Master Thesis

Utilization of Robot as Avatar and Its Effectiveness

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Abstract

In recent years, robots that can communicate with people have emerged and are being used in a variety of situations, including societal and domestic. Meanwhile, there have been attempts to use robots that can communicate with people as their own alter egos, called avatars. There has been a lot of research on robot avatars, and it is very important to consider and try to find out in what situations the robots can be used as a substitute for humans. In this study, to investigate the utilization and effectiveness of robots as avatars, two experiments were carried out, “product explanation by a robot” and “English conversation with a robot”.

In the “product explanation by a robot” experiment, the participants watched videos of a person or a robot explaining about sweets and answered a questionnaire. The questionnaire consisted of the following categories: ease of imaging the sweets, willingness to buy, desire to eat, and likeability to the person or robot. The results of the experiment showed that there was no statistically significant difference between in the case of the human and in the case of the robot in the ease of imaging, willingness to buy, and desire to eat, meaning that the robot was able to obtain the same level of evaluation as the human condition. There was statistically significant difference between in the case of the robot and in the case of human in the likeability.

In the “English conversation with a robot” experiment, the participants were asked to speak English with a human or a robot through a computer and to answer a questionnaire. The questionnaire consisted of categories such as ease of speaking, ease of listening, and nervousness. The results of the experiment showed that the values in the human condition are better than the robot condition and there were statistically significant differences in every category, except for the nervousness that was the same in the both conditions. On the other hand, when the participants were categorized into two groups according to their social communication skills, there was no statistically significant difference in the nervousness between in the case of the human and in the case of robot. However, the nervousness in the case of the robot is less than in the case of the human. From these results, there is a possibility that the use of a robot can be one of the ways to reduce nervousness in online English conversation.

The results of the two experiments showed that robots can be used as a substitute for people in one-way communication such as explanation and guidance, but in two-way communication that require advanced communications such as conversation, where the robot's response is necessary, using people is more desirable. However, it was suggested that the use of a robot might be an effective method in terms of reducing nervousness.

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1. Introduction

In recent years, with the development of technology, robots have been playing an increasingly important role. In the past, robots that performed a single task, such as industrial robots, were common. However, there is an increasing number of interactive robots that can, through communication, perform tasks and activities in collaboration with humans. The demand for robots is expected to increase in the future due to social factors such as labor shortage and countermeasures against infectious diseases caused by the new coronavirus.

There have been attempts to use communication-capable robots as avatars to perform tasks and to communicate with remote areas. In fact, there have been many studies using robots as avatars, and Nogami et al. proposed a system using humanoid robot avatars to participate in informal communication with local people in remote areas [1]. In addition to large humanoid robots, small wearable robots have also been used as avatars. Kashiwabara et al. have proposed a system in which two persons can share spatial awareness and use the demonstrative pronouns, by placing a small robot on the shoulder of one user for telecommunication [2]. There are also many important factors to consider when designing a robot as an avatar. In order to make the robot user friendly for anyone, Jun Ki Lee et al. have developed a communication model of robot made of six elements. First, the robot should respond to user's attention. Second, the robot should share attention and focus on an object with the user. Third, to understand the situation the robot should give real-time sensory information. Fourth, the robot should be easy to operate but still have wide range of expressions. Fifth, these expressions must be understandable and its personality should be endearing. Finally, the robot can be used from anywhere [3]. Thus, there is a wide range of applications and research using robot avatars, and it is very important to consider and try to find out in which situations robots can be used as a substitute for humans in the future.

In this study, two experiments were carried out, "product explanation by a robot" and "English conversation with a robot" to investigate the utilization and effectiveness of robots as avatars.

In Part 2, the background and purpose of the research are described. In Part 3, the effects of product explanation by a robot on the image of the product as well as the impressions of the robot and the effectiveness of robot as avatar are discussed. In Part 4, the effect of online English conversation with a robot, and the effectiveness of the robot as an avatar are discussed. Finally, in Part 5, the discussion of this study is addressed.

2. Background and Purpose of the Research

2.1 Research Background

In recent years, the development of technology has led to an increase in the use of robots. With the emergence of robots that can communicate with humans, robots are being used in a variety of situations, including societal and domestic. The demand for these robots is expected to grow further in the future due to external factors such as the labor shortage and need for improvement in the working environment, which are social problems.

There are also attempts to use robots that can communicate as avatars. For example, there is a case in which a person in Japan and a person in Hawaii can use a shoulder-mounted teleoperated avatar robot in their respective locations to communicate remotely across borders and cultures [4]. Another example is a service that allows people to enjoy fishing without going to a fishing spot by using an avatar robot to share sensory information about the moment a fish bites the bait, so that they can fish in a remote location [5]. As described above, there is a wide range of applications using robot avatars, and it is expected that the evolution of the Internet and robot technology will further expand the possibilities of robots and related research.

2.2 Purpose of The Research

There have been many studies on the use of robots as avatars, and it is very important to consider and try to find out in which situations robots can be used as substitutes for humans in the future. In this study, two experiments are conducted, “product explanation by a robot” and “English conversation with a robot” to investigate the utilization and effectiveness of robots as avatars.

3. Experiment I: Product Explanation by A Robot

3.1 Research Background I

In recent years, communication robots, which are capable of communicating with humans through conversation and other means, have come to be used in the fields of commerce, medicine, and nursing. As the market for robots expands [6], there are more and more opportunities to interact with robots in our daily lives, and a society in which humans and robots coexist is being constructed. Furthermore, due to the impact of the new coronavirus, our way of living is also changing, with the increase of non-face-to-face communication and online meetings. In this context, the need for non-contact communication become popular and robots are being used to guide people at train stations, to attract customers at supermarkets and so on [7]. From this point of view, more robots are expected to be used in various situations in the future [8].

On the other hand, onomatopoeia is also gathering attention. Onomatopoeia, originally from French, is a word that comprehensively expresses sensation and mimetic words [9]. There are about 4,500 onomatopoeic words in Japanese [10], which is far more than in any other language. Examples of onomatopoeia include さらさら (“sarasara” ie dry and smooth), きらきら(“kira-kira” ie shining), and てくてく(“tekuteku” ie trudgingly) which can describe the sensation and appearance of an object or phenomenon in a few short words, and are said to be more realistic and vivid than general phrases [11]. For this reason, it is often used not only in manga and novels, but also in advertisement and marketing.

3.2 Related Works: Onomatopoeia and Robot

There have been many studies on onomatopoeia and robots, and this research is still ongoing. The use of onomatopoeia by robots and its effect were investigated as well as the impression of these robots. Jimenez et al. investigated the learning effects from robots using onomatopoeia to talk to learners, and found that although there was no difference in test scores between the groups of robots using onomatopoeia or not, the learners' impressions of the robots were more “pleasant” when the robots used onomatopoeia[12].

There have also been studies on the effects of onomatopoeia on object impressions. Xue et al. simultaneously showed onomatopoeia and a picture of an object to participants, and examined how the impression of the object changed. The results showed that objects described as “silky smooth” even if they are not, tended to be perceived as “silky smooth”, indicating that onomatopoeia can change the image of an object [13].

Furthermore, there have been studies on onomatopoeia and advertising. Sumida examined whether word-of-mouth using onomatopoeia or word-of-mouth without onomatopoeia can convey product information more accurately. As a result, using word-of-mouth, advertisement using onomatopoeia were proven to be more efficient and gave a clearer image of the product than advertisement without onomatopoeia [14].

Purpose of The Research I

Related research focused on the effects of onomatopoeia on objects and the effectiveness of onomatopoeia in advertisement, but there has been no research on product explanations using onomatopoeia by robots or comparisons with the human scenario. In this study, the ease of imaging products, willingness to buy, and impressions of robots when they explain products using onomatopoeia were investigated. To study the effectiveness of the robot as an avatar, the same experiment was conducted with a human and compare with it.

3.3 Experiment Outline I

3.3.1 Purpose of The Experiment

The purpose of this experiment is to investigate the effects of the use of onomatopoeia in product explanations by a robot or a human on the willingness to buy, impressions of the robot or person, and the effectiveness of the robot as an avatar. Table 1 shows the experimental conditions and categories that are investigated in this experiment.

Table. 1. Conditions of experiment

Product Explanations	By Robot	By Human
With Onomatopoeia	Impression of Robot Willingness to buy etc	Impression of Human Willingness to buy etc
Without Onomatopoeia	Impression of Robot Willingness to buy etc	Impression of Human Willingness to buy etc

3.3.2 Methods

In the experiment, the participants were made to sit on a chair and watch four videos using a computer : a video of a product explanation by a robot with onomatopoeia, a video of a product explanation by a robot without onomatopoeia, a video of a product explanation by a human with onomatopoeia, and a video of a product explanation by a human without onomatopoeia. In addition, after each video, the participants were asked to answer a question about the content of the video and fill a questionnaire about their impressions. The order of the videos was switched for each participant in the experiment to avoid an order-dependent bias. The participants were 24 graduate students of Doshisha University (17 males and 7 females). None of the participants were acquainted with the person in the video, and 6 of them had seen the robot in the video before. Figure 1 shows procedure of the experiment, and Figure 2 shows the setup of the experiment.

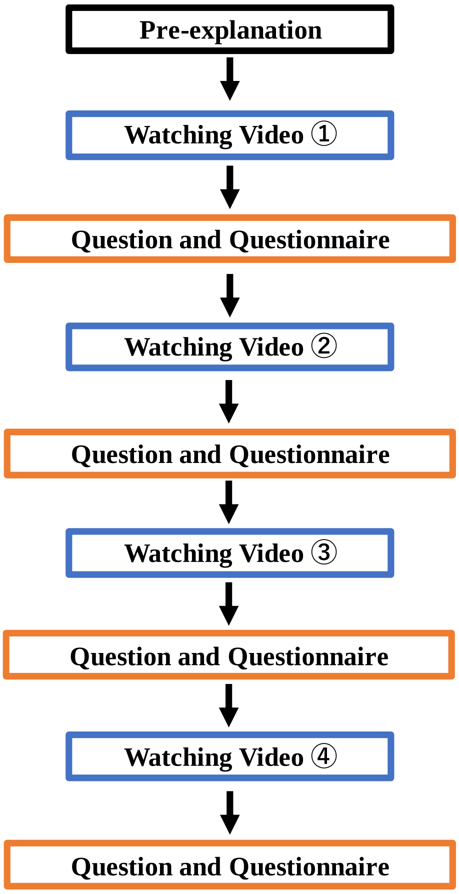


Fig. 1. Procedure of the experiment

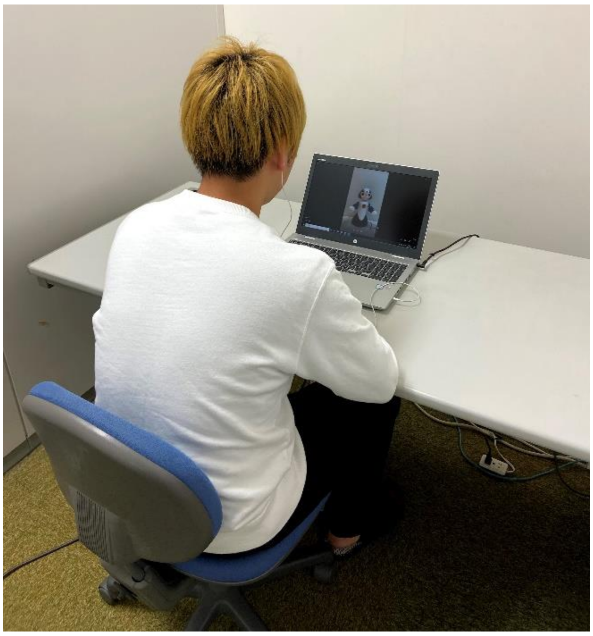


Fig. 2. Setup of the experiment

3.3.3 Actors of The Video

Figure 3 shows the appearance of the robot and human in the experiment. The product explainer in the video is a male Doshisha University graduate student. The robot in the video is Sota (Sota developer version) from Viston Corporation, which is equipped with Intel(R) Edison with LinuxOS, and is capable of image recognition, voice recognition, and speech synthesis. Sota is 28 cm tall and has 8 degrees of freedom (3 axes of head, 1 axis of torso, and 2 axes of arms), which enables it to move in various ways.

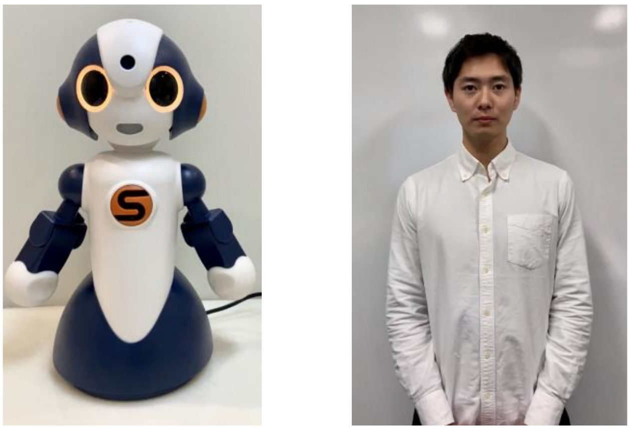


Fig. 3. Appearance of robot and human

3.3.4 Video

Four types of videos were shown to the participants: a video of a robot explaining a product with onomatopoeia, a video of a robot explaining a product without onomatopoeia, a video of a human explaining a product with onomatopoeia, and a video of a human explaining a product without onomatopoeia. In each video, a person or a robot explains about sweets, and the description is about 300 Japanese characters long. There are no pictures of the sweets being described, nor are the sweets shown in the videos. The explanation consists of an overview of the sweets, a description of the appearance, a description of the texture, and a description of the taste, in that order. In the videos with onomatopoeia, the number of onomatopoeias is set to 8. In this experiment, there were two types of speaker, human and robot, presence or absence of onomatopoeia, and four types of sweets. In total, 16 videos were created. Table 2 shows the description script of the sweets with and without onomatopoeia. Note that onomatopoeias are underlined in the description script.

Table. 2. Script of video

Script of video	
With Onomatopoeia	**Without Onomatopoeia**
このお菓子はパイ生地の上に砂糖と一緒に，長い時間をかけて，コトコト煮たリンゴを，隙間ができないようにたっぷり乗せてオーブンで丁寧に焼いたお菓子です．見た目はきつね色にこんがり焼かれた綺麗な光沢のあるリンゴがぎゅうぎゅうに詰まっていて，底には焼かれたパイ生地があります．口の中に入れるとリンゴのスッキリした甘さが徐々に広がって，そのあとにリンゴの酸味がほんのり感じられます．最後にパイ生地の香ばしい香りがします。噛むと，甘く煮た，リンゴの歯ごたえの良い触感と，パイ生地のザクザクとした触感が同時に楽しめます. スッキリとした，甘さになるように煮たリンゴを使っているので，後味もしつこくなく甘さもすぐに引いていきます.	このお菓子はパイ生地の上に，長い時間をかけて砂糖と一緒に煮たリンゴを，隙間ができないようにたくさん乗せて，オーブンで丁寧に焼いたお菓子です．見た目は，きつね色にまで焼かれた，綺麗な光沢のあるリンゴが，たくさん隙間なく詰まっていて，底には焼かれたパイ生地があります. 口の中に入れると，リンゴの爽やかな甘さが徐々に広がって，そのあとにリンゴのしつこくない酸味がかすかに感じられます．最後にパイ生地の香ばしい香りがほのかにします．噛むと，甘く煮たリンゴの歯ごたえの良い触感と，パイ生地の触感が同時に楽しめます．さわやかな甘さになるように煮たリンゴを使っているので，後味もしつこくなく甘さもすぐに引いていきます.
[Translation] This pastry is a pie crust filled with "many"(tattupuri) "simmered"（kotokoto） apples with sugar, carefully baked in the oven, taking all the space. The "many" (gyuugyuu) apples are "golden brown" (kongari) and shiny, and there is a baked pie crust at the bottom. When you put it in your mouth, the "subtle" (sukkiri) sweetness of the apple gradually spreads, followed by the "slight" (honnori) sourness of the apple. Finally, there is a savory aroma from the pie crust. When you bite into it, you can enjoy the texture of the sweetened apple and the "crunchy" (zakuzaku) texture of the pie crust at the same time. The apples are cooked to a "light" (sukkiri) sweetness, so there is no aftertaste and the sweetness recedes quickly.	[Translation] This pastry is a pie crust filled with many simmered apples with sugar, carefully baked in the oven, taking all the space. The many apples are golden brown and shiny, and there is a baked pie crust at the bottom. When you put it in your mouth, the subtle sweetness of the apple gradually spreads, followed by the slight sourness of the apple. Finally, there is a savory aroma from the pie crust. When you bite into it, you can enjoy the texture of the sweetened apple and the crunchy texture of the pie crust at the same time. The apples are cooked to a light sweetness, so there is no aftertaste and the sweetness recedes quickly.

3.3.5 Questionnaire

Figure 4 shows an example of Q1 about the content of the video, in which students are presented with four pictures of sweets and have to choose the one that was described in the video. The pictures of the sweets used in the experiment were taken from the Internet [15-18]. Table 3 shows the details of the questionnaire. The questionnaire consists of questions about the image of the described sweets and the willingness to buy them, questions about the likeability of the speaker, and questions about the anthropomorphism of robots. The question about anthropomorphism was asked only for the robot condition. The questions on likeability and anthropomorphism (Q5 and Q6) were asked following the Godspeed scale of Bartneck et al. [19]. In Q2-Q4, the participants were asked to answer the questions using the 7-point scale from “1: Strongly Disagree” to “7: Strongly Agree”. In Q5 and Q6, the participants were asked to rate the adjectives on a 7-point scale from “1: Negative” to “7: Positive”. For “likeability” and “anthropomorphism”, the average of the five items was used in statistical analysis.

Fig. 4. Example of Q1

Table. 3. Questionnaire

	Questionnaire
Q1	Select the image explained in the video?（four-choice question）
Q2	Did you feel that you were able to imagine the sweets explained in the video?(7-poimt Likert Scale)
Q3	Did you feel that you want to buy the sweets explained in the video?(7-point Likert Scale)
Q4	Did you feel that you want to eat the sweets explained in the video?(7-point Likert Scale)
Q5	Please rate your impression of the robot/human on these scales:(7-point Likert Scale) ・Dislike-Like ・Unfriendly-Friendly ・Unkind-Kind ・Unpleasant-Pleasant ・Awful-Nice
Q6	Please rate your impression of the robot on these scales: (7-point Likert Scale) ・Fake-Natural ・Machinelike-Humanlike ・Unconscious-Conscious ・Artificial-Lifelike ・Moving rigidly-Moving elegantly

3.4 Results I

3.4.1 Results: All Participants

The t-test was used for Q1 which had quantitative results. The p-values were adjusted according to Bonferroni method. Figure 5 shows the results of Q1 for all participants and for all conditions (HO: by human with onomatopoeia, HN: by human without onomatopoeia, RO: by robot with onomatopoeia, RN: by robot without onomatopoeia). Although there was no statistically significant difference between conditions, the average correct answer rate was slightly higher with onomatopoeia than without onomatopoeia in the case of a robot speaker. In the case of a human speaker, there was no difference between with and without onomatopoeia. This suggests that the use of onomatopoeia may be effective in conveying information correctly in the case of robots, while in the case of humans, participants were too focused on facial expressions and movements to pay attention to what was being said and were not aware of onomatopoeia.

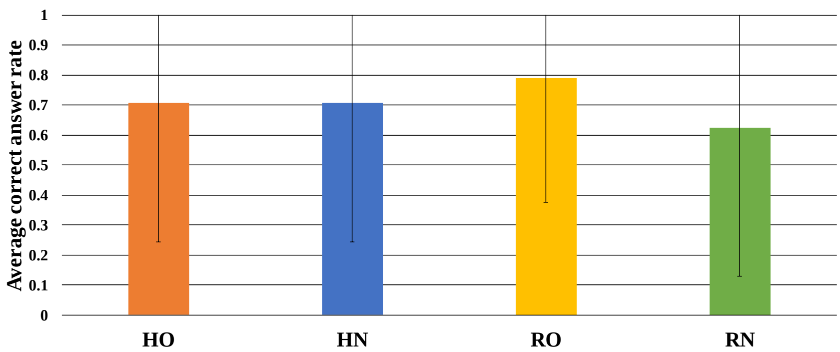


Fig. 5. Average correct answer rate

Wilcoxon signed rank test was used for Q2-Q6 which had qualitative answers. The p-values were adjusted according to Bonferroni method. Figure 6 shows the results for “ease of imaging”, “willingness to buy”, “desire to eat” and “likeability”. Likeability is the average of the five items shown in Table 3. From the results of the questionnaire, there was no statistically significant difference for the “ease of imaging”, “willingness to buy”, and “desire to eat” across conditions. On the other hand, there was a statistically significant difference ($p<0.1$) between HN and RO, and between HN and RN in “likeability”. This may be due to the appearance and size of the robot used in this study.

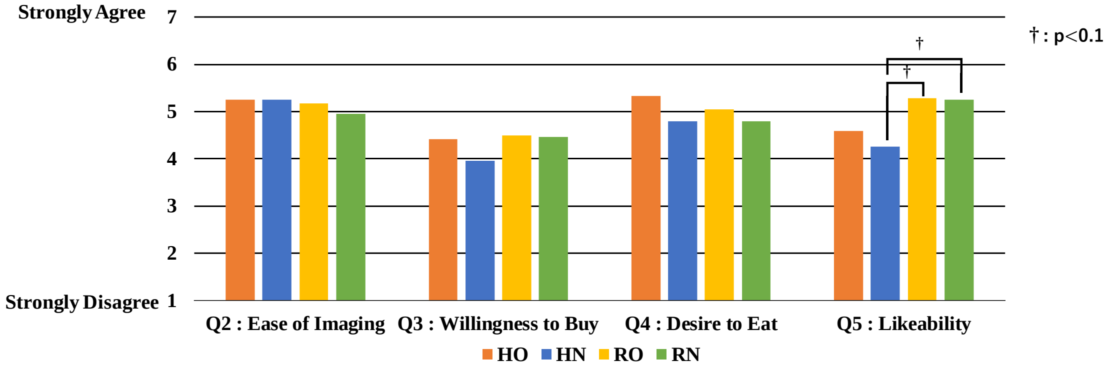


Fig. 6. Ease of Imaging, Willingness to Buy, Desire to eat, Likeability

Figure 7 shows the average values of the five items shown in Q6 (Table 3) about anthropomorphism toward the robot. There was no statistically significant difference between the two conditions, the values were low in both conditions and the robot was not seen as human-like. The robot used in this experiment can move its neck, body, and arms, but it cannot express facial expressions or mouth movements, therefore it did not look human.

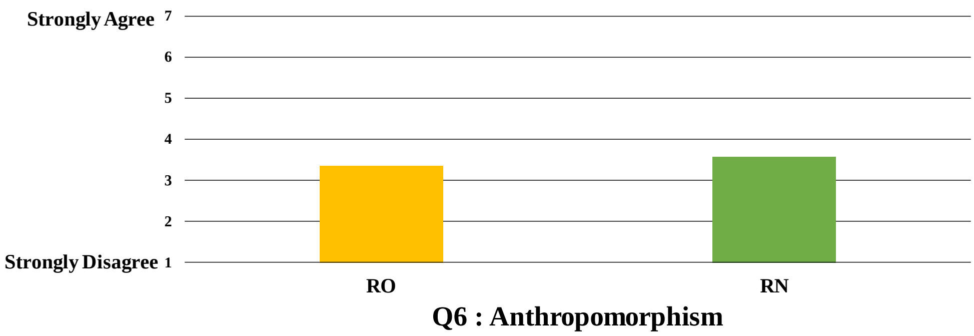


Fig. 7. Anthropomorphism

3.4.2 Results : With or Without Onomatopoeia

Additionally, in order to investigate the effect of onomatopoeia, the data of all the participants were categorized depending on the presence or absence of onomatopoeia. Figure 8 shows the results of Q1 classified by the presence or absence of onomatopoeia. Although there was no statistically significant difference, the average correct answer rate was slightly higher with onomatopoeia than without.

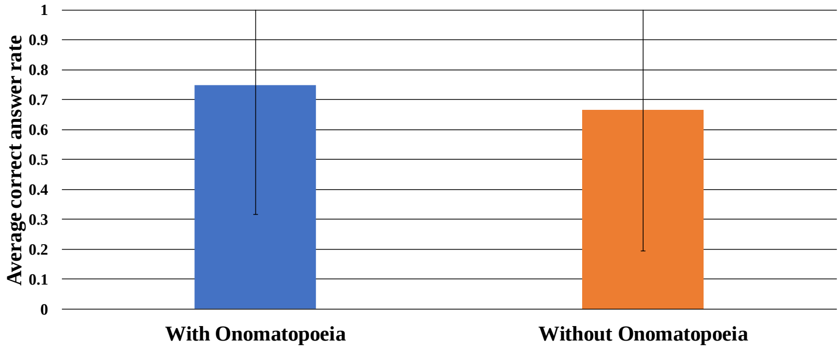


Fig. 8. Average correct answer rate
(With and Without Onomatopoeia)

Figure 9 shows the results for “ease of imaging”, “willingness to buy”, “desire to eat”, and “likeability" categorized depending on the presence or absence of onomatopoeia. Although there was no statistically significant difference in the categories between with and without onomatopoeia, there was a tendency for the values to be slightly higher with onomatopoeia in many categories. Although there may be a positive effect of onomatopoeia on each category, it may not have been felt by the participants in this experiment.

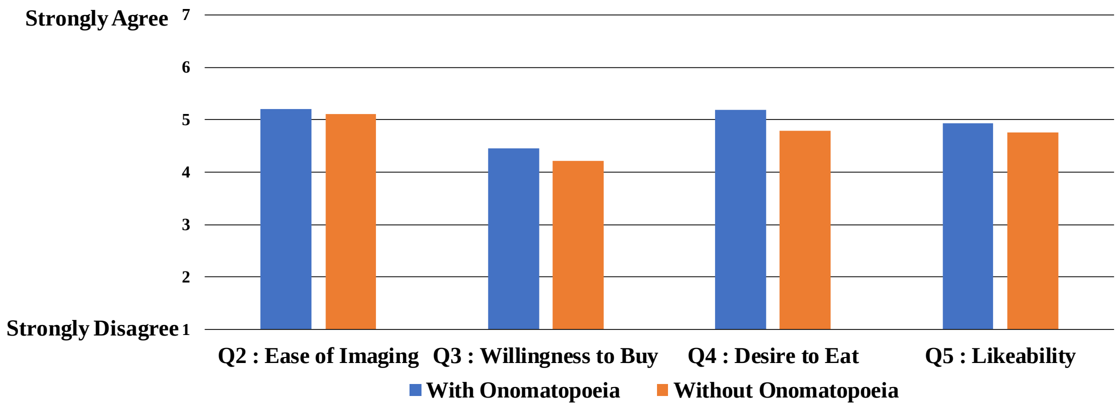


Fig. 9. Ease of Imaging, Willingness to Buy, Desire to eat, Likeability
(With and Without Onomatopoeia)

3.4.3 Results: Human or Robot

In order to investigate the effectiveness of robots for explaining the products in comparison to humans, the data of all the participants were classified according to the human or robot condition. Figure 10 shows the results of Q1 classified by speakers. There was no statistically significant difference between humans and robots, but the average correct answer rate was almost the same for the human and robot condition. This suggests that robots can be used as a substitute for humans because they can convey information as accurately as humans.

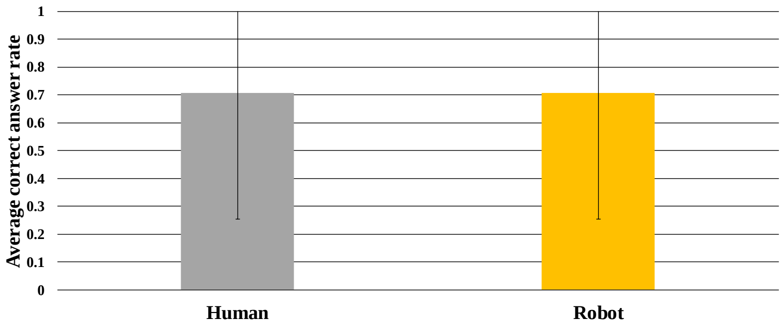


Fig. 10. Average correct answer rate
(Human and Robot)

Figure 11 shows the results of "Ease of imaging", "willingness to buy", "desire to eat", and "likeability" classified according to the human and robot condition. There was no statistically significant difference between the human and robot condition in "ease of imaging", "willingness to buy", and "desire to eat", but there was a statistically significant difference ($p<0.01$) in "likeability" between the robot and human condition. The statistically significant difference in likeability may be due to the cuter appearance of the robot "Sota" used in this experiment compared to the male human speaker.

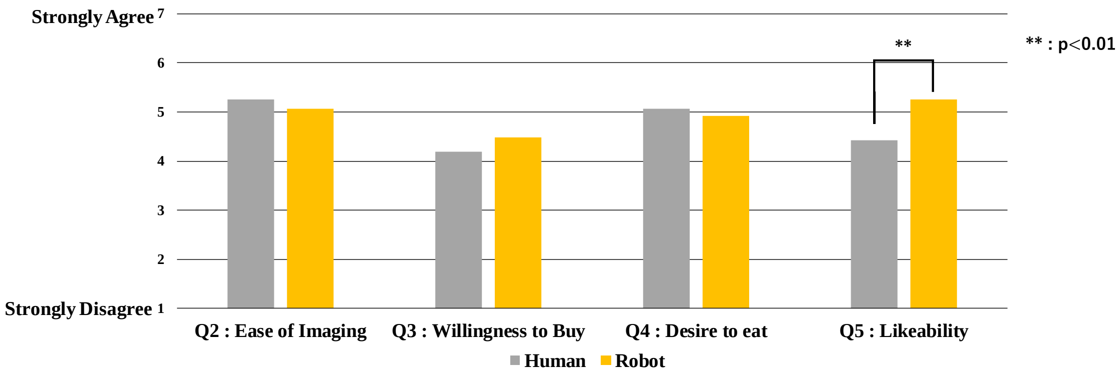


Fig. 11. Ease of Imaging, Willingness to Buy, Desire to eat, Likeability
(Human and Robot)

3.5 Conclusion I

In this experiment, it was investigated that the effect of onomatopoeia on product explanations by a human or robot, and the effectiveness of the robot as an avatar. The results of the experiment showed that there was no statistically significant difference for “ease of imaging”, “willingness to buy”, and “desire to eat” whether onomatopoeias were used or not. In related studies, for participants to be aware of onomatopoeia, it was used in short sentences of about 20 characters or in short utterances of about 5 seconds. On the other hand, in long sentences of about one minute, such as this experiment, the onomatopoeia was buried in the sentence, and the participants may not have been aware of its existence. In other words, in order to use onomatopoeia effectively, it is necessary to emphasize the onomatopoeia in short sentences, or to use the same onomatopoeia repeatedly for the participants to be aware of its existence. In addition, the willingness to buy and the desire to eat are determined by various factors such as the person's situation and the surrounding environment. It is possible that simply watching a product description video once may not lead to an increase in the willingness to buy and the desire to eat. Furthermore, the evaluation of anthropomorphism to the robot may have been low in both conditions with and without onomatopoeia because the robot used in this experiment did not have any facial expressions, and its speech intonation was not natural. In the future, as the accuracy of speech generation is improved and robots get facial expressions, it will be able to speak more human-like and the anthropomorphic view of the robot will improve.

As for the effectiveness of robots as avatars, the results of the question about the video’s content classified depending on the human and robot condition showed that robots can convey information as well as people. The results of the questionnaire showed that the robot had the same evaluation as the human, except in the “likeability” category where the robot had higher evaluation. This suggests that it may be better to use a robot as a substitute for a person in situations where likeability is needed, such as when talking to children or when a beginner learns English.

4. Experiment II: English Conversation with A Robot

4.1 Research Background II

In recent years, with the increase in availability of the Internet and digital devices, the number of people using e-learning has been on the rise. E-learning refers to the use of computers and networks for education, training, and learning [20]. The market size in Japan has been increasing year by year, from 176.7 billion yen in 2016 to 246 billion yen in 2020 [21], and the demand is expected to increase in the future due to the influence of the recent coronavirus. In addition, with the rapid progress of globalization in business and academia, there are more and more opportunities to speak foreign languages such as English with people of various nationalities, and language learning is popular among e-learners. On the other hand, it is not easy for beginners to speak English with native speakers in a non-face-to-face environment such as online English conversation lessons. They may also feel nervous and uncomfortable speaking.

4.2 Related Works: English and Robot

There have been many related works on English conversation learning using robots. In their study, Ichiryu et al. compared learning with regular English teaching CD and learning with a communicative robot. They also monitored the improvement in motivation and perseverance of English conversation beginners. The results showed that the participants who used the robot, viewed the robot not as a teaching tool but as a friendly "talking partner". Consequently, they felt that they wanted to talk more, which encourage them to keep using English and improved their motivation to study [22].

In the above-mentioned study, the robot and the learner did not interact with each other, the robot was used just as a teaching tool. Sungjin et al. conducted a class in which a robot acted as a salesclerk and conversed in English with Korean elementary school students, and found that their speaking test scores improved [23]. In addition, Hirano et al. conducted a conversation in English using a communication robot during break time at an elementary school involving about 200 students [24]. The results showed that the scores of the English listening comprehension test were higher after the experiment than before. On the other hand, there was no statistically significant difference between the group that spent a long time talking with the robot and the group that spent a short time talking with the robot in the scores of the English listening comprehension test. This suggests that the improvement in test scores was due to the effects of familiarization with the English test and learning triggered by the initial test, meaning that the conversations with the robot did not have any effects on English acquisition.

Thus, research is being conducted on robot teaching English as well as learning English with robots as classmates. Matsuzoe et al. tested the vocabulary of young children learning English words along with a Care-Receiving Robot (CRR), a type of robot that learn from students. They found that the percentage of correct answers on a vocabulary test with the robot was statistically significantly higher than without the robot [25]. As a result, the children with the robot were able to learn more English words than those without the robot.

4.3 Purpose of The Research

However, there has been no research on the use of robots in online English conversation, for which demand has been growing recently. Since the results of experiment I showed that robots are expected to be used in situations where likeability is needed, it is important to investigate the effects of using robots as English teachers and their effectiveness. Therefore, the purpose of this study is to investigate the effects of using a robot as an avatar in online English conversation and its effectiveness.

4.4 Experiment Outline II

4.4.1 Purpose of The Experiment

The purpose of this experiment is to investigate the effect of online English conversation on learners with a robot and the effectiveness of this robot as an avatar through questionnaires.

4.4.2 Methods

In the experiment, participants were asked to answer a pre-questionnaire, then take part in online English conversations with the teacher under three conditions: in the case of a human, in the case of a robot, and in case of a black screen. Besides, the participants answered a questionnaire and took a listening test. Figure 12 shows the setup of the experiment. The participant and the teacher were in separate individual rooms, and were asked to use headphones with microphones to speak English with a computer. In the experiment, Zoom, a web conferencing service provided by Zoom Video Communications Corporation, was used and the conversations were recorded during the experiment. Figure 13 shows the procedure of the experiment. Each conversation is about 5 minutes long, and the teacher tells the participant that the conversation is over after 5 minutes. In the listening test, the participants also had to answer five questions asked by the teacher through the computer using the same setting as the English conversation. The order of the three conditions was switched for each participant in the experiment to avoid an order-dependent bias. The participants were 24 graduate students of Doshisha University (15 males and 9 females), who are Japanese and native Japanese speakers.

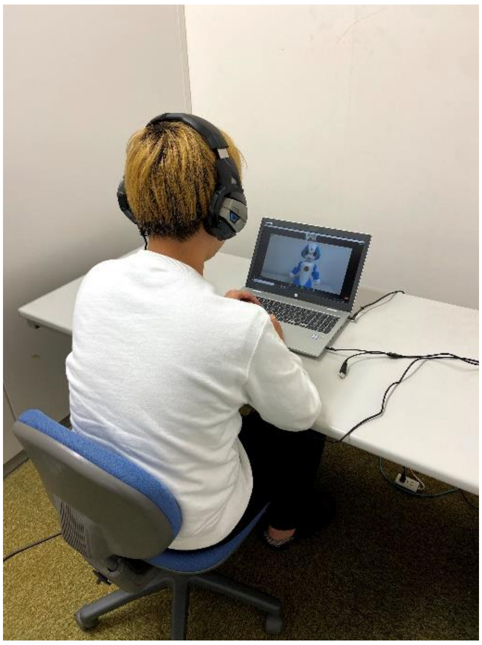


Fig. 12. Setup of the experiment

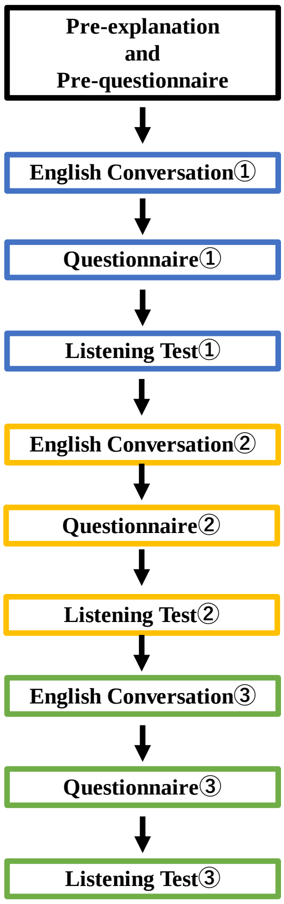


Fig.13. Procedure of experiment

4.4.3 Conversation Partner

The robot used in the experiment is Amaryllis (RoboConnect version of Sota, hereafter referred to as Sota) from NTT East Corporation. The appearance of Sota is the same as the one used in experiment I, but Sota's movement can be operated in real-time such as neck and arm movements. Sota is also equipped with telecommunication functions where its mouth glows red when it speaks. Fig. 14 shows the list of movements that Sota can perform, the operator can choose from 10 different movements such as "nodding" or "raising both hands".

Fig. 14. List of robot movements

The teacher in the experiment was a French student (female) from the graduate school of Doshisha University. Her native language is French, but she is fluent in English and has a TOEIC score of 980, making her a suitable teacher.

4.4.4 English Conversation

Japanese is not allowed to be used during the English conversations between the participants and the teacher. The topic of the conversation is not specified, so the students can talk freely, but the teacher is instructed to introduce herself at the beginning of the conversation. In addition, a list of topics such as travel and food is given in advance to the teacher for when the conversation stalls.

In the "human" condition, the participants can talk with the teacher while seeing her on the screen.

In the "robot" condition, the participants can talk with the teacher while seeing the robot as avatar. The teacher can control the robot in real time during the conversation by using a PC at hand, and can watch the participants through a camera attached to the robot. The teacher's voice is sent directly to the participants through Zoom.

In the "black screen" condition, the participants cannot see the teacher and only hear her voice, but the teacher can see the face of the participants. Figure 15 shows the computer screen of the participant in the "human" condition, the "robot" condition, and the "black screen" condition.

Fig. 15. Screen of computer
(Left: Human, Middle: Robot, Right: Black Screen)

4.4.5 Listening Test

The listening test was conducted three times using the same setup as the English conversations. The listening test consisted of five questions taken from the official TOEIC book [26]. The questions and answers were not written on the answer sheet, and the participants had to select the best response to the question or statement from three options (A), (B), and (C). At the beginning of the test, the explanation of the listening test was read out loud, then, the test started. During the listening test, the computer screens of the participants were turned on, and the conditions were the same as in the preceding English conversation: “human”, “robot”, and “black screen”. During the listening test, the teacher was able to see the participants at all times, and in all three conditions, the teacher read the questions and answers in real time rather than playing a recorded voice or CD. In this experiment, each question and answer were read out twice. Table 4 shows an example of the questions. The correct answer is written in red.

Table. 4. Example of the listening test

Question or Statement	Responses
1. Shall I contact you by e-mail or by phone?	(A)OK, I'll take a look at the contract.
	(B)Oh, did you?
	(C)Actually, I'll be seeing you tomorrow.
2. Didn't you organize the employee picnic last year?	(A)You can use the Milton room.
	(B)I've done it the past seven years.
	(C)No, it was free.
3.I found a new supplier for the garden fertilizer we use.	(A)Do they have good prices?
	(B)In the warehouse.
	(C)We sold a lot of flowers.
4.Why don't we offer a vegetarian dish at the lunch?	(A)I've been there a few times.
	(B)It may be too late to change the menu.
	(C)No, let's wash the dishes later.
5.How should I pay the deposit on the rental car?	(A)Do you have a credit card?
	(B)It's less expensive than that.
	(C)Yes, there's plenty of space.

4.4.6 Questionnaire

The participants were asked to answer the KiSS-18 as the pre-questionnaire in advance. The KiSS-18 is a five-level, 18-item questionnaire designed by Kikuchi to measure the social communication skills of young people [27]. The higher the total score of the 18 items, the better the communication skills. The mean score of male university students was 56.40 and that of female university students was 58.35 [27].

Table 5 shows the questionnaire. The questionnaire contains six questions in total, and each category is answered on a 7-point scale from "1: Strongly Disagree" to "7: Strongly Agree". Q1 and Q2 are questions about speaking, Q3 and Q4 are about listening, and Q5 and Q6 are about the atmosphere of the conversation.

Table. 5. Questionnaire

	Questionnaire
Q1	Did you feel that it was easy to talk?
Q2	Did you feel that the conversation partner listened to you carefully?
Q3	Did you feel that it was easy to listen?
Q4	Did you understand what the conversation partner said?
Q5	Did you talk without feeling nervous?
Q6	Did you talk without feeling unnatural?

4.5 Results II

4.5.1 Results: All Participants

■Quantitative Evaluation

In this study, t-test was used for all statistical analysis of quantitative results. The p-values were adjusted according to Bonferroni method. Figure 16 shows the average score of listening test for all participants. Although there was no statistically significant difference between the conditions, the average score was the highest for the human condition and the lowest for the robot condition. In addition, Tatsukawa's study showed that seeing the speaker facilitated listening comprehension compared to audio alone [28]. Therefore, it is possible that in the case of the human, the average score of listening test was the highest because the participants were able to obtain information about the speaker's face and lip movements by looking at the computer screen. On the other hand, in the case of the robot, there was no information about facial expressions or lip movements, and the robot's movements may have been distracting, resulting in the lowest average correct answers.

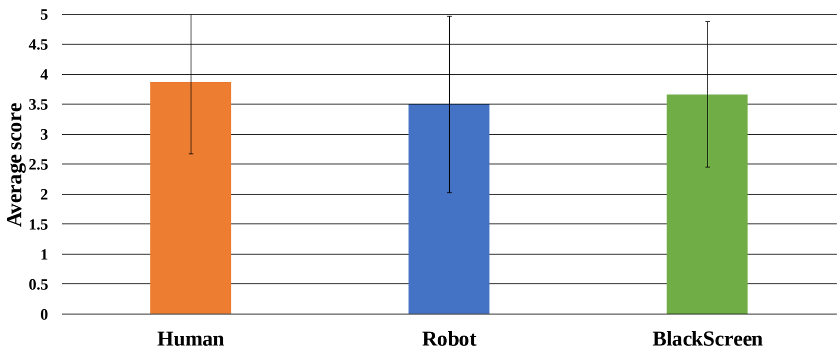


Fig. 16. Average score of listening test

Figure 17 shows the average screen gaze time during the English conversation for all participants. Statistically significant differences($p<0.01$) were found between the “human” and “robot” conditions, between the “human” and “black screen” conditions, and between the “robot” and “black screen” conditions. The results showed that the average screen gaze time was longer in the human condition than in the robot and black screen condition. When the computer screen was completely dark, there was no need to gaze at the screen, so the gazing time was shorter than that of the human and robot conditions. The reason why the average screen gaze time of the robot was shorter than that of the person was that the robot only had arms and neck movements and a glowing mouth whereas the human also had facial expression, such as eye and lip movements.

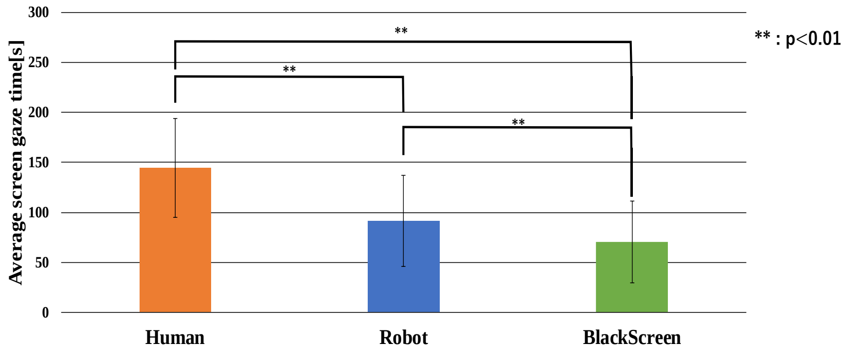


Fig. 17. Average screen gaze time

Figure 18 shows the average utterance time during the English conversation for all participants. There was no statistically significant difference between the three conditions; the average utterance time was about one minute out of the five minutes in all three conditions. Moreover, there were many occasions when they were silent or thinking about how to express themselves in English.

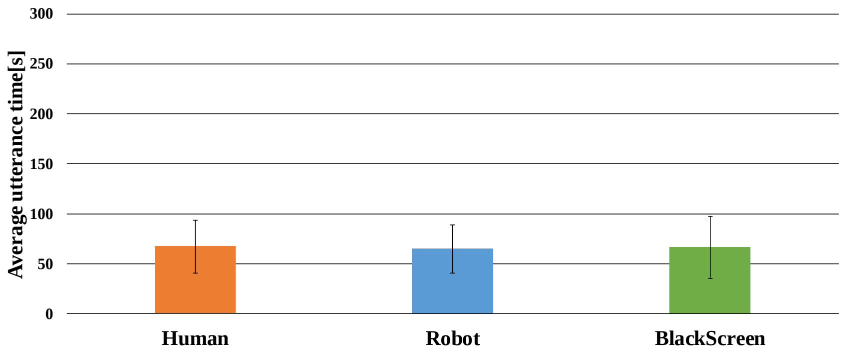


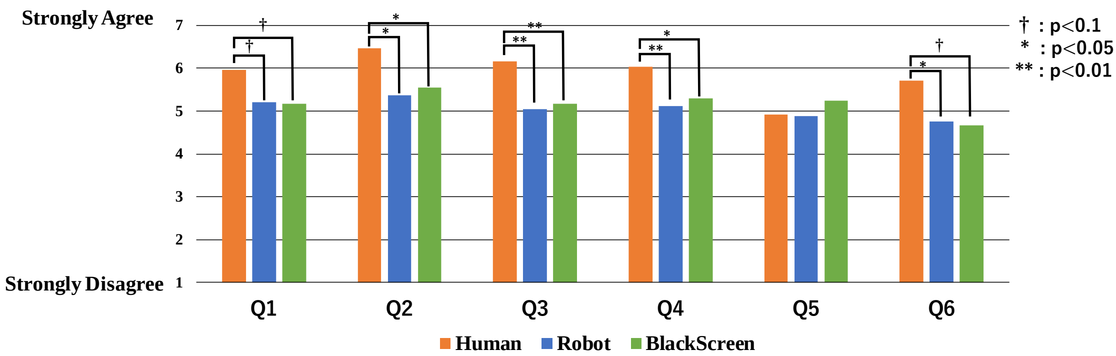
Fig. 18. Average utterance time

■Qualitative Evaluation

Figure 19 shows the results of the questionnaire. The Wilcoxon signed rank test was used for the questionnaire. For the questions in Q1-Q4 and Q6, the highest values tended to be obtained in the human condition, and there were statistically significant differences ($p<0.1$, $p<0.05$, $p<0.01$) between the robot condition and the black screen condition. This suggests that non-verbal information such as facial expressions, gestures, and hand gestures of an actual person makes it easier to understand and speak English.

On the other hand, for Q5 “Did you talk without feeling nervous”, there was no statistically significant difference between the conditions, but the rating was highest when the video was turned off.

In the case of the robot, the questionnaire results for many categories were lower than those in the other conditions, possibly because there was a time lag in the robot's response behavior when the participants asked the robot a question. Although the teacher was able to control the robot's movements from a PC at hand, there was a time lag between the time when the robot was instructed to move and the time when the participants actually sees the robot move. Therefore, it was difficult for the robot to move at the appropriate timing, and the movements that did not match the flow of the conversation may have negatively affected the results in the questionnaire.



Q1	Did you feel that it was easy to talk?
Q2	Did you feel that the conversation partner listened to you carefully?
Q3	Did you feel that it was easy to listen?
Q4	Did you understand what the conversation partner said?
Q5	Did you talk without feeling nervous?
Q6	Did you talk without feeling unnatural?

Fig. 19. Result of questionnaire

4.5.2 Results: Classification by KiSS-18

In order to investigate the results in more details, the participants were classified according to their KiSS-18 scores. In this experiment, those whose KiSS-18 scores were higher than the median of 62.5 were classified as the upper KiSS-18 group of 12 participants, and those whose score was lower than the median were classified as the lower KiSS-18 group of 12 participants as well. Figure 20 shows the average KiSS-18 scores of the upper and lower KiSS-18 groups. As a result, the mean KiSS-18 score of the upper group was 68.6, the mean KiSS-18 score of the lower group was 57.75.

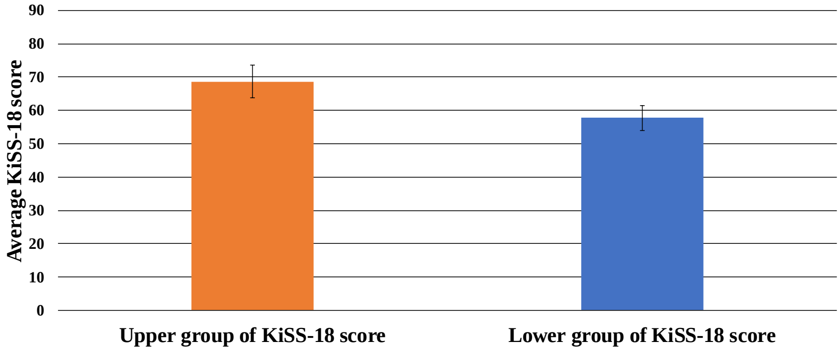


Fig. 20. Average KiSS-18 score

(Left: Upper group of KiSS-18 score, Right: Lower group of KiSS-18 score)

■**Quantitative Evaluation**

Figure 21 shows the results of the listening test in which the participants were classified by their social communication skills: the upper KiSS-18 group tended to give more correct answers than the lower group, and there was a statistically significant difference ($p<0.1$) between the KiSS-18 upper group and the lower group in the case of human. The average of correct answers was higher in the upper KiSS-18 group than in the other conditions in the case of human. It suggests that, while listening, people with good communication skills are able to understand more from facial expressions and mouth movements when people are speaking, which may have led to the increase in the average number of correct answers.

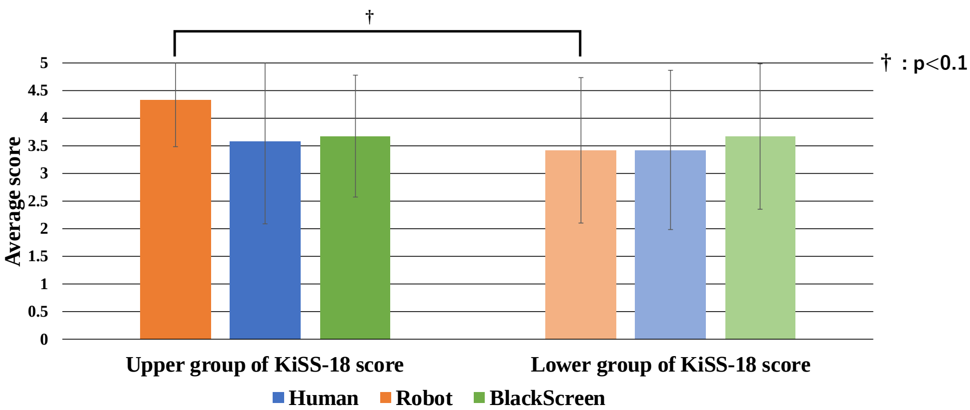


Fig. 21. Average score of listening test

(Left: Upper group of KiSS-18 score, Right: Lower group of KiSS-18 score)

Figure 22 shows the average screen gaze time of the participants classified by their social communication skills, and Figure 23 shows the average utterance time. There was no statistically significant difference between the upper and lower KiSS-18 groups in terms of screen gaze time and utterance time. This suggests that the effect of social communication skills on screen gaze time and utterance time during online English conversation is inconsequential.

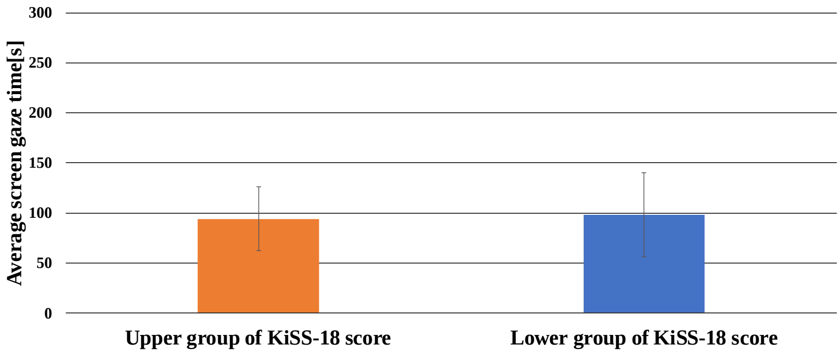


Fig. 22. Average screen gaze time

(Left: Upper group of KiSS-18 score, Right: Lower group of KiSS-18 score)

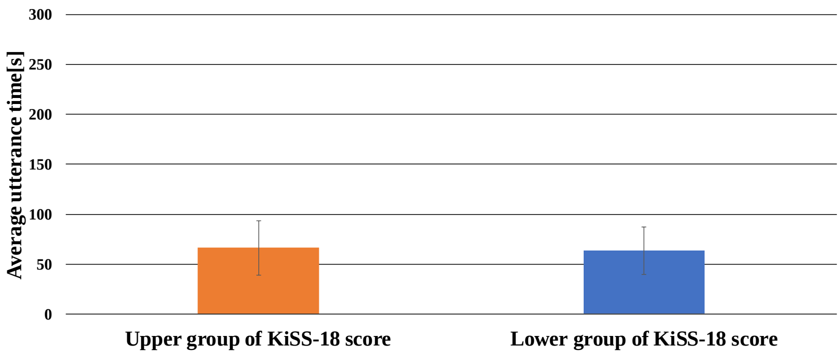


Fig. 23. Average utterance time

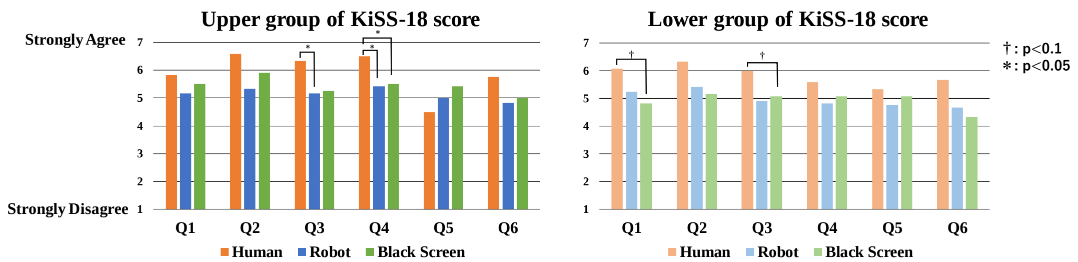
(Left: Upper group of KiSS-18 score, Right: Lower group of KiSS-18 score)

■Qualitative Evaluation

Figure 24 shows the results of the questionnaire categorized by social communication skills. As a result of the questions regarding speaking, Q1 “Did you feel that it was easy to talk” and Q2 “Did you feel that the conversation partner listened to you carefully”, in the upper group of KiSS-18, there was no statistically significant difference between the three conditions. On the other hand, in the lower group, the values were in descending order as follow “human”, “robot”, and “black screen”, and there was a statistically significant difference ($p<0.1$) in the Q1 “human” and “black screen” conditions. This suggests that the upper group of KiSS-18 was more sensitive to human speech and non-verbal information than the lower group of KiSS-18, and felt uncomfortable with the robot's delayed response and lack of facial expression, which may have resulted in the lowest values for the robot condition.

As a result of the questions regarding listening, Q3 “Did you feel that it was easy to listen” and Q4 “Did you understand what the conversation partner said”, both the upper KiSS-18 and lower KiSS-18 groups gave the highest values for the human condition, and the values for the robot and black screen were almost the same. The reason for this is that when listening to the other person speaking, how they speak is more important than their response. Therefore, it is possible that the delay in the robot's response did not bother them much, and that there was no big difference between the robot and the black screen.

In Q5 “Did you talk without feeling nervous”, there was no statistically significant difference between the three conditions for the upper KiSS-18 and lower KiSS-18 groups. In the upper group of KiSS-18 score, the nervousness is the highest in the human condition. This suggests that the group with higher social communication skills may be more sensitive to the other person's reaction, and therefore, they may have been more nervous in the case of a person. On the other hand, the group with lower social communication skills felt less nervous when talking with a person, which they were most familiar with, and felt more nervous when talking with a robot, which they did not usually do.



Q1	Did you feel that it was easy to talk?
Q2	Did you feel that the conversation partner listened to you carefully?
Q3	Did you feel that it was easy to listen?
Q4	Did you understand what the conversation partner said?
Q5	Did you talk without feeling nervous?
Q6	Did you talk without feeling unnatural?

Fig. 24. Result of questionnaire

(Left: Upper group of KiSS-18 score, Right: Lower group of KiSS-18 score)

4.5.3 Results: Classification by Listening Score

In order to investigate the results depending on English skill, the participants were divided into two groups: the upper and lower listening score groups. Figure 25 shows the average listening test scores of the upper and lower groups. The median score of 11 is used as the criteria to divide the participants. However, since six students had the same score as the median, they were omitted, and the two groups were formed. As a result of the classification, 10 students were in the upper group of listening scores and 8 students in the lower group.

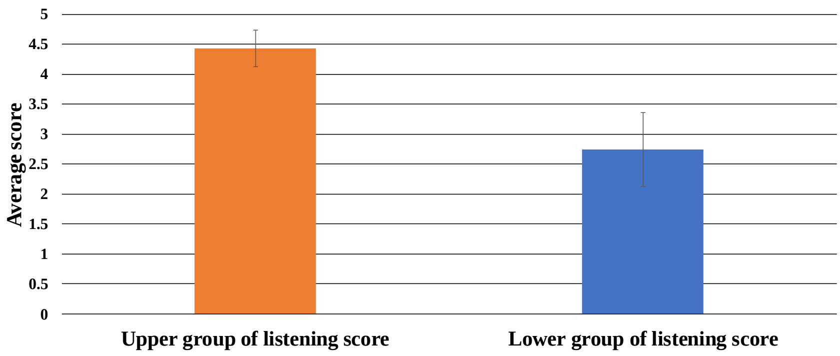


Fig. 25. Average score of listening score
(Left: Upper group of listening score, Right: Lower group of listening score)

■**Quantitative Evaluation**

Figure 26 shows the average KiSS-18 scores for each group of participants classified by their listening scores. The average KiSS-18 score was slightly higher for the upper group than the lower group, but there was no statistically significant difference between them. This result suggests that the relationship between English proficiency and social communication skills is inconsequential.

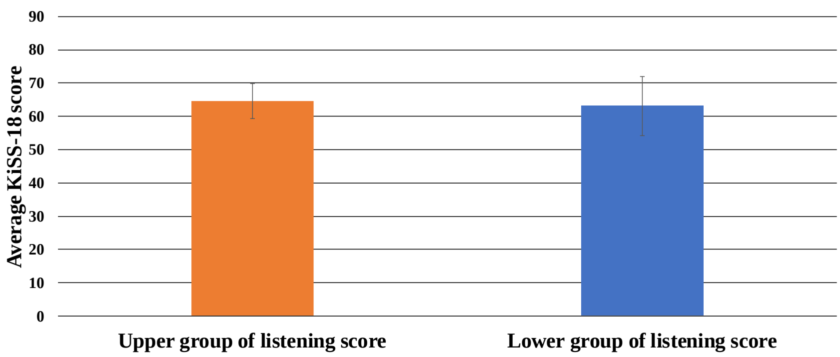


Fig. 26. Average KiSS-18 score
(Left: Upper group of listening score, Right: Lower group of listening score)

Figure 27 shows the average utterance time of the participants classified by their listening scores. The group with the upper listening score had a longer utterance time than the group with the lower score, and the difference was statistically significant ($p<0.01$). This suggests that those in the upper listening score group spoke more English. In addition, the fact that the utterance time was almost the same in the upper and lower groups of social communication skills suggests that utterance time may be affected by English ability rather than social communication skills.

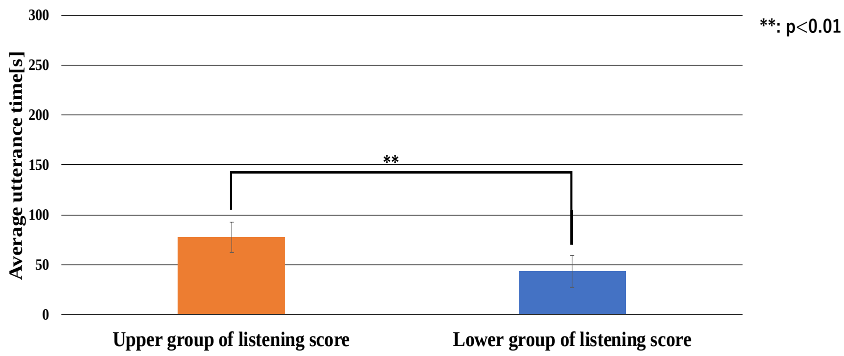


Fig. 27. Average utterance time

(Left: Upper group of listening score, Right: Lower group of listening score)

Figure 28 shows the average screen gaze time of the participants classified by their listening scores. The group with the upper listening test score spent more time gazing at the screen than the group with the lower score, and there was a statistically significant difference ($p<0.1$). This may be because when they are talking, people tend to look at their conversation partner. In addition, since the average screen gaze time was almost the same in the upper and lower social communication skills groups, it is possible that the time spent gazing at the screen is affected by the utterance time rather than by social communication skills.

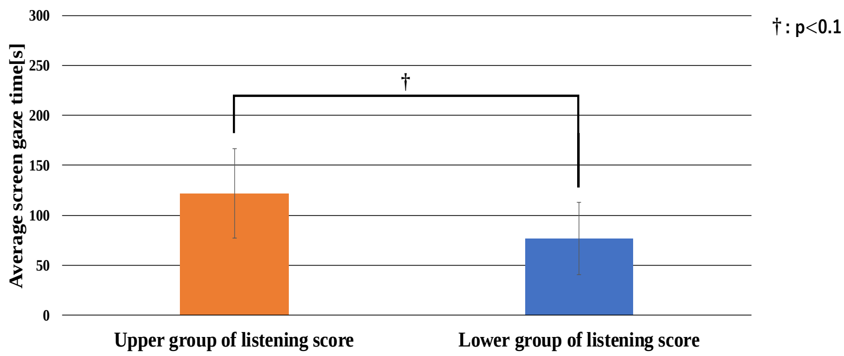


Fig. 28. Average screen gaze time

(Left: Upper group of listening score, Right: Lower group of listening score)

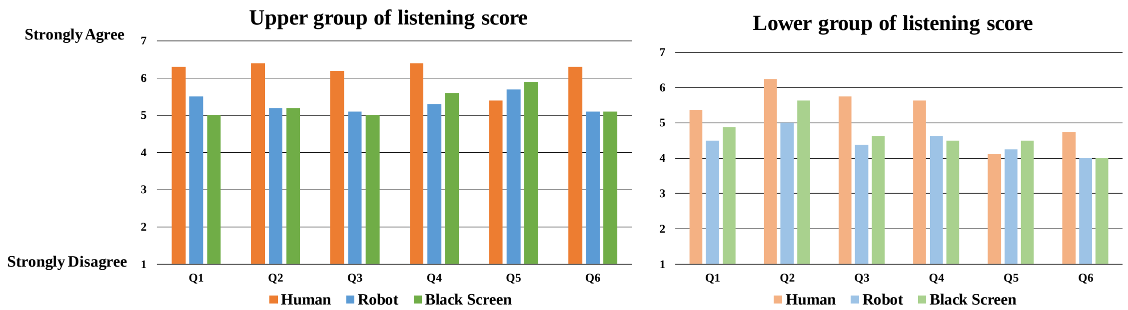
■Qualitative Evaluation

Figure 29 shows the results of the questionnaire in which the participants were classified by their listening scores. There was no statistically significant difference between the upper and lower groups in the listening test scores for all categories.

The results of the questions about speaking, Q1 “Did you feel that it was easy to talk” and Q2 “Did you feel that the conversation partner listened to you carefully”, showed higher values for the human condition in both upper and lower groups. The robot had the lowest value for the lower listening score group. The reason for this may be that the lower listening score group had their hands full with speaking English, and the unsettling behavior of the robot added to this, resulting in a lower value for the robot condition.

The results of the questions about listening, Q3 “Did you feel that it was easy to listen” and Q4 “Did you understand what the conversation partner said”, showed that for all conditions the upper group of listening score had higher values than the group with the lower score. This suggests that the upper group of listening score may have been more familiar with English and thus where more at ease in listening and comprehension.

The results of the conversation atmosphere questions Q5 “Did you talk without feeling nervous” and Q6 “Did you talk without feeling unnatural” showed that for all conditions the upper group of listening score had higher values than the group with the lower score. This suggests that the upper group of listening score may have been more familiar with English and therefore felt less nervous or uncomfortable when speaking in English.



Q1	Did you feel that it was easy to talk?
Q2	Did you feel that the conversation partner listened to you carefully?
Q3	Did you feel that it was easy to listen?
Q4	Did you understand what the conversation partner said?
Q5	Did you talk without feeling nervous?
Q6	Did you talk without feeling unnatural?

Fig. 29. Result of questionnaire

(Left: Upper group of listening score, Right: Lower group of listening score)

4.6 Conclusion II

In this experiment, it was investigated that the effect of online English conversation with a robot on English learners and the effectiveness of this robot as an avatar. From the results of all the participants, the human condition got the highest listening score followed by the black screen condition and the lowest score was in the robot condition. However, there was no statistically significant differences between the three conditions. This was probably due to the fact that the participants were concentrating on listening without looking at the screen during the listening test, and the questions were short.

For most of the categories of the questionnaire, the highest values tended to be found for the human condition, and there were no significant differences between the robot and black screen condition. This may be due to the fact that the participants were used to communicating with people rather than with robots or black screens. Additionally, the teacher was a woman, which made her more approachable. On the other hand, the participants often gave higher values to the robot and black screen conditions than the human condition in Q5 ("Did you talk without feeling nervous"), especially in the upper group of social communication skills. This suggests that the participants felt pressure from the human. In addition, the participants were a little less nervous in the robot condition than the human condition, but they felt most at ease in the black screen condition. Therefore, it is possible that the robot reduces the nervousness compared to the human condition, but the robot needs improvements. In the study by Ichiryu et al., when using a robot as a practice partner for English conversation, it was shown that seeing the robot facial expressions is important to feel involved in the conversation [29]. Additionally, in the study by Danbara et al. they prepared a robot avatar that moved its arms, blinked, and made other movements in response to the speech of the conversation partner, and compared it with a robot avatar that did not make any movements. The results showed that the robot avatar that moves in response to the speech gave higher values in the categories of "how talkativeness is the robot", "how entertaining is the robot", and "how relaxed is the atmosphere". This indicates the effectiveness of the robot's appropriate response to the partner's speech [30]. However, the robot used in this study does not have any facial expressions except the mouth glowing red when talking, and the robot's response was unnatural because it was delayed. Therefore, it is possible that compared to human, robots that can respond appropriately and make facial expressions at the right time would make it easier to speak and reduce the nervousness.

These results show that conversing with a human is the more desirable way to learn English, but they also show the effectiveness of robots in some aspects. Therefore, by using a robot that can produce appropriate responses and facial expressions according to the speech, it is expected that English conversation with robot is as effective as with human, and it reduces the nervousness.

5. Discussion

The purpose of this study was to investigate the utilization of robots as avatars and their effectiveness in two situations: "product explanation by a robot" and "English conversation with a robot".

In the experiment "product explanation by a robot", it was shown that the robot condition obtained the same level of evaluation as the human condition in the categories "ease of imaging", "willingness to buy" and "desire to eat". In addition, for the "likeability", the value in the robot condition was higher than that of the human condition. This suggests that robots can be used as a substitute for humans, especially in situations where likeability is needed. In the experiment "English conversation with a robot" the human condition tended to have the highest values for many categories such as Q1 ("Did you feel that it was easy to talk") and Q3 ("Did you feel that it was easy to listen"). Additionally, in many categories there was no significant difference between the robot and the black screen condition. On the other hand, the value of Q5 ("Did you talk without feeling nervous") was often higher for the robot and black screen condition than for the human condition. Although there was no statistically significant difference, especially in the upper group of social communication skills, the participants were slightly less nervous in the robot condition than the human condition. This suggests that while it is more desirable to speak with a person in the English conversation, the use of a robot that can respond appropriately at the right time and make facial expressions can be considered as one of the ways of reducing nervousness.

In the "product explanation by a robot" experiment, the participants listened to the product explanation from the robot or the human, which was a one-way communication. Therefore, there was no need for the robot to respond to the participants, making the robot's behavior less unsettling and the evaluation equivalent to that of the human condition. On the other hand, the "English conversation with a robot" experiment was a two-way communication in which the participants conversed with the robot or the human. Therefore, the robot had to respond appropriately to what the participants were saying. The robot, which had no facial expressions and limited body movements, could not respond naturally to the participants, which made it difficult to talk. This may have resulted in a lower evaluation than that of the human condition in which the participants got natural reactions.

When considering the use of robots in the future, it is necessary to take into account whether the robot will be used for one-way or two-way communication, and to make sure that the robot can produce the appropriate facial expressions and body movements. On the other hand, the appearance of the robot is also considered to be an important factor. If the robot is too far from the human appearance, the affinity with the robot will be reduced [31], therefore, it is important to choose an appropriate appearance. As robots are expected to be used in many situations in the future, it is necessary to further investigate the appropriate ways of using them.

Acknowledgments

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