



## Benefits of Social Robots



# Contents

<b>Introduction</b>	<b>3</b>
<b>Types of conversational interfaces available</b>	<b>4</b>
Chatbots	4
Virtual Avatars	5
Voice Assistants	6
Social Robots	6
<b>Advantages of having Social Robots</b>	<b>8</b>
<b>Summary</b>	<b>11</b>



# Introduction

With the increased availability of high-end smartphones at affordable prices, the number of people interacting with artificial agents have increased dramatically.

An artificial agent could be broadly defined as a system that operates autonomously without any human intervention to make decisions based on the inputs from the environment, users, and its experience. For example, every time one converses with “Siri” or “Alexa”, they are interacting with one such artificial agent.

As the exposure and interactions with artificial agents become more widespread, there has naturally been a focus on how to improve the interactions to make the experience seamless and more helpful. This has eventually led to the creation of Social Robots which are looked at as the next step in realizing seamless/ natural interactions between humans and artificial agents which is otherwise known as Human-Robot Interactions (HRI) or Human-Machine Interactions (HMI).

In the subsequent sections we will discuss the types of conversational interaction interfaces available and how they evolved over time, highlighting the advantages of one interface over the other.

# Types of conversational interfaces available

From Chatbots to Virtual Avatars, and from 2D smartphone screens to physically embodied robots, the types of conversational interfaces have seen paradigm shifts in a short period of time.

## Chatbots

Chatbots are software applications that are capable of conducting real-time text-based conversations with humans. The name chatbot comes from the term “ChatterBot” that was coined by Michael Mauldin in 1994. We can trace the origin of chatbots to as far back as 1966 when ELIZA was created, a chatbot simulating a psychotherapist.

```
Welcome to
      EEEEE LL   IIII  ZZZZZZ  AAAAA
      EE  LL   II    ZZ  AA  AA
      EEEEE LL   II    ZZ  AAAAAA
      EE  LL   II    ZZ  AA  AA
      EEEEE LLLLLL IIII ZZZZZZ  AA  AA

Eliza is a mock Rogerian psychotherapist.
The original program was described by Joseph Weizenbaum in 1966.
This implementation by Norbert Landsteiner 2005.

ELIZA: Is something troubling you ?
YOU:  Men are all alike.
ELIZA: What is the connection, do you suppose ?
YOU:  They're always bugging us about something or other.
ELIZA: Can you think of a specific example ?
YOU:  Well, my boyfriend made me come here.
ELIZA: Is it important to you that your boyfriend made you come here ?
YOU:  He says I'm depressed much of the time.
ELIZA: I am sorry to hear that you are depressed.
YOU:  It's true. I am unhappy.
ELIZA: Can you explain what made you unhappy ?
YOU:
```

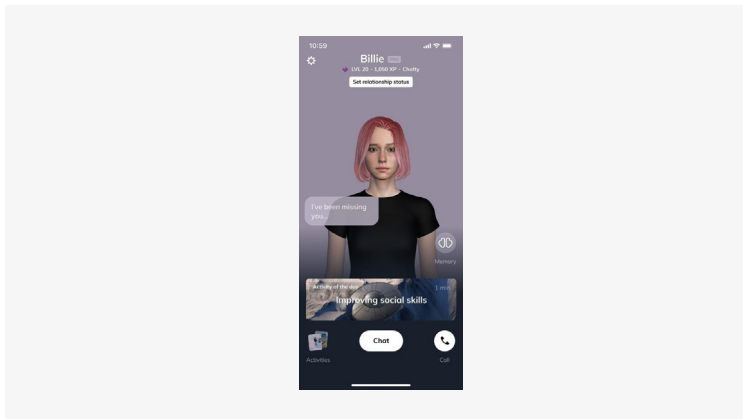
Since then, with the advancement of the field of Natural Language Processing (NLP), Chatbots have evolved into being very realistic and difficult to differentiate from that of a human. A few recent examples of Chatbots are ALICE (1981), Cleverbot (1997), Mitsuku Chatbot (Loebniz winner 2013, 2016-2019 and Google Meena (2020).

However, as is the case with text-based conversations (otherwise popularly known as chats), there are inherent limitations to what can be achieved using Chatbots. For example, a key limitation is the lack of ability to convey emotions using text. While one can argue that emotions can be inferred from the context, it is difficult to do so during a chat. Human beings make use of facial expressions clubbed with speech to convey the same, which is not possible for a chatbot. This led to the creation of chatbots that also had an animated face which are popularly known as Virtual Avatars.

## Virtual Avatars

As the name suggests, Virtual Avatars are graphical representations of characters on the web or applications. They could be 2D or 3D animated characters used to emulate facial expressions. These facial expressions when used in conjunction with the texts, make it easier for the chatbots to convey the underlying emotion in the text.

Use of Virtual Avatar powered chatbots try to go beyond just holding normal conversations. From the facility to customize the Virtual Avatar to learning chat models personalized to specific users over time, Chatbots are providing opportunities to form a personal connection with humans. For example, a Chatbot called Replika claims to be able to become a friend for the users.



Another term to keep in mind are Virtual Assistants. The key difference between Chatbots and Virtual Assistants is that Chatbots are mainly used to chat, whereas Virtual Assistants are expected to accomplish some tasks for the user along with chatting. For example, depending on the use case, a Virtual Assistant could make entries in a calendar, retrieve and display flight reservation data, or connect the user to a human support staff if required. Nowadays, many websites offer Virtual Assistants in their support sections. Subsequently the application areas range from using Virtual Assistants to pre-diagnose health conditions to making cartoon characters like Spiderman as a Virtual Avatar which lets fans converse with Spiderman.

While Virtual Avatars seem to do a good job at improving the Chatbot's conversational capabilities, a few inherent drawbacks remain. Using text to chat makes it difficult to have a natural conversation as typing the replies takes time. Additionally, humans make use of various prosodic features to signal their intents or emotions when talking, which when clubbed with the speech and facial expressions, makes it easier for others to interpret. This is not possible using text based

Chatbots or Virtual Assistants. To overcome these challenges, a new type of Chatbots called Voice Assistants were built.

## Voice Assistants

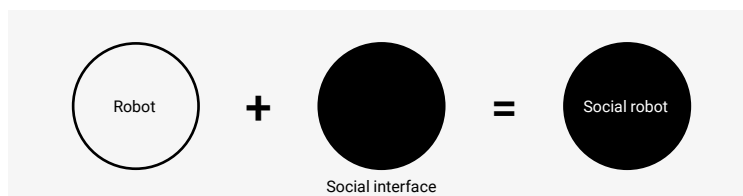
The main idea behind the development of Voice Assistants was to have the ability to hold conversations with humans using voice/ audio. This opened a lot of possibilities starting from normal conversations like small talks to complex order processing using voice commands. Voice Assistants are able to perform tasks for the users ranging from managing calendars or playing songs to complex tasks such as booking a hotel or flight reservation. Some of the popular Voice Assistants are “Siri”, “Alexa” and “Cortana”.

Voice Assistants provide two main benefits; they are faster to communicate with as one doesn't have to wait to type responses and the conversations with them seem more natural as it is more convenient to converse using voice. A recent study by Heetae Yang and Hwansoo Lee<sup>1</sup> shows that users tend to use Voice Assistants such as Google Home or Amazon Alexa due to the perceived usefulness and perceived enjoyment.

However, just as it is difficult to communicate over telephone at times, Voice Assistants are also susceptible to the same limitations. “Co-presence” refers to the presence of individuals in the same physical space at the same time. Interacting with each other in a shared space comes naturally to us as we are able to make use of both verbal and non-verbal cues to compliment each other and make communication more effective. Social Robots are the next step forward that try to address these issues to make conversations seem more natural.

## Social Robots

Bartneck and Forlizzi<sup>2</sup> define Social Robots as “A social robot is an autonomous or semi-autonomous robot that interacts and communicates with humans by following the behavioral norms expected by the people with whom the robot is intended to interact”. Hagel and his team represented the definition using a visual representation<sup>3</sup> as shown in the figure below:



<sup>1</sup>Yang, H., & Lee, H. (2019). Understanding user behavior of virtual personal assistant devices. *Information Systems and e-Business Management*, 17(1), 65-87.

<sup>2</sup>Bartneck, C., & Forlizzi, J. (2004, September). A design-centred framework for social human-robot interaction. In *RO-MAN 2004. 13th IEEE international workshop on robot and human interactive communication (IEEE Catalog No. 04TH8759)* (pp. 591-594). IEEE.

<sup>3</sup>Hegel, F., Muhl, C., Wrede, B., Hiescher-Fastabend, M., & Sagerer, G. (2009, February). Understanding social robots. In *2009 Second International Conferences on Advances in Computer-Human Interactions* (pp. 169-174). IEEE.

Robots here mean the physically embodied agents that can share the same space with us facilitating co-presence. Social Interface includes all the different social expectations out of the robot. A few such expectations are:

- The robot should be socially situated, meaning that it should facilitate co-presence
- The robot should be socially interactive, meaning that it should be able to communicate as humans do in a social setting.
- The robot should be Socially Intelligent, meaning that it should be able to pick up social cues and adapt accordingly.

Based on the physical embodiment, Social Robots can be broadly classified as Humanoids and Non-Humanoids. Humanoid robots are those that emulate the physical characteristics of a human being. A few commercially available humanoid robots are “Pepper”, “Nao” and “Furhat”. A few examples of Non-humanoid robots are “cozmo” and “Jibo”.

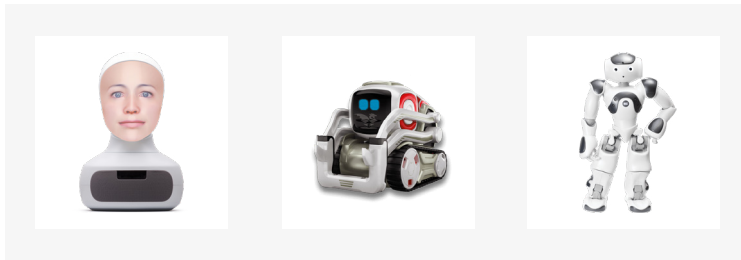


Figure 1: Furhat, Cozmo and Nao robot.

Due to their co-presence, it is easier to converse with Social Robots. It is possible to make use of both verbal and non-verbal signals to emulate human interactions on a Social Robot which facilitates seemingly natural conversations with Social Robots.

# Advantages of having Social Robots

We have seen how better platforms were developed to overcome the limitation of the old interfaces. Social Robots have been designed to address all those limitations and seem to have an advantage over other platforms when it comes to holding natural conversations with humans. However, there are other advantages that make Social Robots a better option as compared to Chatbots, Avatars and Voice Assistants.

We have discussed how a physically embodied robot can be a better platform for conversational interfaces than the rest. A key aspect to establish this claim more concretely is to evaluate the **preference** of the users (humans) when it comes to choosing a platform. Researchers have looked into **user preference** for Social Robots by contrasting them with other artificial agents. In one such study<sup>4</sup> Sandra Costa and Byung-Chull Bae explored the hypothesis *“is a physically embodied agent preferable to a virtual agent or a voice-only narration?”*. They observed the participant’s non-verbal behaviors and used a 7-point Likert Scale questionnaire to evaluate their hypothesis. Their results confirm that a physical robot was **preferred** over virtual agents. Fridin and Belokopytov<sup>5</sup> provide a list of previous studies that have investigated user preference for embodied robots as compared to virtual agents and report that *“Almost all of the reported results show preferable interaction and performance with an embodied robot than with its virtual agent”*

Results of Previous Studies on Embodied Robots and Their Virtual Agents

Publication	Subjects' Age (Year)	Sample Size (N)	Robot	Task	Results	
					Interaction	Performance
Shinozawa et al., 2005	18–50	178	Zoomorphic	Cognitive	U.S.: er > va Japan: er < va	U.S.: er > va Japan: er < va
Kidd & Breazeal, 2004	18–61	32	Humanoid-like head	Cognitive, manipulation	er > va	NA
Lee et al., 2006	UCLA students	82	Zoomorphic	Cognitive	er = va	NA
Tapus et al. 2009	> 70	32	Zoomorphic	Nonstructured	er > va	NA
Heerink et al., 2008b	elderly	9	Humanoid	Cognitive	er > va	er > va
Takeuchi et al., 2006	20–45	42	Zoomorphic	Cognitive	er > va	NA
Jung & Lee, 2004	Undergraduate students	31	Humanoid	Cognitive	er > va	NA
		36	Zoomorphic	Cognitive	Lonely people, er > va Nonlonely people, er > va	NA
Bartneck et al., 2004	56	16–57	Zoomorphic	Cognitive	NA	er > va
Pereira et al., 2008	8–12	5	Zoomorphic	Cognitive	er > va	er > va
	19–32	13	Zoomorphic	Cognitive	er > va	er > va
Woods et al., 2006	15	33	Nonhumanoid	Cognitive	er > va	NA
Wainer et al., 2006	11	NA	Nonhumanoid	Cognitive, manipulation	er > va	er = va

Note. er = embodied robot; va = virtual agent.

<sup>4</sup>Costa, S., Brunete, A., Bae, B. C., & Mavridis, N. (2018). Emotional storytelling using virtual and robotic agents. *International Journal of Humanoid Robotics*, 15(03), 1850006.

<sup>5</sup>Fridin, M., & Belokopytov, M. (2014). Embodied robot versus virtual agent: Involvement of preschool children in motor task performance. *International Journal of Human-Computer Interaction*, 30(6), 459-469.



In another study<sup>6</sup>, Sebastian Schneider and Franz Kummert tested if physically embodied robots had any effect on the **motivation** of a human being. the hypothesis “*A robot companion enhances a human’s motivation to persist on an exercise compared to a virtual partner*”. They used a NAO robot to perform plank exercises (see figure 2 below) together with the human partner and compared it to different combinations such as human partner with a video and human partner with a 3D graphical character. They found out “*that the human participants paired with a co-located RC (Robot Companion) are more **motivated** to exercise longer than with a telepresent or virtual representation of the partner*”.

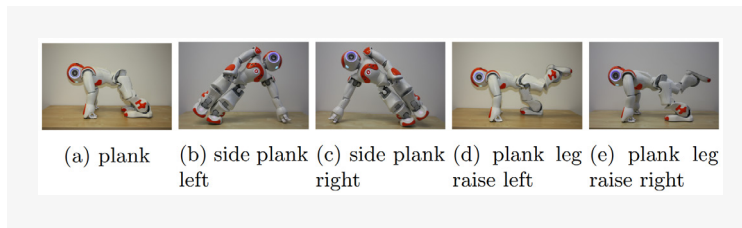


Figure 2: Various plank positions performed by NAO robot. Image Source (6)

Another key dimension that needs to be looked into when considering Social Robots is **trust**. With Social Robots that are able to perform many tasks for the user starting with managing daily schedules to recommending restaurants, the user’s trust on the robot determines how seamless and effective a conversation between the user and a robot can be. Let us consider a simple example where Furhat (a Social Robot) is recommending a good restaurant for sushi to the user. If the user trusts Furhat, it is likely that the user will consider going to the restaurant. However, if the user is unable to trust Furhat, then the recommendation scenario will never work. This is also the case with Human-Human Interactions (HHI), where we consider the recommendations from the people that we trust as compared to the people we do not.

There have been many researchers who have focused on studying the impact of having a physically embodied Social Robot on the **user’s trust**. A study<sup>7</sup> by Erwin Marsi and team investigated the user preference for expressing uncertainty and found that users preferred uncertainty expressed using non-verbal cues over spoken/ linguistic means. This in turn can be applied to Social Robots and they are capable of performing these non-verbal cues as compared to the other conversational interfaces available. Another study<sup>8</sup> by Ye Pan and Anthony Steed compared the user’s **trust** in Avatar, Video and Robot

<sup>6</sup> Schneider, S., & Kummert, F. (2018, November). Comparing the effects of social robots and virtual agents on exercising motivation. In International Conference on Social Robotics (pp. 451-461). Springer, Cham.

<sup>7</sup> Marsi, E., & Van Rooden, F. (2007, January). Expressing uncertainty with a talking head in a multimodal question-answering system. In MOG 2007 Workshop on Multimodal Output Generation (p. 105).

<sup>8</sup> Pan, Y., & Steed, A. (2016). A comparison of avatar-, video-, and robot-mediated interaction on users’ trust in expertise. *Frontiers in Robotics and AI*, 3, 12.

mediated interactions and found that when making trust assessments the physical presence of the robots makes them **more trustworthy** as compared to Avatars.

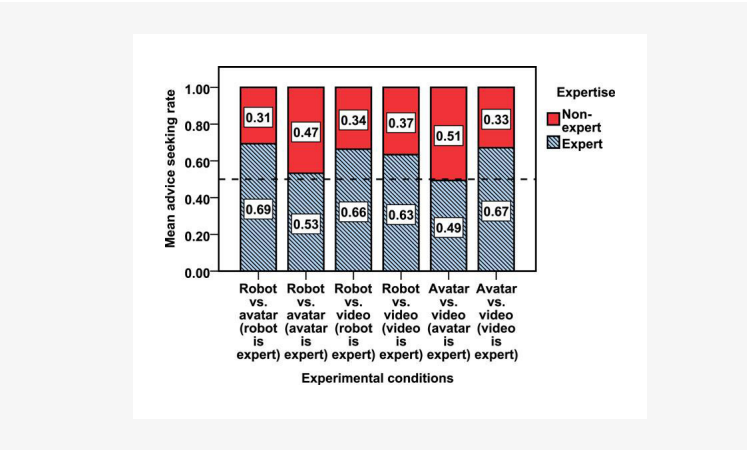


Figure 3: Chart showing how users seek advice from experts based on the scenarios [Image Source]

Other than the advantages listed above, Social Robots also come with many practical applications that would not be possible with virtual agents, Avatars or Chatbots. For example, it is possible to use Social Robots to do medical screening at clinics or hospitals where there is shortage of staff. They can record personal data and symptoms of the patients and then direct him/her to the nurse or doctor who is free. Social Robots could also be used to help children with autism as they find robots less intimidating as compared to humans. Social Robots like Furhat that have a human face can be of immense help in teaching the children social skills and getting acclimatized to interacting with humans.



## Summary

While Chatbots, Avatars and Voice Assistants each have their advantages, Social Robots can be seen as a platform that integrates all the features from these systems into one. Interacting with Social Robots is easier and more natural because of co-presence and access to both verbal and non-verbal dimensions of conversations. However, the field is still at a growing stage and needs a lot of work before Social Robots can actually perform the role of a social entity.



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