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The influence of attitude towards individuals' choice for a remotely piloted commercial flight: A latent class logit approach

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A R T I C L E   I N F O

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A B S T R A C T

The Remotely Piloted Commercial Passenger Aircraft Attitude Scale (RPCPAAS) was created to measure positive and negative attitudes towards a new and plausible form of air travel. This information was then used, in combination with a latent class logit model built on data generated from a stated choice experiment to gain insight into the choice behaviour between conventionally piloted aircraft (CPA) with a pilot on-board and remotely piloted aircraft (RPA) with a pilot on the ground. The results revealed that individuals, on-average, if presented a choice between a CPA and a RPA of equivalent attributes, would elect for the CPA option. However, there is variability in the passengers' sensitivity to various flight attributes, and these sensitivities were influenced by individuals' attitude towards the new technology (i.e., RPA). From an operational perspective, and assuming that one day passengers of commercial airlines are offered the choice between CPA and RPA, the strategies employed by airlines to encourage the use of the new technology need to be different, based on individuals' attitude towards RPA.

1. Introduction

Advancements in technology have made it possible for an unmanned (i.e., remotely operated or autonomous) commercial flight (i.e., passenger fare paying). Despite this possibility, there are many challenges that need to be overcome before this is realized, one involves user/passengers' acceptance of such technology. Therefore, the aim of the present research is to investigate the factors that influence a passenger's decision to fly on a remotely operated commercial aircraft when comparable safety standards exist between piloted and remotely piloted aircraft.

Automation refers to technology that performs a task or series of tasks that would be or otherwise has been performed by a human. In complex socio-technical environments such as aviation, this can involve: the selection of data/information, transformation of information, decisions, and/or actions (Parasuraman and Wickens, 2008). Automation however should not be thought of as all or nothing (Sheridan and Verplank, 1978). Further, the decision to automate should not hinge on whether it is possible, but whether it is justified (Hancock, 2014). The benefits of automation need to be clearly articulated where careful consideration is afforded to both the potential economics savings, as well as improvements in safety. These benefits, of course need to be demonstrated, most importantly in the non-routine operations when the automation fails and human intervention is required (i.e., recovery).

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Automation is prevalent in aviation, particularly on the flight deck (Tsang and Vidulich, 2003; Merritt et al., 2015). However, it is rare that all end users (e.g., pilots) of such technology are consulted prior to its introduction. Take for example the introduction of Ground Proximity Warning Systems (GPWS) into commercial aircraft. Pilots were expected to use this technology before it was fully proven, and hence many either ignored or switched the technology off because of its unreliability (i.e., false alarms; Endsley and Jones, 2004; Hammer, 2009). To this day, many pilots fail to fully understand the various automated technology in aircraft as seen recently with the Asiana Flight 214 into San Francisco where the co-pilot failed to accurately set-up the autopilot, resulting in the aircraft impacting the sea wall on approach (National Transportation Safety Board (NTSB), 2013).

Whether operating an aircraft remotely alleviates these problems, or just changes the nature of the problem/s remain unclear. What appears less ambiguous is the potential cost savings from remotely operating aircraft, as opposed to the conventional operation of an aircraft with a pilot on-board. These involve, although are not limited to: costs associated with accommodation, airport transfers, crewing costs including scheduling and coordination. In addition, arguably factors such as fatigue can be better managed, since it is easier to replace a fatigued pilot on the ground than in the air. There may also be potential productivity gains from operating aircraft remotely, as pilots engaged in long haul operations are able to perform a greater number of take-offs and landings per shift, since they are not physically constrained to one aircraft.

In an attempt to protect fare paying passengers against commercial changes that could have an adverse impact on safety, aviation governing bodies such as the Civil Aviation Safety Authority (CASA) in Australia require airlines to demonstrate comparable levels of safety between the proposed, and existing approved operations (originally deemed to achieve an acceptable level of safety performance; Civil Aviation Act, 1988; CASA, 2015). Such a requirement should naturally extend to the introduction of an unmanned aircraft (beyond initial certification). However, convincing the aviation governing authorities is presumably only one step in this process, as airlines need to sell the new technology to the end user, in this case their customer (i.e., fare paying passenger).

Research investigating factors that predict individuals' willingness to use or accept automation highlight the importance of design, in terms of user interface (i.e., ease of use and user-friendliness) and perceived usefulness (Davis et al., 1989) in influencing their decision. Not surprisingly, the quality of the automation (i.e., precision, accuracy, reliability) also influences individuals' decisions to accept/use automation (Wixom and Todd, 2005). Prior experience with automation has also been linked with willingness to accept new technology/automation (Bailey and Scerbo, 2007). However, ensuring the existence of these factors does not guarantee acceptance (Bekier et al., 2012). Moreover, Bekier and colleagues found that there is a threshold or tipping point where users of automation are no longer willing to use or interact with high(er) levels of automation; the point on a continuum from no automation to full automation where the technology replaces the human as the decision-maker.

For airline passengers however, it is conceivable that many of these known predictors of automation acceptance such as perceived ease of use or user-friendliness will have no predictive validity in explaining their decision to board an unmanned aircraft, as they will not be in direct use with the automated technology. Conversely, factors such as: trust (Muir and Moray, 1996), quality (i.e., reliability) of the automation (Wixom and Todd, 2005), emotional state (Rice and Winter, 2015) and cultural background (Winter et al., 2015) are expected to play a pivotal role, as well as prior exposure/experience with automation or technology (Bailey and Scerbo, 2007).

Trust as a concept regarding automation and decision support systems has proven to be robust. It is however a construct that constitutes multiple dimensions. Barber (1983) provides one of the earliest definitions of trust in human-machine relationships and defines trust based on three specific expectations (expectation of): *persistence*, being technically *competent* to perform role, and performing/carrying-out duties (*responsibility*). Using this definition of trust, Muir and Moray (1996) asked a series of questions based on these three dimensions of trust and found that participants' trust in an automated system controlling a pasteurization process could be manipulated simply by altering the reliability of the technology.

The relationship between trust and decision to fly on an autonomous aircraft has also been investigated. Moreover, Hughes and colleagues surveyed 201 undergraduates in an attempt to investigate the relationship between trust towards the entity flying the aircraft (e.g., an automated pilot or a human pilot) and the cost of a flight (Hughes et al., 2009). Participants had to rate on a 9-point Likert scale ranging from low to high, 'their trust in the pilot'. Two piloting conditions were presented, a human pilot or an automated pilot, along with three flight costing condition, no pricing, $500 or $1000. In general, participants rated the human pilot more favourably than the autonomous autopilot. In addition, they rated pilots higher on the trust question in the $500 flight condition as well as in the $1000 flight condition compared to the automated pilot.

Rice and colleagues found similar result in a follow-up study with the same number of participants (Rice et al., 2014). However this time, participants were asked to rate on a 7-point Likert scale from 'Extremely Distrust' to 'Extremely Trust' 'how much they would trust the entity piloting the aircraft' when either themselves, their child or a work colleague would be on the flight. Three different flight conditions were presented: human pilot on board, a fully autonomous machine without any human interference, or a human pilot in a ground station controlling the aircraft (i.e., remotely operated). Irrespective of the passenger, participants were more trusting of the entity piloting the aircraft when it was a human pilot on board, than in the other two conditions.

The present study builds on the results of Hughes et al. (2009), Rice et al. (2014) and Rice and Winter (2015) in three ways. First, and in a similar vain to many choice modelling studies (see for example, Collins et al., 2012), main factors influencing flight choice are controlled for. This procedure enables *ceteris paribus* effects to be estimated (e.g., reduces omitted variable bias). Participants in the above studies had to make inferences about the quality of the automation supporting