Acceptance of Self-Driving Cars: Does Their Posthuman Ability Make Them More Eerie or More Desirable?

Andrew Gambino
Media Effects Research Laboratory
Penn state University
andrew.gambino@gmail.com

S. Shyam Sundar
Media Effects Research Laboratory
Penn State University
sss12@psu.edu

ABSTRACT

The arrival of self-driving cars and smart technologies is fraught with controversy, as users hesitate to cede control to machines for vital tasks. While advances in engineering have made autonomous technology a reality, design work is needed to motivate their mass adoption. What are the key predictors of acceptance of self-driving cars? Is it the ease of use or coolness aspect? Is it the perceived control for users? We decided to find out with a survey (N = 404) assessing acceptance of self-driving cars and discovered that the strongest predictor is "posthuman ability," suggesting that individuals are much more accepting of technology that can clearly outclass human abilities.

1 INTRODUCTION

Self-driving cars are more than a new convenience for consumers. They are a step towards the transformation of entire transportation systems - connecting pedestrians, vehicles and traffic to build smart cities [13]. However, transformative technologies often come with unique consequences.

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KEYWORDS

Self-driving Cars; Autonomous Smart Technology; Social Robots; Technology Acceptance; Agency.

In March of 2018 a self-driving Uber test car was responsible for a pedestrian death in Arizona, and concerns over the safety of these autonomous cars has caused Toyota to remove from the road their line of self-driving cars. Self-driving cars may have clear societal benefits, but individuals have personal concerns. People may choose to forgo these benefits in favor of greater agency, or control over their own situation. Despite controversies and setbacks, it appears that industry leaders feel that more self-driving cars are the future.

While approximately 90% of car crashes caused by human error might be avoided by the full adoption of self-driving cars, each death may face greater scrutiny. Fully adopting self-driving cars may cause considerable scrutiny in the case of crashes, especially when considering that the artificial intelligence (AI) made a choice to take a life to save two [5]. There are potential solutions that include a sharing of agency [2], or the technology as augmenter. For example, human-AI hybrid automated driving systems enhanced the driver's capabilities, specifically their ability to make safe decisions [3]. These hybrid systems represent more of the current state of car automation available to the public.

It appears that we are at a crossroads with several AI technologies—while the technology holds enormous potential, there seems to be inertia among consumers when it comes to adopting them. Therefore, the most critical question now is: What can enhance adoption of technologies such as self-driving cars? Prior research has focused heavily on a given technology's perceived usefulness and ease of use, which can predict its level of adoption, according to the Technology Acceptance Model (TAM) [1]. However, perceived usefulness and ease of use are not specific or precise in ways that might inform the design of modern smart technologies, whose novel features afford users more action than their predecessors [2]. As such, these two predictors of TAM are minimal expectations for technology-user interaction, but insufficient to guide design and marketing.

While it may seem counter-intuitive, principles of user-experience (UX) design should be considered even in autonomous technologies. For example, it has been proposed that better UX design in self-driving cars may afford the "users" the ability to pay attention to other devices during transportation, in essence affording them convenience and fun [7]. Given the potential implications for design as well as HCI theory, this research project explores the predictors of acceptance of self-driving cars from the standpoint of the individual or potential user.

1.1 Posthuman Ability and Predictors of Self-Driving Car Acceptance

In addition to novel features, smart technology and social robotics bring about new tensions as they occupy traditionally human roles. This is often viewed through a pessimistic lens (e.g., anthropocentrism, or the belief that humans are the best species). How well a technology can perform its job may combat negative factors. Take the case of a calculator, a very basic tool that performs mathematical calculations, previously done in an individual's head or on paper. This technology was defined by its ability to massively outperform a human, a concept termed "posthuman." Ultimately, the efficiency, or the ability to perform tasks at a very high level may be the key to the public acceptance of the technology.

Table 1: Hypotheses and Research Questions

RQ1: Perception of a technology's posthuman ability will positively predict an individual's acceptance of the technology.
H1: Perceived sense of agency will positively predict an individual's acceptance self-driving cars.
H2: Perceived convenience will positively predict an individual's acceptance self-driving cars.
H3: Perceived fun will positively predict an individual's acceptance of self-driving cars.
H4: Perceived coolness will positively predict an individual's acceptance of self-driving cars.
H5: Perceived danger will negatively predict an individual's acceptance of self-driving cars.
H6: Perceptions of discomfort and creepiness (uncanny valley) will negatively predict acceptance of self-driving cars.

A relevant example in our context: although individuals may have issues and very important ethical dilemmas regarding driverless cars and their lack of control over their potential fatalities, they may still conclude that the technology is acceptable based on the sheer abilities of the driverless car and its network. As such, we propose that a key predictor of acceptance of technology may be its posthuman ability. We will explore this and other potential predictors of user acceptance by conceptualizing them as potential cues transmitted by smart technologies (via interface features).

The Theory of Interactive Media Effects (TIME) [8] offers a paradigm through which researchers can break down technological affordances into their conceptual underpinnings and directly link those with outcomes. According to TIME, interactions with technology have effects on users via two routes, cues and actions. Cues about the existence of an affordance, which may appear on the technology's interface, trigger cognitive heuristics (or mental shortcuts) that lead to psychological effects. For example, the presence of several interactive features on an interface, promising the affordance of interactivity, can trigger the 'interaction heuristic' (i.e., the more interaction, the better). The action route depends on the user actually engaging with the interface and realizing the affordance. For nascent technologies that are not yet widely adopted, the action route is applicable only to a small group of users, the early adopters. For this reason, we focus on the cue route.

Agency (how much control an individual has, or how empowered one feels) can be enhanced by self-driving cars. In general, research has shown that increases in sense of agency leads to positive attitudes towards technology [11]. As identified by Riener [7], self-driving cars offer the potential for users to have more control of their own lives while they participate in the act of being transported. This afforded freedom will likely lead to greater acceptance of the technology. Additionally, this feeling of being "freed up" may also be explained better not by an increased sense of agency, but rather by increased convenience. Based on the consideration of individuals as hedonistic beings [14], we further suggest that individuals will potentially enjoy themselves being driven around, in part they can more readily access entertainment and games while being transported.

Although we have discussed the effects of increased agency, convenience and fun in the context of self-driving cars, the same effects are likely to be true for other smart and autonomous devices. In addition to these three, several scholars [4, 9, 10] have identified *coolness* as an important potential factor in consumer's willingness to adopt new technologies. Research has shown that coolness is a key predictor in individuals' willingness to use new technologies [4].

Models such as TAM have focused mostly on positive predictors of technological acceptance, but it is also important to consider factors that may hinder the adoption of new technology. In order to gain a comprehensive understanding of relevant predictors, we also considered the impact of perceptions of danger and discomfort. Researchers have discussed [10] and found [12] that individuals believed that the adoption of companion robots would have negative effects on young adults. If we find that perceptions of danger in self-driving cars predicts acceptance of the technology, it may speak to a general fear of automation or loss of personal control.

Table 2: Measures

Acceptance of technology was comprised of four items measured on a 7-point scale, with the following statements: "I would feel comfortable with technology as driver," "I would accept technology being my driver," "I want technology to be my driver," "I want technology be a driver in all of society." The reliability for the measure was very good (α = .94).
The concepts of ***coolness***, ***danger***, ***fun*** and ***convenience*** were measured by asking participants how well they identified with statements on a 7-point scale from (1 = not at all to 7 = very well), the items used were as follows: "Technology in the role of driver would be dangerous," "Technology in the role of driver would be fun," "Technology in the role of driver would be cool," "Technology in the role of driver would be convenient."
Posthuman ability was measured using the statement "Technology in the role of driver would be able to handle the role better than a human." **Agency** was measured on a 7-point scale with the following two items: Technology in the role of driver would give me *control;* and …driver makes me feel *empowered*.
The **uncanny valley** effect also comprised of two items: Technology in the role of driver makes me feel *uncomfortable*; … is *creepy*).
Demographic and control variables were measured as covariates, including gender, education level, political orientation, and psychological openness.

This is to be considered not only in personal roles such as a babysitter, but also in more routinized roles such as a driver. The Uncanny Valley theory [6] suggests that machines are acceptable as they become more humanlike up to a very close point, at which our level of acceptance drops considerably. In terms of its relationship to technology in given roles, it is likely to produce negative outcomes on the overall acceptance of a given technology. We thus additionally predict that the level of effectiveness of the technology will be negatively related to the Uncanny Valley effect. Predicted hypotheses and research questions can be found in Table 1.

2 METHOD

A survey was administered on Amazon's Mechanical Turk (N = 404). The sample was comprised of North Americans, with an average age of 34 years (53% male). In addition to demographics, the questionnaire required participants to answer a series of questions about self-driving cars (See Table 2), as well as the option to fill out open-ended questions that probed further for any 'additional reasons' they may or may not accept self-driving cars. Given the real-world implications, the main focus of the study was to identify the level of acceptance (and its predictors) of self-driving cars.

3 RESULTS

To test the research question and hypotheses, a hierarchical regression analysis was conducted. Overall, acceptance of technology as a driver was at the scale midpoint (M = 3.99). The first block of the regression analysis (See Table 3 for Full Results) revealed that gender (B = .15 p < .01, males more accepting) and political orientation (B = .11, p < .05, more liberal attitudes more accepting) predicted acceptance, accounting for 8.8% of the variance. In the second block of the hierarchical regression, the predictors were entered simultaneously. This analysis revealed posthuman ability to be a strong predictor of acceptance (B = .44, p < .001). In support of H1, sense of agency was found to positively predict acceptance (B = .10, p < .05). Additionally, convenience (B = .08, p < .01), fun (B = .16, p < .001), and coolness (B = .18, p < .001) all significantly positively predicted acceptance. Supporting H5 and H6, danger (B = -.06, p < .05) and the uncanny valley effect (B = -.08, p < .01) were found to be negative predictors. The model explained 83% of the variance in the acceptance of self-driving cars.

As a final note, there were more specific, personal themes identified in the rationales. As such, although our model on the whole explained a considerable amount of variance (83%) with a rather small number of predictors, we have identified some further rationales through more in-depth, personal answers from our participants (See Table 4).

4 DISCUSSION

Our study has revealed many key factors governing acceptance of autonomous vehicles. In summary, we find strong support for the concept of posthuman ability as a key predictor of acceptance.

Table 3. Hierarchical regression (acceptance of self-driving cars)

	β
Step 1	
Gender	.15***
Political Orientation	.11**
Education	.04
Openness	.20***
Step 2	
Posthuman Ability	.44***
Agency	.10***
Convenience	.08**
Fun	.16***
Coolness	.25***
Danger	-.06**
Uncanny Valley	-.08**

Note. N = 404 individuals.
* $p < .1$. ** $p < .05$. *** $p < .01$

Table 4: Open-ended Question Analysis

177 Individuals felt strongly enough to leave remarks regarding why technology as a driver would be acceptable or unacceptable, in an open-ended question asking, "For what additional reasons do you feel technology as a driver is acceptable or unacceptable." A thematic analysis of the messages revealed common issues that were unaccounted for in the predictors. (Cont. on P. 6)

Consistent with most of our hypotheses, we find perceptions of coolness, fun, convenience, danger, sense of agency, and the uncanny valley to be significant predictors of acceptance. Additionally, gender (males were more accepting) serves as a significant predictor of acceptance, as well as political orientation (liberals were more accepting) and openness. The strongest predictor of acceptance was posthuman ability.

Therefore, an important design implication emerging from these findings is that the features and functions of these technologies ought not to use the human role counterpart as the gold standard, but rather explore ways in which autonomous technology can surpass human ability. In this respect, the use of human roles, such as driver or car, to describe these technologies is somewhat limiting and, as our data imply, unattractive to users (as evidenced by the negative effect of the 'uncanny valley' variable). Just as we do not market calculators or computers as approximating the function of a human accountant for example, we probably should not emphasize the "driver" role of autonomous vehicle, but instead focus on what the entire technology can do for meeting our transportation needs.

When considering the value of the posthuman quality, it behooves designers to come up with entirely new labels for their technology. This can be quite liberating to designers, especially in terms of providing them choices for interaction tools. There is no need, for example, to map the in-car and dashboard interfaces to what a human driver would normally use. The steering wheel could be dispensed with, and instead a whole new suite of interaction tools can be deployed in autonomous vehicles. Pointing tasks as well as navigation and other instructions may be embedded in mobile interfaces that users can customize based on their personal preferences and carry from one autonomous vehicle to another, which in addition to being useful for meeting concerns over control, may also provide the riders with increased senses of agency, convenience, and even fun, all of which were positive predictors of acceptance in this study. Further, finding perceptions of danger to be a negative predictor of acceptance may be attributed to the public misunderstanding of the current state of automation in vehicles. Upon reflection, we find danger to be a rather broad, blanket term, and future research on users and designers should explore it in more depth, addressing potential specific dangers, such as hacking, due to the connected nature of smart cities. At the community level, designing technologies that expand or augment human capabilities and expand the universe of eligible users may prove integral in designing successful posthuman technology. For example, a system of self-driving cars would allow much easier transportation for disabled individuals as well as those who may not currently live in an area with quality transportation infrastructure.

Although limited by the cross-sectional nature of the study, our results provide a building block in discerning key variables that predict the acceptance of self-driving cars: Specifically, the importance of posthuman ability emerging as a key predictor. Researchers should validate these predictor variables in future studies, adding depth to the questions where necessary (e.g., danger), and furthering the understanding of posthuman ability. This will facilitate more user-centered design, reveal user concerns that need to be addressed, and ultimately result in a more positive user experience of smart technologies.

Table 4 Continued:

Individuals are not accepting because of concerns over the technology's *insufficient humanness* / inability to react. Further, individuals are worried about how a machine might make calculations in situations that require their own judgment. (Cont. on P 6)
Additionally, many participants felt that the potential for malfunction, perhaps akin to a computer shutting down, might be a great concern for the individual driver. Analysis revealed there is a fear over exactly how the self-driving car might make important decisions, particularly life-threatening ones. It would therefore be in the designer's interest to transparently communicate how these decisions are made. Further, allowing the user to engage in the decision-making process is encouraged.
Individuals who had a more positive outlook often echoed opposite sentiments, with one prevalent theme being the safety of autonomous vehicles, either through a technically higher skill level or through the elimination of negative human factors (from drowsiness to emotions). Additionally, many participants noted that autonomous vehicles could help disabled individuals find safe transportation and keep the roads safe from those under any kind of influence. It is of great interest that two important themes appear to be that the autonomous vehicles are either a) acceptable because they are not human-like, and b) unacceptable because they lack human ability. We find that this tension may provide more depth to the concept of posthuman ability, and that it may encompass both analytical skills as well as regulatory skills, such as better control over emotions.

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