Replicating the Nature of Cooperative Behavior in the First-Person Perspective Task

Shota Matsubayashi
Institutes of Innovation for Future Society (InFuS)
Nagoya University
Aichi, Japan
e-mail: matsubayashi.shota.v0@f.mail.nagoya-u.ac.jp

Yuki Ninomiya
Institutes of Innovation for Future Society (InFuS)
Nagoya University
Aichi, Japan
e-mail: ninomiya.yuki.t1@f.mail.nagoya-u.ac.jp

Kazuhisa Miwa
Graduate School of Informatics
Nagoya University
Aichi, Japan
e-mail: miwa@is.nagoya-u.ac.jp

Hitoshi Terai
Faculty of Humanity-Oriented Science and Engineering
Kindai University
Fukuoka, Japan
e-mail: terai@fuk.kindai.ac.jp

Takuma Yamaguchi
Graduate School of Engineering
Nagoya University
Aichi, Japan
e-mail: t_yamaguchi@nuem.nagoya-u.ac.jp

Hiroyuki Okuda
Graduate School of Engineering
Nagoya University
Aichi, Japan
e-mail: h_okuda@nuem.nagoya-u.ac.jp

Tatsuya Suzuki
Graduate School of Engineering
Nagoya University
Aichi, Japan
e-mail: t_suzuki@nuem.nagoya-u.ac.jp

***Abstract*—The nature of cooperative behavior has been shown to reach self-goal earlier and achieve self-benefit by reducing interruption to others using the bird's-eye perspective task. This study examines whether the nature of cooperative behavior is replicated in the first-person perspective task using a driving simulator. The results showed that behavioral performance was nearly identical in the bird-eye perspective experiment and the first-person perspective tasks. This finding indicates that the nature of cooperative behavior was confirmed in the realistic first-person perspective and that the bird-eye perspective task has high validity in verifying moving behavior.**

Keywords-cooperative behavior; shared space.

I. INTRODUCTION

A. Cooperative Behavior in Traffic

The cooperative behavior of humans plays an important role in traffic. Previous studies have considered acceleration or deceleration for others as the typical cooperative behavior [1]–[3]. Such cooperative behavior promotes efficiency and safety [4] and generates positive emotions in the surrounding individuals [5][6]. Conversely, uncooperative behavior can cause serious accidents and delays [7][8] and arouse stress and anger [9]. In recent years, cooperative behavior that takes into account the others surrounding us has been developed from the perspective of social robotics [10]–[12].

B. Nature of Cooperative Behavior

The main scope of previous studies is separated space, where each traffic participant is provided with its own space, such as a sidewalk for pedestrians or a motorway for vehicles. However, such separated space is replaced by shared space. In the shared space, all traffic participants can move bidimensionally [13] and it is not clear who has priority to cross [14]. We have shown what kind of cooperative behavior individuals take in the shared space [15].

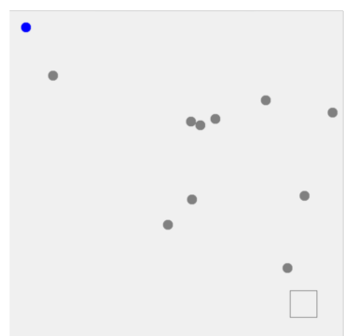

Figure 1. Overview of the bird-eye perspective task [15].

Our previous study [15] examined the nature of cooperative behavior using the Bird's-Eye Perspective (BEP) experiment (Figure 1). Participants were required to move to their goals by operating a joystick in the simulated space shared with the other autonomous agents. Participants were given one of the following three instructions, and their behavioral performance was compared across the three conditions: "Reach your goal while considering others" (cooperative condition), "You have enough time and can go to your goal slowly" (nonurgent condition), and "You do not have enough time and should reach your goal as fast as you can" (urgent condition).

The results showed that the urgent behavior decreased

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completion time compared to no instruction baseline, but increased the amount of interruption to others. Meanwhile, the cooperative and nonurgent behavior increased completion time. Furthermore, only the cooperative behavior decreased the amount of interruption compared to the baseline. An additional comparison among the three conditions showed that completion time and interruption were lower in the cooperative condition than in the nonurgent condition. We concluded that the nature of cooperative behavior is to reach the self-goal earlier and to achieve self-benefit by reducing interruption to others.

C. Difference in Perspective

In the authors' previous task, participants had a BEP [15]. However, in actual situations, individuals move in a First-Person Perspective (FPP). Therefore, it is necessary to examine whether the nature of cooperative behavior can be reproduced in FPP. This study examines cooperative behavior compared to urgent and nonurgent behavior in the experiment in the FPP using a driving simulator.

Although there are not many studies that directly compare the BEP and FPP, several studies have suggested the effect of perspective on moving behavior. For example, in a maze task, it is more difficult to accurately understand the positional relationship from the FPP than from BEP [16]. In addition, providing a highly objective perspective influences moving behavior [17]. This experiment shows that adding BEP reduces lateral deviation when driving straight ahead and increases speed when turning left or right. Individuals evaluate the risk of contact with vehicles higher in FPP than in third-person perspective [18].

In the non-traffic field, the effect of FPP has also been shown. Virtual experience in the FPP using virtual reality elicits stronger physiological responses, emotional experiences, and subjective reactions than in the third-person perspective [19]–[21].

Based on these previous studies, the following effects can be predicted when the perspective is changed to FPP in the moving task as a shared space. First, cooperative behavior may not reduce the interruption to others in the FPP although it does in the BEP. This is because it is more difficult to understand the positional relationship in the FPP than in the BEP. Conversely, the nature of cooperative behavior may be observed in the FPP as well as in the BEP. This is because the FPP evokes a stronger emotional experience of cooperation or consideration. Examination of the effect of perspective on cooperative behavior is also important to use BEP and FPP tasks for verification of cooperative behavior.

The rest of the paper is structured as follows. Section 2 describes the experimental method and Section 3 describes the results of the experiment. In Section 4, we discuss the difference in the effect of perspectives and the applicability of the tasks.

Figure 2. Overview of the first-person perspective task.

II. METHOD

A. Participants

A total of 24 participants joined the experiment ($M_{age} = 48.08, SD_{age} = 12.18$). Informed consent was obtained from participants prior to the experiment. This experiment was approved by the Institutional Review Board at the Institutes of Innovation for Future Society (InFuS), Nagoya University (approval number: 2021-13).

B. Stimulus

The task in the previous study [15] was changed from BEP to FPP using a driving simulator (Figure 2). A total of seven displays were used to project the images from the FPP using Unity [22]. A vehicle was placed in the center of the displays, and the joystick used in the BEP task was set to control the vehicle. The up/down directions of the joystick corresponded to forward/backward movement, and the left/right directions corresponded to left/right turns, while the joystick input corresponded directly to the direction of travel in the BEP task. A trial was defined as lasting until participants reached their own goals.

C. Procedure

The procedure was almost identical to the BEP task. After some practice trials with the joystick, a total of five sets were performed. In Sets 1 and 2, participants were asked to reach their goals without any instructions. In Sets 3, 4, and 5, participants performed the same task after receiving one of three instructions, i.e., cooperative, urgent, or nonurgent instructions, or no instruction. Trials with no instruction were regarded as baseline. The order of instructions was counterbalanced across participants. A set consisted of 12 trials, including four trials each with 16, 24, and 32 other autonomous agents.

The index of moving performance was also the same as in the BEP experiment. The completion time corresponds to the time it took participants to reach their goal, and the amount of interruption corresponds to the total time it took participants to interfere with other agents. If an agent was in the direction of another agent and the distance between them was less than 3 meters, it was considered to be an interruption.

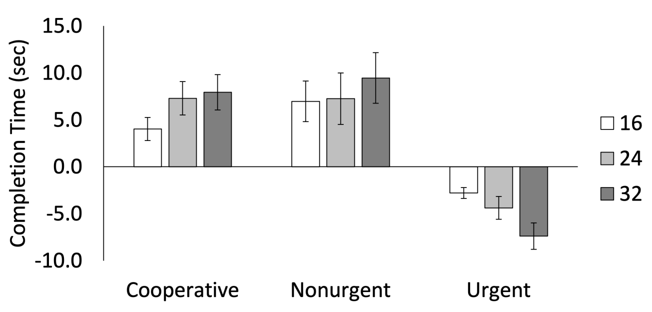

Figure 3. Means of Completion Time. Values indicate the differences from baseline with no instruction. Error bars indicate standard errors. The legend indicates the number of other agents.

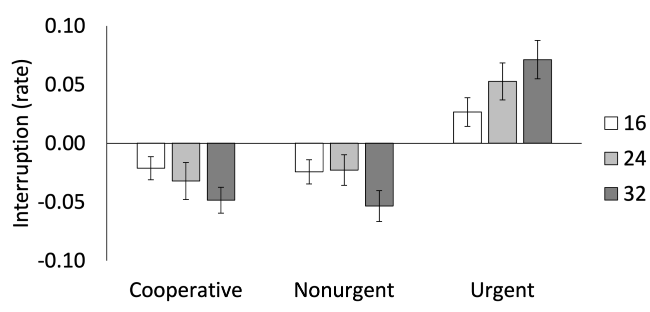

Figure 4. Means of Interruption Rate. Values indicate the differences from baseline with no instruction. Error bars indicate standard errors. The legend indicates the number of other agents.

III. RESULTS

One participant was excluded due to incomplete data, and the remaining 23 participants were analyzed.

A. Completion Time

The values in Figure 3 indicate the differences from baseline. One-sample t-tests were performed with the baseline for all conditions. The results show significant differences from the baseline in all nine conditions. The completion time in the cooperative and nonurgent conditions was significantly longer, while the completion time in the urgent condition was shorter than baseline. Comparisons of the results of t-tests between the BEP and the FPP are shown in Table I.

As in the BEP experiment, direct comparisons were made between the cooperative and nonurgent conditions. The results of the 2 (instructions) × 3 (number of others) ANOVA showed that there were no main effects of instructions ($F(1, 22) = 0.411, p = .527, \eta_p^2 = .018$) and number of others ($F(2, 44) = 2.796, p = .071, \eta_p^2 = .112$), nor interaction between instructions and number of others ($F(2, 44) = 1.110, p = .341, \eta_p^2 = .047$).

Therefore, the trend of cooperative behavior could be observed for completion time in the FPP task, although there was no salient difference from the nonurgent condition.

B. Interruption

The same t-tests were performed for interruption (Figure 4). The results showed significant differences from baselines in all but 24 others conditions in the cooperative and nonurgent conditions. This means that the amount of interruption was less in the cooperative and nonurgent conditions and greater in the urgent condition. A direct comparison showed that there were no main effects of instructions ($F(1, 22) = 0.002, p = .962, \eta_p^2 = .000$) and number of others ($F(2, 44) = 2.270, p = .115, \eta_p^2 = .093$), nor interaction between instructions and number of others ($F(2, 44) = 0.533, p = .590, \eta_p^2 = .023$).

Therefore, the trend of cooperative behavior was also observed for interruption in the FPP task, although there was no salient difference from the nonurgent condition. The results that interruption was not reduced in some cases are consistent with the results in the BEP experiment (Table I).

TABLE I
RESULTS OF ONE-SAMPLE t-TESTS WITH BASELINE.

	Bird's-eye pers.			First-person pers.		
	5	10	20	16	24	32
Completion Time						
Cooperative	+	+	+	+	+	+
Nonurgent	+	+	+	+	+	+
Urgent	−	−	−	−	−	−
Interruption						
Cooperative	−		−	−		−
Nonurgent				−		−
Urgent	+	+	+	+	+	+

Notes: "+" indicates a significant positive value and "−" indicates a significant negative value compared to the baseline based on the results of one-sample t-tests with baseline.

IV. DISCUSSION

This study examined whether the nature of cooperative behavior observed in the BEP task was replicated in the FPP task. The results of the baseline comparison showed that behavioral performance was almost identical in the BEP and FPP tasks. That is, both cooperative and nonurgent behavior increased completion time and decreased interruption compared to baseline. Surprisingly, interruption was affected by the number of other agents in both experiments. Thus, this research shows that the nature of cooperative behavior is independent of perspective. This also indicates the high effectiveness and reliability of the BEP task as an experimental paradigm for verifying various moving behaviors.

However, the direct comparison revealed some differences between the BEP and FPP tasks. Significant differences between the cooperative and nonurgent conditions were found for completion time and interruption in the BEP task, but these differences were not found in the FPP task.

A. Effect of Perspective

In general, the nature of cooperative behavior was somewhat less salient in the FPP task than in the BEP task, although these trends were similar. One possible reason for this is that it is difficult to understand the positional relationship between oneself and others in the FPP [16]. From the FPP, individuals could only get the positional information in front of them. Thus, they may not notice the presence of others approaching from the left or right and may inadvertently obstruct others. In addition, the FPP makes it difficult to identify the path to the goals, which leads to an increase in completion time in the cooperative condition. As a result, the differences with the nonurgent condition may be eliminated. In other words, the reason for the increase in completion time in the cooperative condition may be that individuals often accelerate or decelerate and make large turns to obtain as much positional information as possible.

B. Fidelity and Validity of Bird's-eye View Experiment

The results of this study show that the nature of cooperative behavior was confirmed in the realistic FPP, and the BEP task has high validity for verifying moving behavior. In the BEP task, participants can obtain objective information more easily than in actual traffic situations. In addition, the fidelity of the BEP task is considered to be lower than the FPP task. In general, low-fidelity environments have the advantage of facilitating factor control, but the behavior observed in such an environment may not be realistic or reliable.

However, the moving behavior in the BEP task is generally consistent with that in the FPP task, and its validity is also sufficiently high. Therefore, we conclude that the BEP task is useful to verify cooperative behavior even in complex traffic situations. Furthermore, these findings suggest that our tasks may be useful for verification of other various behavior.

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