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Effect of robot utterances using onomatopoeia on collaborative learning

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***Abstract*—We investigated the effect of robot's utterances using onomatopoeia on collaborative learning. The robot was designed to praise or comfort by using onomatopoeia when learners are given problem to solve through a learning system. When learners can correctly solve a problem, the robot praises the learner's success. When learners cannot solve it, the robot comforts the learners to keep working at it. Eight college students learns mathematics by using a learning system with a robot for three weeks and took exams. We found that a robot could comfort learners that used onomatopoeia more than a robot that did not use onomatopoeia. This suggests that the robot that praises or comforts by using onomatopoeia helps learners maintain their motivation in collaborative learning.**

I. Introduction

With the growth in robot technology, more robots are supporting learning. For example, one robot supports the learning of students [1]. Another robot helps students learn English better [2]. Interaction between robots and humans promotes a more realistic learning experience. This could lead in making learners more interested in learning [3]. Moreover, a robot's recommendations are taken more seriously than those from one displayed on a screen agent. For example, Shinozawa [4] experimentally confirmed through quantitative evaluation that the degree of recommendation effect firmly depends on the interaction environment. The results show that a three-dimensional body has an advantage when the interaction environment is a three-dimensional space. This suggests that when a robot describes an object that exists in real space to a human. Additionally, Bainbridge [5] explored how a robot's physical or virtual presence affects unconscious human perception of the robot as a social partner. Participants collaborated on simple book-moving tasks with either a physically present humanoid robot or a video-displayed robot. Each task examined a single aspect of interaction: greetings, cooperation, trust, and personal space. Participants readily greeted and cooperated with the robot in both situations. However, participants were more likely to fulfill an unusual instruction and afford greater personal space to the robot in the physical situation than in the video-displayed condition situation. Therefore, a robot's physical presence has a beneficial effect on learning and problem solving.

Most studies have been focused on robot behavior and investigating the effect. For example, Koizumi [6] used a series of Lego-block building classes run by a robot to promote spontaneous collaboration among children. Robots not only manage collaborative learning between children but also have positive social relationships with children by praising their efforts. These experimental results suggest that robots promote spontaneous collaboration among children and improve their enthusiasm for learning. Moreover, Tanaka [7] reported on a robot that can promote learning by teaching to children. He conducted an experiment at an English language school for Japanese children (4-8 years old). He introduced a small humanoid robot into situations in which children completed tasks issued by their teacher. While children were completing the task, the robot intentionally made a mistake. However, few studies have been focused on robot utterances. Therefore, we do not know how such utterances affect learning and motivation.

Education studies have been focused on teacher utterances and reported that teacher utterances affects learners. For example, if a teacher encourages a learner faced with completing a task, the teacher can prompt the learner to increase their motivation [8]. Teacher utterances using onomatopoeia has recently gained attention. Onomatopoeia is a sensuous representation of an object, sound, or state. It can express an object that has a clear realistic sensation [9]. Physical education studies have suggested that teachers that instruct using onomatopoeia prompt learners to learn content and increase their motivation [10]. The study that analyzed teacher utterances in a nursing school reported that a teacher uses onomatopoeia when explain the instruction content. This suggests that onomatopoeia can stress teacher's utterances and increase learner motivation [11][12]. Therefore, we believe that utterances with onomatopoeia are more effective in learning than utterances without onomatopoeia. We also believe that onomatopoeia can be used for robot utterances.

We investigated the effect of robot's utterances with onomatopoeia on learners in collaborative learning. We compared such utterances with normal utterances. The robot was designed to encourage using onomatopoeia when learners are faced with solving a problem issued by a learning system. For

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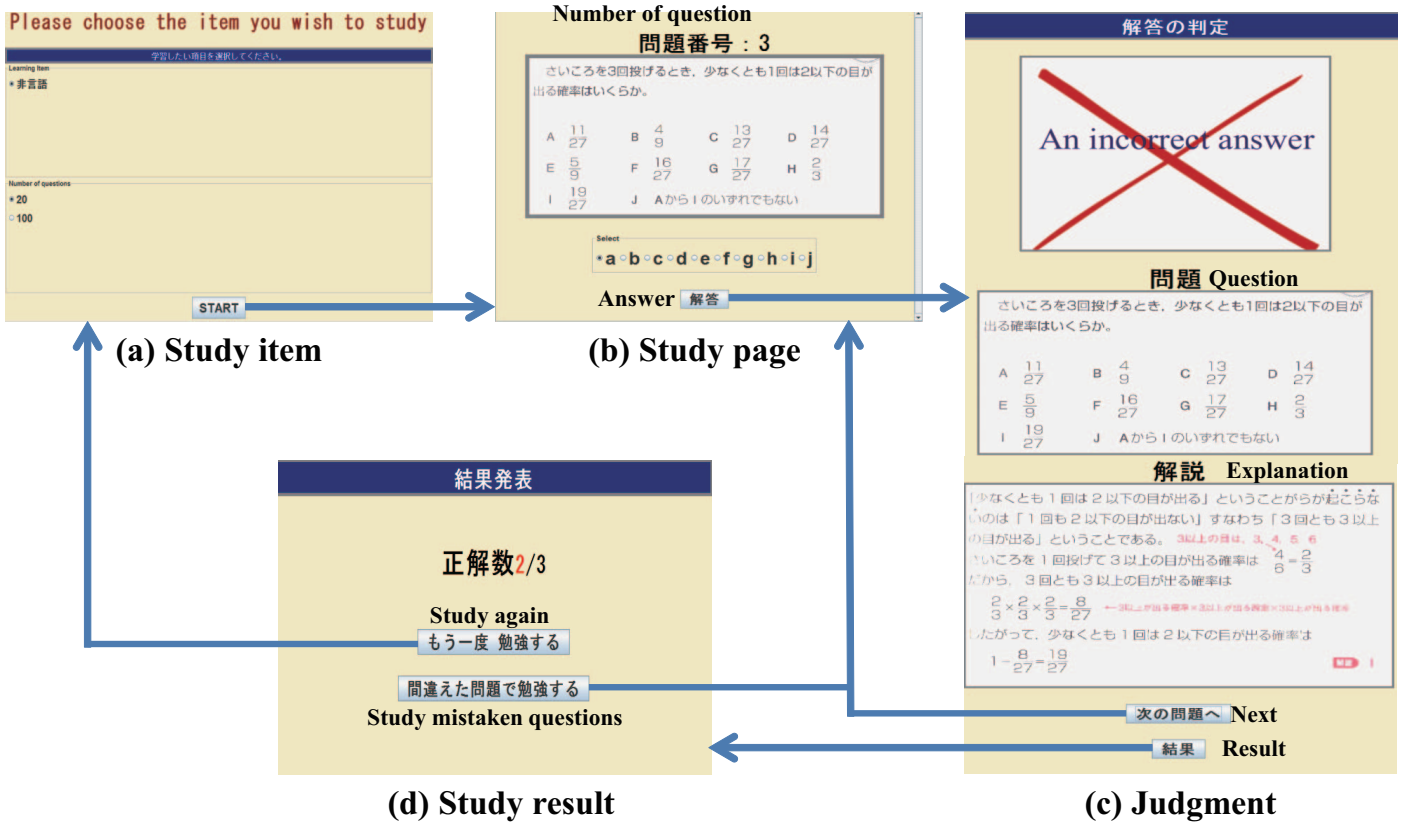


Fig. 1. Learning System

example, when learners can solve a problem, the robot praises the learner's success by uttering, "You're *gungun*(really) improving." When learners cannot solve it, the robot comforts the learners by uttering, "Keep up the *kibikibi*(good) work".

This paper consists of five sections. The second section explains the learning system with which the robot and learner learn. The third section describes the robot used in this study. The fourth section evaluates the involvement of the robot after describing the its effect on learning. The final section is the discussion.

II. Onomatopoeia

Onomatopoeia is a generic term for an "echoic word" and "imitative word." If you utilize Japanese verbs including onomatopoeia, you can easily express what you would like to communicate. For example, "*quickly* walking" or "*trotting*" can be expressed as "*sakusaku*" in Japanese and "*plodding*" can be expressed as "*tobotobo*". Such onomatopoeia is used as sounds independent of linguistic meaning and is known as sound symbolism, which is said to be universal and can be expressed image of sound form the sound and behavior of reality. Therefore, onomatopoeia can more fully express reality than general vocabulary.

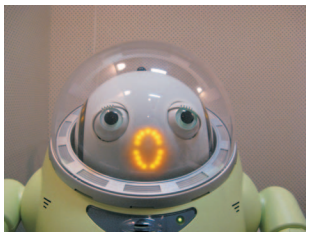
III. Overview of Learning System

We used a learning system (Fig. 1) for mathematical problems called"Synthetic Personality Inventory 2 (SPI2)." The SPI2 is used as a recruitment test for employment. The

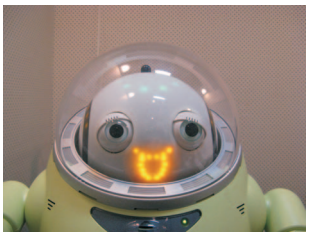
Fig. 2. Apperance of Ifbot

mathematical problems are junior high school level, such as profit and loss calculation and payment of fees. Therefore, college students did not need additional knowledge. The problems in the learning system were created by consulting the "2014 SyuSyokukatudou no Kamisama no SPI2 mondaisyu (in Japanese) [13]."

First, learners enter their account number to log in. A menu of study items is shown (Fig. 1(a)). The items are mathematical problems. The column from which the number of problems is chosen is shown under the study items. When the learner selects "20," 20 problems are displayed at random. When

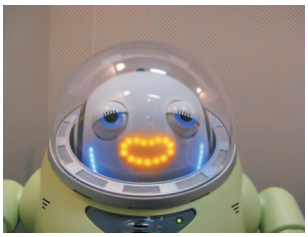


(e)Happy expression 1

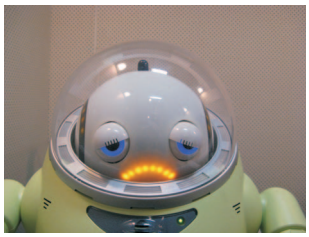


(f)Happy expression 2

Fig. 3. Examples of happy expression with Ifbot



(g)Unhappy expression 1



(h)Unhappy expression 2

Fig. 4. Examples of unhappy expressions with Ifbot

"20" is selected again, 20 different problems are displayed. This is done until all problems have been completed (100 problems). This enables learners to solve the problems within the selected study item. When the learner selects the study item and the number of problems, the learning screen (Fig. 1(b)) appears and the learning process starts. The learner provides an answer to the problem from the selection list. After the answer is given, the system displays whether it is correct, as shown in Fig. 1(c). When the learner selects "Next" (Fig. 1(c)), the system moves on to the next problem. When the learner selects "Result" (Fig. 1(c)) or solves all the problems, the system moves on to the results page (Fig. 1(d)). This page presents the number of correct and incorrect answers. When the learner selects "Study again," a menu of learning items is displayed (Fig. 1(a)). When the learner selects "Study mistaken problems," the study page presents problems that were answered incorrectly (Fig. 1(b)) .

IV. Overview of robot

A. Robot

We used Ifbot (Fig.2), which is a conversation robot. Ifbot can be used as an English learning robot and promote more effective learning [14]. It can also express various expressions. We implemented the learning system inside Ifbot. Therefore, Ifbot and the student could face the monitor and learn together.

B. Robot's utterances

We examined whether learners can learn from a robot's utterances in collaborative learning. Therefore, the robot did not use a function that enabled it to interact with human directly such as voice recognition. The robot acted in accordance with the screen of the learning system. Recent studies reported that teacher encouragement affects the learning motivation when learners solve problems [15]. Moreover, an agent's sympathy has been reported to improve the motivation of learners [16]. Therefore, Ifbot was designed to display a happy or unhappy expression and utter phrases of encouragement when learners solved a problem (Fig.SpiSystem(b)) and display the results (Fig. 1(c)). When learners could not solve the problem, Ifbot expressed sadness. Utterances were created by consulting recent education studies and included onomatopoeia.

(1) Praising motion
] The robot displays a happy expression, as shown in Figs. 3(e)(f) and utters, "You're *gungun*(really) improving (Table I(right))." when learners correctly solve a problem.

TABLE I. Example of Ifbot's utterances

	Normal utterance	Onomatopoeia utterance
Praise	You're improving. That's an improvement. You certainly did today.	You're *gungun* improving. That's *patto* an improvement. You certainly did *balibali* today.
Encouragement	Keep up the work. Let's do our best Keep working on it.	Keep up the *kibikibi* work. Let's do our *dondon* best Keep *gangan* working on it.

(2) Encouraging motion
The robot displays an unhappy expression by beginning to shed tears, as shown in Figs. 3(g)(h), and utters, "Let's do our *dondon*(more) best (Table I(right))." when learners cannot solve a problem.

These two motions are performed when the learning screens (Fig. 1(c)) are shown.

V. Examination

We conducted two examinations. One was to investigate the effect of Ifbot's utterances using onomatopoeia on learning. Another was to evaluate if Ifbot's action were able to interest the learners in learning.

A. Investigating effect on learning

1) Method: This examination was conducted to determine the effect of Ifbot's utterances with onomatopoeia on learning in two groups of learners. In both groups, learners learned with Ifbot. However, in one group, the robot praised and comforted with onomatopoeia. This group was called the Onomatopoeia Group. In the other group, the robot praised or comforted without onomatopoeia. This group was called the Normal Group. Sixteen college students participated. Both groups consisted of eight learners. The learners learn mathematics on the learning system for 40 minutes, three times a week for three weeks; a total of 9 times.

2) Evaluation: The point of the evaluation was to determine the difference in learning gains between the Onomatopoeia Group and Normal Group. The learning gains were calculared by subtracting the pre-test scores from the post-test scores. Each pre-test and post-test was presented as an SPI test, as shown in Fig. 5. The SPI test was based on the problems in the learning system and consisted of 95 problems. The analysis method involved a t-test. A significant difference is permitted if the p value is under the significance level of 5%.

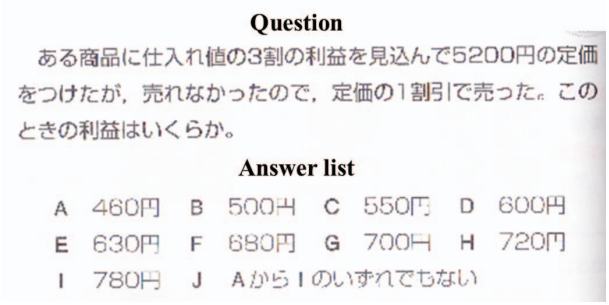


Fig. 5. SPI test

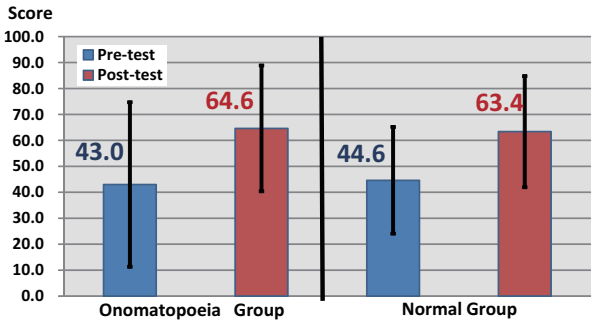


Fig. 6. Average scores for Pre and Post-test of each group

3) Results: The average pre-test and post-test scores are shown in Fig. 6. The average learning gains scores are shown in Fig. 7. Both Figs. 6 and 7 show the scores of the Onomatopoeia Group on the left and those of Normal Group on the right. The scores of learners in the Onomatopoeia Group were better than those of the learners in the Normal Group. We also conducted a t-test to determine how effectively learners learn the questions by using the learning gains scores of each group, as shown in Fig. 7. The results indicate that there was no significant difference ($t = 0.3, df = 14, p = 0.37$). Therefore, there was no difference in the effect on learning between the Onomatopoeia Group and Normal Group.

B. Examination to evaluate robot's action

1) Method: The robot's action was evaluated using the semantic differential scale method (SD method) [17]. The SD method is used to evaluate the image of company and good. Recently, the SD method has been used in robotics. For example, Ogata [18] used the SD method for evaluating the interaction between robots and humans. Kanda [19] used the SD method involving 28 adjectives for psychological evaluation experiments on robotic interaction. We use the SD method involving the following four adjectives, "approachable," "sociable," "fulfilling," "pleasurable." The SD method is shown in Fig. 8. The evaluation values are defined in the top left part as "-3" and increase by one as they progress right. We used the Mann-Whitney U-test. A significant difference is permitted if the p value is under the significance level of 5%.

2) Results: The average evaluation values of each group are listed in Table II, and the analysis results are listed in Table III. The results indicate that the values of the learners in the Onomatopoeia Group were better than those of the learners

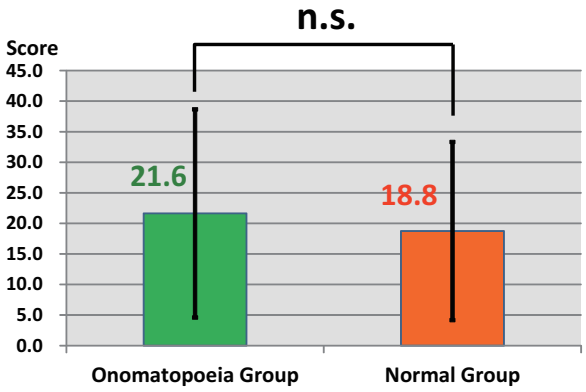


Fig. 7. Average learning gains of each group

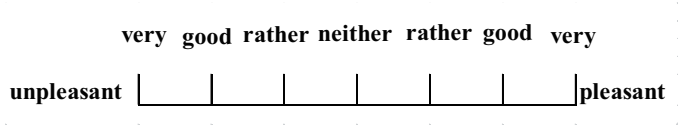


Fig. 8. SD method used in this study

in the Normal Group for sociable, pleasurable, fulfilling. On the other hand, the values of approachable of the learners in the Normal Group were better than those of the learners in the Onomatopoeia Group. The Mann-Whitney U-test results indicate that there was a significant difference between the Onomatopoeia Group and Normal Group in cheerful and fulfilling. Therefore, the learners in the Onomatopoeia Group were more fulfilled than those in the Normal Group.

VI. Discussion

The results suggest that our robot encourages learners. However, there was no difference in learning between utterances using onomatopoeia and normal utterances.

Recent education studies, in which teachers used onomatopoeia, suggests that onomatopoeia can help stress a teacher's utterances [11][12]. We believe that the same result is possible with robots.

The learning period in our study was short; three weeks, which is one reason that there was no difference in the effect on learning between utterances using onomatopoeia and normal utterances. From recent education studies, if learners increase their motivation, it takes time for this motivation to be reflected in the learning [20]. However, we found that the learning gains of learners in the Onomatopoeia Group were greater than those of learners in the Normal Group, as shown in Fig. 7.

VII. Conclusion

We investigated the effect that robot's utterances using onomatopoeia has on learners in collaborative learning. We evaluated the effect of utterances using onomatopoeia by comparing them with normal utterances. The robot was designed to praise or comfort with onomatopoeia when learners were faced with solving problems issued by a learning system. For example, when learners correctly solved a problem, the robot praised the learners by uttering, "You're *Gungun*(really) improving."

TABLE II. SD METHOD RESULTS

Adjective		Onomatopoeia Group	Normal Group
unpleasant	pleasant	$1.38(\pm 1.1)$	$0.13(\pm 0.8)$
stuffy	sociable	$1.25(\pm 1.1)$	$0.25(\pm 1.5)$
depression	fulfilling	$0.63(\pm 0.5)$	$-0.75(\pm 1.2)$
unapproachable	approachable	$0.75(\pm 1.1)$	$1.75(\pm 1.0)$

TABLE III. RESULT OF ANALYSIS

Adjective		U	$p\ value$
unpleasant	pleasant	17	0.02
stuffy	sociable	20	0.19
depression	fulfilling	10	0.01
unapproachable	approachable	11.5	0.09

When learners could not solve a problem, the robot comforted the learners by uttering, "Keep up the $Kibikibi$(good) work".

These results suggest that the robot encouraged learners. However, there was no difference in the effect on learning between utterances using onomatopoeia and normal utterances.

We are currently developing a robot that praises or comforts by using adjectives and adverbs for comparing the effect on learning between utterances with and without onomatopoeia. We also plan to conduct a longer-term examination.

REFERENCES

[1] T. Kanda, T. Hirano, D. Eaton and H. Ishiguro : "Interactive robots as social partners and peer tutors for children: A field trial," Hum-Comout. Interact., vol.10, No.1, pp.61-84, 2004.

[2] O.H. Kwon, S.Y. Koo, Y.G. Kim and D.S. Kwon: "Telepresence robot system for english tutoring," IEEE Workshop on Advanced Robotics and its Social Impacts, pp.152-155, 2010.

[3] T. Kand: "How a communication Robot Can Contribute to Education," Journal of Japanese Society for artificial Intelligence, Vol.23, No.2, pp.229-236, 2008.

[4] K.Shinozawa, F.Naya, J.Yamato and K.Kogure: "Differences in effect of robot and screen agent recommendations on human decision-making," International Journal of Human-Computer Studies, Vol.62, No.2, pp.267-279, 2005.

[5] W.A. Bainbridge, J. Hart, E.S. Kim and B. Scassellati: "The effect of presence on human-robot interaction," IEEE International Symposium on Robot and Human Interactive Communication, pp.701-706, 2008.

[6] S. Koizumi, T. Kanda and T. Miyashita: "Collaborative learning experiment with social robot," Journal of the Robotics Society of Japan,Vol.29, No.10, pp.902-906, 2011.

[7] F. Tanaka: "Social robotics research and its application at early childhood education," Journal of the Robotics Society of Japan,Vol.29, No.1, pp.19-22, 2011.

[8] H. Namiki: "Kotobakake no kouka no zikkenkekka kara," Child psychology(in Japanese),Vol.47, No.5, pp.474-477, 1993.

[9] T. Komatsu and H. Akiyama: "Expression system of onomatopoeias for assisting users' intuitive expressions," The Journal of the Institute of Electronics, Information and Communication Engineers A,Vol.J92-A, No.11, pp.752-763, 2009.

[10] Y.Fujino, M.Kikkawa and Y.Sagisaka: "A collection of onomatopeias in japan sports," Proc Oriental Cocosda, pp.160-164, 2003.

[11] M. Takano and M. Udo: "Onomatopoeia in the utterances of teachers at special schools," The Japanese Association of Special Education, Vol.48, No.2, pp.75-84, 2010.

[12] M. Takano and M. Udo: "Contribution of onomatopoeia to educational support for children with severe mental retardation," The Journal of School Education,Vol.19, pp.27-37,2007.

[13] H. Shinagawa: "2014 SyuSyokukatudou no Kamisama no SPI2 mondaisyu," U-CAN-pub(in Japanese) ,2012.

[14] F.Jimenez and M.Kanoh: "Robot that can promote learning by observing in collaborative learning," IEEE International Conference on Systems, Man, and Cybernetics, 2013.

[15] E.B.Hurlock: "An evaluation of certain incentives used in school work," Journal of Education Psychology, Vol.16, pp.145-150, 1925.

[16] H. Nakajima, Y. Moroshima, R. Yamada, S. Kawaji, S. Brave, H. Maldonado and C. Nass : "Social Intelligence in a Human-Machine Collaboration System : Social Responses of Agents with Mind Model and Personality," Journal of Japanese Society for Artificial Intelligence,Vol.19, No.3, pp.184-196, 2004.

[17] C.E.Osgood: "Studies on the generality of affective meaning systems," American Psychologist, Vol.17, pp.10-28, 1962.

[18] T. Ogata and S. Sugano: "Experimental Evaluation of the Emotional Communication between Robots and Humans," ISCIE Journal 'Systems, Control and Information,Vol.13, No.12, pp.566-574, 2000.

[19] T. Kanda, H. Ishiguro and T. Ishida: Psychological Evaluation on Interactions between People and Robot, Journal of the Robotics Society of Japan, Vol.19, No.3, pp.362-371, 2001.

[20] Y. Miyake and N. Miyake : "Pedagogical psychology," Foundation for the Promotion of The Open University of Japan, 2012.