A Typology of The Receptivity of Humanoid Robots by Students In A Thai International University: Results of A Multivariate Cluster Analysis

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Abstract
Despite the rapid advances in the development of humanoid robots (HRs), inquiries regarding their receptivity (user acceptance) by humans is still quite limited with no studies involving a substantial number of respondents being conducted in Southeast Asia and, specifically, Thailand. Therefore, this a pioneering study that examined students in the MBA program of an English-medium division within an international university in Bangkok, Thailand. A self-administered, anonymous questionnaire was developed to generate data. A typology of receptivity to humanoid robots was then created by using a factor analysis that generated four significant factors (HRs viewed as beneficial, viewed as potential friends, viewed with fear, and viewed as potential sex partners) which were then used for a multivariate cluster analysis with demographic classifications. The results indicated that none of the clusters displayed significant difference in demographic make-up. However, the groupings involving gender and nationality were close to significance and may be worthy of further examination in subsequent studies.

Keywords: Humanoid Robots, Multivariate Cluster Analysis, Principal Component Analysis, Receptivity of Robots, Typology.

1. Introduction

Both the private and public sectors across the world are aggressively engaged in the development of humanoid robots (hereinafter referred to as 'HRs'). This is especially true of the Defense Advanced Research Projects Agency of the U.S. Department of Defense that plans to use such robots for military combat, including as pilots and drivers of military vehicles. Others are developing HRs for use as social robots involved in direct human-robot interactions within the fields of healthcare, retail sales, tourism, office work, and other areas (Dahlin, 2019, Ford, 2016, 2021). HRs are machines that are designed to aesthetically resemble a human being (including with bipedal locomotion) but also to act as much as possible as a human during human-robot interactions (Cangelosi & Schlesinger, 2022). To accomplish this, humanoid robots are being developed to have ample foundational knowledge that they do not lose since they are synthetic and not organic, and to build from that foundational knowledge with machine learning capabilities. The ideal is a combination of aesthetic and mobile similarities paired with rapid-response familiarity in normal sounding communication and behavioral norms similar to humans that will allow these machines to fulfill a wide variety of functions in all sectors of society in an autonomous or semi-autonomous mode (Cangelosi & Schlesinger, 2022; Grupen, 2023).

Academic research regarding the receptivity of HRs is at its infancy, understandably so, given the state of technological development of the subject being studied. Much of the literature has relied on photographs or exposure to early, primitive semi-humanoid models mainly used for educational and promotional purposes, for example, Aibo (Bartneck et al., 2006), ASIMO (Choi, Lee, & Han, 2008), iCub (Pandey & Gelin, 2018, Tsagarakis et al, 2009), Kismet (Trovato, Kishi, & Endo, 2013), Pepper (Castelo & Sarvary, 2022; Pandey & Gelin, 2018), and ROBOTOR (Han et al., 2009). Research instruments to gauge receptivity have varied in what could be described as pioneering efforts to explore different aspects of the phenomenon. Most survey instruments have been in the form of a psychological inquiry, dealing with fear and anxiety regarding social acceptance of and exposure to HRs. The Negative Attitudes Toward Robots Scale (created in 2006) utilized psychometric testing with 14 examined items that primarily focused on assessing fear and anxiety. The other most prominent research instrument is the Frankenstein Syndrome Questionnaire, (created in 2012) which examined 30 items that also served as a psychological tool to study aspects of trustworthiness and apprehension regarding humanoid robots (see Krageloh et al., 2019 for an analytical discussion of the two instruments cited above). Most of the studies exploring receptivity of HRs, that used a substantial number of respondents, have focused on the United States, Europe, and Japan, with some comparing respondents from these three regions (see list of reviewed articles in Lim, Rooksby, & Cross (2021) and Merkle (2021). In the Pacific Rim of Asia, there have also been limited studies involving mainland China and South Korea (Lim et al, 2021). However, to date, no studies involving receptivity of HRs have been conducted in Southeast Asia and, specifically, Thailand.

2. Theoretical Perspective and Research Questions
- Typology
The term 'typology' refers to a classification system used in research to group and categorize people, objects, or phenomena based on shared characteristics (Nichols, 2007). Typologies are vital in research because they can facilitate identifying patterns and trends in their data that may not be immediately apparent without classification. This can help in identifying similarities and differences between groups and in developing hypotheses for further investigation (Creswell & Poth, 2018; King, Keohane, & Verba, 1994; Mithun, 2016; Nichols, 2007). As an initial step towards developing a receptivity typology, a framework was created using 15 questions that constituted the attitudinal questions of a survey given to students. These 15 items were created to provide data for a principal component analysis and then a factor analysis to provide key factors that explained the majority of the variance in the data.

- Benefits Associated with HRs
The literature of humanoid robots indicates disparity as to the overall benefits of introducing such robots (Brynjolfsson & McAfee, 2016; Carbonero, Ekkehard, & Weber, 2018; Choi et al., 2008; Dahlin, 2019; Ford, 2016, 2021; Miller & Atkinson, 2013; Morikawa, 2017; Oxford Economics, 2017, 2019; Rodgers & Freeman, 2019). Out of the fifteen questions used in the study's survey, the following five were used to address the individual considerations of the respondent as well as the perceived overall (macro) societal benefits:

1. When available, I intend to buy an HR.
2. I would patronize a business using HR, if HRs resulted in lower prices.
3. HRs will help the economy become more efficient.
4. I believe that HRs will be widely accepted by society.
5. I like the fact that HRs cannot get angry at or abusive to people.

Academic literature on HRs also focused on the ability to befriend such robots with the expectation that such exchanges would emulate real human interpersonal communications as much as possible with the added possibility of friendship with an entity that did not insult, abuse, or lie while providing unbroken loyalty, resolute trustworthiness, and overall support as a moral agent (Archer, 2021; Emmeche, 2014; Jecker, 2021a; Marti, 2010; Samani et al, 2013; Samani & Cheok, 2010; Sullins, 2006). The items that focused on friendships included:

6. I believe I can share my emotions with HRs.
7. An HR can be as good a friend as a human.
8. HRs may be able to tell right from wrong.
9. I believe I can work well with an HR.

The sentiments of fear and anxiety regarding interaction with HRs are prominent in academic literature and in the press. This negativity ranges from fear of job displacement to physical harm and also to a belief that humanoid robots will eventually control, enslave, or even destroy humans (Barton, 2010; Cheshire, 2015; Ford, 2021; Kaplan, 2004; Kamide, et al., 2012; Miller & Atkinson, 2013; Morikawa, 2017; Rodgers & Freeman, 2019). Three items on the survey addressed fear and anxiety:

10. I think HRs may try to control humans.
11. I think HRs might lose control of HRs.
12. I believe HRs may take my job in the future.

- HRs and Intimacy

There is a growing body of literature exploring various aspects of physical intimacy, even of a sexual nature, since there are HRs that are fully anatomically correct (Cheok & Levy, 2018; Earp & Grunt-Mejer, 2020; Fosch-Villaronga & Poulsen, 2020; Frank & Nyholm, 2017). The implications of widespread sexual activity with such robots could challenge traditional relationships between humans (including the possibility of marrying a robot) and, over time, possibly lowering the population of the more prosperous nations where HRs will be incorporated sooner (Goldfeder & Razin, 2015; Horton,2015; Jecker, 2021b; Levy, 2007, 2020; Rigotti, 2020; Zhou & Fischer, 2019). Three items explored this subject:

13. It is OK to have sex with a HR.
14. I plan to have sex with an HR possible.
15. People who have sex with a HR are sick.

3. Methodology and Data Collection

- Respondents

To create a typology of receptivity of HRs, this study utilized convenience sampling to examine students in the English-medium division of an MBA program in an international university in Bangkok, Thailand. The ample diversity in this group regarding the demographic variables of age, ethnicity, gender, and marital status allowed for a more robust analysis pertaining to the diversity that exists in actual work environments. The total population of the English-medium division was 460, and therefore, a sample of 210 was determined as appropriate as per Krejcie and Morgan's (1970) table for tabulating an inferential sample size. The sample population came very close to the actual percentage breakdown by age, ethnicity, and gender. Regarding age, it ranged from 21-25: 30% sample (63 students) v. 32% actual; 26-30: 33% sample (69 students) v. 32% actual; and 31-52: 37% sample (78 students) v. 36% actual. Nationality was divided into two groups: Thais at 74.3% (158 students in the sample) v. 73.5% actual and international students at 25.7% (52 students) v. 26.5% actual. Regarding gender: Males in the sample were: 41.5% (87 students) v. 43% actual; females in the sample: 58.5% (123 students) in the sample v. 57% actual. The institution had no data regarding the marital status of students.

The sample breakdown was the following: 151 single students (72% of the sample) and 59 married students (28% of the sample).

- *Research Instrument*

A self-administered questionnaire of 15 attitudinal questions, consisting of a 4-point force-Likert scale, was given to students in a classroom setting during a one-semester period. The 4-point forced-Likert scale ran from "Strongly Disagree" (weighted as 1) to "Strongly Agree" (weighted at 4). A neutral option (e.g., "Not Sure") was not used since Thai culture discourages the practice of asserting opinion (*kreng jai*) when possible (Calderon et al., 2015; Holmes, Tangtongtavy, & Tomizawa, 1997; Suntaree, 1990). The questions used in this survey were designed by the authors based on the literature review conducted for this study since no previous surveys had been developed to cover the dimensions of such an analysis. As indicated in the review of the relevant literature in the previous section, the items developed express the content of numerous scholarly works that examined thoughts and concerns related to the receptivity of HRs. As such, the items developed, while not intended to be a scale measuring the magnitude of receptivity, do have content validity in that they fall within the domain of considerations related to receptivity (DeVellis & Thorpe, 2021).

Students signed a participation form which indicated that they were engaging in a voluntary action and that the survey was to be administered in an anonymous fashion with no specific identification data requested. The participation form was collected before the questionnaire was administered so that the two documents were not physically linked or attached. No slang or idioms were used. The questionnaire was translated from English to Thai and then translated back by a qualified Thai native speaker to assure accuracy and that no loss in understanding resulted from the translation process (Behling & Law, 2000; Dornyei & Taguchi, 2009). Thais received a Thai-language questionnaire and the foreign MBA students (from outside Thailand) were given a questionnaire in English because the majority were English native speakers or possessed high proficiency in English as a second language. Participants were encouraged to ask questions if they had any confusion as to the instructions. Statistical analyses were conducted on the raw data. These analyses are explained in the next section.

4. Analysis and Results

A principal component analysis (PCA) was conducted on the 15 items included in the survey. The first task was to determine sampling adequacy. The KMO test for sampling adequacy was shown to be .708 which is deemed acceptable (Field, 2009). Items were first checked to determine if there was enough correlation across the items to run the analysis and not so much that multicollinearity would be a problem. This was done by examining their correlation. While correlations were shown across the items, none of the correlations exceeded .6 and the determinant of the R-matrix was .033, which, as recommended by Field (2009), exceeds the .00001 lower limit, indicating no problems with multicollinearity. Bartlett's test of sphericity $X^2 (105) = 694.074$, $p < .001$ indicating adequate correlation and sufficient relationship among the items to proceed (Field, 2009). Therefore, none if the items were eliminated. A factor analysis using an oblimin rotation method was then conducted to determine the appropriate rotation method for use in this analysis. Examination of the component correlation matrix indicated that there was independence across the factors such that an orthogonal rotation should be employed (Field, 2009). A Varimax rotation was selected. Table 1 shows the factor loadings after rotation. The four-factor solution explained 55.9% of the variance in the data.

Table 1: Summary of Exploratory Factor Loadings for Human Robot Questionnaire (N = 210)

Item	Rotated Factor Loadings			
	Viewed as Beneficial	Viewed as Friends	Viewed with Fear	Viewed for Sex
When available, I intend to buy a HR	**.742**	.057	.024	.231
I would patronize a business using HRs if HRs resulted in lower prices	**.709**	.074	.096	.227
HRs will help the economy become more efficient	**.702**	.035	.083	.148
I believe HRs will be widely accepted by society	**.648**	.297	-.072	.002
I like that HRs cannot get angry at or abusive of people	**.548**	-.179	.138	-.095
I believe I can share my emotions with HRs	.162	**.784**	-.006	.003
An HR can be as good a friend as a human	-.148	**.710**	.056	.082
HRs may be able to tell right from wrong	.029	**.591**	.321	.119
I believe I can work well with a HR	.423	**.524**	-.031	.045
I think HRs may try to control humans	.009	-.031	**.837**	.047
I think humans might lose control of HRs	.041	.048	**.815**	-.065
I believe HRs may take my job in the future	.205	.271	**.617**	-.054
It is OK to have sex with a HR	.144	-.003	.026	**.819**
I plan to have sex with a HR if possible	.143	.048	.116	**.815**
People who have sex with a HR are sick	.073	.151	-.223	**.605**

Note: Loadings > .5 in bold

The factor loadings shown in Table 1 indicated four different views or attitudes as expressed by reactions to the items posed. HRs were viewed as: (i) beneficial, (ii) potential friends, (iii) representing fear for what they might do and (iv) potential sex partners. Responses to the four views expressed in the data were then further examined to identify patterns in the data across groupings of respondents resulting in a typology of human attitudes toward HRs. In order to develop this typology, the factors identified in the previous phase of the analysis were examined through a multivariate cluster analysis. The analysis grouped individuals based upon the similarity of their voiced views toward the items that comprised the four factors. A two-step cluster procedure was selected because it produced what Kent, et al. (2014) reported as an excellent ability to detect subgroupings and classify individuals within those subgroupings. The two-step method revealed an average (.3) silhouette measure of cohesion and separation for a four-cluster solution. The factors most important to this solution were 'Beneficial' with an importance score of 1.0, followed by 'Sexual' with an importance of 0.98, 'Friends' with an importance rating of 0.67 and finally 'Fear' rated at 0.62. As shown in Table 2, a one-way analysis of variance revealed each cluster to be significantly different on all mean factor scores at the $p < .001$ level.

Table 2: Cluster Centroids (Group Means) for the Four Cluster Solution

Cluster	Relative Size	Beneficial	Friends	Fears	Sexual
Cluster 1	30.0%	-1.0217	-.4964	-.3153	-.1476
Cluster 2	27.6%	.4369	-.4916	.8533	.4001
Cluster 3	30.5%	.4244	.7042	-.1551	-.7480
Cluster 4	11.9%	.4746	.5886	-.7880	1.3586
	F	56.12	34.54	31.39	54.64
	p-value	< .001	< .001	< .001	< .001

Note: Scores were standardized with higher magnitudes indicating stronger views on the factor

Table 2 also presents the cluster centroids for each of the four factors across the four clusters. Those placed in Cluster 1, the second largest cluster at 30%, could well be termed "Adverse to HRs." They tended not to view HRs as potentially beneficial. They did not view them as presenting an opportunity for friendship or a sexual relationship, but neither did they show much fear of HRs.

Cluster 2, which might be termed "Hopeful but Afraid," is the third largest with 27.6% of the respondents. This cluster does view HRs as being potentially beneficial nor does it see them as potential friends. IT exhibits the highest level of fear toward them. Interestingly, the cluster indicated sex with HRs as a strong possibility.

The third cluster, "Welcoming Friends," is only slightly larger than Cluster 1 with 30.5% of the respondents. This cluster is also hopeful about the benefits that HRs may bring and sees a definite opportunity for friendship. Correspondingly, their fear levels are low, but while they do welcome the opportunity for HR friends, they see this as a platonic relationship.

The final cluster, which might be termed, "Friends with Benefits," sees the future of HRs as being beneficial, providing the opportunity for relationships with HRs that extend beyond friendship. Not surprisingly, this groups had the lowest level of fear about HRs potential effects on society.

Table 3: Cluster Membership by Demographic Grouping

Cluster	Gender Male Female	Marital Status Married	Single	Age 21-25	26-30	31-52	Ethnic Thai	Inter	
Cluster 1	18	45	21	42	15	23	25	42	9
Cluster 2	29	29	16	42	16	20	22	43	24
Cluster 3	27	37	16	48	26	15	23	49	12
Cluster 4	13	12	6	19	6	11	8	24	7
Chi Square	7.215		1.374			6.923		6.711	
p-value	.065		.712			.328		.082	

Captured demographic classifications were examined across the four clusters. As shown in Table 3, none of the clusters was significantly different in demographic make-up. However, the Gender and Ethnic groupings were close to significance and may be worth further examination in subsequent studies. It is also worth noting that Cluster 4, termed "Friends with Benefits" did have three times as many single persons as married persons. That may have been an influence on this cluster's high rating as to their view of potential sexual relations with HRs.

5. Conclusion and Suggestions for Future Research

This study provides two principal contributions. For one, the attitudes of the respondents fell into four distinct groupings. These ranged in a continuum of acceptance from being averse to HRs, to responses of total acceptance including the desire for intimate relations with HRs. Overall, only about 30% of the respondents (Cluster 1) actually oppose the introduction of HRs into the marketplace. While the remaining 70% do vary in how willing they are to accept HRs, they did show that they are receptive. This indicates that once HRs do become available, they may be well received. However, since respondents indicated that they varied in their expectations of what HRs would to be able to do in terms of interaction with humans (making friends, sharing emotions, forming intimate relationships) and their effect on business and jobs, there will need to be some major education of the public so that people are not dissatisfied.

Since satisfaction is often conceptualized as a disconfirmation of expectations, unrealistic expectations of what HRs will be able to do could slow the diffusion of this new-to-the-world innovation. The second contribution focuses on the lack of demographic differences in the make-up of the clusters of acceptance. While gender and ethnic background neared statistical significance and therefore warrant further study, age and marital status were not useful discriminators when it comes to acceptance. Since the sample selected for this study consisted of university students, it may be that the ages of the sample did not vary enough (55% 28 or younger) to capture age as a discriminant variable. An understanding of user acceptance of new technology is crucial for business, organizations, and society as a whole in order to remain competitive and innovative in today's rapidly evolving business world. The World Economic Forum (2019) emphasized the necessity for business to adopt and adapt to new technologies in order to survive. The need for employees to comfortably transition toward the use of new technology will dictate an organization's competitive advantage and its long-term success or failure (American Management Association, 2019; DeRue et al., 2012; Khanna, Palepu, & Sinha, 2005).

This study has served as a pioneering attempt to learn about HR acceptance and in doing so has pointed out several areas for future study. First, since significant differences were found between the clusters of acceptance even among persons with much in common as university students, this study should be replicated using a sample more representative of the population at large. Greater variance in the sample's characteristics may reveal acceptance clusters that more closely represent how HRs will be accepted by the public at large. Additionally, other variables should be included to further define the characteristics of the individuals that make up each cluster. Education level, occupation, innovativeness, income and personality type might likely prove to be discriminant variables that might vary across clusters.

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