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# Children's Knowledge and Imaginary About Robots

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## Abstract
The aim of this paper is to investigate on children's knowledge and imaginary about robots. To do so, we administered to 704 children from 17 classes of 8 elementary and secondary schools, a survey with close and open questions about their conceptualization of robots. To carry out this study we took as point of reference the theoretical framework of social representations. The main results are that children evaluate toys, robots and human beings as significantly different on all the characteristics considered. More than toys, robots have mechanical movements, they move, are more intelligent than toys but they do not keep company to them. By contrast, human beings are perceived by children starting from their corporeity: they eat and sleep, move by themselves, are intelligent and speak, keep eye-contact and company. However, children complain about the fact that human beings do not play with them. The imaginary about robots that children receive from media is characterized by anthropomorphic shapes, bodies and by human-like cognitions, feelings and behavior. The more examples of visual products with robots children are able to evoke, the higher they evaluate robots on all human-like characteristics (e.g., it looks into my eyes). Hence, the tension between imaginary and knowledge can be confounding because the human-like features of fictional robots are more advanced than those reachable by the factual ones.

**Keywords** Child imagination · Robots · Toys · Human beings · Social representations

## 1 Introduction
Much effort is being expended trying to get robots to be able to cope with the world we live in, a world which is engineered for humans. Robots must act and perform not only responding to the laws of physics but also dealing with the diversity of the environments and other artificial artefacts. Therefore, engineers and programmers must take into consideration not only the design constraints afore mentioned but also other issues arising from the fact that robots will "live" with humans. Knowing people's conceptualizations and attitudes towards the different kind of robots (from industry robots to service ones, from humanoids to nonhuman shaped ones) is a necessary premise to design social robots in the right direction and to target different users (e.g., men or women, experts or not experts, children and/or old people) according to their specific expectations, needs and requests [8,17,29,38].
In this contribution, we present a preliminary investigation of children's knowledge and imaginary about robots. Indeed, together with explicit knowledge, imagination about robots has much strength in influencing people's attitudes and behavior towards them [19]. Robots are cultural artefacts, which are at the dawn of their social use [32].
The starting point of the present study is that robots are going towards a critical phase that will see more and more interactions, confrontations, and conflicts between social imaginary, everyday practices and technical knowledge about robots.
On the one hand, very few people in general have had a concrete experience of a robot. According to the World Robotics Report 2014, in 2013 industrial robot sales arrived at 178,132 units, showing an increase of 12%. Service robot sales both for professional use (in the fields of military defense, agriculture, logistic, medicine, mobile platforms, construction, cleaning, underwater, inspection, rescue and security), and for

personal/domestic use, in 2013 decreased of 4% in comparison to 2012, arriving at 20,200 units. This limited diffusion of robots in the industrial and service settings, and at home, explains why only few people have a direct experience of robots. A study promoted by Eurobarometer [9] found that only 13% of European citizens have used a robot in their lives [34]. This means that for the majority of the European population the imaginary about robots is largely inspired by science fiction literature, movies, cartoons etc. Our idea is that this percentage is even lower among children and youth who have not been involved yet in a labor experience.

On the other hand, people, and especially youngsters, are more and more exposed to initiatives and practices which are spreading technical knowledge about robots. We are thinking about: (1) the launch of many educational initiatives using robots in schools in order to familiarize pupils and students in general with a complex, technological artefact (see, for example, the work done by the Robotics School of Genova, http://www.scuoladirobotica.it/); (2) the entering in the robotics field of the Do It Yourself (DIY) movement by using for example the 3D printer, in order to build humanoids (see, for example, InMoov,theprojectinitiatedinJanuary2012by Gael Langevin, a French model maker and sculptor, http://www.inmoov.fr/); (3) the entry of social robots in the sphere of social reproduction [12,34].

Due to the criticality of this phase, where the imaginary co-exists with the direct familiarization with robots, the time is ripe for an exploration on the social representations of robots. Reconstructing how social robots are being metabolized in the system of social thought enables us to understand how they will be integrated in the future everyday life. Several research have explored the practices of robot use both in industrial settings [3] and domestic spheres [4,33]. Other research underlines the relevance of cultural and media context inhuman-robot interaction processes, such as the persistence of the uncanny valley [40]. Empirical studies begin to investigate about the process of integration of robots and social robots in domestic life [16]. The present paper aims at reflecting on how this domestication is taking place at the socio-cognitive level. In particular, we focus on young generations: we argue that children and pre-teens from 9 to 14 are being socialized and are already developing their own lay knowledge of robots. Since this generation will probably witness the spread of robots tomorrow, their representations of robots are likely to affect meanings and attitudes, and their practices of use.

## 2 Social Representations Approach

We take as point of reference for the present study the theoretical framework of social representations [25,27]. This notion was introduced by Durkheim [6], who spoke of "collective" representations. In a second moment, this concept was worked out by Moscovici [25,28]who developed and situated it at the frontier of the social and psychological domain.

According to Moscovici, social representations are "systems of values, ideas and practices, which have a twofold function. First, they aim to define an order to shape the material and social world and control it; second, they aim to make it possible to communicate among the members of a social group or community by supplying them with a code for naming and classifying the various aspects of their world and their narrativity." [26, p. XIII]

Social representations are characterized by stability and dynamism. “We stabilize representations of ourselves and of things in concert with others, with a shared pool of categorical perceptions, symbols and conventionalized and habitual behavior patterns. But this stability is precarious, permanently open to challenge” [2, p. 169]. Whenever something new and challenging enters the everyday life of social groups it becomes object of communication trough different channels, including social practices, public discourses and, of course, media (from newspapers and film to music and television programs). Such collective elaboration contributes to attribute features and meanings to objects which become parts of a group’s social world [37]. In this way, groups assimilate the novelties through previously shared representations; at the same time, new elements transform representations, modify their contents or even radically disrupt their structure. The anchoring and objectification processes are at the core of these procedures Anchoring allows to incorporate something unfamiliar into our stable net of categories by integrating it cognitively in the pre-existing system of thoughts. Objectification helps us transform something abstract into a concrete form and embody it in conceptual schemes. The resulting representation is not necessarily accurate or scientifically correct. “That is, whether an image is accepted or not by a group is neither a problem of truth nor an arbitrary choice but determined by the group’s experiential world and the negotiated consensus of the group members” [37, p. 100].

A series of consequences derive from this assumption, above all the fact that knowledge is bound to social contexts, and that different universes of knowledge coexist in societies, as well as, at the cognitive level [24]. Social representations are knowledge-in-context: they are not elaborated in a vacuum; they are culturally and historically embedded sets of meanings and practices. In order to understand how novelties are accepted, ignored or refused we shall thus understand local and broader contexts, the positioning of specific groups within societies, and the communicative systems in which individuals and groups are involved.

Social representations are a specific form of knowledge: an analysis of the universes of knowledge goes beyond the goal of this paper (for a critic see [1], suffices here to say that the theory initially distinguished between the reified and consensual universes of knowledge). These can be conceived as two ideal-types, two poles of a continuum that correspond to science and common sense. The reified universe is ideally characterized by formal knowledge, structured roles, rationality, and quest for factual and impartial knowledge. Consensual universes are characterized by social thinking, aimed at explaining objects, making them accessible, and enabling communication among members of a specific group. Once established, a social representation can be conceived as a “socially elaborated and shared form of knowledge that has a practical goal and builds a reality that is common to a social set” [22, p. 48].

Direct and mediated communication is thus pivotal in the social representation theory: it links individual cognitions with the social dimension, transforms something unknown into something familiar. It is the arena where the battle of ideas takes place [20–22]. Although we tend to assume that knowledge is shared through verbal communication, artistic, pragmatic and visual media shall be considered as well [2]. Visual media are particularly relevant for their capacity to use, manipulate, and foster images, which are a special doorway into the very essence of a social representation. The use of images “implies jointly occurring and simultaneous processes of genesis, transmission and objectification of social representations” [5, p. 241]. Indeed, images are at the core of anchoring and objectification processes: images, symbols and metaphors help making an unfamiliar object easier to understand [23]. Moreover, to objectify is "to discover the iconic quality of an imprecise idea or being, to reproduce a concept in an image" [28, p. 38]. Finally, images are also specific forms of transmission: they can be used to activate specific contents or to foster the development of new social representations [5].

The social representation theory has been largely advocated for going beyond the 'impact' or 'acceptance' frameworks in the study of technology–society relationships. New technologies, especially when they start being spread out of niches of innovators and early adopters, often become objects of representations: they are multifaceted, their use involves pros and cons, people are pushed to take position about their use and limits. From these premises, studies have been already conducted on social representations of single technologies, such as the computer (see, for example [30,36]), the mobile phone and Internet [13] and the main telecommunication technologies [14]. The present study is, at the best of our knowledge, one of the first attempts to examine robots from a social representation perspective. Indeed, many studies in the field of robotics, have examined people's reaction to (real or imagined) interaction with robots. Results often show that experts and non-experts have different knowledge and attitudes towards robots: the former being usually more informed and more positive [8,38].

Although these studies are fundamental, the social representation theory takes a different stance. Whereas research on attitudes, examines 'how' individuals respond to an object, the social representation theory is mainly concerned with the processes through which the 'objects' that constitute our everyday reality are co-constructed. An analysis of current social representations of robots thus starts from the consideration that's what a robots' is a controversial issue even among experts [38] and it shares the same premises of mutual shaping frameworks when it "suggests that the social values of technology for different groups and the meaning of various technological choices can and should be questioned throughout the process of technology design" [29, p. 445].

In the present study, we introduce a research project addressed to children and pre-teens. This study regards a survey about robots that we administered to a sample of 704 children of elementary and secondary schools in two cities of the region Friuli Venezia Giulia (IT)—Udine and Pordenone—, a region on the border with Austria and Slovenia. Drawing on the theoretical premises illustrated so far, in the present study we will examine some of the main facets of the representations shared by children and pre-teens:

RQ1 Cognitive facets: what are the main characteristics of robots or social robots perceived by children?
RQ2 Pragmatic facets: What do children think that a robot does/does not, and what hey believe they can/cannot do with it?
RQ3 Images: What are the prototypes of robots to which they have been socialized by visual media?
RQ4 Communicative system: How does(self-reported) exposure to visual media interact with cognitive and pragmatic facets of the social representations of robots?

With these research questions, we aimed to advance the understanding of how robots are actually conceptualized by children, whether and how they are socialized to consensual knowledge about robots. The findings will provide insights for roboticists, as well as for the social science research community.

In the next section, we shall describe the methods applied, which are both qualitative and quantitative. Then we shall go on to present the results of the research and describe the study we have carried out. Finally, we will provide a discussion of the results by also illustrating the strong and weak points of the study presented and indicating future research directions.

## 3 Methods

To describe and understand the level of domestication of robots and social robots, we decided to organize in 2013 a study covering the age group 9–14, by using a questionnaire as methodological tool.
Three main assumptions were considered in the selection of the sample:

- Children's reality is structured by social representations that define the world into which they were born. "Yet, the circulation of representations around the child does not lead to them being either simply impressed upon the child, or simply appropriated by the child. Rather, their acquisition is the outcome of a process of development, and a focus on this process can in turn illustrate something about the structure of social representations themselves" [7, p.1].
- Children and pre-adolescent aged between 9 and 14years have already developed the cognitive abilities that are required to elaborate synthetic and coordinated meanings, communicate with peers, develop sufficiently complex images. At the same time, the considered age range gives us the possibility to explore ontogenetic processes linked to social representations.
- We wanted to collect data of children and preadolescent living in the same geographical area. We were able only to approximate the objective to have the entire universes of children attending the fourth and fifth classes of elementary schools and the three classes of secondary schools in Pordenone and Udine. However, the selected sample is likely to reflect quite well the characteristics of the children of the same ages in these two cities.

On the whole,704 children were surveyed on robots in this study. The males are 376 (53.4%) and the females are 328 (46.6%). The age distribution is: children of 9 years old are 71 (10.1%), of 10 years are 193 (27.4%), 11 years are 182 (25.9%), 12 years are 118 (16.8%), 13 years are 90 (12.8%), 14 years are 49 (7.0%) and 15 years is 1 (0.1%).
In Pordenone, we randomly selected two out of its four Comprehensive Institutes (which are the territorial organizational structures of the Italian school system comprehending kindergarten, primary and lower secondary school) and precisely the "Central" Comprehensive Institute and the "Torre" Comprehensive Institute. In the first Institute, we selected all the primary schools ("Gabelli", "Collodi", "IV Novembre") and its secondary school ("Centro Storico").In the se primary schools, we selected all the fourth classes (5 in total) and the fifth classes (4 in total). In the secondary school, we selected two sections out of three and hence two first classes, two second classes and two third classes. In the second Institute, we selected its two primary schools ("Odorico da Pordenone" and "Narvesa") and its secondary school ("Lozer"). Among its primary schools we selected all the fourth classes (4 in total) and all the fifth classes (4 in total) and in the secondary school we selected 2 sections out of 7 (2 first classes, 2 second classes and 2 third classes). In Udine we selected all the five first classes of the secondary school "Valussi", where a previous experiment on robot building was conducted in 2013, involving children of one of the classes.

A simple questionnaire (organized in different sections) was distributed to the children. The questionnaire included a few personal data questions (name, class, age, gender, and place of residence), some prior information on robots, (we asked: Do you know what a robot is? and Do you know cartoons or other TV programs or movies with robots?). This section was followed by a series of questions aimed at understanding the children's frames of toys, robots, and human beings. These aspects were measured on a four-point Likert scale (0 = not at all, 1 = a little, 2 = enough and 3 = for sure). Part of the questionnaire e was already used in the above mentioned study involving 18 children from the secondary school "Valussi", in Udine (Italy) [15].

The data coming from the survey were analyzed by means of descriptive statistics, t-test for independent samples, the GLM model, chi-square test and standardized residuals. In particular, we used contingency tables with Pearson's chi-squared test to show how the children's knowledge of cartoons or other television programs or movies with robots is distributed by gender. In the case of age, when the relationship between the two variables was significant, to verify which particular variable was responsible for a significant chi-square test result we exploited standardized residuals, which are considered statistically significant if the value lies outside ±1.96 [10].

# 4 Results

## 4.1 Factual Knowledge

Almost all the children (98.2%) reported knowing what a robot is. There are no gender or age differences in this concern. Then we asked the children to describe the main features of robots and for purpose of comparison also those of toys and human beings by giving them a battery of 16 statements to be judged on a four-point Likert scale. Table 1 reports all the scores obtained in terms of averages computed on four Likert scale points and respective standard deviations (SD). Children answered that a robot moves, also by itself, has gears and mechanisms, has an engine, and has a battery (Table 1). At the same time, they are unconvinced that they can control it, that the robot is intelligent, can speak, looks into their eyes, looks like a human, it keeps them company, they play with it, it is like a cartoon/movie character, and it is good. Children, instead are sure that robots do not look like animals and do not eat or sleep, showing that zoomorphic robots such AIBO or Paro [35] are unknown to them.

As to the terms of comparison, children distinguish very sharply the features of toys, from those of robots and human beings. Indeed, a repeated GLM measure shows that toys, robots and human beings are evaluated as significantly different on all the characteristics considered (Table 1). More than toys, robots have mechanical movements, they move, are more intelligent than toys but they do not keep the children company. By contrast, human beings are perceived by children starting from their corporeity: they eat and sleep, they also move by themselves, they are intelligent and speak. They keep eye-contact and keep company; however, children declare that human beings do not play with them.

At test for independent samples was applied to the scores expressed by boys and girls in order to verify gender differences. Girls more than boys are convinced that robots are not very intelligent ($t = 2.786$; $p < .01$), do not look into their eyes ($t = 2.107$; $p < .05$), do not look like a human being ($t = 3.423$; $p < .01$). In sum, for girls robots have less human features than for boys. Boys more than girls stress the fact that robots have gears and mechanisms ($t = 3.861$; $p < .01$) and an engine ($t = 3.561$; $p < .0001$).

Both boys and girls are convinced that a robot is not like a cartoon/movie character, but girls are more radical in this judgment ($t = 2.009$; $p < .05$). Finally, both boys and girls are scarcely convinced that robots can be described as good, but girls even less than boys ($t = 2.409$; $p < .05$).

**Table 1** Children's evaluations of the characteristics of toy, robot and human being

| | Toy | Robot | Human being | $F_{(2,1098)}$ |
|---|---|---|---|---|
| 1. It has a battery | 1.69 (SD 0.958) | 2.29 (SD 0.896) | 0.86 (SD 0.447) | 1289.89** |
| 2. It moves | 1.52 (SD 1.006) | 2.41 (SD 0.798) | 2.58 (SD 0.857) | 272.48** |
| 3. It moves by itself | 1.25 (SD 1.080) | 2.25 (SD 0.974) | 2.78 (SD 0.649) | 497.34** |
| 4. It is intelligent | 0.80 (SD 1.077) | 1.73 (SD 1.125) | 2.76 (SD 0.595) | 704.24** |
| 5. It speaks | 1.14 (SD 1.034) | 1.87 (SD 1.005) | 2.79 (SD 0.584) | 605.32** |
| 6. It looks into my eyes | 0.79 (SD 0.963) | 1.15 (SD 1.065) | 2.49 (SD 0.869) | 606.20** |
| 7. It looks like a human | 1.16 (SD 1.020) | 1.26 (SD 1.096) | 2.56 (SD 0.945) | 416.62** |
| 8. It looks like an animal | 1.25 (SD 1.018) | 0.86 (SD 0.975) | 0.55 (SD 0.889) | 80.87** |
| 9. It has gears, mechanisms | 1.67 (SD 1.100) | 2.43 (SD 0.893) | 0.19 (SD 0.646) | 1063.72** |
| 10. It has an engine | 1.23 (SD 1.136) | 2.02 (SD 1.052) | 0.19 (SD 0.655) | 658.39** |
| 11. I can control it | 1.89 (SD 1.050) | 1.98 (SD 1.050) | 0.19 (SD 0.681) | 814.88** |
| 12. It keeps me company | 1.55 (SD 1.140) | 1.30 (SD 1.075) | 2.35 (SD 0.930) | 194.96** |
| 13. I play with it | 2.25 (SD 0.951) | 1.56 (SD 1.118) | 1.30 (SD 1.252) | 149.05** |
| 14. It is like a cartoon/movie character | 1.69 (SD 1.043) | 1.17 (SD 1.070) | 0.67 (SD 0.992) | 185.01** |
| 15. It is good | 1.01 (SD 1.093) | 1.01 (SD 1.067) | 2.06 (SD 1.036) | 265.43** |
| 16. It eats and sleeps | 0.43 (SD 0.828) | 0.57 (SD 0.921) | 2.68 (SD 0.759) | 1523.56** |

Results are reported in terms of averages computed on four-points Likert scale (range from 0 = not at all to 3 = for sure) and respective Standard Deviations (SD). For each comparison, *F* value from the GLM model is reported. ***p* < **.01**

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In order to detect age differences, we applied the t-test for independent samples to the pupils attending the elementary and secondary schools. Pupils attending secondary schools are more convinced than youngsters that robots are intelligent ($t = -3.820$; $p < .0001$). By contrast, pupils attending elementary schools are more convinced that robots move by themselves ($t = -3.796$; $p < .0001$), have an engine ($t = -2.603$; $p < .01$), can play with them ($t = 2.728$; $p < .01$), are like a cartoon/movie character ($t = 2.705$; $p < .01$) and are good ($t = 2.257$; $p < .05$). However, even though we found differences according to the gender and age, the relative positions on toys, robots and humans do not vary. For example, even though the children attending elementary schools state that they can play with robots more than those attending secondary schools, forth is question both the groups rated higher the toys and lower the humans with respect to the robots.

In the following section, it was investigated whether factual knowledge fits with the prototype of robots that children receive from visual media.

### 4.2 The Fictional Knowledge

When asked: "Do you know cartoons or other television programs or movies with robots?" 65.6% of the children reported knowing the name of some visual products with robots. Among the 242 who declared not being able to cite any visual product with robots, girls are again significantly more than boys ($\chi 2 = 53.535$, df = 1, $p < .0001$) and children aged 10 more than the older children ($\chi 2 = 55.575$, df = 6, $p < .0001$, adj.res. = 6.1). Children were then asked to list examples of robots they know from cartoons, TV or movies. This question foresaw multiple open answers: we collected 1243 answers. Children named a total of 125 visual products with robots. The most named visual products together with their naming frequency are reported in Table 2.

The visual products reported in Table 2 cover more than half of the children's answers. This may suggest that such visual products express the prototypical child imagery of robots and contribute to define the robot representation shared by children. The remaining robot names not reported in Table 2 are associated with a very low naming frequency (less than 1%) and thus are considered expressions of individual preferences. The most known visual products considered as robots are Transformers, Futurama, Iron Man, and Star Wars. The data clearly suggest that the interviewed children have lost any connection with the archetype and the myth of the robot. The images that come from mass media are products in which the mythical features of robots have given way to the mystification power of mass culture [11]. Apart from The fairly odd parents and The Power Rangers, where the magic plays a central role, in all the remaining most cited productions, featuring robots are products of technological efforts, either terrestrial or alien.

The Transformers are a species of sentient, living robotic beings originating from an alien planet. The name comes from their ability to transform, change their bodies, rearranging their components from a robotic primary mode (usually, but not always, a humanoid robot-shape) into an alternate shape, which is generally a car, truck or other vehicle.

Futurama is an adult animated science fiction sitcom, set in an adult animated thirty first century. One of the main characters, Bender Bending Rodriguez, is an anthropomorphic robot playing the role of the movie's protagonist best friend and roommate.

Iron Man is a fictional character, a superhero that first appeared in comics, then it was featured in a series of cartoons, and finally it was adapted for movies. The main character is an inventive human, which is a genius in electrical and mechanical engineering. Some artificial organs have been transplanted into him and he wears a robot-looking armour enhanced with an artificial intelligence. The armour gives him superhuman strength, durability and power.

As to Star Wars, probably the children are referring to the TV cartoon derived from the two film trilogies. Robots are present in the form of "droids" (humanoids and not), generally built to serve their owners, both heroes and antagonists. Their sizes are compatible with a fictional futuristic living environment.

Wall·E is a computer-animated science fiction film. The main characters are two service robots: Wall·E, designed to clean a futuristic, abandoned Earth, and EVE, which is

**Table 2** The most frequent visual products with robots named by children

| Visual products | Frequency | (%) | Media-genre | Transmediality | Country |
|---|---|---|---|---|---|
| Transformers | 156 | (12.6) | Cinema | Yes | US |
| Futurama | 122 | (9.8) | TV-Anim. | No | US |

| | | | | | |
|---|---|---|---|---|---|
| Iron man | 110 | (8.9) | Cinema | No | US |
| Star wars | 108 | (8.7) | Cinema | Yes | US |
| Wall·E | 91 | (7.3) | Cinema-Anim. | No | US |
| I Robot | 90 | (7.2) | Cinema | Yes | US |
| The terminator | 55 | (4.4) | Cinema | No | US |
| Dragon ball | 34 | (2.7) | TV-Anim. | Yes | JP |
| Power rangers | 25 | (2.0) | TV-Series | Yes | US |
| UFO robot | 24 | (1.9) | TV-Anim. | No | JP |
| The fairly oddparents | 21 | (1.7) | TV-Anim. | No | US |
| Subtotal | 837 | (67.3) | | | |
| Total | 1243 | (100) | | | |

On the rows are reported the visual products with the robots named by children; on the columns are reported for each visual product the naming frequency, media-genre, trans-mediality, and the country of origin of the visual products

programmed to search for living traces. Both robots show some form of free will and human-like emotions. Their nonhumanoid appearance is due to their service tasks.

I, Robot is a science fiction action film inspired by Isaac Asimov's collection of nine science fiction short stories. The plot of the film revolves around anthropomorphic robots programmed with the Three Laws of Robotics directives and used as servants.

The Terminator is a series of science fiction films and additional media such as television series, comic book series and videogames. The central theme is the battle between the human race and a self-aware artificial intelligence, Skynet, which uses as weapons terminators (in the shape of cyborgs), androids or non-humanoid robots.

Doragon Bōru (Hepburn transliteration of the Japanese name, Dragon Ball in English) is a media franchise consisting of manga, anime series and animated feature films. The plot follows the adventures of the lead character from his childhood through to his adulthood. Among the featuring characters, there are robots and androids, cyborgs (organic beings modified with mechanical parts) and machine mutants (a full artificial race).

Power Rangers is a franchise consisting of children's action television series, comics, films and games. Protagonists of the adventures are teams of costumed heroes able to utilize special powers and drive enormous robot machines, some of them in the shape of humanoids.

UFO Robot is a Super Robot TV anime and manga. The protagonist is member of a humanoid alien species who fights on the Earth piloting his 30 meters tall, human shaped battle robot.

The fairly odd parents is an animated television series revolving around the character of a young boy who has two fairy godparents. The series is set in a fictional American city and in a fairy world where the boy meets diverse sentient robots created by invention or magic. Some of them are the product of a "technological" creation process; some others are the result of a magical intervention.

At this point, we examined the contingency tables crossing the most frequent visual products with gender, age and grade of school. We applied to the Pearson's chi-squared test in order to show how children's knowledge of visual products with robots is distributed. The robot names listed in Table 2 were especially provided by boys (61.6%)

The robot more named by girls is Futurama (adj.res. = 2.9), while Terminator (adj.res. = 2.2) is chosen more by boys ($\chi2 = 16.730$, $df = 9$, $p < 0.05$).

As to the age (in years and excluding the only participant aged 15) significant differences emerge ($\chi2 = 111.112$, $df = 50$, $p < 0.01$). In particular, pre-adolescents evoked I, Robot, which requires higher capacity of reasoning and is preferred by respondents aged 13 (adj.res. = 2.3) and 14 (adj.res. = 2.2), together with Power rangers, which are probably the memories of their infancy (13 years old: adj.res. = 2.6; 14 years old: adj.res. = 2.0). Younger respondents tend to refer to the fairly odd parents (9 years old: adj.res. = 3.3; 10 years old: adj.res. = 2.0), or to The Transformers (10 years old: adj.res. = 4.9). Children attending the elementary schools indicate significantly more The Transformers (adj.res. = 4.4), Iron Man (adj.res. = 2.5) and the fairly odd parents (adj.res. = 3.8), while participants attending the secondary schools choose more Futurama (adj.res. = 3.0), Wall·E (adj.res. = 2.2), I, Robot (adj.res. = 3.3) and Terminator (adj.res. = 2.2) ($\chi2 = 66.578$, $df = 10$, $p < .01$).

In the elaboration of these preferences there is also a clear influence of the school and the class the children attended. We crossed the most frequently named visual products with robots by all the schools and the classes involved in the research and we built two distinct contingency tables. It turned out that children attending the same school focus generally on two robot images, apart from the school "Lozer" where they focus on three (Futurama, I, Robot and Power Rangers) and the schools "Collodi" (only Power Rangers), "IV Novembre" (only Transformers) and "Odorico" (only Iron Man). Children attending the same class generally named one robot product, except for the classes 3A, 4B and 5A, which named two robot products.

From these analyses, it clearly emerges that also socialization plays an important role. The educational institution and the class-group creates a specific cultural climax that mediates the message conveyed by media and reworks it in a direction or another, influencing children's preferences and tastes.

An element, which is surely interesting is the medium involved in this symbolic building. To understand this we investigated on what are the main mass media through which the image of robots is conveyed. We asked: Do you know any cartoons or other TV programs or movies with robots? The results of this investigation are reported in Table 3, after a careful cleaning and correction of the answers given by children.

**Table 3** The media conveying visual products with robots

| Medium | Frequency | (%) |
|---|---|---|
| Cinema | 797 | (53.7) |
| TV | 455 | (30.6) |
| Videogames | 5 | (0.3) |
| Not classifiable | 16 | (1.08) |
| No answer | 242 | (16.3) |
| Total | 1485 | (100.0) |

Surprisingly the golden share in the robot image diffusion is held by the cinema, which conveys more than half of the visual products with robots, followed by the TV with almost a third of them. We would have expected a more important role of TV in this concern, because children continue to be intense users of it. Analogously we would have expected a less important role of the cinema, given the crisis against which cinema actually struggles.

In the data, what is also surprising is the almost absent role of videogames, the weight of which is very marginal. Children do not find in videogames the same characters that they like to see at the cinema or on TV. There are no significant gender and age differences in the indication of robots belonging to the various media.

In this concern, we added to this analysis of the medium conveying the visual products named by children a further analysis on the genre of the visual products. The genre has a different impact on the type of reception by children, as, for example, animation movies versus movies show a more limited capacity to make the robot look alive. Distinguishing the genre, it turns out that while animation is very popular on television (26.9%), where it is more effective than the series, this is not the same for the cinema, where the animation is much less important with respect to movies (9.7 vs. 42%, Table 4). The difference between a movie and an animation movie is a language difference, in the sense that in the first case the language is more denotative and, in the second case, is more connotative. It is also worth noticing that almost half of the visual products named by children have been recoded from a medium (and thus a language) to another medium and language (i.e. from a TV series to toys or from a TV series to a movie). Transmedia products belong to a chain that usually includes toys, animations and movies or TV series. The character is reshaped in another medium and language to build loyalty among the child public or attract new audiences.

However, as to the genre (Table 4), boys more than girls indicate robots movies, while girls more than boys refer to animation cinema and TV series ($\chi^2 = 40.886$, df = 6, $p < .0001$). Animation cinema is also preferred by secondary schools pupils, while video games are more indicated by the youngsters ($\chi^2 = 13.047$, df = 6, $p < .05$).

We also analyzed the role attributed to robots in the visual product named by children. It turns out that the robot is protagonist in 61.2% of the cases, is one of the characters in 10.5% and is a technological tool used in 13.5%. From a qualitative point of view, it turns out that the aliens and the superheroes are marginal, while previous generations were fascinated by E.T., Batman, Cat Woman and so on.

It may be worth considering which cultures have contributed more to set up the children's imaginary about robots. In 83.9% of the cases, the more named visual products were produced in the US, in 11.9% of cases from Japan culture and in 1.4% of cases from the Netherlands.

**Table 4** The genre of visual products with robots named by children

| Genre | Frequency | (%) |
|---|---|---|
| Cinema | 623 | (42.0) |
| Animation cinema | 144 | (9.7) |
| Television series | 49 | (3.3) |
| TV animation series | 400 | (26.9) |
| Videogames | 5 | (0.3) |

| | | |
|---|---|---|
| TV entertainment programs | 6 | (0.4) |
| Not classifiable | 16 | (1.08) |
| No answer | 242 | (16.3) |
| Total | 1485 | (100.0) |

Many other countries have contributed to this imaginary in a marginal way(lessthan1%ofcases). These results suggest that US holds the largest influence on the figurative nucleus of children's social representation of robots. The United States dominate the medium cinema (99.4%)and cinema animation (94.4%), while they have to share with Japan a small share of the TV animation series (61.5 vs. 36.8%) (Table 2).

### 4.3 Interactions Between Factual and Fictional Knowledge

Do factual and fictional knowledge interact? In order to provide a tentative answer to this question we examined the relationship between the different characteristics associated with robots and the quantity and quality of self-reported exposure to prototypes presented by media.

For each respondent we counted the number of media products with evoked robots, and we examined the correlations between this 'quantity' index and the characteristics children attribute to robots (Table 5). It turned out that the more fictional examples of visual products with robots children refer to, the more they believe that robots have characteristics that are typically human (e.g. It is intelligent, It speaks, It looks into my eyes, It looks like a human) and typically mechanical (e.g. It has gears, mechanisms; I can control it).

We then examined, for each participant, which media product with robots was evoked at the first place (remember that participants could give more than one answer). The first answer, in fact, indicates which media product is the most salient to our respondents, and provides a rough index of the 'quality' of media exposure. Among those who reported knowing the name of some visual products with robots, 69 first cite Transformers, 60 Futurama, 49 I, Robot, 39 Iron Man,39StarWars,35 Wall·E,16TheTerminator,9Dragon Ball, 8 Power Rangers, 6 UFO Robot, 5 The fairly odd parents, and 125 respondents evoke other different examples.

**Table 5** Correlation between the number of media products with robots evoked by children (range from 0 to 15) and their respective evaluation of the robot characteristics (four-point Likert scale 0 = not at all –3 = for sure)

| | |
|---|---|
| 1. It has a battery | 0.034 |
| 2. It moves | 0.102** |
| 3. It moves by itself | 0.111** |
| 4. It is intelligent | 0.118** |
| 5. It speaks | 0.089* |
| 6. It looks into my eyes | 0.111** |
| 7. It looks like a human | 0.112** |

| | |
|---|---|
| 8. It looks like an animal | 0.078* |
| 9. It has gears. mechanisms | 0.124** |
| 10. It has an engine | 0.055 |
| 11. I can control it | 0.089* |
| 12. It keeps me company | 0.092* |
| 13. I play with it | 0.045 |
| 14. It is like a cartoon/movie character | 0.04 |
| 15. It is good | 0.063 |
| 16. It eats and sleeps | −0.024 |

As it can be noticed, Transformers and Futurama are not only the most frequently evoked (Table 2) but also the more salient visual products. This data suggests that products such as Transformers and Futurama are considered by our respondents the two prototypical examples of robots. I, Robot was evoked a total of 90 times and more than a half of the times in the first position; it is in particular the older children who consider this product the most prototypical.

However, no significant differences emerge as regards the evaluation of robot characteristics between the groups of respondents defined on the basis of their first answer. The only exception ($F_{10,317} = 2.091$, $p < .05$) regards the item number 10 "Robots have an engine": those who first evoke The fairly odd parents tend to disagree ($M = 1.2$), whereas those who first evoke Power rangers express the highest values ($M = 3.0$).

Genre (cinema/animation) of the most salient media products does not show any significant relationship with the characteristics associated with robots.

## 5 Discussion and Final Remarks

The present study moves from the assumption that we are going to face the rise of new social representations of robots. Robots, which for the large majority of people were restricted to the imaginary domain, are going to be more and more present in our society. Moreover, their functions and role will change, with the development of social robots. This will create new worries, expectations, and discussions in society. Reified and consensual universes of knowledge about robots will interact more and more. In sum, we expect that the representation processes are soon to be activated and boosted. Novelties will be anchored to previous images and knowledge, bringing to adjustment or to radical change of already established representations. Indeed, as discussed in the introduction, robots (and social robots in particular)present all the characteristics that favor the emergence of social representations: robots are multifaceted cultural artefacts, emotionally loaded, and a challenging novelty for individual and social life. Moreover, the intersection between technology, fiction and myth makes robots an ideal arena for the clash between the techno-scientific and the consensual universes [24,37].

In this study, in particular, we focused on children and pre-teens and explored the different facets of the representations to which children refer, when thinking of robots. Our goal was to describe what the main characteristics of robots for children are. It shall be stressed that since social representations are situated forms of knowledge, we did not look at children in general, but we conducted our study on almost the entire universe of children and pre-teens from 9 to 14 in Pordenone and Udine. This is a specific economic, social and cultural milieu, characterized by high levels of industrialization and a strong presence of the Makers movement.

As to the cognitive and pragmatic facets, results show that children are well aware of the differences between toys, robots and human beings. They consistently recognize robots as a mechanical device, able to move more than toys, yet without the bodily and cognitive characteristics that are typically human. These results, which are coherent with previous research [18] show that children from the age of 9 are already aware of what the key characteristics of robots are.

Nevertheless, a different picture emerges when we look at the imaginary that is conveyed to children by visual media (and in particular by the cinema). Robots in this domain of knowledge are advanced technical devices too: however, they are also characterized by anthropomorphic shapes and bodies (e.g., Transformers, The Terminator) and by human-like cognitions, feelings and behavior (e.g. Futurama, Wall · E). Moreover, the correlations between quantity of examples reported by children and the characteristics associated with robots show that media play a powerful role in constructing a human-like representation of robots: the more examples children are able to evoke, the higher they evaluate robots on all human-like characteristics (e.g., "It looks into my eyes"). In sum, even though the representations of robots are still techno-centric, the boundaries between robots and humans that was so clear in the cognitive and pragmatic facets shared by children tend to become less sharp when images are considered. This anthropomorphic representation is at the core of the fracture between imaginary and practical knowledge associated with robots [39]. Indeed, whereas the primary function of robots in the media is to interact with humans and like humans (both as help or menace), children state that in real life robots do not keep company. This disillusion mirrors in the youngsters the disappointment expressed by adults as regards expectations and evaluation of social interaction with robots [8,31]. At the same time, it questions one of the more successful metaphors that currently accompanies the presentation of social robots as companions.

A final remark, which requires further investigation and reflection: children state that human beings do not play with them. Both children and adults may be included in the category of human beings. This sounds like a cry of alarm by children who are alone in front of playing. Playing from a social and socializing activity par excellence has become a solitary adventure. Children seem to denounce an obvious difficulty both in finding playmates (many of the current generations of children are only children) and in enjoying the company of their parents in their playing activities. The parents are often compressed by intense rhythms of work and domestic tasks.

Concluding, even though this study suffers from the limits of using self-report data gathered especially from young people, the results discussed provide preliminary answers to our underlying question concerning what the main characteristics of the robots perceived by children are.

Children in our convenient sample are already socialized to different spheres of knowledge and are able to discriminate between several facets of shared knowledge according to the context. Moreover, from this study, it emerges that there is a significant distance between the cognitive, pragmatic and figurative elements of the representations regarding robots. This suggests that the conflict between these different representations is likely to increase together with the spread of these technologies in society.

Further studies in different local and societal milieu, and with different methodological strategies and tools are thus needed to investigate how different facets and forms of knowledge—reified and consensual, factual and fictional, imaginative and pragmatic—interact in order to understand whether and how children(and adults)will be able to manage the conflict between techno-scientific knowledge and imaginary about robots in a constructive and effective way.

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