (Kim, 2019). Trust can be understood as the willingness to place oneself in a relationship that establishes or increases one's own vulnerability (Lee and See, 2004). Prior research suggests that trust is a pivotal determinant in the formation of evaluations and adoption intentions of AI-enabled technologies and related services (Al Haddad et al., 2020; Choi and Ji, 2015; van Pinxteren et al., 2019). Wirtz et al. (2018) suggest that the provision of human supervision can foster trust formation and ameliorate cognitive barriers to the adoption of service robots. Similarly, in the context of airborne mobility, research indicates that the most effective way to foster trust is to provide some form of human supervision of the aerial vehicle, which could be ensured by an onboard or remote pilot (Chancey and Politowicz, 2020). Studies indicate that consumers show higher levels of trust and confidence in human supervision than in automation (Hughes et al., 2009; Mehta et al., 2017). This may be even amplified in the case of new technologies, such as passenger drones, where consumers have little knowledge about the technology and no prior experience (Midden and Huijts, 2009). Therefore, we hypothesize:

H1: Human supervision (vs. no human supervision) during an autonomous UAM flight increases trust.

The mediating role of affective and cognitive evaluations

Building on the discussion of dual-process models in Section 2.3, we argue that the positive influence of trust on the adoption intentions of passenger drones is mediated by two paths, comprising affective responses and cognitive evaluations.

The link between trust and affective responses has been under-investigated in the context of automated mobility offerings (Osburg et al., 2022). However, previous research suggests that trust helps people evaluate innovative technologies through affect: feelings of trust generate positive or negative affective responses that form the basis for acceptance decisions (Midden and Huijts, 2009). Following earlier suggestions to move beyond measuring aggregate, valence-based responses (Valor et al., 2022), we define affect based on two discrete emotions that have been shown to be influential factors in the adoption decisions related to automated technologies (Chen, 2019; Keszey, 2020; van Pinxteren et al., 2019): perceived enjoyment and anxiety. In the context of human–computer interaction, perceived enjoyment is understood as the extent to which the usage of a new technology is perceived to be enjoyable (Davis et al., 1992; Pitardi and Marriott, 2021), while anxiety refers to feelings of apprehension or uneasiness related to interacting with and using a new technology (Osswald et al., 2012). We expect trust to positively influence perceived enjoyment while simultaneously reducing anxiety (Kim, 2019; van Pinxteren et al., 2019). Thus, we hypothesize:

H2: Trust increases perceived enjoyment.
H3: Trust reduces anxiety.

One important role of trust is reducing uncertainty and risk perceptions (Choi and Ji, 2015). For consumers, the use of a new AI-based technology is related to a high level of uncertainty (Kyriakidis et al., 2015). In this context, trust serves as a mechanism that permits consumers to overcome uncertainty and rely on the automated system (Liu et al., 2019b). A high level of trust, therefore, positively affects cognitive beliefs about the technology or service offering, such as its perceived usefulness (Choi and Ji, 2015; Xu et al., 2018), benefit perceptions (Liu et al., 2019b; Liu et al., 2019), and perceptions of safety or risk related to the use of the focal technology (Liu et al., 2019b; Xu et al., 2018). We therefore hypothesize:

H4: Trust increases benefit perceptions.
H5: Trust increases safety perceptions.

Research shows that emotions play an important role in consumers' evaluations of and subsequent behavioral intentions toward intelligent technologies and AI applications (e.g., Blut et al., 2021b; Liu et al., 2019). In particular, Rice and Winter (2015) indicate that fear and wariness of the technology may be some of the most important negative determinants of usage intentions related to unmanned aircraft, while enjoyment has a strong positive influence on willingness to fly. Similarly, studies focusing on both individual and shared autonomous mobility confirm the positive influence of perceived enjoyment on adoption intentions (Chen, 2019; Madigan et al., 2016), while fears and anxiety have been shown to negatively influence the willingness to use the technology (Hohenberger et al., 2016). Similarly, preliminary evidence suggests that affective responses to automated technology will not only influence consumers' usage intentions but also their willingness to pay (WTP) for related services (Liu et al., 2019a). Therefore, we expect perceived enjoyment and anxiety to strongly influence both intentions to use UAM services and consumers' WTP for related services. Thus, we hypothesize:

H6: Perceived enjoyment increases adoption intentions (H6a) and WTP (H6b).
H7: Anxiety reduces adoption intentions (H7a) and WTP (H7b).

It is well known that cognitive considerations, including perceptions of benefits and safety related to automated technologies, exert a strong influence on adoption intentions (Blut et al., 2021b; Choi and Ji, 2015). In the context of UAM, perceptions of safety have been identified as a focal construct in acceptance formation (Al Haddad et al., 2020). Additionally, the specific benefits provided by automated technologies strongly influence consumers' evaluations and adoption intentions (Liu et al., 2019b). Further, previous studies suggest that cognitive considerations, such as benefit and risk perceptions, also influence WTP for automated technology (Jing et al., 2020; Liu et al., 2019a). We, therefore, expect perceptions of benefits and safety to positively influence both consumers' intention to use UAM services as well as their WTP for such services. Thus, we hypothesize:

H8: Perceived benefit increases adoption intentions (H8a) and WTP (H8b).
H9: Perceived safety increases adoption intentions (H9a) and WTP (H9b).

2.4.2. *The moderating effect of risk aversion*

In Study 2, we additionally investigate the potential moderating effect of risk aversion. Risk aversion is considered a stable personality trait, describing consumers' tendency to avoid situations or outcomes related to high uncertainty (Huang and Qian, 2021;

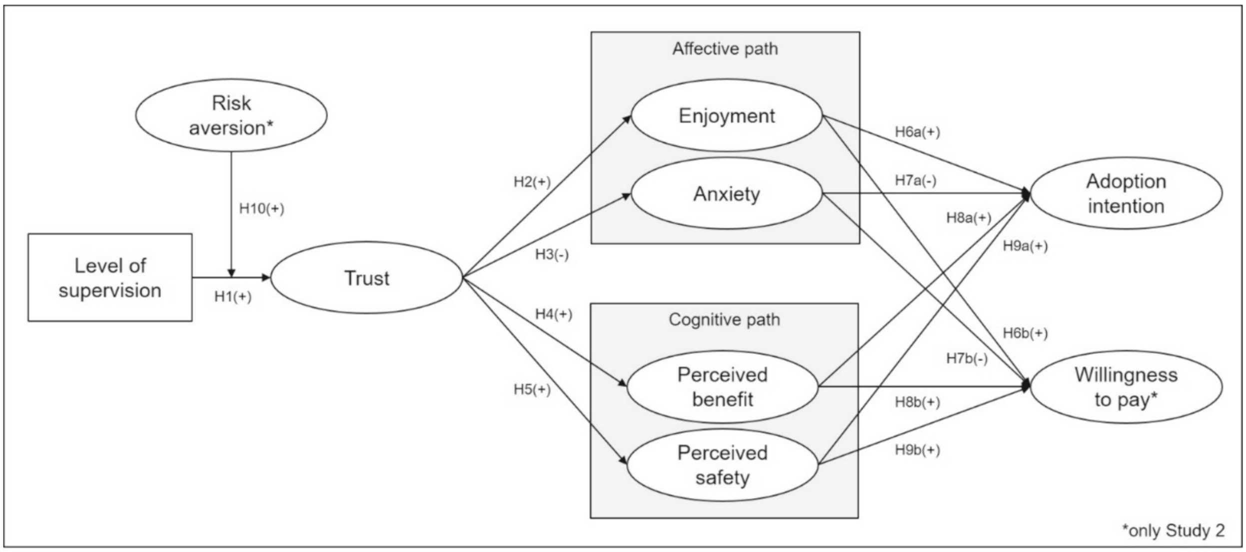


Fig. 1. Conceptual model.

Rejikumar et al., 2022). Consumers with high levels of risk aversion seek to reduce uncertainty by choosing alternatives that appear more certain or familiar (Casaló et al., 2015). Previous research indicates that risk aversion may amplify negative beliefs about automated technologies (e.g., autonomous vehicles) and thus intensifies the negative relationship between consumers' reasoning against automated vehicles and their attitude toward them (Huang and Qian, 2021). As human supervision and control have been the standard of operation ever since the start of commercial aviation (Vance et al., 2019), it can be assumed that highly risk-averse consumers would prefer this proven mode of operation to autonomous flights. In the context of our research, we, therefore, expect risk aversion to intensify the positive effect of human supervision on trust. We hypothesize:

H10: The positive effect of human supervision on trust is amplified by risk aversion, i.e., for highly risk-averse consumers, human supervision exerts a stronger effect on trust than it does for consumers low in risk aversion.

Fig. 1 summarizes our model and the hypothesized paths.

3. Methodology and analysis

3.1. Study overview

We conducted two experimental studies to investigate the factors influencing adoption intentions of future mobility services in the context of autonomous passenger drones, specifically focusing on the role of trust as well as the dual paths of affective and cognitive evaluations. Study 1 employed a VR simulation in a university lab environment, which allowed the participants to experience a flight in an air taxi from a passenger's perspective. VR simulations enable a realistic experience of new technologies and thus allow for the assessment of acceptance as well as aspects related to the user experience while ensuring sufficient controllability and reproducibility (Cipresso et al., 2018; Harz et al., 2022). To validate our findings from Study 1 and examine the potential moderating effect of risk aversion, we conducted a second study (Study 2) online with the help of a panel provider and replicated the initial stimulus provided to participants by including a video recording of the flight experience based on the simulation used in Study 1.

3.2. Study 1

3.2.1. Method

We used a randomized one-factor, two-level (human supervision vs. no human supervision) factorial design to investigate the effect of human supervision (represented by the presence of a human pilot inside the passenger drone) on adoption intentions, mediated by trust and affective and cognitive evaluations. To provide a more realistic visualization and enable respondents to better empathize with the experimental scenario, we commissioned a professional service firm specializing in 3D modeling and simulation design with the development of a VR simulation. The VR scenario provided an approximation of a potential flight experience and displayed the entire sequence of steps related to a flight in a passenger drone, from approaching the drone to boarding and take-off, flying across the city, landing, and disembarking. We omitted details such as the booking process or security checks, as our main focus was on the flight experience. Depending on the respective experimental conditions, participants were either able to observe a human pilot upon entering the virtual drone or found themselves in an autonomous passenger drone. In both cases, three other passengers were seated inside the aircraft (details about the experimental scenarios and technical specifications related to the VR simulation can be found in Appendices C and D).

3.2.1.1. Measurements. All latent measures were adapted from existing multi-item scales and were assessed using 7-point Likert scales, with responses ranging from 1 (strongly disagree) to 7 (strongly agree) to indicate agreement with the statements reflected in the items. Descriptive statistics and construct measures can be found in Appendix A.

Control variables and manipulation check: We included three variables to control for rival explanations and unexplained variance: age, gender, and physical discomfort. Previous research indicates that age and gender influence consumers' evaluations of new technologies (Venkatesh et al., 2003; Blut et al., 2021a). Additionally, while participants were encouraged to speak up and terminate the simulation immediately in the event that they experienced any form of physical discomfort, we assessed mild symptoms of dizziness, which often occur when using VR, as an additional control variable using one item. Finally, we included a manipulation check, asking participants to indicate whether the flight was supervised by a pilot or conducted autonomously, according to the respective scenario description they were given in the beginning. All participants were able to correctly recall the flight mode that matched the condition they were assigned to. Thus, our manipulation was successful.

3.2.1.2. Procedure and sample. Participants were recruited on the university campus as well as through announcements on social media and local news outlets to reach a more diverse audience. A monetary incentive of 20€ was offered to boost the overall participation rate and compensate respondents for the additional effort required to visit the university's lab for participation. To form a common understanding of the subject, participants were first provided with a general explanation of UAM and a scenario description to provide a context for the VR sequence. The scenario described a flight between two middle-sized cities in a Western European country. Participants were told that their flight (approx. 30 km) would take about 10 min to complete, reflecting one of the most likely exemplary use cases of UAM services (Volocopter, 2021). Depending on the experimental condition, the text indicated that the flight was either supervised by a human pilot or fully autonomous (see Appendix C for the scenario description). Subsequently, participants were asked to put on HTC VIVE Pro headgear to experience the VR flight simulation. Upon concluding the VR flight, they completed an online questionnaire, which consisted of Likert scale items measuring their trust in air taxis, enjoyment, anxiety, perceptions of benefits and safety, their intention to use air taxis in the future, as well as demographic questions. Completion of the entire experiment took approximately 30 min, of which 4:30 min were spent immersed in the VR scenario.

In total, we recruited 277 participants, who were randomly assigned to one of the experimental conditions. We had to exclude 16 participants due to failed quality and attention checks. This left us with a final sample of 261 respondents, with 130 in the autonomous condition and 131 in the piloted condition (46.4 % female, 18–73 years old, $M_{age} = 30.05$ years, $SD_{age} = 13.2$). The vast majority ($n = 243$) of the participants indicated being at least somewhat familiar with the concept of UAM, but they had no actual experience with the service. For more information on the demographics, see Appendix B.

3.2.2. Results

The proposed conceptual model was tested in a two-step process using Mplus 8.6. In the first step, we conducted a confirmatory factor analysis (CFA) to test the adequacy of the measurement model. Following this, we tested the proposed structural model and hypotheses using covariance-based structural equation modeling (SEM) using the MLM estimator to assess the magnitude and direction of the proposed relationships.

3.2.2.1. Assessment of the measurement model. We conducted the CFA to assess convergent and discriminant validity. Overall, model fit measures suggest the model fits the data well ($\chi^2 = 211.599$, $df = 120$; CFI = 0.962; RMSEA = 0.055; SRMR = 0.058). We verified convergent validity by checking the reliability, factor loadings, and extracted variance for each construct. Cronbach's alpha values were consistently above 0.70, while composite reliabilities (CR) and average variances extracted (AVE) were all above the recommended minimums of 0.70 and 0.50, respectively (Fornell and Larcker, 1981). Additionally, all factor loadings for indicators of the same construct were statistically significant ($p < 0.01$), supporting convergent validity. To examine discriminant validity, we assessed whether the square root of the AVE for each construct was greater than the construct's correlation with any other construct (Fornell and Larcker, 1981) and found that this criterion was met for all constructs. Additionally, we applied the heterotrait–monotrait (HTMT) criterion as a more conservative approach to test for discriminant validity, following Henseler et al. (2015). All construct correlations yielded HTMT ratios well below the conservative threshold of 0.85 (see Appendix E, Table E.1), suggesting sufficient discriminant validity. Correlations, reliabilities, and validity statistics for all constructs can be found in Table 1. Finally, we examined the degree of multicollinearity among the model constructs. Variance inflation factor (VIF) values were well below the cut-off threshold of 5 (Hair et al., 2017), varying from 1.086 to 1.559, suggesting low levels of multicollinearity.

3.2.2.2. Common method variance. As our research employed mostly perceptually anchored items, we addressed potential common method variance (CMV) both by applying procedural remedies in the data collection stage and by empirically testing for potential variance in the data (Sharma et al., 2009; MacKenzie and Podsakoff, 2012). Following previous recommendations, we sought to mitigate the risks of CMV by reminding participants that there were no correct or incorrect responses and that their anonymity was guaranteed throughout the study (Podsakoff et al., 2003). Additionally, we randomly permuted the order of items in multi-item constructs to prevent sequence effects (MacKenzie and Podsakoff, 2012). Construct validity is viewed as a contraindication of CMV (Conway and Lance, 2010), which we established previously. To empirically test for CMV, we compared our hypothesized six-factor model (trust, enjoyment, anxiety, perceived benefit, perceived safety, adoption intentions) with an alternative model, in which the covariances between all constructs were constrained to 1. This alternative model exhibited inferior fit with the data ($\chi^2 = 275.135$, df = 126, CFI = 0.949, RMSEA = 0.067; SRMR = 0.121; $\Delta\chi2 = 63.536$, $\Delta df = 6$, $p < 0.01$), thus supporting the six-factor model.

3.2.2.3. Assessment of the structural model and hypothesis testing. Model fit indices indicate a good fit of the structural model ($\chi^2 = 271.369$, $df = 141$; CFI = 0.951; and RMSEA = 0.06; SRMR = 0.069). All hypothesized paths were supported by the data. The presence of a human pilot positively affects trust ($\beta = 0.20$, $p < 0.001$), supporting H1. In accordance with H2 and H3, we find that trust increases perceived enjoyment ($\beta = 0.521$, $p < 0.001$) and decreases anxiety ($\beta = -0.625$, $p < 0.001$). Focusing on the proposed cognitive path in our model, we find that trust positively influences both benefit perceptions ($\beta = 0.35$, $p < 0.001$) and perceived safety ($\beta = 0.416$, $p < 0.001$), supporting H4 and H5. In addition, the results indicate a positive effect of perceived enjoyment ($\beta = 0.272$, $p <$

Table 1
Correlations, reliability, and validity statistics for Study 1.

	1	2	3	4	5	6	α	AVE	CR
1. Trust	**0.883**						0.913	0.779	0.913
2. Enjoyment	0.523	**0.850**					0.880	0.722	0.885
3. Anxiety	−0.627	−0.555	**0.821**				0.851	0.674	0.860
4. Perceived benefit	0.360	0.296	−0.212	**0.762**			0.771	0.580	0.803
5. Perceived safety	0.434	0.409	−0.507	0.089	**0.818**		0.839	0.669	0.854
6. Usage intention	0.460	0.518	−0.487	0.361	0.418	**0.820**	0.857	0.672	0.859

Notes: Correlations; Values in bold = Square root of AVE; AVE = Average variance extracted; CR = Composite reliability; α = Cronbach's alpha. All variables are measured on a 7-point Likert scale (1 = "strongly disagree," 7 = "strongly agree").

0.001, H6a), perceived benefit ($\beta = 0.236$, $p < 0.001$, H8a), and perceived safety ($\beta = 0.194$, $p < 0.001$, H9a) on usage intentions. Finally, anxiety negatively affects usage intentions ($\beta = -0.229$, $p < 0.001$), supporting H7a.

Mediation test. Our theoretical model proposes a serial mediation of the presence of a human pilot on usage intentions, mediated by trust as well as affective and cognitive evaluations. The mediation analyses showed that all hypothesized mediation effects were significant at the $p < 0.05$ level (see Table 3). The mediated paths via perceived enjoyment ($\beta = 0.027$, $p < 0.01$) and anxiety ($\beta = 0.028$, $p < 0.05$) showed the strongest effects.

3.3. Study 2

With Study 2, we validated the results of Study 1 in an online setting to reach a larger sample, avoiding the potential bias that could have been caused by the unique experience of the VR simulation. We also included WTP as a second dependent variable (H6b–H9b) and examined the potential moderating effects of risk aversion (H10).

3.3.1. Method

As in Study 1, we employed a single-factor between-subjects experimental approach to quantitatively assess the factors that influence consumers' affective and cognitive evaluations and, ultimately, their usage intentions and willingness to pay for UAM services. To provide an experimental scenario comparable to Study 1, we included a video showing a screen recording of the VR simulation from Study 1 in the questionnaire. The questionnaire contained the same general explanation of UAM and scenario description we used in Study 1.

3.3.1.1. Measurements. We used the same constructs and items as in Study 1. Additionally, we included three items measuring the hypothesized moderator risk aversion. All constructs were assessed using 7-point Likert-scales, with responses ranging from 1 (strongly disagree) to 7 (strongly agree) to indicate agreement with the statements reflected in the items. The descriptive statistics and construct measures can be found in Appendix A. Additionally, an open question asked participants to indicate the exact Euro amount they would be willing to pay for the described flight.

Control variables and manipulation check: We included age and gender as control variables. Additionally, as previous publications pointed out that consumers' general fear of flying might influence their evaluation of UAM services, we included fear of flying to control for potential bias (Bennett and Vijaygopal, 2021). We assessed fear of flying using one item stating "In general, flying makes me feel uncomfortable" on a 7-point Likert-scale, with responses ranging from 1 (strongly disagree) to 7 (strongly agree). As in the previous study, we included a manipulation check, asking participants to indicate whether the flight was supervised by a pilot or conducted autonomously, according to the respective scenario description they were given in the beginning. Again, all participants were able to correctly recall the flight mode that matched the condition they were assigned to.

3.3.1.2. Procedure and sample. We recruited a total of 345 consumers from a Western European country with the help of an online panel provider. Participants received a monetary incentive in the amount of 5€. Completion of the questionnaire, on average, took 15 min. We had to exclude four participants due to failed quality and attention checks, leaving us with a final sample of n = 341. Participants received a small monetary compensation and were randomly assigned to one of the experimental conditions (human supervision vs. no supervision), resulting in 163 participants in the human supervision condition and 178 in the autonomous condition (43.1 % female, 18–65 years old, $M_{age} = 45.55$ years, $SD_{age} = 13.356$). The majority (57.8 %) of the participants indicated being at least somewhat familiar with the concept of UAM. For more information on the demographics, see Appendix B.

3.3.2. Results

Again, we tested the proposed conceptual model in a two-step process using Mplus 8.6, employing covariance-based SEM using the MLM estimator. We first conducted a CFA to test the adequacy of the measurement model and subsequently tested the proposed structural model to assess the magnitude and direction of the proposed relationships.

3.3.2.1. Assessment of the measurement model. We conducted a CFA to assess convergent and discriminant validity. Overall, the model

Table 2
Correlations, reliability, and validity statistics for Study 2.

	1	2	3	4	5	6		α	AVE	CR
1. Trust	**0.960**							0.972	0.922	0.973
2. Enjoyment	0.763	**0.962**						0.974	0.926	0.974
3. Anxiety	−0.657	−0.762	**0.934**					0.952	0.872	0.953
4. Perceived benefit	0.467	0.450	−0.266	**0.913**				0.937	0.834	0.938
5. Perceived safety	0.788	0.765	−0.735	0.408	**0.950**			0.965	0.903	0.965
6. Usage intention	0.763	0.817	−0.700	0.485	0.691	**0.952**		0.967	0.907	0.967
7. Risk aversion	−0.425	−0.437	0.496	−0.330	−0.408	−0.468	**0.850**	0.884	0.723	0.886

Notes: Correlations; Values in bold = Square root of AVE; AVE = Average variance extracted; CR = Composite reliability; α = Cronbach's alpha. All variables are measured on a 7-point Likert scale (1 = "strongly disagree," 7 = "strongly agree").

fit measures suggest the model fits the data well ($\chi^2 = 239.272$, $df = 120$; CFI = 0.987; RMSEA = 0.054; SRMR = 0.018). Cronbach's alpha, composite reliability, and average variance extracted all indicate adequate reliability at the construct level. Again, we applied Fornell and Larcker's (1981) criterion and the HTMT criterion (Henseler et al., 2015) to test for discriminant validity. The square root of the AVE for each construct is greater than the construct's highest correlation with any other construct (see Table 2), and all HTMT ratios of the correlations are well below the conservative threshold of 0.85 (see Appendix E, Table E.2), suggesting sufficient discriminant validity. Finally, variance inflation factor (VIF) statistics range between 3.006 and 3.259, indicating low levels of multicollinearity (Hair et al., 2017).

3.3.2.2. Common method variance. As in Study 1, we addressed potential CMV using both ex-ante and ex-post measures, following previous recommendations (MacKenzie and Podsakoff, 2012; Podsakoff et al., 2003). We sought to mitigate threats of common method bias by reminding participants that there were no correct or incorrect responses, guaranteeing their anonymity, and randomly permuting the order of items in multi-item constructs (MacKenzie and Podsakoff, 2012; Podsakoff et al., 2003). To empirically test for CMV, we compared our hypothesized six-factor model with an alternative model, in which the covariances between all constructs were constrained to 1. This alternative model exhibited inferior fit with the data ($\chi2 = 1000.441$, df = 126, CFI = 0.903, RMSEA = 0.142; SRMR = 0.435; $\Delta\chi2 = 788.842$, $\Delta df = 6$, $p < 0.01$), thus supporting our model.

3.3.2.3. Assessment of the structural model and hypothesis testing. Overall model-fit indices are within the required thresholds and indicate a good fit of the structural model ($\chi^2 = 402.263$, $df = 194$; CFI = 0.973; RMSEA = 0.056; SRMR = 0.053). Most of the hypothesized paths were supported by the data, also validating the results of Study 1. Again, we find that human supervision positively affects trust ($\beta = 0.183$, $p < 0.001$), supporting H1. Following the affective path, we find that trust increases perceived enjoyment ($\beta = 0.687$, $p < 0.001$, H2) and decreases anxiety ($\beta = -0.564$, $p < 0.001$, H3). Focusing on the proposed cognitive path in our model, we find that trust positively influences both benefit perceptions ($\beta = 0.493$, $p < 0.001$) and perceived safety ($\beta = 0.747$, $p < 0.001$), supporting H4 and H5. In addition, the results indicate a positive effect of perceived enjoyment ($\beta = 0.579$, $p < 0.001$, H6a) and perceived benefit ($\beta = 0.164$, $p < 0.001$, H8a) on usage intentions. Anxiety negatively affects usage intentions ($\beta = -0.225$, $p < 0.001$), supporting H7a. In contrast to Study 1, we find that perceived safety exerts only a marginally significant influence on adoption intentions ($\beta = 0.078$, $p = 0.072$, H9a). Additionally, we find that WTP is significantly influenced by perceived enjoyment ($\beta = 174$, $p < 0.01$, H6b) and perceived benefit ($\beta = 0.172$, $p < 0.001$, H8b), while anxiety ($\beta = 0.027$, $p = 0.647$, H7b) and perceived safety ($\beta = 0.038$, $p = 0.421$, H9b) do not affect WTP.

Mediation analysis: Our theoretical model proposes a serial mediation of the presence of a human pilot on usage intentions, mediated by trust as well as by affective and cognitive evaluations. The mediation analyses showed that, for the mediated effect of human supervision on usage intention, three of our hypothesized mediation effects were significant at the $p < 0.05$ level (Table 3). The mediation path via trust and perceived safety was not significant ($p = 0.110$). Focusing on the mediated effect of human supervision on

Table 3
Structural model results.

Structural relationships	Path coefficients	
	Study 1	Study 2
Main effects		
H1: Supervision → Trust	0.199***	0.183***
H2: Trust → Perceived enjoyment	0.522***	0.687***
H3: Trust → Anxiety	−0.625***	−0.564***
H4: Trust → Perceived benefit	0.376***	0.493***
H5: Trust → Perceived safety	0.434***	0.747***
H6a: Perceived enjoyment → Adoption intention	0.262***	0.579***
H7a: Anxiety → Adoption intention	−0.224***	−0.225***
H8a: Perceived benefit → Adoption intention	0.242***	0.164***
H9a: Perceived safety → Adoption intention	0.194***	0.078*
H6b: Perceived enjoyment → WTP[a]	–	0.174***
H7b: Anxiety → WTP[a]	–	n.s.
H8b: Perceived benefit → WTP[a]	–	0.172***
H9b: Perceived safety → WTP[a]	–	n.s.
Indirect effects		
Supervision → Trust → Perceived enjoyment → Adoption intention	0.027***	0.073***
Supervision → Trust → Anxiety → Adoption intention	0.028**	0.023***
Supervision → Trust → Perceived benefit → Adoption intention	0.018**	0.015***
Supervision → Trust → Perceived safety → Adoption intention	0.017**	n.s.
Supervision → Trust → Perceived enjoyment → WTP	–	0.022**
Supervision → Trust → Anxiety → WTP	–	n.s.
Supervision → Trust → Perceived benefit → WTP	–	0.016***
Supervision → Trust → Perceived safety → WTP	–	n.s.
Interaction effect[a]		
H10: Supervision × Risk aversion → Trust	–	0.266***

Notes: n.s. = not significant; WTP = willingness to pay; *p < 0.1 **p < 0.05 ***p < 0.01; [a] = only assessed in Study 2.

WTP, we find that the mediated path via trust and enjoyment (β = 0.022, $p < 0.05$) and the path via trust and perceived benefit (β = 0.016, $p < 0.01$) are significant, while the other two paths remain non-significant.

Moderation analysis: We included the individual personality trait of risk aversion as a moderator of the effect of human supervision on trust. The analysis of the hypothesized interaction reveals that risk aversion emphasizes the positive effect of human supervision on trust (β = 0.266, $p < 0.01$), supporting H10. Thus, more risk-averse consumers are more strongly influenced by the presence of a human pilot compared to consumers with lower risk aversion.

4. Discussion and conclusion

4.1. Summary of findings

Our results show that adoption intentions related to autonomous passenger drones are driven by both affective and cognitive considerations, which are firmly grounded in trust. The results confirm that (1) human supervision serves as an important cue in trust formation related to autonomous passenger drones, and (2) trust strongly influences both subsequent affective and cognitive evaluations of passenger drone services, which in turn (3) affect adoption intentions. Most noteworthy, our findings show that affective responses exert a stronger influence on the willingness to use autonomous passenger drones than on cognitive evaluations. Additionally, the results suggest an asymmetric impact of positive and negative affective responses (Merk and Pönitzsch, 2017), indicating that the evaluation of UAM services is more strongly guided by perceived enjoyment than by anxiety. We find these effects in both Study 1 and Study 2, demonstrating the robustness of our theoretical framework. Additionally, Study 2 shows that WTP for a specific flight scenario is strongly driven by perceived enjoyment and considerations of potential benefits of UAM services, while both anxiety and perceived safety do not significantly influence WTP. Finally, our findings in Study 2 suggest an amplifying effect of risk aversion on the relationship between human supervision and trust, providing important implications for service providers.

4.2. Discussion of empirical results

In this research, we proposed and tested an empirical model that integrates important determinants of the intention to adopt autonomous passenger drones. The dominant models used to investigate technology adoption have traditionally focused strongly on functional attributes of technologies and the cognitive evaluations made by consumers while overlooking the role of emotions, despite their importance in consumer decision-making (Valor et al., 2022). Therefore, building on dual-process theory (Samson and Voyer, 2012; Smith and DeCoster, 2000), we developed and examined a context-specific model of adoption intentions of UAM services, which encompasses not only cognitive evaluations but also emotional aspects of adoption intentions, thus ensuring a more holistic perspective on consumer perceptions of autonomous passenger drones. Integrating previous findings, we show that the formation of behavioral intentions to use UAM services is guided by both affective and cognitive considerations. As such, our research provides important insights into the mechanisms that underlie the formation of adoption intentions of AI-enabled autonomous transport services and contributes significantly to a better understanding of the factors that shape consumer evaluations of new technologies.

Our research also adds to the growing body of literature on the importance of affect in consumer judgment and decision-making (Bagozzi, 2007; Lerner et al., 2015). While there is preliminary evidence of the importance of both affective and cognitive responses in the formation of adoption intentions of other automated technologies (e.g., Liu et al., 2019; Shi et al., 2021), no research has taken into account the critical role of affective evaluations in usage intentions of autonomous UAM services. Our findings indicate that positive affect (in our case, enjoyment) is the most important mediator between trust and adoption intentions. Thus, consumers are more strongly influenced by their affective responses than by considerations of benefits and safety perceptions when it comes to evaluating autonomous passenger drones. As such, our findings also relate to previous research, which suggests that affective responses may be particularly dominant in attitude formation and adoption decisions in the context of new technologies in cases where knowledge about and exposure to the technology are still limited (Merk and Pönitzsch, 2017). Finally, our results suggest that perceived enjoyment may be the most important determinant of WTP for UAM services. While Liu et al., (2019a) found perceived dread, which is conceptually similar to anxiety, to be a significant predictor of WTP, to the best of our knowledge, no previous study examined the influence of positive emotions on WTP for automated technologies and related services. Thus, we contribute to a better understanding of emotions as a psychological mechanism enabling or impeding the adoption of automated transport technologies.

In terms of cognitive evaluations, previous research maintains that perceptions of usefulness or relative benefits provided by the focal technology play an important role in the formation of adoption intentions (Blut et al., 2021a; Keszey, 2020). In line with this, we found that the perceived benefits of passenger drones are a strong determinant of both adoption intentions and WTP. Additionally, prior research suggests that safety is crucial for future users of UAM services and may be one of the key determinants in fostering confidence in and usage intentions related to autonomous passenger drones (Al Haddad et al., 2020; Kim et al., 2022). While we find support for the significant influence of safety in one of our studies, our results indicate that of the four factors hypothesized to influence usage intentions, perceived safety has the lowest impact. This may indicate that, as consumers naturally expect air taxi operations to provide an adequate level of safety and reliability, safety is considered a hygiene factor. This echoes previous findings indicating that safety aspects can pose a barrier to user adoption if service providers fail to meet consumers' safety expectations but are not a driving factor in consumer adoption of UAM services (Hogreve and Janotta, 2021).

Since commercial aviation started operations, passenger-carrying aircraft have been commanded by human pilots aboard the aircraft (Vance et al., 2019). Thus, the transition to autonomous flight operations, which is considered to be inevitable in the context of UAM services, will mark a dramatic change in consumers' flight experiences, and it could have detrimental effects on their perceptions of safety and subsequent adoption intentions (Chancey and Politowicz, 2020). Previous research suggests that consumers' trust and subsequent adoption intentions of autonomous passenger drones may be affected by varying forms of human supervision (Osburg et al., 2022). By manipulating the presence of human supervision in our experimental scenario, we examine the potential impact of the anticipated switch to autonomous UAM operations and provide causal evidence indicating that the presence of a human pilot onboard a passenger drone is an important source of trust. This finding is consistent with previous research in the area of commercial aviation indicating that consumers show reluctance toward fully autonomous flight operations (e.g., Hughes et al., 2009; Mehta et al., 2017). Extending previous research, which often overlooked the moderating role of psychological factors (Blut et al., 2021a), we include the moderator risk aversion in our analysis and find that the positive effect of human supervision is even stronger for consumers high in risk aversion. As such, our findings suggest that highly risk-averse consumers prefer human supervision to autonomous flight operations, providing important implications for service providers.

While most previous studies focused on consumers' usage intentions related to UAM services (e.g., Al Haddad et al., 2020; Kim et al., 2022), we included respondents' WTP for a specific, realistic flight scenario, thus offering additional insights into the main factors affecting the longer-term operability and success of UAM service offerings. Our results show that WTP is strongly driven by perceived enjoyment and considerations of the potential benefits of UAM services compared to other transport alternatives. Interestingly, both anxiety and perceived safety do not significantly influence WTP. This finding may be surprising at first, considering the importance that has been attributed to perceived safety (e.g., Al Haddad et al., 2020; Johnson et al., 2022). The non-significant effect of safety perceptions on WTP can be interpreted as further evidence that safety, indeed, represents a hygiene factor in consumers' decision-making related to automated technologies (see Hogreve and Janotta, 2021).

Finally, we add to the methodological variety in research on the adoption of automated transport technologies by employing a VR simulation. To the best of our knowledge, VR simulations are still a nascent presentation form in the field of transportation research, and previous research has often relied on surveys providing respondents with descriptions of scenarios about the technology under study. However, providing respondents with more immersive visualizations of new technologies is crucial, especially in situations where respondents' mental image of a technology or service is limited (Venverloo et al., 2021). With this novel approach, we add to the small base of publications in transportation research that have employed this method (e.g., Stolz and Laudien, 2022; Venverloo et al., 2021). Previous research suggests that respondents act similarly in VR scenarios as they would in real-life scenarios (Alghamdi et al., 2017; Durlach and Slater, 2000). Thus, VR seems to be a useful method for visualizing new or emergent technologies to study participants' perceptions and evaluations of those technologies. By replicating our findings in an online setting, we demonstrate the robustness of our findings.

4.3. Implications for industrial stakeholders

It is expected that autonomous passenger drones will initially be treated with skepticism. Hence, it is crucial for service providers to understand and appropriately address concerns and negative perceptions that consumers may hold. The findings of this research help service providers better understand the factors that motivate consumers' usage of manned and unmanned passenger drones and successfully implement such technologies.

The transition toward autonomous air mobility services will require careful understanding and consideration of passenger trust and affective responses to maintain adequate levels of consumer acceptance. Previous research indicates that many consumers are concerned about the risk of system malfunctions in the absence of a human operator or supervisor (Ameen et al., 2021; Vance and Malik, 2015). Relatedly, our findings suggest that service providers should consider ensuring some type of human supervision at all times, independent of regulatory requirements, to instill confidence and trust in potential users. While, from an economic standpoint, it may be desirable for service providers to swiftly move from human supervision on board the aircraft to automated operations, it seems that consumers are not ready for autonomous operations (Huang and Rust, 2022). Thus, providers are advised to explore the potential of remote modes of human supervision to foster trust and willingness to use automated services, particularly in more risk-averse customer segments (Osburg et al., 2022). Service providers should, therefore, consider different measures and design elements to ensure social support at all times during flight and provide passengers with a sense of social presence, even when there is no human pilot onboard the aircraft. Conceivable options include the implementation of a service button inside the cabin, which connects passengers with a ground-based service representative or contact persons displayed via virtual avatars inside the drone (Beaudry and Pinsonneault, 2010). Previous research indicates that, especially for women, knowledge of the possibility of receiving ground support inside the cabin could help foster trust in UAM services and reduce the negative impacts of anxiety, thus helping more risk-averse consumers become comfortable with the unfamiliar situation of being "trapped" inside an aerial vehicle with strangers (e.g., Hogreve and Janotta, 2021; Paddeu et al., 2020).

Broad adoption and usage of UAM services will be based on achieving and maintaining the perception that passenger drones are an enjoyable, safe, and efficient alternative to current transport services (Chancey and Politowicz, 2020). Consumer usage of passenger drones may not exclusively be motivated by utilitarian considerations; it may be strongly driven by hedonic motivation as well. Given the important role of perceived enjoyment in both the formation of usage intentions and the WTP for UAM services, manufacturers and service providers should carefully consider the customer experience in piloted, remote-piloted, and autonomous air taxis and focus on creating positive affective experiences on future flights (Liu-Thompkins et al., 2022; Winter et al., 2020). Marketing communications should include emotional appeals that highlight the experiential aspect of flying in an autonomous passenger drone while highlighting the relative advantages of UAM offerings compared to other transport alternatives.

4.4. Policy implications

Besides the previously discussed recommendations for service providers and industry stakeholders, this research's findings provide important implications for responsible policymaking. Policymakers and regulatory authorities play a central role in fostering acceptance of piloted and, in particular, autonomous urban air mobility operations (Koo et al., 2022).

As discussed previously, the transition toward autonomous air mobility services will require targeted measures to foster trust and safety perceptions in users. From a policy perspective, unified safety standards regarding in-vehicle safety features, such as surveillance cameras, emergency buttons, or parachutes, could help maintain adequate levels of trust and acceptance (Rice et al., 2022; Ward et al., 2021). Previous studies have shown a preference of consumers for such safety features and it will be up to the responsible authorities to enforce appropriate regulations on these aspects (Ward et al., 2021).

Similarly, our findings suggest that ensuring some type of human supervision at all times will be crucial to instill confidence and trust in potential users. While the physical presence of an on-board supervisor may not be desirable from an economic standpoint, it may be an important task for authorities and policymakers to specify adequate emergency solutions that take effect in the event of a failure of the automated system. This could include the mandatory availability of a ground-based operator at any time (Al Haddad et al., 2020).

As highlighted by previous research (Koo et al., 2022), a crucial prerequisite to the successful implementation of Urban Air Mobility services will be the balancing of conflicting interests: the interest of industry stakeholders and potential users in implementing this new form of mobility, and the legitimate concerns of the general public and local residents who might be affected by air taxi operations. It will be an important task for policymakers and authorities to enforce appropriate regulations to master this balancing act.

4.5. Limitations and future research

Despite the important contributions we make, this research is not without limitations. First, we identify risk aversion as a significant moderator affecting consumers' trust in UAM offerings. However, there might be other relevant moderators in the context of consumers' evaluations of autonomous passenger transport services. For example, previous research suggests that consumers differ in terms of their personal needs for human interaction in service contexts (e.g., Blut et al., 2021b; Fernandes and Oliveira, 2021). Considering various possible types of human supervision in passenger drone operations, it seems reasonable to assume that consumers with a higher need for social interaction are less open to fully autonomous flights. In addition, contextual factors, such as the purpose of the trip (utilitarian vs. hedonic) or the presence of other passengers, could play a role in consumers' perceptions of safety and willingness to use air taxis, especially when human supervision is lacking (Lu et al., 2020). Future research is needed to examine the potential effects of such individual-level characteristics on the evaluations and adoption intentions of autonomous passenger drones.

Second, it may be that the relative weight of evaluations (both cognitive and affective components) will change as consumers learn more about UAM as we move closer to the market entry of such services (Ward et al., 2021). In addition, emotions experienced during actual usage may differ from anticipated emotions, which affect evaluations in the contemplation stage, before the innovation has actually been trialed (Valor et al., 2022). Therefore, an interesting avenue for future research is to examine how the relative weight of cognitive and affective components changes over time.

Third, in our study affect and arousal levels have been measured by asking the respondents the tradition scales after they have perceived the VR simulation. Future studies might rely on sensor data measuring arousal via measuring skin conductance or heart rate variability. Analyzing this data in combination with traditional scales and open questions would make the results stronger and even more robust.

Finally, bearing in mind that, in the long term, passenger drone operations will necessarily become autonomous, future research should seek to examine different options to support trust. We know that consumers' evaluations and adoption of advanced automated technologies depend on the social and emotional attributes of the technology in question (Fernandes and Oliveira, 2021; Wirtz et al., 2018). For example, prior research suggests that perceived humanness and social presence affect consumers' willingness to interact with service robots (e.g., Pitardi and Marriott, 2021; Heerink et al., 2008), which has led researchers to conclude that making consumers "feel that they are in the company of another social entity" (Van Doorn et al., 2017, p. 44) may improve their perceptions of and attitudes toward the focal technology (Esmaeilzadeh and Vaezi, 2022). Thus, future research could investigate different ways of creating a sense of social presence even during the autonomous operation of passenger drones as an approach to foster trust, perceived safety, and, ultimately, usage intentions in this context.

CRediT authorship contribution statement

Frederica Janotta: Conceptualization, Investigation, Methodology, Writing – original draft. **Jens Hogreve:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of competing interest

This research was supported by the German Federal Ministry of Digital and Infrastructure (BMDV) within the Unmanned Aerial Applications and Air mobility Solutions funding program under grant no. 45UAS1011A.

Data availability

Data will be made available on request.

Appendix A

Table A1
Constructs, measurement items, and descriptive statistics.

Constructs	Measurement items	Study 1 (Study 2)		
		Factor loadings	M	SD
Trust (adapted from Choi and Ji, 2015)			4.95 (4.33)	1.21 (1.60)
	I believe air taxis are reliable.	0.763 (0.937)		
	I believe air taxis are trustworthy.	0.899 (0.971)		
	Overall, I believe I can trust air taxis.	0.973 (0.972)		
Enjoyment (adapted from Venkatesh, 2000)			6.28 (4.57)	0.94 (2.04)
	I believe I would enjoy flying in air taxis.	0.912 (0.970)		
	I believe that flying in air taxis is enjoyable.	0.726 (0.940)		
	I believe it would be fun to fly in air taxis.	0.898 (0.976)		
Anxiety (adapted from Osswald et al., 2012)			2.72 (4.06)	1.31 (1.98)
	I have concerns about using air taxis.	0.778 (0.924)		
	I am worried about flying with air taxis.	0.903 (0.963)		
	I find flying in air taxis somewhat frightening.	0.775 (0.914)		
Perceived benefit (adapted from Liu, Yang and Xu 2019)			5.96 (5.59)	0.99 (1.98)
	I believe that air taxis are the fastest way for me to get from A to B in urban areas.	0.720 (0.890)		
	I believe that air taxis will reduce my travel time.	0.882 (0.953)		
	Using air taxis will prevent me from spending time in traffic congestion.	0.666 (0.896)		
Perceived safety (adapted from Kaur and Rampersad, 2018)			4.91 (4.48)	1.28 (1.76)
	I believe that air taxis have sufficient safety measures.	0.916 (0.940)		
	I am certain that I am protected against safety risks when using air taxis.	0.901 (0.949)		
	I believe that, in general, air taxis are a robust and safe means of transportation.	0.596 (0.961)		
Usage intentions (adapted from Choi and Ji, 2015)			4.74 (3.79)	1.49 (2.04)
	I intend to use air taxis in the future.	0.898 (0.967)		
	I expect that I will use air taxis in the future.	0.760 (0.946)		
	I plan to use air taxis in the future.	0.795 (0.944)		
Risk aversion (adapted from Huang and Qian, 2021, only in Study 2)			(4.18)	(1.58)
	I'm rather reluctant to try out new products and technologies.	(0.888)		
	I prefer to use products I already know instead of trying something new.	(0.868)		
	I don't like to take risks when it comes to new products or technologies.	(0.791)		

Notes: M = mean; SD = standard deviation. All variables are measured on 7-point Likert scales (1 = "strongly disagree," 7 = "strongly agree"). All factor loadings are significant at the 0.01 level.

Appendix B

Table B1
Demographics (Study 1 and Study 2).

Demographics	Study 1 (n = 261)		Study 2 (n = 341)	
	Human supervision (n = 131)	Automation (n = 130)	Human supervision (n = 163)	Automation (n = 178)
Gender				
Female	61 (23.4 %)	60 (23.0 %)	77 (22.6 %)	70 (20.5 %)
Male	70 (26.8 %)	70 (26.8 %)	86 (25.2.%)	108 (31.7 %)
Non binary	0 (0 %)	0 (0 %)	0 (0 %)	0 (0 %)
Age				
Mean age	29.8	30.3	44.6	46.4

Appendix C. Experimental scenarios

Scenario description and screenshots from VR simulation/videos

(*continued on next page*)

(*continued*)

Please imagine the following situation: You live in City A* and are planning to visit a friend in City B*. Because you want to avoid the evening rush hour and weekend traffic on Friday afternoons, you decide to use an air taxi to fly from City A city centre to City B main station (approx. 30 km distance). From there, it is only a few minutes to walk to the restaurant where you have arranged to meet with your friend. The flight takes around 10 min.

Human supervision condition:

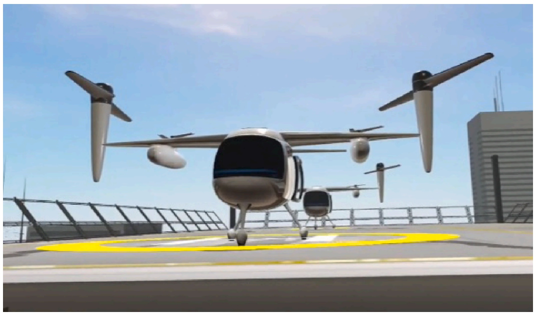
The air taxi flies autonomously in principle, i.e. without human control. However, there is a trained pilot on board who permanently monitors the system and can take over control manually if the situation requires it.

Screenshot human supervision condition:

No human supervision (autonomous) condition:

The air taxi flies fully autonomously, i.e. without human control.

Screenshot autonomous condition:



*The scenario description utilized two middle-sized cities in a Western European country. City names were removed from the manuscript.

Appendix D. Summary of system specifications and further information about the created virtual environment

Graphics	NVIDIA GeForce RTX 2080 Ti
Video Memory	11 GB GDDR6
System memory (RAM)	64 GB
Processor model	Intel Core i9-9900 K
CPU	3.6 GHz, 8 cores

The virtual environment used for the VR condition was developed by a professional service provider specialized in 3D modeling and simulation using Unity 2019.3. Participants experienced the VR scenario using HTC Vive Pro headgear.

Appendix E

Table E1
HTMT ratios Study 1.

	Variable	1	2	3	4	5
1	Usage intention					
2	Trust	0.436				
3	Benefit	0.396	0.416			
4	Safety	0.439	0.485	0.166		
5	Enjoyment	0.506	0.519	0.362	0.425	
6	Anxiety	−0.493	−0.583	−0.240	−0.554	−0.581

Table E2
HTMT ratios Study 2.

	Variable	1	2	3	4	5	6
1	Usage intention						
2	Trust	0.762					
3	Benefit	0.490	0.484				
4	Safety	0.688	0.790	0.414			
5	Enjoyment	0.816	0.766	0.461	0.771		
6	Anxiety	−0.701	−0.666	−0.274	−0.741	−0.773	
7	Risk aversion	−0.462	−0.426	−0.327	−0.406	−0.440	0.510

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