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SURVEY PAPER

Design Space Survey on Social Robotics in the Market

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Abstract
Socially interactive robots are being introduced in daily life as common objects that facilitate people's life. A wide range of possibilities are offered and the trends show a growing market. In this survey 40 commercial robots were analysed to evaluate the state of the art from a design space perspective, aspects like embodiment, task, social role, context of use, DOF (Degrees of Freedom) and user studies performed on the robot are included. As a result, a clear design pattern was identified: an egg-shaped, white plastic robot with a rendered face that displays expression of emotions and a speech interface is the common base of the majority of the social robots available in the market. The preference for this kind of embodiment is not even studied nor documented in the literature and varies according to the target group and culture.

Keywords Social robots · Design space · Embodiment design

1 Introduction

Social robots have become desirable objects to have at home, often advertised as ideal emotional companions or smart assistants. Every year during CES (Consumer Electronic Show), new designs of social robots are presented to fill a variety of roles, such as cooking assistant, language teacher and sports trainer. Likewise new social robots are being promoted in platforms like Kickstarter, where people attracted by a concept support its development, creating the opportunity for new devices to come to life. Consequently, the market of robots has grown dramatically in the last two decades. It is foreseen to be one of the fastest-growing markets in the next 15 years [35], [11].

Social robots must be capable of interactions that people will find meaningful [20], and therefore, the human factor is of the highest priority. When designing a social robot, how it will function in the home environment, come across as trustworthy, and be accepted are vitally important considerations. Thus the robotics field is increasingly interdisciplinary, with engineers teaming up with designers, psychologists, animators, and other creatives to create robots that users will perceive as having distinct and original personalities in addition to the interactions that are the robot's main function.

The main goal of this survey is to investigate state of the art social robots on the market from a design space perspective, identifying the most important aspects that a designer can use to modify impressions of a social robot, such as visual impression, social role, context of use, and specific behaviours. These aspects were not analysed in isolation. This survey considers design space dimensions as interrelated categories that influence each other, providing a more holistic perspective. Approximately 50 robots were considered, and 40 social robots were surveyed. Criteria for inclusion were robots that did not reach the uncanny valley, intended for use in home or services areas by users without technical skills, which are currently available for purchase or which were on the market in the last three years. The remainder of this paper is organised as follows: in the next section we detail the selection criteria of the robots, followed by the introduction of Design Space and the explanation of the categories therein. In section four, we present the survey, and follow with the discussion.

2 Selection Criteria

To select robots to be analysed in our survey, the main criteria were robots that were available in the market, designed to interact with non-technical users, with social interaction

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modalities. We used non-academic search engines with the key words "social robots" and "social robots in the market". Then we checked official websites, technology blogs, and company and user videos to corroborate that the robots were actually available in the market in a period no later than three years ago. The reason why we also included robots that are not in the market at the moment but were in the last three years is that many of the companies that produce these robots faced financial, pricing and production challenges, which are not necessarily related to the design approach. Finally, we decided to focus on robots whose embodiments do not reach the uncanny valley. Fully anthropomorphic agents are designed for a specific market and the retail prices are inaccessible for the majority of the population. For instance, the robot Sophia [29] is only available for specific uses and researchers. Some robots belong to the "Sexbot" category, which are part of "Sextech" which is an industry whose value is approximated at 30 billion US dollars [9].

3 Design Space

According to Eric et al. [10] "the design space comprises the elements that designers can manipulate to create variations in the appearance, behaviour, and overall structure of a product". In this paper, we used the factors of the design space for robots proposed by Hegel et al. [13]: form, function, and context, combined with interaction modalities of social role, embodiment, and communicative behaviours [10]. These factors are not independent, as stated in [12]: users create expectations and mental models regarding the robot depending on its actual appearance, functional and social abilities. They are most attracted to the robot which has behaviours appropriate to its function and the situation. Function is therefore a category that is important to consider. Hence, in this survey discussion, the results combine different design space dimensions. Likewise, the target group, mechanical degrees of freedom of the robot, and approach of user studies were included as part of the survey to have a more comprehensive overview of the social robots in the market from a complex design space perspective. As follow, the seven categories of the design space survey are: (1) Design metaphor and level of abstractions, (2) Task, (3) Social role, (4) Context of use and degrees of freedom, (5) Target group, (6) Interaction modalities, and (7) Approach for user studies.

3.1 Design Metaphor and Level of Abstraction

To analyse the physical appearance and aesthetics of the social robots on the market and to understand the current design trends, the concepts of design metaphor and level of abstraction used previously in [6, 10] were adopted. The relation between both is well known in the design field and allows for a comprehensive study of the aesthetic of the socially interactive robots. The design metaphor refers to the most resembling and identifiable concept of inspiration for the embodiment of the robot, which can vary from humanoid to animals, or from common day objects to abstract shapes. The level of abstraction refers to the degree of realism in the design metaphor. It is important to identify both elements because the level of abstraction of the design metaphor has a direct implication in the expectation that users create regarding the social robot [6].

3.2 Function

Considering that there are not any standard definitions on what concepts such as "general assistance", "edutainment" and "companionship" mean, which in most of the cases relies on personal preferences [7], the function categorization is based completely on what companies advertising material promotes, for instance, assistant, surveillance, entertainment among others. Sometimes a robot can have a function of assistant, teacher and monitor simultaneously, which leads it to be multitasked. In some other cases, robots like Furhat have different tasks: it can be used to hire employees sometimes, and provide customer service at other times. This affects the social role assigned to the robot. To the best of our knowledge, there are no studies that have a standardised definition of the functionalities that a robot can perform, and consequently, two robots promoted to fill the same function can differ in capabilities. For instance, two robots might both be promoted as cooking assistants, but one helps the user to cook by projecting images on a table, while the other narrates the instructions by speech. Both robots belong to the same category, fulfilling the same task, but through different actions.

3.3 Social Role

Previous studies have explored the possible roles that a robot can play when interacting socially. In the work of Deng et al. [6] they used the organisation theory [21] to establish three classes of social role: subordinate, peer and superior. The work of Dautenhahn et al. [5] postulated five other classes: assistant, machine, servant, mate and friend. Nevertheless there is a gap in both works. While [5] is missing a class for a superior position, and the social role "peer" suggested in [6] might leave behind possible social roles that are in the same line of hierarchy but with a different social meaning like friend or mate. Therefore in this paper, the following 5-class categorisation is proposed: superior, subordinate, friend, pet and subordinate-friend.

Superior: is the position in which the robot can give instructions and be perceived as someone that needs to be listened to and followed. Subordinate: is the role played when the user is in control of the robot and can give instructions to it, and the robot has to follow indications. Friend: the robot is considered as a mate with the same level of hierarchy as the user, with a higher level of intimacy than a regular peer. Pet: the robot is considered as a friend that needs more nurture and care than a peer. Subordinate-friend: the robot follows orders from the user as a subordinate. However these robots spend plenty of time in home settings and they use interaction techniques with more emotional cues that may lead to a deeper relationship with its user.

As the role is not always clearly specified in available documentation about the robot, we aimed to make an educated guess to establish the social role of robots based on the functionality, context of use, target group and embodiment. As is acknowledged by Deng et al. [6] "Understanding how people respond to agents of varying social roles is critical for designing socially interactive robots.". It is important to highlight that this categorization is not based on a user's perspective, but from what companies advertised as functions and type of user.

3.4 Context of Use and Degrees of Freedom

Context of use refers to the area where the robot performs its function, based on the pictures, videos and descriptions provided by the companies five categories were found: 1) Floor, 2) Table, 3) Table and floor, 4) Users' lap, and 5) Users' arms. This analysis was combined with the mechanical degrees of freedom and the robot's capability of 3D mobility (i.e. the robot can navigate in space or can only stay in one place). Due to the nature of the study and the lack of detailed information from the manufacturers of the robots, some slight discrepancies may appear with the real details of the robots in the DOF part. Unifying these categories results in a clear pattern of where is the most common area of use and the extent of mobility of the social robots present in the market.

3.5 Target Group

Even though the study includes only social robots that are developed to interact with non-technical users, a variety of potential users were found. From the general population to adults, kids, kids with special needs, elderly, or in specific cases, adults that belong to specific industries such as nurses are present in this survey.

3.6 Interaction Modalities

The reported and visible interaction modalities of the social robots were analysed. Interaction modalities are divided by input and output modalities. When facial expressions are included, it is understood the intention of the robot to convey emotional cues. There is a direct relation with facial expressions and the intention of conveying emotions, on the grounds that humans read faces to infer information about the emotional states of others, facilitating communication [26]. The ability of the robot to recognise emotions and to use affective computing was not included in the survey, unless the official description of the robot provided by the company explicitly says that it reads emotions.

3.7 Approach for User Studies

This dimension incorporated the studies where users are included to evaluate different aspects of HRI including user experience and aesthetic perceptions. We aimed to analyse the type of studies, sample size, whether the studies were qualitative or quantitative, also if the studies are one time or long term interaction. To find studies, scientific databases were used, and the search was using the specific names of the robots. When several studies were available, a maximum of three studies were included per robot. However, not all robots had studies to be shown. This paper does not include studies where the system, mechanical or technical part are evaluated.

4 Survey

The summary of the survey is represented in the Table 1.

5 Discussion

5.1 Design Metaphor

Based on the analysis of the data, a clear design pattern appeared (Fig. 1): a high level of abstraction egg round shape with a rendered face is the most common approach for the robot embodiment. Clicbot is the only exception that changes according to the parts chosen by the user and adapts to multiple design metaphors. Humanoid and animal-like design metaphors are less common. Interestingly, Walters M et al. [34] explained that people tend to prefer more humanistic aesthetics, however, basic robot's appearance may be more acceptable for a majority of people. Similarly, Dereshev et al. [8] found that abstract designs in a robot like Jibo (C8 in Fig. 1) are perceived more positively in a pre-interaction setting. This could lead to a first hypothesis that the common pattern in basic and abstract shapes is because most of the robots are designed to interact with the general population (Fig. 2). Another important aspect is the lack of use of extremities such as arms or legs, and the majority use of the white colour, although

Table 1 Summary of the survey. HLA = High level of abstraction, MLA= Medium level of abstraction, LLA = Low level of abstraction

Position (Fig. 1)	Robot	Design Metaphor	Function	Social role	Context of use	DOF	Target group	User Studies
A1	Lynxs	Humanoid (HLA)	Assistant, surveillance. exercise instructor.	Subordinate	Floor/ Table	18	General	NA
A2	Robohon	Humanoid (HLA)	Education, entertainment, surveillance, assistant	Subordinate/ Friend	Table	10	General	Semi-structured interviews , obser-. vations on the use of robots in real-life settings, case studies, and one experiment, to investigate attitudes, perceived benefits, and disadvantages of using robots [17]. Quantitative study using a questionnaire to evaluate the impression and effectiveness of activities using robots N80 [32]
A3	Pepper	Humanoid (HLA)	Reception, guidance, Education, and research.	Subordinate/ Friend	Floor	20	General	Statistical analysis N43 rating trust. in the robot after a video demonstration, a live interaction, and a programming task [30]. Detecting users' habits to find the right balance of a robot that speaks. Long term exploratory data collection (8 weeks) N10 European homes [28]. Quantitative study, Evaluation of culturally competent socially assistive robots among older adults residing in long term care homes N45 [27]
A4	Farnese Robot	Humanoid (HLA)	Guidance.	Subordinate	Floor (Public areas)	4	Adults	NA
A5	Amy	Humanoid (HLA)	Reception, guidance, surveillance, telepresence, education	Superior	Floor (Home)	4	General	NA
A6	Furhat	Humanoid head (LLA).	Hire and train new employees, teach language	Superior	Table	2	Adults	Survey after short term interaction, large sample [23]. Survey to evaluate recognition of facial expressions. N31 [31]

Table 1 (continued)

Position (Fig. 1)	Robot	Design Metaphor	Function	Social role	Context of use	DOF	Target group	User Studies
A7	James Zora Robots	Abstract	Assistant	Subordinate	Floor	3	Elderly	NA
A8	Zenbo	Humanoid (HLA)	Assistant, entertainment, surveillance, education	Subordinate	Floor (Home)	5	General	Mixed Methods Study. Identifying Features that Enhance Older Adults' Acceptance of Robots. N33 [13]
B1	Ipal	Humanoid (HLA)	Entertainment, education, companion, surveillance.	Subordinate/ Friend	Floor (home or public areas)	14/24*	Kids, elderly.	NA
B2	QTrobot	Humanoid (HLA)	Education and support	Friend	Table (Schools, homes)	8	Kids with special needs, parents and educators.	Exploratory study, Statistical analysis N10. [4]
B4	Aido	Abstract	Entertainment, assistant, education, home manager.	Subordinate/Friend	Floor (Hospitals, homes, elderly houses)	3	General	NA
B5	Cutii	Abstract	Assistant, communication mediator	Subordinate/Friend	Floor (Homes)	3	Elderly	NA
B6	Mabu	Humanoid (HLA)	Healthcare companion	Subordinate/Friend	Table	2	Elderly	NA
B7	Buddy	Humanoid (HLA)	Entertainment, personal assistant, (connect to smart home's devices.) Surveillance.	Subordinate	Floor. (Home)	4	Elderly and kids	Qualitative Study to evaluate Initial reactions, concerns and impressions, N20 [8].
B8	Hub Robot	Egg shape	Assistant	Subordinate	Table (Home)	4	General	NA
C1	Moxi AI Nurse Robot	Human, (MLA)	Helping clinical staff with routine tasks that are not related to patients.	Friend	Floor (Semi-structured hospital environments.)	11	Nurses	NA
C5	JELLY	Abstract	Assistant for business	Subordinate	Table	3	General	NA
C6	EQL Qubi Robot	Abstract	Security and vacuum cleaner.	Subordinate	Floor, (Homes)	3	General	NA
C7	Hugo	EggShape	Assistant	Subordinate	Table (Home)	2	General	NA

Table 1 (continued)

Position (Fig. 1)	Robot	Design Metaphor	Function	Social role	Context of use	DOF	Target group	User Studies
C8	Jibo	EggShape	Assistant, telepresence	Subordinate/Friend	Table (Home)	2	General	Qualitative Study to evaluate Initial reactions, concerns and impressions, N20 [8]
D5	3EA18 Empathy robot	Humanoid/ Egg shape (HLA)	Guidance and support	Subordinate/Friend	Floor (Public areas)	3	General	NA
D6	Kuri	Egg Shape	Assistant, surveillance.	Subordinate	Floor, Homes	6	General	NA
D7	Gong Zi	Egg Shape	Assistant	Subordinate/Friend	Table, (Home or a service area)	2	General	NA
D8	Egg alpha	Egg shape	Education, assistant	Subordinate/ Friend	Table (Home)	0	Kids	NA
E5	Elliq	Abstract	Assistant, communication mediator, and telepresence.	Subordinate	Table (home)	3	Elderly	Long term interaction study Tested with beta users. (Details not provided)
E6	Pudding	Egg Shape	Education,Assistant	Subordinate/Friend	Table (Home)	3	Kids	Comparing how children and adults with different amount of experience talk to the Pudding robot N12 [33]
E7	Pico	Egg Shape	Assistant, Entertainment	Subordinate	Table/floor	5	General	NA
E8	Tapia	Abstract	Assistant	Subordinate	Table (home)	1	General	NA
F1	Vector	Toy Excavator	Assistant, Entertainment.	Subordinate	Table/ Floor (Home)	5	General	Quantitative study, one time interaction evaluating curiosity toward the robot addressing the difference of age and personal interest N100 [2]
F5	Clicbot	Abstract	Education, games.	Subordinate	Tables or floor (Home and outdoors)	1/20**	General	NA
F6	Qoobo	Cushion with soft and smooth fur	Therapeutic robot	Pet	User’s lap.	2	People who cannot own pets	Evaluation of Tail interaction, 3 weeks experiment N4 [14]
F7	Leka	Ball/ Toy Like	Education, mediator communication	Friend	Table/Floor	3	Children in the ASD spectrum and parents.	NA

Table 1 (continued)

Position (Fig. 1)	Robot	Design Metaphor	Function	Social role	Context of use	DOF	Target group	User Studies
F8	Pillo	Abstract	Assistant	Subordinate	Tables (Home)	0	Elderly and their family	Statistical analysis of the Design Space of Rendered Robot Faces N50 [16]
G1	MarsCat	Catlike (LLA)	Entertainment/ company.	Pet	Floor (Home)	16	General	NA
G2	Sony Aibo ERS-1000	Dog/Puppy (LLA)	Entertainment	Pet	Floor (homes)	18	General	Quantitative Cross-cultural study on peoples' negative attitude toward robots N467 [1].
G3	Paro	Seal (LLA)	Therapeutic	Friend	User's lap	6	Elderly	Qualitative study, Interaction, storytelling with multimedia and focus group. N233 [25]. Quantitative study: Understanding Older Adults' Perceptions of Usefulness, N30 questionnaires and interview questions [22]. Quantitative study: Effectiveness of Paro N23 long-term (year and a half) observation and tabulation of behaviour [19].
G5	Lovot	Penguin/pet like, High level of Abstraction	Companion, surveillance	Pet	user arms and floor (homes)	13	General	NA
G6	Fribo	Cat like High Level of Abstraction	Mediator	Subordinate	Table (Home)	0	General	Evaluation of effectiveness of objectives (social connectedness) four-weeks study N12 [15]
G7	Domgy	Dog-like (HLA)	Education	pet	Floor (Home)	7	Kids	NA
G8	Kiki	Cat Like	Entertainment,	Pet	Table, (home)	6	General	NA

*Depends of the model

**Depends of the parts

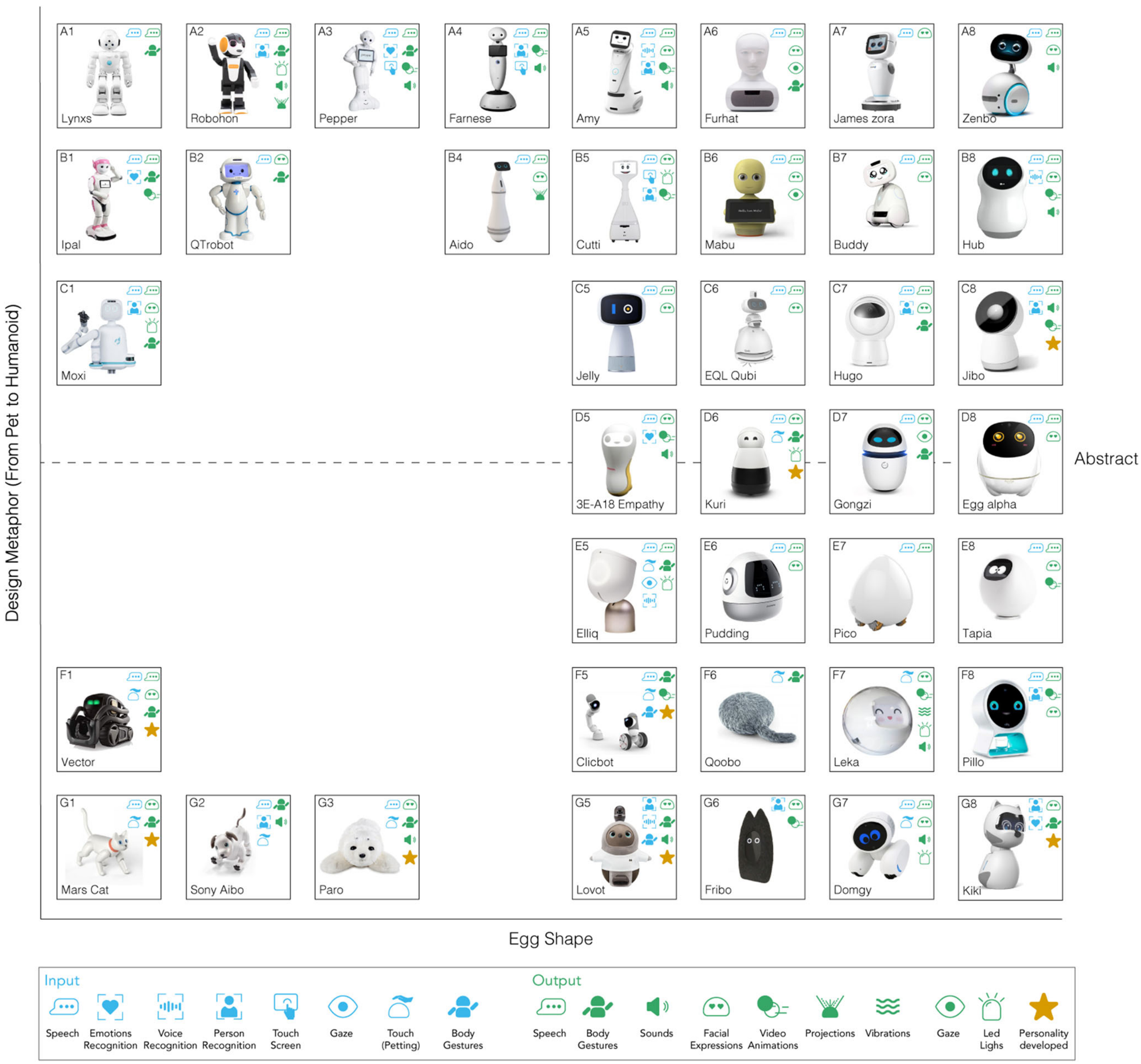

Fig. 1 Overview of the 40 social robots surveyed, ordered vertically by Design metaphor (From Pet/Toy-like To humanoid), and horizontally by shape level of abstraction. The interaction modalities are given with the icons on the right side of each robot card. *Fribo Robot recognises the presence of a person however does not identify the person

there is no apparent reason for this pattern beyond the friendly and approachable yet neutral appearance that these characteristics bring. This leads to another hypothesis which is a cost of production-oriented-approach, that basic shapes, cheap materials and low mobility have. To sum up this section, there is non-scientific evidence that supports the white egg-shape metaphor which yet is the most common. It is acknowledged in this survey that the preference towards basic or more humanoid aesthetics can change according to the target population and culture in which the robot is going to perform. For example, while [8] found a preference for basic aesthetics in social robots for participants from the UK on age rank of 22-44 years, [3] identified a preference for more humanoid embodiment in a population of Taiwanese participants from 59-82 years.

In interaction modalities (Fig. 1), all the robots surveyed demonstrated some level of emotional behaviour, especially through facial expressions. In this aspect, the eyes play an important role and rendered eyes is the most common way to do it (27 out 40 social robots use rendered eyes), since mechanical faces limit the expressions that a face can convey. Regarding interaction techniques, the analysis

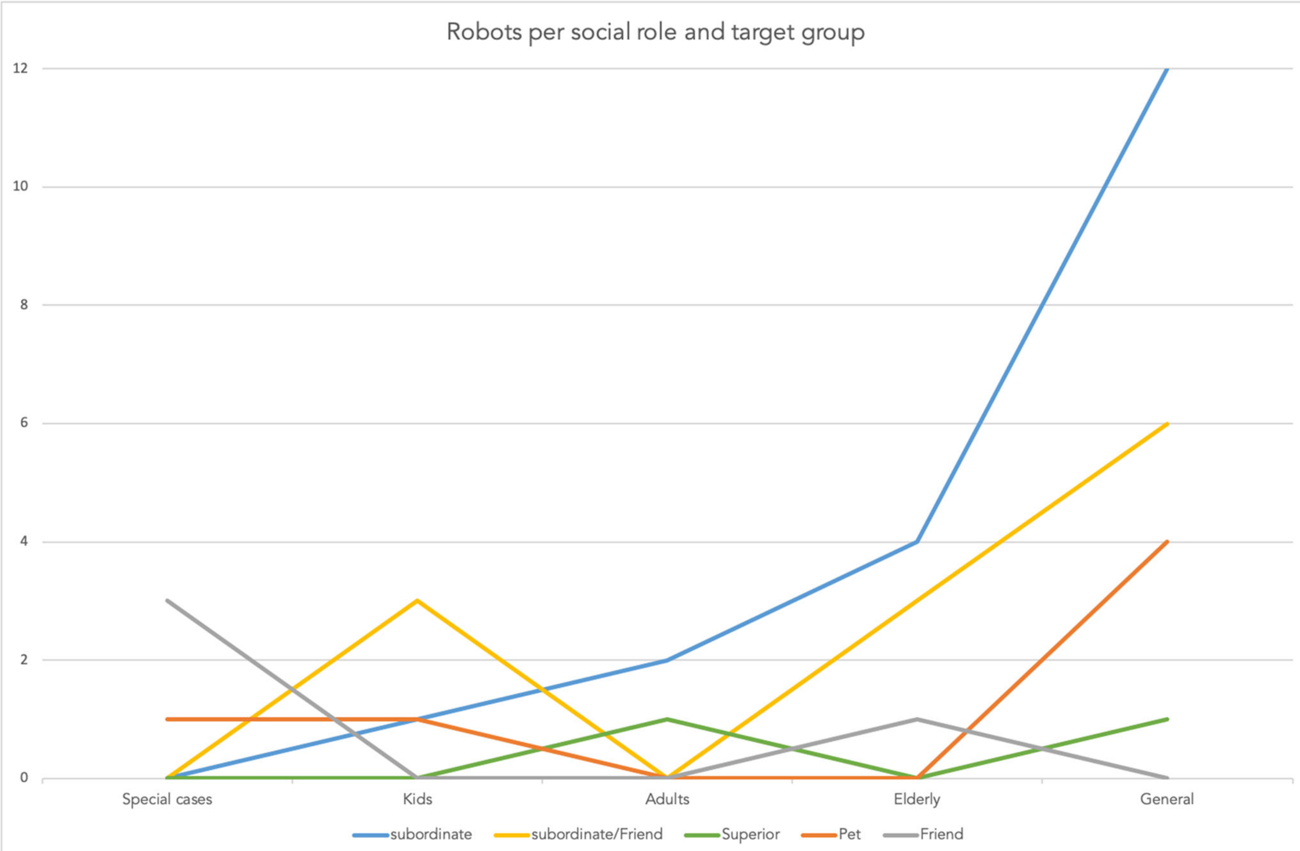

Fig. 2 Number of robots per social role and target group. In the target group the special cases are: 1. Moxi with target group nurses and hospital staff social role friend.2 QTrobot with target group Kids with special needs, parents and educators and social role friend. 3 Qoobo with target group People who cannot own pets and social role Pet. 4 Leka with target group Children in the ASD spectrums and parents and social role friends

of the interaction modalities category (Fig. 1) shows that speech is the modality most present in robots. It is the most common way to interact with robots (36 robots integrate speech for interacting with the users). Body gestures is the second most important interaction technique after speech. Most of the robots use the head as the main body part for gestures. Even though developers are clearly avoiding the use of extremities and relying on eyes or facial expressions to convey emotions there is space for new kinds of body parts that express emotions, like Qoobo, that explores the ability to express emotion using a "tail" or Lovot with the penguin-like "wings" that ask for a hug. However, there is also a research gap in terms of users studies that analyse the user perception, preferences about the expression of emotions and that compares facial expression vs non-human types of emotional expressions.

Robots like (Fig. 1) Vector(F1), Sony Aibo(G2) and Paro(G3) have character and personality developed, meaning a set of specific behaviours that goes beyond the generic and standardised manners of conduct that most of the robots present, but that can be recognised to that specific robot and help the user to make sense of it. For instance, Vector has a curious personality that is all the time looking for something to do and discover. As stated by Lacey et al. [18] "The acceptance of social robots as socially significant companions in the domestic space is considered to be extraordinarily reliant on the ability of the user to make sense of the robot's behaviours, including thought patterns, reactions, and future actions, along with a familiar, even comforting, pattern—precisely that which is 'known and long familiar". Such ability increments when the robot has a clear personality that the users can identify and extrapolate with human-human interaction. Norman [24] explains personality as a social tool that helps people to create a mental model of someone else's social behaviour, and humans are likely to assign a personality to robots because it may help to recognise patterns of behaviour and to shape the interaction. Another important finding related to the interaction techniques is that robots like Kiki (G8), Amy (A5), Farnese (A4), Moxi (C1), Sony Aibo (G2), Lovot (G5), Pillo (F8), Cutti (B5), Hugo (C7) and Jibo (C8) (Fig. 1) have person recognition as input modality which makes the robot to behave according to the person they are interacting with, providing customised interactions and thus making the robot easier to adopt for people.

5.2 Function

The function varies according to the target user, however, the most common functions for those robots are to be home assistants, surveillance, entertainers and educators. Since the functions are generic and there is no standard definition on what a “robot assistant ” or “robot entertainment” is, what differentiates the robot in the function category is the features, embodiment and interaction techniques to perform the job. There are some specific cases like Moxi which was designed for a specific scenario, a hospital setting with non patient facing tasks such as pickin bed clothes such as, or like Furhat that is designed to be an unbiased work recruiter. Furthermore, there is a relatively small body of literature that is concerned with the actual and potential value that users extract from smart speakers and companion robots, especially in view of the fact that these robots were designed to be socially-assistive rather than task-oriented. For instance, [22] evaluated the seniors’ perceptions of “Usefulness” for Paro, finding that the participants were neutral about the usefulness of the robot. However, the study found the need to research the “Perceived enjoyment” provided by robots that are intended to bring social benefits rather than functional benefits. According to Dereshev et al. [7] “providing an average experience for many kinds of users may prove much less desirable for companion robots given expectations, than providing a superior experience for a specific kind of user”. Nevertheless, the study shows that the target group (Fig. 2) of most of the robots is the general population and just 10 out of 40 robots surveyed demonstrated person recognition and adapting behaviour and functionalities to the specific person.

5.3 Social Roles

Even though all the robots are promoted and sold as family members, pets, friends or to have some level of social role there is a lack of studies that demonstrate that the robots surveyed are able to generate social presence, especially in long term interactions. Based on the functions performed, most of the robots that interact with the general population act as subordinate (Fig. 2). That is aligned with the finding of [5], which expound that the most desirable social roles for a robot companion at home are assistant, machine, and servant, while fewer people prefer to have social robots as a mate or a friend. Additionally, there is a lack of studies that evaluate the change in impressions of social robots over time. Most studies are short term interactions and often first time interactions.

5.4 Target Group

The most common target group after the general population (23 robots) which refers to multiple users such as a whole family, including adults, kids and teenagers, are kids (5 robots) and seniors (8 robots) are. Even though most of the robots support multi-user interaction, and some of them offer multi-user adaptation, there are no studies supporting multi-user interaction beyond the master user.

5.5 Degrees of Freedom (DOF) and Context of Use

Mobile social robots that are used on the floor and that have from three to seven DOF are the most common trend (Fig. 3). They are followed by robots used on tables without mobility and have from zero to six DOF. Few robots are built with a high degree of mobility, namely Marscat, Sony Aibo, Lynxs, Pepper, Clicbot and Ipal with more than 16 DOF. Though many DOF could improve the robot’s mobility and the possible range of task it could achieve, a hypothesis for having so many robots with fewer DOF is that the cost of production of building robots with a higher amount of DOF does not bring benefits for the user, considering the tasks and functionalities that the robots perform. However, no studies prove this design choice to be relevant. Lovot and Clicbot are special cases of robots with higher DOF than the average of the sample, while Lovot uses its penguin-like wings to “hug” being this action one of the most distinguishable features of the robot’s personality. Clicbot can have multiple adaptations and uses according to the parts that the user has implemented. For the purpose of the study, Clicbot was included in what can be assumed the higher amount of DOF, in light of the lack of detailed information provided by the developers. And thus, these two cases should be evaluated with users to understand the potential value extracted by the user when the robot has a higher amount of DOF.

5.6 Studies

The most important finding related to the approach for studies is that while robots like Paro and Pepper have multiple and diverse types of user studies, most of the robots have not been tested or analysed under scientific methods. The studies found for the robots surveyed are both qualitative and quantitative, with large (N400) and small samples (N11) of participants. Most of the studies are short term interaction, evidencing what [34] found about the

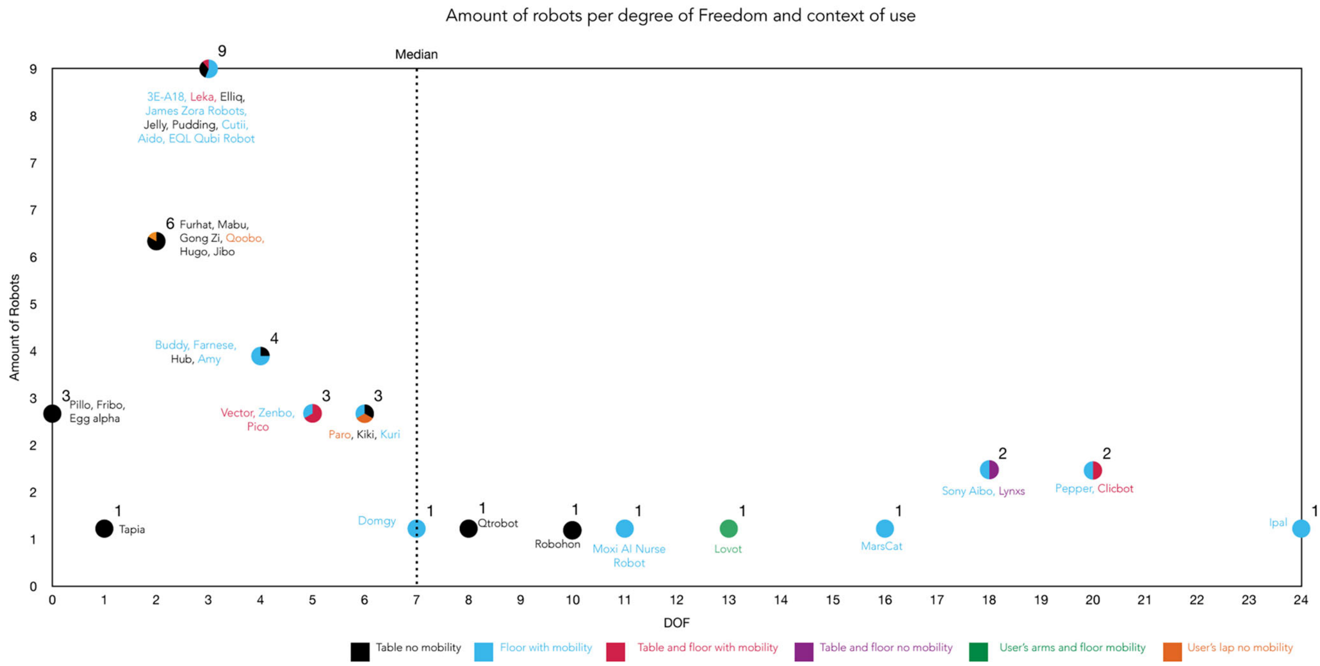

Fig. 3 Amount of robots per degree of Freedom

need of longer term studies that focus on the aesthetics and behaviour of the robot. These studies could deliver deeper information about the user perceptions that helps the design and development process of robots.

6 Perspectives

At the moment smart speakers replace and perform better the functions that many of the social robots presented in this survey do. And thus, it is not the embodiment of the social robot that is bringing the adoption of smart devices at home but the functionalities and the technology level. Being “cute” or “funny” is not enough for the customers when talking about long term interactions. The egg-white shape design trend in the social robots of the market lacks scientific evidence that supports it. Sooner or later users end in disappointment because their expectations did not match the actual capabilities of the robot and most of the robots launched have to be taken out of the market. Therefore, companies should question more the design decisions that lead to this common shape and functions when creating and advertising the next social robot as the ultimate solution. Likewise, a greater focus on the preferences of the type of embodiment, type of function and social roles in different cultures and type of users could produce interesting findings that account for better design guidelines for future social robots. In Addition, further research is required to achieve, a standard definition of functions that a social robot can or should perform. The use of plastic and low number Degrees of freedom might help to reduce the production costs, however the robots may not be what users are expecting at the moment. Possibly different materials should be considered when developing new robots. As was presented in this survey, three out of forty robots (Qoobo F6, Paro G3, and Lovo G5 in F.1) use different materials than plastic as a skin, which may bring more pleasurable interactions to the users. Little studies have been made on the material and haptic sensations when touching a social robot. Another important aspect is the customisation of robots in order to appeal to different types of persons, and to follow the technological trends that allow users to personalise almost everything they buy, could bring benefits and accelerate the adoption curve of social robots. Finally, long term studies that focus on the perception toward aesthetics, functionalities, emotional value and pleasurability of the materials should be conducted when developing new robots.

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Declarations

Competing Interests The authors declare that they have no conflict of interest.

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