# Which improves efficiency, changing or monitoring messages in the continuous-time cheap talk? -Experimental Evidence-

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**Abstract**

Continuous-time cheap talk is known to increase the achievement of Pareto-efficient outcome in minimum effort games. This study analyzes what features of continuous-time cheap talk are important for achieving Pareto efficient outcome. The features of continuous-time cheap talk are that players can change their messages as many times as needed and players can constantly monitor the distribution of messages in the group. Our analysis shows that message changes do not lead to the achievement of Pareto efficient outcome and that monitoring messages is important for the achievement of Pareto efficient outcome.

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JEL classification: C72; C92

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## 1. Introduction

It is known that Pareto efficient equilibrium is difficult to achieve in the minimum effort games (Van Huyck et al. 1990). In recent years, there have been studies on continuous-time cheap talk, where participants can change their own messages and monitor each other's messages in real-time (Deck and Nikiforakis 2012; Leng et al. 2018; Toku et al. 2020a). These studies show that continuous-time cheap talk is more effective to improve social welfare than ordinary one-shot cheap talk. This study analyzes what feature of the continuous-time cheap talk is important for achieving the Pareto efficient outcome.

Continuous-time cheap talk has two main features. The first is that a player can change the message any times. The second is that a player can constantly monitor the distribution of messages in the group. As soon as someone in the group changes the message, the screen is updated to show the latest distribution.

We used the data from two continuous-time cheap treatments conducted by Toku et al. (2020b): Limited Feedback treatment and Full Feedback treatment. In Limited Feedback treatment, subjects are informed only the minimum effort in the group at the end of each round. In Full Feedback treatment, subjects are informed the distribution of effort within the group at the end of each round.

Our main results are as follows. Changing messages does not contribute to improve efficiency. This implies that monitoring other's message contribute to improve efficiency.

## 2. Method

We obtained the data from Toku et al. (2020b). A total of 144 undergraduate students from various disciplines at Kansai University participated in 6 sessions. Their experiments were conducted using the z-Tree (Fischbacher, 2007). The experimental instructions and confirmation tests replicated those used by Blume and Ortmann (2007). Participants were randomly and anonymously divided into groups of nine and played eight rounds of the minimum effort game. Group members were fixed throughout the session and did not receive any prior information about the number of rounds to be played. Table 1 shows the payoff table. The minimum effort game of this payoff table has seven Pareto-ranked Nash equilibria. In the Pareto efficient equilibrium all members choose the effort level 7. However, if the participant chooses the effort level 7, the participant's payoff can be minimal.

They conducted two treatments: Limited Feedback and Full Feedback. Each treatment consisted of the message stage and the action stage. In the message stage, participants choose a number between 1 and 7 and send it as a message to members of the same group. In the message stage, participants can change their messages as needed and can constantly monitor the distribution of messages within the group in real-time. The distribution of messages in the group is updated

whenever a group member chose a message or changed it. Figure 1 shows an example screen of the message stage. The message stage end when everyone selects the "Next stage" or when five minutes after the start of the message stage. Participants then proceed to the action stage. In the action stage, the distribution of messages within the group is displayed and each participant choose their effort level. After the action stage, in the limited feedback treatment, each participants' screen is displayed the group's minimum effort, round earned payoffs, and cumulative earned payoffs, while in the Full Feedback treatment, each participants' screen is displayed the distribution of effort levels along with minimum effort, earned payoffs, and cumulative earned payoffs.

Table 1. Payoff table

| | | Smallest effort chosen within group | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Your choice of effort | 1 | 0.7 | - | - | - | - | - | - |
| | 2 | 0.6 | 0.8 | - | - | - | - | - |
| | 3 | 0.5 | 0.7 | 0.9 | - | - | - | - |
| | 4 | 0.4 | 0.6 | 0.8 | 1 | - | - | - |
| | 5 | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 | - | - |
| | 6 | 0.2 | 0.4 | 0.6 | 0.8 | 1 | 1.2 | - |
| | 7 | 0.1 | 0.3 | 0.5 | 0.7 | 0.9 | 1.1 | 1.3 |

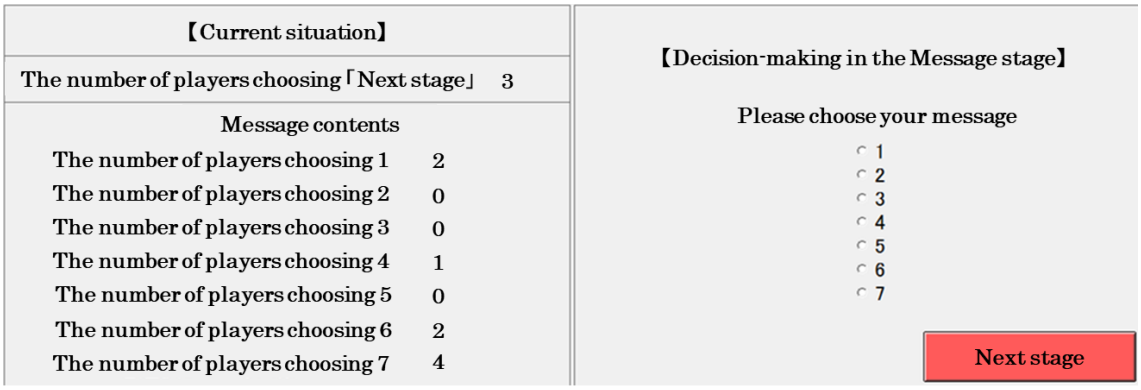



Fig. 1. Screen shot of the message stage

## 3. Results

We analyze which is more important to achieve Pareto efficient outcome, monitoring messages or changing messages. In minimum effort games, the effort levels chosen by participants is known to converge as they approach the final round (Van Huyck et al. 1990, Toku et al. 2020a). Therefore we say a group *achieves Pareto efficient outcome* if every member choose effort level 7 in the

final round.

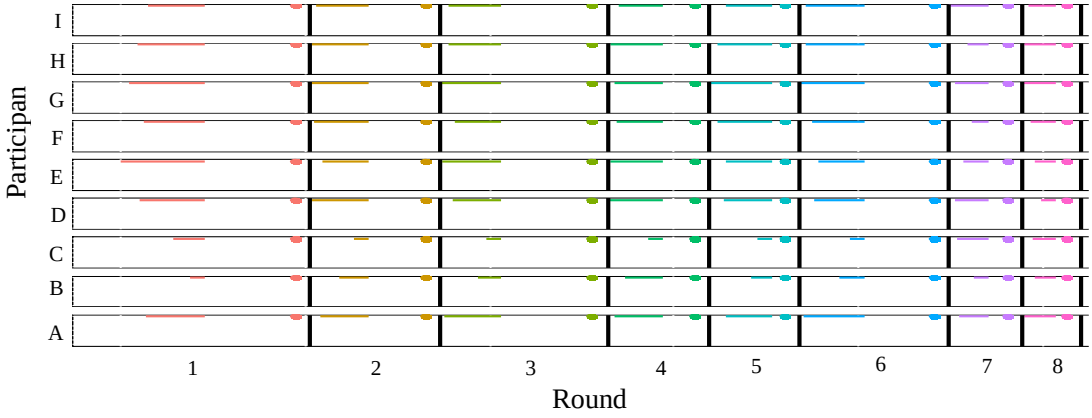
Consider the following example of two groups that succeeded or failed to achieve the Pareto efficient outcome in the Full Feedback treatment. Figure 2A show the time-series graph of the message stages and action stages for one group that achieved Pareto efficient outcome. The horizontal axis is round and the vertical axis is the message level or effort level, separated by each participant. Each line is the message level and each point is the effort level. The same applies to Figure 2B which shows a graph for Pareto inefficient outcome. As can be seen in Figure 2A, participants rarely changed their messages when their first message choices were aligned with 7 in the first round. In many groups that achieved Pareto efficiency outcome, the first chosen messages were aligned with 7 in the first round.

It is important to align the first chosen message 7 in the first round for achievement of Pareto efficient outcome. We define *the initial message* as the first message that each participant chose in the first round. 7 out of 16 groups achieved Pareto efficient outcome, and 5 of those groups aligned the initial messages 7. According to the data from Toku et al. (2020a), there were no group that initial messages are aligned with 7 in one-shot cheap talk without monitoring messages. In the continuous-time cheap talk, it is easy for participants to align initial messages because the participants know the message level of the members chose before they choose the initial message. Therefore, we consider that the alignment of the initial messages 7 is due to the effect of monitoring messages. The feature of monitoring messages in the group affect the achievement of Pareto efficient outcome.

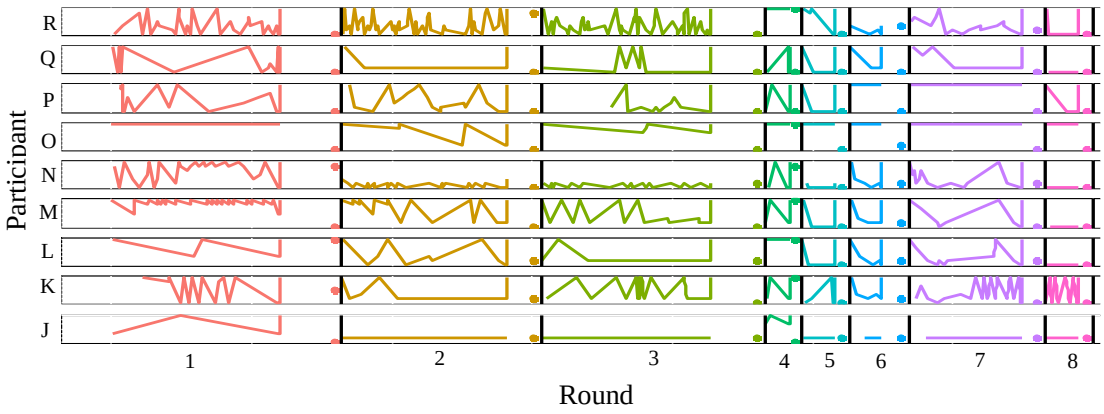
On the other hand, as can be seen in Figure 2B, participants in the group that failed to achieve Pareto efficient outcome frequently changed their messages. Some participants changed their messages from 7 to another level and then back to 7 if members' message levels did not align with 7. This behavior implies that members who did not choose 7 were prompted modifying to choose 7. We confirmed this indication in most of the groups that did not align the initial messages 7.

Changing messages seems to be an important way to communicate within the group if the initial messages did not align with 7. However, as can be seen from Table 3, changing the messages, including induction, rarely lead to achieving Pareto efficient outcome. Table 3 summarizes whether the group that has changed the message led to achieving Pareto efficient outcome. We define *the group that has changed the message* as a group that has changed the message at least once in all rounds. Groups in which all members chose the initial messages 7 are excluded because if the initial messages are aligned with 7, the subsequent messages do not need to be changed. In Table 3, 8 out of 9 groups have changed the message. In most of the groups, participants change their messages when initial messages did not align with 7. However, almost none (1 out of 8) that have changed the message achieve Pareto efficient outcome. We did not confirm that changing messages in continuous-time cheap talk direct effectiveness for achieving Pareto efficient

outcome.




(A) A group that succeeded to achieve Pareto efficient outcome




(B) A group that failed to achieve Pareto efficient outcome

Fig. 2. Real-time message level by participant for a group in Full Feedback treatment. (A) A group that succeeded to achieve Pareto efficient outcome, (B) A group that failed to achieve Pareto efficient outcome. Each row indicates the behavior of a single participant. Each line is current message and each point is effort level. The height of each row indicates the message and effort level from low (1) to high (7). The vertical lines indicate the start of a round.

Table 3. Summary of results for groups which changed message even once.

| | Pareto efficient outcome | Other outcomes |
|---|---|---|
| Group that has changed the message | 1 | 7 |
| Group that has not changed the message | 1 | 0 |

Note: Except for groups in which every member chose the initial message 7.

## 4. Conclusion

In this study, we analyzed what feature of the continuous-time cheap talk is important for achieving the Pareto efficient outcome. Continuous-time cheap talk allows participants to change their messages as many times as needed, and participants can constant monitor the distribution of messages in the group.

Our findings are as follows. First, every member choosing initial message 7 is important for achievement of Pareto efficient outcome. Monitoring message help participants to align initial messages. Therefore, in minimum effort games, monitoring messages is important for achievement of Pareto efficient outcome. Second, changing messages is not important for the achievement of Pareto efficient outcome. When initial message did not align with 7 in the group, participants change their messages, including induction. However, changing the messages rarely lead to achieving Pareto efficient outcome. We did not confirm the improvement of the efficiency by changing messages.

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