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[International Conference on Science and Technology 2015](#), RMUTT Author version [Using Animated Social Feedback to Motivate Air Conditioning Energy Saving](#), [Wayan G. Santika Dept. of Mechanical Engineering Bali State Polytechnic Bali, Indonesia wayan.santika@pnb.ac.id](#) I Ketut Gede [Sudiarta](#) & I.G.P. Mastawan E. Putra [Dept. of Electrical Engineering Bali State Polytechnic Bali, Indonesia Abstract](#) — In 2009, Midden & Ham found that social feedbacks motivated users to reduce energy consumption in washing experiments with a simulated washing machine. They also found that having negative social feedbacks reduced energy consumption better than having factual, positive social, and no feedbacks. [The present study](#) compares [the effect of](#) positive [and negative social](#) and factual [feedbacks on](#) user [preferences](#) in air conditioning (AC) temperature setting. A higher room temperature setting means a lower energy use. We predicted that having any of the feedbacks increased chosen temperatures compared to having no feedback and that having negative social feedbacks increased chosen temperatures compared to having either factual, positive social, or

no feedbacks. An interface was made in order for the AC remote controller to be able to communicate with computers. Animated faces which are able to smile or frown were made representing positive and negative social feedbacks. The factual feedback is represented by a bar indicator that turns red when users choose low temperatures and green when high. 159 participants were asked to participate for the experiment and randomly assigned to either control, factual, positive, or negative feedback groups. A computer screen was put in front of respondents to display the animated feedbacks. Participants set their preferred AC temperature by means of a remote controller and the screen deliver feedbacks according to the chosen temperature. One-way ANOVA were used to analyze the data with temperatures as the dependent variable and feedbacks as independent variables. Results show that there was a significant effect of feedbacks on chosen temperatures,  $F(3, 153) = 20.96, p < .001, r = .54$ . There was a significant linear trend,  $F(1, 153) = 60.55, p < .001, r = .53$ , indicating that as the feedback changed from factual to positive and negative social, the temperature increased proportionally. Planned contrasts showed that having animated social feedbacks increased chosen temperatures compared to having no feedback,  $t(152) = 6.80, p < .001$  (1-tailed),  $r = .39$ , and that having negative social feedbacks increased chosen temperatures compared to having positive social feedbacks,  $t(152) = 2.14, p < .05$  (1-tailed),  $r = .17$ . However, having factual feedbacks did not increase chosen temperatures compared to having no feedback,  $t(152) = 1.10, p > .05$  (1-tailed),  $r = .09$ . Keywords—social feedback, animation, air conditioning, persuasive technology, human-computer interaction, energy conservation.

I. INTRODUCTION Persuasive technology is all interactive technology systems which are designed to alter human attitudes and behavior [1]. Despite of being relatively a new branch of study, persuasive technology has been widely applied in the field of marketing, health and safety, environmental protection, websites, computer and video games, robots, cell phones, smart environment, sport devices, toys, etc [1-4]. However, current development in persuasive technology is based on research in the United States and intended for their market [3,4]. US is believed to have unique cultures which distinguish it from other countries [5]. Some studies have suggested that societies with different cultural backgrounds will respond a persuasive message differently [6,7]. Considering that Indonesian culture is different from American culture, there is an urgent need to develop persuasive technology that takes local culture into account. The study of [8] shows that social feedbacks motivate users to reduce energy consumption in washing experiments with a simulated washing machine. The study reveals that having negative social feedbacks reduces energy consumption better than having factual, positive social, and no feedbacks. The present study compares the effect of positive and negative social and factual feedbacks on user preferences in air conditioning (AC) temperature setting. A higher room temperature setting means a lower energy use. We predicted that having any of the feedbacks increased chosen temperatures compared to having no feedback. We also predicted that having negative social feedbacks increased chosen temperatures compared to having either factual, positive social, or no feedbacks. An interface was made in order for the AC remote controller to be able to communicate with computers [9]. Animated faces which are able to smile or frown were made representing positive and negative social feedbacks. The factual feedback is represented by a bar indicator that turns red when users choose low temperatures and green when high.

II. LITERATURE REVIEW Computers are better than humans in their role as persuasive agents: more persistent, offer great anonymity, capable of processing large volume of data, scale easily, use many methods to persuade, and reach (private) places where humans cannot enter or may not be welcome [1]. Computers (and technology in general) can do their job continuously without getting tired or bored. Computers may hide persuader's identities

when needed especially in sensitive areas such as sexual activities. Computer ability to manage huge amount of data is advantageous especially when accurate information is required. Computers and technology as persuasive agents can be duplicated easily. Some cross-cultural studies conclude that societies with different cultural backgrounds respond a persuasive message differently [6,7]. In their study about persuasion effects of ads in American and South Korean popular magazines, [6] suggest that ads emphasizing individual benefits are more persuasive to the Americans than Koreans and that ads emphasizing family and group values are more persuasive to the Koreans. In a discussion about knowledge transfer in human resource development from US to Indonesia, [10] suggests adaptation to Indonesian culture, in which people are collectivistic and show a large power distance. Since persuasive technology is a new branch of research subjects, there are not many studies considering the influence of cultural orientation. The study of [8] applied persuasive technology on a washing machine simulation. The effects of different feedbacks (factual vs. social and social positive vs. negative) on energy consumption from washing activities was assessed. The study, conducted in The Netherlands (a very individualistic country), reveals that, compared to factual feedbacks, social feedbacks from a robot agent have positive association with washing behavior which conserves energy. The study also reveals that negative social feedbacks are better than the positive ones in promoting washing behavior that save energy.

III. METHODS The present study compares the effect of positive and negative social and factual feedbacks on user preferences in air conditioning (AC) temperature choices. AC is chosen as it is one of the energy devices that consumes a large fraction of energy. A computer, connected to an AC remote controller interface, is programmed to read temperatures set by the AC users. We know that the higher the temperature the lower the energy consumption. Fig. 1 shows the schematic of the system. Fig. 2 shows the remote controller interface. It has a power supply, a microcontroller unit, and an infrared sensor. Figure 1. Schematic of the system Figure 2. The Interface Figure 3. Display of a positive factual feedback Figure 4. Display of a negative factual feedback The computer is also programmed to display factual or social feedbacks. Fig. 3 and Fig. 4 show displays of positive and negative factual feedbacks. When users choose room temperatures that range from 22 to 25oC, the display shows green bars: one bar for temperature set of 22oC to four bars for 25oC. There is also a pleasant sound when users choose those temperatures. When users choose room temperatures that range from 18 to 21oC, the display shows red bars: one bar for temperature set of 21oC to four bars for 18oC. The display comes with a disturbing sound. An example of a positive social feedback is shown in Fig. 5. The display shows a face with a smiling expression. The higher the temperature the happier the face. The face also utters pleasing comments, from "it's okay," "good!" to "very good...!" and "excellent...!". The negative social feedbacks are displayed with frowning faces and unpleasant utterance.

A. The Experiment 156 students, aged from 17 to 22 years old and with only 6 female participants, from a medium-sized university in Indonesia participated in the experiment. They were randomly assigned into one of the experimental groups: control, factual, positive social, and negative social feedback groups. 1) Control group: Each respondent was asked to turn on an AC and choose the temperature she/he wanted in a classroom without any feedback or intervention. The initial temperature was preset to 22oC and the chosen temperatures were recorded by an experimenter. 2) Factual feedback group: Respondents of this group were asked to turn on and set the temperature of the AC in the same classroom. Factual feedbacks were given when a participant set the temperature. Participants were told that the feedbacks informed them whether the temperature they set consumed less energy or not. 3) Positive social feedback group: Before the group turning on and setting the temperature of the AC, they were

told that the character on the display was a boy named Rai who is smart and loves to help people conserve energy. Rai will be happy if people choose temperatures at which less energy is consumed. 4) Negative social feedback group: Participants of this group got a similar initial treatment to those of the previous group. The different is that Rai will be sad if people choose temperatures at which more energy is consumed. Temperatures set by participants in the treatments groups were automatically recorded by the computer. IV. RESULTS The descriptive statistical analysis shows that the average room temperature set by the control group, factual feedback group, positive social feedback group, and negative social feedback group are, respectively, 20.95 oC, 21.42 oC, 22.97 oC, and 23.87 oC. There is a significant effect of feedbacks on chosen AC temperatures,  $F(3,153) = 21.235$ ,  $p < 0.05$ ,  $r = 0.54$ . We found a significant linear trend,  $F(1,153) = 61.25$ ,  $p < 0.05$ ,  $r = 0.53$ . Fig. 6 shows the graph of the average set temperatures for each treatment. Happy and sad represent positive and negative social feedbacks, respectively. Figure 5. Display of a positive social feedback Figure 6. Average temperatures set for each treatment Planned contrasts showed that having animated social feedbacks increased chosen temperatures compared to having no feedback,  $t(152) = 6.80$ ,  $p < .001$  (1-tailed),  $r = .39$ , and that having negative social feedbacks increased chosen temperatures compared to having positive social feedbacks,  $t(152) = 2.14$ ,  $p < .05$  (1-tailed),  $r = .17$ . However, having factual feedbacks did not increase chosen temperatures compared to having no feedback,  $t(152) = 1.10$ ,  $p > .05$  (1-tailed),  $r = .09$ . Table 1 shows details of the planned contrast. Results confirm that feedbacks significantly increase room temperatures set by participants. Participants in the feedback groups significantly chose higher room temperatures than those in the control group. Providing feedbacks to people who are setting AC room temperatures will help them choose higher temperatures than people having no feedback. Participants in the factual group chose higher temperatures than those in the control group, however the difference is not statistically significant. Factual feedback seems to have no effect on the set temperatures. TABLE 1. PLANNED CONTRAST RESULTS Contrast Value of Contrast Std. Error t df Sig. (2- tailed)

Contrast	Value of Contrast	Std. Error	t	df	Sig. (2- tailed)
Control vs feedbacks	5.40	1.182	4.570	52.818	.000
Control vs social feedback	4.95	.828	5.974	62.262	.000
Control vs factual	.45	.432	1.044	65.807	.300
Control vs positive social	2.03	.449	4.511	69.819	.000
Control vs negative social	2.92	.472	6.192	73.761	.000
Factual vs social	4.05	.622	6.500	91.069	.000
Factual vs positive social	1.57	.356	4.418	75.747	.000
Factual vs negative social	2.47	.385	6.422	72.298	.000
Positive vs negative social	.90	.404	2.224	74.736	.029

Participants in the social feedback groups significantly chose higher temperatures than those in the control and factual groups. It means that social feedbacks have positive association with set temperatures. This finding confirms the statement of [1] saying that computers have a role of social agents that can give rewards and positive feedbacks, provide examples of attitudes and behaviors to follow, and offer social support. In other words, our attitudes and behavior may be altered by a machine. The last finding is that participants in the negative social feedback group set higher temperatures than those in the positive social feedback. In evolutionary perspectives, humans give more attention to negative emotions and feedbacks (e.g. sad, anger, and fear) than positive ones because negative expressions usually come with threats to our chances of survival. Another explanation comes from [11,3] who suggests that people in a collectivistic society are accustomed to negative reinforcement to shape behavior. The findings are similar to those found in [8]. Ref. [8] have found that, compared to positive social and factual feedbacks, the negative social feedback influences washing machine users to conserve energy the most. V. CONCLUSIONS The present study compares the effect of factual and social feedbacks on room temperatures set by AC users. Results reveal that the negative social feedback has the

[strongest effect in](#) promoting air conditioning use that consumes less energy by persuading users to set higher expected room temperatures. The finding is similar to the study of [8] which was done in The Netherlands, an individualistic country. ACKNOWLEDGMENT [The present study](#) is [funded by The](#) Indonesian Directorate General [of](#) Higher Education (Fund No. 023.04.1.673453/ 2015). REFERENCES [1] [B.J. Fogg](#), "Persuasive Technology: Using Computers to Change What We Think and Do," [San Fransisco, CA: Morgan Kaufmann Publishers, 2003](#). [2] [P. King](#) and [J. Tester](#), "The landscape of persuasive technologies," [Communications of the ACM](#), vol. [42\(5\)](#), [1999](#). [3] [R. Khaled](#), [R. Biddle](#), [J. Noble](#), [P. Barr](#) and [R. Fischer](#), "Persuasive interaction for collectivist cultures," in [W. Piekarski \(Ed.\), Conferences in Research and Practice in Information technology, vol. 40, 2006](#). [4] [R. Khaled](#), [P. Barr](#), [J. Noble](#), [R. Fischer](#) and [R. Biddle](#), "Our place or mine? Exploration into collectivism-focused persuasive technology design," in [IJsselsteijn et al. \(Eds.\), Persuasive 2006, LNCS 3962, Berlin: Springer, 2006](#), pp. 72-83. [5] [G. Hofstede](#), "Cultures and Organizations: Software of the Mind," [London: Harper Collins Business, 1994](#). [6] [S.P. Han](#) and [S. Shavitt](#), "Persuasion and culture: Advertising appeals in individualistic and collectivistic societies," [Journal of Experimental Social Psychology](#), vol. [30](#), 1994, pp. [326-350](#). [7] [J.L. Aaker](#) and [D. Maheswaran](#), "The effect of cultural orientation on persuasion," [The Journal of Consumer Research](#), vol. [24](#)(3), 1997, pp. [315-328](#). [8] [C. Midden](#) and [J. Ham](#), "Using negative and positive social feedback from a robotic agent to save energy," [Proceeding of the 4th International Conference on Persuasive Technology](#), Claremont, California, [2009](#). [9] [W.G. Santika](#), [I.K.G. Sudiarta](#), [A. Winarta](#) and [I.G.P.M.E. Putra](#), "Pembuatan Interface Remote Controller AC Terintegrasi Komputer dan Animasi dengan Aplikasi Teknologi Persuasif untuk Mendorong Perilaku Hemat Energi," [Proceeding of Seminar Nasional dan Pertemuan Peneliti Technopreneurship](#), Bali, Indonesia, 2013. [10] [G. Hofstede](#), "The applicability of McGregor's theories in South East Asia," [Journal of Management Development](#), vol [6](#) (3), 1987, pp. 9-18. [11] [H.C. Triandis](#), [Individualism & collectivism](#), [Westview press, 1995](#).