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Personality of social robots perceived through the appearance

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Abstract. Past research showed that people are able to perceive the personality of others at zero acquaintances. There are two main ways, verbal and non-verbal methods, which play an important role for one in perceiving personality of others. Extensive research was conducted in relating personality with verbal, paralinguistic and gestures cues. However, there are not much research, to our knowledge, that relates the appearance and perceived personality of robots. The main objective of this research is to relate individual design features with big five perceived personality of the robots. We used the results of rated perceptions across 100 pictorial images of robots and relate the results with the 40 individual design features using General Linear Model (GLM). The initial results of the GLM analysis showed that participants' rating of personality of robot fell along the dimension of perceived friendliness which is a common rotation of extroversion and agreeableness. Some relationships were found between humanlike design features and perceived friendliness of robots. Since participants are more familiar with humans, participants perceived robots with humanlike features friendlier than the others. Some other findings such as color and surface material were found related with participants' perceived friendliness as well. In the future, we will work on the analysis of the main and interaction effects of individual features on user's perceived friendliness.

Keywords: social robots, perceived personality, visual appearance, generalized linear model

1. Introduction

Recently, personality has been introduced as a new design dimension in social robots. The implementation of personality on social robots is supposed to enhance robot affordances and cues to the users [1], facilitate spontaneous, intimate and effective interaction between humans and robots [2], and also increase satisfaction of interaction between two parties [1, 3, 4].

Out of the five widely used personality dimensions, namely the extroversion, agreeableness, conscientiousness, neuroticism, and openness [5], the most important dimensions for social interactions are those that concern individual differences in social behavior, namely extroversion and agreeableness or their common rotations, 'friendliness' and 'dominance' [6]. The two factors and some typical labels, including dominant-submissive, friendly-cold, and extroverted-introverted were proposed as a two dimensional interpersonal-space circumplex model [e.g., 6, 7-9] which can be used to explain a large proportion of variance in ratings of personality traits [6, 10-14].

With such importance of personality, designers and researchers have been emphasizing personality communication between robots and users. There are various ways of communicating personality by providing verbal and non-verbal cues to the users. The non-verbal cues can be further differentiated into visual and paralinguistic cues.

1.1. Verbal and paralinguistic cues

One of the most popular and common ways of presenting personality is the verbal behaviors. For example, an extroverted person is more likely to use strong, confident words and phrasing, whereas an introverted person would be more hesitant in speech

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and use less direct and confident phrasing [15]. A significant amount of similar research work was conducted by various researchers as well to show that users are able to recognize the personality of the digital voice [1, 16, 17]. These studies showed concrete evidences on the effect of verbal cues on users' perceived personality of social agents and/or robots.

1.2. Visual cues and perceived personality

Studies in social science showed that one can tell a great deal about the personality traits of others through the movement and gestures [18]. For example, dominant personality trait are strongly communicated by postures and gestures that demonstrate a readiness for aggressive actions whereas for submissive personality persons, they tend to adopt postures that minimize size, such as slouching or kneeling, and position their bodies at an angle [19]. Using postures and gestures to communicate personality of social agents has received some promising results from previous research [2, 17].

To design the robot appearance, researchers and industrial designers have been putting efforts on the micro perspectives which relate robot appearance with individual and their subjectivity [20]. One example is Mori's [21] Uncanny Valley, which relates users' emotional responses with the robot human-liked appearances and behaviors. This theory has been widely applied in the consideration of appearance design for humanoid robots. With only limited exceptions [e.g., 20], previous research did not discuss robot appearance in a macro perspective which focuses on the social structure, such as social role and personality.

Though similar research of facial [e.g., 9, 22, 23] and bodily perceptions [e.g., 9, 24, 25] of personality has been extensively conducted with human and other social characters, similar research remained limited on the design of social robots.

The literature review showed concrete evidences of the relationships between verbal cues, posture, and gestures with perceived personality. These findings have been largely applied on the manipulations of the personality of social agents or robots. However, not much research attention was found on the relationship between appearance and perceived personality, especially in the human-robot interaction (HRI) research. To further understand how designers can communicate personalities with the appearance of humanoid robots, the author would like to place the focus of this study on the correlations between design features of humanoid social robots with the perceived personality.

2. Methods

In order to understand the correlation in between users' perceptions and the design features of robots, participants' perceptions across the 100 images of different robots were firstly investigated. The individual features of the robots of 100 images were then analyzed individually. These individual features were then correlated with the rated perceptions of these robots. The final results yield the relationships between robot design features on appearance and their perceived personality.

The methods in this study involved the subjective ratings of perceived personality of pictorial image of robots, coding of design features, and relating the two parts with general linear model (GLM) which would be discussed subsequently.

2.1. Participants

Total number of 15 subjects, including 8 males and 7 females, were recruited from various faculties in Nanyang Technoglogical University of Singapore. The participants' ages range from 20 to 27 years old (M=22.9, SD=2.09). Upon completion all the sections of the experiment, each participant was compensated with SGD 25 for their time spent in the experiment. No participant had reported prior experience of working or interacting with robots.

2.2. Variables

The five dimensions of users' perceived personality toward robots were included in the questionnaire. These five dimensions included perceived extroversion, agreeableness, conscientiousness, neuroticism, and openness [5].

Sample questionnaire of 100 items were extracted from International Personality Item Pool (IPIP) [26] and used as the basic questionnaires to study perceived robot personality in this study. Selected appropriate items were modified according to the context of robots' personality and included in the questionnaire. For example, the perceived robot extroversion was measured with two items, *'This robot looks quiet around strangers'* and '*This robot seemingly makes friend easily'*. Perceived robot agreeableness was measured with two items, '*This robot is seem-*

ingly interested in people' and *'This robot seemingly feels at ease with people'*. Participants rated whether they agree with the statement on a seven point Likert scales (1=strongly disagree, 7=strongly agree).

Besides the five dimensions of personality, three key variables of robots in HRI suggested by Bartneck et al. (2008) were included in this study. The first variable is the perceived anthropomorphism which refers to the attribution of a human form, human characteristics, or human behaviors to non-human things such as robots, computers, and animals. Six items, namely *'Fake/Natural', 'Machinelike/Humanlike', 'Unconscious/Conscious', 'Artificial/Lifelike',* and *'Moving rigidly/Moving elegantly'* were included to measure perceived robot anthropomorphism [27]. The second variable is perceived robot animacy which refers to lifelikeness of the robots. Perceived robot animacy was measured with six items, namely *'Dead/Alive', 'Stagnant/Lively', 'Mechanical/Organic', 'Artificial/Lifelike', 'Inert/Interactive',* and *'Apathetic/Responsive'* [27]. The third variable is perceived robot safety which describes the user's perception of the level of danger when interacting with a robot, and the user's level of comfort during the interaction. Three items, namely *'Anxious/Relaxed', 'Agitated/Calm',* and *'Quiescent/Surprised'* were included to measure perceived robot safety [27].

2.3. Experimental design

Subjective questionnaire was designed to capture participants' perception of different social robots that are shown to the participant in pictures. Though Albright et al. [28] commented the inability to generalize the results of using photographs in the experiment, some researchers advocate using photographs in the experiments due to the ease of manipulations [29, 30]. Photographs used in experiments were careful selected and filtered to prevent biases in subjects' ratings.

2.4. Procedures

2.4.1. Selection of pictures

Pictures to be used for the experiment is collected from several sources, including research paper, technical report, newspaper, internet, illustration in literatures, and movies. Among the pictures collected, famous robot images from movies (e.g. R2D2, C3PO from StarWars) were excluded because the familiarity to the original film or story can give strong contextual information which may influence the evaluation of the participant. Only images which were able to show clear and unambiguous physical appearance of a robot will be selected. Additionally, a question asking whether the participant had seen the picture before is added in order to record the previous exposure. Screened pictures were normalized by the size and quality of the picture in order to make them look as uniform as possible.

2.4.2. Experimental procedures

Before the experiment, participants were required to complete the pre-experimental questionnaire online. Their results will be collected for further analysis. Next, participants were required to sign the consent form indicating their voluntariness of participation in the research. After that, the participants provided their demographic data, including their email addresses and phone numbers for further collaboration.

In the main experiment, different pictures of social robots were shown to the participants one after another. For each of the pictures, participants were required to reflect their perceptions towards the particular robot shown in the picture. Each questionnaire consisted of 10 questions to access subjects' perceived personality of each illustrated robot. Due to the large number of pictures, the experiment was segmented into three sessions. Each session took less than two hours. After each section, participants took fifteen minutes break.

3. Results

3.1. Rated perceptions across 100 robots

The five dimensions of personality of the 100 robots, namely perceived extroversion, agreeableness, conscientiousness, neuroticism, and openness were measured in the experiment. The overall Cronbach's alpha value is 0.71. Whereas, the alpha values for perceived animacy, anthropomorphism and safety measurements are 0.92, 0.90 and 0.86 respectively.

The overall mean of perceived extroversion was 3.06 (SD=0.97), overall mean of perceived agreeableness was 2.90 (SD=1.10), overall mean of perceived conscientiousness was 3.30 (SD=0.80), overall mean of perceived neuroticism was 3.20 (SD=0.90), and overall mean of perceived openness was 3.10 (SD=0.90). The overall mean of perceived

animacy was 3.10 (SD=1.13), anthropomorphism was 3.12 (SD=1.12), and safety was 3.68 (SD=1.02).

Since extroversion and agreeableness are claimed to be important in interpersonal communication, these two dimensions of personality were selected for further analysis. With the results of perceived extroversion and agreeableness of social robots, a two-dimensional map was generated (see Figure 1). Perceived extroversion is on the horizontal axis whereas agreeableness is on the vertical axis. Two reference lines of X-Y axes were drawn based on the mean value of perceived extroversion (M=3.08) and agreeableness ratings (M=3.24). The diagonal line on the two dimensional map symbolizes the friendliness-cold dimension as a common rotation of extroversion and agreeableness proposed by the two-dimensional circumplex model [9].

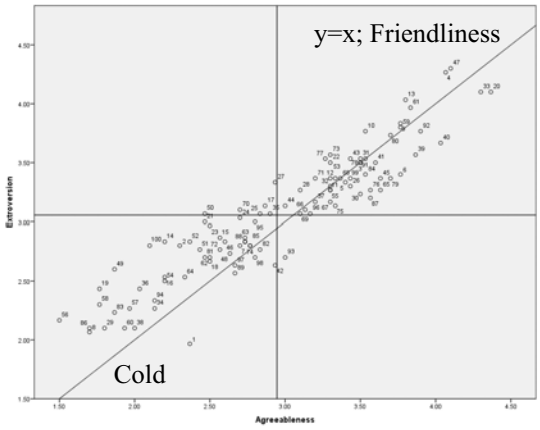

Figure 1 Scatter plot of robots personality ratings on two dimensional maps of perceived extroversion and agreeableness

From the result of the mapping, the robots can be mainly divided into two types by two quadrants; the first quadrant of high extroversion and high agreeableness and third quadrant of low extroversion and low agreeableness. Forty-four percent of robots fall in the first quadrant whereas fifty two percent of robots fall in the third quadrant. Four percent of robots fall in the second and fourth quadrants. The results showed a goodness-of-fit of the robots on the trait dimension of friendliness and imply that the participants may judge the robot from the dimension of perceived friendliness of robots. Since majority of the robots (96%) fall along the dimension of friendliness-cold, the analysis will be conducted along this dominating dimension.

3.2. Relating rated perceptions and coded features through general linear model (GLM)

Since the focus of this present study is on the personality design for humanoid social robots, twenty-five pictures of non-humanoid robots were removed for further analysis. Hence, a total of 75 humanoid robots were selected for the analysis.

Relating the design features and the perceptions of robots, this present study focuses on both main and interaction effects of 40 predefined design features of robot appearance.

The initial results of analysis showed that participants see the robots with more humanoid features, such as two upper limbs, skin surface material, mixed and warm color, and with clothing were perceived to be friendlier than the robots with more mechanical features, such as one upper limb, metallic surface material, cold color, and without clothing.

This initial result implies the direct correlation between perceived anthropomorphism with perceived robot friendliness.

4. Discussion

The result of scatter plot on two-dimensional personality map showed that the perception of robots personality scattered along the dimension of friendliness-cold as suggested by the two-dimensional circumplex model. The majority of the robots fall in the quadrant of high extroversion and agreeableness as well as the quadrant of low extroversion and agreeableness. This result indicated friendliness-cold as an important dimension in primary personality judgment of humanoid robots. And this result is similar with the previous findings of Dryer [31] that friendliness-cold is an important dimension of the perceived personality judgment of social agents.

Relating the design features with perceived robot personality, the results indicated that robots with highly humanoid features were perceived friendlier than the robots with highly mechanical features. This is probably because users are normally more familiar with communication with other human beings than machines. They may think that humans are more easily communicating than the machines and hence rated the robots with human-like features friendlier than those with machine-like features.

Overall, the results of this present study indicate that human perceptions of robot friendliness are dependent on their perceptions of anthropomorphism.

Hence, one rule of the thumb for robot designers to design a friendly humanoid robot is to consider some basic humanoid features. Whereas, if robot designers are to design a cold robot, they may consider including some mechanical design features.

5. Conclusions

This study serves as the first study to relate the big five dimensions of perceived personality of humanoid robots with their visual appearance. A careful analysis of results can provide a set of basic guidelines for designers to design a robot with their intended personality.

References

[1] Lee, K.M., et al., Can Robots Manifest Personality?: An Empirical Test of Personality Recognition, Social Responses, and Social Presence in Human-Robot Interaction. Journal of Communication, 2006(56): p. 754-772.

[2] Kim, H., S.S. Kwak, and M. Kim. Personality design of sociable robots by control of gesture design factors. in Robot and Human Interactive Communication, 2008. RO-MAN 2008. The 17th IEEE International Symposium on. 2008.

[3] Dryer, D.C. and L.M. Horowitz, When Do Opposites Attract? Interpersonal Complementarity Versus Similarity. Journal of Personality and Social Psychology, 1997. **72**(3): p. 592-603.

[4] Tapus, A., C. Tapus, and M.J. Matarić, User-robot personality matching and assistive robot behavior adaptation for post-stroke rehabilitation therapy. Intelligent Service Robotics, 2008. **1**(2): p. 169-183.

[5] Goldberg, L.R., The development of markers for the Big-Five factor structure. Psychological Assessment, 1992. **4**(1): p. 26-42.

[6] Wiggins, J.S., A psychological taxonomy of trait-descriptive terms: The interpersonal domain. Journal of Personality and Social Psychology, 1979. **37**(3): p. 395-412.

[7] Gurtman, M.B., Evaluating the Interpersonalness of Personality Scales. Personality and Social Psychology Bulletin, 1991. **17**(6): p. 670-677.

[8] Wiggins, J.S. and R. Broughton., The interpersonal circle: A structural model for the integration of personality research, in Perspectives in Personality R. Hogan and W.H. Jones, Editors. 1985, JAI Press: Greenwich, CT. p. 1-47.

[9] Dryer, D.C., Getting personal with computers: How to design personalities for agents. Applied Artificial Intelligence, 1999. **13**(3): p. 273-295.

[10] Becker, W.C. and R.S. Krug, A circumplex model for social behavior in children. Child Development, 1964. **35**: p. 371-396.

[11] Foa, U.G., Convergences in the analysis of the structure of interpersonal behavior. Psychological Review, 1961. **68**: p. 341-353.

[12] Conte, H.R. and R. Plutchik, A circumplex model for interpersonal personal traits. Journal of Personality and Social Psychology, 1981. **40**: p. 701-711.

[13] Horowitz, L.M. and J. Vitkus, The interpersonal basis of psychiatric symptoms [Special Issue]. Clinical Psychology Review, 1986. **6**: p. 443-469.

[14] Kiesler, D.J., The 1982 interpersonal circle: A taxonomy for complementarity in human transactions. Psychological Review, 1983. **90**: p. 185-214.

[15] Jung, C.G., Psychological Types. 1971, Princeton, NJ: Princeton University Press.

[16] Nass, C. and K.M. Lee, Does computer-generated speech manifest personality? Experimental test of recognition, similarity-attraction, and consistence-attraction. Journal of Exeprimental Psychology: Applied, 2001. **7**: p. 171-181.

[17] Isbister, K. and C. Nass, Consistency of personality in interactive characters: verbal cues, non-verbal cues, and user characteristics. International Journal of Human Computer Studies, 2000. **53**(2): p. 251-267.

[18] Collier, G., Emotional Expression. 1985, Hillsdale, NJ: Lawrence Erlbaum Associates.

[19] Givens, D.B. The Nonverbal Dictionary Of Gestures, Signs and Body Language Cues. 2011; Available from: http://center-for-nonverbal-studies.org/6101.html.

[20] Whan Oh, S., S. Min Jeong, and C. Kyung-won. Applying Sasang Typology Theory to Robot Appearance Design. in Robot and Human interactive Communication, 2007. RO-MAN 2007. The 16th IEEE International Symposium on. 2007.

[21] Mori, M., The Uncanny Valley. Enery, 1970. **7**: p. 33-35.

[22] Currie, T.E. and A.C. Little, The relative importance of the face and body in judgments of human physical attractiveness. 2009. **30**(6): p. 409-416.

[23] BBC. Reading Faces: Face Value. Science: Human Body & Mind 2011 [cited 2011 27th April]; Available from: http://www.bbc.co.uk/science/humanbody/mind/articles/emotions/faceperception1.shtml.

[24] Richmond, V.P. and J.C. McCroskey, Nonverbal Behavior in Interpersonal Relations. 4th ed. 2000, Needham Heights, MA: Allyn & Bacon.

[25] Sheldon, W.H., S.S. Stevens, and W.B. Tucker, The varieties of human physique: An introduction to constitutional psychology. 1940, Oxford, England: Harper & Brothers. 347.

[26] Goldberg, L.R., A broad-bandwidth, public domain, personality inventory measuring the lower-level facets of several five-factor models, in Personality Psychology in Europe, I. Mervielde, et al., Editors. 1999, Tilburg University Press: Tilburg, The Netherlands. p. 7-28.

[27] Bartneck, C., E. Croft, and D. Kulic. Measuring the anthropomorphism, animacy, likeability, perceived intelligence and perceived safety of robots. in Metrics for Human-Robot Interaction Workshop in affiliation with the 3rd ACM/IEEE International Conference on Human-Robot Interaction (HRI 2008), Technical Report 471. 2008. Amsterdam: University of Hertfordshire.

[28] Albright, L., D.A. Kenny, and T.E. Malloy, Consensus in Personality Judgments at Zero Acquaintance. Journal of Personality and Social Psychology, 1988. **55**(3): p. 387-395.

[29] Little, A.C., D.M. Burt, and D.I. Perrett, What is good is beautiful: Face preference reflects desired personality. Personality and Individual Differences, 2006. **41**(6): p. 1107-1118.

[30] Stirrat, M. and D.I. Perrett, Valid Facial Cues to Cooperation and Trust. Psychological Science, 2010. **21**(3): p. 349-354.

[31] Dryer, D.C., Personalities of user interface characters, in Technical report for Walt Disney Pictures and Television. 1995: Burbank, Calif.