

# Analyzing the Effect of Sense of Being in the Same Room through Video Chat Systems on Work Efficiency

Koudai Shingou, and Takahiro Kawaji

**Abstract**— Video and audio communication over a network lose its sense of presence over time. However, social facilitation is more efficient when several people work in the same room than when one person works alone. Although there is no research on whether telework and distance learning using video chat systems can provide the same performance as face-to-face environments. This study examined whether social facilitation could occur when one person worked alone while a monitor was set up to project another person doing the same task. The Uchida-Kraepelin performance test was used to measure work efficiency using speed and accuracy. The results showed that the work efficiency is the same as when several people worked in the same room, even though it did not provide the sense of being in the same room.

**Index Terms**— *Sense of being in the same room, Video chat system, Work efficiency, Social facilitation.*

## I. INTRODUCTION

THE pandemic due to COVID-19, which began in 2020, has made telework and distance learning commonplace. At the peak of the pandemic, 69.0% of employees in the U.S. [1], and 62.0–97.8% in Japan teleworked [2]. Telework is expected to continue to be utilized in the future.

The development of Internet technology has diversified the means of online communication. Text-based communication is not limited to e-mail; text chat systems (e. g., Internet Relay Chat) and social networking services (e. g., Twitter) are utilized as well. Furthermore, there are image-based communication services such as Instagram.

Moreover, there is communication through the video. In one example, video chat systems such as CU-SeeMe began to be commonly used in the mid-1990s. Today, they have become installed as standard in smartphones. Video-based communication has become common and is utilized for business.

However, some issues remain regarding the efficiency of telework and distance learning. The video and audio over a network (e. g., Internet) is widely used in telework and distance learning. In this environment the sense of presence is lost over time [3]. Therefore, it is unknown whether telework and distance learning using video chat systems can achieve the same performance as face-to-face environments.

## II. RELATED WORK

The effect of people's presence on performance is explained in social psychology by social facilitation and inhibition. The former refers to the finding that a simple task is more efficient when performed by several people than by one person. Social inhibition is known to occur when an unfamiliar and complex task is targeted.

### A. Research on Social Facilitation and Social Inhibition Using Virtual Human

The participants were presented with three different types of subjects: a real human, a projected virtual human, and a virtual human reflected in a head-mounted display. Social inhibition was observed in the two conditions in which the virtual person was presented whereas social facilitation did not [4].

In the brainstorming session, higher-quality ideas were generated when the participant was a robot [5]. Hence, creative activities can be considered for complex problem solving, as self-efficacy during group communication is enhanced when the other party is not a human being.

### B. Research on Social Telepresence in Education

In remote education, there is an attempt to provide a real-time 360-degree video stream to the classroom using a head-mounted display with a pass-through view of the user's hands and mixed reality [6]. The effect is recognized with more physical interaction between students and teachers.

There is also research on personalizing telepresence robots for students who are absent to help them make social connections [7]. The participants examined their perceptions of the robot and the sense of self-presence. The results showed that they were comfortable with the telepresence robot.

### C. Research on Work Efficiency

Work efficiency related to creative matters (such as highly original ideas) is partial. For example, Nonaka et al. [8] assigned typing as a task to measure work efficiency. The efficiency of working alone in a room was compared to that with another person in the room. The results showed that participants who first occupied the room felt "comfortable" and their work efficiency improved. Regarding the positional relationship between the two participants, they recognized each other's presence and improved their work efficiency while avoiding eye contact, even when others were in the same room.

Yoshida et al. [9] assigned tasks such as simple manual

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work (folding origami paper into triangles twice), adding two digits, and erasing hiragana (erasing certain letters from a sentence). Moreover, an associative task was set up to measure creativity: “Show a picture that looks like a black inkblot and try to name the items it looks like in five minutes.” Three conditions were set up to study work efficiency: solitary (only one person in the room), partitioning screen (a group of 3 to 4 people separated by partitioning screen), and group (a group of 3 to 5 people in a separate room). As a result, the amount of work in the solitary condition was the lowest, and that in the group condition was the highest. This result indicates that work efficiency is better when multiple people work in the same room.

In both cases, the measurement focus of work efficiency is on speed and accuracy. Therefore, we also define work efficiency as completing a task (1) fast and (2) without errors.

### III. PURPOSE

The research in Section II.A reports on how the projection of virtual humans and robots on projectors and monitors affects social facilitation and inhibition. However, there is no comparison to a living person projected on a monitor.

The research on social telepresence in Section II.B assumes that the participants communicate with each other. Although, the sense of being in the same room has not been examined.

The study in Section II.C reports on shared real space. Therefore, it is not based on the assumption of virtual adjacency by the video chat system, and as in Section II.B, it does not examine the effect of the sense of being in the same room.

Thus, we use the environment proposed by Kawaji [10] to explore the impact on work efficiency when assuming virtual neighboring seats. Furthermore, work efficiency in this study is defined as (1) the speed of doing a task and (2) the error-free processing of the task, as derived from the study in Section II.C.

### IV. METHOD

#### A. Experimental Conditions and Environment

In this paper, we compare the work efficiency of the two conditions below.

- Condition A: Participants work next to each other in the same room.
- Condition B: Participants work in different rooms but are displayed on each other's monitors through a video chat system.

In Condition A, two experimental participants were seated next to each other in the same room. Initially, the space between the two participants was planned to be 2,000 mm, which is required for physical distancing to prevent COVID-19 spread. However, in the pre-test stage, some of the test collaborators reported that the distance was too much and they did not feel like they were sitting next to each other. Hence, it was set at approximately 1,700 mm, as declared appropriate by the test collaborators. A transparent acrylic panel was placed between the participants.

In Condition B, both participants were placed alone in

separate rooms. The rooms are usually used as conference rooms, and both are approximately the same size (approx. 5,450 x 6,900 mm).

To simulate a side-by-side situation, the 27-inch (Full HD) monitor was placed horizontally on the participant's right side, and their image was projected through the video chat system. The 27-inch monitor was adopted because it is the size typically used for desktop PCs. Distance between the monitor and the participant was approximately 1,000 mm, sufficient for the test collaborator to feel like a person was next to him in the pre-test stage.

Skype was used as the video chat system for the experiment. We asked the test collaborators to adjust the monitor so that collaborator's head aligned with the other's hand. The test collaborators confirmed that face-to-face video chats were available.

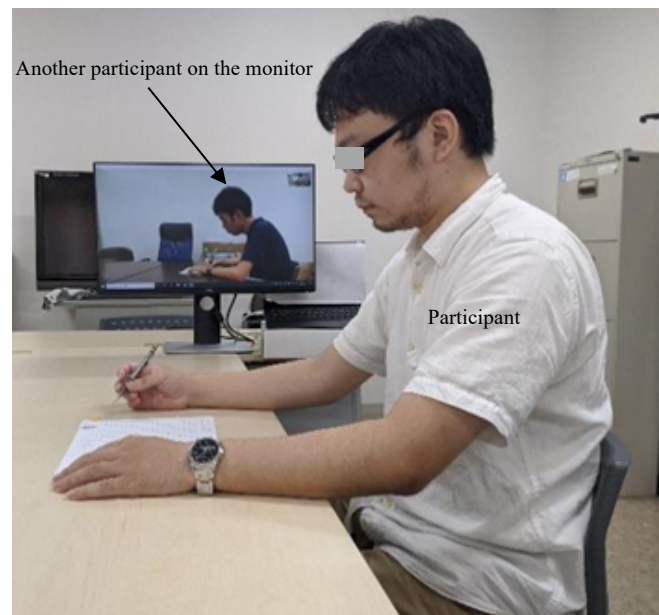


Fig. 1. Experimental environment in Condition B. A monitor is placed to the participant's right, and another participant is displayed on the monitor.

#### B. Experiment Overview

In this study, we used the Uchida-Kraepelin performance test (U-K test) as a task. Since the content of the U-K test is a simple task, social facilitation is expected in Condition A.

The U-K test is used initially to assess personality; whereas, in this study, to measure work efficiency, we only used the results of how many problems could be solved in a given time (speed) and how many could be answered correctly (accuracy). Speed is measured by the number of questions in the U-K test. Accuracy is measured as the percentage of correct answers.

The test used questions from the U-K test provider site [11]. One test form consists of one A4 size sheet. The test time was 15 minutes for the first half and 15 minutes for the second half, with 5-minute break in between.

Along with the U-K test, a questionnaire survey was conducted to ascertain the sense of being in the same room. The questionnaire was developed based on the items used by Nakanishi et al. [12] to determine the social telepresence.

Q1: I felt as if there was a person next to my desk.

Q2: I felt like I was looking at the person next to me.

Q3: I felt like I was being watched by the person next to me.  
Q4: I felt distant from the person next to me.

We used a 5-point Likert scale for questionnaire, where 1 = "I do not feel that way at all," 3 = "Neither," and 5 = "I felt that way a lot." Moreover, an unstructured interview was conducted after the questionnaire survey to discuss their feelings through-out the experiment.

#### 1) Details of the Experimental Procedure

First, the explanation of the U-K test prepared by the authors was read to the participants, and the method was explained orally. If there were any questions, we explained the contents and assumed that they understood the method of the U-K test. This explanation was conducted in the same room with two participants for Conditions A and B.

In the U-K test, the examiner must give instructions to move on to the next question every minute. However, in Condition B, we thought it was necessary to maintain a situation where there was only one person in the room, so substituted it with a timer that signaled three seconds before the minute was up.

In both Conditions A and B, the experiment was supposed to be conducted with two participants, but when only one participant could be secured due to circumstances, he or she was paired with a test collaborator. In Condition B, the participants were asked to confirm that they could communicate with the other participant on the monitor by waving their hands at each other.

#### 2) Participants in the Experiment

The participants in the experiment were 21 undergraduate and graduate students (13 males and 8 females). A total of 11 and 10 participants were assigned to Condition A and B, respectively. The data of one participant (male), who did not understand how to answer the U-K test, was not used for statistical processing.

The data of the collaborators were also not used for statistical processing. The participants in the experiment were informed in advance that the results obtained from the U-K test would not be used to judge their personality and behavioral tendencies.

### V. RESULT

#### A. Speed and Accuracy Results

First, we examined the speed at which the U-K test was solved. Since there was no normal distribution in the number of answers for Conditions A and B, the Mann–Whitney U test was used. No significant difference was found ( $p = .97$ ). TABLE I shows the results.

TABLE I  
SPEED RESULT ANALYZED WITH MANN–WHITNEY U TEST.

Condition	Median (Number of answers)	Quartile deviation
A	1662.00	200.50
B	1783.50	391.50

The next step is to examine the correct answer rate in the U-K test. The Mann–Whitney U test was used because the correct answers for Conditions A and B were not normally distributed. No significant difference was found ( $p = .91$ ). TABLE II shows the results.

TABLE II  
CORRECT ANSWER RATE RESULT ANALYZED WITH MANN–WHITNEY U TEST.

Condition	Median (Number of answers)	Quartile deviation
A	0.97	0.00
B	0.99	0.00

#### B. Results of the Questionnaire to Analyze the Sense of Being in the Same Room

The Mann–Whitney U test was used to examine each item of the questionnaire to confirm the sense of being in the same room. There was a significant difference in Q1 "I felt as if there was someone next to my desk." ( $p = .01$ ). However, there were no significant difference in Q2 "I felt like I was looking at the person next to me." ( $p = .50$ ), Q3: "I felt like I was being watched by the person next to me." ( $p = 1.00$ ), and Q4: "I felt distant from the person next to me." ( $p = .37$ ). TABLE III shows the results.

TABLE III  
RESULTS OF A QUESTIONNAIRE TO ANALYZE THE SENSE OF BEING IN THE SAME ROOM.

Question number	Condition A		Condition B	
	Median	Quartile deviation	Median	Quartile deviation
Q1	4.00	1.00	1.00	0.50
Q2	1.50	1.00	1.00	0.50
Q3	1.00	0.00	1.00	0.00
Q4	2.00	0.50	3.50	2.00

#### C. Results of the Interview to Confirm the Sense of Being in the Same Room

The results shows that although they felt the presence of the person in Condition A, they did not feel it to the extent that it interfered with their work, as expressed by, "If I had done it alone, it would have been tough. Hearing the sound of the person next to me flipping through the paper motivated me not to lose focus." "If I had done the test alone, I would have lost motivation and would have completed the test at a slower pace." However, we could also confirm that they did not care about the other participants in the same room, such as "I was concentrating on solving the problem and did not pay attention to others."

In Condition B, all participants reported a lack of other people's work sounds, such as "I cannot hear the sound of pencil writing," "I cannot see the monitor as a person." "I cannot see the whole body," or "It makes me aware of the bezels of my monitor." They also pointed out the lack of presence of people, such as "There is no sign of people." and "I feel like I am working alone." However, there was a response that suggested that the participants could be aware of the existence of the other participants in the experiment, "I felt that the timing of turning over the paper was different from mine."

### VI. DISCUSSION

First, U-K test was used to measure the speed and accuracy of the work in Conditions A and B. This showed that there was no difference in speed and accuracy between the two conditions. Therefore, it is thought that social facilitation occurs by showing another person doing the work on the monitor, similar to when working with multiple people in the same room.

The questionnaire results show a significant difference in Q1, “I felt like there was a person next to my desk,” indicating that there is more of a sense of someone in Condition A. However, there is no significant difference in Q2 to Q4. Based on those observations, in Condition B, the participants were able to sense the existence of a person next to them but could not properly feel it.

Nonetheless, in the interviews, many respondents indicated that Condition A had a better impact on work efficiency. This is inconsistent with the result of no difference in work efficiency (speed and accuracy). It is difficult to assume the environment adopted in Condition B, wherein a person sits next to a monitor showing another person. This indicates that the environment caused a discrepancy between the actual behavioral results and the feeling.

## VII. CONCLUSION

While collaborative work between remote locations, using audio and video over a network is rapidly advancing, there has been insufficient research on the efficiency of such work. To compare the work efficiency, we set up two conditions: one in which people work next to each other in the same room (Condition A), and one in which people work in a different room. Their images are projected on a monitor placed next to each other through a video chat system (Condition B). In Condition A, social facilitation occurs, and it is assumed that the work efficiency will be higher than when working alone.

Thus, no difference in work efficiency was observed between the two conditions. The questionnaire results showed that Condition A was more likely to convey a sense of working together. However, Condition B does not require as much social telepresence as conventional face-to-face communication. Thus, even if the sense of working together is not significant, it does not seem to have a significant impact on work efficiency.

The interview survey results also showed that the experimental participants did not feel a sense of working together in Condition B. As a rationale for this, the experimental participants stated that they would be more motivated to work if there were sounds and presence. This is also inconsistent with the results of work efficiency; however, the environment in Condition B is uncommon in real-world situations. Accordingly, it did not affect the work efficiency, but it may have affected the way the participants felt.

Many issues remain to be addressed. In this study, we focus on simple tasks in which the social promotion of work efficiency is supposed to occur. It is also necessary to try using complex tasks that are known to cause social inhibition. Further, to make the environment in Condition B more realistic, a monitor with the narrow bezels or a projector covering an entire wall to display a person in another room could be used.

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