14th Annual International Conference on Industrial Engineering and Operations Management Dubai United Arab Emirates (UAE), February 12-14, 2024

Publisher: IEOM Society International, USA DOI: 10.46254/AN14.20240656
Published: February 12, 2024

The Subjective Idea of the Physical Appearance of a Humanoid Robot

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Abstract

This study was looking to find what the general public thought about how they would want the form of a humanoid robot to appear physically and that robot's general physical capability. In much of the available research, there was little if any information on polling people for what they wanted a humanoid robot to appear as physically before development. There are dozens of humanoid robots with vastly different size, colors, levels of realistic appearance, and physical capability (Raju et al. 2020). There are many studies about how people feel about the physical appearance of humanoid robots (Kanda et al.). There are studies on how people feel about specific robots (Mutlu et al. 2006). There was extremely minimal information on robots being designed from general polling of people before development occurred. A survey was created to ask people what a group of survey takers would desire a humanoid robot to look like and its general physical capability. The survey contains responses from 170 people. The people range from 18 to over 65. The purpose of this study was to get the general idea of what people wanted a humanoid robot to physically appear as regardless of other demographic factors. The survey also asked about how much physical capability that theoretical robot would have in their interactions with people and the general knowledge of humanoid robotics the survey taker possessed. The final results showed some interesting and distinct trends.

Keywords

Humanoid robot, Uncanny valley, Robot development, Human perception of robots, Survey

1. Introduction

There is a lot of research involving robots. In the field of humanoid robotics, there is an expansive amount of research for many facets within the field of study. The research includes robotic speech (Lee 2021). There is research about robot's ability to walk (Ames). There is research about the physical appearance of robots (Tung 2016). There was one type of research that had only limited information available, and had aspects of that research with extremely limited information. The information deficit involved what people actually wanted a humanoid robot to look like. There is research available for why existing robots look the way they do (Hanson, 2019). There is research on how people perceive currently existing humanoid robots (Phillips et al. 2017). There was a dearth of research involving the designing of a robot based on how people wanted a humanoid robot to look like in general. Perhaps this information exists in the proprietary archives of the groups and companies of those making humanoid robots, but those records

were not readily available for public reference. There may also have been technological limitations involved in the creation of humanoid robots, but that was also rarely mentioned. This was information that was also unable to be located during the research process. Due to this seeming lack of information, I created a survey in order to try and obtain information on the topic of what people wanted in the form of a humanoid robot's appearance as well as their general physical capability.

While information on specific research done before the creation of a specific humanoid robot is extremely limited, general research on the perception of humanoid robots is not. Before humanoid robots were common knowledge, a robotics professor in Japan at the Tokyo Institute of Technology wrote a very innovative essay (Mori et al. 2012). This essay, written in 1970, was about humanoid robotic appearance and how humans would perceive them and was called "The Uncanny Valley" (Mori et al. 2012). This professor, Masahiro Mori, did not receive hardly any recognition for decades after this essay's initial publication (Mori et al. 2012). As technology advanced, and robots and computers became more commonplace, The Uncanny Valley gained in popularity as its insight increasingly helped robot and software developers design humanoid robots (Mori et al. 2012). What the concept of the Uncanny Valley says is that as robots become more human-like, people's affinity toward the robot increases (Mori et al. 2012). This trend increases until a certain threshold is reached when approaching a fully human appearance (Mori et al. 2012). When the appearance is close, but not exact, the affinity people hold toward a humanoid robot declines rapidly (Mori et al. 2012). People generally got an eerie feeling and held a level of distaste far greater than even robots that had little if any humanoid characteristics (Mori et al. 2012). This negative perception would then rapidly improve as appearance drew very near actual human appearance (Mori et al. 2012). The study went on to show the differences between moving and unmoving objects (Mori et al. 2012). While the trend of positive or negative perceptions were the same, they became magnified in intensity (Mori et al. 2012). A stationary prosthetic hand was viewed negatively and with an eerie feeling, but it became more eerie when that same prosthetic hand began to move. On the positive side of the spectrum, a realistic puppet was viewed favorably. When that same puppet was moving as part of a show, people's affinity toward that puppet increased (Mori et al. 2012) (Figure 1).

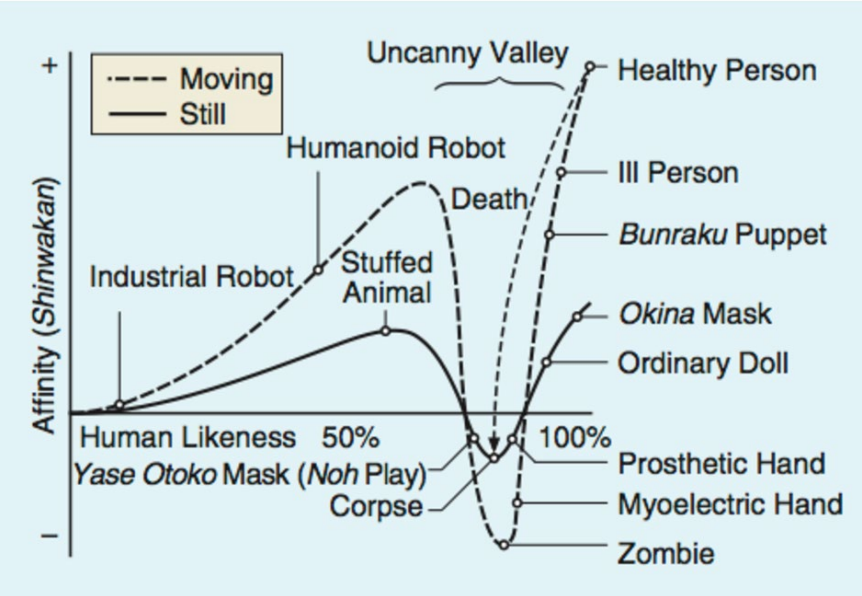

Figure 1. Uncanny Valley visualization and examples (Mori et al. 2012)

The original paper being from the past had much more limited examples for study. The specifics called out were early industrial robots, toy robots, and early prosthetics (Mori et al. 2012). This does not diminish the insight and importance of this early research as it is still referenced and used in many instances today.

In much more recent history, there have been many studies about the perceptions of humanoid robotic appearance as well (Trieu and Thinh 2023). These more modern studies have researched more specific aspects of the Uncanny Valley and how people perceive human-like humanoid robots (Trieu and Thinh 2023).

1.1 Objectives

The research objectives were to gain information about what a sampling of people knew about humanoid robots and how they would desire one to look and its physical capability. The information was collected utilizing a survey of questions created with these thoughts in mind. The purpose of this survey was to gain an understanding of how knowledgeable the survey takers were of current, more well known, humanoid robots. The survey also then asked about what the survey taker would desire in a robot for different attributes a theoretical humanoid robot would possess. The purpose of this survey was to get information on the theoretical development of a humanoid robot before any designs or ideas were decided on or implemented.

2. Literature Review

During research into the topic of the development of humanoid robots, there was an extreme deficiency of information about preemptive research into the form and functionality of humanoid robots. The available information stated there was usually a goal, task, or personal opinion of a creator that guided a robot's development. There was no lack of information about studies after the creation of different humanoid robots and how people felt about those robots. The latter information had extremely nuanced information from just physical appearance (Phillips et al. 2017) to empathy (Quick 2022) and trust (van Pinxteren et al. 2019). This survey was created to try and gain understanding about this void of information in robot development. It was unclear if this information was just secret or if it did not exist. Using the information of the survey would give insight whether or not different humanoid robots took a developmental path that was consistent with what the survey takers desired in a humanoid robot. This is, in theory, what the general public would desire a humanoid robot.

3. Methods

A survey was created in order to pole the general public about what they would like a humanoid robot's appearance and abilities to be. There was no attempt to limit or control who took the survey. Only age was asked for demographic information because the overall goal was to see if there was a general consensus about humanoid robotic appearance as a whole. The idea was that it did not matter if it was an engineer, waitress, retiree, or student, the general consensus would converge on similar trends regardless of other factors. There was also a concern that asking too much personal information would discourage people from taking the survey to begin with. One additional concern was people would lie about the personal information and potentially compromise the accuracy of the survey results. These were concerns due to the open distribution of the survey into an unsecured public setting. The survey was released to friends, family, social media, co-workers, professors and classmates at the university, and then encouraged anyone who took it to further distribute the survey to anyone else they wanted to send it to. This survey was created using google forms and sent via an internet hyperlink. The survey itself asks the survey taker about specific knowledge of many currently existing humanoid robots. After showing images of many real humanoid robots and several fictional humanoid robots, it asks about how robotic or humanlike the survey taker would like certain aspects of a theoretical humanoid robot to appear. The survey additionally asks about physical capability of a humanoid robot such as the ability to walk and talk. There is a final general question of all the individual aspects combined into a single question about the full scope of a humanoid robot. The questions after that ask about if that individual would want their theoretical robot to exist, if they would want to encounter it, or if they would want to own one personally. The last question is about the age range of the survey taker. At the time of the creation of this research paper, there were 170 responses to the survey and no new responses were being collected.

4. Data Collection

The survey data was collected as participants took the survey through the Google forms feature in Google. The information was collected over the course of several months from September of 2023 through January of 2024. The final tally of survey takers was 170. While many of the survey takers were from Michigan, the use of social media expanded the survey takers to many other states in the USA and potentially some non-US residents. There was an introduction to the survey that was as follows:

> "This survey is about humanoid robots and their ability to perform human expressions and emotions. There are many robots with varying degrees of ability to express themselves. The humanoid part of

> a humanoid robot means that this would be specific to robots with at least a general shape of a person. A good reference for this would be the fictional C-3PO from star wars. C-3PO is a humanoid robot, whereas R2-D2 is NOT a humanoid robot. Other examples of fictional humanoid robots would be Bender from Futurama and Data from Star Trek: The Next Generation. When answering questions on this survey, it is okay to consider real, fictional, or even have your own ideas for how you would desire a humanoid robot to be able to express itself. Part of a robot's ability to express itself is also tied to how close to a real human the robot's appearance is. The purpose of the robot is not relevant. This is asking about the desired form a humanoid robot would take to you as the survey taker."

After the introduction of the survey were pictures of the fictional robots C-3PO, R2-D2, Bender, and Data so that all survey takers would know what they looked like even if they had no previous knowledge of the robots that were mentioned. All questions also included images of all robots discussed in those questions. The survey questions were as follows:

1. Have you ever heard of any of the below humanoid robots? (Ameca, Pepper, ASIMO, Nao, Nadine, Junko Chihira, Jia Jia, or Octavia)
2. How familiar are you with any of the humanoid robots from the previous question that you selected?
3. How familiar are you with the humanoid robot Atlas from Boston Dynamics?
4. How familiar are you with the humanoid robot Sophia from Hanson Robotics?
5. How important would moving arms be on a humanoid robot to you? (1 being not important to 5 being very important)
6. How important is the ability to talk? (1 being not important to 5 being very important)
7. How important is having a physical appearance of a human? (1 being not important to 5 being very important)
8. Focusing specifically on the face, how close to human should it be? (1 being not important to 5 being very important)
9. How important is the ability to walk or move? (1 being not important to 5 being very important)
10. How close to a full human appearance with full human expression would you want a humanoid robot to appear and act? For the purposes of what it means to express itself, think of arms that can move, eyes that can blink, being able to listen and talk, a moving head that can turn and look at you. Able to walk and follow you. Realistic human face that can smile, frown, twitch, or any other full human facial expression. (1 being not important to 5 being very important)
11. Would you want a robot in the form you selected above to exist if technology allowed it?
12. Would you want to be able to encounter a robot in the form you selected above if technology allowed? (think shop clerks, receptionists, greeters, entertainers)
13. Would you want to own a robot in the form you selected above if technology allowed and you were able to afford it? (think something like a Roomba and Alexa, but far more advanced with much greater ability. Also humanoid or full human shaped depending on above answers)
14. What is your age? (this is only for the purpose of determining if age has a distinct trend in the answers above)

The questions had answer schemes of select from a list, never heard of/heard of it/some knowledge/know a lot, 1 through 5, yes/no, and a standard age range selection. All questions required an answer except for the first question asking about the grouping of robots allowing multiple, or in many cases, no answers.

5. Results and Discussion

The results were surprising and enlightening. The results will be shown in order of the questions as listed on the survey. Question 1 had results as follows in Figure 2.

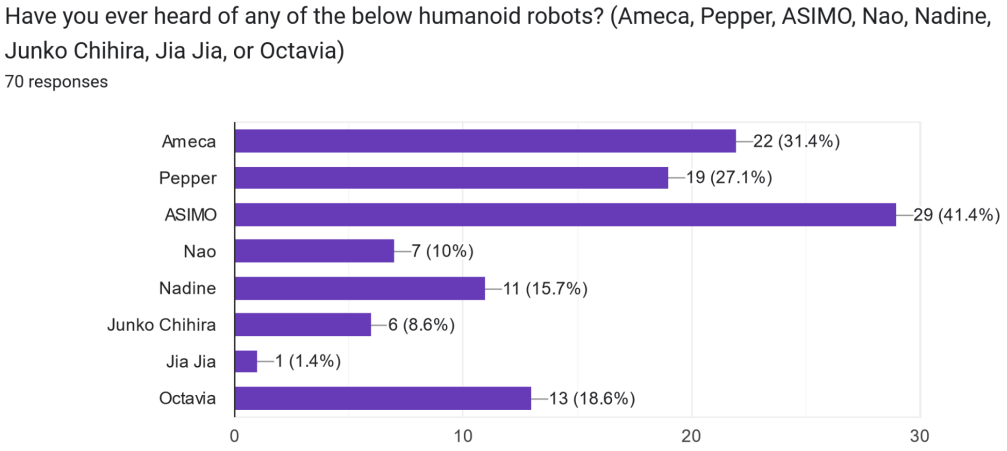

Figure 2. Question 1 result

Question 1 only had 70 out of 170 people answer, or 41.2% of survey respondents. This question had some survey takers answering they knew multiple of these robots, while most only knew one. 22 of 70 respondents knew 2 or more of the robots listed. 8 out of 70 respondents knew 3 or more of the robots listed. 4 of 70 respondents knew 4 or more of the robots listed. Only 1 of 70 respondents knew 5 or more of the robots listed, and they stated they heard of all 8 of them. This means that only 12.9%, 4.7%, 2.4%, and less than 1% knew of 2, 3, 4, or 5 or more of these robots respectively. This tells me that more than half of the survey takers had no knowledge of these 8 robots before getting to the part of the survey where they would state what they would desire in a humanoid robot.

Question 2 had results as follows in Figure 3.

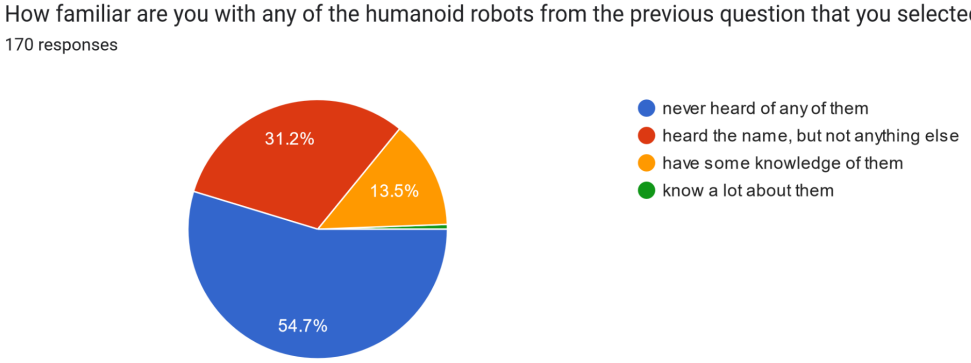

Figure 3. Question 2 results

Question 2 and all further questions required an answer and therefore all had 170 responses. This question was to gauge the level of knowledge about the previous 8 robots the survey takers had. The majority of survey takers had little or no knowledge of the initial 8 robots that were asked about. There was a slight inconsistency as 70 of the survey takers listed a robot that they were aware of, while 77 of the survey takers answered that they had at least heard of one of the robots from question 1.

Question 3 asked about a different robot that had more news media presence, Atlas from Boston Dynamics (Figure 4).

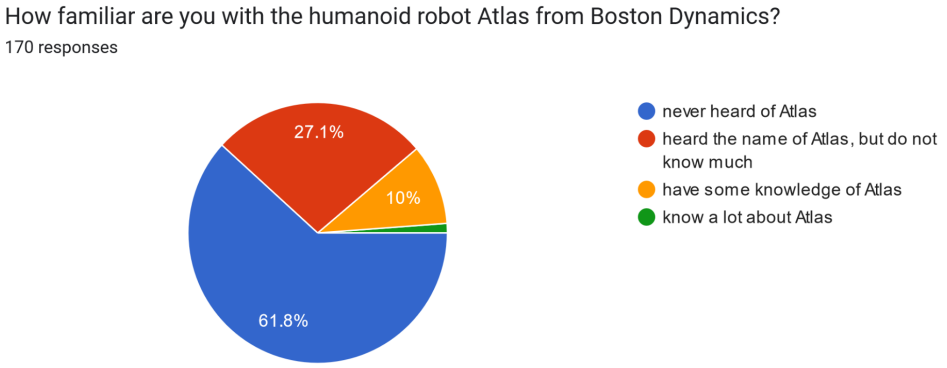

Figure 4. Question 3 results

Question 3 asked about a more well known robot. The company Boston Dynamics has commercially available robots and additional media presence (Boston Dynamics). While their non-humanoid robot Spot is their more well known robot, they have released many music videos and other media featuring all of their robots, including Atlas (Boston Dynamics). 65 of 170 survey respondents said they have at least heard of Atlas. ASIMO by comparison only had 29 of 170 respondents recognize the name. That was the most of any one of the original 8 robots that were asked about. Question 4 goes on to ask about arguably the most well known humanoid robot, Sophia from Hanson Robotics (Hanson Robotics) (Figure 5).

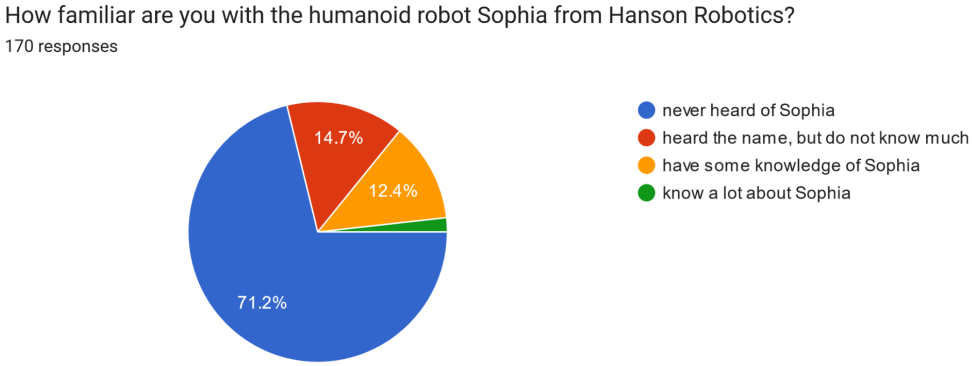

Figure 5. Question 4 results

While Sophia has a much larger media presence, only 49 of 170 survey respondents had at least heard of Sophia the robot. This is still more than ASIMO, but 16 less than Atlas. Sophia is also, arguably, one of the most human-like of the humanoid robots that exist today (Mulko 2023). The first 4 questions were to establish how knowledgeable the survey respondents were, and to show images of all these robots to the survey takers so they were fresh in their mind for the next questions.

Question 5 starts setting up what people are looking for in a humanoid robot by individual features. The first question asks about moving arms (Figure 6).

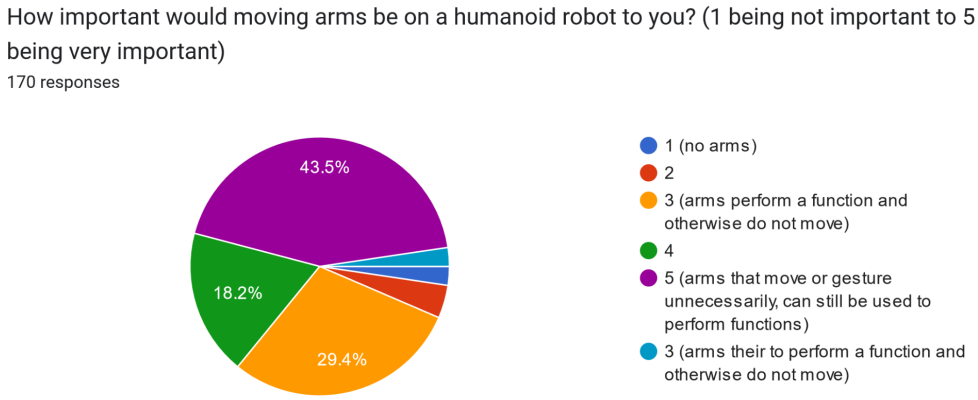

Figure 6. Question 5 results

Question 5 required a response of a number between 1 and 5. 1 meant no arms, and 5 meant fully articulated arms that would potentially move outside of functional necessity. 2 through 4 ranged between the 2 extremes. There are 2 number 3s. This was due to a corrected typo after the release of the survey. No meaning was changed during that update, only the spelling correction. Arms were rather desirable with only 11 of 170 survey respondents giving an answer of 1 or 2. Close to a majority of respondents, 74 of 170, answered with a 5, which would be arms tantamount to an actual human.

Question 6 moves on to ask about the desirability of speech and to what level of speech the robot would exhibit (Figure 7).

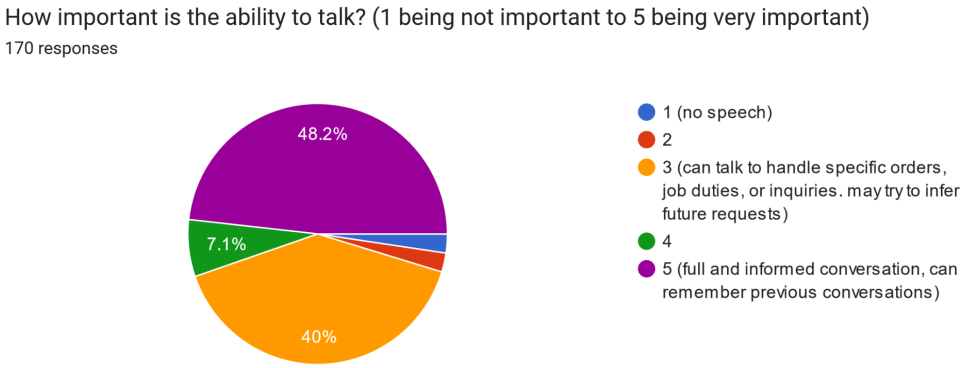

Figure 7. Question 6 results

The ability to talk was an even more popular option. Only 8 of 170 respondents gave this response an answer of 1 or 2. 82 of 170 respondents answered with a 5 and that was almost a majority of the respondents. With existing speech-based technology available to the public, such as Alexa from Amazon, the respondents may already be more familiar and comfortable with this technology (Gallagher 2023).

Question 7 asks about the physical appearance of a robot. This diverged from the previous questions. Previous questions were more about physical capability, even if they had components in appearance (Figure 8). This question was the first to involve pure physical aesthetics.

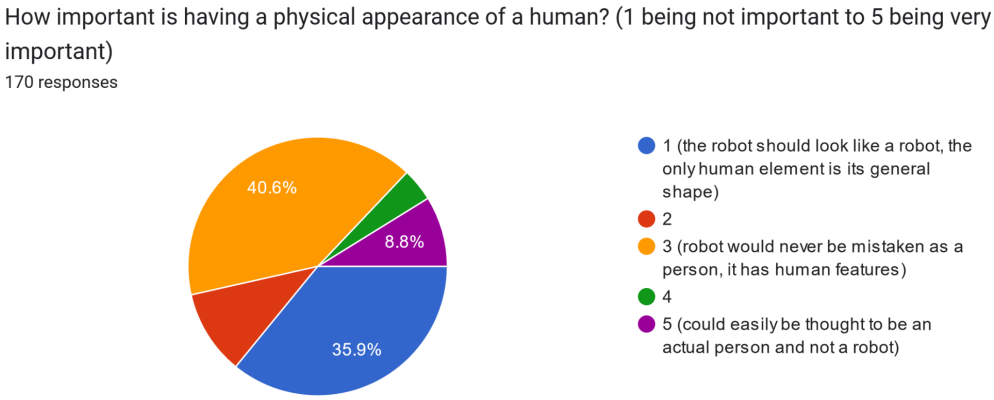

Figure 8. Question 7 results

Question 7 also diverged from the previous questions in the responses received on the survey. While previous answers weighted heavily to the more human-like side of the spectrum, this weighted toward the less human-like. The category with the most responses was a 3 out of 5 with 69 of 170 respondents. Answers of 1 and 2 amounted to 79 out of 170 respondents, and 4 and 5 only 22 of 170 respondents. This means that a 3 or less came out to 87.1% of all survey respondents.

Question 8 remained on the aspect of physical appearance, but focused on the face (Figure 9).

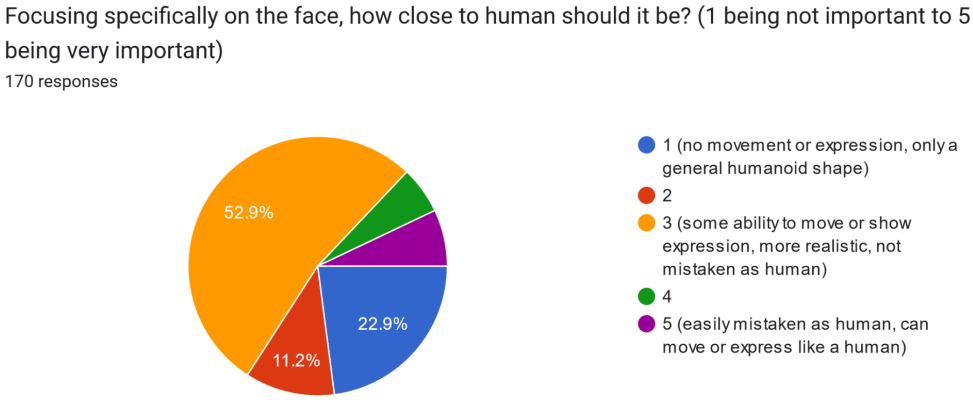

Figure 9. Question 8 results

Question 8 had a very similar breakdown to question 7. The middle category of 3 was the most selected, but more so at 90 of 170 respondents. Answers of 1 and 2 came in at 58 of 170, and 4 and 5 at 22 of 170. This left the 3 or less at the exact same percentage of 87.1% of respondents. This appears to show that the theoretical face of a humanoid robot is considered near identically to the body as a whole by the survey respondents.

Question 9 ventures back into the realm of physical capability with only some elements of appearance or physical appearance (Figure 10).

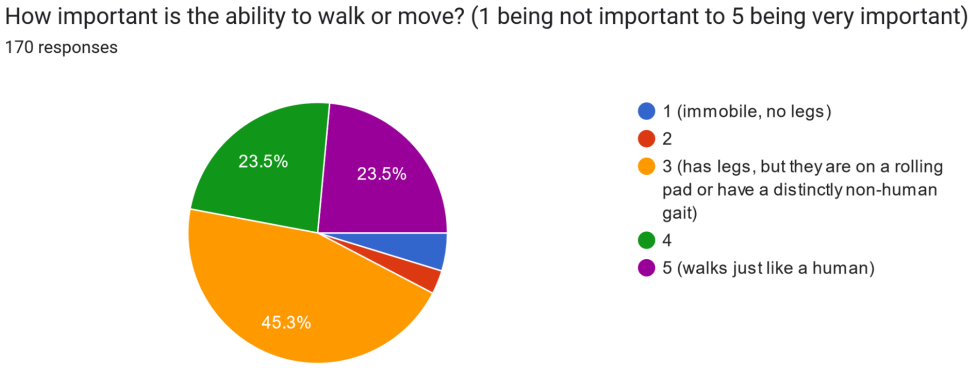

Figure 10. Question 9 results

Question 9 once again goes back heavily into the 3 and above answers like arms and speech. While there are more answers of 3 than answers of 5, 3 and above account for 157 of 170 respondents or 92.4%. This compares to the 93.5% of 3 or above on arms, and 95.3% of 3 or above on speech.

Question 10 ties all the previous individual questions about desirable traits in humanoid robots together. It asks about the full package of all elements put together into a complete robot (Figure 11).

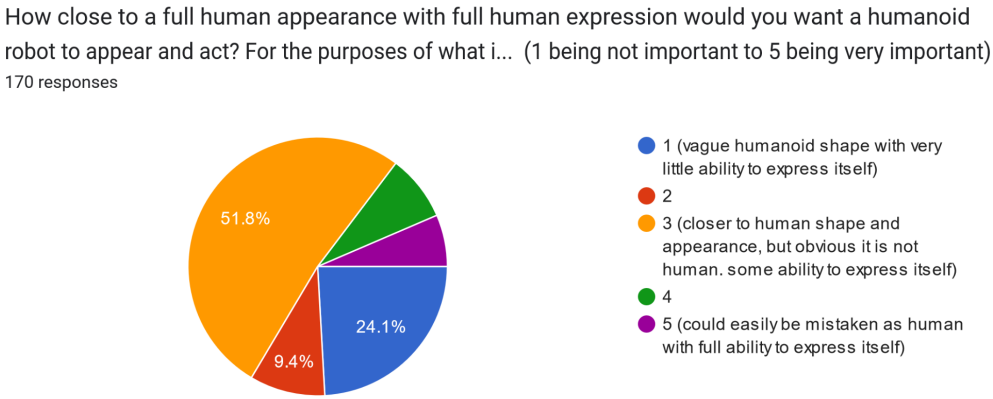

Figure 11. Question 10 results

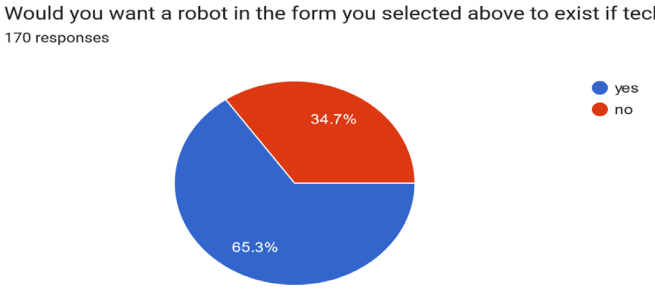

Figure 12. Question 11 results

Once again 3 was the most popular selection and the majority. The results were much closer to the appearance aspect of previous questions than the function aspects. 145 of 170 respondents answered this with a 3 or less or 85.3%. This left only 25 of 170 who answered with a 4 or a 5, which was only 3 more than the previous questions asking about physical human-like appearance. These results seem to show that people want a humanoid robot to function like a person, but not necessarily look like one.

Question 11 asks if people would want a robot in the form they designated previously to exist (Figure 12).

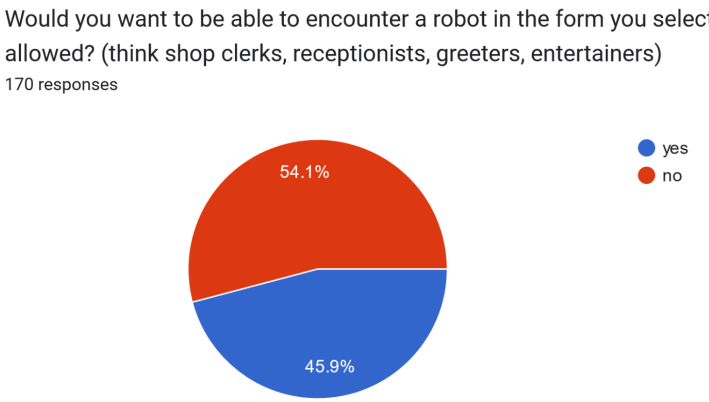

Figure 13. Question 12 results

This yes or no question showed that almost 2 out of 3 people would like this theoretical robot to exist and ties into the next question.

Question 12 advances question 11 into if the survey taker would like to encounter or meet the theoretical robot that they designated previously (Figure 13).

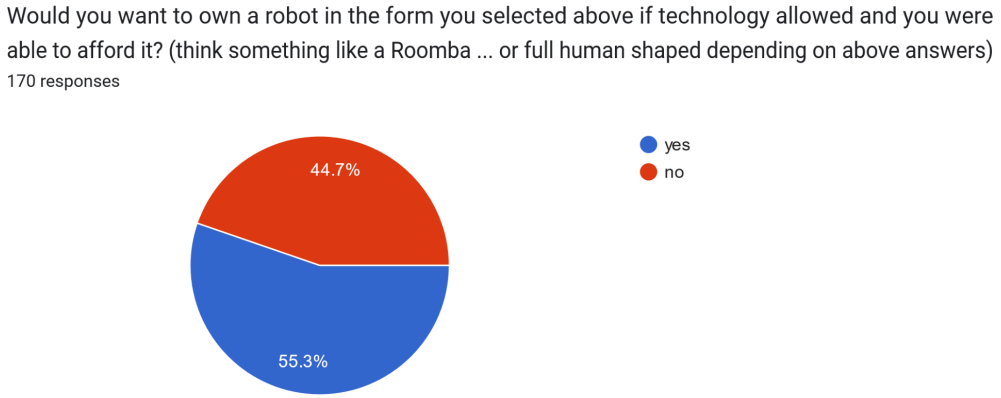

Figure 14. Question 13 results

This was a somewhat surprising result that there was such a difference in answers. While 111 of 170 respondents wanted their theoretical robot to exist, only 78 of 170 respondents wanted to encounter that same robot. That is a difference of 33 survey takers or 19.4% of all respondents. This was also a difference of 29.7% of the formerly yes answers from question 11.

Question 13 takes this line of questioning 1 step further and asks if the same survey takers would want to own the same theoretical robot they designated previously (Figure 14).

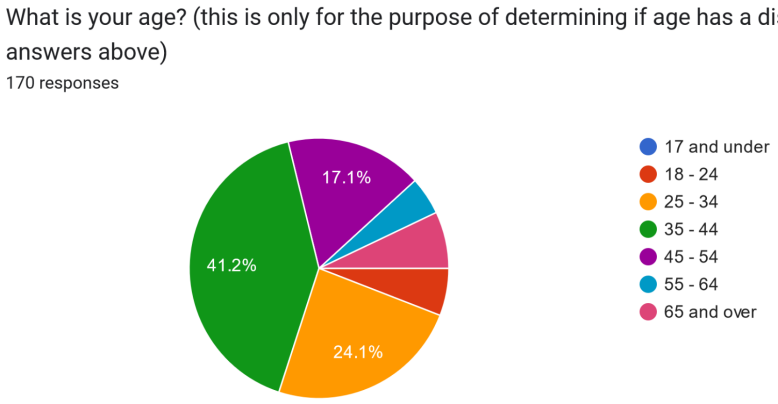

Figure 15. Question 14 results

Question 13 had very interesting results compared to question 11 and 12. The assumption was there would be an ever decreasing number of survey takers as existence became encountering and then finally owning this robot. Instead question 13 was about halfway between question 11 and 12. 94 of 170 respondents said they would like to own the previously discussed robot. This was 17 less than existence and 16 more than encountering. Looking at the data breakdown further I found some oddities in the data. I found 10 respondents who said no to the robot existing and yes to wanting to encounter the robot. Of those same no to existence respondents I found 13 who wanted to own the robot. Of those no to existence respondents, 4 of them said yes to both encountering and owning the robot. 56 of 170 respondents answered yes to all 3 questions, while 40 of 170 respondents answered no to all 3 questions. This means 74 respondents had some mix of yes and no answers to the 3 questions. 11 of 170 said yes to existence and encountering and no to ownership. 19 of 170 respondents said yes to existence and no to encountering and ownership. This leaves 44 respondents that stated no to what would be considered a prerequisite to a question they answered yes to afterwards. There may have been a misunderstanding of the questions. There may also have been a unique point of view I did not consider for why they would want to own a robot, but not encounter the same robot outside of the one that they owned. It is unclear how anyone could consider encountering or owning a robot that was not able to exist.
Question 14 was the age range question. This was the only demographic question asked on the survey, as well as the last question on the survey (Figure 15).

Table 1. Percentage breakdown of questions 1 through 4 by age range

Age	Knowledge 1 or more robot	Knowledge of Atlas	Knowledge of Sophia	Total in age range
18 - 24	50.00%	60.00%	50.00%	10
25 - 34	32.50%	21.95%	46.34%	41
35 - 44	42.86%	42.86%	25.71%	70
45 - 54	48.28%	41.38%	13.79%	29
55 - 64	37.50%	50.00%	25.00%	8
65 and over	41.67%	33.33%	8.33%	12

There were no expectations on age due to the uncontrolled distribution method of the survey. It was directly sent to individuals of every age category except 17 and under. As the survey was then encouraged to be sent on to whoever would be willing to take part, it fell to random distribution. As there is a somewhat even split in the middle age category dropping off toward the younger and older groups, it seems that the middle age group had the highest level of distribution. Those of that age group may have distributed to a similar age group that declined in frequency the

further away it got from their age category. There are charts showing percentages and average answer values by age range in the survey (Table 1).

This table shows by percentage by age range the respondents who were aware of the humanoid robots discussed in this survey. While the low survey numbers within certain age ranges could have skewed the data, it was not very consistent between the different robots and different age ranges. The one exception to this is the youngest age range, they had the highest knowledge of all robots in all age ranges. This Table 2 will show the mean value by age range and overall, for all the 1 through 5 questions.

Table 2. Mean values of answers from the 1 through 5 preference questions

Age	Average value arms	Average value talking	Average value appearance	Average value appearance face	Average value walking	Average full human like appearance	Total in age range
18 - 24	3.8	3.2	1.9	2.5	3.2	2.4	10
25 - 34	3.93	3.93	2.32	2.56	3.41	2.76	41
35 - 44	3.94	4.09	2.39	2.7	3.7	2.51	70
45 - 54	4.21	3.97	2.45	2.59	3.59	2.72	29
55 - 64	4	4	3.25	3	4	3.5	8
65 and over	2.75	4	2.42	2.42	3.5	2.33	12
Average all	3.96	3.96	2.39	2.63	3.58	2.64	170

These numbers show that knowledge and desire of humanoid robots is not necessarily consistent. While the youngest age range had the highest knowledge, they had among the lowest desire for human-like appearance in the individual categories. The oldest age group had very inconsistent results between the categories. They ranged from the absolute lowest in some areas, while being near the top in others. The second oldest age range was either the highest average, or very close to it, in every category. There is the issue that all 3 of these age ranges had the lowest number of respondents and that could have affected the results.

The results of the survey have shown some weaknesses of this survey. The low number of total respondents allowed for small numbers of individuals to potentially skew the data, especially once it was divided out into the separate age groups. The lack of demographic information may have assisted in the stated goal of getting additional participants, but could have hidden other factors regarding the results. Gender would have been a question that, in hindsight, could have illuminated additional information about the results. Gender may have played a much larger role than age, or maybe not. The survey did not require any registration and was not controlled. This means that 1 individual could have submitted multiple responses to the survey. There were precautions taken to make this more challenging, but it was not impossible to do so. The issue with having some kind of registration to take the survey is that it may have scared off potential survey takers. The largest issue remained getting more people to take the survey to mitigate small numbers of people from skewing results.

6. Conclusion

The results of the survey proved to be very enlightening. The Uncanny Valley appears to be a distinct factor in most of the survey respondents' minds. There seems to be a general acceptance of robots and for the physical capability of those robots. Moving arms, walking, and talking all were viewed fairly favorably. Humanlike appearance and full human-like robots were viewed much less favorably. Knowledge of specific humanoid robots and age played a factor in the responses the survey takers provided, but the results are very clear. The survey takers have shown that they want their robots to not look too much like an actual human.

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Biographies

Steven Broownlee is a recently graduated student from Lawrence Technological University. He earned his Bachelor's degree in Robotics Engineering, with honors, from Lawrence Technological University. Upon graduation there was news of a brand new degree program in the form of a Master's Degree in Artificial Intelligence. He proceeded to immediately apply to the program and was accepted as one of the first students to participate in the degree program. He would go on to be the first student to graduate with a Master's Degree in Artificial Intelligence from Lawrence Technological University. While working on both degree programs he worked for the largest utility company in Michigan, as well as one of the largest utility companies in the United States, DTE Energy. He is still working for this important organization at the time of the publishing of this document. He learned to build and program robots, create and analyze Artificial Intelligence models, and the importance of leadership and teamwork while acquiring his degrees. He also has worked on self-driving vehicles, autonomous robots, image processing, creating 3-d printed models for various applications and more. Having studied and worked on many elements of robotics and artificial intelligence he will continue to try and advance in the world and is confident in doing so.

Dr. George Pappas is an Assistant Professor and Director Master in Artificial Intelligence program in the Department of Electrical and Computer Engineering (ECE) and currently working with several graduate and undergraduate students in research in a multitude of developing areas ranging from automotive to medical applications. He has over 15 years of teaching, research and work experience in embedded systems and high-performance computing. Artificial Intelligence (AI) in Autonomous vehicles, employ machine-learning techniques to collect, analyze and transfer data for safer driving experience. Also, he investigates encryption and optimization algorithms and security of the transfer of electronic medical data using wireless cellular communication systems for evaluation, diagnosis, and treatment of patients in remote locations. Some of the research interests are: Artificial Intelligence (AI) within radiology, specifically computerized tomography (CT) image reconstruction. Precise data analytics for pathology images. Virtual Reality (VR) in medical applications, Artificial Intelligence (AI) to aid diagnostics, Telemedicine, Medical and Health Informatics, Wireless implantable sensors and biomedical Transducers.