Appearance of Robots and Privacy Concerns

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***Abstract*—With recent advances in robotics and artificial intelligence, robots have the potential to support healthcare, manufacturing, military, and agriculture In this report, we aim to establish that the appearance of a robot impacts human-robot interaction and the human-robot relationship. The uncanny valley paradigm leads us to assert that people trust a human robot more than an animal robot or an android robot. We validate our research hypotheses with the results of an online survey to demonstrate that an ethical design and framework of the robot affect trust among the users and largely influence physical, psychological, social, and informational privacy.**

***Index Terms*—Robots, Privacy, Humanoid robots, Animal-like robots, Appearance**

I. Introduction

Robots are computer-programmed and capable of performing complex actions automatically [1]. In movies, robot saves people's lives, fights opponent, and performs tasks that seem tremendously fatal with ease. Even, in reality, robots are used in environments that are inaccessible or dangerous to humans. Robotic operations include, but are not limited to, planetary exploration, search and rescue, activities that impose hazardous tasks on workers, and activities that require complex tactical skills and information integration [2]. Human-robot partnership and trust are vital if humans and robots perform a task together, even if the mission is as simple as cooking or as dangerous as rescuing from fire [2]. Robots are designed to assist humans or to complete a job autonomously per their operating environment, such as healthcare, business, and education. Trust between man and machine is crucial when task completion depends on a robot's efficiency and abilities to understand human behavior, emotion, and cognition [3]. Robots that look and behave like humans are created to establish trust. Human or humanoid robots are not the only kind of robots used extensively. Robots that look like animals or stationary machine robots are also employed in almost every sector to assist humans in their work. Robots are designed as mobile and fixed based on interaction mechanisms. They are made legged or wheeled as per the use case. Robots find application in industrial domains such as logistics, manufacturing, and service domains such as defense, home, educational and medical. Our survey focuses on robots used in the healthcare domain. Robotic systems are implemented in nursing homes for the elderly, children, and the disabled, hospitals, rehabilitation and walking assistance facilities, and other care facilities. Robotic agents can improve the treatment experience by reducing patient care tasks and tedious and repetitive manual tasks [4].

Robotic systems are implemented in nursing homes for the elderly, children, and the disabled, hospitals, rehabilitation and walking assistance facilities, and other care facilities. Our survey focuses on robots used in the healthcare domain that interact with people under medication or require supervision. They are employed as companions for the elderly, assist nurses by periodic monitoring, and aid patients or children in mobility. Most social or assistive robots' appearances are bio-inspired.They are designed like humans, animals, flowers, and other bio-entities as embodiment improves interaction and perception with intelligent entities. [5]

In this paper, section II provides a brief background about robots, types and applications. Section III provides more information about robots in the field of healthcare and the privacy implications here. We detail our study, research methodology and hypotheses in section IV. Survey details and results are elaborated in section V. Finally, we state our findings and provide a brief conclusion in section VI.

II. Background

Over the last few decades, robots have evolved by a large extent. The earliest robots date back to the 1950s. A programmable robot known as 'Unimate' was one of the first known robots developed by George Devol [6]. Joseph Engleberger, known as the father of robotics, invented the first industrial robotic arm that was put into practice [7]. Since then, the number, purposes, and types of robots have vastly increased. Robots enable greater flexibility for organizations by helping with difficult and repetitive tasks. From being used in assembly lines, landing on Mars, to being used to perform surgery, the field of robotics has grown leaps and bounds. Robot appearance has also changed over the years. Each robot has unique features, sizes and shapes. Robotic arms, wheeled robots, robots with the appearance of a human, or an animal, and so on. With the wide variety of robots on offer, robots can be classified into 6 common types [8].

A. Types of Robots

1) **Articulated Robots:** Articulated robots are more commonly known as robotic arms and are prosperous in industrial manufacturing. The arms can move at high speeds and with great accuracy. However, they are fixed at a location and lack any mobility. [9].

2) **Automated Guided Vehicles (AGVs):** AGVs operate in controlled environments and are often superintended by an operator. They rely on pre-fixed tracks to move around [8]. AGVs are useful to deliver necessities in large spaces or hospitals, for instance.
3) **Autonomous Mobile Robots (AMRs):** AMRs are mobile robots that do not need any supervision from an operator. They are equipped with sophisticated sensors which help them interpret their surroundings and perform their tasks efficiently [10].
4) **Humanoid and Zoomorphic Robots:** Humanoid robots are those that have a human-like shape or features [11]. A well known example of a humanoid robot today is Sophia - the world's first robot citizen [12]. Fig. 1 shows an image of Sophia.

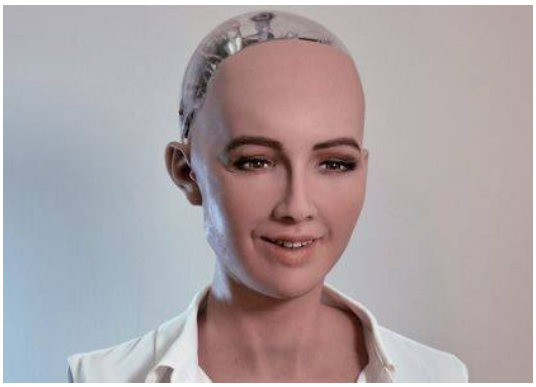


Fig. 1: Humanoid Robot - Sophia [12]

Zoomorphic robots on the other hand, have a body or features which are animal-like. Fig. 2 shows an image of Sony's Aibo robot [13] which resembles the shape and features of a dog.

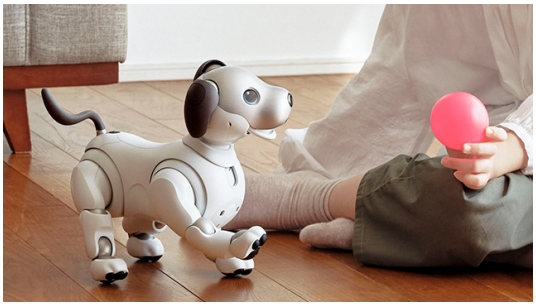


Fig. 2: Zoomorphic Robot - Aibo [13]

Both humanoid and zoomorphic robots are AMR, since they are independent mobile robots who provide services to humans [8].
5) **Cobots:** Collaborative robots or Cobots are designed for collaborating with and assisting humans with their tasks [14]. Cobots are often utilized to perform strenuous or dangerous tasks that are risky for humans.
6) **Hybrid Robots:** Hybrid robots are formed as a combination of the above robots. For example, combining an articulated robot with an ARM [8].

B. Applications of Robots

As mentioned earlier, the use of robots has grown by a large amount in the past few years. This increase can be attributed to the fact that robots have become more advanced over the years. Use of artificial intelligence and machine learning techniques have enabled robots to intelligently and precisely interact with their environment [15]. Today, They are used in a wide variety of industries for performing different tasks. The earliest known robot was used as an industrial robot [6]. Robots have hence evolved into different fields. Apart from being used in the manufacturing industry, robots are also used in households, the military, space exploration, for agricultural purposes, as social robots, and even as medical assistants in the healthcare industry [16]. Robots have been integrated into many applications today and are beneficial for assisting humans.

In this paper, we focus on the healthcare application of robotics. The following section provides more information about the application of robots in the medical industry.

III. Robots in Healthcare

The advancements in robotics and Artificial Intelligence (AI) have enabled robots to be slowly integrated into the field of medicine. Robots in the healthcare world is not a new concept. The first surgical robotic application was seen in 1985 [17]. Since then, robots have been used in different areas of healthcare, and there has been constant improvement. During the COVID-19 pandemic of 2020, robots played a major role in assisting healthcare workers and patients alike [15]. Below we list some applications of robots in healthcare.

- **Medical Device Packaging:** Handling medical devices requires high caution towards sterilization and contamination. Utilizing robots in this process allows less risk of contamination the medical equipment [18].
- **Automation in Labs:** Medical labs perform numerous tests everyday. This task while tedious and repetitive, is essential. Robots can help perform these tests more accurately and quickly [18].
- **Surgery:** Robots are valuable in performing precision based and minimally invasive surgery such as neurosurgery or heart surgery [19]. The Da Vinci surgical system is widely used for robot assisted surgery [20].
- **Nurse Robots:** Nurse robots perform functions such as taking vitals or delivering medications. Nurse robots are especially favorable during quarantine periods [15]. An example of a nurse robot is Spot. Spot robot can take human vitals and was specially programmed for assistance during COVID-19 [21]. Fig. 3 shows an image of Spot robot.
- **Care Robots:** Care robots are used to provide assistance during patient care. They may be used in homes or outpatient care to help patients recover from their procedure. Care robots can also provide mobility assistance to patients who have difficulties in movement [22].

Fig. 3: Nurse robot - Spot [21]

Fig. 4: Robot equipped with a camera - Aibo [13]

- **Companion Robots:** One of the recent applications of robots in healthcare is providing therapeutic assistance and companionship to improve mental health. Often, animal-like robots are used to provide emotional support. This is especially used for the elderly and children [23].

In this research, the focus is mainly on robots that can interact with patients during assistance. For this purpose, we only consider nurse robots, care robots and therapeutic assistance robots in the research.

A. Challenges & Privacy Concerns

Although robots are beneficial to the field of healthcare, their acceptance in the industry has been slowed. Robots raise some safety and privacy concerns in medical environments.

Privacy Concerns: Privacy is of the utmost importance in the field of healthcare. Doctors even take an oath to protect the patients' medical and personal information during treatment [24]. Having a robot during such treatment may not be welcomed by all patients.

- *Collection of health data*: Healthcare robots used for patient assistance in homes and hospitals. They collect data from their surroundings and medical data of the patients. This data is used to assist and monitor patients, and may be additionally used to learn behaviours for aiding better. The data gathered potentially increases the chances of patient exposure [23].
- *Potential for hacking:* Some robots collect and store information on cloud platforms. Robots can easily connect to the internet and possibly to other robots. This results in a high susceptibility to hacking. Once hacked, outsiders may be able to access all sensitive data about a patient [25].
- *Physical privacy violations:* Robots are equipped with various sensors to be able to monitor and move around their surroundings without being guided. These sensors can collect private information in a patient's environment. This causes a violation of the person's physical privacy and may make the patient feel threatened [25]. Fig. 4 shows an example of a robot equipped with a camera for monitoring.

We see that privacy is a major concern in integrating robots in the healthcare domain. However, robots are beneficial and can potentially become a necessity to assist people in the future. In our research, we examine whether the appearance of robots has an impact on how people perceive their privacy. In the following section, we detail our study and provide our findings.

IV. Research Methodology

We signify the importance of robot appearance in human-robot interaction and the foundation of trust. We developed research hypotheses after analyzing human-like and animal-like robots used in healthcare. We aim to validate these through people's views about robot ownership and willingness to interact with it.

A. Impacts of Robot's Appearance

Robot appearance includes anthropomorphic, caricatured, zoomorphic, and functional designs [26]. Many human-centric robots have been developed because research has shown that the human-likeness of robots enable rich social interactions [26]. Hence, humanoid robots play an important role in serving or helping humans [27].shows Fig. 5 some humanoid robots [28].

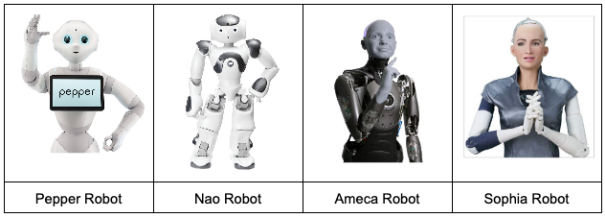


Fig. 5: Robots with human-like appearance [29]

Some studies has shown that humanoid robots can improve human-robot interactions and promote trust and acceptance. However, Mori's uncanny valley theory provides some new insight into this relationship. It states the relationship between a robot's looks and a person's emotional response [30]. Mori suggests that the more a robot's appearance resembles a realistic human appearance, the more uneasy people feel around

the robot. However, if robots were almost indistinguishable from humans but not perfect, humans would have negative emotional responses [31].

Zoomorphic robots have been growing in popularity over the past few years [32]. Zoomorphic or animal-like robots may be preferred by humans based on certain criteria. Some people find themselves more comfortable with pets. Hence they prefer animal-like robots for assistance in treatment or care. Based on these claims, we aim to investigate whether robot appearance affects perceived trustworthiness and privacy in people.

B. Study Design

We focus on robots used in healthcare and analyze people's perspectives based on their functionality and appearance. We found Home care robots, Companion robots, and Service robots with bio-centric designs, specifically human and animal-like robots, used in healthcare facilities and home assistance. We carried out a comprehensive analysis of robot functionality, use cases, and appearance. We selected robots with human-like features such as human-like limbs, faces, and expressions for our study. Fig. 6 illustrates the humanoid robots used in our research. Therapeutic practices for elders and children use animal-like robots for their treatment. These robots have features like animals and engage with people like pet companions.

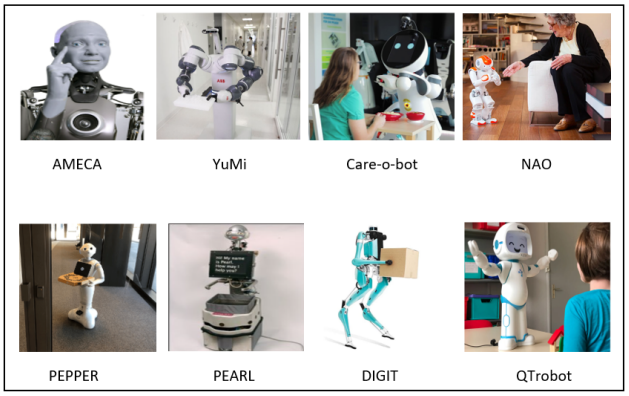


Fig. 6: Robots with human-like appearance used in our study

Fig. 7 shows the animal-like robots used in our research.

Fig. 7: Robots with Animal-like appearance used in our study

Robots designed like seal, dog, cat and duck are used in therapy for children and elders. Our study also includes robots with only animal-like limbs or animal-like faces without any characteristic similarities with the animals in the real world. Fig. 8 shows a child or a toy-like robot used for therapy.

Fig. 8: Other Robots Used in our Study

To formulate our conclusions about robot appearance and human-robot trust, we drafted hypotheses to be validated with our experiment.

C. Research hypotheses

For our study, we formulated a set of 15 hypotheses based on robot appearance, human tendencies and privacy guidelines. With these hypotheses, we intend to demonstrate that robot appearance plays a key role in how humans perceive privacy information about the said robot. We enlist our hypotheses as follows:

*1) **H1**: People prefer interacting with robots that have human-like facial features.*
If robots are designed like humans and have distinct characteristics of the human face, such as a face with eyes, nose, ears, mouth, and facial expressions, they are more likable to people. They have a near-human design and are better interaction partners for humans than robots with eyes represented with LED or no facial structure.

*2) **H2**: The willingness to interact and trust an animal-like robot over humanoids depends on a person's age.*
Animal-like robots provide companionship to people. We hypothesize that elderly people and young children would prefer the company of an animal-like robot, which makes them trust it more. The younger generation of people between 18 - 40 years of age would much rather prefer the company of a humanoid robot.

*3) **H3**: Older People prefer to interact with child-like robots over animal-like robots*
Although animals provide valuable companionship to humans, studies have shown that the older generation benefit from interacting with younger children [33]. We believe that the child-like appearance of a robot builds an attachment between the robot and a human that could be stronger than an animal-like robot. Hence, we hypothesize that older people would prefer child-like robots more.

*4) **H4**: Parents prefer that their children interact with animal-like robots over humanoid robots.*
It is common knowledge that animals play a powerful role in motivating and proving joy to children [34]. Animals have also widely been used in therapy sessions for children. We conjecture that parents would prefer that their children interact with an animal-like robot more than a humanoid robot.

*5) **H5**: The willingness to interact and trust an animal or pet-like robot over humanoids depends on gender.*
We suppose that gender plays a role in how humans perceive and trust robots based on their appearance. Based on a survey conducted in 2018 [35], women generally prefer the companionship of animals more. We hypothesize that the female gender would trust an animal-like robot more than the other genders.

*6) **H6**: People trust humanoid robots over animal-like robots to deliver necessary items (such as medicines, packages) and for movement assistance.*
Animals are perceived to be playful and not carry out every task as per detailed instructions, while humans try to perform tasks with perfection. People prefer humanoid robots for assistive needs as robot embodiment affects choices.

*7) **H7**: People prefer to interact with zoomorphic robots that are lively and communicative.*
People who have had pets, have pets, or want to have pets prefer interaction with an animal-like robot. Pet owners love communicating with their pets as if they are their friends. People like robots that are sensitive and react to their actions.

*8) **H8**: People are less likely to share personal information with a doctor in the presence of a humanoid robot than an animal-like robot.*
Doctors require all information to cure and suggest remedies. In the presence of service robots or assistive robots people are more comfortable sharing their private details with a humanoid robot than a zoomorphic robot.

*9) **H9**: People prefer animal-like robots over humanoid robots as therapy robots.*
Animals with playful traits are loved by all humans. Humans perceive that animals are easier to share private details with. During therapy, people prefer to be with, and are more trustful towards animal-like robots.

*10) **H10**: People prefer a personalized robot interaction at hospitals, even though facial recognition might be a violation of personal privacy* Facial recognition features enable robots to recognize the patient and provide personalized interaction. Although this may result in storage of image data, people prefer a more user-oriented interaction during their time at the hospital.

*11) **H11**: Trust is affected by the presence of sensors (e.g.: camera, microphone, etcetera) on robots.*
We speculated that people receiving healthcare from robots perceive that their privacy is affected due to the appearance of sensors. Visible cameras and microphones have a negative effect on humans' trust of robots.

*12) **H12**: People prefer animal-like robots with a well-defined privacy policy for medical assistance.*
Animal-like robots with inbuilt sensors for vision, hearing, and talking can be very intimidating. To promote trust, they should have a well-defined policy for privacy maintenance so that people share their medical needs during therapy with the robot.

*13) **H13**: People do not trust robots that transfer their data to third parties or other intelligent devices.*
If a robot is capable of real-time communication and provides intelligent responses to user questions, it collects and handles a lot of data. Personal data of people might reach third parties during the process. For instance, the policy of Pepper robot states that the data may be transferred to a third-party [36]. Data may also be transferred to other robots through a synced cloud platform [37]. Robots capable of these phenomena are not preferred for interaction due to privacy concerns.

*14) **H14**: People prefer to interact with and trust a robot with speech capabilities over robots that can only communicate through text*
Speech is an essential form of communication for humans [38]. For this reason, we hypothesize that humans prefer robots that are able to communicate with them through speech with the help of synthesizers.

*15) **H15**: People with pets trust animal-like robots more than humanoid robots*
Many studies have been conducted to evaluate the effects of having pets [39]. Studies show that people with pets have a more positive view on animals and feel joyous around their pets. We suppose that this influences people with pets to trust zoomorphic robots more.

V. Study Overview and Results

This section provides information on the survey and the respective results and implications. Based on the hypotheses mentioned in section IV-C, we developed a set of questions that were presented to participants. All participants are expected to be devoid of any medical condition that made them unconscious, dizzy, or distracted. The questions were configured in the form of a survey.

A. The Survey

The survey [40] was conducted within the framework of the research group "Computer Security and Privacy" of the George August University of Göttingen. For the survey, we used a collection platform hosted on the University's server - LimeSurvey. The platform stores the collected data in the EU and follows the European privacy regulations. The data collected is anonymised and no data can be traced back to a particular participant. The data is also used only for the purpose of this study. All participants are made aware of the data protection policy and guidelines before they begin the survey. The survey consisted of a total of 30 questions and was presented entirely online. We divided the questions into two categories.

1) General Questions: Out of the 30 questions, we included 4 questions to be able to get an idea about the participant. We term these as 'General Questions'. Here we ask the participants about their age group, their gender, whether they own pets or wish to in the future, and if they have a child. Although the questions are personal, they were formulated in a manner that they do not leave any identifiable information about the participant. For instance, age is collected in the form of age groups. In addition, the participant was allowed to choose not to answer a question by choosing the option 'prefer not to say'. The general questions help us make inferences whether survey answers vary based on participant characteristics.

The following figures show the distribution of participant answers.

Fig. 9a shows the age groups to which participants belong. We categorize participants under the age of 18 as *youngsters*, between 18 - 25 are *young adults*. Ages 26 - 40 are broadly categorized as *adults*, and participants over the age of 40 are categorized as the *elderly*. A majority of about 47% of the participants belong to the age groups of 26 - 40.

Fig. 9b shows the distribution of participant genders. We offered the choices of *male*, *female*, and *other*. We note here that a majority of the participants were male.

Fig. 9c shows the distribution of participants who have or don't have pets currently. 18 of the 55 participants have pets, and the remaining do not. We further note the distribution of the kind of pet (e.g.: cat or dog) a participant has, if mentioned. A large amount of participants (around 67%) do not own a pet during the time they took the survey.

We also note the distribution of participants based on whether they have a child or do not. About 29% (16 participants) have at least one child, the remaining 71% (39 participants) do not have a child.

2) Research Based Questions: The research based questions are aimed to directly validate or invalidate our hypotheses from section IV-C. The general questions, combined with certain research-based questions also play a role in ascertaining our suppositions. We formulated 26 research-based questions. Participants were provided both information and images of robots, where required, to answer the questions [40].

B. Study Results and Observations

To portray the results of our study we group the survey outcomes into four categories - Robot features, robot appearance, human characteristics as influential factors and privacy measures.

1) Robot Features:

i. **Facial Recognition Capabilities**: Facial recognition plays an important role for personalising a human-robot interaction. The results from our survey prove that *hypothesis H10 is correct*. Robots equipped with facial recognition are able to differentiate between humans and provide personalized responses. For example, robots use this capability to recognize a person and address them by name, or provide a user-centric interaction or assistance [41]. Patients at a hospital possibly appreciate the personalization during treatment or recovery. Table I shows that around 67% participants would prefer robots with a facial recognition feature.

	Count	Percentage
Robot with facial recognition	37	67.27%
Robot without facial recognition	10	18.18%
No Preference	8	14.55%

TABLE I: Participants' view on facial recognition capabilities in a robot

ii. **Camera & Microphone Sensors** We aimed to determine whether the presence of sensors affects human-robot interaction and trust. We asked participants how likely they are to trust robots that have visible sensors(microphone or camera) capable of recording conversations and image feed. From our results, we find that a majority of 25.45% of the participants are unlikely to trust such a robot. Table II shows the participant distribution on a scale of 5. The results are close and we believe that people are generally wary of being recorded. If they were made aware of consequences, the results would be more precise. We conclude that *hypothesis H11 is valid*.

Very Unlikely	Probably Not	Neutral	Probably	Very Likely
25.45%	18.18%	21.8%	20%	7.27%

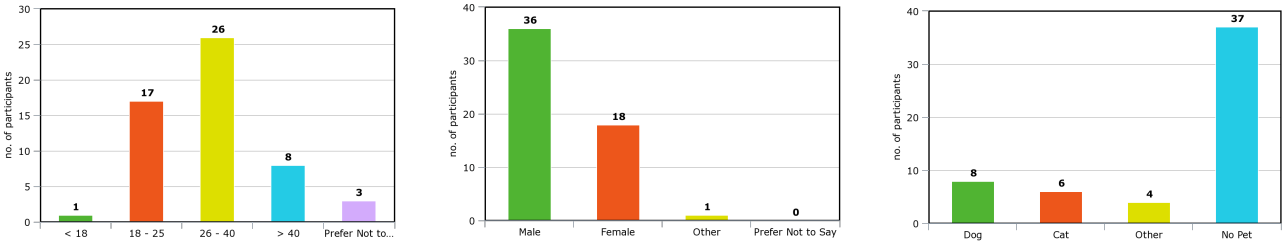
TABLE II: How likely is a participant to trust a robot with sensors that record their data

iii. **Touch Sensors & Reaction** Based on hypothesis H7, we asked participants whether they would prefer to interact with a robot that can react to touch and make movement or a noise. We used Tabby robot as an example for this question. Tabby robot, which looks like a tabby cat makes a movement or purrs when it is touched by a human.
Fig. 10 shown an image of Tabby robot. Based on our results, around 75% participants agreed to this question. Hence, *hypothesis H7 is valid*.

iv. **Speech vs Text Communication** The survey shows that participants prefer interacting with robots which can communicate with them through speech. We asked robots to choose between the two kinds of robots and around 76% participants chose a robot with speech capabilities. This proves that *hypothesis H15 is valid*

2) Robot Appearance: In this section we cover some questions and hypotheses results regarding robot appearance.

i. **Humanoid facial structure:** We asked participants questions regarding the humanoid appearance of a robot which they would trust more. Participants prefer
a) robots with a human facial structure (e.g: Pepper) over a robot without a facial structure (e.g: Digit).
b) robots with facial expressions and eye movement



(a) Age Distribution (b) Gender Distribution (c) Pet Ownership Distribution

Fig. 9: Distribution of Participants

Fig. 10: Tabby cat-like robot

similar to a human (e.g: Ameca). This proves that *hypothesis H1 is correct*. Around 65% participants put more trust in robots that communicate back with them through facial movements during healthcare assistance, similar to a human.

ii. **Appearance of Limbs:** Robot limbs are useful for delivering necessities like medicine, or providing support to patients during their movement. Participants were given a choice between three robots - human-like (Digit) and animal-like (Spot and RIBA). Fig. 11 shows the survey results. This is attributed to the fact that humans generally trust bigger and stronger embodiments for strenuous tasks. This proves that *hypothesis H6 is invalid*. Trust for movement or delivery assistance rather depends on the perceived strength of the robot.

Spot Robot	Digit Robot	RIBA Robot
		
Least preferred	More prefered than Spot	Most prefered

Fig. 11: Trust depends on the perceived strength of robot

iii. **Therapy Robots:** Robots help provide a sense of comfort and companionship during stressful situations. Animal therapy is a growing field of medicine that has proven to show positive results for human beings [42]. Our results show that participants feel the same way about animal-like robots.

Animal-like Robot (PARO)	Child-like Robot (Kabochan)	Humanoid robot (QTrobot)
		

Fig. 12: Therapy Robots. PARO is more trusted compared to Kabochan and QTrobot

Fig. 12 shows options provided to participants. Compared to a human-like robots (QTrobot) and child-like robot (Kabochan), a majority of the participants feel that they would trust an animal-like robot (PARO) more. Thus, *hypothesis H9 is valid*.

iv. **Companion Robots:** Robots provide companionship to patients during their treatment with the doctor and ease the process. We assume that a humanoid robot presence would be similar to a human nurse presence which would ease patients to share more personal information. We gathered data for two robots - Nao and Paro. However, our results were inconclusive as participants remained neutral on this matter. *Hypothesis H8 is, thus, deemed invalid*. We believe that the question would have better results if framed more precisely.

3) Human Characteristics: This section contains some results regarding how human characteristic like age, gender, pet ownership and having children may affect how privacy is perceived in robot interaction. We note that the missing percentages in the below tables accounts for people who had no preference.

i. **Age:** Based on the participant age distribution and the choice of robots, survey results show the following results shown in table III. Since the data for people under the age of 18 is not enough, we discard this data.
From the above results, we see that people between the age of 18 - 40 generally prefer and trust animal-like robots more than humanoid robots. Whereas, older people over

	18 - 25	*26 - 40*	*40*
humanoid	28.4%	37.82%	**41.66%**
zoomorphic	**46.08%**	**41.66%**	33.33%

TABLE III: Age group vs robot preference percentages

the age of 40 may prefer humanoid robots more. Thus, *hypothesis H2 is valid*. We note that all other factors are ignored and only age and preference is considered here. We also observe that out of the 8 participants over 40 years of age, 62.5% chose a child-like robot (Kabochan) over an animal-like robot (Paro). This validates *hypothesis H3*.

ii. **Gender:** The gender vs robot appearance preference percentage is shown in table IV.

	Male	Female
humanoid	**39.81%**	36.11%
zoomorphic	36.11%	**49.08%**

TABLE IV: Gender vs robot preference percentages

This shows that females prefer to interact with and trust animal-like robots more than humanoid robots. Once again, all other factors other than gender and type of robots is not considered. Thus, we deem that *hypothesis H5 is valid*

iii. **Children:** We asked participants who have children, which kind of robot they would prefer their child interact with. The participants chose that animal-like (Paro) robots over humanoid (Nao robot). This is shown in table V. *Hypothesis H4 is valid* We also observe that animal-like or zoomorphic robots are preferred over child-like (Kabochan) robots.

	Percentage preference
humanoid	18.75%
zoomorphic	**56.25%**

TABLE V: Parents prefer their children interact with zoomorphic robots

iv. **Pets:** Another observation from our study was that people who currently own pets or want to in the future are generally more likely to choose animal-like robots. This *proves hypothesis H15*. Although the amount of data is quite low, we noted that dog-owners preferred AIBO robot (Fig. 2) over other animal-like robots.

4) Privacy Measures: This category covers some additional aspects of robots that would affect how a person interacts with a robot during their medical needs.

i. **Data Protection guideline or policy:** Privacy and trust go hand-in-hand [43]. Privacy policies and guidelines provide privacy and data protection information to users. Participants agree that this is a crucial factor in determining their trust towards robots. Table VI shows that more than 85% users prefer some forms of policies or guidelines, thus *proving hypothesis H12*.

	Count	Percentage
Robot with data-protection guideline	47	85.45%
Robot without data-protection guideline	1	1.82%
No Preference	7	12.73%

TABLE VI: Influence of Data-Protection Guideline on Human Trust

ii. **Data Transferring:** Robots collect large amounts of sensitive data. Transferring this data could be a privacy violation. This information is specified in the privacy policy. We asked participants how likely they are to trust such robots. Our results were inconclusive. Many participants were neutral regarding the topic. Thus, *hypothesis H13 is invalid*. We attribute this to the reason that they were not properly made aware of the implications of sharing their private data to outside parties. Table VII shows our results.

Very Unlikely	Probably Not	Neutral	Probably	Very Likely
26.36%	7.27%	27.27%	22.7%	12.7%

TABLE VII: How likely is a participant to trust a robot which transfers private data to outside parties

Our survey results validate 13 of our hypotheses and 2 are invalidated.

VI. Conclusion

Robots are evolving at a fast pace and being integrated slowly into our lives. Robots are specially effective in the field of healthcare. However, privacy implications of this are abundant. With this study, we aimed to infer whether robot appearance affects how humans perceive this privacy. With this in mind, we formulated 15 hypotheses and created a survey to prove our conjectures. The survey was completed by 55 participants and validated a majority of our hypotheses. From the survey results, we note that robot appearance does play a vital role in how humans interact with and place trust in these robots. Many human characteristics like age, gender and pet ownership also play a role in this regard. Additionally, we also observe that a well defined privacy policy for a robot that details their data protection rules is also important to the participants. Our detailed analysis and outcomes are noted in this paper. Thus, we conclude that our study successfully validates our claim.

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