A Cross-Cultural Study of Trust Building in Autonomous Vehicles

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Abstract
Trust in autonomous vehicles (AVs) has become as a key determinant of drivers' acceptance of AVs and explanations are often at the heart of this trusting relationship. This study explores, in consideration of cultural and personality differences, how explanation timing and permission of AV's action affect trust building in the AV. To examine the research question, we design a video-based online survey platform and collect data from participants with different cultural backgrounds and personalities. We expect that our results will have important implications for the design of AV's information delivery.

Author Keywords
Trust; Autonomous vehicle; Culture; Personality; Explanation

ACM Classification Keywords
Human-centered computing [User interface design]

Introduction
Advancements in artificial intelligence, computing power, and deep learning have led major automakers such as BMW, GM, and VW to release statements regarding intentions to bring automated vehicles (AVs) to market. AVs have the potential to help provide our society with safer and more efficient driving and reshape transportation and logis-

tics [7]. However, one of the greatest barriers to widespread acceptance of AVs stems from consumers' lack of trust in AVs [8, 16].

Previous studies have revealed that the information delivered by automation is critical to trust development in the automated systems [6]. Specifically, Koo et al. found that providing only "why" information describing reasoning for driving actions led to the least anxiety and highest trust toward a semi-autonomous vehicle [10, 11].

Meanwhile, humans' preferred communication style with an AV is dependent upon their cultures' level of context [19], and personality [3]. According to Hall's culture theory, people in low-context culture expect a more direct, explicit, and highly verbal communication style to increase positive trust levels, whereas in high-context society, greater nonverbal and indirect style is expected [4]. Li et al. found that when social robots behaved in more culturally normative ways, participant trusted them more and were more likely to heed their recommendations [12]. For example, Chinese participants, who are in high-context society, evaluated the robots as being more likable, trustworthy, and credible, if the robots communicated with them implicitly [17]. Regarding personality, Merritt et al. showed that extraversion was positively related to an operators' propensity to trust machines [13]. Locus of control is also another significant driving-related personality traits found to impact intention to adopt an AV among the driving-related personality traits [2, 3]. These studies all demonstrated that characteristics of AV need to match with users' personality and culture contexts.

This study introduces the importance of explanation timing and control of AV's action in building trust in the AV. Moreover, the effects of cultural and personality differences are examined as well. We hypothesize that cultures and personality moderate effects of explanation timing and control of AV's action on driver's trust in an AV.

Method

Participants

We plan to recruit 120 participants from all over the world. Participants will be screened for various inclusion criteria including driver's license status and basic computer skills. Participants will be paid $8 for participating in the 30-minute study.

Experimental Design

A video-based online survey platform has been built using Qualtrics software (Qualtrics, Provo, UT), an online survey tool that allows researchers to build, distribute, and analyze online surveys in real time. The independent variables in the study include: driving conditions, culture and personality measures.

The treatments will consist of four driving videos each representing a different driving condition. The videos are taken from a first person driving perspective using a high-fidelity driving simulator (Figure 1). The driving simulator was programmed to be an SAE Level 3 [18], where the AV is responsible for the driving task and the human driver will only be asked to resume control if the AV exceeds its system limits.

The four driving conditions include: DC1 - the AV provides no explanation about its actions; DC2 - explanations are presented 7 seconds prior to the AV actions; DC3 - explanations are presented within 1 second after actions have been taken by the AV; and DC4 - explanations are presented 7 seconds before the AV takes action and the participant is asked to approve or disapprove the AV's proposed action on a pop-up window. The AV's subsequent action will follow the participant's choice.

All participants will be exposed to all four driving conditions. However, the order of four driving conditions on the survey platform will be counterbalanced. Each driving condition will contain three unexpected events. The three unexpected events will come from one of three categories events by other drivers, events by police vehicles, and unexpected re-routes. Each event is designed to have the AV take unexpected actions. Events occur at prescribed times, are unique to each condition, and are balanced by type across conditions.

The level of cultural context will be measured by a 5-point cultural-context inventory consisting of twenty items developed by Halverson [5]. Personality will be measured using the big five personality measures [9] along with desirability of control [1].

The dependent variables include trust [14], anxiety [11, 15], and driver preference [11, 15]. Participants will also rank order of each driving condition based on their degree of trust from 1 (most trust) to 4 (least trust).

Procedure
First, all participants will sign an informed consent. Then the culture questionnaire measuring participants' high or low context culture dimension and personality questionnaires measuring their five factors and desirability of control will be presented on the computer. When all the questionnaires are filled out, participants will be asked to imagine themselves as a driver of an SAE Level 3 autonomous vehicle and watch videos of the four driving conditions. After each driving condition, they will complete a questionnaire measuring their trust, anxiety and preferences. After viewing all four conditions participants will be asked to rank the trustworthiness of the AV in the four driving conditions from highest (1) to lowest (4). Measurements of demographic characteristics will be obtained at the end of experiment.

Figure 1: Video screenshot of driving conditions taken from a first person perspective driving view in a high-fidelity vehicle simulator

Analysis
We will conduct a repeated measures analysis of variance (ANOVA) to analyze the relationship between the independent variables (driving conditions, high or low context culture dimension, personality) and dependent variables (subjective attitude in automated vehicle and rank order).

Expected results and Discussion

Generally, we hypothesize that Americans will evaluate AVs as being more trustworthy, followed by Japanese, Chinese, Indians and Germans.

We speculate that when an AV behaves in more culturally and personally normative ways, participants will be more likely to trust the AV. For people who are in high-context culture with nonverbal and indirect communication style such as Chinese, the positive behavioral and attitudinal

measures of trust in the AV will be the greatest in the no explanation driving condition (DC1). For people in low-context culture such as Americans, driving condition 2 (DC2), where the explanation is given before the action, will yield the highest measure of trust both by attitude rating and by rank order. With regard to personality, we assert that providing drivers with an option to decide whether the AV will take the action (DC4) should lead to more trust beyond just providing an explanation for people with high desirability of control. Meanwhile, people scoring high on extraversion will report a higher trust in driving condition 2 (DC2), while people with high values of introversion prefer and trust more in no explanation driving condition (DC1).

Our study is excepted to reveal that people with different national cultures and personality respond differently to the explanation provided by the AV. If this true, it would suggest that the design of AV information delivery should vary across cultures. Incorporating cultural and personality differences into the design of AV interface reinforces the importance of culturally and personally sensitive design. The consideration of cultural and personality should facilitate the development of more effective trust building in AVs across the global. Therefore, drivers should be much more willing to choose to employ their AVs because they trust them.

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