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Gabriele Trovato*, Josue G. Ramos, Helio Azevedo, Artemis Moroni, Silvia Magossi, Reid Simmons, Hiroyuki Ishii, and Atsuo Takanishi

A receptionist robot for Brazilian people: study on interaction involving illiterates

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Abstract: The receptionist job, consisting in providing useful indications to visitors in a public office, is one possible employment of social robots. The design and the behaviour of robots expected to be integrated in human societies are crucial issues, and they are dependent on the culture and society in which the robot should be deployed. We study the factors that could be used in the design of a receptionist robot in Brazil, a country with a mix of races and considerable gaps in economic and educational level. This inequality results in the presence of functional illiterate people, unable to use reading, writing and numeracy skills. We invited Brazilian people, including a group of functionally illiterate subjects, to interact with two types of receptionists differing in physical appearance (agent v mechanical robot) and in the sound of the voice (human like v mechanical). Results gathered during the interactions point out a preference for the agent, for the human-like voice and a more intense reaction to stimuli by illiterates. These results provide useful indications that should be considered when designing a receptionist robot, as well as insights on the effect of illiteracy in the interaction.

Keywords: Human-Robot Interaction, illiteracy, education, service robotics, socially assistive robotics, anthropomorphism, uncanny valley, receptionist

***Corresponding Author: Gabriele Trovato:** Faculty of Science and Engineering, Waseda University, #41-304, 17 Kikui-cho, Shinjuku-ku, Tokyo 162-0044, Japan, E-mail: contact@takanishi.mech.waseda.ac.jp
Josue G. Ramos, Helio Azevedo, Artemis Moroni, Silvia Magossi: Center for Information Techonology Renato Archer - CTI Rodovia D. Pedro I (SP - 65), Campinas, 13069-901 São Paulo, Brazil
Reid Simmons: Robotics Institute, School of Computer Science, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, USA
Hiroyuki Ishii: Research Institute of Science and Engineering, Waseda University, Tokyo, Japan
Atsuo Takanishi: Department of Modern Mechanical Engineering, and with the Humanoid Robotics Institute (HRI), Waseda University, Tokyo, Japan

1 Introduction

In the near future, robots will perform services and assistive tasks, and be extensively used as helpers in activities of daily living. In order to achieve acceptance of robots, their design should be planned carefully according to their role. Receptionist is a job that is useful as support for common people in everyday life, and that can potentially be performed by conversational agents as well as robots.

The behaviour profile of a robot receptionist is a type of "socially interactive robot" (SIR). The term SIR was introduced by Fong et al. [1] to describe robots where social interaction is an essential feature in the construction and evaluation of robotic devices. As it provides assistance through social interaction, a robot receptionist could also be considered "socially assistive robot" (SAR) [2].

A "roboceptionist" was first employed in Carnegie Mellon University, and it featured a conversational agent called Valerie displayed on a screen and interacting with visitors through a dialogue system [3].

The most recent robotic receptionist is Otonaroid, an android which will be employed in a museum, while in the Henn na Hotel in Japan robots are already employed [4], although the user experiences were not always positive (M. Rajesh, Inside Japan's first robot-staffed hotel. The Guardian. Online: http://www.theguardian.com/travel/2015/aug/14/japan-henn-na-hotel-staffed-by-robots). Another previous android is Saya, which is capable of having a small conversation and of performing some facial expressions [5].

MechaDroid C3 can also perform facial expressions, although through LEDs screens [6]. All these examples feature different robotic embodiments, which determine also the way the receptionist can communicate.

1.1 Brazilian population and illiteracy

The final goal of this research is to build a roboreceptionist for Brazilian people. Therefore, first we should consider in what kind of context the robot should be employed.

Brazil, a developing country and the most populated in Latin America, is a country with high economic inequality. This fact causes inequality in education, as 9% of the population above 10 years old are illiterate [7]. Such inequality may ultimately affect acceptance of technology, including robots and consequently how they should be designed.

Regarding education, the Brazilian Geographical and Statistics Institute (IBGE) counts as "functionally literate" those individuals older than 15 years who have completed four grades of schooling and "functionally illiterate" those who have not (18.3%, according to [8]). However, the IBGE definition is slightly different from that of UNESCO [9]: "Functional literacy is the ability to use reading, writing and numeracy skills for effective functioning and development of the individual and the community". In other words, a functional illiterate may know how to write and read, but is unable to use these skills to extract relevant information from a text, or to compose an essay. This fact limits people ability to involve in activities, which according to Cree et al. [10] may include: understanding government policies and voting in elections; using a computer to do banking; shop online; and access up to date news and information.

The consequence of functional illiteracy is technological illiteracy: according to [10], without solid literacy and numeracy skills, technological literacy is hard to achieve", since the basic interaction with technological things may require some ability to read and understanding the meaning of the text. Illiterates' lesser exposure to technology than other people has to be considered. In the same way as elderly and disabled persons, illiterate people need specific studies, which have not been extensively done so far.

1.2 Objectives of the present manuscript

The motivation for this research is to investigate the factors that could be used for designing a receptionist robot to be employed in Brazil, considering the social and educational gaps within the country. In order to achieve this, two studies have been carried out: a preliminary investigation and an interaction experiment. The present experiments took place in Campinas, Brazil, in a centre for technology.

The preliminary investigation consists in a survey to determine the ideal receptionist for Brazilian people, specifically taking into consideration the factors like appearance and communication, which we manipulate in the second study.

In the interaction experiment, two different types of participants (literate people vs. illiterates) interact with two receptionists with different embodiment (a conversational virtual agent and a humanoid robot) and voice (human-like vs. robotic). We assume that these manipulated variables do not interact with each other.

Both receptionists give directions to the participants to reach certain rooms where evaluations are done through questionnaires. Non-verbal reactions are also collected during the whole experiment.

Some other variables are fixed: the path to follow, the contents of the directions, and the fact that both receptionists are shown on a screen and controlled in Wizard-of-Oz style by the experimenter. Since both interactions happen through a screen, proxemics is also fixed.

The rest of the paper is organized as follows: in Section 2 we do a survey of related work; in Sections 3 and 4 the two studies are described; Section 5 contains an overall discussion; in Section 6 we conclude the paper.

2 Related work

2.1 Embodiment and appearance

The embodiment of robots, specifically the face in case of humanoids, should be carefully considered, as appearance and human-likeness are factors which may cause repulsion in human users. This is a particularly sensitive issue, since studies on social robots involve complex sociodemographic factors such as age, gender, education, ethnic group, social class, religion, profession and others. The literature review in [11] presents a broad view of how many of these factors are critical for certain segments of users, such as elderly people. A subtype of them, illiterate elderly people, were the focus of the experiment of interaction with the robot NAO described in [12].

Regarding external appearance, face is particularly important as it can relay information about emotion as well as other non-spoken messages. For instance, the dimensions of the head and the presence and number of facial features can heavily influence the perception of human-likeness in robot heads [13].

Proxemics is one important factor related to embodiment. The effect of proxemics could be noticed in studies such as [14], where subjects keep more distance around a robot with physical body compared to a screen. Nevertheless, the physical robot and an agent on screen were compared, and the former was preferred by subjects.

Li [15] summarised the results of several other studies in which robots were perceived more persuasive and more positively when physically present rather than on a screen.

On the other hand, participants' responses were not different to physical robots and virtual agents when both were displayed on a screen, suggesting that physical presence is more important than physical embodiment in users response.

In our experiment we fixed the same physical presence for both receptionists, displaying them on a digital screen, as our study focuses only on appearance rather than proxemics.

Communication and cognition are further factors that may have an effect on how the robot's appearance is perceived. According to Minato et al. [16], when robots appearance and associated behaviour are more consistent and more human like, they are better accepted and effective when interacting with people. The more human-like robots face display is, the more people will attribute mind and positive personality characteristics to them, while appearing uncanny can be related to negative impressions of robots personality [14]. Appearance has an important effect on anthropomorphism, as humans commonly treat mechanical-looking robots in a subservient way compared to more human-looking robots, and have different expectations [17]. In particular, the attributions of tasks vary between more human-like robots and other kinds of appearances [18]. Acceptance of humanoids can also be influenced by cultural factors, as differences in the attitude towards man-made creatures in different, especially between Western and Asian countries [19].

2.2 Voice types

Our study involves communication with a receptionist, which is mostly verbal. Therefore, it is necessary to determine which voice type fits a robotic receptionist.

Voice in HRI has been studied before: Walters et al. [20] compared the human approach distances depending on voice quality in an experience with a mechanical looking robot: a robot with synthesised voice was found to induce significantly further approach distances than the one with human male and female voices. The explanation was that the robot with synthesized voice was perceived as more consistent with the robots mechanical appearance and influencing the perceived threat. The Uncanny Valley, originated by fear of the strange, which can apply to mechanical robots too, is also an explanation. Perceptual conflict in the appearance causing uncanny effect was also discussed in [21].

The gender of the voice is also important: in our case it will depend on the identity of the receptionist. In the study by Eyssel et al. [22], regarding male or female voice types, participants felt more psychological closeness to the same gender robot, but the same-gender robot was anthropomorphized more strongly only when it utilized a human-like voice, indicating that a projection mechanism could underlie these effects.

Niculescu et al. [23] investigated the effect of voice pitch on the evaluation of a social robot receptionist: it was shown that a female high-pitched voice was perceived significantly more attractive in terms of behaviour and personality compared to the calm, low-pitch one. The type of voice can also influence task performance [24].

2.3 Communication styles

Human receptionists are required to have communication skills, which involves being able to listen carefully, take notes, synthesise the information and report it accurately. Receptionists should manage multiple requests in efficient way and possess time management skills. Job offers even require being respectful and possessing cultural awareness [25].

Intelligibility is a primary requisite for designing a robot receptionist: talking an understandable language is not only necessary to convey the meaning of a message during a conversation, but can significantly alter the perception of the robot [26].

Holthaus et al. [27] did a study about proxemics, which is important because people far away may be less interested in an interaction with the receptionist than people coming closer. By adapting its attention, the receptionist can signal interest in an increasing manner to visitors coming closer.

Salem et al. [28] performed a cross-cultural study on politeness, competency, extroversion, warmth and psychological closeness comparing English and Arabic.

Studies on patterns during dialogues have also been made by Chee et al. [29]. The patterns of the receptionists conveying information to the visitors were defined in [29] as "simple, clear and direct". Especially when time has to be managed strictly, short answers are preferable; conversely, in some circumstances detailed answers may be more effective for the task of giving directions.

3 Study 1: preliminary investigation

3.1 Study design and hypotheses

We made a preliminary survey in the form of a questionnaire, with the purpose of understanding which are the most important traits that a receptionist should have for Brazilian people.

Based on the fact that Brazil is a culturally diverse country, in which racial diversity is considered a resource [30], we hypothesise that appearance in terms of race will not be an important aspect for Brazilians. Since the job of receptionist requires smooth communication, we expect that the traits involving effectiveness of communication will be highlighted.

3.2 Methodology

This survey was done with employees and visitors of an IT centre. This includes not only people involved with computer science or robotics, but researchers in other fields as well as staff who have different backgrounds. The were 48 participants, all Brazilians, all literate (graduates were 67%). Average age: 34.5; SD: 13.3; male: 28; female: 20. The group of participants was mixed in terms of classes and race, although not representative of all the possible races and classes in Brazil, which include even natives living in rural areas and the lowest social class living in slums.

The questionnaire consisted in only one question: "How do you imagine a receptionist?". This specific question would give us the answer about people's expectations without biasing towards some answers (which would have been the case if we wrote "How should a receptionist be" or "What is the ideal receptionist?"). Participants could chose 5 to 8 characteristics from a list of 28.

This unstructured checklist does not make characteristics mutually exclusive but, by limiting the amount that can be selected, it forces to choose only what is relevant. Other ways of posing a questionnaire, e.g. through open questions such as "are they of a particular gender or race?" would induce the participants to think about it and probably they would be more likely to come up with some comment. That would mean predisposing towards some categories and it is not desirable, because we don't want one answer for each category, but rather understand which categories are really important.

There are no negative characteristics, as they would not be desirable in a robot, and would make the list unnecessarily longer: only positive or neutral. For the same reason, in the "Culture and Language" category, there are no choices which are clearly never going to be selected. Conversely, the category about appearance is expanded in order to include all pertinent races.

The possible choices are listed in Table 1, second column, divided into categories (first column). The list was selected based on the references mentioned in Section 2.4, which include job ads looking for a receptionist. In the questionnaire, category names were not present, and the order was randomised.

3.3 Results

Analysing the results (Table I, last column), in the category Human likeness, being human does not seem to be significantly preferred to machine ($p = 0.35$ according to Mann-Whitney U-test, and $p = 0.45$ according to the Chi-squared goodness of fit test, confirming the null hypothesis of equal distribution). The whole category Human likeness does not seem much relevant compared to other categories like Behaviour.

No significant preference is either found in the category Voice ($p = 0.11$) through Kruskal-Wallis test, just that high pitch voice is less preferred ($p = 0.03$) through Chi-squared. In the category Behaviour, Polite is significantly higher than all the other characteristics ($p<0.001$). On the other hand, no preference is found for Direct answer against Detailed neither through Mann-Whitney ($p = 0.29$) or Chi-squared ($p = 0.27$)). The category Age seems unimportant, as none of its characteristics went over 10%.How much each category was selected is quantified in the percentage shown in the first column of Table 1.

3.4 Discussion

From these results, we could extract useful findings that will be used for planning the experiment described in Section 4.

The traits of a receptionist, according to our participants, are the following:

- Human likeness: not specified
- Appearance: good looking, no matter the race
- Gender: female
- Age: not specified; non important
- Voice: not specified
- Culture: speaks Portuguese
- Behaviour: polite
- Ability: competent; answer type not specified.

Table 1: List of choices of characteristics of a receptionist.

Category	Characteristics	Number of preferences
Human likeness (19%)	– Human	– 16 (33%)
	– Machine (humanoid robot)	– 3 (6%)
	– Machine (computer)	– 9 (19%)
Appearance (11%)	– Latino race	– 2 (4%)
	– Native race	– 0 (0%)
	– Asian race	– 1 (2%)
	– White race	– 1 (2%)
	– Black race	– 0 (0%)
	– Good looking	– 28 (58%)
Gender (22%)	– Male	– 3 (6%)
	– Female	– 18 (38%)
Age (9%)	– 20 years old	– 5 (10%)
	– 40 years old	– 5 (10%)
	– 60 years old	– 4 (8%)
Voice (22%)	– Neutral voice	– 10 (21%)
	– High pitch voice	– 3 (6%)
	– Warm voice	– 14 (29%)
	– Soft voice	– 16 (33%)
Culture and language (37%)	– Speaks Portuguese	– 27 (56%)
	– Brazilian	– 9 (19%)
Behaviour (43%)	– Polite	– 40 (83%)
	– Kind	– 17 (35%)
	– Friendly	– 22 (46%)
	– Intimate	– 3 (6%)
Ability and communication (45%)	– Competent	– 39 (79%)
	– Responsive	– 19 (40%)
	– Gives a direct answer	– 12 (25%)
	– Gives a detailed answer	– 18 (38%)

Percentages in the first column indicate, on average, how much a category has been selected; in the last column they indicate the percentage out of 48 subjects.

We noticed that "Brazilian" was not the one of preferred characteristics, but rather intelligibility ("Speaks Portuguese") was enough. This may be due to the fact that Brazilian society is multi-cultural and therefore relatively tolerant towards different races and cultures.

The traits in human likeness and answer type were not clearly defined by these results. Another feature that needs attention is the voice. These aspects require a more detailed analysis that was conducted through the experiment described in the next sections.

4 Study 2: experimental investigation

4.1 Study design and hypotheses

This experiment consists in a within-subjects study involving two receptionists with different embodiments (a conversational virtual agent and a humanoid robot) and voice (human-like vs. robotic). Participants are divided into literate people and functional illiterates.

Our main hypothesis regarding them is that the interaction stimuli will have a bigger effect, either positive or negative impression, on the illiterate people, because of their lesser exposure to technology.

Regarding the receptionists, since the previous survey outlined the preference for good looking persons, we expect the conversational agent to be rated higher as more attractive. A human-like voice may also make a better impression, but we expect it to be less appropriate to the mechanical looking robot, as it does not fit its appearance.

4.2 Methodology

4.2.1 Materials: conversational agent

Conversational agents are a subset of Intelligent Virtual Agents (IVA), defined as interactive characters with human-like qualities that communicate with humans through facial expressions, speech and gestures, and capable of perception, cognition and action.

For our experiment, the conversational agents developed in [3] have been used and modified for our purposes. Several versions have been made, including some of different ethnicity [28] and human likeness [31]. Refined facial animation and visemes, such as the ones of De Martino et al. [32] can also improve the realism of the agent.

As the receptionist job is typically associated with female gender (according to the Annual Report of Social Information - RAIS [33], provided by Brazilian Ministry of Labour, 82% of receptionists are women), and since this fact has also been confirmed by our preliminary survey, the agent we used and customised is female too. Her appearance is shown in Figure 1.

Despite the fact that in the findings of the previous experiment there are no clear preferences about race, we decided that she should have brown skin.

According to the 2010 census [7] on race, in Brazil 47.8% of population white skinned, 8.1% black, 43.1% brown skinned, 0.6% red skinned and 0.4% indigenous. Since the total of brown and black is superior to white, we settled with brown, as more representative of the average.

Her speech is in Brazilian Portuguese; her voice was recorded by a Brazilian woman. These choices are important because according to [34] and [35], conversational agents are found more persuasive and trustworthy when ethnically congruent.

We assigned the name Ana to this agent, as it is a common name in Brazil.

Figure 1: The first receptionist: a female conversational agent called Ana.

4.2.2 Materials: humanoid robot

In this experiment, we used the whole body emotion expression 48-DoFs humanoid robot KOBIAN [36] (Figure 2). KOBIAN is designed to provide support for the activities of daily living for elderly and disabled people, and to clarify the influence and effectiveness of physicality and expressivity during interaction. Besides emotion expression, KOBIAN is capable of bipedal walking. These two abilities combined together make KOBIAN potentially able, in the

future, to work as assistive robot in a human environment, such as a family or a public facility.

The robot should be perceived as female, to be consistent with Ana, as different genders have an effect of prejudices towards robots too. According to Eyssel et al. [37], a male robot tends to be seen more assertive and dominant, while a female robot tends to be seen more affable, affectionate, and friendly.

In order to make KOBIAN (originally an asexual robot) look female, pink tape was used to add colour to face and body. Most important, female voice was added later to the motion of the lips and slight periodic oscillations of the head. Gender manipulation effectiveness was later verified (see Section 4.4.2).

The robot's body parts are controlled by both position-based and velocity-based controllers that have been implemented using YARP [38]. The coordination of the different joints involved in the motion and the timing of the different movements were designed to achieve a natural behaviour with smooth trajectories and mild transitions between the different motions.

As the experiment has to be made in a country that is distant from the robot, which is physically present in Japan, a recorded video of the robot was shown through a simulated video conference. Another reason for this choice is that since this is a study involving appearance, the bias due to proximity and contact has to be left out: as the robot is behind a screen, it is in the same condition as the virtual agent, leaving only the appearance as variable.

While there is no issue about ethnicity of a robot with a mechanical appearance such as KOBIAN, the impression of the robot may be different depending on its nationality [26, 39]. Therefore, it will be introduced as Brazilian, and speak Brazilian Portuguese like the other receptionist.

The name we chose for the robot was "Kobiana", a name that reminds Ana and that is more humanised compared to the original name KOBIAN.

4.2.3 Participants groups and illiteracy

In total, 62 people participated in this experiment. Among them, two outliers were discarded as their nationality was later found out to be respectively Japanese and Chilean. This resulted in having 60 participants divided into two groups: the employees and visitors of the centre where the experiment was held (Group EV), and a group of illiterates, which we gathered from the cleaning staff of the same centre (Group CL). The groups are disjoint from the pool of participants of the study 1.

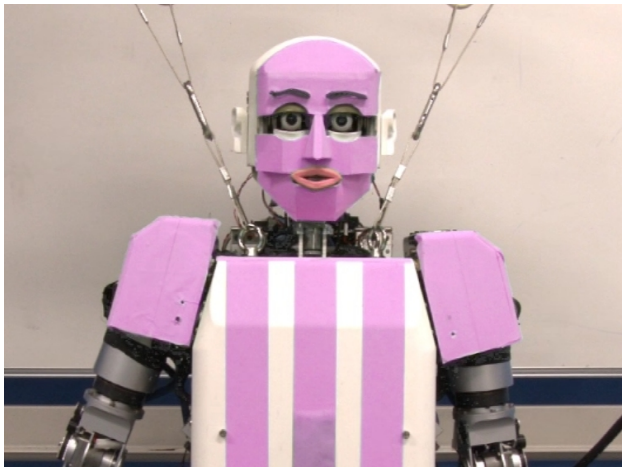

Figure 2: The second receptionist: a female humanoid robot called Kobiana.

Demographics is as follows: EV age mean: 39.12; SD: 14.02; 25 male, 15 female. CL age mean: 43.55; SD: 14.19; 9 male; 11 female. In total, Group EV is composed by 67% of the participants against 33% of CL.

Both groups had no previous experience of HRI user studies, as this one is the first to be done in this location.

For both groups, the fact that the employees are familiar with the building cannot be a bias because, besides the building being quite large, for the experiment we fixed a path with landmarks and labelled two rooms which they were not aware of.

Recruitment policy was especially strict in case of the Group CL: not only it was made sure that education level was extremely low (for all of them, education was to be limited to the Brazilian primary level (elementary or technical school) or below), but also made sure, consulting with their employer's documentation, that they were really unable to read and understand text. Among the group, besides functional illiteracy, total illiteracy [40] was also common as they had difficulties in reading. They had to be supported when filling the survey. Conversely, Group EV was made as a mixed group, in which, although not all were graduates, there were 4 Ph.D., 14 Master graduates and 17 holders of Bachelor's degree.

4.2.4 Experiment flow

The experiment took place in a technology centre in Campinas, Brazil. The area where the experiment was held was organised in a way that the participant would follow a path suggested by the two receptionists. Some landmarks were

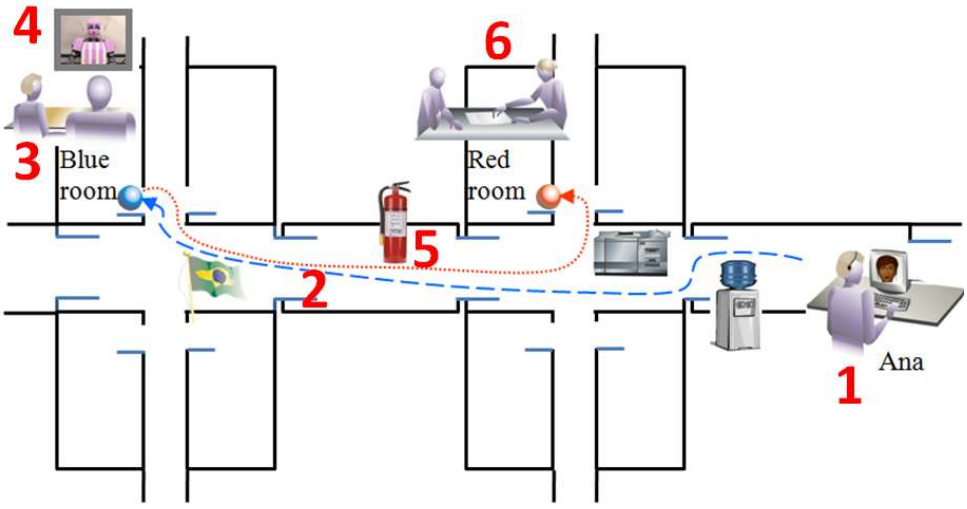

Figure 3: Map of the environment showing the location of the receptionists, the landmarks, and the paths. Dashed arrow represents the path to the Blue room; pointed arrow to the Red Room.

also placed and referred in the directions. The map of the environment is shown in Figure 3.

Participants were filmed during the interactions and constantly followed when moving through the following steps:

1. Interaction with Ana: Each participant is invited to sit at a desk and wear earphones, in front of a screen (Figure 4). The receptionist agent Ana is remotely triggered as the participant is ready to start. Ana turns her head up, says "Olá" (Hello) and waits approximately 4 seconds. In this short time, participants may reply to the greeting. Afterwards, Ana starts talking and gives indications to reach the "Blue Room". One experimenter takes note of all the reactions of the participant.
2. Reaching the Blue Room: The participant heads to the corridor (Figure 5), where some landmarks have been placed (a water cooler, some printers and a Brazilian flag). A blue sign marks the correct room. In case the participant gets lost, one experimenter comes in assistance, and the negative outcome of finding the room is recorded.
3. Evaluation of Ana: Once reached the Blue room, the participant fills a questionnaire about Ana. After answering the questionnaire, the participant is told that the experiment is not over and that there is a second part; then changes his/her position in the room to a table containing the video conference equipment.
4. Interaction with Kobiana: At this point, the participant is explained that we are going to make a call to Japan through a video conference device (Figure 6), to interact with a receptionist robot which speaks Portuguese. A previously recorded video instead will be shown, as the TV is not connected to the device, but to a PC. No actual call is made, but the participant is tricked into believing that he/she is watching a live connection. As one examiner pretends to start the call, video begins and connection is established with a Japanese student, who switches the camera to Kobiana, which greets, does a self-introduction and gives indications to reach the Red Room. Two examiners are present in the room, to explain and answer to any participant's question, and to take note of any verbal or non-verbal cue noticed during the interaction. This Wizard of OZ style experimental setup introduced in [26] is effective in stimulating spontaneous reactions of the participant, and this would not happen if the participant knew to be watching a recorded video.
5. Reaching the Red Room: After closing the connection, the participant has to reach the Red Room, walking again through some landmarks.
6. Evaluation of Kobiana: In the Red Room, the participant fills the questionnaire to evaluate Kobiana and express a preference for one of the two receptionist, possibly explaining the reasons. He/she gets a prize and the experiment is over.

The order of the two receptionists was fixed: the implications of this choice are discussed in Section 5.2.

4.2.5 Speech

Each speech had the duration of approximately one minute. Directions contents are slightly different between

Figure 4: One participant during the interaction with Ana. As the location was in the middle of a corridor, the desk was covered by some panels at the two sides.

Figure 5: One participant walking towards the Blue Room, passing through a corridor with a Brazilian flag acting as landmark.

the Blue and the Red room, but similar in length and complexity.

Brazilian Portuguese speech was recorded by a Brazilian woman. The recorded speech was then processed and a robotic effect was added. The kinds of effects were chosen according to the purpose of making the robotic voice sound clearly artificial, but still completely intelligible. The original recorded voice is from the same person for both receptionists, but the effects make it sound enough different as if it were not from the same person.

Different videos were made, in which either of the receptionist speaks the same sentences with human or robotic voice. For these conditions, we showed to half of the participants (randomising the order), the agent with human voice and the robot with robotic voice; to the other half the agent with robotic voice and the robot with human voice.

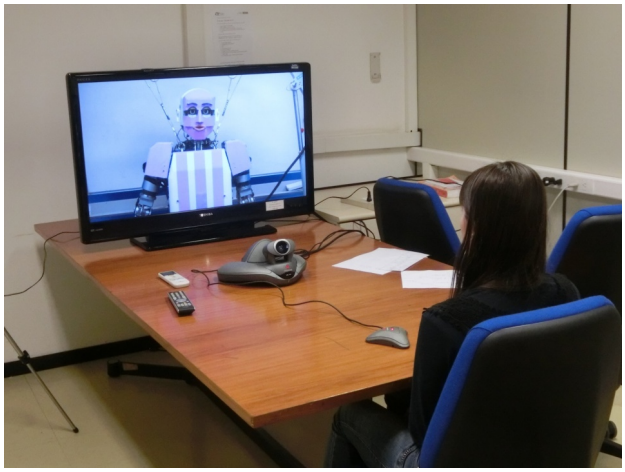

Figure 6: Simulated video conference with Kobiana. A microphone nearby could be used in case the participant wanted to reply.

4.2.6 Questionnaires

Ana and Kobiana were evaluated through written questions structured in differential semantic scales. Godspeed Scales [41] were partly used (the categories Anthropomorphism, Animacy, Likeability, Perceived Intelligence), and one additional set was added regarding uncanniness.

We named the set "Familiarity" (as the word uncanny means the opposite of familiar [42]), and defined it with the following scales:

Creepy	1	2	3	4	5	Pleasant
Scary	1	2	3	4	5	Innocuous
Eerie	1	2	3	4	5	Familiar
Weird	1	2	3	4	5	Ordinary
Sinister	1	2	3	4	5	Reassuring

The scale "Perceived safety" was left out, as in this kind of interaction it did not prove to measure effectively in previous experiments [26].

Additional scales ("Good as a receptionist"; "Gives useful directions"; "Has a good voice"; "Has a voice appropriate to its appearance") were added at the end together with the prompt to choose explicitly the preferred receptionist, in a scale from 1 (Ana) to 5 (Kobiana), and a space below where comments could be written.

All questions were translated in Portuguese. All differential semantic scales were checked beforehand through Cronbach's alpha, a coefficient of internal consistency used to estimate the reliability of a psychometric test. Results were all greater than 0.8.

For participants of Group CL, additional support was required. Illiterates find difficult to understand different nuances of synonyms and do not understand at all difficult words. All the participants of the group asked to be supported (Figure 7) for reading and answering. Evaluation of the sets of scales resulted in a single evaluation of the whole scale, explained by the experimenter with simple words.

Experimenters took care in not influencing the answers of the subjects in any way, limiting their role to making sure that the correct meaning of the questions was understood.

Figure 7: One participant of the cleaning staff being helped by the experimenter in reading and filling the questionnaire.

4.3 Results

4.3.1 Semantic scales

Gathered data were analysed using the Kruskal-Wallis test [43] in case of multiple groups of data and Mann-Whitney U-test [44] in case of two groups of data. Student's t-test and ANOVA could not be applied, because the shape of the distribution graph resulting from the semantic differential scales data is not a normal distribution.

Differential semantic scales were validated calculating Cronbach's alpha, a coefficient of internal consistency used to estimate the reliability of a psychometric test. Results were: 0.848 for Anthropomorpism; 0.904 for Animacy; 0.835 for Likeability; 0.883 for Perceived intelligence and 0.854 for Familiarity. We conclude that all scales are consistent.

In Table 2, results of the main part of the questionnaire are reported. Comparing Ana with Kobiana, significant differences are found for Group EV in categories Anthropomorphism (p = 0.003); Likeability (p = 0.021); Familiarity (p = 0.002); Good as receptionist (p = 0.001); and Appropriate voice (p = 0.005), all in favour of Ana. Conversely, for Group CL only category Anthropomorphism is significant ($p < 0.0001$).

Apparently, Group CL perceived significantly higher than EV the categories Likeability, Perceived intelligence, Familiarity and Good as receptionist for both robots ($p < 0.001$ in all cases).

Instead, Anthropomorphism was a different case, as Kobiana was judged significantly ($p < 0.001$) less anthropomorphic by Group CL compared to group EV.

The last two rows of Table 2, regarding voice, require further investigation, which is done in Section 4.3.3; while "Gives useful information" is examined again in Section 4.3.4.

Comparing the differences (Ana_EV - Kobiana_EV) and (Ana_CL - Kobiana_CL) for each scale, a similar trend can be noticed: Ana is always rated higher than Kobiana except for the two categories "Perceived intelligence" and "Gives useful information".

4.3.2 Explicit preference

In the last question, participants had to choose explicitly the receptionist that they liked more, in a scale from 1 (Ana) to 5 (Kobiana).

Result for Group EV was 2.85 (SD: 1.37); for Group CL was 2.70 (SD: 1.87). Both equal to slight preference for Ana.

Participants were also asked to justify their choice adding a free comment. We collected all the comments and divided them into the following categories (in brackets, subcategories), in order to group similar comments together:

- Appearance (good looking, material appearance, more human like)
- Behaviour (more natural, more interactive, better body movement)
- Emotion (nice, likeable, trustworthy)
- Dialogue (nice voice, accurate information).

We calculated the average number of comments per participant. Among these categories, Appearance and Dialogue

Table 2: Mean values and SD (in parenthesis) of the evaluation of both receptionists by the two groups.

	EV		CL	
	Ana	*Kobiana*	*Ana*	*Kobiana*
Anthropomorphism	3.00 (0.71)	2.59 (0.95)	3.50 (1.54)	1.20 (0.89)
Animacy	3.14 (0.80)	2.84 (0.98)	3.15 (1.66)	2.50 (1.82)
Likeability	3.95 (0.64)	3.56 (0.74)	4.85 (0.49)	4.65 (0.99)
Perceived intelligence	3.65 (0.75)	3.78 (0.70)	4.45 (0.89)	4.75 (0.91)
Familiarity	3.98 (0.51)	3.43 (0.77)	4.65 (0.81)	4.55 (1.23)
Good as receptionist	3.98 (0.89)	3.23 (1.27)	4.85 (0.49)	4.80 (0.89)
Gives useful information	4.15 (0.92)	4.33 (0.69)	4.90 (0.31)	5.00 (0.00)
Has a good voice	4.12 (0.97)	3.98 (0.86)	4.65 (0.67)	4.45 (1.05)
Has a voice appropriate to its appearance	4.23 (0.97)	3,53 (1.11)	4.20 (1.15)	3.40 (2.01)

were regarded as the most important factors: respectively 33.6% and 34.5% of the comments were related to them. However, if we consider only negative comments, the ones regarding appearance raise to 54.5%. The total amount of comments related to body, rather than face, was just 5.9%.

The breakdown of the comments in Figure 8 shows the comparison between Ana and Kobiana for all the subcategories (except the ones regarding voice). In the graph, the positive comments regarding Ana are put together respectively with the negative regarding Kobiana, and the positive comments regarding Kobiana are counted together with the negative regarding Ana. Body movement and emotions are subcategories in which no significant difference is found. With respect to body movement, Ana is limited to moving face and head orientation, as well as facial expression. This result confirms again that body appearance has a marginal importance for a receptionist compared to other factors, as it was hinted from the preliminary survey.

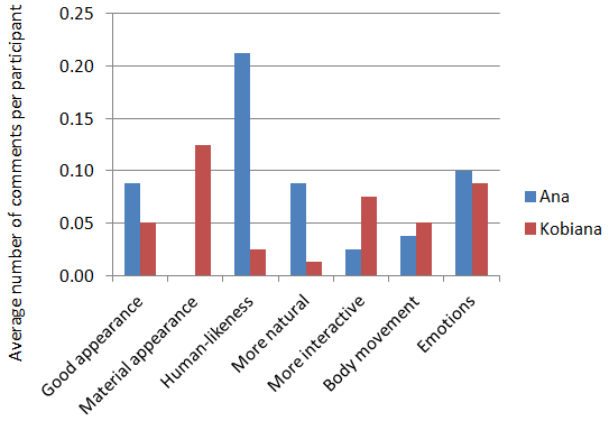

Figure 8: Average number of comments per participant in favour of Ana or Kobiana, divided by subcategory.

Some significant comments in each subcategory:

- "Ana looks more like a common person"
- "Ana's appearance is more pleasant"
- "Ana is too much abstract. Kobiana is more real"
- "Kobiana offered a more interactive conversation"
- "Kobiana does not try to imitate a human"

4.3.3 Voice

Detailed results about the evaluation of the voice by group EV are shown in Table 3. On these data, two analysis were done: evaluation of human voice versus robotic voice through Mann-Whitney test, and finding correlation between voice and other parameters, such as general preference, through Spearman's Rho.

Human voice was rated significantly higher (p<0.001) than the robotic one. However, it was judged less appropriate for the appearance of Kobiana (p = 0.03), while appropriate for Ana (p = 0.001).

The second analysis consists in crossing results regarding voice with results on explicit preference. Calculations of Spearman's Rho reveal a significant (r = 0.46; p = 0.002) correlation between the ratings of explicit preference with the differences of the ratings of the voices of the two receptionists.

Finally, another correlation was found between Familiarity and Good voice: Spearman's test highlighted a significant correlation (r = 0.29; p = 0.007). This means that any of the two receptionists, whenever associated with a bad voice, were rated more uncanny. This correlation is stronger in case of Kobiana (r = 0.52; p = 0.006).

Table 3: Evaluation of voice: mean values and SD in parenthesis.

	Ana		Kobiana	
	Human	***Robotic***	***Human***	***Robotic***
Has a good voice	4.55 (0.76)	3.70 (0.80)	4.25 (0.85)	3.70 (0.80)
Has a voice appropriate to its appearance	4.75 (0.55)	3.70 (1.03)	3.10 (1.20)	3.95 (0.83)

4.3.4 Directions effectiveness

The route to the Red Room seemed to be easier than the route to the Blue Room, despite it was approximately the same distance and contained the same amount of landmarks; nevertheless, 25% of the participants of group CL got lost or had some hesitation, while this did not happen at all with group EV. Conversely, there was no significant difference in the data of the route to the Blue Room between the two groups. Results are reported in Table 4.

We expected the illiterate people to perform as well as the literate, because their problems are only with written text, and because the spoken sentences did not contain difficult terms.

Further information was gathered examining participants' behaviour during the interaction, rather than during the route. In particular, some unusual behaviours were noticed: - asking to the experimenter to confirm what the receptionist said; - running away to the next room even before the experimenter finished talking; - not going at all at the end of the receptionist's explanation, and waiting for the experimenter to exhort to carry on. Although analysing the reasons of such odd behaviours is interesting, no correlation was found with the perception of getting useful directions or with reaching the destination successfully.

4.3.5 Verbal and non-verbal reactions

During the course of the experiment, we kept track of participants reactions, either verbal or non-verbal. The categories of reactions were the following:

- Replied to the receptionist's initial greeting
- Replied by gesture to the receptionist's initial greeting
- Replied to the receptionist's final greeting
- Replied by gesture to the receptionist's final greeting
- Made any other spoken comment
- Did any positive non-verbal reaction (such as smiling)
- Did any neutral non-verbal reaction (such as eyebrows raising and nodding)
- Did any negative non-verbal reaction (such as eyebrows corrugation and head shake)

In Table 5, the results of this part are summarised. The total amount of interaction (which includes all the categories of Table 5) per participant is not statistically different between the two groups.

In Table 6, the comparison between the receptionists through the breakdown of significant categories is shown. For Group EV there is no significant difference, while Group CL showed more positive reactions ($p = 0.04$), negative reactions ($p = 0.03$) and total interactions (one tailed $p = 0.03$) for Kobiana.

No significant sign of habituation was found. We hypothesise that spontaneous interactions would be less common for Kobiana if there were habituation; however, this is proven untrue in Table 6. In fact, we noticed the cases of subjects nervous with Kobiana but not with Ana, and vice versa. Measuring individual differences, the standard deviation of the difference of number of interactions (Kobiana minus Ana) is always quite high, being 2.25 for Group EV and 4.17 for Group CL. Furthermore, the mean value is negative for Group EV (–0.234) and positive for Group CL (1.45). This contradicts the habituation hypothesis and suggests that differences in results between the two groups appear stronger than possible effects due to habituation.

4.4 Discussion

4.4.1 Embodiment

When comparing Ana and Kobiana through all the questionnaire categories, we can conclude that Ana was preferred by both groups. In the case of Group EV, this is confirmed by the higher score of Likeability.

The main reason seems to be the appearance, in particular human-likeness. Ana was considered less uncanny according to Group EV, and more appropriate as a receptionist. However, this preference is only limited to appearance, since according to Table 2, Kobiana is perceived more intelligent and more useful.

These findings add more insights to the results of the experiment of Bainbridge et al. [14]. In that case, an embodied robot was preferred to an agent. The main differ-

Table 4: Evaluation of direction types: mean values and SD in parenthesis.

	EV		CL	
	Ana	***Kobiana***	***Ana***	***Kobiana***
Gives useful directions	4.15 (0.92)	4.33 (0.69)	4.90 (0.31)	5.00 (0.00)
Percentage of participants who got lost	45%	0%	50%	25%
Average number of confused behaviours per person	0.53	0.40	0.30	0.85

Table 5: Mean values (SD) of the number of reactions per participant.

	EV	CL
Initial greeting: words	0.51 (0.43)	0.43 (0.47)
Initial greeting: gesture	0.05 (0.15)	0.08 (0.18)
Final greeting: words	0.29 (0.46)	0.25 (0.44)
Final greeting: gesture	0.08 (0.18)	0.10 (0.21)
Other comment	0.18 (0.48)	0.15 (0.46)
Negative non-verbal reactions	0.28 (0.69)	0.40 (0.67)
Neutral non-verbal reactions	0.59 (0.89)	0.73 (1.33)
Positive non-verbal reactions	0.58 (0.71)	0.45 (0.59)

ence, however, is that in our experiment both receptionists were displayed on a screen, like in [45]. This setup took away the effect of proxemics in the stimuli, important in [14], and focused only on appearance. The results obtained, namely, a slightly preference for the agent, agree with the findings of [45], where people gave preference for robots more similar to humans. Moreover, this preference can be related with the findings in [17], where people gave more consideration to robots with human appearance.

4.4.2 Suspension of disbelief

The concept of "suspension of disbelief" revolves around the assumption that the social robotic entity has an internal purpose and intent driving its actions. Otherwise, the robot will be perceived as an abstract pattern of movement rather than a social entity [46].

The experiment itself proved to be believable, as no participant noticed the Wizard of OZ trick. Gender manipulation of Kobiana was also effective, as in the open comments Kobiana is always attributed feminine adjectives in Portuguese (such as simpática).

Within the results, the more enthusiastic ratings and bigger reactions to both robots by Group CL (even though Kobiana was anthropomorphised less) may be due to a deeper suspension of disbelief, originated by the less exposure to new technologies.

Future studies should clarify whether the results were due to the deeper suspension rather than other possible psychological factors involving response to the researchers' authority. If this hypothesis is true, we should be careful in considering that the benefits in terms of suspension of disbelief may fade away when the technology becomes common enough to be comfortably used by illiterates too.

4.4.3 Voice

Human voice seems to be always preferred, especially in the case of the conversational agent. A purely human voice is judged less appropriate for a humanoid robot like Kobiana; however, this finding goes in contrast with the strong correlation between uncanniness and bad voice. Human voice, despite being less appropriate, can make the robot appear more familiar. That correlation, however, is also in contrast with studies such as [21], because a mechanical robot talking with a human voice is a case of misalignment of cues, and supposed to cause additional uncanny effect.

4.4.4 Getting lost and odd behaviours

In our experiment, the fact that 26% of the participants did not reach the destination does not compromise the validity of the study; however it makes us wonder what could be the reasons.

As there was no correlation with the manipulated variables, our best guess is that getting lost is merely subjective. According to [47], people often get lost in buildings because of three contributing factors: the spatial structure of the building, the cognitive maps that they construct as they navigate, and their own strategies and spatial abilities.

Other odd behaviours like running away before the receptionists finished talking, or sitting and waiting instead of following instructions, happened in all the conditions,

Table 6: Mean values (SD) of the total number of reactions per participant for each receptionist.

	EV Ana	EV Kob	CL Ana	CL Kob
Total interactions	2.65 (1.97)	2.43 (1.89)	1.85 (2.43)	3.30 (2.90)
Positive non-verbal reactions	0.53 (0.68)	0.63 (0.74)	0.25 (0.55)	0.65 (0.59)
Neutral non-verbal reactions	0.70 (0.99)	0.48 (0.78)	0.65 (1.60)	0.80 (1.06)
Negative non-verbal reactions	0.23 (0.73)	0.33 (0.66)	0.05 (0.22)	0.75 (1.12)

and seem to have no correlation with neither literacy, receptionist appearance, or voice.

We hypothesise that many participants, since it is the first time that they do a human-robot interaction experiment, were quite nervous and did not want to fail it. Probably for this reason, a few of them took the words "please go now" literally as an order and left the room; a few others waited for further instructions or confirmation by the experimenter. In any of the two cases, these types of behaviours would be inappropriate when interacting with humans.

5 Global discussion

5.1 Impact of the present findings

The two studies provided a considerable amount of data, and the main findings can be summarised as follows:

- Our most important contribution is in the findings regarding illiterate people, which could be applied to other developing countries around the world sharing the same problem. Our hypothesis that illiterates would react more to stimuli of interaction was confirmed and exceeded, as they were even more positive towards the robot receptionists compared to educated people. Therefore, we hypothesise that illiteracy may make suspension of disbelief easier for the experimenters (and for robot designers in general) to achieve. Further studies involving illiteracy could be carried out in order to verify whether the evaluation of robots changes after a period of exposure.
- The present experiment also highlighted a methodological research question on how to make use of questionnaires with the presence of illiterates. Similar issues may be present when dealing with children and elderly persons.
- All the other findings from both the first and the second study are useful to identify the characteristics of a receptionist to be used in Brazil. The survey provided guidance for what a receptionist for Brazilian people should ideally be: good looking regardless the race; female gender; not specified age; able to speak Portuguese regardless of the nationality; polite and competent behaviour. These findings are country specific; however the importance of robot's understandable language seems to be common to other countries and confirms the findings in [26].
- Finally, the results regarding likeability have to be considered. Although the animated agent was preferred to the robot, appearance of the head and human likeness are complex matters that require further investigation before drawing some conclusion. On the other hand, the results obtained on voice provide a contribution to the studies on the Uncanny Valleyand and are significant for the next steps in designing a robotic receptionist, highlighting the need of high quality text-to-speech.

5.2 Limitations

5.2.1 Order of the receptionists

The order of the two receptionists was fixed because the robot is not physically present in our location. This brings some constraints: the interaction has to be enacted in a room with a video conference device and with staff to assist. The call has to be credible, and the setup is fixed in one room used for that purpose. If the order were inverted, participants would have to start from the conference room and reach Ana's location. This would make the purpose of the experiment less believable to the eyes of participants, and it would make the path to follow different (possibly easier) for half of them.

The possibility of different expectations between the two interactions was also controlled, as participants were not taught of a second receptionist until they finished the questionnaire about the first.

While is it still possible that there may have been habituation effects, we did not detect any, as shown in Section 4.3.5.

5.2.2 Physical co-presence

Making equal conditions between the two stimuli came with a cost in terms of realism. A robot is naturally embodied while a virtual agent is not, by definition: therefore in our experiment the interaction with the virtual agent was typical (through a screen), while the interaction with the robot was less realistic than a physical co-present interaction.

Even though the manipulation of robot location was necessary, the setup was made in a way that none of the two receptionists would be perceived as more locally present.

Given the present conditions of the two stimuli, results seem to point out that the animated agent is preferred to a robot.

5.2.3 Head vs. upper body

In the video of Kobiana, it is possible to see most of the upper body, while Ana is represented only by a head. This bias may be a drawback to this study, but we quantified the effect of the presence of the body through the questionnaires. In Fig. 8, comments related to body movement are just a small part (6%) of total comments. We can assume that being more interactive might be due to the presence of body as well. Including this correlation, the amount of comments related to body reaches 13%, which is still a low value.

5.2.4 Location and subjects

A point to consider is that the experiment was carried out in an IT centre. A more complete view of the attitude of Brazilians could be obtained if the interactions were performed in a public office as well as in a rural area, although especially the latter is of difficult actuation.

The number of subjects is also unequal between the groups, as illiterates were difficult to find: this problem was solved by analysing the data through Mann-Whitney test, capable of handling unequal sample sizes. Moreover, gender balance between groups was also slightly different; gender-related significant data were not found.

6 Conclusion

In order to design a receptionist robot to be employed in Brazil, in this paper we described a preliminary survey about the expectation of people regarding the attributes of a receptionist, and an experiment of human-robot interaction. The results gathered through the surveys provided useful indications on the traits that a receptionist robot should have. The second experiment was performed with the participation of two groups of Brazilians, in which one of the two was composed by functionally illiterate people. The experiment consisted in inviting Brazilian people to interact with two receptionists: a conversational agent and a humanoid robot with a mechanical look. Communication was also manipulated, as the voice type was different. In the flow of the experiment, both receptionists gave directions to the participants to reach certain destinations. Results suggested that both groups prefer the agent as it tends to be more anthropomorphised and to be seen less uncanny. The preference is stronger for the group composed by illiterates. Voice type seems to be correlated to uncanniness too. The final goal of this research is to employ a receptionist robot in Brazil, designing it with the help of these initial findings, which are of interest for similar studies in Service Robotics and Assistive Robotics, and could be applicable to other countries. Future works will focus on illiterates, investigating the effect of exposure to technology on the perception of robots.

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Ethical statement: All the participants of the experiments signed a statement of consent in which they agreed to the collection of data from questionnaires, movies and photos.

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