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Robo Sapiens Bankerius: An Ideally Designed Humanoid Banking Service Robot?

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Autonomous intelligent robots are playing an increasingly prominent role in the banking sector. The acceptance and perception of these robots as social actors depends on various factors. Through the process of anthropomorphisation, people attribute human-like characteristics, behavioural patterns or intentions to robots. This essay explores the anthropomorphisation of banking robots and examines the interactions between key robot features: social skills, functionality and appearance. It presents the theoretical concept of an ideally designed "Robo Sapiens Bankerius". A questionnaire-based survey involving 26 robots which focused on the evaluation of the anthropomorphic appearance of banking robots was conducted between 2023 and March 2025: it found that majority of respondents preferred less human-like robots. Age, gender, concerns and attitudes showed no significant correlation with the choice of robot. The analysis of the open-ended responses revealed trade-offs between robots' social capabilities, functionality, and appearance. These findings point to new directions for research and provide an opportunity to compare the results with international literature.

Journal of Economic Literature (JEL) codes: O3, G21, L62

Keywords: anthropomorphisation, humanoid banking service robots, human-robot interaction, dehumanisation

1. Introduction

The integration of autonomous, intelligent robots into the current civilisational and economic system may result in a paradigm shift (*Ivanov 2017*), facilitating the emergence of a society where humans and robots coexist (*Amelia et al. 2022*). This trend is particularly evident in companies undergoing digital transformation. As we move from the Industry 4.0 framework toward the Industry 5.0 ecosystem, robots are playing an increasingly prominent role through disruptive innovation

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(*IFR 2024*). Artificial intelligence (AI) and AI-based robots are also revolutionising the financial system. Banking customers are already experiencing the integration of physically embodied robots (*IFR 2016; Song – Kim 2022; Prisznyák 2023*) as well as software robots into banking processes (*Jung et al. 2018; Diener – Špaček 2021; Jovanović et al. 2019; Abraham et al. 2019; Prisznyák 2022, 2023, 2024*). Virtual robots, such as Erica (Bank of America), Amy (HSBC), Aida (Skandinaviska Enskilda Banken), Eno (Capital Bank), Ally Assist (Ally Bank), Haro and Dori (Hang Seng Bank), Ceba (Commonwealth Bank of Australia), Sia (State Bank of India), Eva (HDFC) and iPal (ICICI Bank), are employed in various front-, middle-, and back-office processes within banks. These robots perform tasks at varying levels of autonomy, contributing to the reallocation of employee time toward higher value-added processes and enhancing efficiency (*Richert et al. 2018; Damiano – Dumouchel 2018; Jovanović et al. 2019*). At the same time, humanoid robots such as NAO (Mitsubishi UFJ Financial Group), Pepper (HSBC, Mizuho Bank, Rabobank, Capital Bank of Jordan, Emirates NBD, Leumi Group, DSK Bank), Lakshmi (Citi Union Bank), Pari (Nepal SBI Bank), Sberbasha (Sberbank), Promobot (Sberbank), Link 237 (Banco Bradesco, Brazil) and OPBA (Nam A Bank) have been deployed in bank branches worldwide (*Prisznyák 2023*). As part of their robot integration strategies, major banking institutions – such as China Construction Bank and Bank of America – are rationalising their branch networks, placing greater emphasis on the development of robotic branches operated by intelligent robots without human tellers (*McLannahan 2017; Roxburgh 2018*).

The design of robots is becoming increasingly sophisticated, determined primarily by their appearance, functionality (*Baraka et al. 2020*) and social interaction capabilities (*Galanxhi – Nah 2007; Cornelius – Leidner 2021*). Human-centred robotics (social robotics) aims to develop artificial agents that possess human-like traits and capabilities (*Sarrica et al. 2019*). Due to the phenomenon of "robot labelling"[1] the term "robot" can refer to agents of different natures (physical and virtual) (*Prisznyák 2025*). Despite these varying forms, such agents are capable of displaying human-like physical and behavioural features – such as body structure, movement, facial expressions, gender traits and communication patterns – which significantly influence user perception and interaction (*Mara – Appel 2015; Złotowski et al. 2015b; Abel et al. 2024*). The social integration – and public perception – of these robots is significantly supported by their ability to respond to social stimuli originating from human counterparts (*Chang – Kim 2022; Wiese et al. 2017; Wykowska et al. 2016; Arora et al. 2024; Castro-González et al. 2016*). In other words, the social skills demonstrated by robots may make it possible for them

[1] The phenomenon of robot labeling encompasses various interpretations of the term "robot", including robotic process automation (RPA), artificial intelligence, machine learning (ML), deep learning, robotic assistants, intelligent chatbots, and physical robots (*Prisznyák 2025*). Thus, the term "robot" refers to both physical and digital forms, despite their fundamental differences in the technologies applied, their modes of operation, and their potential uses.

to be perceived as (social) living beings (*Breazeal 2003; Fong et al. 2003; Richert et al. 2018; Damiano – Dumouchel 2018; Gambino et al. 2020*).

Anthropomorphism is a cognitive response in which people attribute human-like characteristics to inanimate objects and living beings (*Duffy 2003; Złotowski et al. 2015a; Urquiza-Haas – Kotrschal 2015; Fischer 2021*). The impressions formed when perceiving robots with anthropomorphic features (*Mori 1970; Fink 2012; Burleigh et al. 2013; Dacey 2017; Appel et al. 2020*) can contribute to their acceptance by humans as social agents – that is, as socially active entities similar to humans (*Wiese et al. 2017*). However, anthropomorphisation does not automatically guarantee the successful outcome of human-robot interaction (HRI) (*Fox – Gambino 2021*). When designing robots, it is advisable to consider findings from psychological research on anthropomorphism. Incorporating these insights into the design of a robot's physical appearance helps foster trust, a sense of closeness, and acceptance toward robots – even among young children (*Heerink 2011; Breazeal et al. 2016; Blut et al. 2021; van Straten et al. 2023*). Nonetheless, striking the right balance between anthropomorphic and dehumanised[2] design elements remains a challenge.

Despite the increasing spread of intelligent robots, the literature focusing on the banking sector mainly addresses software robots (e.g. RPA, robotic assistants, robo-advisors), with only a few publications examining the appearance of embodied banking robots.[3] In their study of retail banking robot acceptance, *Amelia at al.* (*2022*) identified 16 dimensions (e.g. usefulness, social interactions, data privacy risks, prior experiences, among others) that influence users' acceptance of robots. *Prisznyák* (*2023*) examined the range of service robots used in bank branches, while *Prisznyák* (*2025*) addressed the operational risk management challenges related to the phenomenon of robot labelling. The current niche-focused essay aims to develop a theoretical foundation for the concept of an ideal banking service robot (Robo Sapiens Bankerius), based on a synthesis of the most important scientific theories on the anthropomorphisation of service robots (*Section 2*) and empirical findings based on primary research (*Sections 3–5*). The results of a questionnaire-based study conducted between 2023 and March 2025 (n=257) (*Section 4*) help identify the functional, appearance-related, social dimensions and moderators[4] that influence preferred robot characteristics, as well as the trade-offs between them (*Section 5*). Based on these findings, the study proposes a robot design aligned with the evolving ideal image (*Section 6*).

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[2] Dehumanisation involves the minimisation of human-like or life-like characteristics.
[3] In this essay, we consider embodied banking robots as autonomous and adaptive machines that interact with, communicate with and provide services to clients of financial institutions.
[4] In this text, the term "moderator" refers to factors external to the robot that influence the perception of the robot's anthropomorphism. Such moderating factors may include the user's relationship to technology, cultural background, the social nature of the situation or the context of the interaction.

The following hypotheses are tested in this study:

- H1: Anthropomorphisation increases robot acceptance: the more human-like a robot is, the more favourable the impression it creates and the higher its acceptance level.
- H2: The preferred banking service robot has a human-like, playful appearance.
- H3: Age, gender and prior concerns or attitudes toward robots influence the preferred robot appearance.
- H4: Enhancing certain robot features does not necessarily increase acceptance or selection preference.

2. Anthropomorphisation of banking service robots

It is natural for humans to strive for order and understanding of natural phenomena, particularly in order to avoid unknown or inexplicable situations (*Gültekin 2022*). In doing so, people tend to attribute intentional attitudes to both living beings (humans, animals) and inanimate objects (*Duffy 2003; Złotowski et al. 2015; Gültekin 2022*). Humans are inclined to interpret the behaviour of other beings or systems as being driven by intentions – a tendency referred to by *Dennett* (*1971*) as the intentional stance, a cognitive strategy that operates even when the observed entity lacks actual consciousness. This is an inductive approach in which people assign human-like psychological states – such as desires, intentions and beliefs – as well as human traits to unfamiliar or inanimate objects, animals or other entities. These serve as reference points for interpreting the phenomenon or object (*Duffy 2003; Złotowski et al. 2015a, b; Spatola et al. 2022, 2023; Gültekin 2022*). Anthropomorphism functions as a fast, automatic cognitive mechanism (a heuristic) that can distort perception by responding to living and non-living things through human-pattern recognition (*Caporael – Heyes 1997; Dacey 2017; Fischer 2021*). As a result, objects that trigger anthropomorphisation – such as robots – can evoke either positive or negative human emotions (e.g. sympathy, empathy or aversion) (*Arora et al. 2024; Spatola et al. 2022*). Thus, anthropomorphism contributes to the formation of relationships between natural and artificial agents (*Breazeal et al. 2016*), or conversely, to the lack of social bonding (*Haslam 2022*).

Depending on the nature of the task, artificial humanoid agents may require physical embodiment. Their shapes and functions are often inspired by various living beings in order to increase their functional utility, positive perception and ultimately their acceptance (*Epley et al. 2007; Robertson 2017*). In interpretive anthropomorphism, emotions and intentions are attributed to non-human agents (*Fisher 1991*). For example, a robot assistant located in a bank's customer zone that avoids the area where clients are already being served and conversing with human staff may give the impression that it is deliberately focusing only on waiting customers. By contrast, imaginary anthropomorphism involves endowing an imagined character with human-like behavioural and cognitive patterns (*Urquiza-Haas – Kotrschal 2015*). The range of human characteristics attributed to social robots is extremely broad (*Fox – Gambino 2021; Arora et al. 2024*). For instance, in the case of a humanoid robot capable of facial expressions, customers may be prone to assign human emotions and traits to the robot based on its facial expressions and apply behavioural expectations accordingly (*Wykowska et al. 2016; Spatola et al. 2023*). These attributed characteristics may include the perception of intention in the robot's actions, leading people to interpret its voice, emotional expressions and written communication as indicators of its supposed "mental" states. However, this can lead to misunderstandings regarding the robot's behaviour, thinking and emotional capacity (*Dacey 2017*).

Culture has a fundamental impact on anthropomorphism (*Epley et al. 2007; Spatola et al. 2022*). Individual cognitive processes are shaped by norms acquired from one's environment, upbringing and experiences, which influence both social behaviour towards anthropomorphised objects and the way those objects are perceived (*Epley et al. 2007*). The perception of anthropomorphic robots varies due to individual differences (*Spatola et al. 2023*), as the psychological effects of anthropomorphism differ depending on personality type (*Richert et al. 2018*). At the same time, this process also depends on the personal responses of observers (*Spatola et al. 2023*). Before we can map out the characteristics that trigger anthropomorphisation in the design of banking robots, we must first ask the question: *What is a robot?*

The term robot originally refers to a programmed machine or physical agent that can take various embodied forms, operates at a certain level of autonomy and is capable of sensing (through sensors or cameras) and manipulating its environment (*ISO 2021*). Beyond this technical definition of robots in robotics, it is difficult to precisely define what qualifies as a robot (*Robertson 2017*). The phenomenon of robot labelling (*Prisznyák 2025*) further complicates this classification. Nevertheless, an intelligent social robot[5] must be capable of communicating with any person it interacts with (*Richert et al. 2018*). The design of robots plays a key role in the successful creation and maintenance of human-robot interaction (*Fox – Gambino 2021; Arora et al. 2024*), as well as in their integration into everyday life (*Arora et al. 2024*). The integration of robots into social contexts is supported when

[5] Robots that reproduce human behaviour, follow cultural norms, participate in social interactions and perform useful tasks (*Sarrica et al. 2019; Asprino et al. 2022; ISO 2023*).

organisational robot-integration strategies take interdisciplinary robot design aspects into account (*Robertson 2017; Coeckelbergh 2022; Prisznyák 2023*).

The external design of humanoid robots is increasingly approximating the natural forms of the human body (*Sugiyama – Vincent 2013*). In bank branches, robots can display varying degrees of anthropomorphic appearance – such as humanoid, android, gynoid or geminoid[6] forms (*Phillips et al. 2018; Prisznyák 2023*) – and these can elicit different responses from individuals depending on their psychological state and social-cognitive mechanisms related to unfamiliar experiences (*Duffy 2003; Złotowski et al. 2015a; Gültekin 2022*).

3. Dimensions of perceiving robots as social agents

According to the Computers Are Social Actors (CASA) theory by Nass, Steuer and Siminoff, when robots are designed with characteristics resembling human appearance, users tend to attribute human traits to them and apply rules of human interaction in their communication with the robots (*Nass et al. 1994*; *Reeves – Nass 1996; Nass – Moon 2000; Song – Kim 2022; Chuah – Yu 2021*).

In their three-factor SEEK model (Sociality, Effectance, Elicited Agent Knowledge), *Epley et al.* (*2007*) explain anthropomorphism as being driven by the following: (1) social motivation – the desire for human connection; (2) effectance motivation – the need to understand and control one's environment; and (3) elicited agent knowledge – the extent to which people use their knowledge and experience to interpret and evaluate non-human entities. However, the extensive body of literature on anthropomorphism does not yet offer full consensus on which factors specifically lead to the attribution of human traits to robots (*Blut et al. 2021; De Graaf – Allouch 2013*). There is still a lack of systematic understanding of which elements – beyond physical appearance – contribute to the perception of robots as social beings (*Phillips et al. 2018; Cornelius – Leidner 2021*). To support the design of Robo Sapiens Bankerius, the following overview is structured around three major categories – functionality, social skills and physical appearance – and summarises key findings from the literature.

[6] Humanoid robots imitate natural intelligence through cognitive processes (decision-making, perception, reasoning, problem-solving ability) and establish relationships with humans through their anthropomorphic features (*Arora et al. 2024*). In order for a robot to be classified as humanoid, it must have a body structure similar to human body parts (e.g. head, arms, fingers, torso, legs, eyes, etc.) and exhibit behaviour similar to that of humans (*Robertson 2017; ISO 2021*). If it resembles a male in terms of gender, it is called an android, while if it exhibits female traits, it is referred to as a gynoid. Another category is the geminoid, which is a highly realistic humanoid robot that closely resembles a specific individual in appearance (*Robertson 2017*).

3.1. Functionality

In terms of functionality, the design of human-robot interactions and the programming of social values are key elements of robot design (*Deng et al. 2019*). In the course of interacting with intelligent robots, users expect robots to behave similarly to humans and to deliver products or services of comparable quality. According to *Kim – Lee* (*2014*), consumer satisfaction is influenced by the robot's physical attributes (appearance, design), responsiveness (movement, expressions) and system quality (stable performance). Based on a survey of 237 drivers in Hong Kong, *Lee et al.* (*2018*) concluded that ease of use, trust and the quality of the output product/service significantly increase users' willingness to adopt robots through perceived usefulness. Robot functions – such as providing information, advice and guidance – play a crucial role in shaping users' perceptions and emotional responses (*Cornelius – Leidner 2021*).

According to an experiment with 254 participants by *Sah and Peng* (*2015*), anthropomorphic appearance decreases the sharing of personal data, while anthropomorphic language increases it, as the latter suggests a more intimate relationship. Supporting this, based on 175 questionnaire responses, *Araujo* (*2018*) found that chatbots possessing human-like characteristics have a stronger influence on consumer attitudes, satisfaction and emotional attachment. However, the more users anthropomorphise the robot, the more negatively they respond to its errors (*Choi et al. 2021*). Errors occurring during human-robot interactions, such as navigation problems, violations of social norms or performance failures, significantly impact users' perceptions of robots. These errors can lead to distrust and rejection (*Tian – Oviatt 2021*; *Cameron et al. 2021*). For example, in 2021, Japanese SoftBank Robotics announced the discontinuation of Pepper's production (*Nussey 2021*). Recent research suggests that the relationship between a robot's reliability and functionality also depends on the relationship between the user and the organisation deploying the robot (*Cameron et al. 2023*). In the case of errors, robots capable of autonomously correcting problems receive more favourable reception than those that only apologise (*Cameron et al. 2021*).

3.2. Social skills

Robots can achieve social presence through behaviour programmed to comply with social norms, creating for the user a sense of being in the presence of others (*Biocca et al. 2003; Heerink et al. 2008; Damiano – Dumouchel 2018*). When a robot demonstrates politeness in its operation, responds adequately to social cues and context, and respects diversity, it can elicit positive social reactions from people (*Araujo 2018; Asprino et al. 2022*). Robots exhibiting intelligence characteristics of humans during communication interactions are often perceived as social actors

(*Kahn et al. 2006*). The usefulness, social abilities and human-like appearance of robots positively influence consumer attitudes and acceptance, increasing the likelihood of successful interactions (*Song – Kim 2022; Beer et al. 2014*). Social skills are crucial for the social integration of robots (*Sugiyama – Vincent 2013*). In an experiment involving 326 participants, *Cameron et al.* (*2021*) found that a robot's ability to apologise in the event of operational errors increases sympathy and the intention to use the robot. Social robots must be capable of understanding and to some degree reproducing human emotions such as happiness, anger and satisfaction (*Murphy et al. 2019*). Analysing the interactions of 48 participants with the AIBO robot, *Lee et al.* (*2006*) concluded that perceiving the robot as a social actor facilitated the formation of a relationship. Service robots use sensors and cameras to monitor human emotions and can respond to them if equipped with the necessary features (e.g. facial expressions, skin, eyes) (*Murphy et al. 2019*). However, the ability to perceive emotions can also evoke feelings of eeriness among users if the programmed emotional reproductions seem less human-like (*Appel et al. 2020; Sugiyama – Vincent 2013*). Social skills such as verbal and nonverbal communication, related responsiveness (speech, emotions, gestures) and the recognition of user intent also positively contribute to the acceptance of humanoid robots (*Tuomi et al. 2021*). Verbal communication can be effectively supported by nonverbal communication, such as expressing emotions like joy or anger, and movements like gestures, body language and facial expressions. Human characteristics such as confidence, warmth, trust (*Cornelius – Leidner 2021*), and intentionality (*Wiese et al. 2017*) play a significant role in the user's psychological state, during which users may perceive the robot as a natural actor in the communication process (*Lee 2004*). Based on online questionnaire responses from 161 participants, *Ruijten et al.* (*2019*) found that the perception of robots' human traits is related to either human or uniquely human characteristics. In other words, users tend to perceive humanoid robots with social skills as similar to kind, polite, helpful, attractive and humorous human beings. Consequently, they often attribute human emotions to them because, based on their perceived traits and programmed reactions, they feel that the robots care about them (*Song – Kim 2022*).

3.3. Physical appearance

The shape and appearance of robots are key factors in their design, as they significantly influence user acceptance (*Deng et al. 2019*). Physical characteristics such as body shape, materials, colour, weight and movement (facial expressions, locomotion) all play a role (*Breazeal 2003; Beer et al. 2014; Kim – Lee 2014*). *Breazeal's* (*2003*) experiment with the KISMET robot highlighted that if the robot demonstrates social skills, these play a key role not only in interactions but also in task performance, self-maintenance and learning. *Powers – Kiesler* (*2006*) found that people are more likely to seek advice from humanoid robots. These robots are often considered more suitable for performing tasks and providing higher levels of service than more simple artificial companions (*Lu et al. 2021*). This is based on the fact that as the level of anthropomorphism increases, so does trust in the robot's competence (*Cameron et al. 2023*). This is related to the tendency of people to attribute higher intelligence to more lifelike humanoid robots with complex body structures (*Bartneck et al. 2009b; Stein – Ohler 2017*). In other words, as human-likeness increases, consumer expectations regarding the robot's capabilities also rise, but failure to meet these expectations can disrupt human-robot interaction (*Phillips et al. 2011*). Robots that exhibit human features – such as humanoid forms with heads, arms, legs, and eyes – can facilitate positive interactions and increase acceptance (*Breazeal 2003; Beer et al. 2014*). This is supported by the experiment of *Broadbent et al.* (*2013*) with 30 participants, which found that users preferred the Peoplebot healthcare robot featuring a human face over one without a face. Analysing 391 Instagram posts, *Chuah – Yu* (*2021*) showed that robots' emotional expressions (e.g. joy, surprise) positively influence how they are perceived. This confirms the assertion of *Lu et al.* (*2021*) that a robot's facial expressions – i.e. the imitation of human facial movements like happiness or surprise – significantly affect its perception. In a preliminary study involving 126 participants, *Brengman et al.* (*2021*) found that dynamically moving humanoid service robots generally elicit more interactions than stationary kiosks. Thus, the dynamic locomotion ability of humanoid robots contributes to their acceptance (*Piwek et al. 2014*).

It is a common assumption that overly human-like robots are better suited for tasks and can provide a higher level of service than more simple artificial counterparts (*Lu et al. 2021*). However, excessively anthropomorphic robot forms often cause discomfort, anxiety or concern among users (*Mori 1970; Fink 2012; Burleigh et al. 2013; Stein – Ohler 2017; Castro-González et al. 2016; Ferrari et al. 2016*). For example, in a questionnaire study with 92 participants, *Stein – Ohler* (*2017*) found that autonomous humanoid avatars were perceived as being less strange. *Ferrari et al.* (*2016*) conducted research with 51 participants, assessing images of robots to understand psychological barriers to their social introduction. The results showed that androids with the most human-like appearance evoked the greatest concern regarding potential harm to people. However, many studies have shown the opposite. For instance, based on a 32-participant experiment, *Bartneck et al.* (*2009a*) concluded that highly realistic robots do not necessarily trigger negative reactions. At the same time, perceiving robots as social agents has other consequences. *Malle et al.* (*2016*) found that consumers expect moral decision-making from robots possessing human traits. Regarding external appearance, if a robot exhibits gender cues (voice, name, clothing), users tend to interpret it according to gender stereotypes (*Eyssel – Hegel 2012*). This is supported by the study of *Rese and Witthohn* (*2025*) involving 300 participants, which showed that a chatbot's gender influences user reactions (male chatbots were less liked when service recovery failed).

3.4. User-related factors

Users' sociodemographic characteristics, such as age (*Heerink 2011; Breazeal et al. 2016; Kamide et al. 2013; Blut et al. 2021; van Straten et al. 2023*), gender (*Heerink 2011; Kamide et al. 2013*), level of education, personality and prior experiences (*Heerink 2011*), as well as users' individual predispositions (*Blut et al. 2021*), sense of social connectedness (*Haslam 2022*) and cultural embedding (*Epley et al. 2007*), along with robot-related attributes such as human-like appearance, social skills and functionality (among many other factors), all influence the perception of robots (*Mori 1970; Burleigh et al. 2013; Breazeal et al. 2016; Blut et al. 2021*). *De Graaf – Allouch* (*2013*) point out that intention to use and attitudes toward robots are influenced by various consumer-related factors, for example, how adaptable the user is to innovative technologies, and the role of age in shaping social and psychological experiences with robots.

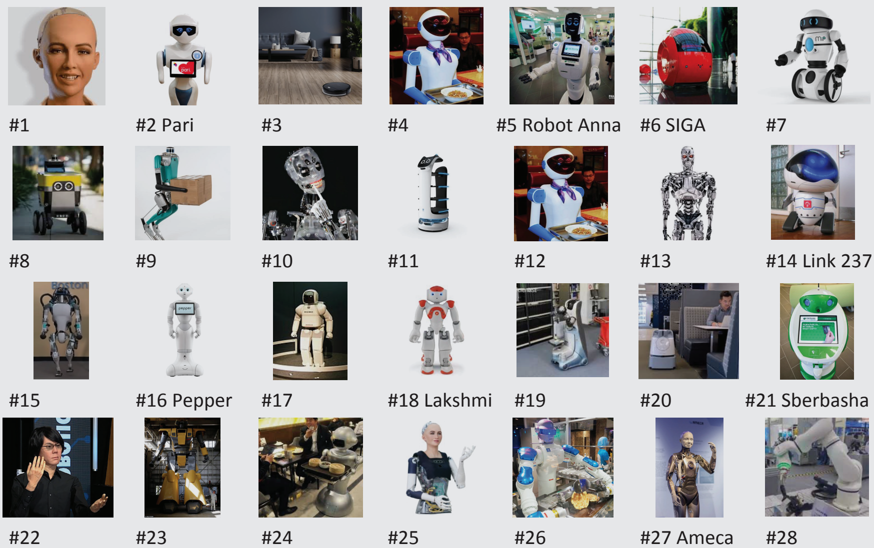
Prior negative experiences – whether imagined or real – and anxiety related to robots can negatively affect interaction and the development of trust (*Nomura et al. 2006*). People perceive anthropomorphic robot movements differently by gender: men are generally more sensitive to these movements, while women tend to attribute more human characteristics to robots' motions (*Abel et al. 2024*). Robot acceptance is assessed based on the ideal service concept, expectations regarding human frontline employees and self-service technologies. Robot functionality (usability, usefulness), the informative nature of human-robot interaction and relational factors (benevolence, satisfaction, understanding) all influence user decisions (*Stock – Merkle 2017*). Based on research with 116 participants, *Van Pinxteren et al.* (*2019*) found that comfort during service provision positively affects perceptions of human-robot interaction: at low comfort levels, robot social characteristics increase trust, while at high comfort levels, humanlike appearance enhances trust and acceptance.

4. Research design

4.1. Research method and data collection

In order to design the ideal banking service robot (Robo Sapiens Bankerius), I conducted a questionnaire survey[7] (via Google Forms) between 2023 and March 2025, completed by 257 respondents (see *Annex 1*). This study analyses the following topics from the questionnaire: perception of the robot (in terms of the dimensions of impression and human-likeness), choice among banking service robots and the reasons behind those choices. Respondents evaluated images of 26 robots based on 70 questions (two images were intentionally repeated[8], so a total of 28 robot images were assessed in two dimensions). Among the robots examined, seven are used worldwide in bank branches: SIGA (#6), Pepper (#16), Lakshmi (#18), Sberbasha (#21), Link 237 (#14), Pari (#2) and Robot Anna (#5) (*Figure 1*). In the course of the full examination, I analysed a total of 26 robots; however, the present analysis focuses exclusively on those used in bank branch environments. Since no highly human-like (humanoid) robot is currently in operation in such settings, I included the Ameca robot in the examination as a potential provider of banking services, in order to illustrate the spectrum and possible future applications.

Figure 1
Robots evaluated during the questionnaire (named in the empirical section)



Note: In addition to numbering, we have indicated the names of those used in the empirical section.

[7] Questions are summarised in *Annex 1*.
[8] The same image appeared for one of the robots, so the evaluation was influenced by the change in context (the robots before and after it). In the other case, one image showed only the human-like head, while the other also included the robot-like upper body.

Based on demographic data, the gender distribution of the respondents was nearly balanced (52 per cent female, 48 per cent male). Participants' ages ranged from 14 to 70 years, with an average age of 35 years and a standard deviation of 11 years (age group distribution is illustrated in *Annex 2*). All respondents had seen a robot in operation (via images or videos), while 69 per cent had personally encountered working robots. 49 per cent of respondents expressed concerns related to robots, while 44 per cent had positive impressions, 43 per cent had neutral impressions, and 13 per cent had negative impressions about robots.

4.2. Perceived human-likeness and impression of banking robots

The perception of the robots was examined in terms of human-like appearance and impression on a scale from 0 to 10, where 0 indicates a complete absence and 10 the maximum similarity or impression. Descriptive statistical information on the scores received by each robot can be found in *Annexes 3* and *4*. As highlighted above, this subsection presents the values of the banking robots used in the examination.

Based on the evaluation of the robots' human-like appearance, Pepper (#16) (M = 3.18) and Lakshmi (#18) (M = 3.04) received relatively favourable feedback, suggesting that their human-like appearance made a moderate impression. Robot Anna (#5) (M = 3.33), although possessing a more humanoid body, also scored moderately, indicating it did not stand out among the other robots. Link 237 (#14) (M = 1.57), Pari (#2) (M = 1.81), Sberbasha (#21) (M = 0.74), and SIGA (#6) (M = 0.28) received lower scores, indicating weak human-like appearance.

Regarding the perception of the robots' overall impression, Pari (#2) (M = 6.14) made an outstandingly good impression (receiving the highest score). It was followed by Link 237 (#14) (M = 5.82) and Lakshmi (#18) (M = 5.58), Robot Anna (#5) (M = 5.55) and Pepper (#16) (M = 5.23), all of which also received favourable feedback, indicating that their design elicited an above-average positive impression. Sberbasha (#21) (M = 5.75) and SIGA (#6) (M = 5.70) received lower, but still moderate, impression scores.

The data show no strong correlation between human-like appearance and impression scores, as for example, Link 237 (#14) received a low human-likeness score but a high impression score. Similarly, Lakshmi (#18) and Pari (#2) received high impression scores, despite not being notably human-like. This supports the view that impression perception depends on factors beyond human-like appearance. The above findings contradict hypothesis H1.

4.3. Preferred level of anthropomorphism: choice among banking robots

In selecting the preferred banking service robot, the aim was to determine whether respondents would rather interact with less anthropomorphic or more anthropomorphic robot clerks. Respondents chose their preferred future banking robot from three humanoid robots with different levels of human-likeness (from left to right in *Figure 2*: #21; #16; #27) and also provided open-ended explanations for their choices.

Figure 2
Ranking of preferred banking humanoid service robots based on choice results

1. 2. 3.

#21 Sberbasha #16 Pepper #27 Ameca

The results of the choice among the three robots can be evaluated as follows: The green robot resembling a kiosk (#21) was the clear leader, being the most frequently chosen (n = 125). The Pepper robot (#16) was the second most popular choice (n = 94). Despite having the highest average human-likeness score (5.96), the Ameca robot (#27) was the least chosen service robot (with 55 selections). At the same time, 40 respondents did not want to interact with a robot at all. The results are detailed in *Annex 5*. This indicates that users prefer less humanoid forms. Based on these findings, hypothesis H2 is rejected.

5. Trade-offs between functionality, social abilities, appearance dimensions and moderators

To examine the relationships between moderator factors in the survey, namely: gender, age groups, attitude and concerns, and the choice of robot clerk, I conducted a Chi-square test in the Google Colab environment (Python 3; CPU). The p-values for each test exceeded the 0.05 threshold (gender: 0.2707; age group: 0.2532; attitude: 0.0826; concerns: 0.5893). These results suggest there is no statistically significant association between the selected robot clerk and the examined variables. Therefore, hypothesis H3 is rejected.

The interpretive framework was established based on the analysis of open-ended responses supporting the selection of preferred banking service robot that includes three main perception dimensions (social skills, functionality, appearance) and three groups of moderators (robot-specific, user-related, environmental factors) (*Table 1*).

Table 1
Functionality, social skills, appearance dimensions and moderators

Dimensions of Robot Capabilities		
A. Social skills	**B. Functionality**	**C. Appearance**
A1. Level of communication A2. Likeability, persuasion, trust A3. Suggestion of robot existence/presence (living being, social agent) A4. Designed personality of the robot, friendliness	B1. Speed of service delivery B2. Natural language processing capability B3. Quality of task performance, reliability B4. Complexity of task performance B5. Level of autonomy B6. Robot intelligence (knowledge, learning, reasoning abilities and level) B7. Secondary, complementary robot functions B8. Ease of robot usability	C1. Human-like appearance – complexity of robot design C2. Friendly design C3. Robot components supporting communication (microphone, touchscreen, others) C4. Human-like facial expressions and expressiveness (facial expressions, others) C5. Human-like movement type and style C6. Robot gender
Moderators		
D. Robot moderators		
D1: Robot model: (a) new; (b) on the market for some time		
E. Customer moderators		
E1. Degree of control exercised by the user during the process E2. User perception of data security and protection E3. Openness to robot use (attitude, trust) E4: Religious beliefs E5: Application under compulsory circumstances (dependency, no other option) E6: Need for control and security E7: Personal disposition: trust in technology E8: Human information processing capacity and response speed E9: Experience with usage (manageability) E10: Previous experience with human agents		
F. Environmental (banking process) moderators		
F1. Complexity of the banking transaction the user must handle F2. Required skills for handling the banking transaction F3. Level of bank digitalisation: technologies used and robot replacement F4: Substitutability of the transaction service F5: Similar application and handling methods of technologies on the market		

Based on the robot capability dimensions and the identified relationships between them, the following trade-offs and conclusions are detailed below.

Perceived trade-offs and conclusions related to the social dimension:

- A1 – B1: Robots with intensive communication capabilities were often judged by respondents as socially advantageous, but several noted that these interactions could slow down the service process. This indicates that a high level of conversational ability may also pose a functional disadvantage if it results in decreased efficiency.
- A2 – C1: Surprisingly, responses showed that robots with less human-like appearances often elicited greater sympathy and trust. Overly anthropomorphic designs caused some users to feel discomfort, artificiality or even distrust, whereas simpler appearances allowed for clearer functional interpretation.
- A3 – C4: The use of human facial expressions and mimicry (eye contact, smiling) evoked ambivalent reactions: some participants saw these as strong signals of social presence, while others experienced fear, confusion or aversion.
- A4 – B3, B1: The friendliness of the robot's personality (open, helpful style) was viewed as an advantage by some respondents, while others stated that reliability and speed of service were more important to them. This suggests that social traits do not always add value.
- A4 – C4: Human-like facial movements, especially mimicry (e.g. smiling), increased acceptance and levels of trust. Robots with friendly facial expressions were more frequently described with positive attributes (kind, helpful) and judged as socially more competent by respondents.

Moderator effects related to the social dimension:

- A2 – E3: Some respondents showed greater openness toward more playful, less human-like robots. Such designs tend to generate fewer expectations for imitating human behaviour, thereby reducing the likelihood of rejection due to artificiality.
- A3 – E3 / E6 / E4: Anthropomorphic robot features suggesting social presence (eye contact, mimicry, body language) evoked feelings of comfort and trust in some users, while triggering suspicion of manipulation or hidden intentions in others. Correspondingly, those who perceived the robot as excessively "alive" reported decreased feelings of control and safety. Some respondents rejected robots as social beings for religious reasons.
- A4 – E10 / E3: Respondents with previous positive experiences interacting with human agents tended to show more trust toward robots with human-

like personalities as well. This indicates that experiences in human interactions significantly shape attitudes toward robots.

Trade-offs related to the functionality dimension:

- B1 – C1: For respondents prioritising robot speed and reliability, appearance played an insignificant role. Functionality and reliability mattered more than design, indicating their expectations were result-oriented.
- B2 – C3: Users with insufficient (functionality different from expected) natural language processing experiences expressed a stronger preference for touchscreen solutions. This shows that robot communication and interaction capabilities directly impact user experience: if the robot cannot reliably interpret speech or text, users tend to prefer intuitive, touch-based interfaces.
- B3 – C1: Those who valued robot accuracy and reliability most also considered appearance unimportant. Functionality remained the primary concern: efficiency, reliability, and speed were sufficient for visual characteristics to recede into the background.
- B4 – C1: Regarding complex, human-like robot bodies, respondents seeking advanced task execution capabilities tended to prefer more anthropomorphic robots. They felt physical appearance and sophisticated design were directly linked to the complexity of tasks the robot could perform. For them, more human-like robots signalled a higher level of task execution capability.
- B5 – C1: Human-like, complex robots may evoke a higher sense of autonomy among some respondents, as the robot appeared capable of making independent decisions, which increased trust and commitment toward the tasks performed by the robot.
- B6 – C1: According to some respondents, human-like robots suggested higher intelligence and better communication skills, which manifested in successful task execution and an increased perception of technological sophistication.
- B7 – B4: Some respondents felt that the lack of supplementary features (tablet, speaker, NLP) resulted in lower task complexity. Simpler robots offer less flexibility, which can be a disadvantage for more complex tasks.
- B8 – C1: Respondents often chose robots that were simpler and resembled already known, widespread technologies. This tendency reflects users' familiarity and attachment to familiar technological solutions, closely linked to easier usability and a shorter learning curve.

Moderator effects related to the functionality dimension:

- B3 – E10: Positive experience with a human agent may increase trust in robots, especially if robots perform tasks reliably, similarly to human agents.
- B4 – F2: According to respondents, those who are initially hesitant toward robots may still choose robot assistants for complex tasks, as task complexity can override initial rejection.
- B7 – E8: Robots equipped with displays were found useful by respondents who were given time to think, evaluate information and formulate responses. The visual support provided by such robots helped users in decision-making and task processing, reducing stress and allowing time for considered responses, which respondents believed would increase their trust and satisfaction toward the robot.
- B8 – F5: Respondents showed greater openness to robots similar to less complex, familiar banking systems, as their simpler design reduced technological anxiety and facilitated use.

Trade-offs related to the appearance dimension:

- C1 – B3: With a more complex appearance, respondents were more likely to perceive a higher task-performing capability (complex robot design = higher-level task performance). Thus, users associated the robot's physical appearance with its functionality.
- A2 – C1: A more complex robot appearance led to higher assumptions of customer manipulation. Some respondents felt that advanced, human-like robots were capable of manipulation, while simpler, cleaner-designed robots inspired more trust and better matched their expectations.
- A3 – C4: Anthropomorphic robots imitating human appearance elicited mixed reactions among respondents. While some experienced more natural interactions and perceived them as social beings, others felt low trust and discomfort. Thus, anthropomorphic appearance had a positive effect for those more easily connecting to human-like robots, but also caused negative reactions among those rejecting robots' human traits.
- C2 – A3: A friendly appearance strongly increased trust and reduced feelings of concern or hidden intent. Respondents felt that robots with friendly and kind appearances were more trustworthy and less likely to cause worry (e.g. in case of malfunction) than those with intimidating or neutral looks.
- C3 – C1: For anthropomorphic robots, some respondents found loud communication disruptive in certain situations. These users often preferred kiosk-

like, tablet-equipped robots because they were impersonal, less distracting and allowed for private transactions without burdensome personal interaction.

- C4 – C1: The presence of a human face/mimicry elicited varied responses among respondents. For some, the robot's facial expressions (such as smiling) generated higher trust and empathy, while for others, it caused a distinct sense of unease.
- C5 – C1: Users often perceived robots with simpler designs as safer and were more willing to choose them.

Moderator effects related to the appearance dimension:

- C1 – E2: For robots with less complex appearances, the sense of security related to data privacy decreased. Respondents perceived that simpler-looking robots provided less adequate protection of personal data.
- C1 – F4: A simpler robot appearance suggested that the robot primarily performed routine tasks, which may have created a feeling of reliability and ease of use.
- C1 – E10: Those who had previous negative experiences with humans tended to associate human intentions with human-like robots, which could increase feelings of distrust and rejection towards the new technology.
- C1 – E6: Some respondents had higher expectations for advanced robots with human-like features. If these robots malfunctioned (e.g. incorrect response/reaction), it was interpreted not only as a technical problem, but also as a danger and a loss of control.
- C3 – E1: For robots equipped with touchscreens, respondents felt as if they had greater control over the process. When using such robots, they attributed more significance to their role in the transaction.
- C4 – E3: Robots capable of emotional expression (smiling, eye contact) increased emotional bonding and generated stronger emotional interactions between users and the robot. Respondents were more likely to respond positively to emotionally expressive robots because they appeared more human and friendly.
- C5 – E3: Robots with dynamic movement also increased the trust factor due to their human-like characteristics. The naturalness and smoothness of the movement contributed to respondents trusting the robot more, as dynamic movement was associated with higher intelligence and autonomy.
- C6 – E3: Robots with female characteristics appeared more trustworthy and empathetic to some. This resulted from the interplay between social dimensions and sensitivity to gender traits, where users associated female traits with qualities such as kindness, trust, and empathy.

6. Instructions for designing Robo Sapiens Bankerius

In designing the Robo Sapiens Bankerius service robot for bank branch applications in the near future, the following aspects should be considered: In terms of functionality, the robot must perform tasks quickly to effectively support in-branch banking services. To enhance usability, it is desirable for the robot to include auxiliary tools that support reliability and a sense of control, such as a tablet and a simple, user-friendly interface. During the initial phase of market adoption, it is advisable to avoid an overly human-like form. The robot should be friendly and align with the bank's ethical and AI codes. Dynamic movement capabilities and a toylike form featuring limbs and a face, along with communication skills, can increase trust and the perception of the robot as a social agent. When designing the robot, it should be taken into account that the research findings may require further validation. Moreover, the impact on acceptance and its determining factors may evolve over time during technological adaptation.

7. Conclusion

The ideally designed Robo Sapiens Bankerius banking service robot is a dynamic (not static) model capable of adapting over time to user needs and preferences. When designing the ideal robot, social skills, functionality and appearance must be taken into account to ensure the best possible user experience. Based on the evaluation of 28 robot images by 257 respondents, it can be concluded that the data do not support the relationship that the more human-like a robot is, the more favourable the impression it creates (rejection of Hypothesis H1). The majority of respondents preferred less human-like humanoid robots (rejection of Hypothesis H2). Furthermore, age, gender, concerns and attitude characteristics showed no significant correlation with the choice between robot service agents (rejection of Hypothesis H3). Analysis of the reasons behind the choice among robot service agents highlighted the trade-offs between the robots' social abilities, functionality and appearance features, as well as client/robot/environmental moderators (acceptance of Hypothesis H4). Validation of these findings can be realised in future research.

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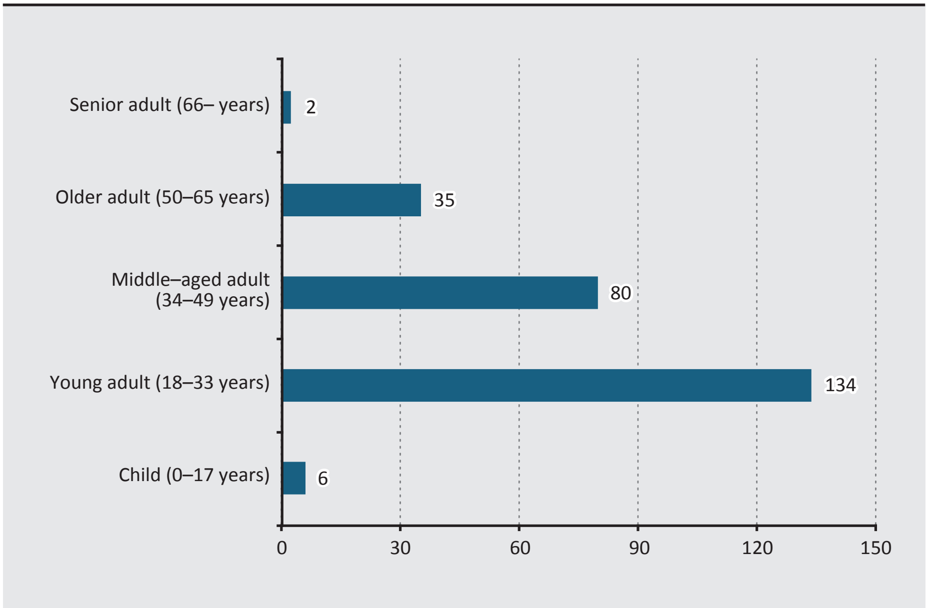
Annexes

Annex 1: Questionnaire questions

- How old are you?
- What is your gender?
- Have you seen robots in pictures or videos before?
- Have you ever seen a functioning robot in real life?
- Do you generally feel positive, negative or neutral when you think about robots? (Please explain your answer)
- Do you have any concerns or fears that robots might harm humanity?
- If you answered yes to the previous question, please specify what you are afraid of. What negative feelings or thoughts do you have?
- How much do you think the following robot resembles a human? (Scale from 1 to 10)
- What impression does the following robot give? (5 points: not disturbing at all; 0-4 points: negative impression; 6-10 points: positive impression)
- Is there a robot visible in the following picture? (The picture shows Hiroshi Ishiguro, the famous Japanese robot designer, and a geminoid.)
- Do you think the robot looks angry? (This question is repeated – showing a female (Robot #1) and a male (Robot #27) robot.)
- Do you think the robot looks surprised? (This question is repeated – showing a female (Robot #1) and a male (Robot #27) robot.) What emotion would you associate with the robot in the picture below?
- Is the robot's smile genuine?
- Do you think it is possible to manipulate human emotions through the robot's facial expressions and body language?
- Do you feel that you understood and perceived the reactions of the robots you just saw?

- Would you trust a robot in a bank customer area if it were this one? (Robot #27's picture is shown.)
- Would you rather trust this robot? (Robot #16's picture is shown.)
- Would you rather trust this robot than the two robots shown earlier? (Robot #21's picture is shown.)
- Please describe which of the three robots above you would rather interact with, and briefly explain why.
- Which ethical concerns among the following do you think designers absolutely need to consider?
- Do you think consumers should always be informed when interacting with a robot? Is notification necessary?

Annex 2: Age distribution of respondents



Annex 3: Evaluation of the human-likeness of the robots' appearance

Robot number	Min	Max	Standard deviation	Mean	Median
#1	0	10	2.33	6.52	7
#2	0	10	1.71	1.81	2
#3	0	5	0.53	0.13	0
#4	0	8	2.22	3.36	3
#5	0	8	2.22	3.33	3
#6	0	9	0.88	0.28	0
#7	0	7	1.87	2.20	2
#8	0	8	1.05	0.52	0
#9	0	8	2.25	2.76	2
#10	0	10	2.79	4.34	5
#11	0	10	1.28	0.74	0
#12	0	9	2.34	3.49	3
#13	0	10	2.94	4.77	5
#14	0	7	1.76	1.57	1
#15	0	9	2.41	3.13	3
#16	0	9	2.38	3.18	3
#17	0	10	2.47	4.29	4
#18	0	9	2.36	3.04	3
#19	0	9	1.29	0.74	0
#20	0	7	0.75	0.25	0
#21	0	6	1.22	0.74	0
#22	0	10	1.97	8.79	10
#23	0	10	2.34	2.46	2
#24	0	8	1.97	2.13	2
#25	0	10	2.54	6.67	7
#26	0	9	2.40	3.38	3
#27	0	10	2.65	5.96	7
#28	0	10	1.22	0.50	0

Annex 4: Impression scores of the robots

Robot number	Min	Max	Standard deviation	Mean	Median
#1	0	10	2.28	4.89	5
#2	0	10	2.38	6.14	6
#3	0	10	2.55	7.38	8
#4	0	10	2.36	5.48	5
#5	0	10	2.45	5.55	5
#6	0	10	2.56	5.70	5
#7	0	10	2.40	5.88	6
#8	0	10	2.64	6.21	6
#9	0	10	2.49	4.71	5
#10	0	10	2.29	2.30	2
#11	0	10	2.64	5.84	5
#12	0	10	2.39	5.48	5
#13	0	10	2.33	1.96	1
#14	0	10	2.60	5.82	6
#15	0	10	2.35	3.99	4
#16	0	10	2.54	5.23	5
#17	0	10	2.23	5.31	5
#18	0	10	2.41	5.58	5
#19	0	10	2.50	5.37	5
#20	0	10	2.57	5.71	5
#21	0	10	2.48	5.75	5
#22	0	10	2.94	4.48	5
#23	0	10	2.79	4.12	4
#24	0	10	2.44	5.52	5
#25	0	10	2.68	4.23	4
#26	0	10	2.36	4.39	5
#27	0	10	2.59	4.16	4
#28	0	10	2.65	6.10	5

Annex 5: Distribution of bank service robot selections

Selected banking robot	Number of Occurrences
Ameca	30
Pepper	60
Kiosk	92
None of them	40
All three	22
Ameca, Pepper	2
Pepper, kiosk	10
Ameca, kiosk	1
Total	257