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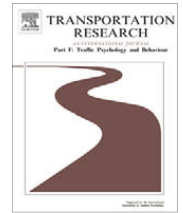
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# The automated cockpit: A comparison of attitudes towards human and automated pilots

Jamie S. Hughes\*, Stephen Rice, David Trafimow, Krisstal Clayton

New Mexico State University, United States

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## ABSTRACT

Automation is being used extensively in aviation, particularly in the aircrafts themselves. The airline industry benefits from automation because it often increases efficiency and performance. To date, automation research has focused largely on operator trust and reliance, while largely ignoring the role of affect and trust in shaping the attitudes of the novice consumer. In two studies, we found that participants rated a human pilot more favorably than an auto-pilot. However, attitudes toward the automated pilot were more favorable in a high priced compared to a low priced ticket condition, indicating that participants used price to infer quality. In Study 2, inducing positive affect increased ratings of an automated pilot. Path analyses provided additional evidence that perceptions of automation are largely influenced by feelings.

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## 1. Introduction

Automation refers to technology that actively selects data, transforms information, makes decisions, and/or controls processes (Parasuraman, Sheridan, & Wickens, 2000). The goal is to increase human performance, accuracy, and reliability. The use of automation is prevalent in our everyday lives, particularly in such arenas as aviation, maritime operation and information retrieval (Lee & See, 2004). Automation is used extensively in aviation, particularly in the aircraft themselves (Tsang & Vidulich, 2003). For example, manual control has been replaced or extended by simple controls to help pilots hold an altitude or heading. More complex automated controls automatically take off, land an aircraft, or fly to a designated navigation point (Sheridan, 2002). The airline industry benefits from increased pilot reliance on automation because such systems often increase efficiency and performance.

In the current paper, we explore consumer opinions regarding automated pilots and compare these attitudes to opinions about human pilots. Automated systems—when engineered with high reliability—can enhance human performance. Further, there are numerous applications of automated aircraft systems beyond commercial aviation. Automated aviation systems can be used in wild fire suppression, law enforcement, disaster and emergency management, search and rescue, and in industrial applications such as crop spraying and surveillance. However, such systems may not be implemented without consumer support. More broadly, consumer attitudes toward automation are not well understood, and it is possible that the processes that govern consumer attitudes toward automated pilots generalize to other, more common systems such as software technology, personal GPS systems, and computer or cell phone applications.

Research indicates that trust and reliability influence the attitudes of operators of automation (Lee & Moray, 1992). In consumer psychology, research shows that price and quality drive consumer opinion (Chapman & Wahlen, 1999). Finally, decision based studies suggest that affect—or one's intuitive and immediate feelings toward an object—influences subse-

\* Corresponding author. Address: Department of Psychology, New Mexico State University, P.O. Box 30001/MSC 3452, Las Cruces, NM 88003-8001, United States. Tel.: +1 575 646 2502; fax: +1 575 646 6212.

E-mail address: [jshughes@nmsu.edu](mailto:jshughes@nmsu.edu) (J.S. Hughes).

quent information processing and judgments regarding a system or object (Alhakami & Slovic, 1994; Cialdini, 1993). Here, we strive to combine these different lines of research to gain an understanding of what drives consumer attitudes toward automation. First, we discuss the relevant research and then turn to two studies that test unique predictions.

### 1.1. Automation research

Much research on automation has focused on factors that influence human reliance on automation when the automation is both perfectly reliable (e.g., Dixon, Wickens, & Chang, 2005) and imperfectly reliable (e.g., Dixon & Wickens, 2006; Lee & Moray, 1992; Riley, 1996). One of the main factors influencing an operator's reliance on an automated system is the operator's level of trust in that system. Trust is an important construct for understanding human–automation interaction (Lee & Moray, 1992; Muir & Moray, 1996), and is a psychological phenomenon. Trust in the context of automation is often defined as an expectancy regarding outcomes, or the subjective probability one assigns to the occurrence of some future event (Rempel, Holmes, & Zanna, 1985). Alternatively, it can be described as a willingness to place oneself in a relationship that establishes or increases one's vulnerability (Johns, 1996). Lee and See (2004) discuss trust in terms of a relationship in which one believes that an agent will help one to achieve one's goals in a context characterized by uncertainty and vulnerability.

Reliance (or dependence), on the other hand, is a behavioral response (Meyers, 2001; Wickens & Xu, 2002) that does not necessarily correlate perfectly with trust (Parasuraman & Riley, 1997). Dependence on an imperfect automated aid, for example, is often not optimal in that human–automation performance frequently falls below that of the automation itself (Dixon, Trafimow, Hughes, & McCarley, 2007). However, in general, it can be demonstrated that people tend to rely on automation they trust, and reject automation they do not trust (Rice & McCarley, 2008).

Lee and See (2004) suggest that humans respond socially to technology; however, they also point out that research conducted in the social psychology domain that focuses on human–human trust does not always generalize to human–automation trust. The roles of trust and dependence seem particularly important, not only for operator interaction with automated systems, but also for consumer opinions regarding automated systems. To date, much of the human factors and automation research has focused on professional operator trust and reliance, while largely ignoring the role of trust in shaping the attitudes of the novice consumer. Although an examination of consumer attitudes toward automation is somewhat lacking in the literature, we believe that consumer opinion should be greatly influenced by their trust in the system.

Lee and See (2004) suggest that, “trust may play a critical role in people's ability to accommodate the cognitive complexity and uncertainty that accompanies the move away from simple technologies” (p. 51). Given that trust is characterized by uncertainty and vulnerability, we believe that trust is an important factor for consumer opinion regarding commercial aviation, because unlike pilots, consumers do not have access to information that would help them form dependability estimates or predict outcomes. Without a rather sophisticated knowledge of aviation automation, it may be assumed that public perceptions of automation are poorly calibrated. Even if consumers could make more educated (and hopefully accurate) choices regarding their use of automated transportation systems, it may be unreasonable to expect them to invest the energy necessary to do so, particularly when automated systems are continuously updated and often opaque. Therefore, it would be profitable for the transportation industry to seek potentially less strenuous methods of increasing the desirability of automated systems.

### 1.2. Consumer heuristics

One way to increase the desirability of automated transport might be to offer a discounted price in the hopes that this would assuage consumer fear. In other words, if the price of a flight with automation was less expensive than a human-piloted flight, individuals may favor the cheaper option. On the other hand, a discounted price may actually heighten one's perceptions of risk. In the field of consumer psychology, research suggests that price and quality are general attributes on which decisions are based (Huang, Lee, & Ho, 2004). However, when information about quality is incomplete, as is the case with automated transportation systems, people may form attitudes based on a number of heuristics, such as the price–quality inference. The price–quality inference refers to the association between high priced items and quality. For example, researchers have found that price positively affects perceived quality (Chapman & Wahleners, 1999) and that consumers consistently overestimate the strength of this relationship (Broniarczyk & Alba, 1994). Thus, we predict that expensive travel will be perceived as indicative of higher quality transport.

Price may influence consumers, but attitudes may also be affected by the perceived risk associated with airline travel. That is, if trust is described as a willingness to place oneself in a vulnerable relationship, perceptions should be partly shaped by an assessment of one's extent of vulnerability. Further, airline automation may be viewed differently than automation used in other forms of transportation because perceptions of safety are influenced by social norms and beliefs (Sheridan, 2002). For example, airline accidents create sensational media reports, and the terrorist attacks of September 11, 2001, have no doubt created additional fear and uncertainty about airline travel. Airline accidents, therefore, are likely to be weighed more heavily in people's safety assessments and affect public perception of risk.

### 1.3. The affect heuristic

Importantly, assessments of both trust and risk are not purely cognitive endeavors. As Zajonc (1980) pointed out, immediate affective reactions often guide information processing and judgment. Affect is believed to help us form complete men-

tal models, as the cognitive complexity of decisions often exceeds one's ability to rationally evaluate the decision situation (Lee & See, 2004). Furthermore, affect works to focus one's attention on relevant details and manage priorities in information processing. Also, Damasio (1996) suggested that emotions guide people away from situations in which there is a high probability of negative outcomes.

Alhakami and Slovic (1994) have studied a phenomenon termed the *affect heuristic* (see also Slovic, Finucane, Peters, & MacGregor, 2002). Affect, in this context, refers to the evaluation of an object as good or bad. The evaluation is experienced as a feeling state and is often immediate and unconscious. Alhakami and Slovic (1994) found that people's feelings toward a technology predict their judgment of risk and benefit, regardless of the actual risk and benefit associated with the technology. For example, when provided with information that a new technology was low in risk, people reported favorable feelings toward the technology and judged it to be beneficial. Conversely, when people were provided with information that a new technology was high in risk, individuals reported unfavorable feelings and judged the technology to be low in benefit (Finucane, Alhakami, Slovic, & Johnson, 2000). The affect heuristic indicates that the perceived inverse relationship between risk and benefit is used as a heuristic in judging a technology. Thus, if a consumer has negative feelings about a technology, she is also likely to view the technology as risky.

Additional evidence for the affect heuristic showed that time pressure, which decreased the possibility for analytic deliberation, increased the inverse relationship between perceived risk and benefit (Finucane et al., 2000). Finally, Loewenstein, Weber, Hsee, and Welch (2001) have shown that emotional responses to risky situations have a different and sometimes larger impact on risk taking behavior than do cognitive evaluations. The affect heuristic suggests that feelings are an essential component of rationality that allows people to make quick decisions and predict outcomes.

The affect heuristic is one line of research that acknowledges the role of affect in judgment and decision making. A similar process has been proposed in the area of consumer psychology. Wright (1975) suggested that consumers use a heuristic termed affective referral, meaning that consumers choose by obtaining a sense of overall liking without retrieving the details on which the overall feeling was originally based. We believe that consumers may rely on their affective impressions because it is more efficient and easier than calculating the pros and cons, or remembering many relevant examples, particularly when the decision is complex and mental resources are limited.

## 2. Study 1: use of affect and price heuristics in consumer judgments

Taken together, the foregoing analysis suggests that consumers, who are at best uncertain about the relative risks of automated systems, should rely heavily on the affect heuristic. Further, because there is a connection between affect and one's level of trust, we believe that one's feelings toward automation should influence related judgments of an automated pilot. Spontaneous inferences regarding automated pilots are expected to be relatively negative when compared to judgments regarding human pilots because automated transport presents more uncertainty and/or risk. In Study 1, individuals were asked to rate their perceptions of a human or automated pilot's ability to handle an emergency. In addition, participants rated their feelings, trust, confidence, and anxiety toward either a human or automated pilot. The price of travel was also manipulated. Two predictions can be generated by the concepts described earlier. If price influences consumer attitudes toward the use of automated transportation, then a high-priced airline ticket would be expected to increase the perceived quality and desirability of automated transportation relative to low priced conditions. Further, if affect influences consumer perceptions, then ticket price should not increase evaluations of an auto-pilot to a level equivalent to ratings of a human pilot. In other words, price may increase evaluations of an auto-pilot, but overall, the human pilot should be evaluated more positively. Finally, if the affect heuristic is especially strong among consumers, then feelings should be predictive of levels of trust because pleasant feelings have been shown to increase trust (Miller, 2005). Trust in turn, should influence judgments of confidence, anxiety, and emergency handling.

To ensure that perceptions of flight quality increased with ticket price, we conducted a short pilot study before beginning Study 1. Forty-seven undergraduate students were randomly assigned to rate the quality of one of three flights from LA to NY. Participants were not provided with information regarding cost, or were told the flight was \$500 or \$1000 dollars. Ratings were made on a 7-point scale from  $-3$  (lowest possible quality) to  $+3$  (highest possible quality). A one-way ANOVA indicated that flight quality was greatest in the \$1000 dollar cost condition ( $M = 2.33$ ,  $SD = 0.72$ ), followed by the \$500 dollar ( $M = 1.38$ ,  $SD = 1.08$ ), and no price information conditions ( $M = 1.00$ ,  $SD = 1.15$ ),  $F(2, 44) = 7.09$ ,  $p < .01$ ,  $f = 0.57$ . Tukey's post-hoc analysis showed that the \$1000 dollar condition differed significantly from the \$500 dollar and no pricing conditions ( $p$ 's  $< .01$ ).

### 2.1. Methods

#### 2.1.1. Participants

Two hundred and one undergraduates from a mid-sized southwestern university participated in exchange for course credit.<sup>1</sup> Seventy-three percent of participants indicated that they flew occasionally or often (27% reported they did not fly often).

<sup>1</sup> Participant gender was not collected due to an error.

2.1.2. Procedure and materials

Participants were escorted to a testing room and asked to complete a consent form and questionnaire. The questionnaire stated, "Please imagine that you have a job interview that requires you to fly from LA to NY. A 99% reliable human (automated) pilot will operate the flight". In the no pricing condition, participants were provided with no additional information. In the other conditions, participants were told that the flight would cost \$500 or \$1000 dollars. Participants were required to make an inference regarding reliability, as a definition of reliability was not provided. Following the scenario, participants were asked to rate their feelings toward the pilot, their confidence in the pilot, and their trust in the pilot. In addition, they indicated the extent to which they felt anxious about the flight, and the degree to which they felt the pilot could handle an emergency situation. Participants responded to questions on a 9-point scale ranging from 1 (*low*) to 9 (*high*) with only the endpoints labeled. Participants indicated how often they flew, and were then debriefed and thanked for their time. In summary, participants were randomly assigned to one of six between-participant conditions: 2 (pilot: automation vs. human) × 3 (price: no information vs. \$500 vs. \$1000).

2.2. Results

A series of two-way pilot × price between-participants analyses of variance were conducted. Simple contrasts were used to examine the effect of price information on evaluations of the pilots. In addition, three planned comparisons were conducted to investigate ratings of the human pilot vs. the auto-pilot within the price conditions. Because only three a priori comparisons were conducted, familywise error rates were not adjusted (Keppel, 1982). Finally, Tukey's post-hoc analyses were conducted to examine whether a discounted price decreased ratings relative to an expensive price. Means and standard deviations for each measure by condition are listed in Table 1.

2.2.1. Feelings toward the pilot

A two-way between-participants ANOVA found a main effect of pilot,  $F(1, 195) = 58.06, p < .01, f = 0.54$ , indicating that, in general, participants rated the human pilot more favorably ( $M = 6.70, SD = 1.74$ ) than the auto-pilot ( $M = 4.72, SD = 2.11$ ). A main effect of price was also found,  $F(2, 195) = 4.09, p < .05, f = 0.20$ . Simple contrasts revealed that participants rated their feelings toward the human and automated pilot higher in the \$1000 condition ( $M = 6.15, SD = 2.00$ ) than in the \$500 dollar condition ( $M = 5.16, SD = 2.29$ ),  $t(198) = 2.67, p < .01, d = 0.38$ . However, there was no difference between the no pricing ( $M = 5.84, SD = 2.19$ ) and \$500 dollar condition or the no pricing and \$1000 dollar conditions,  $t(198) = 1.84, p > .05$  and  $t(198) = 0.42, p > .05$ , respectively. An interaction between pilot and price was found,  $F(2, 195) = 4.87, p < .01, f = 0.22$  (see Fig. 1). Planned comparisons indicated that participants felt more negatively towards the auto-pilot than towards the human pilot in the no pricing condition,  $t(63) = -1.72, p < .05, d = 0.43$ , the \$1000 condition,  $t(64) = -5.59, p < .01, d = 1.40$ , and the \$500 dollar condition,  $t(67) = -6.76, p < .01, d = 1.65$ . In addition, Tukey's post-hoc analysis revealed that the auto-pilot was rated more negatively in the \$500 dollar condition relative to the \$1000 dollar condition,  $p < .05$ , indicating that price increased ratings of the auto-pilot. No significant differences were found for affect ratings of the human pilot in the \$1000 dollar vs. the \$500 dollar condition,  $p > .05$ .

2.2.2. Ratings of trust

A two-way between-participants ANOVA found a main effect of pilot,  $F(1, 195) = 54.70, p < .01, f = 0.53$ , indicating that, in general, participants rated the human pilot more favorably ( $M = 6.65, SD = 1.72$ ) than the auto-pilot ( $M = 4.73, SD = 2.07$ ). There was a significant difference for ratings of trust by price condition,  $F(2, 195) = 6.97, p < .01, f = 0.28$ . Simple contrasts revealed that participants reported higher trust ratings for the human and auto-pilot in the \$1000 dollar condition ( $M = 6.00, SD = 2.05$ ) compared to the \$500 dollar condition ( $M = 4.96, SD = 2.21$ ),  $t(198) = 2.92, p < .01, d = 0.42$ . Participants also reported higher trust ratings in the no pricing condition ( $M = 6.04, SD = 1.99$ ) compared to the \$500 dollar condition,

**Table 1**  
Means and standard deviations by pilot and price conditions for Study 1.

Condition	Measures				
	Feelings	Trust	Anxiety confidence	Emergency	
<i>Auto-pilot</i>					
No pricing	5.44 <sub>b</sub> (2.40)	5.72 <sub>a</sub> (2.12)	3.92 <sub>a</sub> (2.54)	5.98 <sub>b</sub> (2.26)	4.39 <sub>b</sub> (2.21)
\$500	3.78 <sub>c</sub> (1.82)	3.72 <sub>b</sub> (1.80)	6.00 <sub>b</sub> (2.23)	3.83 <sub>c</sub> (2.02)	3.08 <sub>b</sub> (1.84)
\$1000	4.97 <sub>b</sub> (1.67)	4.75 <sub>c</sub> (1.81)	4.75 <sub>b</sub> (2.37)	5.19 <sub>b</sub> (1.84)	4.00 <sub>b</sub> (1.95)
<i>Human pilot</i>					
No pricing	6.34 <sub>a</sub> (1.82)	6.45 <sub>a</sub> (1.78)	3.31 <sub>a</sub> (2.30)	6.97 <sub>a</sub> (1.61)	7.28 <sub>a</sub> (1.41)
\$500	6.67 <sub>a</sub> (1.73)	6.30 <sub>a</sub> (1.79)	3.67 <sub>a</sub> (1.93)	6.73 <sub>a</sub> (1.70)	6.52 <sub>a</sub> (1.94)
\$1000	7.23 <sub>a</sub> (1.63)	7.14 <sub>a</sub> (1.52)	4.00 <sub>a</sub> (2.30)	7.26 <sub>a</sub> (1.56)	7.54 <sub>a</sub> (1.42)

Note: Ratings were made on 9-point scales ranging from 1 (*low*) to 9 (*high*). Standard deviations are listed in parentheses. Column averages that do not share subscripts differ significantly at the  $p < .05$  or less.

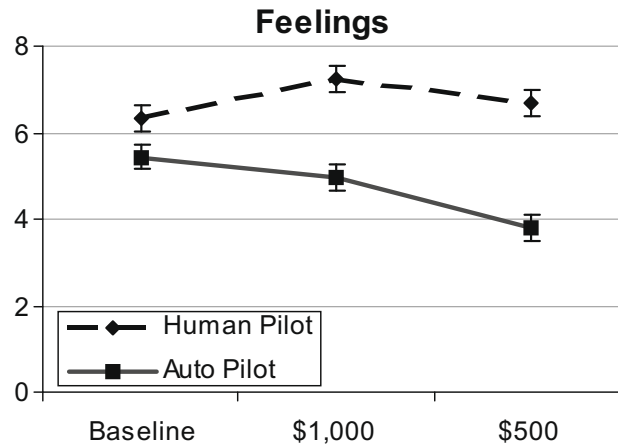


Fig. 1. Feelings toward a human or automated pilot by price condition ( $\pm$ SE).

$t(198) = 3.02, p < .01, d = 0.52$ . However, there were no differences between the no pricing and \$1000 dollar conditions,  $t(198) = 0.12, p > .05$ . A significant interaction between pilot and price was found,  $F(2, 195) = 5.18, p < .01, f = 0.23$  (see Fig. 2). Planned comparisons indicated that trust ratings did not differ significantly in the no pricing condition,  $t(63) = -1.50, p > .05$ . However, participants trusted the auto-pilot less than the human pilot in the \$1000 dollar,  $t(61) = -5.83, p < .01, d = 1.49$ , and the \$500 dollar condition,  $t(67) = -5.96, p < .01, d = 1.46$ . Tukey's post-hoc analyses revealed no significant differences in trust rating between the \$500 and \$1000 dollar conditions for the automated or human pilot,  $p > .05$ .

### 2.2.3. Ratings of anxiety

A two-way between-participants ANOVA found a main effect of pilot,  $F(1, 195) = 14.41, p < .01, f = 0.27$ , indicating that, in general, participants reported less anxiety in the human pilot condition ( $M = 3.68, SD = 2.18$ ) than in the auto-pilot condition ( $M = 4.89, SD = 2.52$ ). A main effect of price was also found,  $F(2, 195) = 4.79, p < .01, f = 0.22$ . Simple contrasts revealed that participants reported greater anxiety in the \$500 dollar condition ( $M = 4.88, SD = 2.38$ ) compared to the no pricing condition ( $M = 3.65, SD = 2.44$ ),  $t(198) = -2.99, p < .01, d = 0.42$ . No significant differences were found between \$1000 dollar ( $M = 4.36, SD = 2.35$ ) and \$500 dollar, or the \$1000 dollar and no pricing conditions,  $t(198) = -1.28, p > .05$  and  $t(198) = -1.71, p > .05$ , respectively. The interaction between pilot and price conditions was not significant,  $F(2, 195) = 2.96, p > .05, f = 0.17$ . Planned comparisons revealed no differences in anxiety in the no pricing condition,  $t(62) = 1.00, p > .05$ . However, participants felt more anxious towards the auto-pilot than the human pilot in the \$1000 dollar condition,  $t(62) = 1.98, p < .05, d = 0.50$ , and the \$500 dollar condition,  $t(67) = 4.97, p < .01, d = 1.21$ .

### 2.2.4. Confidence ratings

A two-way between-participants ANOVA found a main effect of pilot,  $F(1, 195) = 56.90, p < .01, f = 0.54$ , indicating that participants reported more confidence in the human pilot ( $M = 6.99, SD = 1.62$ ) than the auto-pilot ( $M = 4.99, SD = 2.23$ ). A main effect of price was also found,  $F(2, 195) = 7.65, p < .01, f = 0.28$ . Simple contrasts revealed that participants reported

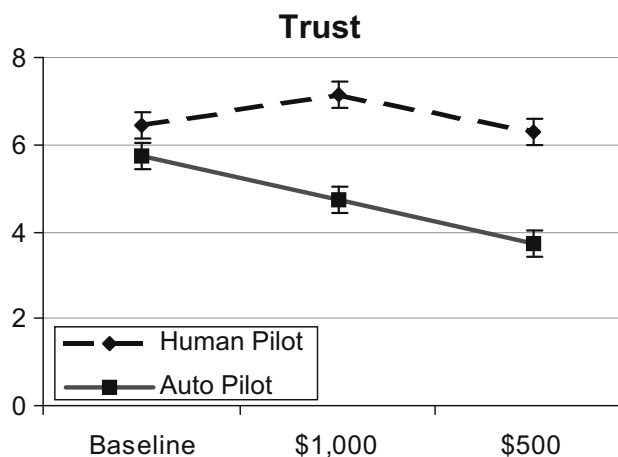


Fig. 2. Trust toward a human or automated pilot by price condition ( $\pm$ SE).

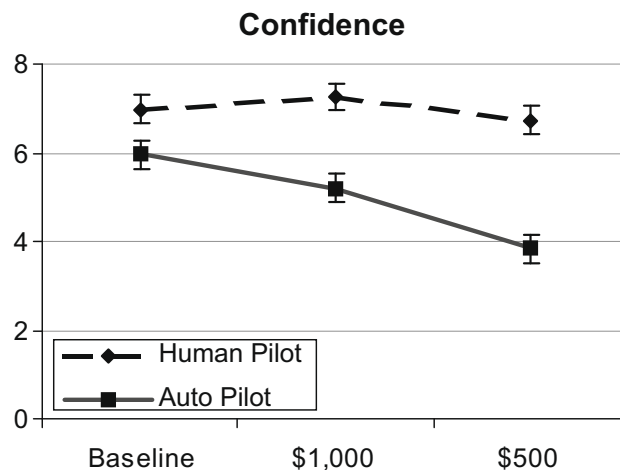


Fig. 3. Confidence toward a human or automated pilot by price condition ( $\pm$ SE).

lower confidence ratings for the human and auto-pilot in the \$500 dollar condition ( $M = 5.22$ ,  $SD = 2.36$ ) compared to the \$1000 dollar condition ( $M = 6.27$ ,  $SD = 1.98$ ),  $t(198) = 2.86$ ,  $p < .01$ ,  $d = 0.41$ . Confidence ratings were also lower in the \$500 dollar condition compared to the no pricing condition ( $M = 6.42$ ,  $SD = 2.04$ ),  $t(198) = 3.24$ ,  $p < .01$ ,  $d = 0.54$ . No differences were found between the \$1000 dollar and no pricing conditions,  $t(198) = 0.39$ ,  $p > .05$ . Finally, an interaction between pilot and price was found,  $F(2, 195) = 4.35$ ,  $p < .05$ ,  $f = 0.21$  (see Fig. 3). Planned comparisons indicated that participants had less confidence in the auto-pilot than human pilot in the no pricing condition,  $t(62) = -2.06$ ,  $p < .05$ ,  $d = 0.52$ , the \$1000 condition,  $t(61) = -4.94$ ,  $p < .01$ ,  $d = 1.27$ , and the \$500 dollar condition,  $t(67) = -6.45$ ,  $p < .01$ ,  $d = 1.58$ . In addition, Tukey's post-hoc analysis revealed that confidence ratings were lower for the auto-pilot in the \$500 dollar condition compared to the \$1000 dollar condition,  $p < .05$ . However, confidence ratings did not differ significantly for the human pilot in the \$500 and \$1000 dollar conditions,  $p > .05$ .

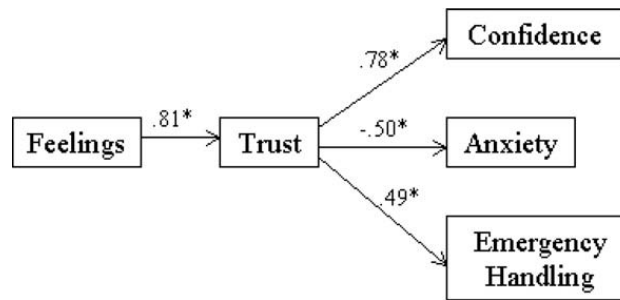
#### 2.2.5. Ratings of emergency handling

A two-way between-participants ANOVA found a main effect of pilot,  $F(1, 195) = 161.44$ ,  $p < .01$ ,  $f = 0.91$ . In general, participants believed that the human pilot was better able to deal with an emergency situation ( $M = 7.11$ ,  $SD = 1.66$ ) than the auto-pilot ( $M = 3.82$ ,  $SD = 2.07$ ). A main effect of price was also found,  $F(2, 195) = 6.80$ ,  $p < .01$ ,  $f = 0.26$ . Simple contrast revealed that participants provided higher emergency handling ratings to both the human and auto-pilot in the \$1000 dollar price condition ( $M = 5.85$ ,  $SD = 2.45$ ) compared with the \$500 dollar condition ( $M = 4.72$ ,  $SD = 2.55$ ),  $t(198) = 2.67$ ,  $p < .01$ ,  $d = 0.38$ . Emergency handling ratings were also higher in the no pricing condition ( $M = 5.68$ ,  $SD = 2.37$ ) compared to the \$500 dollar condition,  $t(198) = 2.24$ ,  $p < .05$ ,  $d = 0.39$ . No significant differences were found between the no pricing and \$1000 dollar conditions,  $t(198) = -0.41$ ,  $p > .05$ . A significant interaction between pilot and price did not emerge,  $F(2, 195) = 0.60$ ,  $p > .05$ . However, planned comparisons revealed that emergency handling ratings were lower for auto-pilot compared to the human pilot in the no pricing condition,  $t(60) = -6.39$ ,  $p < .01$ ,  $d = 1.65$ , the \$1000 dollar condition,  $t(56) = -8.43$ ,  $p < .01$ ,  $d = 2.25$ , and the \$500 dollar condition,  $t(66) = -7.52$ ,  $p < .01$ ,  $d = 1.85$ .

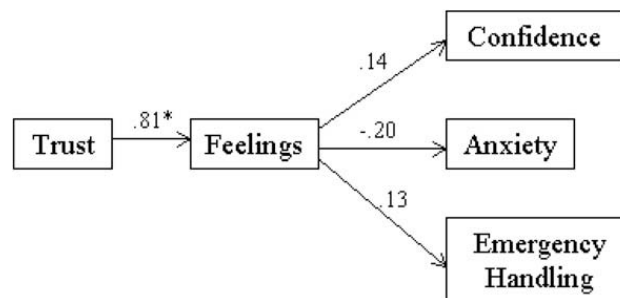
#### 2.2.6. Path analysis

Thus far, it appears that increased ticket prices enhance positive ratings of automated pilots. However, it is not clear why an automated pilot should consistently receive less favorable ratings than a human pilot. One potential explanation is that consumers rely on their feelings about the pilot as a heuristic to judge other relevant factors. If participants' feelings act as a heuristic in judging the pilots, then participant's ratings of their feelings should influence trust, anxiety, and confidence judgments in addition to ratings of emergency handling. We predicted that feelings would influence these other factors regardless of pilot condition. Path analyses were used to explore the possibility that feelings would predict ratings of trust, which would in turn predict levels of anxiety, confidence and judgments of emergency handling (see Fig. 4). Only participants who evaluated pilots in the no pricing condition were included.<sup>2</sup> First, ratings of participants' feelings toward the pilots were regressed on ratings of trust; feelings were a significant predictor of trust ratings,  $\beta = 0.81$ ,  $t(63) = 10.84$ ,  $p < .01$ ,  $d = 2.73$ . Next, feelings and trust were entered as predictors of confidence ratings. The beta coefficients revealed that trust was a significant predictor of confidence while controlling for feelings,  $\beta = 0.78$ ,  $t(62) = 8.09$ ,  $p < .01$ ,  $d = 2.05$ . Further, feelings and trust accounted for a significant proportion of variance in confidence ratings,  $R^2 = .89$ ,  $F(2, 62) = 124.68$ ,  $p < .01$ . Feelings and trust were then regressed on anxiety ratings. Controlling for feelings, trust was a significant negative predictor of anxiety ratings,  $\beta = -0.50$ ,  $t(62) = -3.12$ ,  $p < .01$ ,  $d = 0.79$ . Both variables also explained a significant proportion of variance in anxiety ratings,  $R^2 = .67$ ,  $F(2, 62) = 25.52$ ,  $p < .01$ . To complete the predicted path model, feelings and trust were regressed on ratings of emergency

<sup>2</sup> Path analyses were conducted separately by pilot condition. Since the beta weights were extremely similar across conditions, we combined the data for a single path model.



**Fig. 4.** Path model of feelings predicting trust, confidence, anxiety, and emergency handling ratings in Study 1. Note: Coefficients are standardized beta coefficients. Only participants who evaluated pilots in the no pricing condition were included. \* $p < .01$ .



**Fig. 5.** Path model of trust predicting feelings, confidence, anxiety, and emergency handling ratings in Study 1. Note: Coefficients are standardized beta coefficients. Only participants who evaluated pilots in the no pricing condition were included. \* $p < .01$ .

handling. Again, trust was a significant predictor of emergency handling while controlling for feelings,  $\beta = 0.49$ ,  $t(62) = 2.89$ ,  $p < .01$ ,  $d = 0.73$ . Also, trust and feelings accounted for a significant proportion of variance in emergency handling ratings,  $R^2 = .74$ ,  $F(2, 62) = 18.30$ ,  $p < .01$ .

To examine the possibility that trust may have been the most important factor in predicting ratings of feeling, which in turn predicted confidence, anxiety, and emergency handling, a series of multiple regressions were conducted with trust as the exogenous variable. This model, presented in Fig. 5 did not fair well. For example, participants feelings toward a pilot did not significantly predict anxiety when ratings of trust were taken into account,  $\beta = -0.20$ ,  $t(62) = -1.28$ ,  $p > .05$ . Also, ratings of confidence and emergency handling were not strongly predicted by feelings while controlling for trust,  $\beta = 0.14$  and  $\beta = 0.13$ , respectively.

### 2.3. Discussion

Supporting the price–quality inference hypothesis, participant’s feelings, trust, confidence, and emergency handling ratings regarding the automated pilot were more favorable in \$1000 vs. \$500 dollar ticket price conditions. The pattern of means in the human pilot conditions suggests that ratings increased in \$1000 dollar ticket condition compared to the \$500 dollar condition, but the differences were not significant.

As expected, the automated pilot was viewed less favorably, overall, than the human pilot (i.e., with mean ratings for the auto-pilot below or around the midpoint, and ratings of the human pilot above the midpoint). We also found that attitudes toward the human and auto-pilot could be partially explained by their feelings toward the pilots. A path analysis found that feelings predicted one’s level of trust, which in turn, predicted confidence, ratings of emergency handling, and one’s level of anxiety. Our belief that the affect heuristic may guide judgments was strengthened because the path model did not differ significantly when ratings of a human pilot were compared to ratings of the automated pilot. This implies that the processes used to judge a human pilot are similar to the processes used to judge an automated pilot. It also indicates that if positive affect toward automated pilots could be increased, then other judgments, such as one’s trust and confidence toward an automated pilot should also increase. Experimental evidence, in addition to correlational findings, would support the hypothesis that consumers rely on their feelings toward automated aviation to judge other relevant variables. Experimental evidence could also demonstrate more convincingly that affect, rather than other heuristics or mental algorithms, help explain consumer attitudes toward automated and human pilots. Study 2 was conducted to explore these possibilities.

### 3. Study 2: the influence of positive affect on consumer judgment

Although Study 1 provides some evidence for the affect heuristic via path analysis, experimental evidence would provide stronger support. Further, an argument could be made that the results obtained from the path analysis were the result of question order. In addition, controllability, or the amount of control an individual believes she has with regard to the flight,

might influence perceptions of risk and trust (Klein & Kunda, 1994). Study 2 was conducted to address these issues. First, we manipulated positive affect between participants. We also counterbalanced question order and conducted a second path analysis to explore the possibility that question order determined beta coefficients in Study 1. Finally, we included a question regarding controllability.

Since feelings predicted attitudes toward automated systems in Study 1, we predicted that inducing positive affect would increase ratings of an automated pilot relative to a neutral condition. We did not expect the positive affect manipulation to increase ratings of a human pilot for two reasons. First, Study 1 suggests that feelings toward human pilots are relatively positive and thus it is unlikely that the ratings would increase substantially. Second, Gorn, Pham, and Sin (2001) have shown that affective evaluations tend to have a stronger impact when people judge ambiguous rather than unambiguous stimuli. As human pilots are well-known, unambiguous evaluative targets, we did not expect the positive affect manipulation to have a very large impact on ratings. In other words, we predicted that ratings would be favorable in each condition except an auto-pilot neutral condition. To test this hypothesis, planned contrasts were used to examine if a mean difference existed in the auto-pilot neutral condition when compared to the auto-pilot affect and human pilot conditions.

### 3.1. Methods

#### 3.1.1. Participants

One hundred undergraduate students (49 female, 50 male, 1 unidentified) from a mid-sized southwestern university participated in exchange for partial course credit. Participants were 20 years of age on average ( $SD = 2.43$ ).

#### 3.1.2. Methods and procedures

To manipulate positive affect, we used the paradigm reported by Strack, Schwarz, and Gschneidinger (1985) and later Bodenhausen, Kramer, and Susser (1994). Strack et al. (1985) found that following the positive affect manipulation procedure, participants reported greater happiness and positive moods than those in a neutral mood condition. In this study, individuals were told that they would be participating in two separate experiments. Participants were randomly assigned to the positive affect or neutral mood condition and then all participants rated a human or automated pilot. Participants assigned to the positive affect condition were told that we were interested in the relationship between mood and memories, and that we sought to understand the psychological structure of happy memories. Participants were asked to recall, re-experience, and write about an event that made them particularly happy. The instructions asked participants to focus on the concrete, vivid, and experiential aspects of the event rather than on an abstract or objective assessment of it. Participants assigned to the neutral condition were told that we were interested in the psychological structure of everyday memories and they were asked to recall and write about the mundane events that occurred the previous day. Following the manipulation, participants were told that because there was extra time they would complete an additional survey, which was the dependent measure.

The survey questions in Study 2 were similar to the materials used in Study 1. Participants were told that they would have to fly from LA to NY for a job interview, and that they would fly with a 99% reliable human or automated pilot. Thus, we used a  $2(\text{pilot: human vs. automated}) \times 2(\text{Affect: positive vs. neutral})$  between participant design. Participants rated the extent to which they felt the pilot could handle an emergency situation, they rated their feelings, confidence and trust in the pilot, and the amount of anxiety and control they felt with regard to the flight. Participant ratings were made on 9-point scales ranging from 1 (*low*) to 9 (*high*). Question order was counterbalanced using a Latin-square.

### 3.2. Results

To examine the hypothesis that the positive affect manipulation would increase ratings of the automated pilot to a level consistent with ratings of human pilots, planned contrasts were used to evaluate whether ratings differed in the auto-pilot neutral condition as compared to the other three conditions. Table 2 lists the means and standard deviations for each measure by condition.

As expected, an effect was found for feelings,  $t(95) = 3.20$ ,  $p < .01$ ,  $d = 0.67$ . Participants reported positive feeling toward the automated pilot following the positive affect manipulation. Further, participants reported positive feelings toward the human pilot in both the positive affect and neutral conditions. Thus, less positive feelings were reported only in the auto-pilot neutral condition. An effect of trust was also found,  $t(95) = 3.46$ ,  $p < .01$ ,  $d = 0.71$ , indicating that participants reported high levels of trust in each condition except the auto-pilot neutral condition. A similar pattern was found for ratings of both confidence,  $t(95) = 3.63$ ,  $p < .01$ ,  $d = 0.74$ , and emergency handling,  $t(95) = 4.48$ ,  $p < .01$ ,  $d = 0.92$ . That is, participants reported less confidence and believed that an automated pilot was less able to handle an emergency situation in the auto-pilot neutral condition compared to the other three conditions. Contrary to our prediction, means did not differ across conditions for anxiety and control ratings (see Table 2).

We also sought to conduct a path analysis to find whether the Study 1 findings would replicate using survey questions that were counter balanced.<sup>3</sup> First, we found that feelings were a significant predictor of trust,  $\beta = 0.77$ ,  $t(97) = 11.94$ ,  $p < .01$ ,

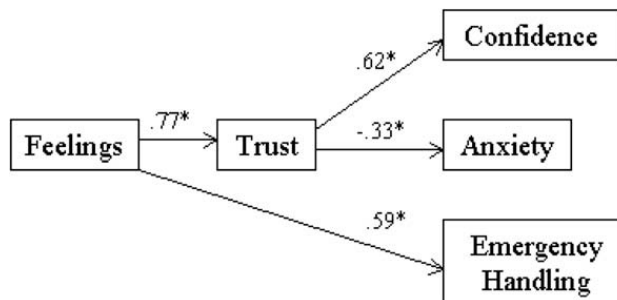
<sup>3</sup> We conducted the path analysis twice: once using only participants in the neutral conditions, and a second time using the entire sample. Beta coefficients did not differ widely across the two replications so we report the analysis with the entire sample. Additionally, beta coefficients were highly similar when we selected only those in the human pilot or automated pilot conditions.

**Table 2**  
Means and standard deviations by affect and pilot condition for Study 2.

Measures	Condition			
	N-Auto	PA-Auto	N-Human	PA-Human
Feelings	5.91* (1.84)	6.75 (2.18)	7.15 (1.84)	7.64 (1.15)
Trust	5.87* (2.21)	7.00 (2.06)	7.35 (1.77)	7.77 (.89)
Anxiety	4.74 (2.70)	4.31 (2.47)	4.62 (2.85)	3.57 (2.47)
confidence	5.89* (2.21)	7.00 (2.07)	7.35 (1.77)	7.79 (.89)
Emergency handling	5.31* (2.32)	6.06 (2.29)	7.47 (1.35)	7.86 (.95)
Control	2.54 (2.51)	2.75 (2.29)	2.38 (2.35)	2.86 (2.82)

Note: Ratings were made on 9-point scales ranging from 1 (low) to 9 (high). Standard deviations are provided in parenthesis. N = neutral condition; PA = positive affect condition.

\*  $p < .01$ .



**Fig. 6.** Path model of feelings predicting trust, confidence, anxiety and emergency handling ratings in Study 2.  
Note: Coefficients are standardized beta coefficients. \*  $p < .01$ .

$d = 2.42$ . Trust, in turn, was a significant predictor of confidence ratings while controlling for feelings,  $\beta = 0.62$ ,  $t(97) = -8.59$ ,  $p < .01$ ,  $d = 1.75$ . Further, feelings and trust accounted for a significant proportion of variance in confidence ratings,  $R^2 = .89$ ,  $F(2, 96) = 189.77$ ,  $p < .01$ . As in Study 1, trust was also found to predict ratings of anxiety while controlling for feelings,  $\beta = -0.33$ ,  $t(96) = -2.38$ ,  $p < .01$ ,  $d = 0.49$ . Trust and feelings accounted for a significant proportion of variance in anxiety ratings,  $R^2 = .26$ ,  $F(2, 96) = 16.82$ ,  $p < .01$ . In contrast from Study 1, trust did not predict emergency handling while controlling for feelings,  $\beta = 0.11$ ,  $t(96) = .91$ ,  $p > .05$ . Instead, feelings toward the pilot were significantly correlated with emergency handling ratings while controlling for trust,  $\beta = 0.59$ ,  $t(97) = 5.05$ ,  $p < .01$ ,  $d = 1.02$ , and feeling alone accounted for a significant proportion of variance in emergency handling,  $R^2 = .68$ ,  $F(1, 96) = 81.92$ ,  $p < .01$ . To ensure that trust did not help predict emergency handling a hierarchical regression was used and trust was entered as a second variable. This analysis revealed that trust did not account for a significant amount of variance in emergency handling ratings,  $R^2\Delta = .005$ ,  $F(1, 96) = .36$ ,  $p > .05$ . Finally, feelings and trust were not correlated with ratings of control. The findings from this path analysis are displayed in Fig. 6.

3.3. Discussion

As predicted, pilot ratings were less favorable only when participants judged an auto-pilot in the neutral condition. Following a positive affect manipulation, participants rated an auto-pilot as favorably as they rated a human pilot. Because individuals' feelings toward human pilots are relatively favorable, inducing positive affect did little to increase reported feelings, trust, confidence, and emergency handling. In contrast to Study 1, anxiety ratings did not differ across conditions; moderate levels of anxiety were reported regardless of affect manipulation and pilot type. Further, perceptions of control did not differ across conditions. One possible explanation for this finding is that both items asked about participant's anxiety and control with regard to the flight, rather than with regard to the pilot. Another possibility is that airline flight arouses moderate levels of anxiety regardless of other factors. Similarly, individuals may believe that airline passengers, in general, have little control over events that occur in flight.

In Study 2, a second path analysis replicated the analysis reported in Study 1 with one exception. In Study 1, feelings predicted trust which predicted emergency handling ratings, whereas in Study 2, feelings were the strongest predictor of emergency handling ratings and trust did not account for a significant amount of variance in these ratings. We believe that this analysis provides strong evidence in favor of the affect heuristic. Since a pilot's ability to handle an emergency is closely associated with risk, our findings replicate and extend those obtained by Alhakami and Slovic (1994), which suggest that feelings toward technology determine estimates of risk.

4. General discussion

We explored consumer attitudes toward automation by drawing on literature from automation, consumer, and decision based psychological research. We developed two main hypotheses. We predicted and found that consumer judgments of

automated aircraft are influenced by affective reaction and the price–quality heuristic. In two studies we found that participants rated a human pilot more positively than an auto-pilot. The data suggest that consumers feel better about human pilots, trust them more, have more confidence in them, and believe they are better equipped to handle emergencies. In Study 2, experimentally induced positive affect increased ratings of an automated pilot, providing support for the idea that consumers use an affect heuristic to simplify judgments of complex technologies. Specifically, although consumers appear to judge human pilots more positively than automated systems, we found that evaluations were more favorable following experimentally induced positive affect; only participants who judged an auto-pilot in a neutral condition provided less favorable ratings compared to human pilots or auto-pilots judged in a positive affect condition. Thus, consumers appear to use feelings as a heuristic to judge human and automated pilots.

Evidence from two path analyses suggests that consumer feelings predict levels of trust, and trust in turn, influences one's confidence, anxiety and ratings of emergency handling. The path analysis from Study 2 suggests, however, that beliefs regarding a pilot's ability to handle an emergency are most strongly predicted by feelings toward the pilot. We interpret this finding as further evidence in support of the affect heuristic because emergency handling is strongly associated with perceived risk. Taken together, the data demonstrate that affective reactions strongly influence attitudes toward automated pilots.

In the field of consumer psychology, the affect heuristic is described in terms of a more general tendency for people to rely on spontaneous inferences and implicit theories to make judgments about objects (Kardes, Posavac, Cronley, & Herr, 2008). Spontaneous inferences arise unintentionally and without awareness, and are based on one's feelings or affective reactions. Implicit theories are people's beliefs about the relation between people, objects, and events. Our data suggest that the processes used to judge automation are similar to the processes used to judge other consumer goods and services. First, our data shows that feelings influence consumer attitudes toward pilots. Second, our data suggests that the implicit connection between price and quality influences attitudes toward automation. In Study 1 we found that participants judged the automated pilot more favorably when the ticket price was \$1000 compared to \$500 dollars. Ticket price increased ratings of feelings, trust, confidence, and emergency handling, and decreased reported anxiety towards an automated pilot. Importantly, a significant difference was not found between ratings of a human pilot in the two pricing conditions. This suggests that when feelings toward a new technology are relatively negative, implicit beliefs regarding the connection between price and quality can enhance or increase positive attitudes. The broader message is that consumers favor heuristics—which conserve cognitive resources, and fill the gaps in rationality—when judging opaque automated systems. Our data also indicate that there are simple tactics, such as increasing the perceived quality or altering consumer feelings toward automation that can be used to persuade an anxious public that automated systems are beneficial.

There are several limitations to the current studies. First, in Studies 1 and 2, the decision situation was not representative of most ticket purchasing situations. Participants were not told what was meant by 99% reliability, and they did not know whether they would pay for the ticket themselves or if the potential employer would pay for the ticket. In addition, participant responses may have been affected by the lack of alternative ticketing options. For example, it is not clear whether consumers would rely on the price–quality inference if they were asked to choose between a \$500 and \$1000 dollar flight operated by an automated pilot. Furthermore, we did not ask participants about their experience with automation or aviation: individual differences in knowledge or experience may influence ratings of human and automated pilots. In fact, it is possible that expert consumers—or those who have experience with automated aviation—may actually prefer automated pilots to human pilots, or judge the two types of pilots equally.

Our analysis of consumer attitudes toward automation points to interesting directions for future research. Although our data suggests that consumers rely on heuristics to make judgments of automation, providing consumers with additional information about automation could influence consumer judgment. Some research supports this assertion. Slovic et al. (2002) suggest that the more precise the information provided to operators, participants, or consumers, the better one will be at using the information to form affective impressions. Hsee (1996, 1998) claims that decision makers might not use important attributes or information unless it can be translated precisely into an affective frame of reference. For example, if a marketing firm or researcher informs an individual that an automated aid is 80% reliable, that person may have difficulty gauging the importance of this information for her evaluation. However, if the researcher is more precise (e.g., the automated aid is fairly accurate, but will make a mistake two out of 10 times on average) then the individual may be better able to form an accurate affective impression. We believe that evaluability of information for consumers and operators is a logical next step to understanding the relationship between feelings, attitudes, and decision making with regard to automated systems. Further, the evaluability of information provided to consumer and operators may help explain what gives rise to negative feelings toward automation in the first place.

An additional direction for future research is based on operator trust and performance. Operators of automated systems tend to comply with systems that are highly reliable and therefore trusted (Parasuraman & Riley, 1997). Highly reliable systems can cause problems for operators (e.g., over trust or misuse), but they could increase consumer's positive reactions. If consumers believed that an automated pilot could outperform a human pilot, one could ask whether positive feelings would increase, or if consumer reactions would still be characterized by fear and anxiety. One could make the prediction, based on the affect heuristic, that consumers who believe that automated systems were beneficial in terms of safety, reliability, and cost efficiency would also have positive affect and positive evaluations of the system.

The current studies have implications for consumers and professional operators of automation. The data presented here indicate that consumer attitudes about automation do not depend on algorithms. Rather, consumer attitudes are formed by

affective reactions and simple heuristics. This finding is important for researchers interested in increasing operator–automation performance because operators rely on systems they trust and reject those that they do not trust (Rice & McCarley, 2008). Other studies have found that operator performance increases as trust in an automated system increases (Lee & Moray, 1992, 1994; Muir & Moray, 1996). Thus, our research suggests that positive affect and simple heuristics (e.g., the price–quality inference, interface style and sophistication, automation etiquette, etc.) may increase operator trust, reliance, and ultimately, performance.

Whereas a move towards more automation in the cockpit would resolve some of the current issues in airline travel (e.g. cost efficiency and safety.), it appears that the general public is not yet ready for it. In fact, consumer attitudes suggest that airline travelers strongly prefer a human pilot to an auto-pilot. Airlines may need to spend time assessing factors that lead to intuitive, affective reactions toward automated pilots before moving forward with plans for unmanned commercial flights. More broadly, if individuals wish to promote the use of automated systems for personal (software technology and web applications), industrial (crop spraying and surveillance) or emergency management use (law enforcement, wild fire suppression, etc.) they should consider how affect heuristics and implicit theories influence consumer reactions. For example, the relationship between humans and computing technology or automation is enhanced by trust, and as our research shows, positive affect. This implies that factors such as computer etiquette (Miller, 2005) and credibility (Fogg et al., 2001; Tseng & Fogg, 1999) that maintain or increase favorable feelings, will also enhance a consumer's decisions to use, buy, or support these systems.

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