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Survey on Psychological Effects of Appreciative Communication via Voice Agent

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Abstract: As many psychologists have suggested, evoking memories of gratitude and then writing them down is recognized as an efficient daily activity to improve people's subjective happiness and well-being. This paper studies how using a smart voice agent, such as a smartphone and smart speaker, affects this activity. Instead of traditional handwriting, expressing gratitude through the voice agent has several benefits in terms of human–computer interaction aspects. As a first step for this study, we conducted short-term experiments using a voice agent with Japanese university students, including native Japanese and foreigners, and evaluated changes in their emotional state by using two psychological measurements, the Positive and Negative Affect Schedule (PANAS) and the Subjective Happiness Scale (SHS). The evaluation results revealed three important findings: (1) expressing and receiving gratitude via voice agent can potentially enhance positive affect and subjective happiness similar to traditional handwriting, (2) generating natural gratitude messages (e.g., from close friends or family) significantly improves positive affect and happiness, and (3) some people experience stress over tasks or methods of expressing gratitude, decreasing positive affect.

Keywords: smart speaker, happiness, gratitude intervention, Japanese, non-Japanese

1. Introduction

With the rapid spread of smart speakers in recent years, voice interaction with the assistance of artificial intelligence (AI) has become familiar. In the field of artificial intelligence, how agents such as AI assistants and chatbots should be designed in order to make people happier has started to be considered as an important issue [1]. Up to the present, many interaction systems have been proposed to positively change emotions by manipulating human behavior, and their effectiveness has been confirmed. People change their facial expressions according to their emotions, and vice versa: people's emotions change with their facial expressions. The following system has been proposed using this effect: a system that aims to improve the user's emotional state by promoting smiles on a daily basis [2] and that generates pseudo facial expressions of pleasure and sadness and presents them to the user to induce the same emotion [3]. Interpersonal physical contact has been reported to bring happiness to people [4], [5]. In particular, many systems using the effects of hugging have been reported, as shown in the following example. There are cases of realizing voice and tactile communication using soft-shaped devices as remote communication research [6]. Hugvie [7] is a human-shaped cushion with a built-in mobile phone that has a stress-reduction effect when someone holds it and talks with it. There are many research examples of devices that give users a realistic sense of being hugged by people in remote locations, and representative examples include those using clothes-type and belt-type devices that expand and contract [8], [9], [10]. Tsuruoka et al. [11] realized a cushion-shaped Internet of Things (IoT) system with built-in sensor, display, and network, which mutually enhances the learning effect between remote learners. The system can positively change learners' emotions by sharing the measured degree of concentration between learners in remote places.

The mechanism of manipulating human physiological responses has been also proven effective at improving human emotions. There are many interactive systems built under the mechanism of manipulating human physiological responses. When people get nervous or have a strong feeling about someone, a physiological excitatory response is produced, such as increased heart rate. It is also well known that people can manipulate their emotions by using feedback of their heartbeat. Some studies have shown the possibility of controlling the attraction to objects using such phenomena, including a study showing that feedback on false heartbeats enhances the attractiveness of photographs of women shown to male students [12], a study showing that the attractiveness of photographs is amplified by a tactile display device that feeds back false heartbeats [13], and others. It has been reported that emotions change as the breathing interval and the length of exhalation and inspiration change [14], [15]. Sonic respiration [16] is an example of a biofeedback method involving calming down one's breathing by changing the music in proportion to the breathing rate. When a person is moved or surprised, changes in not only heart rate and respiration but also pilomotor response (also known as goose bumps) occur. Fukushima et al. [17] conducted two experiments to compare participants'

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surprise emotions. One involved an audio stimulus presented with a five-second alarm sound, and the other involved a horripilating stimulus with static electricity in addition to the audio stimulus. It was reported that participants showed higher subjective surprise emotions when the horripilating stimulus was added.

These systems for manipulating human emotions positively have been proposed in the field of engineering while psychological intervention methods to enhance people's subjective well-being have been researched in the field of psychology [18]. There have been many reports on the effectiveness of gratitude intervention [19]. McCraty et al. (1995) investigated the relationship between gratitude intervention and heart rate to show the physiological effects of gratitude [20]. In their survey, participants used a method to compare two states of mind: thinking about being dissatisfied for 100 seconds and thinking about being thankful for 100 seconds. After comparing the participants' heart rates while in these two states, it was shown that the heart rate became mild in the state of remembering thankfulness. Also, McCraty et al. (2002) investigated the relationship between gratitude and alpha waves [21]. That survey compared the condition in which participants thought of something thankful to the condition in which they did not think about anything. The results showed that more alpha waves were detected in the state of thankful thinking. These two cases show that gratitude changes the physiological indicators of heart rate and alpha waves. Emmons et al. (2003) reported that feeling appreciative improved subjective well-being through experiments with participants in three different conditions [22]. In other studies, participants who wrote gratitude letters felt happier, less depressed, and more satisfied with their lives at the end of the intervention [23], enjoyed a larger boost in subjective well-being both immediately following the intervention and six months later [24], and expended more effort when asked to perform kind acts [25] than participants asked to do other tasks. Studies in children examining the effect of writing down feelings of gratitude showed that students assigned to count their blessings every day had increased life satisfaction and feelings of belonging to their school [26], [27]. As an additional effect of this intervention, it was reported that people who were asked to write about gratitude in a way of thinking that might never have happened had more benefit than people assigned other ways of writing about grateful things [28]. While many gratitude interventions have used methods lasting for several weeks, Watkins et al. (2003) reported that their gratitude intervention improved subjective well-being even if it was only a single occasion [29]. The method of gratitude intervention in these studies was handwriting. Other interventions exist, such as viewing gratitude letters and thinking about content that expresses gratitude [30], [31].

Through these researches, it has been confirmed that being thanked by others (receiving gratitude) and thanking others (expressing gratitude) enhance people's subjective well-being level. However, most of the means of gratitude intervention were description methods including handwriting and e-mail. The attention of the market has changed recently from traditional interactions via buttons and screens to voice interactions with natural dialogue as the input and agents on smartphones and smart speakers as the output. This research investigates how subjective well-being changes with gratitude interventions using voice interactions with agents on smart devices. Insofar as we know, there has been no research investigating how gratitude intervention using a voice interface changes people's subjective well-being level, assuming interaction with speech agents. In this research, we use smart speakers to investigate changes in people's subjective well-being with two interventions, appreciating others and being appreciated by others. The investigation is consisted of two phases, the first study with Japanese students and the second study with students from various countries, to be discuss whether results could be independent to the survey targets' culture and universally true or not. In this paper, Section 2 shows details of the survey method of the first study of Japanese university students, and Section 3 reports the first study's results. Section 4 describes the survey method of the second study of various countries' students. Section 5 considers the results of all studies, and Section 6 gives a summary.

2. Method of First Study

2.1 Participants

We recruited 22 Japanese students (15 men and 7 women) from undergraduate and graduate programs of Sophia University, Japan. Their average age was 22.27 years old. We randomly divided them into 2 groups: the first group (G1), made up of 13 students, expressed gratitude, and the second group (G2), made up of 9 students, received gratitude. Before conducting the experiment, we collected information on the participants' friends, including their names, what they called the participants, and their community (e.g., club activity, department, etc.), by using Web-based questionnaires. The participants were informed of the expected time they would spend in the experiment and the rewards before the experiment began.

2.2 Procedure

Each participant was individually invited into an experimental room located in the department of Information and Communication Sciences, Sophia University, Japan. In the room, an experimenter carried out the following procedure: tasks m1, m2, and m3.

m1: At the beginning of the experiment, the experimenter explained to the participant how to use the voice agent system. The experimenter asked the participant to answer the questionnaire (see Section 3 for further details) to extract his/her baseline emotional state.

m2: In this task, the experimenter gave the participant a piece of paper with several short sentences in Japanese, then asked him/her to read it aloud in front of the voice agent system. As described in the system design, once the system receives the voice input, it recognizes the content of voice input, and responds to the recognized content with voice feedback. The participant can see whether the system correctly recognizes the input voice or not. Japanese sentences were randomly picked from available content on the Internet, such as news, weather forecasts, biographies in Wikipedia, stock information, etc. Length of sentences was 10 to 200 words in Japanese. We refer to the task as a common task. After the

task, the experimenter gave the same questionnaire in m1 to the participant to see his/her emotional state after using the voice agent system. As an example, when the sentence spoken by the participant was a topic related to weather, the following sentence was read:

"Kyō no tenki wa haredesu. Saikō kion wa 20°C, saitei kion wa 10°C desu" (English translation: "The weather is sunny today. The maximum temperature is 20°C and the minimum temperature is 10°C.").

m3: In this task, the experimenter gave the participant another task selected based on the group, as described below. We refer to the second task as a dedicated task to distinguish this from the common task.

Task for G1: The experimenter asked the participant to consider 5 messages of gratitude for his/her familiar person, and then speak them aloud one by one to the voice agent system. In this experiment, to mitigate stress, the experimenter gave participants unlimited time to consider the messages and assured them that the messages would be kept secret.

Task for G2: The experimenter asked the participant to listen to 5 gratitude messages played back from the voice agent system. These were created based on fixed gratitude messages with private information about the participant, such as names of and relationships with friends and familiar persons. As an example, when participant X received a gratitude message from friend Y, who was enrolled in the same university course as X, the following gratitude message was created:

"X san kara no messe-ji destu. 'Itsumo warawase te kurete arigatou. Y no okage de daigaku seikatsu wo tanoshiku sugoseteiruyo'" (English translation: "You've got a message from X. 'Thank you Y. You're always making me smile. So, I can enjoy my campus life because of you.'").

After the task, the experimenter gave the same questionnaire in m1 to the participant to see his/her emotional state after expressing or receiving gratitude.

The experiment was performed while the experimenter was present during the experiment, and the experimenter could see the participants and hear the conversation, and no conversation was recorded.

2.3 Design and Implementation of Voice Agent System

Here we introduce the voice agent system used in the experiment described in Section 3.2. The voice agent system, as illustrated in **Fig. 1**, provides 2 function modes: voice input mode and text read mode. The voice input mode detects a participant's voice message and provides acknowledgment to the participant by using a voice synthesis function and speaker. By using this process, the participant can clearly understand whether the system recognized the voice message or not. The voice input mode is used for both common tasks and dedicated tasks by G1 participants, while the text read mode provides a text input interface so that the experimenter can freely generate voice messages from text data. This mode was used for the dedicated task for G2 participants. In addition, it was required that the voice recognition function in voice input mode was capable of converting up to 200 words to accept natural gratitude messages.

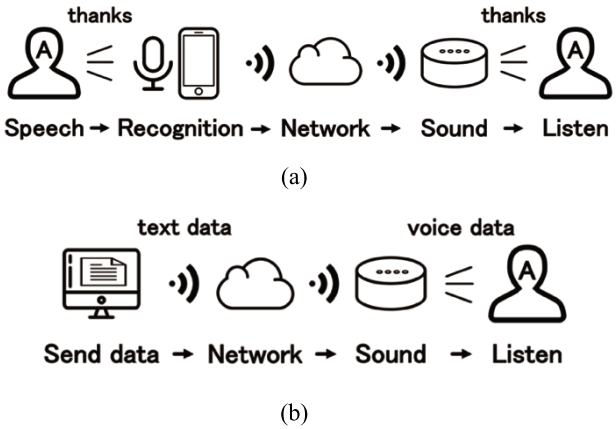

Fig. 1 Voice agent system: (a) voice input mode used for common and dedicated tasks by G1 participants, and (b) text read mode used for dedicated task by G2 participants.

We implemented the voice agent system based on the Google Home Mini smart speaker [32]. As far as we know, the Google Home Mini used in our experiment in October 2017 had a limitation in the number of dictated characters for Japanese voice recognition (up to 20 words). Thus, instead we used the Slack service as a common message input interface. For voice message input, we used an iPhone, which provides a high-quality voice-to-text input function, to input text messages to the Slack service; we used the laptop to input text messages to Slack. We configured the laptop to receive text messages from Slack by using Slack's outgoing webhook setting. Upon receiving a text message, the laptop synthesized an artificial voice message by using google-home-notifier [33] and sent that message to be reproduced by the Google Home Mini.

2.4 Measures

The experimenter asked participants to submit self-reported questionnaires for each task (m1, m2, and m3). We evaluated both emotional state and happiness by using 2 psychological measures. The Japanese version of the Positive and Negative Affect Schedule (J-PANAS) [34] was used to measure emotional state. Compared with the original English version (PANAS) [35], J-PANAS consists of two 8-item scales measuring positive affect (PA) and negative affect (NA). Each item is rated with a 6-point scale. The Japanese version of the Subjective Happiness Scale (J-SHS) [36], which was used to measure subjective happiness, consisted of a 4-item scale measuring subjective happiness (SH), the same as the original English version [37]. Each item was rated with a 7-point scale.

Further, to reduce experimenter effects, we used 2 additional questionnaires regarding personality analysis [38], [39], [40], [41] during m2. After the experiment was finished, the experimenter conducted a short interview with each participant to get his/her impression of the experiment.

2.5 Statistical Analysis

We evaluated the effectiveness of the gratitude intervention

with the voice agent system based on multiple comparison of the datasets, consisting of the mean values of PA, NA, and SH rated by participants at m1, m2, and m3. The mean values for each participant were obtained by dividing the sum of the scores for each PA, NA and SH question by the total number of questions for each PA, NA and SH. First, analysis of variance (ANOVA) was performed for the datasets before conducting multiple comparison. Since the datasets had both regularity and homoscedasticity, in which properties were verified with Kolmogorov–Smirnov and Bartlett's tests, we conducted a one-way repeated-measures ANOVA to compare the effects of gratitude expression and reception on the datasets in m1, m2, and m3. The significance level was 0.05. We corrected each significance level by controlling the False Discovery Rate using the Benjamini–Hochberg (BH) procedure as a multiple test correction for ANOVA results. Second, if significant differences were found, we conducted multiple comparison with the BH procedure for the datasets. The significance level was 0.05. We corrected the significance level with the total number of all tests in the group that performed the multiple comparisons. Throughout this analysis, we used R, the statistical computing language. If the multiple comparison showed a significant difference between m2 and m3, it indicated that gratitude expression or reception influenced the participant's emotional state. If the multiple comparison showed a significant difference between m1 and m3 and not between m1 and m2, it indicated that gratitude expression or reception influenced the participant's emotional state.

3. Results of First Study

3.1 Results

Figure 2 shows the mean scores and standard errors of PA, NA, and SH rated by N participants. According to the one-way repeated-measures ANOVA, we found that there was a significant effect of gratitude reception on PA, with $F(2, 16) = 11.67$ and $p = .004$. The one-way repeated-measures ANOVA was performed six times in total for PA, NA, and SH of G1 and G2. The analysis of multiple comparison with BH showed that there were significant differences in PA of G2 participants between m1 and m3 ($p = .003$), and between m1 and m2 ($p = .015$), as shown in Fig. 2. The total number of tests performed in multiple comparisons was three. On the other hand, although SH of G1 and G2 participants and NA of G2 participants slightly improved and degraded, respectively, from m2 to m3, there were no significant differences. As a result, the effectiveness of expressing gratitude with the voice agent was not found in this experiment.

However, during the interviews after the experiment, six G1 participants said, "Pronouncing gratitude phrases to the voice agent made me embarrassed." This suggests that feelings of embarrassment over expressing gratitude may have a negative impact on one's emotional state. To support this hypothesis, measurement results of the six participants were compared with those of the remaining seven participants, as shown in **Fig. 3**.

According to the one-way repeated-measures ANOVA, the null hypothesis was not rejected. However, for the participants who felt embarrassed, the result of one-way repeated-measures ANOVA showed that there was a close to significant effect of gratitude expression on PA, with $F(2, 10) = 7.81$ and $p = .054$. For the remaining participants, the result of one-way repeated-measures ANOVA showed that there were close to significant effects of gratitude expression on both PA and NA, with $F(2, 12) = 4.09$ ($p < .088$) for PA and $F(2, 12) = 4.38$ ($p = .088$) for NA. The one-way repeated-measures ANOVA was performed six times in total for PA, NA, and SH of G1 and G2.

Japanese G1 participants ($N = 13$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	3.32	0.26	3.51	0.34	3.53	0.34
NA	2.31	0.28	2.13	0.25	2.14	0.37
SH	4.88	0.29	5.10	0.25	5.37	0.26

Japanese G2 participants ($N = 9$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	3.51	0.22	3.88	0.23	4.01	0.27
NA	2.19	0.25	1.83	0.24	1.71	0.20
SH	5.39	0.22	5.39	0.29	5.72	0.30

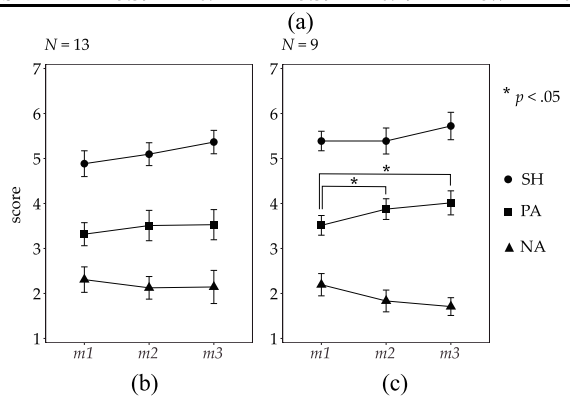

Fig. 2 Experimental results of the first study. (a) Mean and standard error of positive affect (PA), negative affect (NA), and subjective happiness (SH); (b) G1: expressing gratitude; (c) G2: receiving gratitude.

3.2 Discussion

In this experiment, we found that the use of the voice input agent could improve PA and SH, and decrease NA with gratitude expression shown in Fig. 3 (c), as the previous studies did with traditional handwriting-based expression. This result is in agreement with the results shown in previous studies examining the effect of handwritten gratitude expression [42]. However, in the handwritten gratitude expression, the existence of those who have negative feeling to the method of expressing gratitude was not mentioned in any previous research. In this study using the voice input method for expressing gratitude, it was confirmed that the effect of expressing gratitude of those who have negative feeling to the input method was reversed from the effect seen with the conventional handwritten method. These could be important findings of using voice input method for investigating the effect of expressing gratitude. Also, there is little research on the effect of receiving gratitude in conventional handwritten research examples. Because it is difficult to design experiments so that par-

Japanese G1 participants (embarrassed, $N = 6$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	3.83	0.29	3.81	0.32	3.29	0.42
NA	2.42	0.38	2.42	0.38	2.73	0.59
SH	4.50	0.26	4.42	0.20	4.75	0.36

Japanese G1 participants (not embarrassed, $N = 7$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	2.88	0.31	3.25	0.56	3.73	0.50
NA	2.21	0.41	1.88	0.29	1.64	0.34
SH	5.11	0.36	5.25	0.39	5.68	0.30

(a)

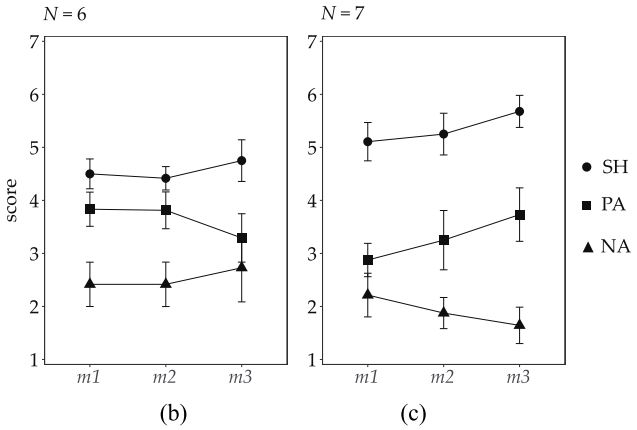

Fig. 3 Negative impact of feeling embarrassed. (a) Mean and standard error of PA, NA, and SH; (b) participants who felt embarrassed; (c) participants who did not feel embarrassed.

ticipants may receive multiple handwritten gratitude messages in both short-term and long-term experiments. In this paper, we also focused on the effectiveness of receiving gratitude messages and found that using the voice output agent could improve PA with receiving gratitude messages. The results also suggest that reduced feelings of embarrassment during gratitude expression can be a key factor in further improving the effectiveness of using the voice input agent. The attendance of the experimenter could have given some participants the feeling of embarrassment. However, the attendance of the experimenter was indispensable to supervise the progress of the experimental tasks.

The reason why participants felt embarrassed to talk to a smart speaker might be assumed from an awareness survey of Japanese voice operation reported by KDDI, a Japanese mobile communication carrier. According to the survey, over 70% of Japanese people feel embarrassed when using voice search services on smart devices in public [43]. The embarrassment that reduced participants' average subjective well-being during the experiment seems to be connected to the result of that survey.

It has been found that people in individualistic cultures show higher subjective well-being [44]. In a study by Hofstede (2001) [45], Japan was ranked in the middle level of individualism, but another study suggested the rise of collectivism in modern-day Japan [46]. Maintaining social harmony is a paramount principle in collectivistic cultures. In this context, the embarrassment of 70% of Japanese people when using voice interaction on smart devices is explainable, because using voice interaction in public may harm others' feelings and will require apologies for reconciliation and relational repair. However, some participants in our experiment felt embarrassed to use voice input even in nonpublic spaces, which decreased their well-being measurement. Further investigation is required to confirm whether these reactions are Japanese-specific or not, and to evaluate the effects of gratitude intervention using voice interaction on smart devices.

In the interview survey, most participants reported that their first-time smart speaker experience and its high-quality voice recognition accuracy enhanced their emotion during m2. The remaining participants, who were not excited to use the voice agent system, said that they used voice-activated systems, including smart speakers, on a daily basis. From these interviews, it can be observed that most participants tended to have higher acceptance for cutting-edge technology than general students. In fact, 20 of the 22 participants in this research were studying computer science.

In addition, some G2 participants said that they did not feel happy when they listened to a gratitude message generated from a fixed phrase during m3 because they thought the voice messages were fixed messages or not from the person close to them. These results suggest that messages of appreciation become effective when one can recognize them as being real.

In order to examine the psychological effect of a certain system or method on a user, there are a method of applying the psychological scale only after the experiment and a method of repeatedly applying the psychological scale in a time series including before the experiment. The one-time application only after the experiment is effective for examining differences in psychological effects between user groups [47]. Multiple applications of repetition are useful for examining short and long term variations in psychological effects [48]. Because some participants will have positive feelings to smart speakers, such as being excited and encouraged, this study has the same content for both G1 and G2, and a common task that has little relation to the purpose of the study was set up. Changes in psychological effects were confirmed before and after the common task (m1–m2), and changes in psychological effects were also confirmed before and after the dedicated task under study (m2–m3). Details of the change in m1–m2 of the 13 participants shown in Fig. 2 (b) were as follows: five had an average PA increase, five had a decrease, and three had no change. Six people with a negative feeling to the voice input shown in Fig. 3 (b) who all have a PA drop at m2–m3. These six were one from those whose PA increased in m1–m2, three from those who declined, and two from those with no change. This result suggests the following possibilities. The effect of increasing the PA value by favoring the smart speaker on m1–m2 and the effect of decreasing the PA value by feeling embarrassed on speaking private messages on m2–m3 were independent events. On the other hand, for the four people whose PA increased in both m1–m2 and m2–m3, the continued effect of increasing the PA value by favoring the smart speaker cannot be denied.

Table 1 Participants in the second study.

	Australia	Austria	Belgium	Chile	China	France	Germany	Indonesia
Men	1	0	0	0	2	1	1	1
Women	0	1	1	1	1	1	1	3

	Japan	Korea	Luxembourg	Philippines	Russia	Spain	USA	Vietnam
Men	15	3	1	1	0	0	1	0
Women	22	2	0	0	3	1	5	1

4. Method of Second Study

4.1 Purpose

To further investigate additional factors that may influence one's emotional state, such as feelings of embarrassment while expressing gratitude, the quality of gratitude messages that G2 participants could recognize as real, etc., discussed in the previous section, we conducted the same experiment in the first study with new participants and some minor changes, as follows:

1. Nationality: We gathered both Japanese and non-Japanese students in order to analyze the effects of embarrassment discussed in the first study. All the non-Japanese participants were assigned to G1 to investigate whether the negative effect of embarrassment is an inherent characteristic of Japanese people.
2. Major: We gathered participants from the same university, except for computer science students, as much as possible to reduce the unexpected improvement of PA during m2. In the first study, over 90% of participants were studying computer science and many were excited to use cutting-edge technology such as a smart-speaker during m2.
3. Gratitude Message: To study effective message generation, we used real gratitude messages taken from participants' friends.

4.2 Participants

A total of 70 students (22 Japanese women, 15 Japanese men, 20 foreign women, 13 foreign men; average 21.36 years old) at Sophia University, Japan, participated in this study, and 64 participants were not studying computer science. Japanese participants were gathered from the same sport club of the university so that we could easily collect information on their relationships. Based on this, we picked 12 participants who had at least 5 close friends among the remaining 25 participants and assigned them and the other 5 participants to G1. The remaining 20 participants were assigned to G2. All 33 non-Japanese participants were assigned to G1 to compare the effect of stress from expressing gratitude between Japanese and non-Japanese participants. Among the non-Japanese participants, 2 Chinese and 2 Koreans declared that they were not good at English. **Table 1** summarizes the numbers of participants and their nationalities.

4.3 Procedure

In this study, the overall experiment followed the procedure described in Section 3.2 with slight modifications in m3 tasks, described below. For non-Japanese participants, the experimenter used only English during this experiment.

Revised task for G1:

- For the 12 Japanese participants in G1 who had at least 5 close friends in G2, the experimenter asked them to consider a gratitude message for the participants in G2, and then speak the messages aloud one by one to the voice agent system. Similar to the first study, the experimenter gave participants unlimited time to consider their messages and assured them that the messages would be kept secret to mitigate stress. These messages were used for the dedicated task by G2.
- For the remaining 5 Japanese and non-Japanese participants, the experimenter carried out the same process described in the original dedicated task for G1. Similar to the first study, the experimenter gave participants unlimited time to consider their messages and assured them that the messages would be kept secret to mitigate stress.

Revised task for G2: Instead of using fixed messages, natural gratitude messages obtained in the revised task for G1 were used. Note that there were no non-Japanese participants in this task. If a participant had 5 or more messages from G1 participants, 5 messages were picked up and used for this task. Otherwise, messages obtained from their friends through the web-based questionnaires were reused.

4.4 Measure

For Japanese participants, we used the same measurement tool as mentioned in Section 3.4. For non-Japanese participants, the original (English) PANAS [35] and SHS [37] were used, and we conducted the experiment in English regardless of nationality. Compared with J-PANAS, there are twice as many items in the original PANAS, so we simply removed four items (interest, guilty, hostile, and attentive) to unify the number of items. In addition, in order to suppress the experimenter effect, we carried out an English version of the psychometric scale regarding personality [38], [40] for the non-Japanese G1 participants during m2.

5. Results of Second Study

5.1 Results

Figure 4 shows the means and standard errors of the measurement results. Based on the analysis with one-way repeated-measures ANOVA, we found that there were significant effects of gratitude reception by Japanese participants and gratitude expression by non-Japanese participants. The one-way repeated-measures ANOVA was performed nine times in total for PA, NA,

Japanese G1 participants ($N = 20$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	3.16	0.23	3.26	0.28	3.14	0.31
NA	1.71	0.12	1.66	0.13	1.58	0.17
SH	5.10	0.19	5.09	0.14	5.31	0.15

Japanese G2 participants ($N = 17$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	3.23	0.25	3.17	0.26	3.52	0.28
NA	2.00	0.16	1.89	0.22	1.57	0.12
SH	5.09	0.22	5.04	0.22	5.40	0.22

Non-Japanese G1 participants ($N = 33$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	4.16	0.10	4.16	0.12	4.23	0.13
NA	2.58	0.13	2.40	0.13	2.29	0.14
SH	5.12	0.17	5.10	0.17	5.14	0.18

(a)

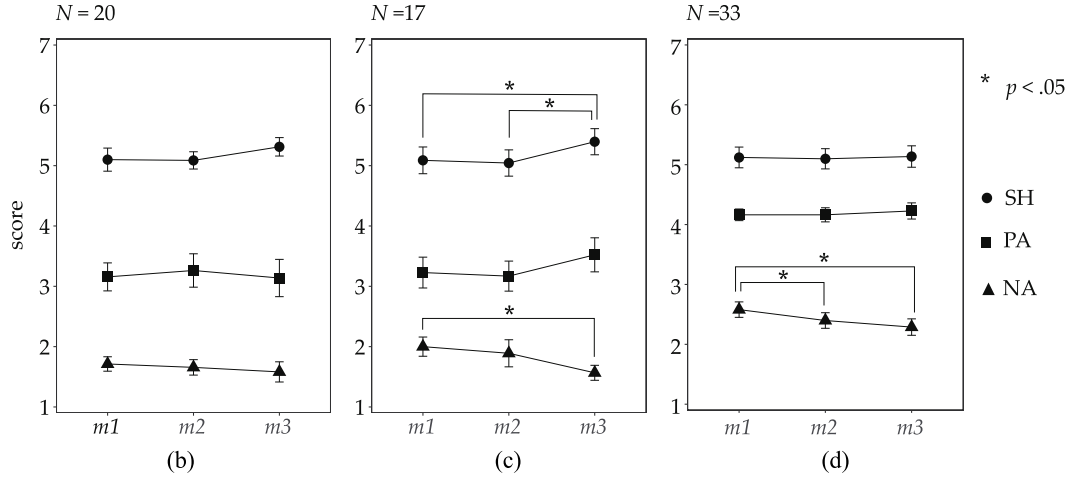

Fig. 4 Experimental results of the second study. (a) Mean and standard error of PA, NA, and SH; (b) Japanese G1 participants; (c) Japanese G2 participants; (d) non-Japanese G1 participants.

and SH of Japanese G1, Japanese G2 and Non-Japanese G1.

For Japanese G2 participants, there were significant effects of gratitude reception on NA ($F(2, 32) = 5.44$, $p = .028$), and SH ($F(2, 32) = 5.76$, $p = .028$). We also conducted multiple comparison with BH for the results and found that the differences in NA difference between m1 and m3 were significant ($p = .002$). For SH, the differences between m1 and m3 ($p = .034$), and m2 and m3 ($p = .027$) were significant. For non-Japanese G1 participants, there was a significant effect of gratitude expression on NA ($F(2, 64) = 11.35$, $p < .001$). According to the multiple comparison the differences between m1 and m2 ($p = .011$), and m1 and m3 were significant ($p = .002$). The total number of tests performed in multiple comparisons was nine.

Based on the analysis above, it can be seen that we succeeded in measuring the actual effects of using the voice agent system by using gratitude messages created by the participants' friends. That is, this result implies that receiving gratitude by using the voice agent system can degrade NA.

After the experiment, four Japanese G1 participants mentioned that expressing gratitude vocally made them embarrassed. Therefore, to study the effects of feeling embarrassed, we further divided the Japanese G1 participants into two subgroups based on whether they claimed that it felt embarrassing or not.

Figure 5 shows the means and standard errors of the measurement results. For the not-embarrassed participants, the result of one-way repeated-measures ANOVA shows that there was a significant effect of gratitude expression on NA, with $F(2, 30) = 5.89$ and $p = .017$. The total number of tests that corrected the one-way repeated-measures ANOVA results was fifteen, including "Japanese G1 participants who did not feel embarrassed", "non-Japanese G1 participants with stress", "non-Japanese G1 participants without stress", "all Japanese G1 participants (ex-

Japanese (embarrassed) in G1 ($N = 4$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	2.38	0.34	2.19	0.25	1.69	0.29
NA	1.34	0.19	1.78	0.35	1.97	0.50
SH	5.56	0.37	5.50	0.34	5.38	0.41

Japanese (not embarrassed) in G1 ($N = 16$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	3.35	0.26	3.53	0.31	3.50	0.32
NA	1.80	0.13	1.63	0.14	1.48	0.17
SH	5.03	0.25	5.17	0.14	5.39	0.16

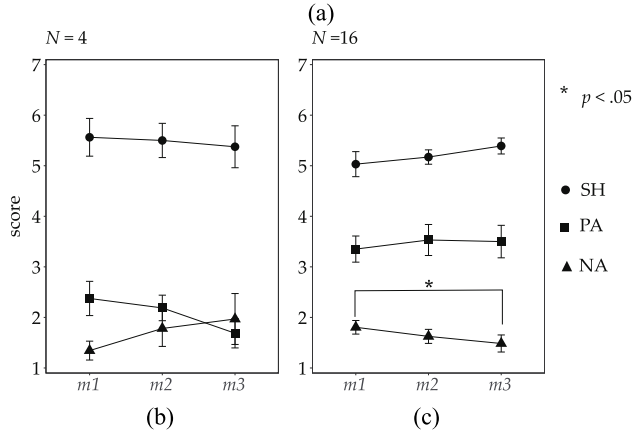

Fig. 5 Negative impact caused by feeling embarrassed for Japanese participants. (a) Mean and standard error of PA, NA, and SH; (b) Japanese G1 participants who felt embarrassed; (c) Japanese G1 participants who did not feel embarrassed.

Non-Japanese (embarrassed) in G1 ($N = 8$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	3.86	0.18	3.73	0.27	3.61	0.30
NA	2.70	0.21	2.55	0.21	2.61	0.26
SH	5.21	0.31	5.04	0.26	4.93	0.33

Non-Japanese (not embarrassed) in G1 ($N = 25$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	4.24	0.11	4.28	0.12	4.40	0.14
NA	2.56	0.16	2.34	0.16	2.20	0.16
SH	5.11	0.21	5.11	0.21	5.18	0.21

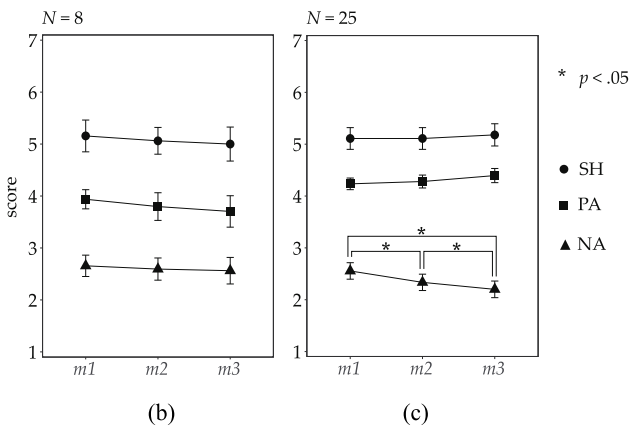

Fig. 6 Negative impact of feeling embarrassed among non-Japanese participants. (a) Mean and standard error of PA, NA, and SH of non-Japanese participants; (b) non-Japanese G1 participants with stress; (c) non-Japanese G1 participants without stress.

pressing gratitude) who did not feel embarrassed to talk to the smart speaker" and "all Japanese G2 participants". The result of multiple comparison with BH shows that difference in NA between m1 and m3 was significant ($p = .020$). In contrast, there was no significant effect of gratitude expression on PA. From this analysis, we found that the tendency of changed emotional state was similar to the first study shown in Fig. 3. The total number of tests performed in multiple comparisons was 21, because 7 one-way repeated-measures ANOVA results were significant.

Among the non-Japanese participants, two Asian participants (one man and one woman) said they felt embarrassed about expressing gratitude. Among five European and one Asian participant (two men and four women), four women felt stressed that their speech was not smoothly recognized by the system. One man and one woman felt stressed about the system's robotic voice. One man felt stressed that he could not understand the significance of using a smart speaker in this experiment. Since embarrassment is a type of psychological stress, we assigned those eight participants to a "stress" group and found that the measurement results of those participants were different from the results of other participants.

Figure 6 shows the means and standard errors of psychological measures. For the participants without stress, the result of one-way repeated-measures ANOVA shows that there was a significant effect of gratitude expression on NA, with $F(2, 48) = 13.41$, $p < .001$. The total number of tests that corrected the one-way repeated-measures ANOVA results was fifteen, which was previously mentioned at Fig. 5. The result of multiple comparison with BH also shows that the differences in NA between m1 and m3 ($p < .001$), m1 and m2 ($p < .001$), and m2 and m3 were significant ($p = .007$). The total number of tests performed in multiple comparisons was 21, because 7 one-way repeated-measures ANOVA results were significant. In contrast, there was no significant effect of gratitude expression on PA and SH. From this analysis, we found that the tendency of changed emotional state of non-Japanese participants without stress was similar to the results of Japanese participants without embarrassment, as shown in Figs. 3 and 5.

Based on the above analysis, it can be seen that expressing gratitude by using smart speakers can improve PA and SH and degrade NA for both Japanese and non-Japanese participants, except participants feeling stress.

5.2 Discussion of Stress

Two participants who said they felt embarrassed in interviews were non-Japanese Asians. This implies that the negative impact of embarrassment is not an inherent characteristic of Japanese people. By recruiting participants more widely in the future, people from other areas who feel embarrassed over voice input as one

of the variations of stress may be included.

On the other hand, only non-Japanese participants attributed their stress to bad feelings about the system, dissatisfaction with the performance of speech recognition, and discomfort with synthetic speech. None of them used English as their mother language and felt inconvenienced by the experiment itself. These impressions of the voice interaction of the experiment may depend on participants' personality and culture. There is no denying that some Japanese participants might have felt the same stress as the non-Japanese participants. Japanese participants may have regarded such stress as their own responsibility or fault and thus expressed feelings of embarrassment. Cross-cultural studies about gratitude interventions have been done, showing that gratitude may contain cultural features and some interventions of gratitude may be culturally dependent [49], [50], [51].

Figure 7 shows the measurement results of all experimental data for Japanese participants in Sections 4 and 5. People who felt embarrassed were excluded from G1 (expressing gratitude). The data for non-Japanese participants is not compared here because they did not meet the condition of using the native language of every participant.

For Japanese participants in G1, the result of one-way repeated-measures ANOVA shows that there were significant effects of gratitude expression on SH and NA, with $F(2, 44) = 4.38$, $p = .040$ for SH and $F(2, 44) = 10.44$, $p = .001$ for NA. The total number of tests that corrected the one-way repeated-measures ANOVA results was fifteen, which was previously mentioned at Fig. 5. In contrast, there was no significant effect of gratitude expression on PA. The result of multiple comparison with BH also shows that the differences in SH between m2 and m3 were significant ($p = .028$), and the differences in NA between m1 and m3, and m1 and m2 were significant ($p < 0.001$ and $p = .016$). The total number of tests performed in multiple comparisons was 21, because 7 one-way repeated-measures ANOVA results were significant.

For the Japanese participants in G2, the result of one-way repeated-measures ANOVA shows that there were significant effects of gratitude reception on SH, PA, and NA, with $F(2, 50) = 8.11$, $p = .004$ for SH, $F(2, 50) = 6.66$, $p = .008$ for PA, and $F(2, 50) = 7.48$, $p = .005$ for NA. The result of multiple comparison with BH also shows that the differences in SH between m1 and m3, and m2 and m3 were significant ($p = .011$ and $p = .010$), the differences in PA between m1 and m3, and m2 and m3 were significant ($p = .005$ and $p = .020$), and the differences in NA between m1 and m3 were significant ($p = .004$). The results in Fig. 7 show that in the absence of stress, interventions using speech agents both expressing and receiving gratitude can increase people's happiness as well as interventions using writing.

5.3 General Discussion

This paper studied whether expressing gratitude to and receiving gratitude from others through a voice assistant can improve happiness just as handwriting-based gratitude expression does. As described in previous sections, we assigned participants to two groups (G1 and G2) and conducted several experiments to study how voice agent-assisted expression and reception of gratitude changed the participants' emotional state. Throughout the experiments, we found that feeling embarrassed while expressing gratitude had a negative emotional impact. For participants in G1 (gratitude expression) who felt embarrassed, the voice agent-assisted expression was not at all effective at improving their emotional state. However, it worked for the remaining participants in G1. For participants in G2 (gratitude reception), we also found that receiving gratitude through the voice agent effectively improved their emotional state if they identified that the gratitude messages were generated by their families and friends even if the messages were artificially generated (i.e., using templates and knowledge of their personal relationships). It was seen that the emotional states of many participants in G1 and G2 were significantly different after the first experiment. These differences were attributed to the fact that many participants were computer science students and were highly interested in cutting-edge technology such as the smart speaker integrated into our voice agent system.

Based on these observations, in this section we (1) collected 6 and 64 new participants from computer science and other disciplines, (2) studied whether gratitude messages created by close friends of participants in G2 improved their emotional state, and (3) studied whether expressing gratitude with a voice agent im-

Japanese (not embarrassed) in G1 ($N = 23$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	3.21	0.21	3.45	0.27	3.57	0.27
NA	2.70	0.21	2.55	0.21	2.61	0.26
SH	5.21	0.31	5.04	0.26	4.93	0.33

Non-Japanese (not embarrassed) in G1 ($N = 25$)

	m1		*m2*		*m3*	
	mean	SE	mean	SE	mean	SE
PA	4.24	0.11	4.28	0.12	4.40	0.14
NA	2.56	0.16	2.34	0.16	2.20	0.16
SH	5.11	0.21	5.11	0.21	5.18	0.21

(a)

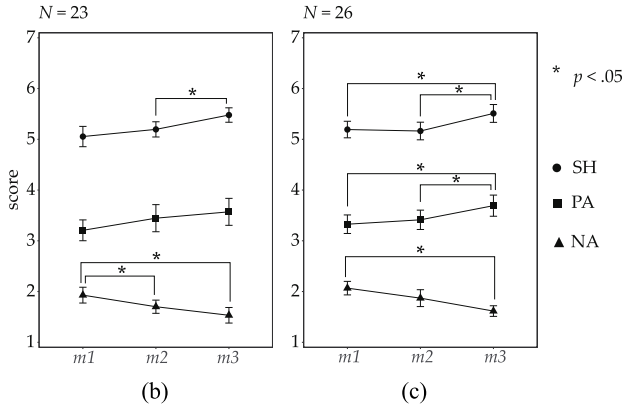

Fig. 7 Comparison results of mean scores. (a) Means and standard errors of PA, NA, and SH; (b) Japanese G1 participants (expressing gratitude) who did not feel embarrassed to talk to the smart speaker; (c) all Japanese G2 participants.

proved the emotional state of non-Japanese participants. As a result, it can be confirmed that receiving gratitude messages through the voice agent system and created by close friends is more effective at improving one's emotional state. It is also found that the intervention of expressing gratitude improved the emotional state of both Japanese and non-Japanese participants, except those who felt short-term stress related to the method of using voice input and output. Several studies have investigated the effects of gratitude by measuring subjective stress with a psychological scale [52]. Specifically, these studies used the Perceived Stress Scale to measure participants' long-term stress levels [53]. There seems to be no standard psychological scale to measure short-term stress brought on by the intervention method itself.

The simplest solution to avoid feeling stress over voice input is to use a traditional handwritten letter interface instead. By using a traditional interface, people do not feel embarrassed or irritated over the gratitude expression task. However, thanks to significant improvements in voice recognition techniques, voice input provides posture-independent messaging and can potentially enable accurate and fast verbal communication between humans and machines. Therefore, long-term evaluation of the use of voice agent systems is needed to study how embarrassment can be mitigated in future work. In addition, the experimental system used in this investigation generated a non-natural robotic voice from text data. In real human verbal communication, nonverbal attributes, such as the quality and intonation of voice, duration between words, and so on, affect one's emotional state. Thus, in future work, we will investigate a voice synthesis mechanism that can naturally give realistic emotional expressions by using facial expression recognition techniques to further improve positive affect and happiness.

6. Conclusion

This paper studied the effectiveness of a voice agent-assisted gratitude intervention. As a first step in the research, we evaluated how voice-assisted gratitude message input and output affect human emotions by tracing emotional changes based on an analysis of emotional affect and subjective happiness. The evaluation results revealed three important findings: (1) expressing and receiving gratitude via the voice agent can potentially enhance positive affect and subjective happiness as much as traditional handwriting approaches can, (2) natural gratitude message generation (e.g., from close friends or family) significantly improves both positive affect and subjective happiness, and (3) speaking gratitude messages aloud makes some people nervous, decreasing positive affect. The evaluation consisted of two phases of survey, the first survey with 22 Japanese students and the second survey with 70 Japanese and non-Japanese students, to confirm that these findings could be independent to the survey targets' culture and universally true. In future research, we will extend this work to construct an intelligent happiness encouragement framework that enables "natural" artificial gratitude intervention based on both handwritten- and voice-based gratitude actions.

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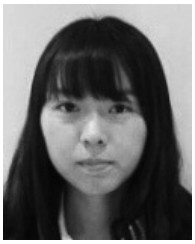

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