CORE CONCEPTS

3.0 ROBOT AS MATERIALITY AND CONCEPT

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ABSTRACT

Robots are conceptual and material beings and notoriously hard to define. In this review article, we draw on a number of sources to refine our understanding of the main concept in the REELER project: the robot. In the following, we explain our methodology in making this review-article as well as give a historical overview. Furthermore, we make a heuristic distinction between the robot as materiality – the way it is pragmatically defined by roboticists in robotics - and robots as conceptual beings – which include the way robots have been conceptualized in the social science and as an impact factor in work life and politics.

3.1 Opening

Robot is a pivotal concept for the REELER project. It is also the material object of analysis in our empirical research. REELER focuses on robots as a point of departure because robots are increasingly expected to co-exist with or replace humans. A review and deeper analysis of the theoretical understandings of what a robot is or can be is pertinent for REELER's objective to close the proximity gap in human-robot interaction design and development, and to ensure a more responsible, ethical uptake of new robots by affecting the process of robot design.

The purpose of this chapter is to provide an overview of various understandings and representations of what a robot is. Over the next years, these definitions will, together with our empirical studies, inform the research work in the REELER project and yield new conceptualizations. As noted by roboticists themselves, it is impossible to capture what a robot is - even as a technical definition – not least because of the high pace of developing new robot technology.

> "Illah Nourbakhsh, a professor of robotics and director of the CREATE Lab at Carnegie Mellon University, writes in Robot Futures (2013): "[N]ever ask a roboticist what a robot is. The answer changes too quickly. By the time researchers finish their most recent debate on what is and what isn't a robot, the frontier moves on as whole new interaction technologies are born'."
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> (op.cit. Nourbakhsh in Robertson 2014, 573)

Albert Borgmann describes the two dimensions of any technology, which therefore also include robots, in his article 'Technology as a cultural force':

> "My suggestion is that for a proper understanding of our cultural malaise we have to get a grip on technology as a cultural force. But what is technology? In its narrow sense, it is an ensemble of machineries and procedures. Take its most recent instance — information technology. On the hardware side, there are chips, discs, screens, keyboards, and fiber optic cables....We can call this the engineering sense of technology. What interests social theorists is the effect that these machineries and procedures have had on our way of life. Social theorists are interested in technology as a cultural force."
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> (Borgmann 2006, 352-353)

To capture the implication of robots as a cultural force, we approach this review by distinguishing between the robot as a *materiality* (the technical, engineering sense) and the robot as a *concept* (the social-scientific and societal understanding).

The review begins with a historical account of the simultaneous development of robots as complex work machines and as reimaginings of the human in stories and in material form. We then move on to the technical definition and categorizations of robots from the robotics community in section 3.4 Robot as materiality. We draw on the governing standards for robotics, which are rooted in machine automation and we include various definitions from robotics associations.

From here, we explore the very many representations of robots discussed in the social sciences, primarily in, but also draw on empirical representations in the media, in fiction and in politics. While the technical and industry-sourced understanding tends to relate to industrial and professional service robots, the STS perspectives take a special interest in studies of social and humanoid robots and apply a broadened definition of social robotics based on an expanded understanding of social interaction:

Since the two dimensions – understanding robot as either materiality or concept – tend to merge, we note in our conclusion that a discussion of robots as both materiality and concept is indeed needed in a comprehensive outline of robot definitions. From our preliminary searches, it seems there are no other studies like REELER that address diversity in both how robots emerge in the world of the technical design *and* how robots evolve when embedded (or envisioned as embedded) in situated practice. In our continued work, we will discuss how the REELER project can further develop the analytical work with this core concept.

By incorporating the historical, technical, social and political perspectives, we hope to present a balanced and nuanced definition of what a robot is. Based on our initial work, we have found that robot technologies are varied and changeable and so we do not aim for a stable definition of *robot,* but a state-of-the-art understanding of robot and robotics at this point in time.

3.2 Methodology

The review of robot definitions involved an extensive EPPI-inspired search on the concepts *robot* and *robotics*[1] as its point of departure. We searched the databases SCOPUS, AnthroSource and ERIC (the US Department of Education database) for the terms *robot* and *robotics*, alone and in combination with other REELER relevant terms like *collaborative learning*, *STS, education,* etc. We sometimes found that additional search terms limited the search unnecessarily. Depending on the databases disciplinary focus, the additional keywords elicited different results. For instance, because ERIC is a database for education / pedagogy, the inclusion of *learning* and *education* was redundant and their inclusion actually omitted results relevant for REELER. As *robot* is at the center of REELER's research, this review builds on a number of searches for our many selected concepts. (See Appendix 1, section i. Robot as Materiality and Concept for an overview of the various search hits.)[2]

1 See detailed description of the quantitative approach under General Methodology.

2 Appendix 1 can be accessed via the REELER Library (http://reeler.eu/resources/reeler-library/) using the following username: reeler and password: library

This review of robot definitions is, however, not only based on classical EPPI-inspired database queries. It is also informed by our experiences with roboticists and robots in the field, by our project partners, by empirical data retrieved from websites and media representations, and by reviewing selected, relevant peer-reviewed and non-peer-reviewed literature. When we moved into reviewed representations of robots in the media, politics and work, we found it necessary to break with the selection criterion of only including peer-reviewed literature. This was necessary because we are including legal documents and journalistic publications that are not necessarily peer-reviewed; yet, the representations of robots in these areas are very important for REELER's work on ethical implications of robots in society and have thus been included in this review.

Moreover, this chapter also draws on expertise knowledge of the REELER researchers[3]. Thus, the insights presented in this review do not come from single articles but from our combined readings and discussions. From this approach, merging the database searches on robots with the REELER researchers' respective experiences and our deep readings of our selected articles, we have developed our understanding of not just the concept of robot as it emerges in the EPPI-inspired search, but also from empirical representations in diverse fields. (For more detailed description of our multi-method search methodologies in e.g. the STS-field, see Appendix 1.)[4]

3.3 A historical account

The word 'robot' originates from the Czech robota, which is related to Old Slavonic rabota meaning forced labourer. 'Robot' was first used to denote a fictional humanoid in the 1920 play R.U.R. (referring to the factory Rossumovi Univerzální Roboti or Rossum's Universal Robots) by the Czech writer, Karel Čapek (Čapek 1923 - see Richardson 2015 for further details). Čapek's fictional story postulated the technological creation of artificial human bodies without souls, and the old theme of the feudal robota class fit the imagination of a new class of manufactured, artificial workers. The play describes a future, where work is conducted by a sort of 'mensch-machine' – a pre-runner for the human-like robots. As noted by Kathleen Richardson this was however not a comment to the robotification of work, but rather the robotification of humans. "A dominant discussion in the 1920s rested on the mass mechanization of commodity production, which rendered the labourer as another 'cog' in the process, just like a mechanism in the machine" (Richardson 2015, 27).

The story of the robot, however, begins before the concept itself with the development of clockwork-like machines and especially the machines with human or animal like appearances. The machines that many consider forerunners of robots are called 'automata' or 'automate' a term that refer to an engine or a machine that moves by itself (Kang 2011, 140). These automatic machines can be found in many cultures.

In Europe, automata at first included watches and other clockworks. Automata were self-moving machines created through human ingenuity, but they soon became deceptive devices, made to appear

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3 For example paragraphs and ideas that are under development for the forthcoming publication Hasse, C. *Posthuman Learning* (2018). Routledge: London.

4 Appendix 1 can be accessed via the REELER Library (http://reeler.eu/resources/reeler-library/) using the following username: reeler and password: library

real while in fact they were mere machines. In Europe in the 17th and 18th century, some of the great watchmakers of the time began to create automata in the shape of animals, women and children. Contrary to the machines of the budding industrial age, these machines had no apparent purpose than to 'wow' their audience. They were "marvel and mirror machines" designed to create a sense of awe in an audience (Hasse 2018 forthcoming).

Today's machine meaning of robot has since evolved to include other forms of automation, but often the robot as a concept retains inspiration in human form and function: "Since R.U.R., the meaning of "robot" has become closely associated with intelligent machines with biologically inspired shapes and functions, particularly humanoids," (Robertson 2014, 574).

There are historically some ambiguities in the concept of 'robot' that is connected to the difference between the discussions of the creation of artificial life raised in philosophies, stories, plays and movies and the technicalities of self-moving clockworks and other machines. Robots in Capek's play refer to biologically created machine-men – and more men-like machines than machine-like men. This is also the case in another famous depiction on the first robot on the screen – the mother of all robots, Maria, in Fritz Lang's movie Metropolis from 1927. Here the humans are like robotic slaves, and the real robotic machine is a creation of the mad scientist Dr. Rotwang who has taken the appearance of a sweet young woman and applied it to a seductive robot to trick nobility and workers in Metropolis alike. This way of viewing the boundaries between humans and machines as blurred had evolved since the philosophies in the 17th century increasingly, following Rene Descartes, began to see Man as a bodily machine with an immortal soul.

In both stories and real life, the concept of robots came to have two meanings referring back to this history of automata: one is an autonomous machine that like a clockwork can perform work, the other is a reflection of the human in material novelties and in fiction.

Robots as machine work and labour Automatic clocks did perform work previously done by humans (measuring time by watching stars etc.) or beyond human capability (measuring time minute by minute). Over time the machinery was refined and connected with artificial intelligence and other new inventions – but the robots used for work remained 'robots as tools and labour'. These robots had a postwar proliferation into factories in the industrial world. They were not designed to resemble humans or animals but to perform work previously done by humans and surpass human capability for work (as in the automobile factories of the 1950s). They were often thought of as a kind of 'slave' labour, like the R.U.R. workers created to be of the purposeful service of humans (Richardson 2015). These industrial robots were developed with purposes, like Unimate, the first industrial robot, which was created to work on the General Motors assembly line in 1961. This machine was not computer controlled but ran on a magnetic drum. From the beginning the industrial robots were though of literally as 'helping hands' or arms (Siddique 2017, 3).

Robots as marvel and mirror Another continuation from the automata-days were the 'robots as marvel and mirror'. Today many robots are objects of modernity that reflect on what it is to be human (Richardson 2015, 24). The same mechanisms in automatic clockworks of humanlike automata were refined with new machinery and inventions, but the robots developed were still used to make humanoid machines that mimics the human or animal body, their movements and increasingly also human intelligence. The world's first anthropomorphic robot (not an automaton) was the so-called “intelligent robot WABOT (WAseda roBOT) started aiming to develop a personal robot, which resembled a person as much as possible. Four laboratories in the School of Science & Engineering of Waseda University joined together on the WABOT project in 1970. In 1984 Wabot-2 was revealed capable of playing the organ. Wabot-2 had 10 fingers and two feet. Wabot-2 was able to read a score of music and accompany a person.” (Ref). These humanoid robots were more tools for research explorations than machines created with a specific purpose in mind. These machines were to explore what life is by using the robot as a scientific mirror that could be used to explore the old Cartesian ideas.

Thus, what make these two historical lines of development of robots distinct from each other is the function of the robots: the mere machines were robots meant to work for humans as robots in a car factory or industry without emphasizing human-like features and with specific tasks. The other line of humanoid robots was created without express purpose to denote a kind of deceptive device pretending to be real like the automata, but simultaneously acted as an exploration tool for scrutinizing what makes a human or an animal different from a machine.

Though these two concurrent histories of the robot can be seen as distinct regarding function and form, they are now increasingly merging both in stories and in real-life machines. Even machines in factories are now developed to be human-like and intelligent – and the humanoids are increasingly placed in real life situations to perform job functions such as receptionists (see the next sections).[5] The following sections explore the robot as both automation of work and as a mechanical reflection of the human; as a contemporary confluence of imagination and machination.

3.4 Robot as materiality

Robots are material artefacts - they are made of materials shaped by humans in the context of their environments. Materials, according to Tim Ingold (following James J. Gibson), can be defined as the stuff things are made of that have three inherent properties: they exist in a medium (e.g. air), they have a substance (e.g. the ‘heaviness of a stone), and surfaces (a wet or dry stone) (Ingold 2007). The roboticists as makers of material artefacts, “joins forces with [the materials], bringing them together or splitting them apart, synthesizing and distilling, in anticipation of what might emerge,” (Ingold 2013, 21). These processes of making are part of the field of robotics, what Borgmann (2006) refers to as an engineering culture. Robotics includes both the craft of creating robots (the practices) and the roboticists, who are the human engineers, IT-experts and so on conducting this work (the practitioners). These engaged engineering experts form what Jean Lave and Etienne Wenger (1991) called a “community of practice”, constructing certain understandings through their shared activities. Indeed, roboticists seem to share a more pragmatic approach to robots than the general audience, seeing them as less ‘humanlike’ and more like pieces of machinery.

5 Selected in part from the forthcoming publication Hasse, C. *Posthuman Learning*. Routledge: London

3.4.1 Defining robots

While shared understandings emerge through practice, they can also be codified and shared in more formal ways. International organizations, such as the International Organization for Standardization (ISO) and the Institute of Electrical and Electronics Engineers (IEEE), produce regulatory standards for robotics. These standards are informed by declared common understandings termed *ontologies:*

> "Ontologies are information artifacts that specify in a formal and explicit way the domain knowledge shared by a community. The availability of well-founded methodologies allow us to develop ontologies in a principled way. The artifacts that result from this process ensure mutual agreement among stakeholders, increase the potential for reuse of the knowledge, and promote data integration."
>
> (Fiorini 2015, 3)

In the ISO standards used in relation to robots and robotic devices operating in both industrial and non-industrial [i.e. service] environments, we find the most basic technical definition of a robot:

> "A robot is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on current state and sensing, without human intervention."[6]

Paragraph 2.28 of that same ISO standard defines smart robots as "a robot capable of performing tasks by sensing its environment and/or interacting with external sources and adapting its behaviour. As examples, the standard gives an industrial robot with a vision sensor for picking up and positioning an object, mobile robots with collision avoidance and legged robots walking over uneven terrain," (Nevejans 2016, 10). Bulgheroni explains that for a robot to work as described above, four main subsystems are developed: "sensors used to perceive the surrounding environment; actuators, e.g. servomotors, to interact with the environment; a control structure i.e. the brain of the robot; the mechanical structure of the robot itself" (2016, 2).

The IEEE offers a compatible, but broader, definition as part of their standard ontology:

> "**Robot**: An agentive device in a broad sense, purposed to act in the physical world in order to accomplish one or more tasks. In some cases, the actions of a robot might be subordinated to actions of other agents, such as software agents (bots) or humans. A robot is composed of suitable mechanical and electronic parts," (IEEE 2015, 5).
> Similar representations and perceptions of the robot have been observed in the robotics field and in related research. In an overview of a technically-informed taxonomy of robots, Bulgheroni (2016) includes an emphasis on the robot as materiality. Bulgheroni explains that the main technical classifications of robots aim at describing working features of the machine or its application area and build on features of the robots which are not linked to interaction with humans, but are technological features facilitating the assigned task (2016, 1). This

6 ISO-Standard 8373:2012 Robots & robotic devices: https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-2:v1:en

attention to the materiality is also evident in Fiorini et al.'s article 'Extensions to the core ontology for robotics and automation' when they state that: "Our definition of robot emphasizes its functional aspects. For our general purposes, robots are agentive devices in a broad sense, designed to perform purposeful actions in order to accomplish a task," (Fiorini et al. 2014, 4). Another advocate for describing and perceiving robots as materiality is Nathalie Nevejans, who is an appointed expert on law and ethics in robotics by the European Commission. In her discussion of the 'European civil law rules in robotics', she presents the robot as a lifeless material artefact when providing definitions like, "a mere machine, a carcass devoid of consciousness, feelings, thoughts or its own will … just a tool … inert … inhuman … nonliving, non-conscious entity" (Nevajans 2016, 15-16).

While there are some commonalities across these regulatory and industry-inspired definitions, the term *robot* is constantly being negotiated, even within the robotics community. The IEEE makes the claim that "The term robot may have as many definitions as there are people writing about the subject. This inherent ambiguity in the term might be an issue when specifying an ontology for a broad community. We, however, acknowledge this ambiguity as an intrinsic feature of the domain" (IEEE 2014, 4). Nevejans points out the wide range of technical or industrial definitions and categorizations of robot: "A common definition would appear to be essential. Yet defining robots is no easy task in the absence of any real consensus within the global scientific community. Current research believes that a robot, in the broad sense, should fulfil several conditions, and consist of a physical machine which is aware of and able to act upon its surroundings and which can make decisions. Only some robots may also have the ability to learn, communicate and interact, and may even have a degree of autonomy," (2016, 10). These diverse perceptions of the material robot come through in the various categorizations made by roboticists. These categorizations indirectly define what a robot is by defining robot subtypes and functions.

3.4.2 Categorizing robots

The robot's historical development from machine automation is evident in the current regulatory and industry standards for robotics. The ISO standards for robots are found within the ISO sections governing manufacturing automation and under the title "Industrial robots. Manipulators" – despite these standards covering many classes of robots being used in many different industries.[7] From there, the robots are generally divided into two categories*,* industrial robots and service robots, which can then be subdivided into many classes of robot, including social robots (ibid; Bertolini 2016). The following categorizations of robots, seem to stem from this initial differentiation between industrial and service robots, but there is some variation among these classifications.

In Bertolini et al.'s article on why current legal, insurance, and regulatory structures related to robotics, robots are also categorized into industrial and service robots, like the ISO standard does. Then, industrial robots are separated into caged and collaborative robots: "It is possible to distinguish two main typologies of industrial robots: robots operating in isolation from human beings, usually constrained inside protective cages; and "collaborative"

7 ISO Technical Committee 299, Robotics; https://www.iso.org/committee/5915511/x/catalogue/

robots, which are designed to interact physically with workers, such as Baxter by Rethinking Robotics or UR5 by Universal Robots," (Bertolini et al. 2016, 383). They offer a broad definition of service robots: "A service robot 'is a robot that performs useful tasks for humans or equipment excluding industrial automation application'. An example of service robot for non-professional use is Roomba by iRobot," (ibid., 384). They go on to identify a number of sub-categories under service robots such as: "chore robots", "entertainment robots", "educational robots" and self-driving cars (ibid., 384).

In the overview by Bulgheroni (2016), robots are categorized by three primary distinctions: 1) based on the mechanical structure of robots 2) based on the working environment and 3) Following the ISO nomenclature robots are grouped in industrial robots and service robots that are also separated in personal service robots and professional service robots.

Turning to empirical examples from the industry/robot communities, we find categorizations that are not concordant taxonomies, but illustrate rather Bulgheroni's point that in practice, robots categorizations are diverse. The following selections exemplify the consistent, but subtly diverse definitions found in the field.

> ***IEEE*** The IEEE's robot ontology[8] distinguishes robots first by their level of autonomy: automated robot; fully autonomous robot; remote-controlled robot; robot group; robotic system; semi-autonomous robot; tele-operated robot. Then, the robot is distinguished by its various parts: robot actuating part; robot communicating part; robot processing part; robot sensing part.
>
> (IEEE 2015, 5)

SPARC The robotics association euRobotics categorizes robots according to "end-user market domains" in their Strategic Research Agenda[9] – a document which provides recommendations for EU Commission funding. These domains consist of: logistics & transport, commercial, civil, consumer, agriculture, healthcare, manufacturing. The report then specifies robot applications for each domains. Essentially, their classifications are first by industry, then by robot service/purpose. Within the same report, there are listed four basic characteristics of robots that distinguish them: where they work, how they interact and collaborate with users, their physical format, and the primary function they perform.

(euRobotics AISBL 2014)

Robotics Today is an open international publishing platform for robotics. Like euRobotics, the website categorizes robots by application, first by sector/industry, then by particular task/application.[10]

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8 IEEE Standard robot ontology http://ieeexplore.ieee.org/document/7084073/

9 euRobotics Strategic Research Agenda http://roboproject.h2214467.stratoserver.net/cms/upload/PPP/SRA2020_SPARC.pdf

10 Robotics Today website: http://www.roboticstoday.com/robots/by-category/

IFR International Federation of Robotics separates industrial robots from service robots and lists a range of subcategories for service robots of which the main groups are "Personal / Domestic Robots and Professional Service Robots."*11*

From a review of regulatory standards, ontologies, and the definitions and categorizations found within the robotics communities, it is clear that there is a focus on the robot as a material – a summation of its parts, defined by its application or function in the world. The focus on the robot as a tool and as a complex machine mirrors the historical development of the robot from advanced automated machines. In the following section, we present the robot as inspired by the parallel history of development of the man-like machine in an exploration of the human-machine boundary.

3.5 Robot as concept

Another way of defining robots is through how they are being perceived and conceptualized. The philosophical understanding of a concept is "an idea or mental image which corresponds to some distinct entity or class of entities, or to its essential features, or determines the application of a term (especially a predicate), and thus plays a part in the use of reason or language". (Oxford Dictionary) In the following sections, we will explore these conceptions through three areas dealing with robots as a cultural force. We first look at how the social sciences, together with roboticists of social robots, reconceptualise 'robots' in multifaceted ways that underline the social and gendered aspects rather than technical aspects. Next, we touch upon existing perceptions and conceptions of robots, including: the role of popular media in both the creation and analysis of robots, the ways humans anthropomorphize robots and understand the human-robot boundary, and how these conceptions are negotiated through legal and political actions. Finally, we move on with a presentation of some of the analytical perspectives used to study robots in the social sciences.

3.5.1 How robots are defined by STS scholars

The Science and Technology Studies (STS) loom large when it comes to redefining robots in a broader sense than their material and technical aspects. The focus has not been on robots as automated *work and labour* with a focus on form and functions of robots. Rather, social scientists have been particularly interested in exploring robots as *marvel and mirror* with a focus on socially and philosophically oriented definitions, such as a robot's ontological status. As such, studies have centred on the implementation of service and social robots, or on the laboratories of these robots, rather than on industrial robots..

STS studies in robotics have been interested in why some roboticists – like Cynthia Breazeal, Rodney Brooks, and Hiroshi Ishiguru, for example – attempt to create humanlike robots as 'marvel and mirror' that deliberately play with imitations of human features without endowing these robots with any specific function (e.g. Breazeal 2003). Social scientists have also studied attempts to implement these robots in everyday settings, even if these human-like robots have no apparent functions (Bruun et al. 2015). While it remains uncommon for social scientists to work directly with roboticists (and especially concerning industrial robots), some have followed roboticists in their laboratories observing them

11 International Federation of Robotics website. https://ifr.org

where they develop their robots (e.g. Richardson 2015). Yet here too, the focus remains on social robots.

True to their interest in ontological categories and conceptualizations of social appearances, STS scholars have tried to make a number of distinctions between humanoids and other robots, and within the 'humanoid' species they have identified different subtypes. The following definitions are drawn from STS studies:

Cyborg In the STS field the concept of robot has been connected to the concept of a cyborg, which is a transversal figure breaking down boundaries between the social and the material - thus breaking down Durkheim's 19th century understanding of the social as strictly human (Richardson 2015, 12). The cyborg is a figure that connects machines and humans in 'trickster like' ways, where boundaries between conceptual and material figurations cannot be expected to be fixed and unmovable – concepts and materials move each other (Haraway 1991).

Humanoid Humanoid robots can be any robot with a human-like form (anthropomorphic) and human-like movements (anthropomimetic), and is the umbrella term for a number of concepts defining humanoid robots into subcategories.

> "To be called a humanoid, a robot must meet two criteria: it has to have a body that resembles a human (head, arms, torso, and legs) and it has to perform in a human-like manner in environments designed for the capabilities of the human body, such as an office or a house. Most Japanese humanoids are gendered female or male. Some humanoids are so lifelike that they can actually pass as human beings—these robots, which are always gendered, are called androids (male) and gynoids (female)."
>
> (Robertson 2014, 574)

Androids and gynoids All androids and gynoids are humanoids, but not all humanoids are androids or gynoids. An android or gynoid will be defined by their respective male or female gendered appearances, reflecting normative conceptions of gendered human form. Androids and gynoids can also sometimes be named *replicants*. Like the wax-dolls that also inspired the automata figures, the android and gynoids will be clad in soft humanlike skin and have very real looking eyes. One humanoid robot, the life-like Jia Jia, entertained the wowed audience at a Chinese robotics fair by recognizing faces, demonstrating micro-expressions by moving eyelids and lips, and 'talking' - her creators programmed her to say "Yes, my lord, what can I do for you?".[12] Other famous examples of these robots are the creations by the philosopher roboticist Hiroshi Ishiguru, director of the Japanese Intelligent Robotics Laboratory. In this laboratory, Ishiguru has created many humanoid robots, some of which are both android and – a new categorization – the geminoid (Bartneck and Kanda 2009).

Geminoid The geminoid is a robot that is created as a literal doppelgänger. Ishiguru, for instance, created the robot Geminoid HI-1, which has the same features as its creator and is presented dressed in the same clothes. It may also 'speak' with his voice and replicate some of his movements. Like many robots from Ishiguru's lab, HI-1 it is remotely controlled and thus gives an impression of being an autonomous being. Through its motion-capture interface, it can imitate Ishiguro's body and facial

12 https://www.youtube.com/watch?v=ZFB6lu3WmEw

movements, and can reproduce his voice in sync with his motion and posture. Ishiguro hopes to develop the robot's human-like presence to such a degree that he could use it as a proxy to teach classes remotely, lecturing from home while the Geminoid interacts with his classes at Osaka University (Bartneck and Kanda 2009).

Whereas the technical definitions focused on the automated work machine, the thus far limited study of robotics in the social sciences have focused on the recreation of the human in the machine. However, with the increase in AI technologies in robotics (see section 9.0 Artificial Intelligence), the interest of the social sciences may extend beyond humanoid robots to other robots that may not resemble human form, but have some semblance of human function. STS scholar Lucy Suchman describes such a situation in which our perception of robots as social might be broadened by increasingly intelligent machines: "In introducing the actions of a user, the [human-machine] environment becomes not only a physical but also a social one, requiring the interpretation of the user's actions and an assessment of the user's understanding of his or her situation," (2007, 55-56). Studies and definitions of other (and as yet, more prolific) robot types are still needed within the social sciences, which is one of the objectives of the REELER research.

In the following section, we explore the role of popular media, human interaction, and political and legal actions in forming these conceptions of robots, and how these ideas inspire debate into a robot's ontological status of existence in relation to our own.

3.5.2 How robots are perceived in social spaces

The attribution of social agency to robots occurs in social spaces with human actors – for instance, when we incorporate our imaginaries from popular media, when we ascribe human characteristics to robots, or when we proffer legal statuses upon them. Thus, the definition of a social robot can be expanded by our practices with other classes of robot. The focus in the social sciences thus far on humanoid social robots can be attributed to the way in which they have differed from industrial robots in how they are created to engage humans 'as if' the robots were human counterparts. Roboticist Cynthia Breazeal claims that:

> "Autonomous robots perceive their world, make decisions on their own, and perform coordinated actions to carry out their tasks. As with living things, their behaviour is a product of its internal state as well as physical laws. Augmenting such self-directed, creature-like behaviour with the ability to communicate with, cooperate with, and learn from people makes it almost impossible for one to not anthropomorphize them (i.e., attribute human or animal-like qualities). We refer to this class of autonomous robots as social robots, i.e., those that people apply a social model to in order to interact with and to understand. This definition is based on the human observer's perspective."
>
> (Breazeal 2003, 168)

As Suchman (2007) and Breazeal (2003) point out, social robots are social not because of their designed function but because they are situated in social spaces with human social actors.

Based on the work of Harold Garfinkel (1984), Lucy Suchman (1988), and Weizenbaum (1976), Cognitive scientist Morana Alač, together with Javier Movellan, and Fumihide Tanaka, concludes that “the meaning of action is constituted not by an actor’s intentions but through the interpretative activity of recipients,” (2011, 895). This suggests that a robot’s actions, and thus the robot itself, are not defined solely from how it is designed and programmed, but also how it is perceived by those who interact with it. “The robot is not treated as a social creature in the absence of coordinated interactional practices,” (ibid, 914).

Alač et al. explain how important it is for robots so be perceived by human observers to resemble a thing that can ‘think’ and ‘make decisions’ in order to be ascribed social agency (2011). The robot is defined through the ways in which the people around it interact with it and perceive it. The technical definition of social agency in social robotics is focused on human-robot interaction based in “the robot’s physical body; of foremost importance are the robot’s appearance, the timing of its movements, and its accompanying computational mechanisms,” (Alač et al. 2011, 894).

However, Alač et al. suggest that the social agency is not rooted in the hardware and software – the material – itself, but is a product of the human interactions and social arrangements of the robot’s environment. “The robot’s social character thus includes its positioning in the space and the arrangement of other actors around it, as well as its interlocutors’ talk, prosody, gestures, visual orientation, and facial expressions,” (2011, 894). Here, the authors point to the importance of understanding that the transformation of the robot as a material artefact into an agential artefact depends upon humans being engaged in interaction and subsequently interpreting the human-robot configuration as social interaction. Thus, social spaces, including the context in which a robot is embedded and the humans with which the robot is engaged, define the robot by contributing to the way the robot is perceived.

Even if both some roboticists and social scientists (like Breazeal and Suchman) agree that social spaces and engagements with human actors are an important part of what constitute the sociality of robots, the empirical studies of how robots are perceived and defined in actual daily practices is still an emergent field. In especially Scandinavia we do, however, find a field of studies of social robots implemented in the everyday lives of healthcare and schools where humans ‘stretch’ themselves to accommodate the robotic newcomers in their everyday practices (e.g. Bruun et al. 2015, Hasse 2013, Hasse 2015, Leeson 2017, Esbensen et al. 2016). In these studies, the focal point is to make use of ethnographic fieldwork to get a sense of how robots affect the people when they engage with robots without any experimental setting to be considered – or, in other words, when we study how humans and robots engage each other in everyday life situations. In the United States and in relation to the field of HRI (Human-Robot Interaction) we also find empirical studies of social robots, but they are often tied to empirical on-site experiments where social scientists work with roboticists (e.g. Sabanovič et al. 2013, Alač et al. 2011).

Furthermore, most of these studies are in healthcare or education. We have, in our search, not found studies of how humans in ‘real-life’ or robots in the wild settings engage with robots in factories. When it comes to robots in small, medium size and big industries the effects of robots are not studied with ethnographic methods (see Annex II and part II for a more extensive explanation of ethnographic methods and case studies).

3.5.2.1 The Hollywood effect

One social space in which robots have been defined is in the cultural imagination, inspired by science fiction stories and movies. Robots have appeared as both heroic and villainous characters since the 1920s when Fritz Lang's Maria in Metropolis stood out as the 'mother of all female movie robots' (Richardson 2015). They have been present throughout the last century with figures like Star Wars' C3PO (1977), Robocop (1987), Blade Runner's replicants (1982), and more recently the female rebel Ava from the movie Ex Machina (2014) or the cartoonish Wall-E (2008) and Big Hero 6's Baymax (2014).

Just as these cultural imaginaries sparked the notion of *robot*, they have continued to shape our understandings of the robot. "Capek's graphic portrayal in R.U.R. of the end of bourgeois humanity at the hands of a violent robot-proletariat helped to shape Euro-American fears about robots that persist to this day," (Robertson 2014, 574). Whereas Euro-American representations have maintained a tendency toward robot revolt scenarios, Japanese representations have shifted in response to political and cultural events. "From the 1920s to the present day in Japan robots have been cast as both threatening and helpful to humans. Since the 1960s, however, when the state embarked on a policy of automation over replacement migration to extend the productivity of the domestic workforce, the general trend in Japanese popular media and culture has been to characterize robots as benign and human-friendly," (Robertson 2014, 574).

These different cultural interpretations of the fictional robot are reflected in science fiction writing of the time. American writer Isaac Asimov and Japanese manga artist Tezuka Osamu each crafted laws of robotics governing human-robot interaction long before the technologies were developed to make such interactions possible. "Tezuka and Asimov were socialized in cultural settings differently shaped by World War II and its aftermath, a fact reflected in how they imagined and described the relationship between humans and robots in their literary work," (Robertson 2014, 583). Asimov's laws drew on the threat of a Frankenstein scenario in which the robots turn against their creator, as in Čapek's *R.U.R.* In contrast, Tezuka's addressed "the integration of robots into human (and specifically Japanese) society where they share familial bonds of kinship and perform familial roles," (Robertson 2014, 584). Returning to Robertson's writings *Robot Rights*, the ways in which robots are interpreted and regarded in Japan – in contrast to their reception in Europe and the U.S. – demonstrate how media representations reflect and reproduce our cultural imaginaries. These cultural imaginaries can influence roboticists' notions of robots and their reproductions of notions of the human through robotics (Suchman 2007). Further, these representations and imaginaries can shape our interactions with robots (ibid.), our regulation of robots (Robertson 2014), and the creation of our common life-worlds (Hasse 2015). Representations of robot within popular media have informed perceptions of robots among layman as well as roboticists.

Recalling the EU Parliamentary resolution "Civil Law Rules on Robotics", fictional robots were referred to in the resolution itself and throughout the workshop discussion at the European Robotics Forum. The first line in the resolution's introduction begins: "From Mary Shelley's Frankenstein's Monster to the classical myth of Pygmalion, through the story of Prague's Golem to the robot of Karel Čapek, who coined the word, people have fantasized about the possibility of building intelligent machines, more often than not androids with human features" (European Parliament 2017). These historical understandings are met with contemporary depictions of robots, resulting in certain popular understandings about what a robot is and what a robot can do - one workshop participant described this as the "Hollywood effect":

> "Last year there were eleven movies in Hollywood that were talking about robotics and AI. And it starts cuddly and nice at Baymax or Hero Number Six, I think it's called in the US. So a Baymax movie, a Disney movie. Then you have Avengers, Age of Ultron – a nice cool action movies. Up to Her and Ex Machina. But eleven movies put robotics and AI and science fiction, for example in this form, in the heads of people. So this leads, on the one hand, to a completely distorted view on the state of technology today. People believe this is going to be real in ten years. We know how hard that is, but they don't."
>
> - Dominik Boesl, KUKA Robotics and Robotic Governance Foundation (ERF 2017)

However unrealistic these popular media inspired imaginaries may be, they have very real implications as Jennifer Robertson stresses: "It remains the case, however, that these metaphors and symbols predominate in the government, the corporate sector, and even the robotics industry, and their influence and impact…cannot be overestimated," (2014, 583). The effects of popular media on cultural imaginaries and ultimately on perceptions of the robot can be seen in the debates within academic literature and within EU political discourse over the ontological status of the robot.

3.5.2.2 Anthropomorphism and ontological status

Social scientists ask questions about how our perception of robots affects how we interact with robots and how we incorporate robots into our practices. From the perspective of *multistability*, these interactions not only inform our understandings of ourselves and the robots, but can actually shape bodies and beings. With that in mind, we turn to the work of Jennifer Robertson on robots in Japan. Robertson emphasizes the importance of sociocultural practices and interpretations of the material artefact. Roboticists and other humans, Robertson included, tend to ascribe human characteristics to the robot and tend to understand the robot through understandings of beings (whether human, non-human, or quasi-human).

Robertson, in her work on robot rights, contrasts the ontological debate of human exceptionalism in Europe and the U.S. to the Shinto-inspired acceptance of robots as beings in Japan.

> "Recent Euro-American literature on robot rights can be characterized as divided along the lines of a Manichean debate about living vs. nonliving, human vs. nonhuman. Scholars from across the disciplinary spectrum have proposed legal precedents based on analogies between robots and animals and even between robots and disabled (or differently abled) humans. Some have also proposed treating robots as occupying a "third existence status" that fits neither the category of human nor that of machine….Efforts to categorize robots as constitutionally separate from humans are shared by neither the Japanese public (at least those persons polled on the subject) nor Japanese roboticists, who proceed from the position that organic and manufactured entities form a continuous network of beings."
>
> (Robertson 2014, 593-595)

What a robot is, whether it is a being or a non-being, is a significant debate. Robertson notes that "Like the history and development of dogs, cats, horses, and other domesticated animals the history of robots is inextricably entwined with the history of humans. The acceleration of robotic technologies and advances in artificial intelligence have moved the idea of robot rights out of science fiction and into real time," (2014, 593). Here, Robertson conflates the debates over human-animal exceptionalism and human-nonhuman exceptionalism. The human-animal debate, acknowledges that all animals are beings, whether or not they are persons. The human-nonhuman debate, involves first acknowledging a robot (or nonhuman) as a *being*, then as a *person*. In Japan, robots are accepted as beings, even as members of the family. There have been instances in which robots received citizenship, a family name, human parentage, and even a date of "birth" (Robertson 2014).

In Europe, a type of electronic personhood was considered in the debates preceding the recent EU Parliamentary Resolution regarding regulating robots under civil law:

> "[The EU Parliament] calls on the Commission…to explore, analyse and consider the implications of all possible legal solutions, such as creating a specific legal status for robots in the long run, so that at least the most sophisticated autonomous robots could be established as having the status of electronic persons responsible for making good any damage they may cause, and possibly applying electronic personality to cases where robots make autonomous decisions or otherwise interact with third parties independently."
>
> (European Parliament 2017, 59.f)

In a workshop at the 2017 European Robotics Forum, Karin Röhricht of Fraunhofer IPA led a discussion of this resolution. The topic of robot ontology came up early in the workshop:

> "Then we have this debate between human and machine – where does a machine end, where does human behavior begin? Some people answered me that a machine cannot and will not be a human, and a civil law is made for citizens and not for machines. Because humans have this sort of self-awareness that machines cannot have, so already a civil law itself is inappropriate for machines. And the fact of liability is also a human invention related to the self-awareness, so it doesn't fit to robots."
>
> (Karin Röhricht, Fraunhofer IPA and euRobotics, ERF 2017)

Robertson expects the debates over being/personhood to continue with the coming advances in artificial intelligence (see section 9.0 Artificial Intelligence): "As robot intelligence continues to develop, debates in Euro-American circles between supporters and opponents of human exceptionalism, or the idea that humankind is radically different and separate from the rest of nature and other animals, will become more contested," (2014, 576).

Whether or not we acknowledge the robot as a human or a being, by ascribing human characteristics to the robot and using anthropomorphic language when discussing robots, we perpetuate the idea that a robot might fit that "third existence status." Robertson herself, like the roboticists she studies, uses anthropomorphic language when referring to robots, including gendered pronouns and human verbs. This type of language indicates personhood or being by:

- ascribing roles: worker, caregiver, student, housesitter, sibling, child, playmate, companion, citizen

- ascribing agency: robots are said to learn, interact, think, know, work, heal, care, calm, cheer

- ascribing characteristics: social, intelligent, chatty, emotional, personality, consciousness

(excerpted from Robertson 2014)

Another way robots are anthropomorphized is by ascribing social behaviour to programmed or performed behaviours – the result of human labours, but ascribed to the machine. Lucy Suchman describes the reliance of the MIT robot Kismet on its human operators. Just as her notions of Cog were transformed by her "backstage" encounter, so were her experiences with Kismet.

> "Those lessons require that we reframe Kismet, like Cog, from an unreliable autonomous robot, to a collaborative achievement made possible through very particular, reiteratively developed and refined performances. The contrast between my own encounter with Kismet and that recorded on the demonstration videos makes clear the ways in which Kismet's affect is an effect not simply of the device itself but of Breazeal's trained reading of Kismet's actions and her extended history of labours with the machine. In the absence of Breazeal, correspondingly, Kismet's apparent randomness attests to the robot's reliance on the performative capabilities of its very particular "human caregiver'."

(Suchman 2007, 246)

Cynthia Breazeal, of MIT's Artificial Intelligence Lab and the aforementioned Kismet robot, writes about social robots and, indeed, ascribes various social classifications to robots, answering her own question: "To what extent is the robot a full-fledged social participant?" (2003, 168). She claims to base the following four levels of social participation on the human's ability and desire to anthropomorphize the robot and socialize with it, but the language she uses ascribes social agency to the robots:

- *Socially evocative*: the human attributes social responsiveness to the robot, but the robot's behavior does not actually reciprocate…more invested in their creation's "lifespan".
- *Social interface*: uses human-like social cues and communication modalities in order to facilitate interactions with people…This class of robot tends to value social behavior.
- *Socially receptive*: benefit from interactions with people…robots that learn from interacting with people…tends to be more perceptive of human social cues…They are socially passive, however, responding to people's efforts at interacting with them but not pro-actively engaging people to satisfy internal social aims.
- *Sociable*: socially participative "creatures" with their own internal goals and motivations… to benefit itself (e.g., to promote its survival, to improve its own performance, to learn from the human, etc.)… Such robots not only perceive human social cues, but at a deep level also model people in social and cognitive terms in order to interact with them.

(Selected excerpts from Breazeal 2003, 169)

Breazeal goes on to describe Kismet, their own "sociable" robot: "A person can infer quite a lot about the robot's internal state by interpreting its gaze and the manner in which it moves its eyes—i.e., what Kismet is interested in or what it is reacting toward," (173). Breazeal's representation of Kismet the reiterative process that Lucy Suchman (2007) described, in which a roboticist creates a robot to simulate something human, then interprets the programmed responses as human behaviour.

Tony Prescott, professor of cognitive neuroscience and director at Sheffield Robotics research institute, writes about the debate over a robot's ontological status from an STS perspective that is maybe more technical than humanist. Rather than fitting robots into the dichotomous categories of human vs. nonhuman, or living vs. mechanical, he suggests a liminal status of being – "more than machine but also less than human," (Prescott 2017, 144). Jennifer Robertson (2014) had noted that a third existence status emerges in response to how we interpret the robot – what a robot is depends on what we perceive it to be. Prescott adds to this argument, suggesting both a *perceived* liminal status ("how robots are seen") and an *actual* liminal status ("what robots are") (2017, 144). He presents a robot that is both socially constructed and mechanically determined (2017).

> "Whilst most robots are currently little more than tools, we are entering an era where there will be new kinds of entities that combine some of the properties of machines and tools with psychological capacities that we had previously thought were reserved for complex biological organisms such as humans."
>
> (Prescott 2017, 146)

Prescott's secondary argument is that whether a robot is perceived as just a tool or as a social agent, real ethical issues will arise from the robot's increasing blurred status of being [Figure 1].

Figure 1 Ethical issues related to perceived/real ontological status of the robot (Prescott 2017, 145)

Table 1. How ontological (*o*) and psychological (*p*) perspectives on robots can combine (after Kahn et al., 2007). Note that only one quadrant of this table (I) is addressed in the EPSRC principles, but that II, III, and IV are all possible, at least theoretically.

I. Robots are just tools (o), and people will see robots as just tools unless misled by deceptive robot design (p). *Ethical issues: We should address human responsibilities as robot makers/users and the risk of deception in making robots that appear to be something they are not.* **This is the position of"the principles"**.	**II.** Robots are just tools (o), but people may see them as having significant psychological capacities irrespective of the transparency of their machine nature (p). *Ethical issues: We should take into account how people see robots, for instance, that they may feel themselves as having meaningful and valuable relationships with robots, or they may see robots as having important internal states, such as the capacity to suffer, despite them not having such capacities.*
III. Robots can have some significant psychological capacities (o) but people will still see them as just tools (p). *Ethical issues: We should analyse the risks of treating entities that may have significant psychological capacities, such as the ability to suffer, as though they are just tools, and the dangers inherent in creating a new class of entities with significant psychological capacities, such as human-like intelligence, without recognising that we are doing so.*	**IV.** Robots can have some significant human-like psychological capacities (o), and people will see them as having such capacities (p). *Ethical issues: We should consider scenarios in which people will need to co-exist alongside new kinds of psychologically significant entities in the form of future robots/AIs.*

Prescott's point about perceptions of ontology mirrors Robertson's point about perceptions from popular media, however unrealistic a perception might be, the perception itself is real and has effects. When robots are perceived as having human form or function, they can take on a different ontological status – a topic that has been recently debated in the political-legal sphere.

3.5.2.3 Political and legal perspectives: negotiating public definitions of robot

The public definition of the robot is negotiated through political, legal, and regulatory. Given the disparate but concurrent imaginary and mechanical histories of the robot, different laws and regulations have emerged with respect to both histories. Asimov's and Tezuka's fictive laws were imagined to govern fictional robots as intelligent beings. Machinery directives and other regulatory standards were written with respect to automation. We are now at a point in time where state-of-the-art robotics fall somewhere between the machinery directives regulating the hardware and the imagined laws regulating the AI. The recent EU parliamentary resolution addresses this pivotal moment in robotics:

> "Whereas now that humankind stands on the threshold of an era when ever more sophisticated robots, bots, androids and other manifestations of artificial intelligence ("AI") seem to be poised to unleash a new industrial revolution, which is likely to leave no stratum of society untouched, it is vitally important for the legislature to consider its legal and ethical implications and effects, without stifling innovation." (EU Parliament 2017, B)

The Civil Law Rules for Robotics resolution finds the current legal framework insufficient for addressing the legal and ethical challenges arising with state-of-the-art robotics and emerging applications of robotics (EU Parliament 2017). The motion for resolution and the first draft of this report was put forth by a parliamentary committee in 2015. This came on the heels of the 2014 conclusion of the EU funded project, RoboLaw, whose arguments closely parallel those in the 2015 motion. Following the initial motion for resolution, a 2016 study was requested to inform the final 2017 report and resolution to the European Commission. The definition and terminology of *robot* has been the source of much discussion in this period from 2014 to present, as reflected in the recent updates to the IEEE CORA and ISO standards (IEEE 2015, Fiorini 2015) (see section 3.4.1 Defining robots) and as demonstrated in the texts from the aforementioned studies and resolutions.

In the RoboLaw project, the authors attempted a definition, but found that the most widely accepted definitions were either too subjective or two broad:

> "According to the most widespread understanding, a robot is an autonomous machine able to perform human actions. Three complementary attributes emerge from such a definition of robot [physical nature, autonomy, and human likeness]….An alternative way to make sense of the word robot…would be to look at a robot's main components. Indeed, there is a widespread consensus among practitioners in describing a robot as consisting of four main elements: sensors, actuators, controllers and power supply. However, the drawback of such an approach is that…too many devices could qualify as robots."
>
> (RoboLaw 2014, 15-16)

In the final resolution presented to the EU Commission, the definition became definitions, plural, and relied on technical definitions:

> "Calls on the Commission to propose common Union definitions of cyber physical systems, autonomous systems, smart autonomous robots and their subcategories by taking into consideration the following characteristics of a smart robot: the acquisition of autonomy

through sensors and/or by exchanging data with its environment (inter-connectivity) and the trading and analysing of those data; self-learning from experience and by interaction (optional criterion); at least a minor physical support; the adaptation of its behaviour and actions to the environment; absence of life in the biological sense."

(EU Parliament 2017, 1)

(For more political and legal definitions, see Annex 1: Full Robot Review)[13]

There is little consensus among the political and legal texts we've reviewed. This discord is evidenced in recent discussions of the parliamentary resolution itself, which has been hotly debated – not least because of the unsettled definition and ontological status of robots.

In March, several representatives of the REELER project attended the 2017 European Robotics Forum. There were workshops with topics related to specific sectors (Agriculture; Logistics; Maintenance & Inspection; etc.) or to broader topics relating to robotics as a field (AI & Cognition; Ethical, Legal, & Social Issues; etc.). The talk among roboticists and other experts during these workshops reflected the ongoing discussion of the terms *robot* and *robotics*.

There was a workshop session on the ethical, legal, and social issues in robotics; the topic was the recent EU Parliamentary resolution regarding the regulation of robotics, "Civil Law Rules on Robotics". The organizer of the workshop opened with a statement defining smart robots and discussing the difficulty of making such definitions:

> "The basis for the resolution is also the definition of smart robots. You can see the four main points: it's the capacity to –so the question is 'what is a smart robot or an autonomous robot?' It's the capacity to acquire intelligence through sensors or by exchanging data with its environment, and the analysis of those data. It's the capacity to learn through experience and interaction. It's a form of robot's physical support. Otherwise, we might not be talking about robots, but already in the morning we had the discussion of 'what is a robot?' 'Where are its limits of definition?'"

Karin Röhricht, Fraunhofer IPA and euRobotics (ERF 2017)

The scope of definition of *robot* and *AI,* and the wide variety of machines covered by these terms, were recurring themes in this workshop and in others. The resolution itself opens with this statement: "…there is a need to create a generally accepted definition of robot and AI that is flexible and is not hindering innovation ," (European Parliament 2017, C).

During the workshop, Dominik Boesl, speaking on behalf of his organization Robotic Governance Foundation, discussed the importance of having common understandings of *robot* and other terms, particularly with regard to regulations. Here, he speaks of his experience at a media seminar held in connection with the parliamentary resolution, and of the confusion over the *robot* concept:

> "The second thing is the journalists were completely / well, it is exactly a representation of what you read in the media. They were mixing up software bots and hardware bots. And they were

13 Annex 1 can be accessed via the REELER Library (http://reeler.eu/resources/reeler-library/) using the following username: reeler and password: library

talking about robots that were industrial robots and they put them on the same page with science-fiction like Jetson's Rosie. And the typical question like, "When do we need Asimov's laws?" And if those robots are now going to rampage in the singularity when artificial intelligence gets better and better, and so on. But the first issue, I really think, is we have to – and they've also already mentioned the general assembly on Tuesday – we have to start to inform the general republic. First of all about what the robot is. We don't have to do scientific differentiations, but we really have to explain to them a robot is something that is physical, and a bot or an agent might be something that lives in software. The two together can do something that might have an implication. And maybe they might also form an autonomous system. But all those things were not clear."

(Dominik Boesl, KUKA Robotics and Robotics Governance Foundation, ERF 2017)

Boesl points to the entanglement of science fiction, media, and complex composition of robot systems in informing a public understanding of the robot. He tasked the robotics community with informing the public about what a robot is. But even that was not settled among the attendees of the workshop. The topic of robot ontology came up early in the workshop when Karin Röhricht was delivering the feedback euRobotics members had given with regard to the resolution. The members considered the resolution to be too broad in that it addressed diverse classes of robots with the same proposed regulations. As one member expressed, "We're talking about robotic toys compared to robots that can lift two or three or five tons, or whatever. Handling molten steel or self-driving cars at 200 kilometers an hour," (ERF 2017).

Dominik Boesl, again, emphasized the point that there really is no consensus on what a robot is: "So what do we consider a robot? Is it something that lives in software, a smart system? Is it something that lives in hardware? Something that is big? Or is it a general purpose machine, or whatever?" (ERF 2017).

The discussion ultimately lead to a debate over whether current laws and regulations were sufficient to regulate robotics. Some classes of robot are currently certified or regulated under a machinery directive, international standards, and/or defective product laws. These laws regulate robots as machines or products, but the European Parliament found such governance insufficient. In their 2015 draft resolution, the committee suggested that robots be governed under a civil law as an agential entity:

"Whereas the more autonomous robots are, the less they can be considered simple tools in the hands of other actor… as a consequence, it becomes more and more urgent to address the fundamental question of whether robots should possess a legal status."

(Committee on Legal Affairs 2015, 5.S)

The proposal also proposed that third existence category which Jennifer Robertson (2014) had discussed:

"Whereas, ultimately, robots' autonomy raises the question of their nature in the light of the existing legal categories – of whether they should be regarded as natural persons, legal persons, animals or objects – or whether a new category should be created, with its own specific features and implications as regards the attribution of rights and duties, including liability for damage."

(Committee on Legal Affairs 2015, 5.T)

The language of legal status and personhood clauses was changed in the final draft to omit the phrases "whether robots should possess a legal status" and removed all mention of particular existing legal categories (natural/legal person, animal, or object) and associated rights, duties, or obligations (European Parliament 2017).

(For a full comparison, , see Annex 1: Full Robot Review)[14]

Although this notion of electronic / legal personhood was ultimately limited in the final draft of the resolution, it remained a heated topic of debate at ERF. Karin Röhricht, reported on feedback that euRobotics had received regarding the EU resolution:

> "Some people answered me that a machine cannot and will not be a human, and a civil law is made for citizens and not for machines. Because humans have this sort of self-awareness that machines cannot have, so already a civil law itself is inappropriate for machines. And the fact of liability is also a human invention related to the self-awareness, so it doesn't fit to robots."

(ERF 2017)

Andrea Bertolini, who participated in the EU-funded RoboLaw project was also present at the ERF workshop and had this response:

> "Like 'Civil laws are not made for machines or robots, but only for human beings' – clearly whoever said that never opened a book of law or civil code. Because in the civil code you'll find a lot of laws about things, regulating things. And civil law precisely addresses the relationship between human beings and human beings and things. So it makes sense. Product liability that some of you mentioned, is actually a part of laws that fall within civil law. So it makes no sense."

(ERF 2017)

The contestation of the political understanding of *robot*, as a mere tool or as a being, is evidenced in the changing language from the 2015 draft resolution, through the 2016 study, and ultimately in the final 2017 resolution. Nathalie Nevejans, author of the 2016 study, was vehemently opposed to the idea of electronic personhood, calling it "as unhelpful as it is inappropriate," (14).

> "Yet how can a mere machine, a carcass devoid of consciousness, feelings, thoughts or its own will, become an autonomous legal actor? …it is impossible today — and probably will remain so for a long time to come — for a robot to take part in legal life without a human being pulling its strings."

(Nevejans 2016, 15)

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14 Annex 1 can be accessed via the REELER Library (http://reeler.eu/resources/reeler-library/) using the following username: reeler and password: library

Nevejans attributes the resolution's proposed personhood to an understanding of the autonomous robot that she considers inaccurate:

> "In reality, advocates of the legal personality option have a fanciful vision of the robot, inspired by science-fiction novels and cinema. They view the robot — particularly if it is classified as smart and is humanoid — as a genuine thinking artificial creation, humanity's alter ego. We believe it would be inappropriate and out-of-place not only to recognise the existence of an electronic person but to even create any such legal personality. Doing so risks not only assigning rights and obligations to what is just a tool, but also tearing down the boundaries between man and machine, blurring the lines between the living and the inert, the human and the inhuman."
>
> (Nevejans 2016, 15-16)

Nevejans' strong objections are reflected in the more conservative language used in the final 2017 resolution.

What these deliberations show are the processes of negotiation that are underway between technical, legal, and political actors in Europe to define what a robot is. There is a push and pull between defining the robot on the basis of its material being (i.e. the robot as materiality) and on the basis of its social, cultural, and agential being (i.e. the robot as a cultural force). Considering the legal, ethical, and human implications of discordant notions of the *robot*, it is essential to extend our understanding beyond technical ontologies, beyond legal definitions, beyond fantastic imaginaries, and beyond humanoid-centric social understandings. To truly understand the concept of *robot*, we must consider both the material machine and the human context in which it is created and embedded.

3.5.3 How robots are conceptualized in STS research

From the various perceptions in social spaces, we've seen that a robot is constantly shifting between being perceived as a material and a socio-cultural artefact. Through social science research, we can come to understand the robot as both materiality and concept. In the social sciences, robots are never seen as stand-alone autonomous beings, but as embedded in networks, cultures, and contexts. Thus, STS scholars concur that robots do not exist as autonomous entities. Within STS however, scholars differ in whether they emphasize the importance of culture and context or rather see robots as embedded in flat networks of humans and non-humans. The STS perspectives, used to study robots in social spaces, can be roughly divided into the following analytical approaches: social and spatial arrangement/interaction, STS-network analysis, multistability and the robot 'becoming', humanizing the robot-other, and the robot as a social construction. When robots are seen as contextualized and cultural, as in the cultural constructivist perspective, there is an emphasis of historical developments as well as an acknowledgement of humans as perceptual participants and observers. In studies of the agency of humans and non-humans, like robots, may be acknowledged, but human perception is an important aspect of how robots gain agency. In the *network analysis* both humans and non-humans are salient as social actors that create and engage with each other. The network analysis is more descriptive and focus equally on the agency of non-humans and humans without granting the humans a particular social and perceptual position in the analysis.

Though studies of robots only occupy a small subfield in STS, it is a proliferating field, which has raised many questions about sociality and relevant conceptualizations in relation to human-machine entanglements.

3.5.3.1 Network analysis

Empirical studies of robots follow different analytical strategies in the social sciences. In the field of STS there is an ongoing development and debate of analytical concepts and approaches to studies of technology like robots. Some scholars in this field, like Karen Barad and Bruno Latour, have questioned the usefulness of concepts like culture and context in relation to technology because these term refer to explicitly human realms of perception – and many STS scholars do not privilege the perception of the humans in their theorizing.

Since the 1990s many STS-analyses of technology have been engaged in what is known as network-analysis – often inspired by a so-called ‘flat ontology’. The focus is on agency. Humans are not granted a more important position than non-humans in the creation of the agency of humans and non-humans entangled in networks (Latour 2005). When looking to robots as ‘mirrors’ of humankind the configurations created by humans and non-humans alike are both material and conceptually distributed in networks.

In her 2007 book *Human-Machine Configurations*, Lucy Suchman explains how certain understandings of humanity inform the production of robots, which then reproduce these understandings of humanity and the subsequently intertwined understandings of robots. This tangled process is best understood by her theoretical grounding in network analysis inspired by Bruno Latour’s ‘ actor-network’ approach.

Suchman’s book is primarily about artificial intelligence and smart machines in general, but many of her arguments are directed at robotics or are relevant to robotics. One primary argument in Suchman’s book is that ideas about what a robot is and about what a human is are woven together through roboticists practices and humans’ inherently social interactions with robots (Suchman 2007).

> “Just what it means to be humanlike, and how the boundary between humans and nonhumans is correspondingly drawn and redrawn, is of course one of the matters in question. A central premise of this book is that projects in AI and robotics involve a kind of doubling or mimicry in the machine that works as a powerful disclosing agent for assumptions about the human. [Footnote: I need to make clear that I am not suggesting, as do roboticists themselves, that these projects work as scientific models of the human but rather, that they make evident how roboticists imagine humanness.].”
>
> (Suchman 2007, 226)

To define the robot as an autonomous social agent based on its material components involves cutting it from this social network in which it is embedded. “In the case of the robot, or autonomous machine more generally (as in the case of the individual human as well), this work takes the form of modes of representation that systematically foreground certain sites, bodies, and agencies while placing others offstage,” (283). In this way, a robot can either be understood as a material artefact cut from the network, or as a sociocultural artefact embedded in its world, in relation to the humans and nonhumans it is engaged with.

Suchman demonstrates these notions with her descriptions of the robots Cog and Kismet, of MIT's Artificial Intelligence Laboratory. Her initial understandings of what these robots were and of what these robots could do, were based on media representations, scientific papers, and the observed interactions between particular people with these particular robots. "Pictured from the 'waist' up, Cog appears in media photos as freestanding if not mobile, and Kismet's Web site offers a series of recorded 'interactions' between Kismet and Breazeal as well as between Kismet and selected other human partners," (Suchman 2007, 237). When Suchman visited these robots in person, no longer cut from the environment or people with which they are entangled, a new understanding developed:

> "We were, however, able to visit the inanimate Cog sitting in a corner of the lab. Although still an imposing figure of a robot, what struck me most powerfully about Cog was the remainder of its "body" not visible in media portrayals. The base of Cog's torso was a heavy cabinet from which came an extraordinarily thick sheaf of connecting cables, running centaurlike to a ceiling-high bank of processors that provided the computational power required to bring Cog to life. Seeing the robot "at home" in the lab, situated in this "backstage" environment, provided an opportunity to see as well the extended network of human labours and affiliated technologies that afford Cog its agency, rendered invisible in its typical media staging as Rod Brooks's singular creation and as an autonomous entity."
>
> (Suchman 2007, 246)

This experience illustrates the role of the robot's network or context, including the humans and nonhumans that make up the network, in forming an understanding of the robot itself.

It has been argued that the division between social and material should be dissolved all together as the social is material and the material social (Latour 2005). Along these STS lines we should be aware of the 'agentic cuts' we make, when we create analytical dichotomies between subjects and objects like robots and humans (Barad 2007). This analytical point refers to the way materials merge with human perception and conceptualization without taking a point of departure in humans as the observers.

However, Suchman offers a way out of the predicament when she says that we need: "a story that can tie humans and nonhumans together without erasing the culturally and historically constituted differences among them ... [and] to keep in view ... the ways in which it matters when things travel across the human-artifact boundary" (Suchman 2007, 270). The cultural constructivist perspective perhaps offers the cultural emphasis that the flat agential model lacks.

3.5.3.2 Cultural constructivist perspective

Like Jennifer Robertson, Selma Šabanović (2014) writes about the social construction of the robot in Japan. Robertson links social acceptance of robots in Japan to Shinto beliefs and to linguistic and cultural conceptions of life and being. Šabanović contributes to this culturally produced understanding to include the political practices which actively shape particular notions of the robot: "The presentation of robots as endemic to local culture is the product of continuing efforts by the government, industry, and academia to encourage popular acceptance of robotics," (2014, 343).

Šabanović goes through specific robot cases to illustrate how the robots are not only products of Japanese culture, but through the practices of roboticists in Japan, these artefacts produce and reproduce certain aspects of Japanese and robotics cultures. She argues that roboticists use their robots and the understandings they produce as political technologies. "The examples of PARO, HRP-2, and kansei robotics present robots as cultural products, performers, and subjects and show how robotics researchers use their cultural standpoint to provide epistemological grounding and social justification for robotics," (359).

Finally, Šabanović supports the idea which Lucy Suchman presented of the human being reflected and reproduced through robot development: "Focus on robotics design as a process of cultural repeated assembly therefore calls for reflection on how the cultural models embodied by and embedded in robots affect people's evolving sense of their relational and cultural selves" (359). Where Robertson presented social construction, Šabanović incorporates the cultural and political into constructions and reproductions of the robot and, consequently, the human. The STS perspective on *multistability* extends both arguments to include the materiality of the technology in these processes.

3.5.3.3 Multistability and the robot "becoming"

Another analytical approach which may prove useful for the REELER project is the postphenomenological concept of 'multistable technology'. A robot from this STS perspective is not a stable artefact, as noted in Cathrine Hasse's text *Multistable Roboethics* (2015). "Neither human nor technology act separately from each other but create each other through processes of 'multistability'," (Rosenberger 2014, in Hasse 2015).

Suchman (2007) had presented a temporal understanding of a robot as it is situated in its network, where the understanding of the robot develops with an understanding of its context. Along the same vein, Cathrine Hasse explains how "technology is embedded in life-worlds of inter-engaging humans and technologies (Ihde 1990)" and how through processes of multistability, the robot and the human create each other (Hasse 2015, 171). This understanding of the robot in the throes of becoming takes into account material, cultural, and political dimensions. "Stability is not embedded in the "thing" but in the material as well as traditions and relations following embeddedness in cultural use," (172).

Hasse gives the example of the Paro and Silbot robots, in use in Danish care facilities. Both robots instigated changes in the workplace to accommodate the robots into their cultural communities. In the case of Silbot, the robot itself had to be adapted to fit the setting. It had come from Korea with programmed interactions perceived as rude in Denmark and had to be "stabilized through re-programming," (180). With Paro, the staff made their own accommodations in their interactions with the robot, with its care, and with their combined interactions with the 'citizens' of the care facility.

> "The staff and citizens have to do a lot of hard work to include these bodies in their local amalgamation. Even when "corrected" the staff and citizens have to keep learning how to stabilize this new category of being. Even so the presences of the robots are never questioned. In the process robot, staff and citizens gradually became stabilised bodies in an amalgamation including material bodies as well as ideas of a robotic future."
>
> (Hasse 2015, 181)

The staff and the robot were materially and conceptually changed by their shared social interactions. These processes of multistability, of co-constitution, and of reproduction of particular understandings of both the robot and the human self, evoke the history of the 'marvel and mirror' robot as an exploration of the human-machine boundary.

This approach to multistability in robotics takes the technical understanding of a material artefact and incorporates the sociocultural interactions that continuously shape the robot in its process of becoming. With this and the other STS perspectives, we have seen how a robot can be defined as both materiality and concept, and how this integrated definition is constructed within the cultural and social spaces from which the robot is inextricable.

3.6 Conclusion

In this review, we have seen that understandings of what a robot is are largely inspired by historical fantasy, interpreted through cultural imaginaries, transformed by media representations, legitimated by regulatory standards and parliamentary resolutions, and made material through incorporation into human social spaces. Robots are notoriously hard to define, both due to rapid changes in their material components and to conceptual diversities over time and across disciplines. Our understanding of the robot, the central concept in REELER, is therefore bound to change with our ongoing research.

What we may note for now is that within the robotics community, there is some agreement, but no consensus, on the technical definition rooted in the ISO definition (see section 3.4.1 Defining robots). Although it may appear to provide a very basic and precise definition, some vagueness also lies implicit in its terminology like "Intended tasks". "Intended by whom?", we may ask. The robot, affected stakeholders or the roboticists? Moreover, the wording "without human intervention" is vague. Does it disqualify an object as a robot if a human is somehow 'intervening'? That would rule out most of the machines called robots today as humans are involved in engaging and intervening with the robots in a multitude of ways[15]. Although the regulatory definitions aspire to be as precise as possible, we (coming from a social scientists conceptual perspective) note that a term like "an environment" in the ISO standard may be perceived differently from a technical compared to a social scientific point of view. In the social sciences 'an environment' will include humans, other non-human material and to some extent even human perception – with no exclusion of 'human intervention'.

This review has also shown that social scientists seem to have been less occupied with studies of industrial robots (with specific purposes) and more interested, like the media, in social robots, which tend to be created without a specific purpose other than an ongoing (philosophical) exploration of what makes machines humanlike (like the robots created by Ishiguro). Thus, the discussions from the historical epoch of automata still seems to be ongoing. Though the purposeful and clockwork

15 Inspired by discussion at LEO Center for Service Robotics' website: http://www.leorobotics.nl/definition-robots-and-robotics

precise industrial robot seem to have little in common with humanoids like Jia Jia, it is the concept of 'robot' and the urge to explore how humans may be replicated that tie these materialities together. In the STS field, these materializations are perceived as created by roboticists, like engineers, engaging in a particular engineering practice. Once created, the robots can be perceived as a cultural force. Robots are imagined and imbued with stories and fantasies; an aspect which is also underlined in the discussions of robots as legal entities in the political arena. This is for instance the case, when policy-makers note that there is a widespread understanding of a robot as "an autonomous machine able to perform human actions" (See 3.5.2.4 Political and legal perspectives). These perspectives seem largely informed by robots as a media phenomenon, and that cultural force of robots has a real effect and impact on labour markets, politics and economy – all of which is also part of the REELER study.

In politics, there is less focus on empirical studies of how most robots, whether claimed to be social or not, do have a direct social impact on people's lives in a wide arrange of everyday life situations from health, education to work life. Instead, media representations and economic surveys seem to be the primary basis for debates. This might be why politicians are prone, like many other people, to have an unrealistic understanding of robot capabilities, whereas the roboticists themselves seem much more pragmatic. Turning to the roboticists, they also seem to lack knowledge from ethnographic practice studies of perceived effects of robots in their design processes.

> This lack of empirically based insight has ethical implications and should be addressed by social scientists versed in explorations of social spaces. However, SSH-research is still only an emergent field in robotics with an unexploited research potential of collaboration between SSH and robot engineers. Even if some roboticist agree with social scientists that social robots are "situated in social spaces with human social actors" (See 3.5.1 How robots are defined by STS scholars) this acknowledgement has yet to be attributed to *all* robots, whether social or not. Here social scientists seem to lack a focus on robots that are not defined as social.

The REELER project has thus identified a need for ethnographic studies that explore how people in real life situations (not formed by external experiments) engage with, or envision themselves engaging with, robots in day-to-day situations. To follow robots, as well as ideas about robots, out into the world where they meet and engage with other human practices than those found in the engineering sciences, is indeed very relevant to the REELER project. It will open for deeper understandings of how robots (beyond any claims) function and affect human lives, which is part of the REELER project's ambition.

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Note: This chapter includes paragraphs and ideas that are under development for the forthcoming publication Hasse, C. *Posthuman Learning*. Routledge: London