

Moral Behavior of Automated Vehicles: The Impact on Product Perception

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Abstract

With further development of automation, more responsibilities will be transferred from users to technology. Consequently, algorithms of highly automated vehicles should be programmed to behave similarly to the affect- and intuition-based reasoning of human drivers. This includes making decisions in various exceptional circumstances, such as moral dilemmas. We assume that the perceived quality of a holistic driving experience is dependent on the accordance of vehicles' moral and ethical decisions with users' expectations concerning values and attitudes. In this work, we discuss implementation strategies for moral behavior in automated driving systems in order to fulfill users' needs and match their values. The reported findings are based on data from an online survey (n=330). We investigated how subjects assess moral decisions and the overall product experience. Initial results show tendencies among subjects in accepting a decision over life and death and significant dependencies concerning the overall product perception.

1 Introduction

An increasing number of automated systems will soon take over tasks that were recently performed by humans, such as automated vehicles, rescue and health robots, assistance for public authorities, etc. (Wintersberger, Frison, Riener, & Thakkar, 2017). As for automated vehicles (AVs), predictions forecast that they will account for 50% of vehicle sales by 2040 (Litman, 2014). Due to the increasing number of automated vehicle tests on real roads, situations in which the safety (fallback) driver has to take over control doubled in California from 2016 to 2017 (Herger, 2018). Thus, it seems not surprising that AVs become involved in road accidents. In June 2016, J. Brown was the first fatally injured (Boudette, 2017) while using an automated driving system (ADS). A main cause of the accident in the SAE level 2 system is attributed to overtrust (Wintersberger & Riener, 2016). Just recently (March 2018), the first pedestrian died in an accident with an AV that was part of Uber driving tests. The car did not even brake, and the safety driver, distracted and fatigued from her job, failed to intervene. Some people claim, that the casualty was forced to participate in a "test without consent"

(Taylor, 2018), which again boosts discussions about ethics and trust in ADS. It is feared, that a downside of tests on real roads could be increasing numbers of humans involved in accidents. Those could affect individuals' and societies' acceptance in new technology and impede its success. However, as technology enhances, failures like the before mentioned might become history. Still, we cannot guarantee that (lethal) accidents will not happen again in the future and thus deeper discussions about the ethical implications of AVs are necessary. In the end, somebody has to decide how AVs should react in moral dilemmas, such as the "Trolley Problem" (Foot, 1967). In the development of AVs, researchers, engineers and designers must decide what is morally acceptable and what is not. In 2017, the Ethics Commission of the German Federal Ministry of Transport and Digital Infrastructure published the first guidelines for politics and legislation, making demands for security, human dignity, *autonomy of decision* and data (2017). In addition, the Vienna Convention on Road Traffic (German federal ministry of transport and digital infrastructure, 2016), which stated that the driver must be able/allowed to deactivate ADSs and in any possible situation, manifests the *autonomy of the driver* itself.

"Users of AV technology" are both drivers but also other traffic participants. The behavior of a vehicle once on the road will highly affect his experiences in any user-role (i.e., driver, passenger, pedestrian, etc.) and, as a consequence, have a major impact on the future perception of the technology in general and individual car brands in particular. The market success of products, systems or services strongly depend on various factors like functionality, usability and aesthetics, but also abstract concepts like Hedonism and Eudaimonia (Hassenzahl, 2003; Hassenzahl, 2008; Mekler & Hornbaek, 2016). To create satisfying and delighting user experiences in ADS, users' psychological needs (i.e., *autonomy*) have to be fulfilled (Hassenzahl, Diefenbach, & Görlitz, 2010). To achieve these higher (sometimes hidden) goals, the quality of product experiences should be maximized in a holistic way. Clearly, the "moral" behavior of ADSs will play an important role in this experience, similar to other humans' moral behavior and ethical values, which play a major role in our personal judgement. Hence, to deal with the loss of *decision autonomy* for road users, we must find and implement accepted behavior to act in morally ambiguous situations. Users' individual needs and values have to be focused and ethical implications of a technology need to be anticipated and assessed (Albrechtslund, 2007). Only if the decisions of AVs are perceived to be in consent with personal values, users will accept and trust them. Having a closer look at humans' individual value compass thus must become a central part of future product development. In this work, we present a survey study analyzing how user experience (UX) and thus product perception is affected by ethical decisions of AVs, and aim to investigate the impact of experiences lacking to fulfill users' need for *autonomy* on trust, and as well in a certain vehicle brand (Friedman & Kahn Jr, 2002).

2 Related Work

Ethical behavior of ADSs was a focused research topic in the last years. However, a direct connection to UX and product perception is not yet existing. The "Trolley Problem" is an often-used example to investigate the problem. In (Friedman & Kahn Jr, 2002) it was shown that subjects' decisions in the Trolley Problem were powered by different motivations. There-

fore, it might be dangerous to consider only the decision, without involving the complex structures of the decision-making processes behind. Thus, Blythe et al. (2015) illustrated the need for a more socially and ethically just perspective for designing vehicles. They presented a framework beyond the techno-centric and utilitarian perspective using participatory design to investigate how future automated driving could look like. Bonnefon et al. (2016) conducted six surveys addressing the Trolley Problem and concluded that data driven approaches can provide new insights into moral, cultural, and legal aspects of ethical decisions. Li et al. (2016) conducted two experiments using moral dilemmas to evaluate the behavior of AVs by presenting narratives to subjects, and emphasized that their research can help to reveal patterns in perception and help lawmakers and car manufacturer in the design process. In a driving simulator study, subjects had to decide (using the “Trolley Problem” in an AV) which behavior they would expect from the technology. The results show significant tendencies for utilitarian decisions but qualitative statements in semi-structured interviews revealed different underlying motivations (Frison, Wintersberger, & Riener, 2016). Further, by analyzing which ethical behavior is socially acceptable, several studies revealed that users are willing to sacrifice themselves (or at least accept severe injuries) to save others (Wintersberger, Frison, Riener, & Hasirlioglu, 2017; Bergmann, et al., 2018). The question is, if such empirical results from experimental ethics, interviews and surveys can lead to pragmatic design suggestions and thus an acceptable and appropriate experience for everyone by a mandatory ethical setting. Some researchers (Holstein & Dodig-Crnkovic, 2018; Nyholm & Smids, 2016) argue that the use of the “Trolley Problem” is misleading, as it is intrinsically unfair by assuming that different lives have different values. However, it is necessary to analyze real complex engineering problems. Therefore, they analyzed regulative instruments, standards, and designs to identify practical social and ethical challenges. Gogoll and Müller (2017) challenge whether every driver should be able to choose his personal ethical setting. They conclude, though people would not be willing a system, which sacrifices themselves, that a mandatory ethical setting is in their best interest to avoid a prisoner dilemma, which prevents to achieve the socially preferred result.

Consequently, it is widely discussed how to get to the best possible solution for society, as a distinct answer to the problem seems hard or even impossible to find. Beside all the efforts aiming to find socially acceptable behavior, we should not forget the individual user and the implications of system decisions on his/her experience. Understanding and satisfying users’ needs is a central component of UX Design and essential for creating valuable experiences.

An experience is “*shaped by both, characteristics of the user (e.g., personality, skills, background, cultural values, and motives) and properties of the product (e.g., shape, texture, color, and behavior)*” (Desmet & Hekkert, 2017). Thereby the quality of UX is dependent on the fulfillment of users’ psychological needs, i.e., autonomy, competence, security, meaning, relatedness, popularity and stimulation (Hassenzahl, Diefenbach, & Görlitz, 2010). By sense-making, users construct their experiences on their perceptions before, while and after interacting with them, and continuously assess if their higher goals (needs but also ethical principles) are met (Wright, McCarthy, & Meekison, 2003). Thus, if users feel impeded in their decision autonomy in a moral dilemma situation, their whole experience is impacted. From a designer’s perspective product aspects like content, features, functionality and interactions are defined to achieve a certain product character with the intention to create a certain level of a pragmatic but as well hedonic quality (Hassenzahl, 2003; Hassenzahl, 2008). The hedonic quality of

identification represents the concept of self-identification with a certain product. Thus, selection for or against a brand is highly dependent on a potential overlap of personal and brand values. Meschtscherjakov et al. (2014) investigated the emotional attachment of mobile phones and referred to the strong connection between Apple and iPhone. Especially when designing automated systems, brands face the challenge of fulfilling users' individual ethical and moral guidelines while harmonizing them with their own brand values. The ethical behavior of an automated vehicle, experienced at several touchpoints, also already before really using it (e.g., media articles), might affect the overall experience similarly as aesthetics, usability and functionality, and thus should match users' higher goals.

Hence, even though a personalized ethical setting for AVs might not lead to the best solution for society, implications of users' individual experience of an ethical behavior on the overall acceptance of ADSs cannot be ignored by the automotive industry. Investigations utilizing the Trolley Problem can thereby help to get insights for real-worlds engineering problems.

3 Utilizing the “Trolley Problem”

Our aim is to understand the complex construct of ethical behavior, users' values and the overall experience with AVs. To investigate general tendencies towards acceptance rates of specific moral decisions of ADSs we applied an explorative research strategy, utilizing a low-fidelity approach. Using this strategy, we wanted to reveal correlations between the acceptance of certain ethical decisions in moral dilemmas and the perception of product qualities.

We distributed an online survey and asked subjects ($n = 330$) about their acceptance of an AV given ethical decisions (presented in form of the Trolley Problem). The AV is not able to break and has to decide who will be sacrificed: the algorithm favored one person over another based on knowledge of the persons' age, comparing a young (20 years) and an old adult (80 years). The Trolley Problem is used here as an extreme example for an ethical behavior which might not match with users' ethical values. It was presented to subjects in form of a short scenario description, a sketch of the situation and a picture of the product (Mercedes F015). Subjects were confronted with randomized decision outputs (between-subject design) of the moral algorithm. The algorithm either chose randomization (representing an equalitarian approach) or saves the young or old person (representing a utilitarian approach). Using respectively a 7-point Likert scale (1: Strongly disagree; 7: Strongly agree), subjects had to rate if they accept the decision and how they perceive the system. For users' perception, we defined four scales: general need fulfillment, aesthetics, pragmatics, and overall product assessment. By statistically analyzing the data of the online survey, we wanted to investigate the general acceptance rates of the different decision outputs as well as correlations concerning subjects' product perception. In total, 122 female and 210 male subjects in the age range 18 to 70 years (77% aged 30 years or younger) participated in this survey.

3.1 Acceptance

Evaluating subjects' acceptance rates of a certain decision output, we can observe a significant

effect in the scenarios, see Figure 1. As the data was not normally distributed, a Kruskal-Wallis test was used. We can report significant differences in acceptance between the two decisions outputs, $H(2) = 86.03$; $p < .001$. With a median (Mdn) value of “6”, most subjects voted for the decision to rescue the younger person of 20 years in favor of rescuing the elderly person. In contrast, saving the 80-year-old person resulted in a median value of only “2”. For comparison, a pure random decision would have been rated by a median value of “4”.

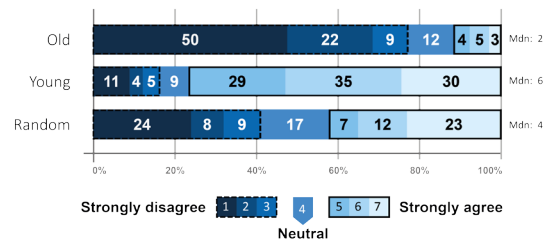


Figure 1: Distribution of acceptance ratings for an ADS's different ethical behaviors

3.2 Product Perception

To investigate the impact of ethical behavior on users' product perception, we evaluated the defined scales. Based on the scenario description (supported by a sketch) and a product picture of the AV, subjects had to assess the product quality by completing scales for users' needs (does the product fulfill users' higher goals), and the product's aesthetic (is the product appealing) and the pragmatic quality (best outcome with least effort). Since the data was not normally distributed, we performed a Kendall-Tau-b test (non-parametric statistic) to investigate correlations between the acceptance of each decision output and components of product perception. We can report positive correlations in all conditions of ethical behavior (see Figure 2). More concrete, as subjects did not vote for rescuing an elderly person in the dilemma situation ($Mdn = 2$), the users' need fulfillment ($Mdn = 1$, $\tau_b = .391$; $p < .001$), the perception of the aesthetics of the product ($Mdn = 2$, $\tau_b = .274$; $p < .05$), and the pragmatic quality ($Mdn = 1$, $\tau_b = .287$; $p < .001$) were rated negatively. This also significantly affects the overall assessment of the vehicle ($Mdn = 1$, $\tau_b = .353$; $p < .001$). In contrast, saving the life of the young person was highly accepted ($Mdn = 6$). All aspects of product perception as well as the general product assessment correlate significantly (*needs*: $\tau_b = .527$; $p < .001$; *aesthetics*: $\tau_b = .419$; $p < .001$; *pragmatics*: $\tau_b = .373$; $p < .001$; *overall*: $\tau_b = .426$; $p < .001$). Random decision were rated lower, what correlates significantly in all other scales (*needs*: $\tau_b = .511$; $p < .001$; *aesthetics*: $\tau_b = .528$; $p < .001$; *pragmatics*: $\tau_b = .309$; $p < .001$; *overall*: $\tau_b = .532$; $p < .001$).

	Acceptance	Users' Needs	Aesthetics	Pragmatics	Overall Assessment
Old	2	1	2	1	1
Young	6	4	4	4	2
Random	4	3	3	3	2

Figure 2: Median values of the product perception ratings. Color-coding indicates possible correlations.

To sum up, all results show a clear connection between the acceptance of ethical behavior and assessment of the overall product in different dimensions.

4 Discussion

In our study, we have investigated how a certain moral behavior affects the overall perception of products. People favor an utilitarian approach (saving the young person) more in highly safety critical scenarios. Although the ethic commission of the German Federal Ministry of Transport and Digital Infrastructure postulates that algorithms are not allowed to weight value of lives (2017) and the general unfairness of the Trolley Problem cannot be disclaimed (Holstein & Dodig-Crnkovic, 2018), results indicate that age is an accepted parameter for moral algorithms. A random decision is, however, not so acceptable.

Our results also show that the acceptance of moral decisions correlates with product quality perception in terms of users' need fulfillment, the perception of aesthetics and pragmatics. Considering that the AV was presented only in form of a simple image, this becomes a strong argument. It shows that moral implications can play an important role for UX. Furthermore, specific moral decisions also affect product perception and vice-versa. Even though a mandatory ethical setting is socially more preferred, our results show that automotive industry will have to deal with the problem that a similar ethical behavior will be perceived differently base on the brand's image.

Investigating moral dilemmas in automated driving is still timely and challenging, as we do not yet have "real" systems, and a low-fidelity approach is just a first step to proceed in this domain. Although the presented studies show some interesting aspects, we are aware of limitations. The different systems were presented only visually, but for a full holistic evaluation of a product and its perception, additional dimensions like context, haptics, size, odor or form must be considered as well as the important dimension of time (before, while and after). In addition, subjects could perceive the implications of the presented moral dilemmas from a distant perspective, as they have not been confronted with the effects of the decisions themselves. In future work we will investigate additional scenarios more common than the Trolley problem, that demand moral behavior of automated systems in everyday situations e.g., normal traffic on the street and concentrate less on dilemmas with high severity. Furthermore, we want to develop strategies on evaluating the impact of moral behavior on UX and brand experience in more high-fidelity approaches, e.g., simulation environment or driving on a test track.

5 Conclusion

Even though we might never find clear solutions for deeply philosophical moral dilemmas, such as the "Trolley Problem", a connection between our perception and ethical implications of products already exists. Following E. Herzberg's death, public and media discussed if companies like Uber or Tesla are going too far when testing their products in safety-critical environments. Brands will have to think about the ethical components in their image, and how they want their products being perceived by individuals and societies. We do not suggest that car

companies should develop algorithms that represent their desired brand expectations in potentially lethal moral dilemmas, but still the Trolley Problem is an easily graspable abstraction that can represent a wide range of scenarios with moral implications. Results of the studies presented in this paper confirm a correlation of ethical behavior and perception of automated vehicles. Since more responsibilities are transferred from humans to technology, involving users and their personal values in design decisions will become more important to increase the general acceptance. Valuable insights into needs and higher goals, such as personal values, can improve products and might lead to more valuable holistic experiences. As users' experience in a vehicle is affected by perceptions also already before the real usage, articles in media and discussions in society can prevent the comprehensive establishment of AVs of single brands on the market. While German brands are still careful and cautious in testing their systems extensively in real road environments (Taylor, 2018), Tesla and Uber already have the challenge to recover and disseminate their desired image.

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