The ACCEPTABILITY of Caregiver Robots in Elderly People

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Abstract: During the last few years, due to the aging of the population, many scientists have developed ICT tools to offer elderly people an independent life at home as long as possible. Most of these researchers focused their efforts on problem solving without adequate care to the agreeability and/or the acceptability of these ICT objects for their users. These resulting artifacts will hardly be used in real life by the users for which they have been developed. In this paper, we will present an experiment done on 202 over 65 elderly people on the acceptability and the likeness features a caregiver robot must have. From the classification and analysis of the emotions elicited by the physical/appearance characteristics of 25 different real robot pictures we found some interesting results for appealing or unpleasant features for caregiver robot design.

1 INTRODUCTION

Populations around the world are rapidly aging. According to an estimation by the OECD by the middle of the 21st century the number of older people will exceed 2 billion (around 21% of the world's population), and this trend will affect and cover not only industrialized nations but also developing nations (OECD, 2015).

To cope with this growing aging population, societies will need to adapt to this changing demographic and invest in healthy aging, enabling individuals to live both longer and healthier lives.

Finding a way to create and strengthen conditions for an "active aging", which also aims to maintain the independence at home of the elderly population, can be a serious challenge but also a great opportunity.

Technology, and particularly AI, could be part of the solution to this problem, offering support for older adults with the difficulties and challenges associated with aging (Pollack, 2005). Specifically robots could have great potential for providing assistance to older adults in their own homes and so the question about robot acceptance is particularly relevant for proper artifact design.

Various researches focused on the study of the functions that a caregiver robot should perform. Numerous attempts to create robotic tools, both in development and commercialization, have been create to carry out specific tasks to help the elderly live at home for longer by performing activities such as medication management, house keeping, social entertainemen and providing emergency monitoring.

However, as shown in literature, technology applications developed for senior users are often discarded due to factors that are specific to this age group of people. Acceptance of a robotic caregiver is a complex and multifaceted issue. Studies conducted on elderly people is usage of ICT tools showed how the reluctance to adopt new technological instruments is not only due to a lack of skills but, also, to the lack of perception of advantages and benefits of using these tools. To ensure acceptance of these new technological tools the age-related changes in perceptual, motor and cognitive abilities must be considered. Combined with these really key aspects, it is necessary to recognize the importance of the compensatory process that older people develop to adapt to their changes and to understand the crucial role played by motivation, affection, and experience in every social interaction. In this context, if we want to increase the likelihood that people will utilize robot assistance, acceptance is a key factor. Indeed, if the development of these robots designed to solve pretended problems, does not lead to agreeable and/or acceptable objects to the elderly, they will hardly be used.

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As a result, we decided to focalize our attention on older adults' attitudes and preferences for robots, focusing on the aspects that are not functional but kinesthetic, because the acceptability of these tools, for this age group, depends heavily on empathetic factors. Keeping this in mind, we could be able to design robot capable to serve the needs of the elderly.

2 CAREGIVER ROBOT

This paper is part of the extensive research landscape that is being carried out today in the field of social robotics. Researches in eldercare proposed robots to be a form of assistive technology with a great potential to support older adults, to maintain their independence, and to enhance their well-being (Ezer, et al., 2009).

In literature, assistive robots are classified in two groups according to the function for which they were developed: rehabilitation robots and social robots (Broekens, et al., 2009).

Social robots, used in eldercare studies, can then be divided into two other categories: service type robots, developed to be used as assistive devices, and companion type robots, developed to enhance health and psychological wellbeing.

The research in this field is rich and fervid and the technology development in the homecare robotic field is developing faster and faster. Probably in the near future, robot caregivers will become feasible and affordable, but, currently, this technology development is mostly technology driven. The question if the elderly would accept a robotic assistant at home has still to be more deeply investigated.

In literature, most of the studies measured the acceptance of specific robots with limited functionality (Smarr, et al., 2013). Some papers cover the definition of the tasks that elderly could delegate to robot assistant. In (Ziefle and Calero, 2017) for example, particular situations where elderly people can accept that some tasks are performed by a robot on behalf of humans are discussed. But this gives little information about general attitudes and perceptions of the elderly about robots because it is too related to the contingency of the performing task.

Other studies investigated the relationship between appearance and functionalities, stated that appearence influences the assumptions that people make of a robot and of the tasks correlated to it (Goetz, et al., 2003). In this meaning, appearance must support the real expectations of the robot's skills. The more the user gets a clear idea of what the machine can do, the less he will be disappointed when using it (Kaplan, 2005). Within this vision, functionalities of the robot loose weight and the appearance should be designed just to help users build a mental model of the robot usage (Lohse, et al., 2008).

On the other hand, researches also emphasized how the technologies for assistance, designed to facilitate autonomy, are often perceived as a handicap or aging signal and this realization can lead to their rejection. Therefore the design of assistive ICT tools should be universal. It should aim at de-stigmatizing assistive robots making them appealing and useful for everyone and not just for the elderly or disabled (Wu , et al., 2014).

Finally, as highlighted by Van der Heijden, in 'hedonic systems', the concept of enjoyment is crucial for the intention to use a techological tool (Van der Heijden, 2004). Obviously, in eldercare, we can't say that a robot is developed just for entertaining, but enjoyment needs to be part of the acceptance model for robotic technology.

Our research moves right from this assumption and seeks to understand in advance what the physical characteristics are that affect acceptability and enjoyability, making them the basis for future developments and functional studies.

3 RESEARCH QUESTION AND PURPOSE OF THE STUDY

This paper examines the physical features that make a caregiver robot fit and usable in order to understand the peculiarities such device should have to be really used by the elderly at home. The caregiver robot should increase independent living and social participation of older people in relatively good health, comfort and safety.

In our experiment, we investigate what appearance a robot shoud have. Our analysis reflects on physical aspects of the robot rather than on functional aspects. We designed an experiment to try to identify empathetic features that, in some way, facilitate the acceptance and desirability of the robot by the elderly.

This experiment was conducted on 202 italian people aged over 65.

Table 1 shows the robots we selected to be evaluated within this experiment. These robots have been chosen among various artifacts developed in the world research scene. We did not limit our choice among social assistive robots, but we also took into account machines belonging to different fields of application like Kismet or ICube.

We created twenty five cards, one for each selected robot, to highlight the physical and functional characteristics and robot dimensions. Each card contains two or more color images of one robot with elements (people or objects of known size) that allowed the observer to informally infer on dimensions and functions of the robot.

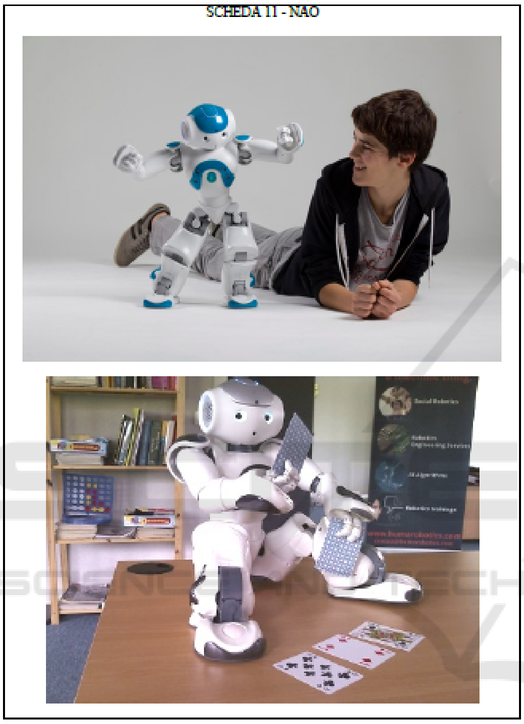

Figure 1: Experiment card example. As you can see, picture 1 displays the Nao robot dimension and its possible social interactions. Picture 2 displays the entertainment activity of Nao robot.

For our experiment we chose to use a robot classification that can be partially riconduced to the Brokens et al. paper (Broekens, et al., 2009). The pool of tested robots was composed as shown in Table 1.

The first group is composed of medical/rehabilitation robots. In this category, the enphasis is focused on the physical assistive technology and function (i.e. Riba II, a robot developed to perform patient-transfer tasks (Toshiharu, et al., 2010)).

The second group is representative of the social robots, systems that can be perceived as social entities with communication capacities. In this case, as stated in literature, we complied with the distinction between service robots and social robots. Service type robots typically investigate which social features can lead to the acceptance of a robotic device at home and how these same social features can facilitate the actual use of the device. Examples of these researches are the German Care-o-bot, a robotic assistant that supports people in their daily living at home performing common tasks like offering drinks, setting the table, switching on the TV or the radio and even calling for rescue service in case of emergency (Graf, et al., 2004), or Giraffplus, a robot developed to check elderly health, ready to rescue in case of emergency and able to put users'video calls through to their relatives and physicians (Coradeschi, et al., 2014). Companion type robots focus on pet-like companionship, like the Japanese seal-shaped robot, Paro, (Wada, et al., 2003 and Shibata and Wada, 2011), the Sony small robot dog, Aibo, or the robotic Japanese cat, Yume Neko Venus.

Table 1: List of the 25 robots evaluated within the experiment.

Medical/rehabilitation robots		iRobi Q
		Riba II
		Medical robot
Social robots	Companion type	Aibo
		Yume Neko Venus
		NAO
		Paro
	Service type	Roomba
		Car-O-Bot
		Giraffplus
		Asimo
		Pepper
		Electronic Sourveillance
		Turtle Bot
		Romeo
		Chess Terminator
		Ramcip
		PR2
General purpose robots		CB2
		ICube
		Kismet
		Mathilda
		Albert Hubo
		Wall-E
		Kobian

Finally, we added the general purpose robots group where we put robots that are not classifiable within the two previous groups. They don't have a specific function clearly understandable by looking at the pictures.

3.1 Method

3.1.1 The Sample

This experiment was conducted on 202 italian people aged over 65, participation was voluntary and anonimity was guaranteed. Each participant signed a disclaimer sheet for privacy. Data was collected through personal interviews conducted by graduates in psychology. The duration of each experiment session was approximately 1 hour.

The experiment started by collecting information about participants' demographics (age, gender, profession and education).

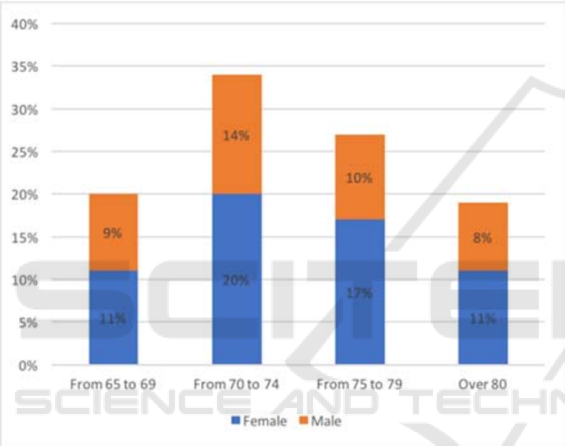

Figure 2: Sample distribution age by gender.

The response sample was composed of elderly Italian adults living independently (N = 202), aged 65 to 87 (M = 74 years; SD =5,5 years). 59% of the sample was composed by female and 41% by male.

Participants varied in their educational background, with 39% having college or university education and with 61% having less than a formal college education (35% having only a first grade education).

3.1.2 The Experiment Process

Each participant was asked to judge the acceptability of the robot based on the feeling elicited by the observation of each card containing the picture of the robot and to put the cards in order by preference: first the preferred one and last the less liked.

The conductor of the experiment, to facilitate the carrying out of this task, presented the participant

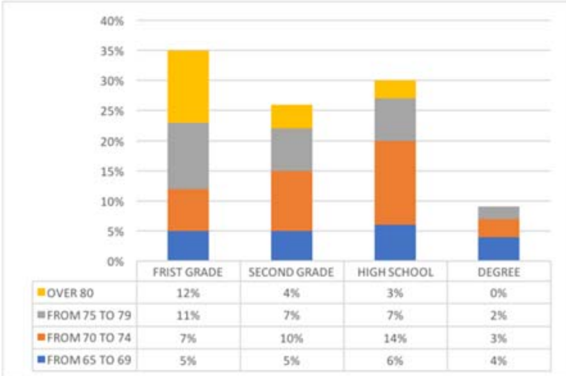

Figure 3: Participant education distribution.

with cards in pairs. Then, he/she asked the question: 'Which robot among these two would you prefer to have at home?'. Among these two cards, the participant had to choose which one he liked more. Iterating this process, all the 25 cards were sorted in order of preference.

No verbal information on the role and/or function of the robot was given to the participants. Conductors were instructed, if questioned about the robot, not to give direct answers, but to stimulate reflection by letting the participants think what he/she might infer from the images.

4 RESULTS

A preliminary analysis was performed in order to evaluate only cards classified in the first or in the last position. Figure 4 shows the number of times each robot obtained the first position.

In the right space of figure 5, the five robots that got the highest number of first places are shown: they are Aibo (12%), the little Sony robot dog, Yume Neko Venus (11%), the Japanese robotic cat, ICube (9%), the baby-like robot developed by IIT, Paro (8%), the small Japanese seal-shaped robot and Giraffplus (7%) the social communication robot.

The experiment results showed a strong preference (about 40% of the sample) for robots similar to small animals or babies.

By analyzing the distribution of the score of robots with the last ratings, we can observe that the worst classified robot is CB2, the baby-like robot (17% of the participants placed it in the last position). CB2 and ICube are both baby robots: what is the difference between them that makes such a big difference in the preferences? CB2 is bigger then a human being, ICube is smaller. CB2 has a more

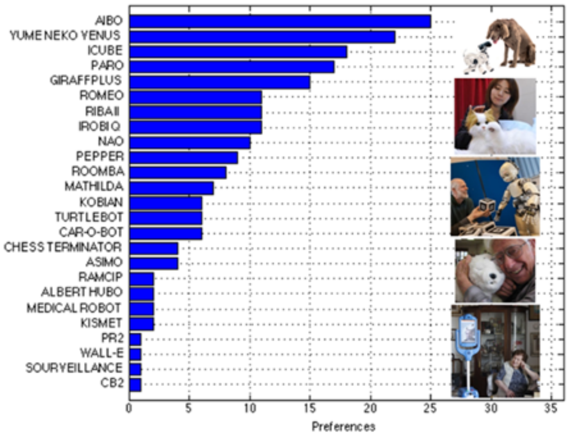

Figure 4: Distribution of number of the first position scores for each robot. On the right side of the picture, an image of the 5 first classified robots is shown.

detailed face than iCube, in this case confirming the Uncanney Valley theory (Mori, 1970). And last , but not least, in recent times, ICube robots have been presented many Italian TV shows and advertisements and maybe its look became familiar.

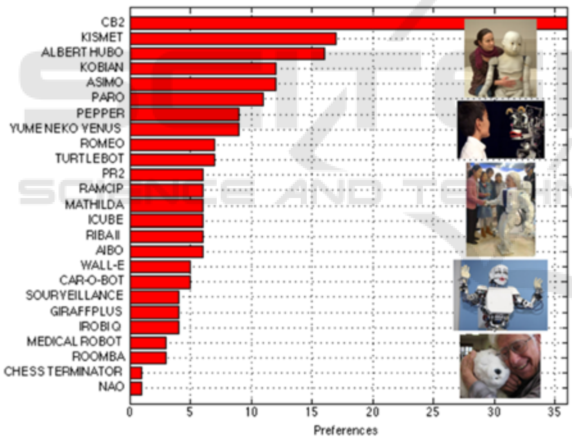

Figure 5: Distribution of number of the last position scores for each robot. On the right side of the picture, an image of the 5 worst classified robots is shown.

It is interesting to underline that the social robots Kismet, Albert Hubo, Kobian and Asimo together account for 46% of the last position. What do they have in common? All of them show a human-like appearance and all of them have dimensions that are greater or equal to human dimensions.

This analysis, however, gives us only a partial picture of the results of the experiment and therefore, in order to be able to take into account the intermediate positions, we made an overall analysis of the order of classification of the cards by extrapolating average, median and mode from the data sample. As seen in Table 2, the arrival order varies according to the statistical value considered.

Table 2: Mean (M), Standard deviation (SD), Median (Me) and Mode (Mo) of the robot scores, ordered by Median.

	Robot	M	SD	Me	Mo
1	GiraffPlus	9,59	7,04	8	2
2	Aibo	9,93	6,7	9	1
3	Roomba	10,98	6,55	10	4
4	NAO	10,48	6,32	10	5
5	Paro	10,94	7,87	10	2
6	Asimo	11,79	7,01	10,5	6
7	Yume Neko Venus	11,25	7,96	10,5	1
8	Romeo	11,68	6,92	11	13
9	I Robi Q	11,79	7,02	12	2
10	Turtlebot	13,02	6,36	12	7
11	Car-O-Bot	12,83	6,94	13	18
12	Riba II	12,48	7,83	13	2
13	ICube	12,19	7,4	13	1
14	Wall-E	13,38	6,53	13,5	4
15	Pepper	13,43	7,03	14	22
16	Medical	13,66	6,71	14	21
17	Chess Terminator	13,29	6,36	14	14
18	PR2	14,82	5,98	14	12
19	Ramcip	14,43	6,07	14,5	11
20	CB2	16	7,34	16	25
21	Kismet	15,35	7,29	16	21
22	Mathilda	13,96	7,91	16	23
23	Sourveillance	15,24	6,53	17	22
24	Kobian	16,2	6,78	17,5	15
25	Albert Hubo	16,3	7,21	18,5	24

If we take the median as a significant value in the first five positions, we find Giraffplus, Aibo, Roomba, Paro and Nao. Among them, there are Paro, Aibo and GiraffPlus, which also appeared among the top 5 of figure 4.

By considering the median, more than 50% of the sample liked Giraffplus and put the robot within the top 8 positions.

Even if Giraffplus is taller than human beings, it is probably non considered dangerous since it is very thin and its functions (allowing video communication with other people), coupled with a non similarity to human being, contribute to rating it in a good position for a wide number of people.

Second, we find Aibo. For 50% of the participants, Aibo is rated between the first and the ninth position. In third place we find Nao, Paro and Roomba (the cleaning robot). For more than 50% of the sample, their rating is located within the top 10 rates.

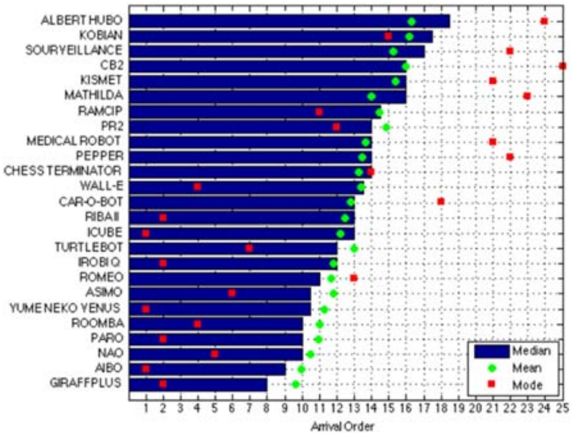

Figure 6: Distribution of Mean, Median and Mode ordered by Median-Mean of robot rating.

To measure the statistical dispersion, we divided the data set into quartile and we computed the interquartile range (IQR) that is equal to the difference between third and first quartiles. Quartiles divide a rank-ordered data set into four equal parts. The values that separate parts are called the first, second, and third quartiles; and they are denoted by Q1, Q2, and Q3, respectively.

For each robot card, figure 7 shows the median of the position value with IQR didtribution.

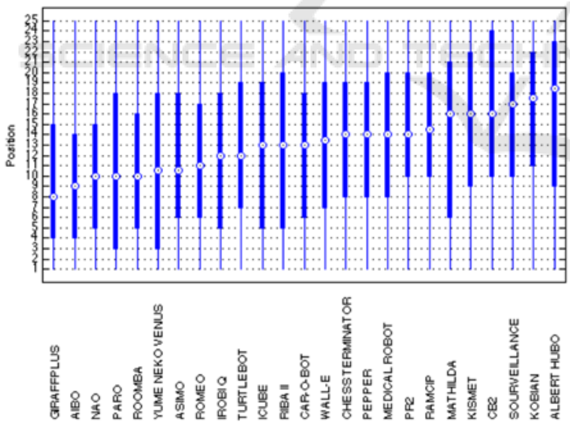

Figure 7: IQR distribution for median of the position values of the card position for each robot.

The interquartile gap indicates a measure of how many values deviate from the sample median.

If we consider the variability of the first 5 robots with lower median (i.e. the 5 best classified robots by using the median of the position rate as evaluation parameter) we can observe that while Giraffplus, Aibo, Nao and Roomba show a comparable variability, Paro show a larger variability in the position.

Giraffplus, which is the best classified in this case, shows IQR valus larger then Aibo, Nao and not perfectly centered.

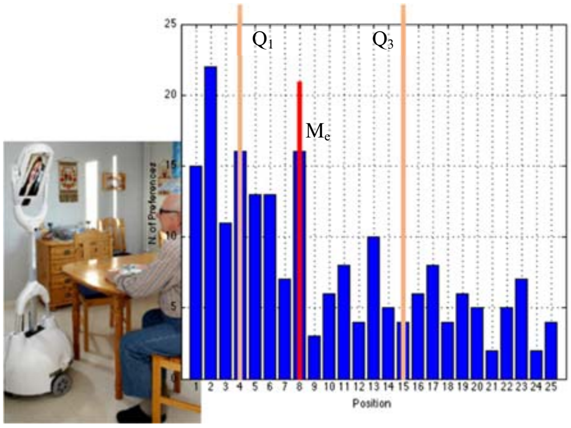

Figure 8: Giraffplus position rate distribution. Q_1 and Q_3 are the first and the third Quartile respectively and M_e is the median value.

Indeed, the 50% of rates falls between Q_1 and Q_3 but it is shifted to Q_3.

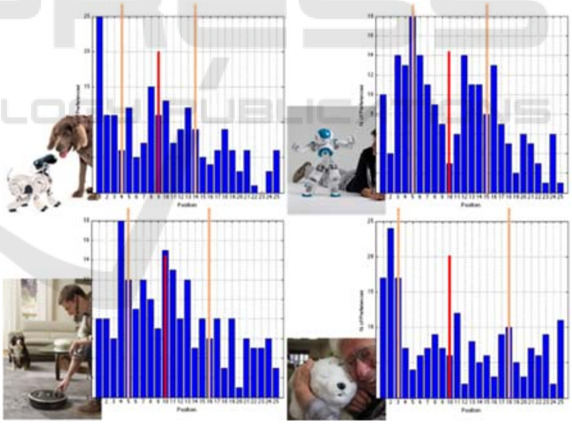

Figure 9: Position rate distribution of Aibo, Nao, Roomba and Paro.

Figure 9 shows the position rate distribution of Aibo, NAO , Roomba and Paro. The high IQR of Paro indicates that this robot shows some characteristics that are considered positive for some and for others are neutral or negative. Paro is a social robot that ‘asks for caregiving’ and its liking may depend on the emotional features, on the story or on the mood the evaluator is experiencing.

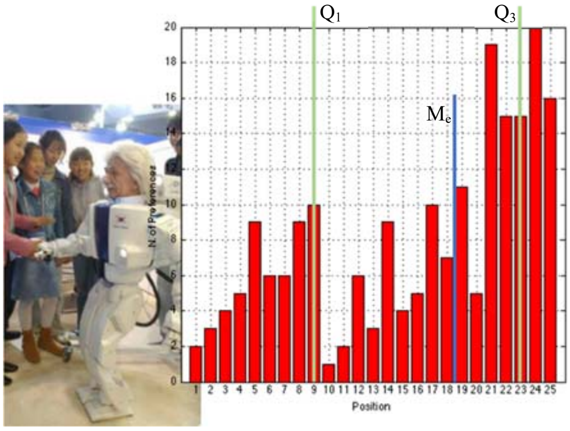

Figure 10: Albert Hubo position rate distribution. Q_1 and Q_3 are the first and the third Quartile respectively and M_e is the median value.

Robots rated with the 5 highest median value in the card evaluation process mostly confirm the previous deductions. Albert Hubo, the Japanese robot with the Albert Einstein face, is placed in the worst position, followed by Kobian, another Japanese humanoid robot with human dimensions that can display seven different emotions. The forth worst position is occupied by CB2, the Japanese baby robot, and in the fifth worst position we can find Kismet, the MIT robot face able to recognize and reproduce emotions.

The presence of humanoid robots in the worst positions also confirms also for elderly people the theory of the Uncanny Valley proposed by Masahiro Mori (Mori, 1970). Indeed humanoid objects which appear almost, but not exactly, like real human beings elicit uncanny or feelings or feelings of strangeness and revulsion in observers. Moreover, the dimension of these humanoid robots seems to be critical to worsen the feeling of discomfort caused by the humanoid robots. The surveillance robot can affect everyone's need of privacy. A robot performing surveillance can be explicitly perceived as a prosthesis, a privacy intrusion or a signal of loss of independence and autonomy.

Furthermore, the presence in the picture of the controller tablet induced a feeling of technological inability.

5 CONCLUSIONS

In this paper, we presented an experiment on the acceptability of robot caregivers done with 202 elderly people as participants. Preliminary results suggest some important tips for designing a usable artefact. While most critical negative factors are large sizes, excess of human similarity, the feeling of low level of controllability or an overly mechanical aspect. The most popular robots seem to be the ones that in some way maintain their robot likeness. They should be small and can be perceived as a toy or a puppy. Even if the puppy likeness seems to elicit empathy, closeness, and confidence, the resemblance to human babies seems not sufficient to guarantee appeal. The robot should maintain its robot identity, clearly recognizable. This experiment showed that the most important features therefore seem to be small sizes, cartoon traits and/or animal appearances.

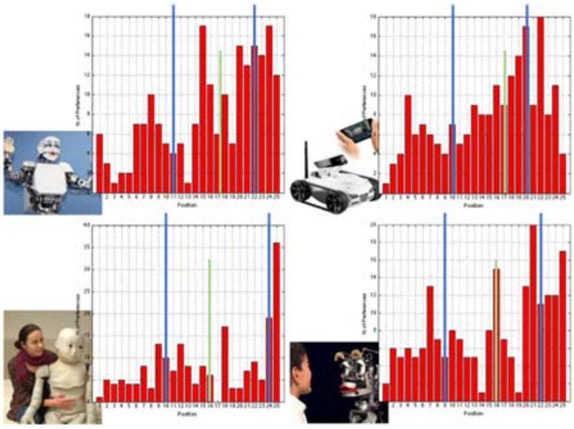

Figure 11: Position rate distribution of Kobian, the sorveillace robot, CB2 and Kismet.

Naturally, this suggestion is critical because it is difficult or impossible for small robots to perform some service tasks. Some solutions can, probably, be found in the direction of the distribution of services: many small robots performing different tasks. Other solutions can be reached by involving elderly people in new robot design.

Last but not least, a robot caregiver should help elderly people, but should also facilitate communication with other human beings (as the high rate of Giraffplus shows).

Our results advance the understanding of older adults' attitudes and preferences which may influence the design of robots more likely to be accepted by older adults.

Future research will investigate in detail the feeling elicited by the single robot, how older adults interact with a physical robot and how/if attitudes change over time.

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