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► **To cite this version:**

Xuezun Zhi, Ronggang Zhou. The Influence of Automation and Culture on Human Cooperation. 6th IFIP Working Conference on Human Work Interaction Design (HWID), May 2021, Beijing, China. pp.123-140, 10.1007/978-3-031-02904-2_6 . hal-03771288

HAL Id: hal-03771288

<https://inria.hal.science/hal-03771288v1>

Submitted on 7 Sep 2022

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The influence of automation and culture on human cooperation

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Abstract. In recent years, intelligent machines which can act on our behalf, such as autonomous vehicles, are in increasing numbers. They follow preset procedures and make decisions for people when certain conditions are reached. These machines improve the efficiency of our daily life as well as bring us a new paradigm of interaction with other people. Setting the program for the machine in advance enables us to make an early decision and provides us with a chance to think more comprehensively from a macro perspective. In this case, how the change of this decision-making paradigm will affect our cooperative behavior with others is the main research question of this study. This article proves that the cooperation rate of participants interacting with others by programming the autonomous vehicle in advance is higher than the direct interaction cooperation rate; a conclusion can be drawn through the experiment that when the system can automatically make decisions and participants can modify the decisions, the higher the initial cooperation rate of the system is, the higher the final cooperation rate of the participants will be. From this, it can be preliminarily concluded that the automation system can guide people to choose cooperation more. In addition, compared with the results of similar studies abroad, it can be found that people's cooperative behavior is different due to different cultural backgrounds. Chinese culture advocates the doctrine of the mean, and the participants' choices of cooperation or betrayal are more balanced. In contrast, western culture is more rational and extreme, in which a large part of the participants choose to cooperate completely or betray completely.

Keywords: Intelligent interaction, Social dilemmas, Autonomous vehicles, Cooperation.

1 Introduction

With the development of science and technology, artificial intelligence has gradually come into people's daily life, such as autonomous vehicles, intelligent speakers and automaton robots, which can act on our behalf. These machines have gradually changed our decision-making mode and provided a new paradigm of interaction and decision for human beings, which may bring new ideas for solving social difficulties.

Social dilemmas represent an inherent time conflict between decisions that bring short-term returns (e.g., betrayal) and decisions that bring long-term returns (e.g., cooperation) [1]. A person chooses to betray because he or she temporarily ignores long-term returns and pays more attention to short-term returns [2]. By programming the autonomous vehicle ahead of time, the temptation of short-term returns can be avoided to some extent [3], in which case, people are more likely to focus on long-term returns and make a favorable choice for the group.

In the field of intelligent machines, the automatic driving vehicle is a hot research topic. The J3016 automatic driving grading standard developed by American International Automaton Engineer Association divides the automatic driving technology into six grades, L0 to L5. The grading method is mainly based on the sophistication of the equipped sensors and the automaticity of perceiving the complex environment and making intelligent decisions. At present, the more popular technology of automatic driving is at L3 level, conditional automatic driving. At this level, the automatic driving system does most of the operation while the driver is supposed to stay focused and answer the requests, which means that on the one hand, when people are designing programs for autopilot, they actually advance the decision time. On the other hand, the autopilot can automatically make decisions in certain situations, while drivers have the final decision-making power, and their final decisions may be influenced by system decisions.

Self-driving cars could change our way of travel to some extent. It would theoretically reduce the mileage, thus reducing environmental pollution, and additionally reduce the number of accidents. However, it may also make people face ethical choices, such as whether to sacrifice the other person or sacrifice oneself in case of danger. In the past, when studying the social dilemmas faced by self-driving cars, most of them have involved the issues of human safety and security, with little focus on directions that do not involve ethical issues, such as whether to choose low-carbon behavior while driving a car.

Considering the above, the research question of this study is how the change of decision-making mode brought by the emergence of an intelligent machine will affect the cooperative behavior of humans in the interaction process.

2 Literature Review

2.1 Social dilemma

Social dilemma refers to the situation when individual interests conflict with collective interests, which was proposed by Dawes in 1980. In a social dilemma, individual rational behavior would cause collective irrational behavior [4]. In other words, if everyone seeks to maximize personal interests, collective interests will be harmed. In some social dilemmas, people are actually facing social and time dilemmas. From the perspective of time, people prefer immediate gains rather than delayed gains. Individuals with a high level of construal consider the future consequences of their actions very thoughtful, showing a higher level of cooperation [5]. When people describe or explain a situation from a higher psychological level,

they tend to focus on a more abstract and comprehensive situation; on the contrary, when people comprehend a situation at a lower level, they tend to focus on more specific aspects related to the environment [6]. When asked to make decisions strategically, participants are more likely to act fairly than participants interacting in real time [7]. This may be because people will consider the opponent's views [8], and people rely on social norms, such as fairness, which provides a consistent metric when people consider all possible outcomes [9].

In social dilemmas, people's decisions may also be related to personal values. In ultimatum games, prosocial people are inclined to cooperate under conditions of high understanding, while individualists tend to compete [10]. Moreover, the same research also puts forward a hypothesis that compared with direct interaction, prosocial people are more likely to let the machine cooperate, while individualists are more likely to make machines betray.

Another aspect is the moral level. Since moral principles are usually more abstract than selfish motives, moral behavior should be seen as having a greater time distance from moral dilemmas [11] [12]. It is found that people will make stricter moral judgments on future moral problems [12], and people are more likely to make moral behaviors when thinking about future events [13].

In summary, time is a critical factor in the issue of social dilemmas. People are more likely to make socially friendly moral behaviors when they make future decisions at a higher level. The intelligent machine provides the possibility to make decisions in advance. Compared with interacting directly with others, interacting through agents may make people behave more fairly. This is because writing an agent program will lead people to adopt a broader perspective, consider each other's position, and rely on social norms (e.g., fairness) to guide their decision-making [14]. In the aspect of self-driving, subjects are more cooperative when setting up self-driving cars than when they are driving by themselves. This is because the selfish short-term rewards become less prominent due to the pre-programming of self-driving cars, and subjects can consider broader social goals. At the same time, it is also proved that programmed behavior is affected by past experience. The final experimental data shows that this conclusion is not limited to the field of self-driving cars. In other words, the design of autonomous machines to make decisions helps build a more cooperative society [15].

From the perspective of the number of participants, the social dilemma can be divided into the two-person social dilemma (only two people participate) and the multi-person social dilemma (more than two people participate). The most typical model of the two-person social dilemma is the prisoner's dilemma, designed by mathematician Albert Tucker according to a game invented by his colleagues. The two prisoners are faced with two choices, cooperation or betrayal, either to testify and report the other party (betrayal) or to remain silent (cooperation). If both parties remain silent, then both parties will go to jail for one year; If one party reports while the other remains silent, the reporting party will be acquitted and the silent party will go to jail for ten years; If both parties report, they will be imprisoned for eight years. It can be seen that no matter whether the other party is silent or reports, their own choice to report can keep their personal interests maximized. If they both make

rational choices (seeking to maximize their personal interests), they will eventually choose to betray and go to jail for eight years; however, from a collective point of view, both parties can maximize their collective interests by keeping silent, and they both go to jail for one year.

From an economic point of view, the main problem of environmental damage is that when we consider the impact of a person's behavior at a specific point in time, the damage to the environment is very small [16]. For example, if a person chooses to drive to work tomorrow, the global temperature will not rise significantly, and if a person chooses to use disposable chopsticks, the global resources will not suddenly disappear, and white garbage will not flood the world. However, in the long run, the dependence on cars and excessive use of disposable items has led to the severe environmental challenges we are now facing.

Regarding environmental issues as a social dilemma, when the decision-maker is faced with environmental protection behaviors or non-environmental protection behavior, he faces two kinds of conflicts: social conflicts (individual interests and collective interests) and time conflicts (short-term return and long-term return). At the level of social conflict, the possible reason for a person to cooperate is that he values the happiness of other people, which may be caused by the person's character or his environment, that is, related to his social value orientation. In terms of time conflict, people are more likely to pay attention to a short-term return, but as time goes by, people will realize that cooperation may bring greater personal and collective benefits [17].

2.2 Factors affecting cooperation

Decision-making is a basic human activity, and people are making various decisions every moment. Decision-making is essentially a many-to-one mapping relationship, in which people process various information in their brains and finally make a choice. When people process information, it will be related to the person's long-term memory, short-term memory, surrounding environment, emotion, state of consciousness, the reaction of others, etc. These conditions will also affect the outcome of human decision-making. This paper explores the influence of gender, social value orientation, culture, and autonomous machines' assisted decision-making on human cooperative behavior.

There have been many studies on the influence of gender on cooperation for a long time. Eagly et al. showed that men are more inclined to take risks than women [18]. Some experiments show that women tend to be more socially oriented, that is, selfless, while men are more personally oriented [19]. In addition, Eckel also concluded that when the risk level is low, women show more cooperation tendency than men, while when the risk is high, there is no obvious difference between men and women in cooperation tendency [20]. Andreoni et al. have proved through experiments that women show a higher cooperative tendency when cooperative behavior needs to pay a higher price, while men show a higher cooperative tendency when cooperative behavior needs to pay a lower price, and men are more likely to

make completely cooperative or completely uncooperative behavior, while women's cooperative behavior is relatively average [21].

Although there are many experimental studies proving that gender affects cooperation, there are still many studies showing that gender has no significant effect on cooperation behavior, especially when using the prisoner's dilemma to investigate whether gender affects cooperation. Simpson argues that previous studies have failed to find differences, mainly because prisoner's dilemmas can trigger people's fear (fear of betrayal) and greed. Simpson conducts experiments on these two emotions respectively and finds that women are more likely to choose betrayal because of fear, and men are more likely to choose betrayal because of greed [22].

To sum up the above contents, it can be known that in some cases, gender has little influence on cooperation, but at the same time, many studies have proved that under certain conditions, such as low risk and less likely to induce fear, women are more inclined to cooperate than men.

People's social value orientation will affect their expectations of the development result of things [23], thus affecting their decision-making choices. Social value orientation can be divided into altruism, prosocial, individualism and competitive orientation. Prosocial people tend to pay more attention to collective interests when encountering conflicts between individual and collective interests, while individualists tend to pay more attention to personal interests in this case. In terms of competitive people, they pursue that their own interests should be more than those of others, rather than maximizing their personal interests. Bogaert et al. show that pro-socialists will cooperate more in social difficulties [24].

From a cultural perspective, cultural backgrounds have important influences on the extent of people's cooperation [25]. The differences between the cultures of Western countries (e.g., Europe and America) and East Asian countries (e.g., China and Japan) are often generalized to individualism and collectivism [26]. The different cultural roots and development processes between China and the West have led to different ways of thinking. The traditional Chinese way of thinking is vague, intuitive, and emphasizes the whole and balance [27], while the traditional western way of thinking is precise and rational, which pays attention to composition and structure. Ho et al. identified no less than 18 different dimensions to make up a more general individualism-collectivism construct (e.g., uniqueness vs. consistency, self-reliance vs. subordination, economic independence vs. interdependence, etc.) [28]. These dimensions are also consistent with traditional Eastern and Western modes of thinking. In summary, these differences make the cooperation choices made by people in Chinese cultural background more average, while the choices made in the Western cultural background may be more extreme.

In addition to the above effects of participants' own characteristics on their cooperative behavior, various factors in human-computer interaction may also influence human decision-making.

During the interaction between humans and intelligent machines, the machine design, specific tasks, and the interaction environment may have an impact on the interaction. In this paper, we focus on the impact of intelligent machine design on human cooperative behavior. The automated systems should be designed to be

reliable, dependable, resilient, secure, usable and accessible [29]. One of the important factors to be decided in intelligent design is the level of autonomy. Sheridan et al. developed a scale for measuring the level of computer autonomy during human-computer interaction, which contains ten discrete variables ranked from the lowest to the highest level of computer autonomy [30]. The fifth level is where the computer performs a behavior with the permission of the user, and the sixth level is where the computer allows the user a limited amount of time to veto a behavior before it is automatically performed. Siegel has shown that intelligent machines with different levels of autonomy may have an impact on participants' decision-making [31]. In their experiment, they asked participants to believe that they were dealing with a robot that was either fully autonomous or completely remote controlled by an operator. In the experiment, the robots tried to convince the subjects to donate as much money as possible, and the results showed that the subjects donated more money when the robots were perceived to be completely involuntary. Definitions and rules have been completed on approaches to levels of automation, human-machine cooperation, etc., that aim to better understand the interaction between human operators and more or less "intelligent" assistive tools. However, the impact of intelligent machine decisions on human decisions at higher levels of autonomy remains less studied. This study hopes to investigate this area experimentally and initially.

3 Method

This experiment is adapted from the machine agent decision-making experiment researched by de Melo, Marsella, Gratch. (2019), and the experimental scene is mainly designed according to the prisoner's dilemma. Economic games, like prisoner's dilemmas, are abstractions of typical real-life situations and ideal choices for studying the underlying psychological mechanism in controlled experiments. In a prisoner's dilemma, subjects can choose cooperation or betrayal. If they only focus on personal interests, they will choose betrayal. If they pay more attention to collective interests, they are more likely to choose cooperation. According to the choice of cooperation or betrayal of the participants, each subject will get the corresponding score. In this experiment, the final reward of the participants is positively related to their score.

The experimental scene is whether to turn on the air conditioner while driving when the temperature is high. Turning on the air conditioner will increase the comfort, but at the same time, it will consume more energy, emit more harmful gases, and aggravate environmental pollution; if the air conditioner is not turned on, the comfort will be reduced, but it is beneficial to environmental protection. Participants played the prisoner's dilemma game with three other people (as control variables, and the other three people were simulated by computers). They respectively chose to turn on or turn off the air conditioner under the conditions of setting the auto-driving program in advance or making direct manual decisions. Turning on the air conditioner was regarded as a betrayal, while turning off the air conditioner was regarded as cooperation.

Information on the gender of the participants and their social value orientation was collected before the experiment began. There are many methods to measure social value orientation (SVO). In this experiment, we adopted the slider test method [32]. The test consists of 6 primary items and 9 sub-items, and the latter 9 sub-items are designed for those prosocial people. All the projects use the same general formula. Decision-makers choose their own preferred allocation options for each project in turn, and then their SVO angle score could be obtained through the following formula (1):

$$SVO^\circ = \arctan [\sum (P_o - 50) / \sum (P_s - 50)] \quad (1)$$

In this formula, P_o is the amount allocated to others for each project, and P_s is the amount of money distributed to oneself. The higher the degree is, the more the decision-maker pays attention to the gains of others rather than their own. 22.45° is the dividing line between prosocial orientation and individualistic orientation. The social value orientations this article focuses on are individualistic and prosocial orientations, so only six primary items are tested on the subjects, and their social value orientation is judged with 22.45° as the boundary.

4 Experiments 1: Machine agent and direct interaction

4.1 Participants

A total of 40 participants were recruited to participate in this experiment, 20 men and 20 women. Their ages range from 18 to 20 years old. All the participants signed the informed consent before the experiment, and they participated in the experiment voluntarily. They could give up the experiment for various reasons. The whole experiment process lasted for 15 to 20 minutes. After the experiment, the participants would get 10 to 15 RMB (according to the experiment results). The results of 40 experiments were all valid.

4.2 Design and Procedure

The experiment will follow a single factor inter-group design (decision-making method: programing / direct interaction) to explore whether decision-making will affect people's cooperative behavior. The participants made decisions simultaneously without communication for ten rounds, and the dependent variable was the cooperation rate of ten rounds of decision-making.

In this experiment, we hope that any strategic considerations that may arise due to repeated interactions can be ruled out, so the subjects will be told before the experiment begins, and they will not know the decisions made by the other three people before the end of the last round. The experimental results of each round and the final scores of the subjects will be displayed after the end of ten rounds of experiments.

The experimental program is written by scratch, and the interface of direct interaction is shown in Fig.1(left). The participants control the AV through the left and right buttons on the keyboard for 10 rounds. After each round of selection, the car will turn and move according to the decision of the subjects. The game income table will be displayed in the experiment interface (top of Fig.1(left), bottom of Fig.1(right)). For example, if the participants and the other three choose to turn on the air conditioning, each of them will get 8 points. If the participant chooses to turn off the air conditioner and the other three choose to turn it on, the participant will get 4 points, and the other three people will get 12 points. If the participant chooses to turn off the air conditioner and one of the other three people turned off the air conditioner and two turned it on, the participant will get 8 points, and the other three people who turned on the air conditioner scored 16 points and so on.

The interface of programming AVs is shown in Fig.1(right). Subjects can decide whether or not to turn on the air conditioner in each round by the mouse button, which is the control variable.

Participants conducted the experiment using a computer browser, and the entire experiment was conducted in May in China with weather conditions.

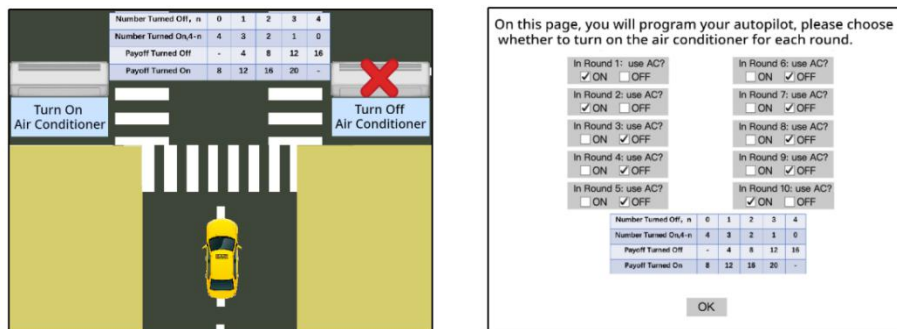


Fig. 1. Experimental conditions in experiment 1: (Left)the interface of direct interaction, (Right)the interface of programming AVs.

4.3 Results

The sample size for this experiment was 40 participants. They were divided into two groups. In this experiment, the average rate of cooperation for decision-making by setting the auto-driving program in advance is 0.5 (SE=0.070), and the average rate of cooperation for decision-making by manual driving is 0.37 (SE=0.060). We can see that participants were more likely to cooperate when programming their AVs than when driving themselves. There was no significant difference in the cooperation rate between the two groups in the one-factor analysis of variance ($F = 1.993$, $p = 0.166$, $\eta^2 = 0.05$).

Taking the cooperation rate as the dependent variable, we ran a gender \times autonomy between-participants ANOVA. The results showed that the cooperation rate of women ($M = 0.51$, $SE = 0.063$) was slightly higher than that of men ($M = 0.36$, $SE =$

0.066). There was no significant difference in one-factor analysis of variance ($F = 2.701$, $p = 0.109$, $\eta^2 = 0.066$). The interaction between decision-making mode and gender was significant ($F = 4.930$, $p = 0.033 < 0.05$, $\eta^2 = 0.120$). It shows that women can make AVs more cooperative. From Fig.2, it can be clearly seen that in the case of direct interaction, the rate of cooperation among men was slightly higher than that of women, but in the case of automatic driving, the cooperation rate of women was significantly higher than that of men. This shows that women were more likely to cooperate when making decisions from a macro perspective.

In this experiment, the average cooperation rate of the participants with SVO of individualism was 0.413 ($SE = 0.076$), and that of prosocial participants was 0.448 ($SE = 0.060$). It can be seen that the cooperation rate of prosocial people was slightly higher than that of individualists. There was no significant difference in one-factor analysis of variance ($F = 0.127$, $p = 0.724$, $\eta^2 = 0.003$). It shows that the social value orientation of the participants does not affect their final choice of cooperation. This is not quite in line with the expected conclusion. In order to analyze the reasons for this phenomenon, this paper counted the frequency of cooperation rate of two social value orientations. We found that 4 prosocial participants chose not to cooperate at all, and the cooperation rate of these 12 prosocial participants was less than 0.5.

The reasons for the above phenomenon are as follows: on the one hand, the sample size is small, and it is difficult to offset some accidental cases; On the other hand, it may be related to the measurement method of social value orientation. In this study, we used the slider measurement method. The interest distribution in the measurement is virtual and does not involve the real reward. However, the score in the experiment is directly related to the final reward, which may lead the participants to be more willing to make scores in line with social norms (such as fairness, selflessness, etc.) in the measurement of social value orientation. In the formal experiment, participants are more willing to make decisions that align with their own interests when it comes to actual rewards, so the influence of social value orientation on cooperation rate was not obvious.

Taking the cooperation rate as the dependent variable, we ran a two-way ANOVA of autonomy \times SVO. The results showed that the interaction between autonomy and SVO was not significant ($F = 1.353$, $p = 0.252$, $\eta^2 = 0.036$). In the case of direct interaction, the rate of cooperation among prosocial people was higher than that of individualists, but in the case of programming AVs in advance, the rate of cooperation among individualists was higher than that of prosocial groups.

There is also a conflict with the theory. In the case of programming the AVs, the proself oriented participants' cooperation rate was higher than that of prosocial oriented participants. The main reason for this is a large number of samples. In the case of programming the AVs, there were 15 prosocial participants, and 5 individualism participants. The sample size of individualism orientation was too small, which made the experimental results deviate from the theory.

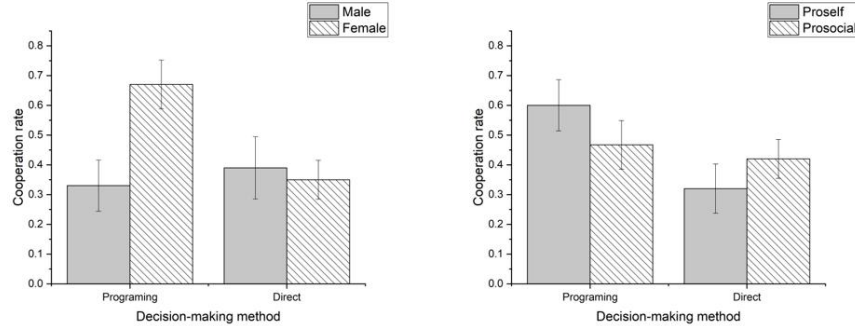


Fig. 2. Results in experiment 1: (Left) cooperation rate for gender, (Right) cooperation rate for SVO. The error bars represent SEs.

In this experiment, the AVs had the minimum degree of automation. If we improve the degree of automation of the automatic driving system and the system has a high initial cooperation rate, can this induce people to choose cooperation more? The next part of this research will study this problem. The initial cooperation rate of the autopilot vehicle system is set to 0.5 and 0.7, respectively. The reason for using 0.5 is based on the results of experiment 1. The reason for using 0.7 is to increase the rate of cooperation on the basis of 0.5, so as to observe whether a higher initial cooperation rate can promote people's cooperation.

5 Experiments 2: The influence of system settings on human cooperation

5.1 Participants

This experiment adopts an in-group design, so a total of 20 subjects were planned to be recruited. There were 22 participants, but two of them did not meet the operation specifications, the data were deleted. Of the remaining 20 participants, 10 were male and 10 were female. Most of the participants were between 18 and 25 years old, and three of them were over 25 years old. All the participants signed the informed consent before the experiment and they participated in the experiment voluntarily. They could give up the experiment for various reasons. The whole experiment lasted for 15 to 20 minutes. After the experiment, the participants would get 10 to 15 RMB (according to the experiment results).

5.2 Design and Procedure

In this experiment, a single-factor intra-group design is adopted, which requires fewer subjects and is more sensitive than inter-group design, and can eliminate the influence of individual differences on the experiment. Meanwhile, there was no need for a long

recovery period between each experimental condition in this design. All the participants made a decision by programming AVs, and the system had a higher degree of automation. The initial cooperation rates of the two groups were 0.5 and 0.7, and each case was carried out twice. The final cooperation rate was an overall result of the two times. In addition, a trial exercise was added so that the participants could better understand the experimental process.

In order to offset the effect of practice or fatigue, one group of subjects adopted the experimental order with system initial cooperation rates of 0.5, 0.5, 0.7, 0.7, while the other group adopted an order with system initial cooperation rates of 0.7, 0.7, 0.5, 0.5. The experimental interface is shown in Fig.3.

**In this page, the system makes decisions automatically.
You can modify the decision results only once per round.**

In Round 1: use AC? <input checked="" type="checkbox"/> ON <input type="checkbox"/> OFF	In Round 6: use AC? <input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF
In Round 2: use AC? <input checked="" type="checkbox"/> ON <input type="checkbox"/> OFF	In Round 7: use AC? <input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF
In Round 3: use AC? <input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF	In Round 8: use AC? <input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF
In Round 4: use AC? <input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF	In Round 9: use AC? <input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF
In Round 5: use AC? <input type="checkbox"/> ON <input checked="" type="checkbox"/> OFF	In Round 10: use AC? <input checked="" type="checkbox"/> ON <input type="checkbox"/> OFF

Number Turned Off, n	0	1	2	3	4
Number Turned On,4-n	4	3	2	1	0
Payoff Turned Off	-	4	8	12	16
Payoff Turned On	8	12	16	20	-

OK

Fig. 3. Experimental conditions in experiment 2. The system generates 0.5 and 0.7 cooperation rates, respectively, and each cooperation rate is presented twice. The figure above shows a cooperation rate of 0.7. Participants can change the decision made by the system.

5.3 Results

In this experiment, there are 10 males and 10 females, among which 5 males are individualistic and 5 are prosocial, 3 females are individualistic and 7 prosocial.

When the initial cooperation rate is 0.5, the average final cooperation rate is 0.55 (SE = 0.043), and when the initial cooperation rate is 0.7, the average final cooperation rate is 0.593 (SE = 0.04). The result of a paired-samples T-test showed that the interaction between paired samples was not significant ($t = -0.732$, $p = 0.473$).

The final cooperation rate of males was 0.49 (SE = 0.057), and the rate of females was 0.61 (SE = 0.062) when the initial cooperation rate is 0.5, while the final cooperation rate of males is 0.56 (SE = 0.052) and that of females is 0.625 (SE = 0.062) when the initial cooperation rate is 0.7. It can be seen that the cooperation rates of women are higher than men in both cases; when the initial cooperation rate is 0.7, the cooperation rates of both males and females are higher compared with the initial cooperation rate of 0.5, and the rate gap between male and female is narrowed (see Fig.4). A two-way repeated-measures ANOVA was performed to analyze the

data, and the results revealed no significant gender \times autonomy interaction ($F = 0.215$, $p = 0.648$). There were no other relevant effects involving gender ($F = 2.61$, $p = 0.124$).

There are 8 individualists and 12 prosocial participants. When the initial cooperation rate is 0.5, the average final cooperation rate of individualists was 0.481 ($SE = 0.016$), and the rate of prosocial people was 0.5958 ($SE = 0.069$); when the initial cooperation rate was 0.7, the final cooperation rate of individualists was 0.563 ($SE = 0.061$), and the final cooperation rate of prosocial people was 0.613 ($SD = 0.054$). As shown in Fig.4, the final cooperation rate of prosocial people is higher than that of individualists in both cases. When the initial cooperation rate was 0.7, the gap between the two groups was narrowed. Taking the initial cooperation rate as the main internal variable, social value orientation as the main inter body variable, and the final cooperation rate as the dependent variable, the results revealed no significant SVO \times autonomy interaction ($F = 0.286$, $p = 0.600$). There were no other relevant effects involving SVO ($F = 1.916$, $p = 0.183$).

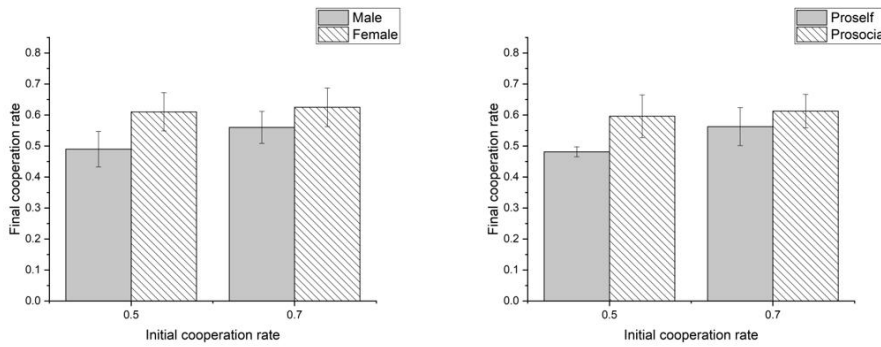


Fig. 4. Results in experiment 2: (Left) Cooperation rate for gender, (Right) Cooperation rate for SVO. The error bars represent SEs.

To further explore the influence of the initial cooperation rate of the system on human cooperative behavior, this paper conducted a difference analysis, that is, the independent variable is the initial cooperation rate of the system, and the dependent variable is the difference between the final cooperation rate and the initial cooperation rate (hereafter referred to as the difference).

When the initial cooperation rate is 0.5, the average difference is 0.05 ($SE = 0.193$), and when the initial cooperation rate is 0.7, the average difference is -0.108 ($SE = 0.179$). To analyze the data, we did repeated measures and the results showed a significant effect of initial cooperation rate on the difference, $F = 17.000$, $p = 0.025$. It can be seen that at the initial cooperation rate of 0.5, people tend to adjust the cooperation rate upward, while when the cooperation rate is 0.7, people tend to adjust the cooperation rate downward, and the downward adjustment is greater than the upward adjustment.

The difference of males was -0.01 (SE =0.181), and the rate of females was 0.11 (SE =0.196) when the initial cooperation rate is 0.5, while the difference of males is -0.14 (SE =0.163) and that of females is -0.075 (SE =0.196) when the initial cooperation rate is 0.7. At the initial cooperation rate of 0.5, males adjusted their cooperation rate slightly downward while females adjusted it upward and to a greater extent; at the initial cooperation rate of 0.7, both males and females adjusted their cooperation rate downward, and the female downward adjustment is greater. We ran a two-way repeated-measures ANOVA to analyze the data, and the results revealed no significant gender \times initial cooperation rate interaction ($F = 17.000$, $p = 0.728$). There were no other relevant effects involving gender ($F = 1.864$, $p = 0.190$).

When the initial cooperation rate is 0.5, the difference of individualists was -0.019 (SE = 0.046), and the rate of prosocial people was 0.096 (SE = 0.239); when the initial cooperation rate was 0.7, the difference of individualists was -0.136 (SE = 0.173), and the difference of prosocial people was -0.088 (SD = 0.187). Taking the initial cooperation rate as the main internal variable, social value orientation as the main inter body variable, and the final cooperation rate as the dependent variable, the results revealed no significant SVO \times initial cooperation rate interaction ($F = 17.000$, $p = 0.667$). There were no other relevant effects involving SVO ($F = 1.229$, $p = 0.283$). It can be seen that individualists tend to adjust the cooperation rate downward at either the initial cooperation rate of 0.5 or 0.7, and the downward adjustment is greater at the initial cooperation rate of 0.5, while pro-socialists tend to adjust the cooperation rate upward at the initial cooperation rate of 0.5 and downward at the initial cooperation rate of 0.7, and the downward adjustment is greater.

In summary, although the final cooperation rate of subjects also increased when the initial cooperation rate of the system was higher, the increase was not significant. Participants would be willing to slightly increase their cooperation rate at an initial cooperation rate of 0.5. However, when the initial cooperation rate was 0.7, participants adjusted their cooperation rate downward to a greater extent. Thus, it can be seen that increasing the default cooperation rate of the system is not the best choice, and the initial cooperation rate granularity can be subsequently refined to seek the optimal value of the system.

6 The influence of automation on human cooperation

When we combined experiment 1 with experiment 2, we ran a one-way ANOVA, which takes the decision-making method (direct manual interaction/programming the AVs / system initial cooperation rate of 0.5/ system initial cooperation rate of 0.7) as the independent variable, and the final cooperation rate as the dependent variable. The result shows that the final cooperation rates of different decision-making methods have significant differences ($F = 3.117$, $p = 0.031$, $\eta^2 = 0.11$).

Taking the final cooperation rate as dependent variable, the data was analyzed in 4 (decision-making method: direct interaction / programming the AVs / initial cooperation rate for 0.5/ initial cooperation rate of 0.7) \times 2 (gender: male / female) two-factor ANOVA. The results showed that gender had a significant effect on the final

cooperation rate ($F = 5.486$, $P = 0.022$, $\eta^2 = 0.071$), and the interaction between decision-making method and gender was not significant ($F=2.395$, $P = 0.075$, $\eta^2 = 0.091$).

Taking the final cooperation rate as the dependent variable, the data was analyzed in 4 (decision-making mode: direct interaction/ programming the AVs / initial cooperation rate for 0.5/ initial cooperation rate of 0.7) *2 (social value orientation: prosocial / individualism) two-factor ANOVA. The results of ANOVA showed that social value orientation had no significant effect on the final cooperation rate ($F = 0.323$, $p = 0.572$, $\eta^2 = 0.004$), and the interaction between decision-making method and social value orientation was not significant ($F = 0.871$, $p = 0.46$, $\eta^2 = 0.035$).

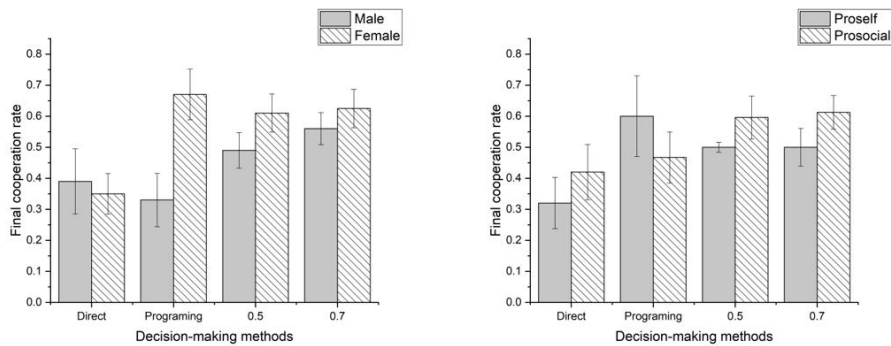


Fig. 5. Results in experiment 1&2: (Left) Cooperation rate for gender, (Right) Cooperation rate for SVO. The error bars represent SEs.

7 The influence of culture on human cooperation

In order to compare people's cooperative behaviors in different cultural backgrounds, this paper compares the data from the above two experiments with that of literature. The design of the experiment in the fourth chapter is the same as that of the first experiment in the literature (de Melo, C. M., Marsella, S., & Gratch, J., 2019). The experimental procedure is basically restored and the variables studied are the same, which meet the comparison conditions.

There were 98 participants in the experiment from the literature. Forty-seven of them programmed the AVs to make decisions, and 51 made decisions through direct interaction. The average rate of cooperation was 0.638 by programming the AVs. The average rate of cooperation in direct interaction was 0.467, $p=0.022$, which showed a significant difference. The specific cooperation rate distribution is shown in Fig.6 (left). The abscissa represents the cooperation rate, and the ordinate represents the proportion of participants with different cooperation rates in the total number of participants. It turns out that the direct interaction part shows a trend of low in the middle and high on both sides, while programming AVs shows a high on the left side, but the rest is approximately flat.

In this paper, the average rate of cooperation is 0.50 by programming the AVs, while the average rate of cooperation is 0.37 for direct interaction. There is no significant difference ($p=0.166$). The specific cooperation rate distribution is shown in Fig.6 (right), the abscissa represents the cooperation rate, and the ordinate shows the corresponding number of different cooperation rates. The two decision-making methods both show a trend of high in the middle and low on both sides, which means the cooperation rate of most participants was 0.4 to 0.5.

The overall rate of cooperation in the literature is about 0.1 higher than that in this paper. In the literature experiment, the number of the participants who set up the autopilot vehicle program in advance chose complete cooperation (cooperative rate was 1) was very large, accounting for 36% of the group. In this paper, the peak cooperation rate of the two groups appeared at 0.4 and 0.5, which makes the overall cooperation rate lower than the literature data.

From the perspective of cultural differences between China and the west, traditional Chinese culture pays attention to reconciliation and compromise, emphasizing avoiding two extremes in treating people and seeking balance in contradictions, so there are more people with a cooperation rate of 0.4 to 0.6; while the western way of thinking is rational, divisive and extreme to a certain extent, so many people choose to cooperate completely or not at all.

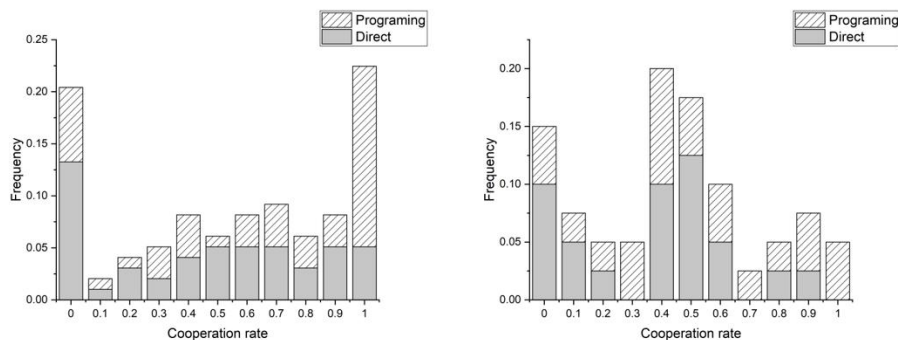


Fig. 6. Frequency distribution of cooperation rate: (Left) US data, (Right) Chinese data. The abscissa is the cooperation rate, and the ordinate is the proportion of participants with different cooperation rates in the total number of participants.

In the literature experiment, there were 39 individualists and 59 prosocial people in 98 participants. The average cooperation rate of the individualists was 0.364 ($SD = 0.333$), and that of the prosocial participants was 0.671 ($SD = 0.349$). One-way ANOVA showed a significant difference ($P < 0.001$).

In this study, the average cooperation rate of individualists is 0.413 ($SD=0.295$), and that of the prosocial participants is 0.448 ($SD=0.30$). There is no significant difference between the two value orientations ($p=0.724$).

In the literature data, the interaction between the decision-making method and social value orientation is not significant ($F(1,94) = 1.636$ and $p=0.202$), which can

not show that prosocial drivers can make AVs more cooperative. In this paper, the interaction between the decision-making method and social value orientation is not significant, either ($p=0.252$).

Under different cultural backgrounds and thinking modes between China and the West, people's cooperative behavior shows different rules. In Chinese culture, the balanced and harmonious thinking mode makes more participants keep the cooperation rate at about 0.5, while the rational and extreme thinking mode of the west makes many participants choose to cooperate completely or not at all, which is the main difference brought by different cultures. In terms of gender, the cooperation rate of men is lower than that of women in both Chinese culture and western culture.

8 Discussion

The following conclusions can be drawn from the experiments. Compared with manual direct decision making, setting the auto-driving program in advance has a more cooperative trend, that is, the cooperation rate is higher. When the system automation level is raised, the initial cooperation rate of the system is higher, and the final cooperation rate of the participants is also higher. From manual direct decision-making, early setting of an autopilot vehicle program, to the initial cooperation rate of 0.5, and to the initial cooperation rate of 0.7, the final cooperation rate of the participants shows an increasing trend. The above data shows that:

1. When the decision-making time is advanced, people will be more cooperative as they are able to think from a broader perspective;
2. When the automation degree of the system is improved, the system can automatically make some decisions, which will affect people's choices. When the system has a higher tendency of cooperation, it can promote people's cooperative behavior.

With regard to gender, in addition to manual real-time decision-making, the cooperation rate of women is always higher than that of men in the other three decision-making modes, and this proves that:

3. Women are more cooperative than men when making decisions from a macro perspective;
4. On the whole, women tend to cooperate more than men, while men show more competitive tendencies.

In terms of social value orientation, there is no clear evidence that prosocial people are more inclined to cooperate than individualists. In the third chapter, in the experiment of programming automatic driving in advance, the rate of cooperation among individualists is higher than that of prosocial people. However, in the other three decision-making methods, the cooperative rate of individualistic participants is low, while the rate of prosocial orientation is high.

In terms of cultural background, the experimental data provided by this study and the literature shows that in Chinese culture, with a balanced and harmonious thinking mode, people's cooperation rate mainly maintains at about 0.5, while in western culture, people tend to make more extreme choices of complete cooperation or complete noncooperation with a rational and accurate thinking mode.

In general, this article makes an initial study on how system default values interfere with people's cooperative behavior, and explores the influence of different cultural backgrounds on human cooperative behavior. The number of samples in this study is not enough, and the experiment was conducted online, so it was not easy to control unrelated variables, which may lead to some contingency in the results. In future research, we can further increase the number of samples to make the results more valid. There are few researches on whether the intelligent system with high automation can promote human's cooperative behavior. Therefore, more researches are supposed to be carried out in this field. Besides, this paper only sets 0.5 and 0.7 two levels of initial cooperation rate, which did not show significant difference under this situation, in which case, different levels of cooperation rate could be established so as to further study the impact of automation system on human cooperative behavior, and explore the optimal value of system defaults in human-computer interaction.

It should be noted that this study hopes to explore the human decision-making style and the influence of intelligent machine cooperation tendency on human cooperation behavior in a human-machine collaboration context at the theoretical level, so the experimental scenarios were designed in an abstract manner, and subsequent experiments could be conducted in more realistic scenarios to verify the conclusions of this paper.

9 Acknowledgments

This study was supported by the National Natural Science Foundation of China (NSFC, 72171015 and 72021001) and the Fundamental Research Funds for the Central Universities (YWF-21-BJ-J-314).

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