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# Meeting with social robots like the cat-cucumber meeting? An integrated model of human-robot first contact. Psychological perspective.

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**Abstract:** People contacts with social robots, especially humanoid ones, are still rare. The vastness of research shows that we have cognitive relationships. Based on the studies in the field of social psychology, we propose an integrated theoretical model of developing cognitive category "social robot" and the mental model as a result of contact with the robot. We are discussing the consequences of this process, both social and personal, such as cognitive conflicts, unmet expectations and disappointments.

**Keywords:** human-robot interaction, social robotics, social categories, robot perception

## 1 Introduction

In relations with machines, people sometimes use analogous perceptual principles that apply to people. Such assumptions underlie the concept developed by Nass and his colleagues [1] of the CASA paradigm – Computers-Are-Social-Actors and formulated a little later, the Media Equation Theory which assumes that people tend to react automatically to the media and computers as for real human beings. Thus we attribute to those machines different competences of personality traits, we use gender stereotypes or ethnic origin, and we behave in the same way as in relation to people [2, 3].

It seems that these rules also apply to robots. For most people, contact with this type of machine is a completely new experience, their knowledge of the behavior of the robot, function or communication with it comes from the western pop culture, from media science fiction movies, myths and novels [4–6]. Also laboratory tests carried out around the world using robots are probably the first contact with such machines for most participants. So we're just learning how to interact with them, our attitudes are just emerging.

Social robots, belonging to category of assistive robots, however, are entering our lives extensively. They find enormous use in the area of health, in the care of the elderly, in education therapy, in the work environment and at home [7]. They are able to cooperate with people using natural language, they are able to interact with people in a way similar to human level, but also with other robots and their environment, respecting existing social and cultural norms [8]. Robots cooperating with a human are equipped with typically human gestures, looks, emotions, behaviors [9]. Especially when they have a "face" with a nose, mouth or eyebrows, we attribute human characteristics to them [10], anthropomorphize them ascribing the ability to think rationally and to feel conscious [11–13]. This is an extremely strong tendency that manifests itself in the fact that even abstract geometrical shapes of the properties of living objects [14]. Perhaps cognitive operations consisting of giving human characteristics to machines allow us to tame them, make them more familiar to us [15] or predictable [16–18].

And it turns out that both adults and children are doing so. Observations show that children treat AIBO robot-dog in a social way, as if he lived almost like a real dog [19]. Other studies using Robovie robot show that children perceived him as if they had mental states (feelings) and he was a social being who has his rights.

Robots change our thinking about social relations, cooperation with them requires a different language of description than in the case of people, because one side only simulates different emotional or cognitive states, and therefore the interaction is asymmetrical [20]. Researchers conclude that social robots are as a special class of entity [21], something like a different species [22] and may in the future be a unique ontological category [18]. Others convincing that for effective communication with robots,

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human features such as the face or human voice are not necessary at all [23]. The basis of communication can be certain movement that we give meaning [24].

It seems that due to the lack of experience, people do not have a separate, specific cognitive category, which would contain information about how the interaction with the robot proceeds, what to expect, how to behave in relation to them. This mental image is just forging. We still do not know how we should establish mutual relations with robots [25]. However, the nature of interaction with them on the basis of social cognition has not yet been determined: there is a discussion whether the robot should be treated as a friend, assistant or butler [26]. Human's task will be to locate "robots" in the cognitive and social system of intelligent machines.

The concept of script theory assumes that people learn how to deal with everyday situations, build mental images of how specific interactions occur, what are the norms to be able to operate efficiently in the world, understand it better, plan their behavior and feel safe [27]. In case of interaction with robots, we do not have a proper script, we do not know how to communicate with them, what to expect, we use the one that is available to us cognitively – i.e. "human-to-human interaction script" [28]. The mere announcement that a robot encounter awaits us may evoke feelings of uncertainty, the expectation of lesser liking, and less social presence (compared to the expected interaction with humans) [29, 30].

Human Robotics Interaction (HRI) is an interdisciplinary field that is defined as "field of study dedicated to understanding, designing, and evaluating robotic systems for use by or with humans" [31]. Despite the fact that this discipline is relatively young, it has received many studies, models and theoretical approaches [32]. There is also a rich literature on the prototyping of interaction with the robot and user experiences developed by engineers and designers [33, 34]. It seems, however, that there is no theoretical model describing the first contact with a social robot from a psychological point of view.

This article aims to fill this gap. It is an attempt to integrate a series of research and theoretical approaches in the field of HRI, social psychology and social cognition and to include them in the theoretical model, which we have named – *An Integrated Model of Human-Robot First Contact*. It will be presented in the final part of the article.

## 2 First contact with the robot

In contact with the robot, a "novelty effects" appears, which entails the cognitive and behavioral need for "search for meaning" [21]. In the course of evolution, we have developed the ability to quickly recognize other people [35], quickly assessing who is a friend and the enemy [36]. Based on the appearance of the object that is in front of us, and especially its face, we can quickly identify it as a robot, not a human being [37–39]. Very specialized facial detectors help us in this identification, thanks to which the face is one of the most recognizable shapes [40]. It communicates identity, emotions and intentions [41], as well as the animacy of the object [42]. But does this mean that we do not use human cognitive categories in the further perception and analysis of the object?

Theoretically, people do not have the mechanism of emotional reaction to inanimate objects [43]. However, physical objects can cause specific associations (with people or situations) and cause emotional reactions. This is related to the phenomenon of face pareidolia, that is seeing known shapes in random details. We share this ability with other species [44].

At the first contact with another being, it is important for us to categorize observed emotions very quickly [28]. Meta-analysis of studies [45] shows that although the accuracy of robotic facial expression is reduced compared to human expressions, there is generally no clear difference between the brain's reaction to facial expression made by a robot, human or virtual agent, also bodily manifestations of emotions are clearly recognized by human observers. What's more, a number of data suggests feelings of empathy towards the robot [45]. Research using neuroimaging revealed that when people observe the emotional expression of facial mimics (*e.g.* happiness, disgust, anger) in the performance of a humanoid robot, no differences in brain activity were observed [46, 47]. In one experiment, participants observed a human interacting with another human or humanoid robot. Some small differences in human brain activity has been shown when studied people was observing Human-Human and Human-Robot interactions [48].

In turn, robots, as it is assumed, do not feel emotions, but are equipped with rich external mimic expression suggesting their experiencing. Although people are aware of this, at the linguistic level, they define these reactions as if they correspond to real mental states – we say, for example, the "robot laughs", "is surprised", etc. [11]. Describing the elements of the robot's structure as a part of the body ("face", "eyes", "legs"), which we also use with impunity in this article, also seems to be a semantic falsehood. These categories of description undoubtedly increase the level of anthropomorphisation of the robot from the first contact with it. As it turns out, it is enough to give the robot a name or determine its gender, and people start to trust them more [13]. In addition, when the robot becomes responsive, empathic, able to identify users and call for the name, it is rated highly [49–51]. The *mind perception* which is understood as the assigning the ability to experience consciously and act intentionally, appears very quickly in human-robot interaction [52, 53]. These are automatic processes that activate social areas in our brain [54] and trigger a number of consequences related to the social perception, such as a sense of similarity, understanding or attribution processes [18].

As in the case of people, in the first step the observer formulates the first impression in contact with the robot [55]. It should be noted that for a humanoid robot, the point of reference will almost always be a real human being. In addition, people have a much richer knowledge about people compared to other objects, especially new to them as robots (though to similar people) [56]. Therefore, one can expect the activation of this (human) cognitive category. Thus, in the case of the perception of humanoid objects, two cognitive categories can be activated: machine and human, as *Categorical Perception Hypothesis* [57] says.

## 3 Assigning specific features to robots and forming expectations in relation to the robot

Robots in social perception are not only anthropomorphized, but people also attribute to them the socialness [58], recognizing them as social agents acting in relations with others, and being members of social groups. The sense of social presence when interacting with a social robot leads to higher enjoyment and his acceptance [59].

If so, they are also subject to the processes of social categorization. The theory of social categorization assumes that people have limited cognitive abilities and resources and that in order to save them they have to group on the basis of various attributes and functions – gender, age or ethnicity. Qualifying a given person into an in-group or out-group group results in biased perception, attitudes and behaviors [60–62].

Categorization allows us to better operate in social situations – to maintain coherence and order in the process of perceiving people, objects or events [63]. For example, the category "dogs" allows us to easily assign animals on the street to this category, and at the same time easily recall information gathered about a given category. Thanks to this, you do not have to learn each object anew. In this way, also gaps filled up in knowledge about a given object, generating an additional portion of knowledge from the description of the category to which we assigned the object. The effect of categorization is the tendency to perceive intercategorical differences stronger than they actually are and to perceive smaller differences between objects within a given category. By categorizing the world becomes for us simpler, more predictable and thus safer [60].

It has been empirically proven that people categorize robots in accordance with the aforementioned concept, including the phenomenon of favoring their own group [64]. On the basis of data about the place of production, people assign robots "nationality" and based on that assess their state of knowledge [65, 66]. In an experiment [12], German and Turkish students were asked to evaluate a robot. Information about the origin of the robot was manipulated (Turkey, Germany), according to hypotheses the robot was assessed by both groups with a bias – the robot representing its own group (*in-group*) was rated higher on the dimensions of heat, mind, closeness, contact or design than belonging to the other group (*out-group)*.

The behavior of the robot, its robotic appearance or tone of voice indicating a specific gender influenced its assessments consistent with the stereotype of roles occurring among people [67–73]. For example, a robot as a short-haired man was seen as more agentic than the long-haired female robot. In turn, the Robot-Woman was also seen as more communal than the male equivalent. In addition, stereotypically male tasks were perceived as more suited to the male robot and vice versa [64]. In one experiment [71] it turned out that the participants preferred the robot to various tasks according to the stereotypical gender roles that matched it. A robot with a male name and voice was preferred to safety roles, while the same robot with the female name was preferred in health care. Another research showed that people are more empathetic with human-like robots than with mechanical-like [74].

The appearance of robots causes assigning them different levels of humanness and familiarity [75, 76]. Physical attributes, especially the face, also determine the attributing of animacy and intelligence to the robot and attract the user's attention [77]. Robot Peoplebot used in health care, when it had a distinctive human face, was seen as more alive, human, sociable and sympathetic than when it had a silver face or had no face at all [78].

Even simulating simple emotions in the zoomorphicrobot iCat such as joy or fear caused the robot to attribute the characteristics of the human personality, compared to the conditions of performing neutral behavioral reactions such as nodding or maintaining eye contact [79]. As in the case of humans, we prefer sympathetic and intelligent robots from less pleasant and less intelligent – in one experiment the subjects hesitated three times longer before they turned off the nice and intelligent robot in comparison with the unworthy and unintelligent robot [80]. It was also noticed that robots with the appearance of the machine are treated less politely than humanoids [81].

Human expectations of robots in terms of functionality are often [82], probably because they are a derivative of their appearance [83–85]. We expect human mental states and competences from humanoid robots as the holders of a human-like body [86, 87]. The sight of a human body with head and limbs can trigger the expectation that the android will operate them efficiently, and since it has eyes, its "visual ability" is equal to human abilities. Therefore, this type of inference can quickly evoke a feeling of disappointment [88]. Children who met the interactive robot humanoid Robovie built high expectations towards him and quickly lost interest in him when they experienced disappointment [89]. The predominance of machine-like robots observed in some studies, higher trust and satisfaction from cooperation with them [90, 91] may result from the fact that the user does not compare constantly to humans, not excessive expectations and may in his assessment focus on its functionality.

In turn, from less similar to people, we expect less cognitive similarity to people [92]. For example, the advanced autonomous vacuum cleaner iRobot Roomba is rarely identified by its users as a social being with personality [93].

## 4 Cognitive and emotional reactions under the influence of interaction with the robot

Sometimes, in the process of categorizing various stimuli, we fall into a cognitive conflict. An example is the classic *Stroop effect* [94]. It turns out, in the case of a simple task which is to determine the color of the text, when there is a discrepancy between the text color and its content (e.g. the word "red" painted in green color) man performs the task more slowly and with a higher probability of error than if the text and its color were compatible. In relation to people, for example, a feeling that accompanies us when we look at the face of a person with facial hair with a generally very feminine appearance (*vide* Austrian singer Conchita Wurst). It seems that two cognitive categories are activated: a woman and a man.

Similarly, it may be in the case of a contact with a robot. Certain signals from him indicate human characteristics, and others - on the features of the machine [95–97].

According to the above-mentioned *Categorical Perception Hypothesis*, people may then fall into a cognitive conflict that involves the problem of cognitive classification of stimuli. Therefore, the hypothesis of perceptual categorization seems to explain very well the effect of the Uncanny Valley, i.e. the similarity of a man to an agent is not linearly related to his liking, because there is a clear decrease around 70% similarity to human traits [57]. Similarly claims Moore [98] based on the Bayesian model of categorical perception. In his opinion, stimuli containing contradictory signals can trigger perceptual tension at the borders of two activated categories. So it can translate into unpleasant emotional feelings after interacting with the robot.

Looking at a humanoid robot, the brain can make a prediction error when it sees an object that appears human but is not human and cannot be able to match human motility, emotional expression and body. It is enough for the robot to move, a short interaction with him, to feel communicative mismatching, incomprehension and then unmet expectations and disappointments [99, 100]. Thus, the sight of the robot activates us, raises expectations of certain specific movements, but in the absence of them can cause discomfort [101]. In one study, the robot working at the reception (Valerie) was disappointing when it communicated in a monologue mode, because people apparently expected dialogue, as well as more advanced functions in interaction with humans [99]. Failure to meet expectations becomes a frequent reason for abandoning the use of robots at home [102] which is a challenge for the designers of these devices.

It turns out, however, that sometimes a robot can positively surprise us and not necessarily due to some sophisticated functions and even show some weaknesses. In one experiment it was shown that we were more sympathetic to a robot that made a mistake than the one that was unmistakable in interaction – which confirms the *pratfall effect* found in social perception [103]. In turn, in other studies, when the robot "cheated" was attributed to him human mental states [104], more often he was referred to interpersonal relationships, maintaining eye contact and using personal pronouns addressing him [105]. Research shows that, if a robot within interaction is perceived as being knowledgeable and being sociable, it mediated the impact of robot physical appearance and whether individuals took the robot's advice [106].

Research also revealed that the programmed personality traits of robots are perceived in a social context. The introverted robot was perceived as more intelligent in a group interaction, but the extraverted robot was perceived as more intelligent in a dyadic interaction [107]. So, definitely we treat robots as social agents.

## 5 Summary of analysis: An integrated model of human-robot first contact

Taking into account the data presented above, we propose a general model that describes the typical course of the first contact between humans and the robot (Figure 1).

It seems that people do not have much difficulty in quickly realizing that they are dealing with a robot, but this state is accompanied by the effects of novelty and cognitive understanding. Therefore, it can be assumed that in the next step, based on observational data, people quickly, almost automatically activate ready-made cognitive categories and run scripts of behavior in a given situation. What will be the category – it all depends on factors such as appearance, behavior, voice or the name of the robot. People will react completely different to seeing the robot RobuLAB (Figure 2d), and differently to the android Nexi (Figure 2e), and differently to the deludedly resembling human Geminod F (Figure 2f) [108], therefore there will be launched other anthropomorphization processes and social presence perceptions, different features will be assigned additionally the machine, other processes of perception activated, other types of social categorization used, and the expectations for the robot with certain visual features will also be different – as mentioned above, robots with a very similar appearance to a human require similar intelligence and similar contact quality as in the case of people Therefore, even during the encounter with the robot, but especially at the end, a feeling of disappointment may arise. Raised expectations often do not correspond to practical experience. Of course, if the expectations were not too high – the observer experiences satisfaction or even a positive feeling with According to our model, the cognitive effect of the meeting is to acquire knowledge to build a mental robot model. It also gives you the opportunity to build the germ of the social category "robot" where the key features of this category are stored, in addition, the interaction allows the participant to construct a preliminary communication script with the robot, which will be launched on the next occasion.

## 6 Discussion

The model presented above is of an integrated nature, probably requires empirical verification in this form, but we hope that it will help thinking about the coexistence of people with intelligent machines and considerations on this subject. It is of course very general and applies to the currently typical situations when someone has no knowledge or experience of interacting with the robot.

A lot depends on the interaction with the robot: how much it suits the user, how well it is programmed. Human-robot cooperation can be better or worse, which determines further behavior. For example – people have less resistance before turning off the robot (when it refuses) when it behaves more like a machine than a human [109] or it is also non agreeable and unintelligent [80]. Also the content and intensity of emotions can change in interaction with the robot [110–112].

So, as in the case of people, top-down processes are accompanied by parallel down-top processes. Perceived intelligence, perceived safety, animacy, anthropomorphism, likeability, can all be modified depending on the course of the interaction and the entire context [112]. However, we did not analyze here role of personality [113–115], gender [116, 117] or cultural factors [118, 119] in the perception of robots.

Probably in the future our model will lose on topicality when humans will be in constant contact with social robots: at home, at work and at school. As research shows, if someone has already met with robots, he trusts those machines more and rates them more positively [120]. Perhaps this is the proof of building the mentioned interaction script and the model of a mental robot. But it can also be associated with the exposure effect known in social psychology [121].

Undoubtedly, the appearance of a humanoid robot launches a whole range of cognitive and emotional reactions, which are activated automatically in contact with a human being. In addition to the aforementioned categorization or stereotyping, we should mention, for example, the fundamental attribution error, correspondence bias or halo effect [122]. The lack of discussion of these effects in the description of the model results from the lack of research on this subject in the area of HRI. That should be pointed out as an important direction for further empirical verification. It should be noted, however, that the ap-

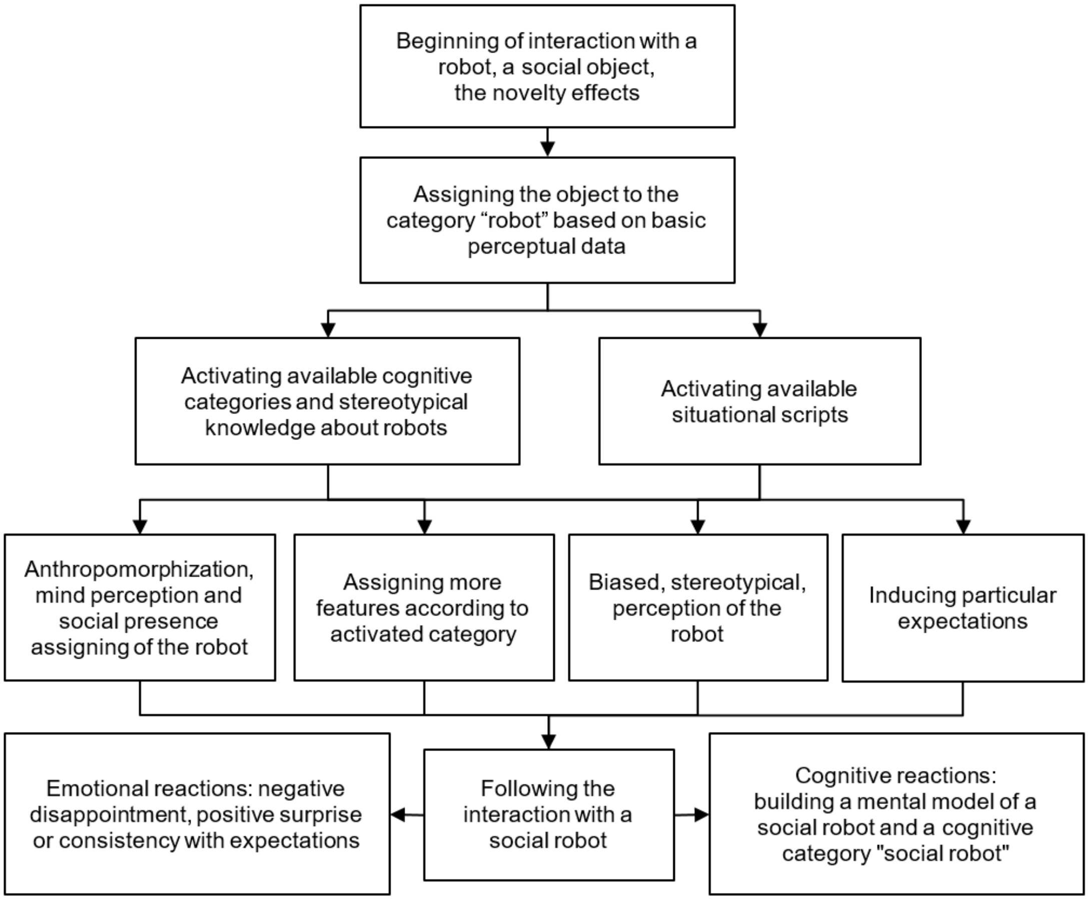


**Figure 1:** An integrated model of human-robot first contact.

pearance of robots in the production process is the least demanding element, the easiest in the whole construction to achieve. Unfortunately, however, the functionality of the entire robot is usually still imperfect so the aforementioned feelings of disappointment and missing the expectations will accompany us probably for a long time. The actual human-robot interaction, its naturalness, smoothness, flexibility, responsiveness of the robot, seems to play a crucial role in how people are satisfied with a robot as a social agent and what social category will they assign to it.

We made also several own observations while working on prototype of social robot (KODI – a prototype of social robot for children with emotional expression, Figure 2c) and working in groups with other social agents (e.g. Amazon Alexa). We observed several behavioral and functional factors that drives the change in human perception of robot, especially inducing a disappointment. Poor speech abilities: Significant latency of response of an agent (robot) with speech interface for a voice command/query from the user; poor Automatic Speech Recognition (ASR) component. Human users show frustration whenever they notice that agent doesn’t understands what they say correctly (especially when they believe conditions are good enough that other human beings would not have trouble understanding speech); Inability to interrupt while agent is responding. This is a clear indicator for human users that robot can not track conversational context in real time; Speaking without emotions for any longer phrase. Human users starts showing disappointment when robot can not support emotionally the conversation. Poor mobility and movements: Significant lack of precision, glitching, stepping, visible in robot movements raises immediate disappointment in human users during interaction. Lack of variability in spoken or shown responses: When robot keeps saying the same response to given stimuli (as well as communicating error in understanding the input) human users identify this as rigid preprogrammed behavior and thus as expression as clear lack of intelligence.

Out own observations confirm also findings in the aforementioned research how interaction, even misguided and unintentional, is leveraging user perception and con-

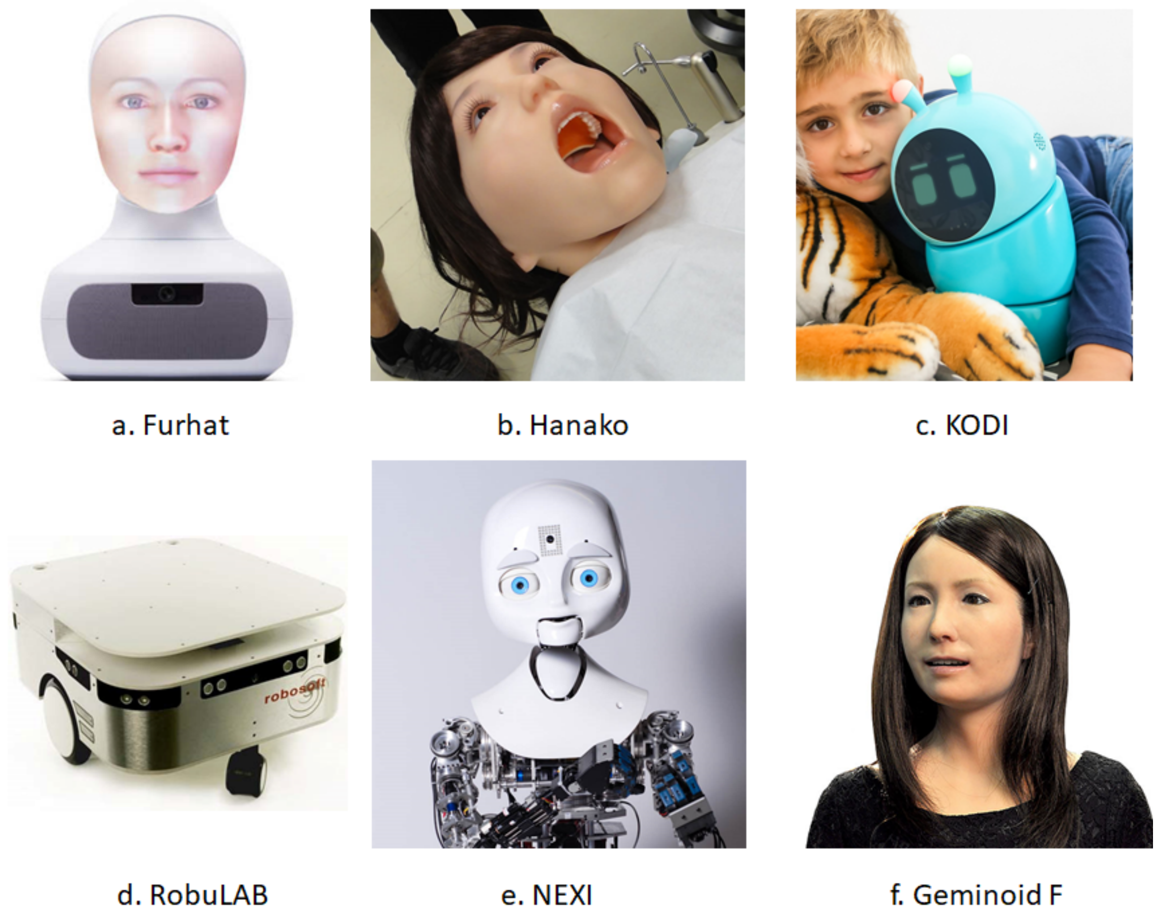


**Figure 2:** Social robots examples: a. Furhat, b. Hanako, c. KODI, d. RobuLAB, e. NEXI, f. Geminoid F.

tributes to overall satisfaction. When robot did not precisely follow human user's command but still reacted instantly showing variability in movements, reactions and spoken text, user tend to show satisfaction and claiming the robot is “smart” and “capricious”.

At the same time, the coexistence of people with humanoid robots can already cause quite a stir in the system of the human cognitive system. In front of our eyes, however, an important category is born, which so far has no established place in social perception. A typical family in most countries of the world are parents with children and some smaller or larger pets. So where is the place in the human mind for home robots?

Despite the extensive research, however, we still do not know what from the point of view of social cognition what a human encounter with a humanoid robot really is: is it a kind of encounter with a man from another culture or maybe an animal or a child or a toy. Or maybe it is something like the cat-cucumber meetings known from the Internet, which often reacts with strong fear because it probably mistakenly categorizes green cucumber as a snake.

There is still no agreement as to what the direction of robotics development should be from the social and psychological point of view. Robert Sparrow [123] claims that creating robots that accompany people is erroneous and unethical. Sherry Turkle [124] also considers social robots as "relational artifacts", developing relationships with them can lead to misunderstandings about the authenticity of this interaction [124]. The robot "pretends" through various programmed reactions that it understands something and experiences it, we in turn pretend that we are dealing with a thinking machine. We begin to function in a falsified reality.

Nevertheless, the most common direction for improving social robots is to simulate human psychological behaviors and processes [125]. We do it probably from the need to ensure comfort and communication convenience – by designing on our machine similarity we do not need to learn how to use them because we know human behavioral patterns. But it must also be noted that man is inherently imperfect – he is guided by various simplifications, stereotypes and emotions (the best proof for having these weaknesses are the research on robot perception described above). At the same time, we ourselves expect from the robots reliability, not having any prejudices or stereotypes, some kind of justice, peace, perseverance or unconditional patience [126]. These motivations seem contradictory: robots are to remind us very much, but at the same time significantly different from us.

According to the new ethorobotics approach [127], we should remain separate in relation to the machines we design. Instead of seeking to build social robots similar to people, we should rather focus on building a new category of device that is able to interact, but keep in a particular niche and maximize its level of performance. Making robot robots look human is therefore a trap that is better to avoid now.

Of course, superhumanidality seems to be fully justified and desirable in the case of training or training where under safe controlled conditions you can practice something on the robot before it goes into impact on people. An example of this is the Showa Hanako 2 dental surgery robot (Figure 2b) built at the Showa University in Tokyo. This robot not only looks a lot like a human being – it also faithfully reproduces the behavior of a real patient, his reflexes, physiological, motor and emotional reactions. Another example is the Furhat robot (Figure 2a) constructed in Sweden, which allows you to display various human faces on the body resembling a manikin. This solution enables, among others conducting exercises on it, eg in the field of customer service, communication, assertiveness, negotiations, etc.

Perhaps the problem of categorizing robots, determining their status and place in our society is responsible for the phenomenon of robophobia or the irrational fear of robots [128]. This phenomenon may increase in the coming years, unless we resolve a number of dilemmas and problems outlined in this article.

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