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Perceived Comfortableness of Anthropomorphized Robots in U.S. and Japan

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Abstract This study focuses on cultural differences in perceptions of comfortableness with robots that have either positive or negative anthropomorphic features. To clarify the effect of the valence of anthropomorphic features in addition to the effect of the number of features in different countries, this study investigated how Americans and Japanese perceive comfortableness with a positively or negatively featured robot. A total of 360 respondents (180 Americans and 180 Japanese) read a cover story about one robot. In the story, the valence and numbers of anthropomorphic features of the robot were manipulated and the respondents completed the comfortableness measurements including Comfort, Controllability and so on. The results demonstrated that Americans perceived more Comfort, Controllability, and Performance than did the Japanese respondents. The Americans show different levels of comfortableness perceptions in response to large number of features, and the Japanese respondents showed different levels of comfortableness in response to small number of features. We discuss the cultural background for the different patterns of perceived comfortableness between U.S. and Japan.

Keywords Comfortableness · Human essence · Japan · U.S

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1 Introduction

More and more humanlike robots have been developed recently to work in nursing homes [5], alleviate humans' feelings of loneliness [1], and care for elderly people's physical and mental health needs [4]. People from different cultures have different impressions toward robots [20]. Considering that humanlike robots work for humans in several cultures, it is important to understand from a cultural perspective how human-likeness affects humans' perceptions of robots. Psychologically, "imbuing the imagined or real behavior of nonhuman agents with humanlike characteristics, motivations, intentions, and emotions is the essence of anthropomorphism" [6]. This is distinguished from attributes of "lifelikeness," "naturalness," "human likeness," or mere "animism" [18]. In this article, we focus on individuals' perceived comfortableness with anthropomorphically featured robots from a cultural perspective.

Previous research revealed that people generally use specific factors when evaluating anthropomorphism (e.g. [9,11]). In the case that Western people anthropomorphize non-human agents, two factors of human nature (HN) and uniquely human (UH) are found [11]. UH traits imply higher cognition, civility, and refinement, and individuals who lack this sense of humanness are implicitly likened to animals. HN traits reflect emotionality, warmth, desire, and openness. UH traits are intended to represent the critical essence of humanness, while HN traits can be shared with other animals. In case of Asian cultures such as Japan, it has been found the factor structure is different from Western cultures as the Japanese distinguish the valence (positive or negative) of these factors [14].

To begin to understand why the valence of anthropomorphic features shows different effects according to differing cultural background, this study manipulated the number of

positive or negative features used. We have investigated how comfortable Americans and Japanese people are with robots with varying numbers of positive and negative features. We then attempted to discover a pattern of perceived comfortableness between the positive and negative features by comparing responses from both countries to consider the effect of valence of anthropomorphic features from a cultural perspective.

Haslam [11] proposed two distinct senses of UH and HN at the trait level. Additionally, Gray et al. [9] indicated there are two main dimensions to attributing a "mind" within an object. The first is agency, which refers to the capacity to act, plan, and exert self-control. The second is experience, which is the capacity to feel pain, pleasure, and other emotions. Gray et al. [10] emphasized that the two dimensions of agency and experience parallel UH and HN traits, respectively. UH emphasizes human cultures, which cultivate human potential by learning, and this is related to the high cognitive skill of agency. HN reflects human-like emotional warmth or positive activation, and this can be experienced through the biological body. Kamide et al. [14] found that the Japanese also clearly distinguish UH from HN, but they also distinguish the valence of each dimension. That is, for the Japanese, there are four factors to evaluate anthropomorphism: positive UH (e.g. "Humble," "Organized"), positive HN (e.g. "Friendly," "Fun-loving"), negative UH (e.g. "Hard-hearted," "Rude") and negative HN (e.g. "Impatient," "Aggressive").

From a cross-cultural perspective, some studies already showed different evaluations between Western countries and Japan. The reason to focus on Japan is because Japan has a specific robot culture, as reflected in popular manga and animated movies. Shibata et al. [19] revealed that European citizens are concerned with the necessity or animal-like qualities of robots, while Japanese citizens focus on the robots' visual and tactile aspects. It suggests that people from different countries have different perspectives or preference to evaluate robots and such different perspectives may also concern anthropomorphized robots. In other study, apart from the popularity of robots in Japan, some Japanese citizens are concerned about the possible negative social influences [2]. Bartneck [3] found that Japanese citizens prefer robot-like robots to highly humanlike androids. Furthermore, Kamide et al. [13] revealed that the relationship between familiarity and humanness in the perception of robots is not linear, as Mori [16] claimed. That is, the anthropomorphized features of robots seem to intricately link to likability according to cultural backgrounds and there is room to study focusing on anthropomorphism of the robots and psychological comfortableness. According to these studies, compared to Westerners, Japanese tend to be sensitive to negative features of the robots, therefore, they clearly distinguish the positive and negative valences even if the number of the anthropomorphic features are few whereas the Westerners distinguish both valences in case that the features are more because usually it is easier to distinguish the valence when the amount of information is more. This study focused on not only the valence but also the number of the anthropomorphic features in relation to psychological comfortableness.

In summary, previous studies have suggested that Japanese people are relatively sensitive to highly anthropomorphic robots and seem to care about the negative qualities of anthropomorphic aspects more so than do Westerners. However, there is no evidence that Japanese citizens react differently to robots with positive, as opposed to negative, anthropomorphic features in comparison to Westerners. It is necessary to evaluate the comfortableness in both cases associated with robots that display either positive or negative features. Furthermore, it is necessary to investigate cultural differences to understand the valence of anthropomorphic features and realize culture-specific adaptive human-robot interactions. To more precisely investigate the pattern of perceived comfortableness for both positive and negative features, we established conditions with different numbers of features (two, four, and six positive or negative features) in addition to two valences. To begin this process of investigation, this study compares the U.S. to Japan as representatives of Western and Asian cultures.

2 Materials and Methods

2.1 Participants

We set six conditions based on two variables of the valence(positive/negative) X the number of anthropomorphic features (two/four/six) in a between-subject design. Each of the six conditions included 30 Americans and 30 Japanese individuals. A total of 180 Americans (mean age = 29.78, SD = 5.27, 90 male) and 180 Japanese (mean age = 31.46, SD = 5.89, 90 male) were recruited online for this study. The company collected the participants was MACROMILL, INC. The participants from both countries lived in urban areas. The American respondents lived near New York, Los Angeles, and Chicago, while the Japanese respondents lived near Tokyo, Osaka, and Kyoto. The company screen-detected the participants based on their profile and none of the participants were engineers or university professors, and no participant was familiar with robots. This study was conducted under a code of ethical conduct of and received approval from the Japanese Psychological Association.

2.2 Procedure and Conditions of Anthropomorphic Features

We used a vignette approach using six different scenarios using a mixed design with two factors; the valence (posi-

Table 1 Presented items and explanations for each condition

Positive anthropomorphic features			
Two items	Four items	Six items	Curiousness (HN): The robot becomes interested in people and things which it sees for the first time, as well as new environments
			Humbleness (UH): The robot is not too assertive and has a low-key attitude
			Friendliness (HN): The robot is able to have close relationships with humans, interacting as if they are friends
			Organizational skills (UH): The robot is practically helpful and works diligently without simplifying things
			Sociability (HN): The robot tries to be associated with humans to establish relationships
			Politeness (UH): The robot is courteous and has proper manners towards humans
Negative anthropomorphic features			
Two items	Four items	Six items	Aggressiveness (HN): The robot is intolerant to humans, criticizing and blaming them in some cases
			Hard-hearted (UH): The robot is not mindful of human sentiment and situations, and shows no consideration
			Distractedness (HN): The robot lacks concentration in terms of staying on guard to keep bad things from happening, and is not careful
			Rudeness (UH): The robot has a "bah-humbug" attitude to humans and responds in an impolite manner
			Impatience (HN): The robot is antsy and quick on the trigger and rushes into things
			Shallowness (UH): The robot reacts to things superficially and has cursory knowledge with limited insight

tive/negative) and the number of the features (two/four/six). The six scenarios had a same introduction statement about a robot but differed with each other in the valence and the number of the features that the robot had (Table 1); the valence(positive/negative) X the number of anthropomorphic features (two/four/six). Participants first read the same introduction stating about the robot with photos of the robot (Fig. 1) as following:

> This robot, as of 2014, is the latest model, but it is still in a developmental stage and is not accessible to the public. We tested a program that makes the robot shown above automatically learn how to communicate with humans. The robot randomly displays some features through communication that could be either good, bad, or both. It was discovered that the robot achieved the following features; (anthropomorphic features shown in Table 1)

To focus the investigation on the valences of the features, the items included in both UH and HN in Haslam's [11] study were mixed, so each condition would have the same numbers of UH and HN items. Additionally, it was determined that the items that were adjectives in Haslam's [11] study would be replaced by nouns in accordance with the cover story. Showing items exclusively could confuse the participants because they would not imagine the robots having such features. Therefore, we added short explanations of each item, and then modified them to aid in the imagining of anthropomorphic robots. After they read each item and the explanation, the participants evaluated the comfortableness of the robot (Fig. 2).

2.3 Measurements

To evaluate the participants' perceived comfortableness with the robot, we used a scale that measures the psychological safety of humanoids [12]. These researchers defined psychological safety as perceived comfortableness from users' perspectives. We used 4 main factors (Comfort, Performance, Peace of mind, and Controllability). Comfort emphasizes benefits that robots may provide to humans, such as men-

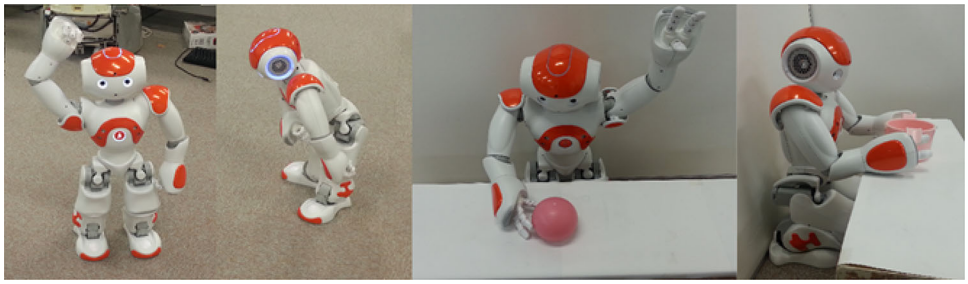

Fig. 1 Photos of a robot shown to participants

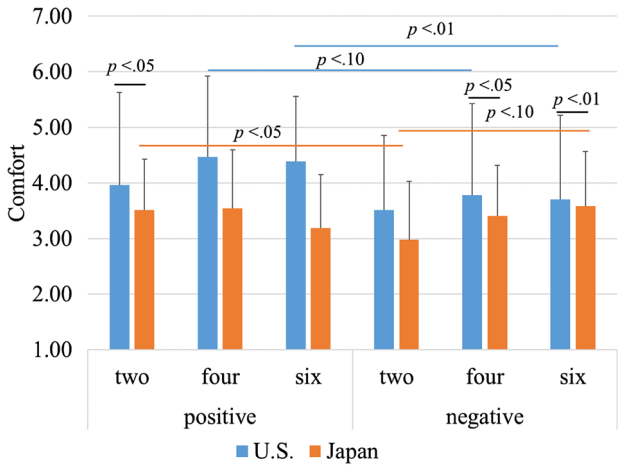

Fig. 2 The results of Bonferroni post hoc test

tal healing and this factor is formed by 8 items ($\alpha = .92$) for example, "This robot seems to provide mental healing for me". Performance refers to a high performance advantage in supporting humans and is composed of 13 items ($\alpha = .94$) such as "This robot seems to respond appropriately to my question". Peace of mind encompasses low disadvantages, such as low mental stress, caused by robots, and is composed of 5 items ($\alpha = .82$) for example, "The robot makes me feel uncomfortable". Controllability refers to a lack of robotic errors in regards to user control and is 14 items ($\alpha = .94$) such as "This robot does not seem to get out of control". The participants evaluated the items on a scale from 1 (totally disagree) to 7 (totally agree).

As Mori [16] claimed, if the robot looks like human very much, people could feel uneasy to the robot. In this study the degree of the anthropomorphism of the robot is manipulated by means of the number of the features but there found a individual tendency to anthropomorphize non-human agents (Individual Differences in Anthropomorphism Questionnaire: IDAQ, [21]). Therefore, we adopted IDAQ in order to control the individual tendency to anthropomorphize the robot in analyses. This scale is composed of 15 items ($\alpha = .94$), and Participants evaluated the items on a scale from 1 (totally disagree) to 10 (totally agree).

3 Results

We used a 3-way ANCOVA controlling the individual attributes of IDAQ to see how each factor of the perceived comfortableness (Comfort, Performance, Peace of mind, Controllability) was affected by the country (U.S. or Japan), the valence (positive or negative), and the number of features (two, four, or six). As we expected, IDAQ has significant effects for all factors of Comfort, Performance, Peace of mind, Controllability. The results controlling the effect of IDAQ are following.

Main effects of the country were found for Comfort, Performance, and controllability. Americans evaluate the robot more comfortable and controllable and also higher performance than Japanese do. Marginal main effects of the valence were found for Comfort and Peace of mind. Both Americans and Japanese tend to feel more comfortable and peace of mind to the robots with positive anthropomorphic features than with negatives ones. We found a significant three interaction effect of the country, the valence, and the number of features for Comfort and also a marginal three interaction effect for Controllability. Results of ANCOVA are shown in Table 2.

A Bonferroni post hoc test (Table 2) revealed that Americans emphasize the different level of comfortableness between positive and negative features when the number of features is six whereas Japanese do when the number of features is two. We also found that Americans marginally show the different level of comfortableness between positive and negative features when the number of features is four.

That is, the relative large number of anthropomorphic features have an effect on the comfortableness for American. On the other hand, Japanese recognize the difference of the comfortableness when the robots have the relative small number of anthropomorphic features.

The results of A Bonferroni post hoc test also show that Americans evaluate the robots more comfortable than Japanese in case that the robot has two positive features, four and six negative features. That is, even though the number of positive features is small, and also the number of negative features is large, Americans are open to such robots compared to Japanese.

Table 2 The results of ANCOVA and Mean scores (SD)

The effect		Comfort	Performance	Peace of mind	Controllability
IDAQ		$F(1, 347) = 154.59$, $p < .001$	$F(1, 347) = 196.37$, $p < .001$	$F(1, 347) = 101.41$, $p < .001$	$F(1, 347) = 80.26$, $p < .001$
The country		$F(1, 347) = 8.96$, $p < .01$	$F(1, 347) = 51.28$, $p < .001$	$F(1, 347) = 0.37$, n.s.	$F(1, 347) = 22.88$, $p < .001$
The valence		$F(1, 347) = 3.68$, $p < .10$	$F(1, 347) = 0.05$, n.s.	$F(1, 347) = 3.08$, $p < .10$.	$F(1, 347) = 0.66$, n.s.
The number of features		$F(1, 347) = 1.02$, n.s.	$F(1, 347) = 1.20$, n.s.	$F(1, 347) = 0.21$, n.s.	$F(1, 347) = 0.31$, n.s.
The country * the valence		$F(1, 347) = 2.43$, n.s.	$F(1, 347) = 1.25$, n.s.	$F(1, 347) = 2.30$, n.s.	$F(1, 347) = 0.96$, n.s.
The country * the number of features		$F(1, 347) = 0.03$, n.s.	$F(1, 347) = 0.32$, n.s.	$F(1, 347) = 1.93$, n.s.	$F(1, 347) = 0.26$, n.s.
The valence * the number of features		$F(1, 347) = 0.09$, n.s.	$F(1, 347) = 1.31$, n.s.	$F(1, 347) = 0.43$, n.s.	$F(1, 347) = 0.89$, n.s.
The country * the number of features * the valence		$F(1, 347) = 4.19$, $p < .05$	$F(1, 347) = 1.85$, n.s.	$F(1, 347) = 1.72$, n.s.	$F(1, 347) = 2.75$, $p < .10$
M (SD)					
U.S.					
Positive	Two features	3.97 (0.66)	4.13 (1.52)	3.89 (1.51)	4.77 (1.15)
	Four features	4.47 (1.46)	4.72 (1.12)	3.64 (1.35)	5.01 (0.92)
	Six features	4.39 (1.17)	4.35 (1.14)	3.82 (1.22)	4.84 (0.97)
Negative	Two features	3.51 (0.34)	3.85 (1.27)	4.22 (1.41)	4.45 (1.33)
	Four features	3.79 (1.64)	4.10 (1.49)	4.00 (1.59)	4.46 (1.42)
	Six features	3.71 (1.52)	4.34 (1.26)	3.60 (1.25)	4.77 (1.02)
Japan					
Positive	Two features	3.51 (0.91)	3.31 (0.75)	4.00 (0.70)	4.22 (0.66)
	Four features	3.54 (1.05)	3.55 (1.07)	4.41 (1.17)	4.13 (1.17)
	Six features	3.19 (0.96)	2.91 (0.88)	4.52 (1.04)	3.90 (0.99)
Negative	Two features	2.98 (1.05)	3.17 (1.00)	3.94 (1.06)	3.77 (0.86)
	Four features	3.41 (0.91)	3.35 (0.83)	3.89 (0.74)	4.22 (0.66)
	Six features	3.59 (0.98)	3.50 (0.84)	4.13 (0.92)	4.21 (0.69)

4 Discussion

This study investigated how Americans and Japanese react to robots with positive or negative anthropomorphic features in relation to perceived comfortableness. We established a different number of features as the conditions to reveal more precisely how Americans and Japanese react differently to each positive and negative anthropomorphic feature.

The results showed that Americans associate more comfortableness (Comfort, Performance, and Controllability) to a robot with anthropomorphic features than do the Japanese. Bartneck [3] revealed that the Japanese have a strong preference for conventional robots, rather than robots with highly anthropomorphic features, which are preferred by Americans. This study supported his finding by showing that Americans seem more accepting than the Japanese of robots with a higher quality of human essences. Specifically, the results of this study revealed that even though the qualities of human essence, such as curiosity and friendliness, may be positive, Japanese respondents tend to be less comfortable with these robots than do Americans.

No main effects were found for the numbers of features. Although the main effect of the numbers of features is insignificant, it is possible that the impact of each item is not equivalent. This study focused on the valence of anthropomorphic features, but future research should investigate the weight of each item, as well as observe the combinations of items on perceived comfortableness in relation to cultural background.

We found an interaction effect between the country, the valence, and the number of features for Comfort and also a marginal interaction effect for Controllability. In the case that the number of features is relative large, positive features significantly make American more comfortable than the negative features. On the other hand, for Japanese, it seems easy to recognize the difference of comfortableness when they evaluate the robot with the relative small number of anthropomorphic features.

When the number of features is large, the discrepancy between positive and negative features is more clear and perceivable. Therefore, it is plausible that people easily distinguish the comfortableness of the robots when the robots have a large number of positive or negative features as Americans do in this study. But Japanese distinguish the comfortableness when the robots have a small number of features and do not show different comfortableness for the robots with a large number of features. As is often said, Japanese find difficulty to say right and wrong clearly and worry about other's opinions. The result of Japanese is potentially explained by that they are confused by the large number of features and the small number of features is relative easy to judge the comfortableness because of the fewer amount of the considerable information. Future research needs to clarify the reason the Japanese specifically react to the small number of anthropomorphic features rather than the large number of features.

As previous studies have shown, Westerners distinguish UH from HN (e.g. [7,8,11]), but there is no reports that they distinguish the valence of these factors. By contrast, the Japanese differentiate UH and HN valence [14]. In line with these findings, the pattern in perceived comfortableness for the positive and negative anthropomorphic features is revealed differently between Americans and Japanese. Although previous studies have suggested such cultural contrasts, this study revealed that the robots' anthropomorphic features almost uniformly determined comfortableness for Americans, and more precisely, Americans show the different comfortableness for the large number of positive/negative features whereas Japanese do for the small number of features.

Mori [16] claimed when human likeness reaches a certain threshold, likability drops drastically because high human likeness causes people to imagine dead humans, and this drop point is defined as an "uncanny valley." Mori [16] did not argue for cultural background, but Bartneck [3] revealed that while Americans mildly increased their likability evaluations for robots that were more anthropomorphic, Japanese had lower likability ratings for these kinds of robots. Because of this, he concluded that the uncanny valley is a strictly Japanese, not an American phenomenon. Our results support this conclusion in the way the Japanese showed more negative evaluations of the anthropomorphized robots compared to the American participants. Moreover, our results suggest that the Japanese tend to dislike humanlike robots because they are very uncomfortable with robots with anthropomorphic features.

Rosenthal-von et al. [17] revealed that cultural difference may partly be explained the different level of prior experience with robots. Actually the experience of the robots could differ among countries so we need to investigate the effect of experience of the robots in the future research. Złotowski et al. [22] claimed that anthropomorphism of the robots has advantages such as to facilitate interaction between robots and humans and also has disadvantages such as the robots portrayed in fiction make people to assume that artificial intelligence has progressed more than the reality. Assumptions or attitudes toward robots could be different among countries and it is necessary to investigate such kind of social background to consider the cultural difference.

One of limitations of this study rests in the fact that we used a static photograph with descriptions of anthropomorphic features, and the participants imagined how a robot with such features would act or behave. And 180 sample is small to represent U.S. people because they have a diversity compared to Japanese, therefore we need to focus to duplicate these results with more sample. This study clarified the effects of country and the numbers of features on comfortableness

perceptions concerning the robot, but future studies are necessary to investigate these results using a video or a robot with anthropomorphic features that displays real behaviors. In addition, this study manipulated the number of items of anthropomorphism. Lay et al. [15] focused on the uncanny valley and designed stimuli including human likeness, emotional response and so on. The future study should investigate other possibilities to manipulate anthropomorphism and also how the difference of the items effects on the cognitive process in relation to the perceived comfortableness.

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