Decision Making in Virtual Dilemma

CSCI 8980 VR for Social Good

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Social scientists have studied moral dilemmas using many different methods. Traditionally, some researchers subject the individuals to hypothetical dangerous scenarios and then follow up with interview about their decision making process. Others have tried to create real incidents to validate their hypotheses in the field. However, some scenarios are subject to response bias if using ad-hoc interviews, but also too hard to build settings in field experiment. In these cases, running experiments using VR not only avoids those limitations but also provides a new direction for running experiments. Through this project, we hope to build up a VR scenario to test a classic study on moral dilemma. We will run the experiment with a few participants with the developed VR scenario. In the end, we hope to compare the result with data collected using traditional methods (interview and field experiment), and give suggestion about whether VR could be used as a new research method for testing hypotheses that are hard to study otherwise.

Additional Key Words and Phrases: Virtual Reality, Moral Dilemma, Trolley Problem

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1 INTRODUCTION AND PRIOR LITERATURE

Humans make complex decisions at any given time, which are hard to measure accurately and consistently [Scott and Bruce 1995]. Moral decisions are even harder to measure because of various reasons. For one, these questions could be sensitive thus ethics need to be taken into more careful considerations [Slater et al. 2006]. Second, because of the sensitivity of the moral questions, responses may be subject to strong social desirability bias or impression management [Randall and Fernandes 1991].

Historically, social scientists have studied moral decision making using many different methods. Traditionally, some researchers subject the individuals to hypothetical scenarios and then follow up with surveys or interviews about their decision making process [Detert et al. 2008]. Others have tried to create real incidents to validate their hypotheses in the field [Matthies et al. 2006]. Many of these methods are subject to different issues. For example, some scenarios are subject to response bias if using ad-hoc interviews - people tend to present themselves in a socially desirable way and thus the responses are inconsistent with their behaviors. Other scenarios might be too hard to build as a field experiment - it might be easy to test whether people would choose public transportation over family car, but really hard to set up an experiment to test whether people would sacrifice themselves over a child in the case of fire.

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Virtual Reality, on the other hand, provides a nice solution for these cases. No ad-hoc interview of surveys are needed because behaviors, rather than only what people say they would do, can be measured directly in real time in the virtual environment. Secondly, it is much easier to simulate the scenario in virtual world for the study, so that it gives a sense of reality and triggers the real decisions people would make.

One classic moral dilemma that has been studied for decades is the Trolley Problem. Judith J Thomson introduced the famous Trolley Problem in 1985 [Thomson 1985]. The original problem is described by Foot [Foot 1967] as follow:

> "*Suppose you are the driver of a trolley. The trolley rounds a bend, and there come into view ahead five track workmen, who have been repairing the track. The track goes through a bit of a valley at that point, and the sides are steep, so you must stop the trolley if you are to avoid running the five men down. You step on the brakes,but alas they don't work. Now you suddenly see a spur of track leading off to the right. You can turn the trolley onto it, and thus save the five men on the straight track ahead. Unfortunately, Mrs. Foot has arranged that there is one track workman on that spur of track. He can no more get off the track in time than the five can, so you will kill him if you turn the trolley onto him. Is it morally permissible for you to turn the trolley?*"

JJ Thomson discussed many things in the original set up, such as the difference between "killing someone" and "letting someone die", and different variations of the problem, such as the "by-stander at the switch" situation in stead of being in the driver's seat. This has inspired many research to continue on this topic. Lanteri et al. conducted an experiment with two scenarios ('lever' and 'stranger') either in the usual or reversed order and found that responses to the lever scenario are subject to moral reasoning, while responses to the stranger scenario are triggered by moral emotions [Lanteri et al. 2008]. Furthermore, Skulmowski et al. investigated in the ten-to-one version and the one-to-one version of the trolley problem and varied avatar properties such as gender, ethnicity and orientation in space in a virtual reality setting. They found that ten-to-one version was faster in response time, and that there were pupil dilatation around the moment of decision [Skulmowski et al. 2014].

In this report, we will describe how we built a series of VR scenario to replicate the Trolley Problem in Virtual Reality inspired by Lanteri et al. and Skulmowski et al. Then, we will run the experiment with a few participants with the developed VR scenario. In the end, we will compare the result with data collected using traditional methods (survey), and give suggestion about whether VR could be used as a new research method for testing hypotheses that are hard to study otherwise.

2 IMPLEMENTATION

2.1 Development Platform and Choice of VR Headset

For building our VR versions of the moral dilemma problem, we decided to use Unity, a popular cross-platform game engine, which has rich resource and strong support community. The Unity game engine itself has a visual editor interface, allowing creating scenes, actions, and animations with user interface easily. Programming with C sharp is required for handling user/player input and event happened in the scenes. It allows quick preview of the built scenes as well, from a interactive simulator.

We modify our VR scenarios for Google Daydream headset, an Android phone-powered VR headset. It pairs with a simple controller that allows users interact with the VR content. Since the headset is mobile phone powered, it has more flexibility and mobility compared to other VR headsets. Considering the complexity of our scenarios, and the capabilities of different VR headsets, we decided to use Google Daydream as our intended VR device.

With the Android package and Google VR package in the Unity, we can simply simulate the built VR scenarios either in the editor, or on real Android phone with the headset (if connecting the phone to the computer via development mode). This feature allows us preview and debug our developed scenarios much more easily, as well as tracking users' view during the following study.

2.2 Interaction and Visual Design

In our scenarios, users has a fixed location in the scenes, which is the same as the camera location. All the interactions with the scenes are triggered by a UI dialogue, which we use to show explanation, instruction, and let users make selections with the pointer controller. Users can look around the scene at any time during the events based on the prompts from the UI dialogue or as they like.

All the assets used in these scenarios are from online assets resources, including Unity Assets store, CG Trader, and Google Poly. A detailed list of these assets can be found in the appendix A.1. Most assets used in the scenarios have a low-poly visual style, which has a less realistic feeling, but still simulate the real-world scenarios well. We decide on this design style because we donâĂŹt want to traumatize users with a too realistic experience.

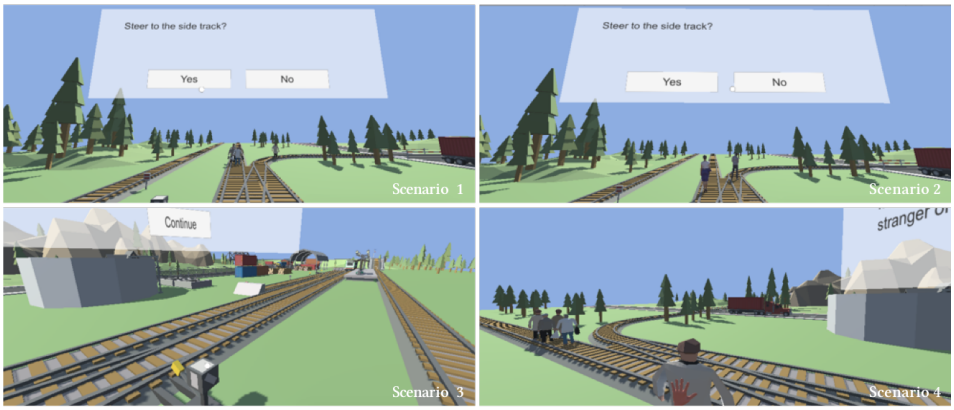

Fig. 1. 4 scenarios.

2.3 Details of Scenarios

As shown in Figure 1, there were four scenarios in the study.

2.3.1 Scenario 1: 1-5 Driver View. Scenario 1 simulates a driver view, where the player camera is placed on the train in the scene. On the left side, users can see a train station, and on the right side of the train, user can see some train carriages, and wood. After user clicks continue, the train starts moving forward, and stops before the track diverts. The straight track has five people standing on the track and the other diverted track only has one person stand on it. All the people are facing backward from the user's view. When the train stops, the UI dialogue prompts users of choosing whether they want to stay on the track or switch to the other track. Right before the train hits the people on the track, the screen goes black and only UI dialogue remains prompting users proceed to the next step.

2.3.2 Scenario 2: 1-1 Driver View. Scenario 2 has the similar setup and flow as Scenario 1, except the setup of people standing on the track is different. A woman wearing a skirt is standing on the left (straight) track, and a man is standing on the right diverted track. A similar dialogue prompts users to proceed to the next step at the end of the Scenario.

2.3.3 Scenario 3: 1-5 Bystander View. Scenario 3 simulates a bystander view. The player camera is place on the side of the train track next to a lever which can divert the incoming train to the other track. On the left side of the users, there are two tracks, where 5 people stand on the straight track and only one person stands on the diverted track. After clicking continue in the UI dialogue, user can see the train coming to the place of the lever, and stops right before the lever. After users choose the whether to pull the lever, the train starts moving again and similarly the screen goes black right before the train hit the people on the track. The UI dialogue prompts users to take the survey on questions regarding this scenario. The other objects in the scene remain the same as the previous scenarios.

2.3.4 Scenario 4: Stranger-5 Bystander View. Scenario 4 is the same as Scenario 3, except instead of having a lever by the train track, a stranger is standing on the left of the player camera. A hand is on the back of that stranger to indicate the potential action associated with that stranger. If user chooses to push the stranger to the track to stop the train (as prompted by the UI dialogue), the animation of that stranger be pushed (by the hand) to the track starts to play. The train stops either right before hitting the stranger or the group of people on the track (if stranger is not pushed). The screen turns black and a dialogue thanks users for completing all sees and prompts them to the survey.

3 STUDY DESIGN

3.1 Independent Variables and Conditions

There are three sets of variables we have in this study: the level of involvement (point of view), the number of people on the track, and the individual characteristics of the people on the track.

3.1.1 Level of Involvement. Inspired by prior studies, we divided the study into two different levels of involvement. One could either be "the driver of the trolley" and experience the scenario in the "first person view" (Scenario 1 & 2). On the other hand, one could be "the bystander next to the track" and experience it in the "third person view" (Scenario 3 & 4). Furthermore, as a bystander, one could either "flip the lever" to change the direction of the trolley (Scenario 3), or "push a stranger onto the track" (Scenario 4).

3.1.2 The number of people on the track. We have two conditions that varied the number of people on the track. In some cases, participants are faced with a choice between five and one (Scenario 1, 3 & 4), while in the other case, participants are choosing between two tracks that each has one person on it (Scenario 2).

3.1.3 Individual characteristics. For the scope of this study, we varied on aspect of individual characteristic: gender. For the one-to-one case, there is a female standing on the track in front of the trolley while a male is standing on the side track.

3.2 Dependent Variables and Measurement

We recorded participants actual decisions in each scenarios, and measured their moral reasoning and the social desirableness of their response using two questionnaires described below.

3.2.1 4Q about Moral Reasoning. We adapted the 4 questions from Lanteri et al. [Lanteri et al. 2008] to measure their moral reasoning process. The questions are as follow:

(1) Under these circumstances, is it morally obligatory for the passer-by to pull the lever (push the stranger)?
(2) Under these circumstances, is it morally acceptable for the passer-by to pull the lever (push the stranger)?

(3) If the passer-by does not pull the lever (push the stranger), is he intentionally killing five people?
(4) If the passer-by pulls the lever (push the stranger), is he intentionally killing one person?

3.2.2 SDS-17. We used J. Stober's Social Desirability Scale (SDS-17) to measure how likely one would say something because it is socially desirable to say so [StÃűber and StÃűber 2001]. The questions are as follow. Answer categories are coded as 1 if "true" and 0 if "false". Items 1, 4, 6, 7, 11, 15, and 17 are reverse keyed. Item 4 was deleted from the final version of the SDS-17.

(1) I sometimes litter.
(2) I always admit my mistakes openly and face the potential negative consequences.
(3) In traffic I am always polite and considerate of others.
(4) I have tried illegal drugs (for example, marijuana, cocaine, etc.). (DROPPED)
(5) I always accept others' opinions, even when they don't agree with my own.
(6) I take out my bad moods on others now and then.
(7) There has been an occasion when I took advantage of someone else.
(8) In conversations I always listen attentively and let others finish their sentences.
(9) I never hesitate to help someone in case of emergency.
(10) When I have made a promise, I keep it – no ifs, ands or buts.
(11) I occasionally speak badly of others behind their back.
(12) I would never live off other people.
(13) I always stay friendly and courteous with other people, even when I am stressed out.
(14) During arguments I always stay objective and matter-of-fact.
(15) There has been at least one occasion when I failed to return an item that I borrowed.
(16) I always eat a healthy diet.
(17) Sometimes I only help because I expect something in return.

3.3 Study Set Up

The experiment was set up as shown in Figure 2. Computer 1 was used to run Unity, and connected to the Daydream participant was wearing. After going to scenarios in VR, participants turned to Computer 2 to take the survey. We also prepared some candies as rewards for our volunteers.

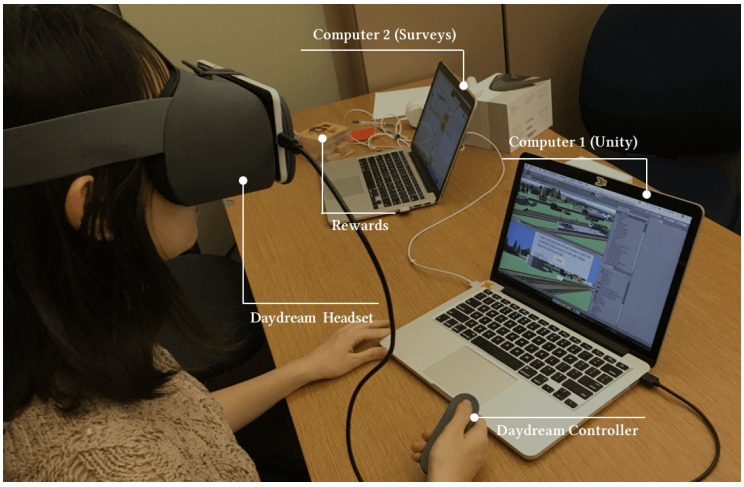

Fig. 2. Study setup.

3.4 Procedure

Figure 3 shows the flow of the study. We began with a introduction of the goal of this study, and obtained consent to record video from our participants. Secondly, we showed participants the driver view scenarios (Scenario 1 and 2). Then we continued with the "lever" condition of the bystander view scenario (Scenario 3), followed by the first set of four question about their moral reasoning process. Next, we repeated the same procedure to the "stranger" condition (Scenario 4). Afterwards, we asked participants to fill out the SDS-17 questionnaire and their demographics. Finally, we ended the study with an exit interview about their overall decision making process.

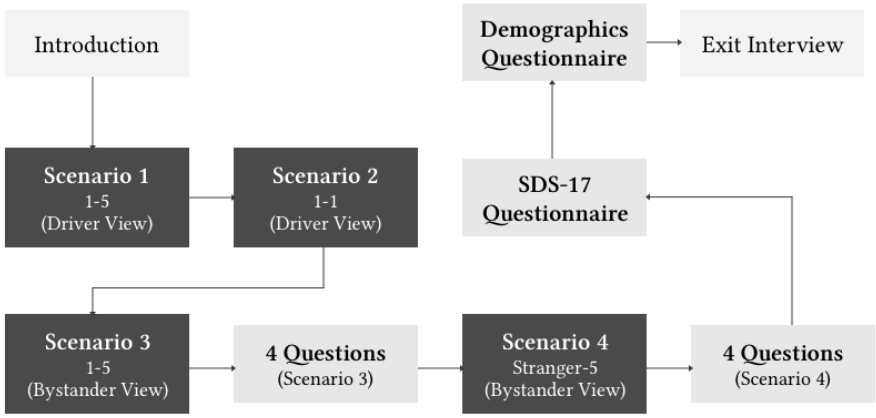

Fig. 3. Study flow.

4 RESULT

4.1 Participant

In total, we had nine volunteers participated in this study. The detailed breakdown of their demographics are shown in Table 1. Overall, we had gender balanced group between 20 and 42 years old with a median age of 30.22. Six of them were Caucasian and 3 were Asian, all with an education level of college and above. When asked to report their familiarity with VR/AR technologies, eight participants said they have tried less than three times while one has heard but never used it.

Gender		**Ethnicity**		**Education**	
Male	5	White	6	College	2
Female	4	Asian	3	Graduate	7
Age		**Familiarity with VR/AR technology**			
20-29	5	Heard of but never used	1		
30-39	2	Tried less than 3 times	8		
40-42	2	Frequent user	0		

Table 1. Summary statistics of the participants

4.2 Moral Decision-Making

We measured participants moral reasoning process using the four questions described in Lanteri et al. [Lanteri et al. 2008]. Specifically, it asked about how obligatory or acceptable one's action was, and whether it should be counted as intentional kill the people on the track they chose.

Figure 4 shows the breakdown of the responses for the "lever" (Scenario 3) and "stranger" (Scenario 4) conditions from our study. To situate our findings, we compared our results to Lanteri et al.'s in Figure 5.

Overall, the trends are very similar.

(1) In both studies, most participants didn't think flipping the lever / pushing the stranger was obligatory, but more considered flipping the level more obligatory than pushing the stranger.
(2) The majority of participants thought flipping the lever was morally acceptable while only half of them thought the same for pushing the stranger.
(3) In our study, no one regarded not taking any action as intentionally killing the five people on the track. While in Lanteri et al.'s study, about 10% considered it intentional.
(4) The majority of Lanteri's participants thought pushing the stranger onto the track was intentionally killing that person, while only half of our participants thought it that way.

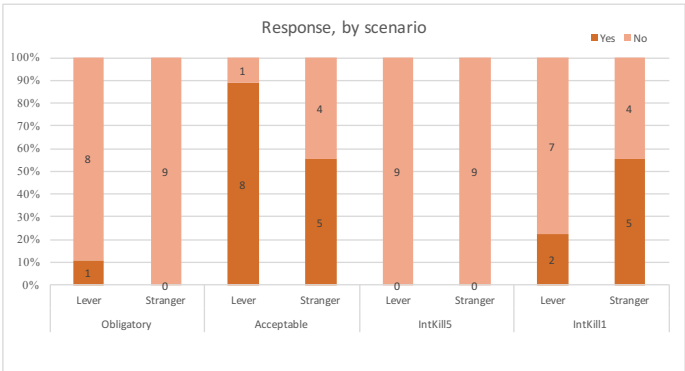

Fig. 4. Response by Scenario

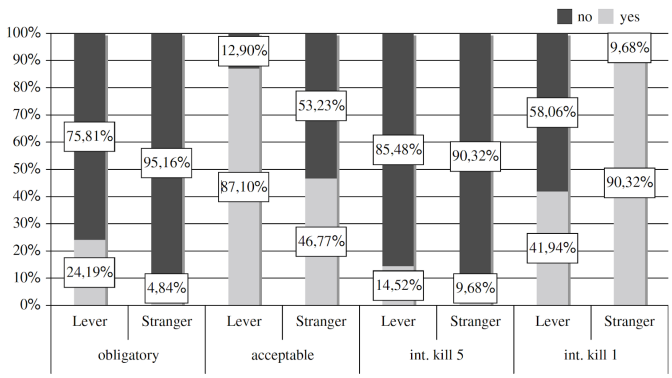

Fig. 5. The "response by Scenario" figure in Lanteri et al.

The high similarity between two studies was very reassuring. First, it suggests that testing moral dilemmas in VR is a valid and effective method of research. Second, because of the discrepancies between these two results, it seems that replicating the study in VR reveals more nuances in how people reason about a moral problem.

4.3 Social Desirability

We also compared the participants' behavioral responses with their tendency to present their behaviors in a socially desirable manner. We recorded their decisions in each scenario as behavioral responses, and measured how likely they were to present their behaviors in a socially desirable manner using SDS-17. The details are shown in Table 2.

In each scenario, a "Y" means one has chosen to take an action - either turn the trolley onto the side track (Scenario 1,2 & 3) or push the stranger onto the track to stop the trolley (Scenario 4) - and a "N" means one decided to not take any action, in which case the trolley would always run over the person/people on the track straight ahead.

We coded participants' social desirable behaviors (SD Behavior) as 0, 1 or 2 by looking at their decisions in Scenario 1 and 2. Since the social norm is to sacrifice few over many (choose "Y" in Scenario 1) and sacrifice male over female (choose "Y" in Scenario 2), we increment their SD Behavior score by 1 if there is a "Y". Then, we derived their tendency to present themselves in a socially desirable manner (SD Tendency) by calculating their score using SDS-17. After reversing the values for items 1, 6, 7, 11, 15, and 17, we coded the answer "true" as 1 and answer "false" as 0.

The SD tendency scores range from 0 to 14, which indicates there might be outliers. Due to our small sample size, it is both hard to identify the outliers and not sensible to get rid of them. Inspired by Skulmowski et al. [Skulmowski et al. 2014], we decided to calculate Spearman's correlation which is less sensitive to outliers than Person's correlation. As a result, the correlation between SD behavior and SD tendency is r = -0.27, p = 0.47. This suggests there is no significant correlation between what people want to present and how they would react in reality, which speaks to the inconsistency between self report and actual behaviors. This is a great example of the importance of conducting moral decision making research in VR, as it avoids the limitation of the traditional self-report methods and directly measures how people would react in different scenarios in real time.

ID	Scenario 1	Scenario 2	Scenario 3	Scenario 4	SD Behavior	SD Tendency
1	Y	N	Y	N	1	7
2	Y	N	Y	N	1	1
3	Y	Y	Y	N	2	1
4	Y	N	Y	N	1	9
5	Y	Y	Y	Y	2	2
6	N	N	N	N	0	14
7	Y	N	Y	N	1	0
8	N	N	Y	N	0	4
9	Y	Y	Y	Y	2	9

Table 2. The behavioral responses of the participants and tendency to present themselves in a socially desirable manner.

4.4 Insights from the Interview

We concluded the study with an exit interview, asking people to describe their decision making process and give feedback for the study. There are a couple of insights we learned from the conversations with participants.

4.4.1 Visual and style. A few participants commented on the visual presentation and style of the VR scenarios. When we showed the driver view scenarios (Scenario 1 & 2), one participant (P4) tried to avoid the incoming collision when the trolley was approaching the interaction by turning her body away in the real world. This shows that the virtual world was successful in providing a sense of immersion. On the other hand, another participant (P5) reported that the style reminded him of a game he used to play, which decreased his belief in the "realness" of the scenarios. These comments suggest that the current visual design can immerse participants in the virtual scenarios, but more work needs to be done to improve the overall style.

4.4.2 Timing. One participant (P9) pointed out that we paused and asked for participants decision during the study rather than letting them to decide within a time frame while the trolley continues to approach the intersection. In retrospect, this might have an effect on people's choice and thus we hope to test out both methods in the follow up studies.

4.4.3 Order effect. In the exit interview, some participants (P1 & P8) revealed that sometimes they made a certain decision not because they thought that was the right choice, but simply want to see what would happen if they would a different option. Thus the order of the scenario might have an effect as people might choose the opposite option in the subsequent scenario.

4.4.4 Level of involvement. Almost all participants explained how they felt differently in the driver's view and the bystander's view. Overall, participants thought steering to the side track (Scenario 1) was an easier decision to make than flipping the lever (Scenario 3), although both actions resulted in killing one person to save five. This is because in the driver's view, one is already deeply involved in this event and killing one rather than five was the best option at that point. Compared to the bystander's view, one is not directly involved in the event until s/he flips the lever.

4.4.5 Emotional neutralizer in the end. One participant (P3) pointed out that this is a heavy topic to study and suggested to include an emotional neutralizer in the end of the study. In the future, we would include more spoiler about the subject of study in the consent process, and add a short comedy clip or cat video to lighten the mood afterwards.

5 FUTURE DIRECTION

There are various lessons we learned from both the study and the interviews. We describe some of them below so that we can improve on them in the future studies.

(1) Update questionnaire. One thing we could do is to use other measurement for social desirability. This could give our more nuance about how people tend to present themselves when the subject is sensitive.
(2) For the prototype:
  (a) Improve VR to simulate the real-world experience. We can also update the style with more realistic scenarios.
  (b) It is important to train on how to use the controller before entering the scenario so that people don't miss out on the reaction window because of technical unfamiliarity.
  (c) We can leave a window open for participants to react instead of pausing and asking for their decision.
(3) Order effect

(a) We should counterbalance the order of the scenarios
(b) We can stress the importance of making decision based on true reasoning rather than the desire to see what the alternative would turn out.

(4) Diverse participant
(a) We should expand the size of the sample to include people from different demographics.
(b) It might be interesting to look at how previous experience with VR and video game affect responses in each scenario.

6 CONCLUSION

In this study, we build a series of scenarios on Unity about the classic Trolley Problem to test the moral decision making process in VR. Through nine participants' responses to the four scenarios, we examined the effect of group size, gender, and the point-of-view in moral dilemma. Our results show that people display a similar moral reasoning pattern in VR compared to what has been found in text-based studies. Moreover, people react differently from what they tend to present themselves, which underlines the validity of using VR for moral decision making studies rather than using traditional self-report methods. We concluded with the insights learned from the exit interviews and proposed directions to go for future studies.

7 DIVISION OF LABOR

We both conducted the study with participants, made slides, and presented the study in class.

7.1 Xinyi

Xinyi conducted literature review of studies on this topic, selected relevant example papers to replicate, designed the study, recruited participants, analyzed data, and wrote the majority of the final report (Section 1, 3, 4, 5, & 6).

7.2 Irene

Irene completed the majority of the implementation of the prototype, edited the demo video, and wrote Section 2 and 5 of the final report.

A APPENDIX

A.1 Video Demo Link

https://vimeo.com/269562842

A.2 Assets Used in VR Scenarios

- Simple Train: https://goo.gl/WuQqfw
- Low Poly Animated People: https://goo.gl/MhSRRj
- Casual Human: https://goo.gl/M7x6NF
- Business Woman: https://goo.gl/u4M8RF
- Hand: https://goo.gl/bHBu38

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