Technology in Society 66 (2021) 101663

Contents lists available at ScienceDirect

Technology in Society

journal homepage: www.elsevier.com/locate/techsoc

What do we expect from robots? Social representations, attitudes and evaluations of robots in daily life ☆

Sonia Brondi [a], Monica Pivetti [b], Silvia Di Battista [b,*], Mauro Sarrica [c]

[a] Department of Philosophy, Sociology, Education and Applied Psychology, University of Padua, Padua, Italy
[b] Department of Human and Social Sciences, University of Bergamo, Bergamo, Italy
[c] Department of Communication and Social Research, Sapienza University of Rome, Rome, Italy

ARTICLE INFO

Keywords:
Robots
Social representations
Attitudes
Contexts of use
Free-associations

ABSTRACT

To foresee the potential acceptance, rejection and adaptation of robots in societies, it is necessary to overcome deterministic and linear assumptions and explore the plurality of meanings that shape our relationships with these emerging technologies. With this goal in mind, this study investigates the social representation of robots and its interconnection with attitudes and images, in a convenience sample of young adults in Italy ($N = 422$). Participants were asked to complete a self-report questionnaire consisting of a free-association task to the word stimulus “robot”, the Robot Attitude Scale, the acceptance of robots in different domains of life and a measure of mind perceptions of robots. The social representation of robots was articulated around three key semantic dimensions opposing: (1) ‘distant/detached’ vs ‘close/integrated’ views; (2) ‘ideal’ vs ‘material’ aspects; (3) assimilation with ‘ICTs’ vs with electric and mechanic ‘devices.’ These three dichotomies defined different positions connected with general attitudes, domain-specific evaluations of robots, and their level of perceived proximity with human beings. In particular, the view of robots as more concrete and integrated objects was related to positive attitudes and acceptance across all considered domains (i.e. Dull/Dirty, Education/Care and Health/Emergency dimensions). In contrast, more distant views were related to negative attitudes. Our study provides insights into how diverse positions could favour or hinder the introduction of robots in different spheres of everyday life.

1. Introduction

There is a growing expectation that we have reached a tipping point in the human-robot relationship. Advances in robotics, from sensors to software and artificial intelligence components, suggest that autonomous systems will be increasingly introduced into the daily lives of citizens in technologically advanced countries over the coming years. The idea of robot as a substitute for the nineteenth-century workforce, which has been such a driving force behind industrial robotics, now seems to have been complemented - if not overtaken - by more contemporary views of robots that are *with* humans (and which can be further differentiated in assistive, social companion, family, and many other typologies of social robots) [1,2]. However, a rapid and significant change of this nature requires careful considerations of other interpretative dimensions beyond the merely functional advantages, including fears of replacement, competition, safety and security issues [3].

The Social Representations Theory (SRT) provides a holistic stance from which to understand processes of meaning-making that take place within social groups. The starting point is that people’s understanding of new social objects, such as emerging technologies, is influenced by socially constructed and continuously evolving symbols, or representations, which serve to render the world meaningful for social actors. SRT provides a rich vocabulary with which to examine the formation, change, and content of these representations, and their relationship to people’s actions (e.g., Ref. [4]).

Originating from the seminal work by Moscovici [5,6]; SRT is a theory of “structured mental (…) content about socially relevant phenomena, which take the form of images or metaphors (…) created in everyday discourse between social groups” [7]; p. 673).

According to Wagner and colleagues [8]; the understanding of a new

☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
* Corresponding author. Department of Human and Social Sciences, University of Bergamo, Piazzale S. Agostino 2, 24129, Bergamo, Italy.
E-mail addresses: sonia.brondi@unipd.it (S. Brondi), monica.pivetti@unibg.it (M. Pivetti), silvia.dibattista@unibg.it (S. Di Battista), mauro.sarrica@uniroma1.it (M. Sarrica).

https://doi.org/10.1016/j.techsoc.2021.101663
Received 26 February 2021; Received in revised form 30 June 2021; Accepted 2 July 2021
Available online 23 July 2021
0160-791X/

technology passed through an intermediate stage where the public compensated for their lack of scientific literacy by using representations, which were the results of a collective symbolic coping with the new technology that maintained them (cf. also [9]. When something new strikes the attention of individuals, they engage in a process of collective material and symbolic coping with the new, that is a sense-making activity which involves naming and attributing characteristics to it in order to make it intelligible and communicable [10]. This process is based on two interrelated processes, anchoring and objectification. Anchoring first serves to associate the new and unfamiliar issue with previous knowledge. Objectification then transforms the abstract into reified realities that can be treated as such. Anchoring and objectification transform the abstract, fuzzy and distant novelty into "an icon, metaphor or trope, which comes to stand for the new phenomenon" [11]; p. 99). These shared conceptual objects, images, and symbols are culturally shared toolkits that help communities grasp the unfamiliar [12], and determine the possibility of behaving and communicating in a meaningful way both for us and the others around us.

As for the relationship between SRs and attitudes, Jaspers and Fraser [13] referred to the attitude as individual responses based on collective representations. In this sense, the notions of attitude and SRs are close, the former being the individual's subjective response to his/her social world.

This study aims to describe the interconnection of the SR of robots, attitudes towards robots and expectations regarding context of use of robots. In the next sections, we will use the SRT to reflect on how the images of robots are interconnected with their acceptance in different spheres of everyday life. Also, the main determinants of attitudes towards robots, and their interaction with users' characteristics will be summarized. An exploratory study is then presented, which depicts alternative visions circulating in the social arena. The study is conducted with young adults, who should ideally be more ready to penetrate these artefacts in everyday life. In the conclusions, we draw on our results to provide insights and suggestions on how the introduction of robots could interact with these pre-established views.

2. Social representations of robots

Human-robot interaction has been thoroughly studied as a dyadic relationship which activates individual attitudes and reactions. However, SRT suggests that it is a clear example of triadic relationship self-other-object instead.

Robots have all the characteristics that foster the emergence of SRs [14].

Robots are a techno-scientific innovation that forcefully connects scientific and lay knowledge [6]. As a result, akin to what happened to other techno-scientific innovations, scientific knowledge about robots is transformed, modified, adapted, distorted and SRs are co-constructed [15].

Moreover, their presence is more and more visible in workplaces as well as on media:

a) The issue is increasingly perceived as being problematic, the pros and cons are intertwined, and this new object touches upon different dimensions of everyday life (health, work, caregiving);
b) Meanings, practices and interactions with robots are highly contextual, that is each community (national, local, at workplaces) is developing its own experiences and perspectives on these new objects;
c) They are becoming a debated issue, their presence fosters debates and sidings, and people are pushed to take a stance for or against these novelties [16].

2.1. Images of robots

Research on robot design and acceptance cannot escape the fact that people have preconceived ideas about robots' capacities: Robots are assimilated to animals [17], they are expected to engage humans in the future [18], or are described as lacking affects and being out of human control [19]. Their image is more likely to be an instrument-like machine used in the workplace than a human-like machine that helps in the home [3,20]. Stafford and colleagues [21]; among many others, suggest that "these ideas may originate from exposure to robots in the media, including books, television, film, and news reports, which often exaggerate the capabilities and dangers of robots" (p. 14).

The role played by media has been confirmed by studies conducted from a social representations approach. The results show how media contribute to the construction of a human-like representation of robots already during infancy: the capacity to retrieve visual products with robots seems to be related to children images of robots as having anthropomorphic shapes and human-like cognitions, feelings and behaviours. However, as a boomerang effects, such high expectations are a source of disappointment when children face real interaction with automata [22].

Media, however, are not a stable environment: an Italian study on about 3000 news stories published between 2014 and 2018 by some 100 different Italian news media showed significant interest in work issues and a thematic shift over time towards the social reproduction functions of robots. Specifically, robots are represented as being able to perform an increasing number of jobs, with the same capacity as humans. These activities go well beyond the dull, dirty and dangerous ones(e.g., chef, butler, waiter, barman, policeman, soldier, and shop assistant), and include the most expressive, creative, spiritual examples (e.g., dancer, orchestra conductor and priest). Robots can also be nurses and surgical assistants, employed in rehabilitation and assisting people affected by many diseases [23,24].

A study conducted in Portugal, and framed within SRT, showed that elements indiverse technologies (e.g., computers) and contexts (e.g., industrial processes) were integrated into the SRof robots [25]. Drawing from a set of characteristics common to traditional machinery (e.g., metal, mechanical, fast) and current technology (e.g., electronics, artificial intelligence) people built a shared SR of robots. As for the role played by socio-demographic variables, the authors found that in the case of male participants and participants over32 years of age, the ideas of technology and help were connected with the concept of unemployment, which *per se* is a negative outcome. More recent studies connect social representations of artificial intelligence (AI), robotics and big data in the healthcare domain. People imagine tailored personal medical care, efficiency, precision, better quality work, 24/7-availability, cost-effective and accessible human augmentation and assistance. As for the risks, the SRs of AI, robotics and big data in healthcare include data misuse and leakage leading to privacy infringements, loss of humanness, human replacement, social stratification, discrimination and manipulation [26].

Finally, it also worth noticing that these preconceptions do not affect only laypeople but interact with the scientific debate leading to mutual influence: "Robot design is influenced from its very inception by the cultural assumptions of designers. Social interactions and evaluations are a fundamental component of the production of technological knowledge and artefacts" [27]; p. 440).Research show, for example, that scientific definitions include connotative facets as well as denotative ones; that agency, materiality and interactivity are shared elements of the scientific and popular definition of social robots; and that whereas popular definitions tend to refer to fully autonomous agents, the scientific definitions underline the limitations of autonomy to predefined functions and tasks [28].

In sum, discrepancies between representations and experience, images circulating on media, conflicts and overlaps between lay and expert knowledge, suggest that the representation of robots is changing, and that further exploratory studies are needed to map the diverse images that circulate in our societies, and their interlink with acceptance and expectation of robots in different contexts.

3. Attitudes towards robots

The importance of shared knowledge and images that laypeople and experts have of robots is recognised also in research on robot attitudes [29]. For example, Takayama [30] underlines that it is crucial to understand "popular sentiment" because it "shapes technology adoption and because technologies are more useable if they take people's expectations into account" (p. 2).

Over the years, a number of studies has investigated distal and proximal determinants of attitudes towards robots, and their interaction with users' characteristics such as age, gender, etc. (for a systematic review see Refs. [31–33].

Four intertwined facets have been identified as key to robot acceptance and use:

Physical embodiment. Ever since the description of the paradox of the so-called 'uncanny valley' [34,35], the design characteristics of robots have been carefully considered. Height, bulk, materiality, bipedality, resemblance to humans have proved to be fundamental characteristics in the evaluation of these artefacts. Material features interact with the mimicry capability of the hardware/software combination, and contribute to the quality of interaction, perceived reality of experience, perceived control, empathy, and anthropomorphism (e.g. Refs. [36–39].

Domain of use of robots. Studies across the years have shown that robot acceptance varies depending on the domain of application. An overall positive view of robots is often associated with utilitarian arguments: robots are mainly accepted for doing 'dull, dangerous and dirty' jobs or for activities that require 'vigilance, responsibility and consistency' [30]. They should be used as a priority to help humans in areas such as space exploration, manufacturing, military and security and search and rescue tasks in this order (e.g., Ref. [40]. On the contrary, robots are perceived as a technology that could steal jobs, and that should be carefully managed when it comes to the education and care of children, older adults and people with disabilities, and the leisure domain [3,20,30,41]. Partially in contrast with those data, elderly care and other health-related work are indeed some of the main applications of social robots (e.g. Refs. [42–46], with relevant interaction with other domains such as education (e.g., Refs. [47–50].

Social embodiment. Integrating robots into our social world [51] calls into question the systemic changes required by their presence in everyday life. If we consider robots -and especially social robots-as mediators between humans and their social environment [52] it is possible to acknowledge that the more they are included in human societies, the more they will hybridise them. Such dynamic of reciprocal influence between society and robots [27] will be potentially able to transform educational, mobility, health, and other socio-technical systems that regulate our everyday life. In this line, the social embodiment of robots is expression of their potency as cultural objects, including their increasing retrievability, rhetoric force, public resonance and institutional retention [53].

Examples of the increasing social embodiment of robots (and of the mutual transformation of design, functions and practices) are provided by the presence of robots in a variety of social and public arenas, as urban surveillance robots or companions [54], in health care and therapy context, in education, work environments and public spaces and events [53,55]. Normative sides of social embodiment concern the debate on robot rights, such as the resolution of the European Parliament A8-0005/2017. Finally, these dynamics are also subject to endogenous and exogenous transformations of the system, as the recent pandemic has shown. During last year, social robots have been proposed as technological solutions to moderate isolation and increase well-being [56–58].

Ideational components. Despite the expectations and the examples provided, robots and collaborative robots are still extraneous to the everyday practices of most citizens [3] and long-term interactions with robots are still perceived as poor and disappointing [21]. It means that interactions with robots are often imagined more than real, episodic more than continuous. However, if we go beyond a purely technocentric and linear perspective of technological adoption and dwell on 'human perspectives' [59] including domestication processes [60], cultural theories [53] and socio-constructivist approaches [28], it is evident that even in the absence of interactions, ideational components play a pivotal role in the way individuals and societies envision, narrate, construct encounters with robots, with the related fears and expectations.

4. Objectives of the study

This study investigates the interconnection of SR, images and attitudes towards robots, within the current debate over the use of robots in daily life.

First, it aims to explore the SR of robot content and field as they emerge via free-association tasks, in a sample of young adults in Italy. Young adults are sometimes defined as digital natives: familiar with new technologies as they have grown up in the digital age, in an inter-reality characterised by continuous interactions with and through ICTs, digital devices and social media. Then, young adults should ideally be readier for the penetration of robotic artefacts in everyday life.

Moreover, we aim to study the ways robots are anchored and objectified, that is how these objects – which are still rare in individual experiences – are associated with previous knowledge and transformed into something 'real' with specific connotations. In this vein, we will explore how SRs anchor to (1) the positive/negative attitudes towards robots [61], (2) the perception that robots have a mind [62], (3) the expectations that robots would be appropriately employed in specific contexts [3]. For this purpose, supplementary quantitative variables measuring attitudes towards robots, perceptions that robots have a mind and expectations concerning context of use, will be projected in the representational field, as it is common practice in this line of research (e.g., Ref. [63].We expected that the SRs of and attitudes towards robots would align, in that a more "cold" representations of robots as mechanic tools would be related with seeing also robots as lacking the capacity to experience and feel, and with being even more apt to use robots for repetitive jobs such as the "dull and dirty" ones. On the contrary, a representation of robots as more cognitive and relationally similar to the human being will relate with a greater acceptance of robots, also being perceived as more fit to be used in the education and care domain.

5. Method

5.1. Participants

The survey involved a non-probability quota sample of 422 young adult and medium educated Italian participants ($n = 193$, 45.7% self-identified male and $n = 229$, 54.3% self-identified female) participants. The mean age was 21.44 years ($SD = 2.81$; range age: 18–31). Participants were mainly students ($n = 354$, 83.9%); eighteen of them reported to be worker students (4.3%), forty-one of them indicated to be employees (9.7%), and the remaining participants were unemployed persons ($n = 2$; 0.5%; missing = 7). The sample was medium educated with 82.5% having completed secondary school ($n = 348$), 15.4% having a university degree ($n = 65$), and 0.5% having a post-graduate degree or a PhD qualification ($n = 2$; the remaining participants completed a middle school = 5 or they were missing for education = 2).

5.2. Procedures

Participants were asked to complete the self-report questionnaire in a paper-and-pencil version or an online version. A convenience sampling method with a snowballing procedure was used. Participation was voluntary, and participants were guaranteed privacy protection according to the ethical standards currently applicable in Italy concerning social and psychological research. In particular, informed consent was obtained from participants. Specifically, the study complied with the Ethics Code of the Italian Psychology Association.

5.3. Instruments

The questionnaire was administered in Italian and consisted of a free association task, followed by closed-ended questions and a section of social and personal information.

Free associations. First, participants responded to the word stimulus "robot", by answering a question in the form of "*what comes to your mind when you hear the word* …" and then reporting the first (up to 5) words that spontaneously emerged in their mind. This task is widely acknowledged and used in empirical research within SRT.

Robot Attitude Scale. The attitudes toward robots were measured using the short version of the Robot Attitudes Scale (RAS; [61]. The scale included eight pairs of opposite attributes, which serve as semantic anchors(friendly-unfriendly, useful-useless, trustworthy-untrustworthy, easy to use-hard to use, reliable-unreliable, safe-dangerous, helpful-unhelpful, and enjoyable-boring). Participants rated robots on each of the eight attributes using a 5-point scale.

We used the Statistical Package for the Social Sciences (SPSS 22.0) to analyse the responses to close-ended questions (i.e. RAS, mind perception and contexts of use) and run descriptive, reliability, correlational and factor analyses. Specifically, principal axis factor analyses with oblique rotation (direct oblimin) were conducted on the three scales.

According to RAS, the Kaiser-Meyer-Olkin measure tested the sampling adequacy for the analysis (KMO = 0.77). Two factors had eigenvalues over Kaiser's criterion of 1. The scree plot was ambiguous and showed inflexions that would justify retaining either one or two factors (see Appendix A). We resorted to reliability analyses based on a theoretical background to justify retaining 8 items. One composite score was computed ($\alpha = 0.73$). Then, the index was split based on the mean ($M = 3.49$; $SD = 0.63$; Skewness = −0.27; Kurtosis = 0.27) and two groups were created: 1 = below the mean, i.e. negative attitude toward robots ($n = 188$); 2 = above the mean, i.e. positive attitude toward robots ($n = 234$).

Mind perception. The mind perception and its two dimensions of mind experience and mind agency [62], were assessed using a scale with eleven pairs of opposite attributes [21]. The scale was composed of two subscales: mind agency (six pairs of features describing robots perceived capacity of doing, i.e. to recognize emotions, to think, to remember, to self-control, to plan and to be moral; e.g. "It has memory vs It has no memory") and mind experience (five pairs of attributes describing robots perceived capacity of feeling, i.e. to feel pleasure, hunger, pain, and to have personality and consciousness; e.g. "It can feel pleasure vs It cannot feel pleasure"). Participants rated robots on each of the eleven attributes using a 5-point scale.

The Kaiser-Meyer-Olkin measure tested the sampling adequacy for the analysis (KMO = 0.87). The scree plot (see Appendix B) highlighted two factors explaining 51.69% of the total variance. Factor 1included six pairs of opposite attributes (with personality – without personality, conscious – unconscious; recognize emotions–does not recognize emotions; thinks – does not think; moral – amoral; feel pleasure-does not feel pleasure), explaining 36.45% of variance($\alpha = 0.82$; $M = 2.45$; $SD = 0.93$; Skewness = 0.56; Kurtosis = −0.16). This factor corresponds to "mind experience", indicating that robots are moderately perceived as lacking the capacity of feeling. Factor 2 included two pairs of opposite attributes (has memory – has no memory; has self-control – has no self-control), explaining 15.24% of variance($r = 0.23$, $p < .01$; $M = 3.53$; $SD = 1.03$; Skewness = −0.50; Kurtosis = −0.36) (see Appendix B for factor analysis results). This factor corresponds to "mind agency," suggesting that robots are moderately perceived as capable of doing. The two factors are weakly correlated (0.09). Two composite scores were computed (see Appendix D for correlations between the study variables). Then, the two indexes were split based on the mean, and four groups were created: 1 = below the mean in both factors, i.e. low experience, low agency ($n = 125$); 2 = above the mean in Factor 1 and below the mean in Factor 2, i.e. high experience, low agency ($n = 95$); 3 = below the mean in Factor 1 and above the mean in Factor 2, i.e. low experience, high agency ($n = 93$); 4 = above the mean in both factors, i.e. high experience, high agency ($n = 109$).

Contexts of use. The degree of acceptance of robots in different domains of life was considered with the following questions based on - and adapted from- Eurobarometer [20] and Taipale et al. [41]: "*Please indicate how much you agree with robotics use in the following areas*" Thirteen domains of life were listed: 1) manufacturing; 2) healthcare; 3) leisure; 4) domestic use (such as cleaning); 5) military and security; 6) search and rescue; 7) education; 8) care of children, elderly, and the disabled; 9) space exploration; 10) agriculture; 11) transport/logistics; 12) repetitive tasks and jobs; 13) precision tasks and work. Participants rated robotics' use on each of the thirteen areas using a 5-point scale (from 1 = *completely disagree*; 5 = *completely agree*). The Kaiser-Meyer-Olkin measure tested the sampling adequacy for the analysis (KMO = 0.82). An initial analysis was run to obtain eigenvalues for each factor in the data. Four factors had eigenvalues over Kaiser's criterion of 1 and in combination explained 58.18% of the variance. The scree plot was ambiguous (see Appendix C) and showed inflexions that would justify retaining either three or four factors. We retained three factors - that explained 50.29% of the total variance - based on an evaluation of factor loading values after rotation and reliability analyses. The items loadings in the same factor suggested that Factor 1 contained six items and represented Dull/Dirty dimension ($\alpha = 0.73$; $M = 4.02$; $SD = 0.64$; Skewness = −0.74; Kurtosis = 1.02); Factor 2 included two items and represented Education/Care dimension ($r = 0.55$, $p < .001$; $M = 2.76$; $SD = 1.14$; Skewness = 0.15; Kurtosis = −0.85); and Factor 3 included twoitems and pointed to Health/-Emergency dimension ($r = 0.57$; $p < .001$; $M = 3.71$; $SD = 1.05$; Skewness = −0.075; Kurtosis = 0.01; see Appendix C for factor analysis results). Higher values indicate acceptance of robots' use in the three domains of life; lower values indicate refusal. Mean values suggest that robots are mostly accepted for dull and dirty uses and – to a lesser extent – health and emergency uses. The three factors were positively correlated. Then, the three indexes were split based on the mean, and two groups were created for each dimension: Dull/Dirty (1 = below the mean, i.e. refusal; $n = 217$; 2 = above the mean, i.e. acceptance; $n = 204$); Education/Care (1 = below the mean, i.e. refusal; $n = 214$; 2 = above the mean, i.e. acceptance; $n = 207$); Health/Emergency (1 = below the mean, i.e. refusal; $n = 188$; 2 = above the mean, i.e. acceptance; $n = 233$) (see Appendix D for correlations between all the study variables).

Demographics. Finally, participants' gender, age, occupation and education were collected.

5.4. Data analyses

The SR of robots was identified by analysing the responses to the free association task. Specifically, the content and field of the SR of robots were examined. To this end, textual data were submitted to different lexical-metric analyses with the support of Spad software[1].

Preliminarily, a vocabulary was created. It was composed of 2060 total associations (tokens), 808 distinct associations (types) and 609 single-occurrence associations (hapaxes). The vocabulary was then processed to reduce data dispersion: first, an equivalence treatment of

[1] The data collection and analysis were run in Italian. Discussions between authors on the results were carried on in Italian. Then, relevant words/concept were translated from Italian into English by the authors, as common practice in qualitative research.

the data aimed at merging synonyms was carried out; second, a minimum threshold was imposed, retaining only those associations with a frequency equal to or greater than four (1% of respondents). The resulting vocabulary was thus made up of 100 distinct associations. Lastly, lexical correspondence analysis was run. It is a multivariate technique that allows for a synthesis of the data on the factorial space. The axes can be interpreted as semantic dimensions to read the textual corpus, illustrating proximity among associations on the factorial space and variations in individuals' positioning by variables' modalities.

Following the work by Doise and colleagues [64]; the study of individual positioning means studying how SRs can change according to the normative, value and belief systems shared by a group of people (cf. also [65]. In particular, the study of individual positioning in representational fields entails an analysis of the anchoring of social representations at the psychological level, that is anchoring individual positioning to attitudes or values at an intra-individual level. The preferred method of analysis is the factorial one. In this case, variable modalities define sub-groups of participants based on responses to closed-ended questions (i.e. RAS, mind perception and contexts of use). Thus, the positioning of sub-groups of participants on the factorial space indicates different nuances in sharing the SR of robots.

6. Results

6.1. Content of the social representation of robots

The content of the SR of robots, defined by the most frequent associations, is articulated around prominent thematic nuclei. Table 1 below reports the associations mentioned at least ten times in descending order.

Their material dimension mainly represents robots. Specifically, on the one hand, robots are defined as systems as a whole (e.g., technology, machine, automaton, creation, advanced technology, object). On the other hand, robots are objectified in commonly used devices (e.g., computer, household appliance, social robot, toy, drone, mobile phone). There are also references to the disciplinary fields to which robots are attributable (e.g., mechanics, computer science, electronics, science, cybernetics, engineering, research, robotics) as well as to their related specificities, characterisations and components (e.g., artificial intelligence, automation, programming, software for computer science; e.g., gear, mechanism, engine for mechanics; e.g., electricity, electrical circuit, cable for electronics). More generally, it can be argued that the material dimension underlying the content of the SR of robots unfolds in two main directions. The first, the most markedly present, concerns the ICT sector; the other, also very much emerging, concerns the mechatronics sector.

Alongside the material dimension, but remaining in the concrete area of the SR of robots, the design dimension stands out. It consists of elements that refer to robots' physical appearance in their similarities and differences with human beings (e.g., metal, humanoid, cold colour, strength, metallic voice, resistance, non-human, voice).

Complementary to the SR of robots' concrete area, the results also highlight an abstract area, which takes on a double value. On the one hand, robots are represented by their imaginative dimension, with particular reference to the media's science fiction imagery (e.g., movie, Isaac Asimov, cartoon, science fiction, song). On the other hand, they are thought of as welcome innovations, but still in progress (e.g., future, innovation, progress, development, modernity, evolution, revolution, futurism). However, concerning acceptance, there are some references, albeit relatively marginal, to a complete rejection of robots. There, a high perception of risk is highlighted (e.g., rebellion, destruction, fear).

Another crucial thematic core, around which the SR of robots' content is articulated, concerns the contextual dimension. It affects the sectors and environments in which robots are most immediately employed. First of all, the workplace, especially in the industrial context (e.g., work, industrialisation, work replacement), and the domestic one (e.g., home, daily life, home automation). However, references to other uses, such as, for example, in the health sector or for space exploration, are not lacking.

In addition to the contextual dimension, the results also highlight the functional dimension, which collects the associations inherent to robots' qualities (e.g., usefulness, speed, autonomy, control, efficiency, reliability, functionality, precision, safety, ease, versatility, effectiveness). As a counterpart, this dimension also underlines the limits most attributed to robots about their use (e.g., dangers, complexity, limits).

Other thematic nuclei through which the results can be summarized give an account of robots' specific characteristics in their similarities and differences with human beings. For the sake of simplicity, they have been operationalised into some main spheres (i.e. cognitive, affective, behavioural and relational). However, it must be taken into account that the boundaries between one sphere and the other are blurred, and overlaps can exist, just as they exist in the case of human beings. The behavioural sphere, the one with the most prominence, collects associations representing robots capable of movement to perform actions desired by - and on behalf of - human beings (e.g., command, human replacement, movement, task execution, semi-movement, mechanical action). On the contrary, the cognitive sphere mainly shows robots as being endowed with intelligence and the ability to think (e.g.,

Table 1
Most frequent associations.

Association	F (%)	Association	F (%)	Association	F (%)
technology	122 (28.9%)	programming	26 (6.2%)	science	14 (3.3%)
future	93 (22.0%)	command	25 (5.9%)	autonomy	12 (2.8%)
machine	87 (20.6%)	cartoon	23 (5.5%)	cybernetics	12 (2.8%)
mechanics	85 (20.1%)	computer science	23 (5.5%)	electric circuit	12 (2.8%)
metal	82 (19.4%)	progress	23 (5.5%)	insensitivity	12 (2.8%)
artificial intelligence	73 (17.3%)	electronics	21 (5.0%)	human replacement	12 (2.8%)
automation	63 (14.9%)	development	20 (4.7%)	work replacement	12 (2.8%)
film	63 (14.9%)	gear	19 (4.5%)	control	11 (2.6%)
help	45 (10.7%)	science fiction	17 (4.0%)	evolution	11 (2.6%)
usefulness	43 (10.2%)	industrialisation	17 (4.0%)	engineering	11 (2.6%)
computer	40 (9.5%)	work	17 (4.0%)	movement	11 (2.6%)
intelligence	39 (9.2%)	without emotion	17 (4.0%)	social robot	11 (2.6%)
household appliance	37 (8.8%)	creation	16 (3.8%)	efficiency	10 (2.4%)
innovation	34 (8.1%)	speed	16 (3.8%)	toy	10 (2.4%)
humanoid	31 (7.3%)	cold colour	15 (3.6%)	mechanism	10 (2.4%)
coldness	28 (6.6%)	modernity	15 (3.6%)	thought	10 (2.4%)
automaton	26 (6.2%)	artificiality	14 (3.3%)	danger	10 (2.4%)
Isaac Asimov	26 (6.2%)	electricity	14 (3.3%)	health sector	10 (2.4%)

Note: Table 1 is divided into three sections (i.e. sub-tables). Each section has two columns: 'Association' and 'F (%)', (i.e. the frequency - also expressed as a percentage in brackets - with which each association is expressed). The associations were translated into English by the authors.

intelligence, thought), even if there are references that express the opposite (e.g., without intelligence). The affective sphere is the one that most marks the difference with human beings, outlining an affectless SR of robots (e.g., without emotion, insensitivity, without feeling). Finally, the relational sphere partly takes up what has already been supported by the behavioural sphere, above all highlighting the dimension of service to being human (e.g., help, obedience). However, there are some references to robots capable of interacting (e.g., interaction, companionship).

6.2. *Field of the social representation of robots*

The field of the SR of robots, defined by the lexical correspondence analysis outcomes, is articulated around some key semantic dimensions. Thinking of these semantic dimensions as the axes of a factorial space, it is possible to visualise a graphic representation of the associations and the positioning of the variables' modalities. The intersection of the first (horizontal axis) and second (vertical axis) dimensions is represented in Fig. 1 below. The points illustrate the associations; the squares show the positioning of the variables' modalities.

The first dimension defines the human-machine relationship as a whole (Table 2). It opposes a 'distant/detached' view on the one pole to a 'close/integrated' view on the other.

The 'distant/detached' pole comprises associations that outline robots as objects, sometimes perfectible, produced by - and for - human beings. Specifically, the associations to the material dimension mostly refer to systems as a whole (e.g., creation), as well as to the disciplinary field of mechanics and related specificities, characterisations and components (e.g., gear, mechanism, engine). Moreover, about design, the differences with human beings, more than the similarities, are stressed (e.g., metallic voice). Coherently, the references to the behavioural (e.g., command, semi-movement, task execution), and affective (e.g., without emotion, without feeling) spheres underline the distance of robots from human beings. Only the associations to the cognitive sphere (e.g., thought, intelligence) account for a certain degree of autonomy of the robots. Finally, the functional dimension, which highlights both strengths and limits, is exclusive to this pole (e.g., limit, usefulness). Female participants, those who have a more negative attitude toward robots, and those who are more opposed to the use of robots in the three contexts considered, are positioned on this pole.

On the other hand, the emerging 'close/integrated' pole is constituted by associations that describe robots as objects, sometimes imaginative, integrated between human beings. Specifically, the associations to the material dimension mainly refer to commonly used devices (e.g., household appliance, drone, mobile phone, social robot), as well as to the disciplinary field of information technology (i.e., cybernetics, robotics) and related specificities, characterisations and components (e.g., software). Moreover, about design, the similarities with human beings, more than the differences, are highlighted (e.g., humanoid). The imaginative dimension is exclusive to this pole (e.g., movie, cartoon, Isaac Asimov, song), as is the contextual dimension, in which industrialisation is mentioned. Male participants, those who have a more positive attitude toward robots, those who think about robots as lacking agency and experience, and those who are more in favour of the use of robots in the

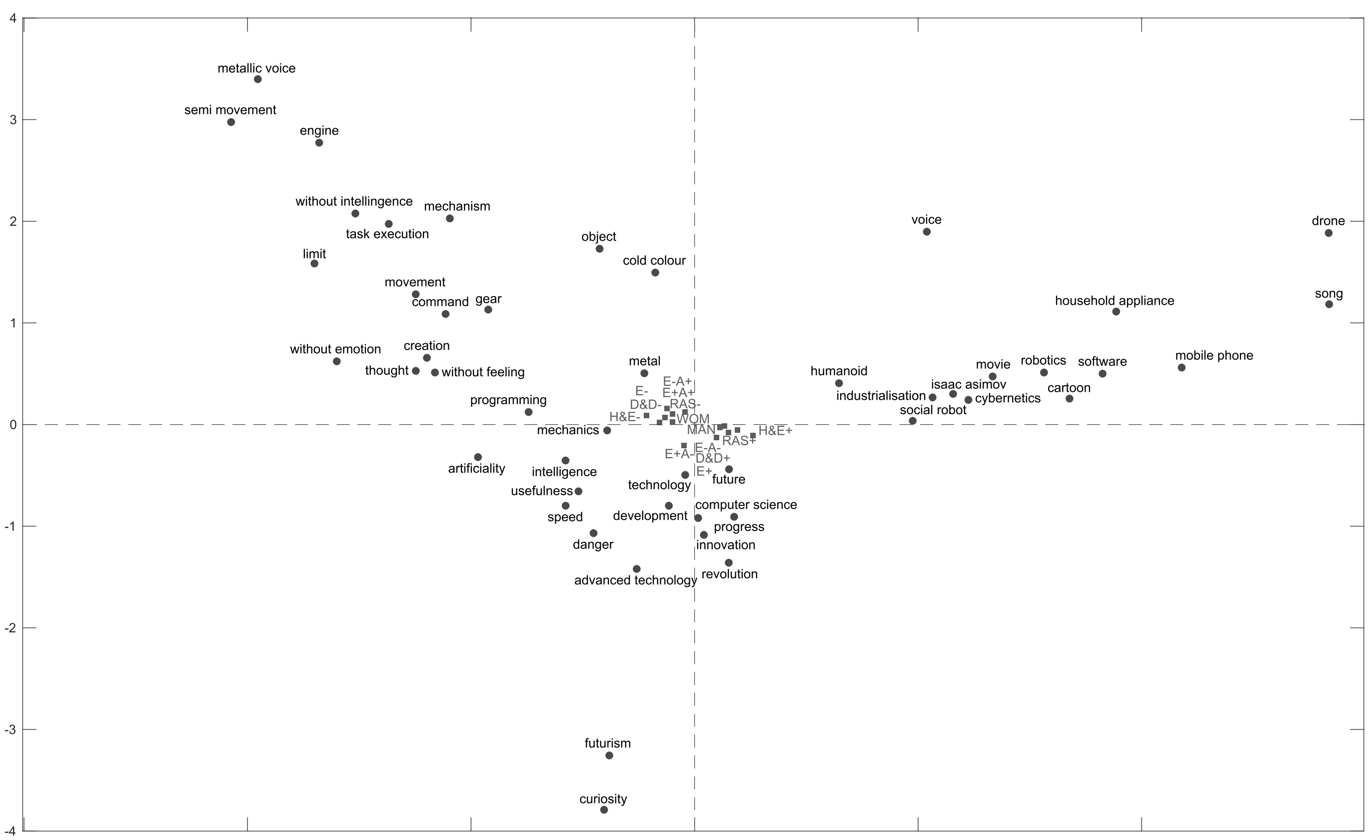

Fig. 1. First (x-axis) and second (y-axis) dimensions. *Note.* The points represent the active variables (i.e. the associations); only those active variables with a contribution greater than 1.00 (i.e. >100/Types) are displayed. The squares represent the positioning of the supplementary variables (i.e. the variables' modalities) on the factorial plane; only those supplementary variables with a test-value higher than 1.96 in absolute value (i.e. that are significantly distant from the origin) are displayed. Labels mean: MAN = men; WOM = women; RAS+ = positive attitude toward robots; RAS- = negative attitude toward robots; E + A+ = high experience and agency; E-A+ = high agency but low experience; E + A- = high experience but low agency; E-A- = low experience and agency; D&D+ = acceptance for dull and dirty uses; D&D- = refusal for dull and dirty uses; E+ = acceptance for education and care uses; E− = refusal for education and care uses; H&E+ = acceptance for health and emergency uses; H&E− = refusal for health and emergency uses.

Table 2
First dimension (2.46% of explained total inertia).

Human-machine relationship					
Distant/Detached			Close/Integrated		
Association	Coord.	Contr.	Association	Coord.	Contr.
without emotion	−1.60	4.22	household appliance	1.92	13.26
command	−1.12	3.06	movie	1.37	11.54
semi-movement	−2.11	2.59	drone	2.92	4.97
metallic voice	−1.97	2.27	cartoon	1.48	4.89
creation	−1.19	2.20	Isaac Asimov	1.20	3.61
gear	−1.06	2.07	song	2.96	3.40
limit	−1.71	1.98	mobile phone	2.32	2.08
movement	−1.29	1.79	cybernetics	1.31	1.99
task execution	−1.38	1.67	industrialisation	1.09	1.96
thought	−1.26	1.54	humanoid	0.70	1.47
programming	−0.73	1.33	software	1.93	1.45
artificiality	−0.96	1.24	social robot	1.02	1.12
intelligence	−0.57	1.24	robotics	1.62	1.02
mechanism	−1.13	1.24	*Male*		
mechanics	−0.38	1.20	*Positive attitude*		
engine	−1.72	1.15	*Low agency and experience*		
usefulness	−0.51	1.07	*Acceptance dull and dirty uses*		
without feeling	−1.15	1.03	*Acceptance education and care uses*		
Female			*Acceptance health and emergency uses*		
Negative attitude					
Refusal dull and dirty uses					
Refusal education and care uses					
Refusal health and emergency uses					

Note. 'Coord.' (i.e. coordinate) is the association's positioning on the dimension. 'Contr.' (i.e. contribution) is the association's weight in explaining the dimension; only those associations with a contribution greater than 1.00 (i.e. >100/Types) are presented. The labels in italics are the variables' modalities; only those modalities with a test-value higher than 1.96 in absolute value are presented.

three contexts considered, are positioned on this pole.

The following dimensions allow to better specify this first dimension on the human-machine relationship, contributing to provide a more complex and multifaceted view of the SR under investigation.

The second dimension defines different components that – together with skills which are not present –prefigure robot-mediated practices (Table 3). It opposes an 'ideal' perspective on the one pole to a 'material' perspective on the other.

The 'ideal' pole collects associations that depict robots as futuristic technologies, approached with fascinations and cautions. Specifically, the associations to the material dimension only generically refer to systems as a whole (e.g., technology, advanced technology), as well as to the disciplinary field of computer science without further specificities, characterisations or components. Moreover, no associations concern the design dimension. On the contrary, the imaginative dimension depicts robots as appealing innovations for the future (e.g., curiosity, futurism, innovation, progress, future, revolution, development). Finally, the functional dimension stresses both potentialities and risks (e.g., usefulness, danger, speed).Male participants, those who have a more positive attitude toward robots, and those who think about robots as lacking the agency but having the experience, are positioned on this pole.

On the other side, the emerging 'material' pole gathers together associations representing robots as current devices, characterised by both advantages and limitations. Specifically, the associations to the material dimension mainly refer to systems as a whole (e.g., object) or commonly used devices (e.g., household appliance, drone), as well as to components characterising the mechatronics sector (e.g., gear, mechanism, engine). Moreover, about design, mostly differences - but also similarities - with human beings are mentioned (e.g., metallic voice, cold colour, metal, voice). Coherently, the references to the behavioural (e.g., semi-movement, task execution, command, movement) and cognitive (e.g., without intelligence) spheres further underline robots' accessory role for human beings. Then, the associations to the imaginative dimension only occasionally refer to the media's science fiction imagery (e.g., movie). Finally, the functional dimension especially highlights the robots' limitations (e.g., limit).Female participants and those who have a more negative attitude toward robots are positioned on this pole.

The third dimension defines different anchoring, especially related to familiar contexts of use (Table 4). It opposes an 'ICTs' focus on the one pole to a 'devices' focus on the other.

The 'ICTs' pole links robots to concrete daily uses. Specifically, the associations to the material dimension mainly refer to systems as a whole (e.g., automaton) or commonly used devices (e.g., mobile phone, social robot), as well as to the disciplinary field of electronics and specificities or components characterising technology information sector (e.g., software, cable, automation). Moreover, the contextual dimension, which is exclusive to this pole, focuses on the domestic environment (e.g., home automation, daily life). Male participants, those who think about robots as lacking agency and experience, and those who are more in favour of using robots in education and care contexts and health and emergency contexts are positioned on this pole.

On the other side, the emerging 'devices' pole connects robots to

Table 3
Second dimension (2.31% of explained total inertia).

Components of Practices					
Ideal			Material		
Association	Coord.	Contr.	Association	Coord.	Contr.
curiosity	−3.78	5.93	metallic voice	3.39	7.15
futurism	−3.25	4.37	semi-movement	2.97	5.48
innovation	−1.09	4.15	household appliance	1.11	4.75
technology	−0.50	3.13	mechanism	2.03	4.25
computer science	−0.92	2.01	task execution	1.97	3.62
progress	−0.92	2.01	cold colour	1.49	3.46
usefulness	−0.66	1.91	engine	2.77	3.17
future	−0.44	1.86	command	1.09	3.05
advanced technology	−1.42	1.66	gear	1.13	2.51
revolution	−1.36	1.53	drone	1.89	2.21
development	−0.80	1.32	metal	0.50	2.16
danger	−1.07	1.18	movement	1.28	1.86
speed	−0.80	1.05	object	1.73	1.85
Male			limit	1.58	1.82
Positive attitude			without intelligence	2.07	1.78
High experience and low agency			voice	1.90	1.49
			movie	0.48	1.47
			Female		
			Negative attitude		

Table 4
Third dimension (2.10% of explained total inertia).

Anchoring in household					
ICTs			Devices		
Association	Coord.	Contr.	Association	Coord.	Contr.
mobile phone	−6.73	20.65	household appliance	1.51	9.59
home automation	−4.84	13.36	curiosity	3.13	4.47
software	−5.29	12.76	futurism	3.06	4.27
social robot	−2.12	5.65	cartoon	1.03	2.79
automaton	−0.92	2.49	drone	1.82	2.26
cable	−2.03	2.34	advanced technology	1.29	1.52
automation	−0.49	1.74	*Female*		
daily life	−1.25	1.24	*Refusal education and care uses*		
electronics	−0.69	1.13	*Refusal health and emergency uses*		
Male					
Low experience and agency					
Acceptance education and care uses					
Acceptance health and emergency uses					

imaginative future uses. Precisely, similar to the negative pole, the associations to the material dimension mostly refer to systems as a whole (e.g., advanced technology) or commonly used devices (e.g., household appliance, drone). However, the imaginative dimension, which is exclusive to this pole, highlights the reference to the media's science fiction imaginary (e.g., cartoon) and, also, a certain appeal for the future (e.g., curiosity, futurism).

Female participants and those who are more opposed to using robots in education and care contexts and in health and emergency contexts are positioned on this pole.

7. Discussion and conclusions

Drawing on the SRT, this study examined shared images and beliefs, connected with our understanding and expectations towards robots [66].

Coherently with previous research, this study shows that the SRof robots mixes concrete elements, rational evaluations and leaded value interpretations [25]. These organised sets of images, beliefs, emotions determine alternate views of what a robot is and are connected with the attitudes that participants have towards robots. In particular, thanks to lexical correspondence analysis, this study shows that different positioning on the SR are associated with general attitudes, domain-specific evaluations of robots, and levels of perceived proximity with human beings (operationalised as perceiving robots as having agency and feelings).

As expected, we have identified diverse views co-present and competing to become hegemonic [6].The contents associated with robots how many facets, confirming that it is still a debated SR, with a mix of pros and cons, ideal and concrete aspects. The prevalence of references to material aspects suggests a strong tendency towards objectification. The contents associated with robots also refer to the sphere of the imagination and invoke functional, cognitive and affective characteristics to define the proximity or distance, the threat or the utility that these machines could represent. It should be noted that both the distance and the similarity are threat sources, especially in terms of replacement and loss of control [2,19,67]. However, the robot is no longer only associated with the figurative core of the metal object, or solely to action: it is also anchored to ICTs, suggesting a possible dematerialisation of the device in favour of its communicative functions [56–58,68]. In this regard, the reference to design is worth noting, demonstrating the aesthetic - and no longer merely functional - interpretation of the object [28].

The lexical correspondence analysis identifies some fundamental dimensions that organise the representational field. These dimensions are based on principles of regulation of the Human-Robot relationship: separateness or integration into society, presence at an imaginary level or translation into the material plane, integration into activities of daily life as ICTs or as devices and appliances.

Viewing robots as more concrete and integrated is related to a positive attitude across all domains (dull, health and emergency and education and care). In contrast, a more distant view is associated with negative attitudes.

Interestingly, the mind perception, i.e., the attribution of agency and feeling to robots, is crucial to explain the organisation of contents associated with robots. A higher perception of agency alone is related to a vision connected with the ideal sphere and imaginary contents, which is not free from threat perception. This vision appears coherent with the topoi present in films and movies. On the contrary, attributing high agency and experience to robots is related to a more integrated vision (first factor). Moreover, this attribution is associated with the assimilation of robots to ICTs (third factor). The same anchoring of robots to ICTs is also related to a more favourable view of robots in education, care and health.

These are preliminary results, given the limited sample and its narrowness in educational level. Of course, some resistances remain firmly rooted, and gender differences in the acceptance of technologies were also found in our data [69]. Moreover, we still lack real everyday experiences with robots and rely on the SRs or mental image of robots' attributes and qualities [50]. However, these results suggest the emergence and affirmation of new figurative nuclei anchored to ICTs and capable of undermining the old image based on mechatronics. This emerging SR could be connected with a similar trend observed in the media [23].

Going beyond the data, such an ICT-based and integrated SR of robots provides insights into the interaction with humans that could be envisaged in future, especially in the health and caring spheres. Overall, the results suggest that assimilating robots to mobile phones and home automation could open the door to social robotics in everyday life, including the sphere of social reproduction. This is coherent with cooperative models of communication that emphasise the ability to feel decisive for significant interaction [70,71]. This vision contrast with the image of robots that characterised science fiction and media imaginary, and that stressed the hyper-efficient bud cold device or the humanoid that substitutes humans [72]. Our study instead suggests that the more robots will be perceived as capable of feeling, the more they will be considered part of communicative practices, and the more they will be accepted in a society of robots and humans [73].

We believe that the significance of this study pertains to the assumption that young adults' representations of robots provide insights into their willingness to use robots in different contexts in future. Exploring the representations shared by this target group would also allow for a better understanding of the acceptance of which robot in which context, in the future [74]. Furthermore, young adults are generally more familiar with novel "smart" technologies than older adults, and easily incorporate these into their everyday lives. For instance, studies on human evaluations of robots typically have investigated young adult participants only (e.g. Refs. [75–77].

Our approach shares some similarities with the Attitude Representation Theory (ART; [78], holding that attitude-relevant responses are informed by mental representations of the attitude object, which include associated exemplars, characteristics, emotions, contexts, and actions. For instance, an individual's attitude-relevant responses toward gay men, for instance, might be informed by accessible exemplars (e.g., Elton John), characteristics (e.g., sensitive), emotions (e.g., surprise), contexts (e.g., discos), and actions (e.g., "ate with" or "support their cause"). However, our approach does not lie in the mainstream social cognition paradigm, while we start from the SRT that resorts to the socio-constructivist approach.

Overall attitudes towards robots are slightly positive. This is a well-established figure that does not seem to have varied significantly in recent years (e.g., Ref. [30]. The presence of robots in repetitive jobs remains, on average, the most accepted (for a review, [32]. However, the socialisation activity promoted by the media (e.g. Ref. [23], regarding the possibility of using robots in sectors other than the dull and dirty ones seems to have made inroads among our respondents. Their presence in the field that we have defined as health &emergency is also evaluated positively. This is a partially new finding, since it associates the emergency domain with that of health, possibly overriding the perceived risks highlighted by previous investigations [26] and is potentially relevant given the pandemic emergency we are experiencing.

Concerning the introduction of robots in education & care, the average opinion on their employment in this area is still negative as in previous research [30,32,41,79]. However, the average evaluation seems to be moving towards a greater acceptance and respondents who score above the mean on this dimension associate very peculiar contents of robots.

In line with this trend in attitudes, data on mind perception also show some novelty. In the study by Gray et al. [62]; humans were attributed with both the highest values of agency and experience. Robots were associated with intermediate values for the agency and shallow values for the experience. Our respondents now report an image of robots much closer to humans' mental capacities: the robots are above the scale midpoint as concerns the agency, and just below as concernsthe experience.

Going beyond the analysis of averages and differentiating groups based on their attitudes and of combined values of agency and feeling, we were able to describe different placements in the representational field associated with robots. Exploring such a multiplicity of views and representations is particularly relevant to obtain map of alternate visions and to connect them with possible explicatory variables.

As for the limitations of the study, we are aware that our convenience sampling is not necessarily representative of young Italians in general. To ensure heterogeneity, candidates were approached across a broad spectrum relating to the study topic. Furthermore, we used a small sample size, which should definitely be enlarged. It would be necessary to collect additional data to support our findings. Also, we are aware that social representations are shared among a specific social group and they are specific of that group. Future studies could explore the social representations of robots in non-Western countries such as collectivistic Asian countries. Moreover, we are aware of the correlational nature of our study, and no causal inferences can be drawn. Finally, translation issues concerning how to express the participants' meaning in English so the voices of the participants could be heard accurately, should be addressed. Data collection, analysis and discussion between authors over the results were run in Italian. Then, relevant words/concept were translated from Italian to English by the authors, as common practice in qualitative research (e.g., Refs. [48,49].

In conclusion, it could be tentatively said that the more robots are considered part of the ICT ecosystem, the more their image will move away from the old representation of a metallic and emotionless object and the active yet threatening image of cold super-human agents. On the contrary, the emergence of an ICT-based vision suggests that they will become part of everyday life and eventually become accepted for health, care and educational tasks. Now that, in the pandemic phase, our communication is increasingly mediated by technologies and that we have been forced to transfer our activities such as teaching, relationship with partners, friends and parents to virtual settings, this link between robots and ICTs observed in a 'pre-COVID' era could find a further boost, encouraging their acceptance in areas hitherto precluded.

Author statement file for authors' individual contributions

Sonia Brondi and Mauro Sarrica: Conceptualization. **Sonia Brondi, Mauro Sarrica, Monica Pivetti**: Data curation. **Sonia Brondi, Mauro Sarrica, Monica Pivetti, Silvia Di Battista**: Formal analysis. **Sonia Brondi, Mauro Sarrica, Monica Pivetti**: Investigation; Sonia Brondi, Mauro Sarrica, Monica Pivetti, **Silvia Di Battista**: Methodology; **Sonia Brondi and Mauro Sarrica**: Project administration; **Sonia Brondi, Mauro Sarrica, Monica Pivetti, Silvia Di Battista**: Resources; **Sonia Brondi, Mauro Sarrica, Monica Pivetti, Silvia Di Battista**: Software; **Mauro Sarrica and Monica Pivetti**: Supervision; **Sonia Brondi, Mauro Sarrica, Monica Pivetti, Silvia Di Battista**: Validation; **Sonia Brondi, Mauro Sarrica, Monica Pivetti, Silvia Di Battista**: Visualization; **Sonia Brondi, Mauro Sarrica, Monica Pivetti, Silvia Di Battista**: Roles/Writing - original draft; **Sonia Brondi, Mauro Sarrica, Monica Pivetti, Silvia Di Battista**: Writing - review & editing.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.techsoc.2021.101663.

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