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Responsible Domestic Robotics

Exploring Ethical Implications of Robots in the Home

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Abstract:

Purpose: The vision of robotics in the home promises increased convenience, comfort, companionship, and greater security for users. The robot industry risks causing harm to users, being rejected by society at large, or being regulated in overly prescriptive ways if robots are not developed in a socially responsible manner. The purpose of this paper is to explore some of the challenges and requirements for designing responsible domestic robots.

Design/methodology/approach: The paper examines definitions of robotics and the current commercial state of the art. In particular it considers the emerging technological trends, such as smart homes, that are already embedding computational agents in the fabric of everyday life. The paper then explores the role of values in design, aligning with human computer interaction and considers the importance of the home as a deployment setting for robots. The paper examines what responsibility in robotics means and draws lessons from past home information technologies.

An exploratory pilot survey was conducted to understand user concerns about different aspects of domestic robots such as form, privacy and trust. The paper provides these findings, married with literature analysis from across technology law, computer ethics and computer science.

Findings: By drawing together both empirical observations and conceptual analysis, this paper concludes that user centric design is needed to create responsible domestic robotics in the future.

Originality/value: This multidisciplinary paper provides conceptual and empirical research from different domains to unpack the challenges of designing responsible domestic robotics.

Keywords: Domestic Robotics, Cyber-Physical Systems, Internet of Things, Responsibility, Regulation/Governance, Law, Trust.

Paper Type: Research Paper (Conceptual; Literature Review and Empirical Findings)

1. Introduction: The Robots are Coming

The vision of robotics in the home promise increased convenience, comfort, companionship, and greater security for users. However, the reality, and impact on users, may not always meet this vision. Fears of robot uprisings are peppered throughout decades of science fiction literature and film (Higbie, 2013). However, visions of technological futures often say more about the period they were written in, than actually forecasting what futures might emerge (Reeves, 2012), as we have seen with computer science research into 'ubicomp' (Bell and Dourish, 2006). Whilst popular science and cultural visions of robots may not have fully emerged, computational agents have most definitely left the lab and entered daily life in a variety of forms. The Internet of Things (IoT) is incrementally making homes smarter by embedding networked, ambient technologies with varying degrees of autonomy into the physical and social fabric of domestic life. These devices can be for security (smart CCTV and locks), comfort (smart bulbs and thermostats) and entertainment (conversational agents in smart speakers). These artefacts may not all be 'robots' in the popular sense of the word, but they are restructuring interactions, social order and relationships in the home. As domestic service robot technologies advance and become more commercially accessible, the smart home will have already changed the domestic setting and laid the groundwork for robots to assimilate. Accordingly, they need to learn from mistakes being made with smart homes, including being designed in more user centric ways. It is important to understand user concerns and respond to these accordingly, to create a more sustainable domestic robot future.

Our paper structure firstly explores changing definitions of domestic robots before considering human computer interaction perspectives on value sensitive, user centric and contextually aware design in the home. Secondly, we unpack the nature of responsibility, arguing roboticists need to understand and respond to user concerns. This often does not occur currently, creating technologies unfit for purpose and disruptive to the social order of the

home. We conclude by presenting user concerns from our small-scale exploratory survey, focusing particularly on trust, privacy and form of robots as key hurdles for creating *responsible domestic robotics*.

2. Definitions

Standards are a good place to start navigating a definition of domestic robots, as they can show what multiple stakeholder consensus is around a topic. The International Federation of Robotics/ United Nations Economic Commission for Europe were influential in classifying robots, culminating in the ISO standard 8373:2012 on Robots and Robotic devices. This standard differentiates between, among others, industrial, mobile, service, personal service and professional service robots. According to them, 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*" (ISO 8373, s2.08). We focus on 'service robots,' which are '*robot[s] that perform useful tasks for humans or equipment excluding industrial automation applications*' (ISO 8373, s2.10) and particularly the sub category of 'personal service robots'; "*service robots for personal use…used for a non-commercial task, usually by lay persons… (i.e.) domestic servant robot, automated wheelchair, personal mobility assist robot, and pet exercising robot*" (ISO 8373, s2.11). As we can see, these definitions foreground the materiality of the artefact (i.e. being able to actuate physically), the varying degrees of autonomy they possess to shape the environment, the relationship of utility to humans, and the split between industrial and personal.

If we look more widely, by turning to academic sources we see robots framed slightly differently. For Mataric, (2007, p. 2) *"a robot is an autonomous system which exists in the physical world, can sense its environment, and can act on it to achieve some goals"*. Bryson and Winfield state *robots* are "artefacts that sense and act in the physical world in real time" and they state a smartphone counts as a robot as it can sense when its falling or orientation changes (Bryson and Winfield, 2017, p117). Both definitions encapsulate the ability to act in the physical world, but don't necessarily prescribe the robots as being physical themselves. In providing a more design orientated definition for domestic robots, Bartneck and Forlizzi (2004, p. 2) highlight the interactional aspects, stating *"a domestic robot is an autonomous or semi-autonomous robot that interacts and commu*nicates *with humans by following the behavioural norms expected by the people with whom the robot is intended to interact''*. This definition foregrounds the interactional aspect, and particularly to what extent robots fit into pre-existing norms and contexts. All of the above perspectives feature in EU legal discussions around civil liability for robots, which recommend defining 'smart robots' by focusing on the attributes of:

" – the capacity to acquire autonomy through sensors and/or by exchanging data with its environment (inter-connectivity) and the analysis of those data;

– the capacity to learn through experience and interaction;

– the form of the robot's physical support;

– the capacity to adapt its behaviour and actions to the environment." (European Parliament, 2017, p. 18)

However, in defining robots, neatly separating them from interactive AI becomes a challenge e.g. human-agent collectives, IBM Watson, Google Duplex, DeepMind AlphaGo etc. Whilst some definitions above focus on the physicality of robots, they do not exclude non-physical, more ethereal robots that actuate in the real world. Given the current trend towards smart homes with integration of more ethereal devices not providing physical interactions, but cognitive support, there is a case for considering interactive AI too. This includes search functionality (conversational agents in different devices, like Amazon Alexa), heating management (smart thermostats like Nest) or observational security of space (Nest Cam).

It is worth briefly reflecting on definitions of AI as digital artefacts that have intelligence, i.e. "capacity to perceive contexts for action…to act…to associate contexts to actions" using techniques like speech or pattern recognition (Bryson and Winfield, 2017, p. 117). This wider framing encapsulates many of the domestic IoT technologies. Accordingly, this paper considers interactive artificial intelligence in addition to more material framings of robots.

3. Commercial State of the Art

Irrespective of definitions, there are various degrees of agency and artificial intelligence emerging in the domestic setting. The number of service robots in the home is growing at an impressive rate globally. The *International Federation of Robotics 2017 Report on World Robotics* states there was an annual increase in sales of personal and domestic service robotics from 2015-2016 of 24% to roughly 6.7m robots, with the market valued at US$2.6bn (International Federation of Robotics (IFR), 2017, p. 14). Interestingly, US companies dominate as manufacturers of domestic service robots, whereas 94% of elderly/handicap assistance bots come from Asian/Australian companies (IFR, 2017, p. 18).

The current domestic service robot market includes both start-ups and major manufacturers' offerings. Companies creating new robot products include Honda's 3E family of modular robot platforms for assisting with mobility and even sports training (Honda, 2018); Panasonic's desktop companion robot complete with child-like voice to 'add realism' (Panasonic, 2017); and Bosch's Mykie which helps with cooking and projecting recipes

onto the wall (Clark Thompson, 2017). Humanoid robots are hitting the market too, performing tasks as diverse as conducting funerals (Gibbs, 2017), teaching yoga (Ubtech Robotics Lynx (Gebhard, 2018)) and personal videography (Kuri, 2018).

For macro level insights, IFR (2017, p. 14) states more than 4.6 million domestic robots sold in 2016, are for "vacuum and floor cleaning, lawn-mowing robots, and entertainment and leisure robots, including toy robots, hobby systems, education and research". In Appendix 1 we provide our non-exhaustive analysis of the domestic robot market, as of May 2018. We now turn to HCI to understand why the home is a complex deployment setting for domestic robots.

4. The Importance of the Home

One of our key arguments is the growth in domestic internet of things technologies, the so-called smart home, is paving the way for domestic robots. However, the process of integrating IoT into the home has impacts for residents living with these devices. There is a growing interface between domestic IoT and robots. Robots that manage and speak to IoT devices act as mediators for users and intermediaries for services, providing more intuitive interactions between user and devices e.g. LGs Cloi (Kelion, 2018). Companies such as Amazon, already established in homes through Alexa/Echo, have robotics aspirations too (Gurman and Stone, 2018). We need to learn from the mistakes that are currently being made in terms of responsibility for privacy, security and trust with IoT, to ensure these are not being replicated for robots.

Like robots, IoT has moved from the lab to the home and the consumer market has grown hugely in recent years (Cisco, 2013; Panetta, 2017). Ownership of domestic IoT devices is anticipated to rise significantly, with the OECD predicting by 2022, a family of four will own 2 connected cars, 7 smart light bulbs, 5 internet connected power sockets, 1 intelligent thermostat and so on ((OECD, 2013). Whilst these predictions may be optimistic, they are no longer constrained to visions like Weiser's ubiquitous computing (Weiser and Mark, 1993) or Philips Ambient Intelligence (Aarts and Marzano, 2003). An IoT future is here, just perhaps not the one originally envisioned of invisible computers and seamless networking (Bell and Dourish, 2006). However, many market offerings are for goods or services individuals do not know they even want or need (Lee, Choi and Kim, 2017).

Domestic technologies being developed without regard for what users actually want and neglecting domestic routines and social practices has been an established challenge in HCI. (Rodden and Benford, 2003; Tolmie *et al.*, 2002; Crabtree and Rodden, 2004). Smart homes deployments, for example, implement an instrumentalist visions whilst neglecting interests of users (Leppënen and Jokinen, 2003). Wilson (2015) found that whilst benefits like increased efficiency, comfort, convenience, energy management, care, security are promised, designers need to look at "how the use and meaning of technologies will be

socially constructed and iteratively negotiated, rather than being the inevitable outcome of assumed functional benefits" (p. 466) because homes are 'internally differentiated, emotionally loaded, shared and contested places' (p. 470) .

Numerous studies examine how individuals live with smart domestic technologies. A US study found user's frustration caused by unreliability, devices requiring iterative tweaking over time, and security concerns about unauthorised remote access (particularly for locks and home cameras) (Brush *et al.*, 2011). Users still desired such technologies, and in a recent study, on user perceptions of privacy risks in IoT, they find users still purchase these devices, despite privacy concerns, showing the privacy paradox continues with IoT (Williams, Nurse and Creese, 2017). Mäkinen (2016) found internal tensions for 13 residents around trade-offs with home surveillance systems in Finland, for example balancing a sense of safety and protection of the home against fear of being watched without knowledge or implications of monitoring other home occupants, such as perceived spying. More recently, Coskun, Kaner and Bostan (2018) explored reasons why smart home technologies don't have greater uptake. They found elements like users want smart home technology to take over chores, but not for automation to interfere with pleasurable activities, such as cooking, or going beyond comfort to improving skills such as cooking. This shows the contested nature of domestic life, and the need to respond to context and users through user centric design approaches. These lessons from smart homes could inform domestic roboticists to and support design of systems users actually want.

5. Responsible Robot(icists)? The Challenges of Domestic Robots.

Robots pose numerous ethical challenges for privacy rights, security management, trust relationships, identity formation and limitations on user autonomy (Coeckelbergh, 2012; Leenes and Lucivero, 2014). As IoT paves the way for domestic robots, security and privacy vulnerabilities are arising (Brown, 2015). This can be unintended, such as publicly accessible unsecured IoT devices with video feeds enabling data to move outside of contextually appropriate boundaries of the home (Nissenbaum, 2009; Osborne, 2016; Wetmore, 2018). Similarly, it can be intended, driven by business models of data repurposing, such as Roomba selling floor plans of user homes (Jones, 2017). Private practices are often made visible in the process of human robot interaction, and data about these practices is used as a resource in the provision of new value-added services with robots, hence perceptions of robots and interactive AI monitoring for surveillance are established (Calo, 2010; Sharkey and Sharkey, 2012; Schafer and Edwards, 2017). Inferences about behaviour based on social sorting (Lyon, 2003) of data doubles (Haggerty and Ericson, 2000) can be used for social control and manipulation, with the home setting making intimate behaviours observable and auditable. Opacity around the ecosystem of stakeholders interested in knowing how users live makes it hard to know if and why they are being watched:

is it to monetise, police or manage their actions? Examples of products being pulled because of privacy concerns, particularly with child users e.g. Mattel Aristotle (Hern, 2017), highlight the public perception of such risks.

Accordingly, a 2015 Eurobarometer study on Autonomous systems (EU, 2015) found "*Eight in ten Europeans (82%) who use robots think well of them, while nine in ten (90%) among them would purchase one*". A more recent 2017 Eurobarometer study (EU, 2017) of c28,000 EU citizens, states that 35% would be comfortable with robot support at work or delivering goods, but only 26% when it is for companionship or services when elderly/infirm or for performing an operation. They find, "*overall, 88% of respondents agree robots and artificial intelligence are technologies that require careful management*." (EU, 2017). Therefore, we now consider questions of responsibility for one stakeholder group in particular: roboticists.

6. The Nature of Responsibility and the Role of Roboticists.

Responsibility is a loaded concept, having different meanings for different communities, morally, legally, and societally. This paper is interested in the responsibilities of roboticists, as opposed to robots themselves. The influential EPSRC Principles of Robotics recognises this divide, targeting their principles towards designers, builders and users of robots. They argue "*Robots are simply tools of various kinds, albeit very special tools, and the responsibility of making sure they behave well must always lie with human beings*." (Boden *et al.*, 2017, p. 125)

Accordingly, by considering responsibilities of roboticists we turn to existing work on the how innovators address their wider responsibilities to society. The case for engineers and developers duty to look beyond function is that "*engineering design is an inherently moral activity*" (Verbeek, 2006, p. 368) and "*in effect, engineers ought to be considered de facto policymakers, a role that carries implicit ethical duties*" (Millar, 2008, p. 4). In foregrounding the needs of users in this, Shneiderman called on 'researchers, system designers, managers, implementers, testers and trainers of user interfaces and information systems' to exert influence, moral leadership and responsibility to find "ways to enable users to accomplish their personal and organisational goals whilst pursuing higher societal goals and serving human needs" (Shneiderman, 1990, p. 2).

One popular tool to support exercise of responsibility is codes of ethics. Professional bodies such as the Association of Computing Machinery (ACM), Institute of Electrical and Electronic Engineers (IEEE) and British Computing Society (BCS) have provide general guidance for members for many years (IEEE, 1963, ACM, 1992). The IEEE Code of Ethics, for example, asks members to consider how their work impacts quality of life of others, and introduces broader notions of responsibility to public welfare, safety and health. However, there are specific codes emerging for robots and interactive AI too. These range from

Asilomar AI Principles and ACM US Public Policy Council on Algorithmic Transparency & Accountability to Japanese Society for AI and Montreal Declaration for Responsible AI. Within these, the concepts of accountability, respect for human values, privacy and safety, among others, recur (Winfield, 2017). More recently, the high-profile *IEEE Ethically Aligned Design Version 2* proposed ethical commitments to human rights, well-being, accountability, transparency and awareness of misuse. A key element the report raises is around legal liabilities. Similarly, principle 2 of the EPSRC Principles states "*Humans, not robots, are responsible agents. Robots should be designed; operated as far as is practicable to comply with existing laws, fundamental rights & freedoms, including privacy*" (Boden *et al.*, 2017).

This charge is being taken up by the EU, where efforts to establish civil law liabilities around robotics are underway (European Parliament, 2017). This includes a proposed *Code of Ethical Conduct for Robotics Engineers* (European Parliament, 2017). Again, it provides utmost importance to the principles of dignity, privacy and safety of humans. But it also includes principles on designing robots to respect fundamental rights, the precautionary principle, inclusiveness, accountability, safety, reversibility, privacy, and maximising benefit/minimising harm. Whilst all can be important for the home, the notes on privacy are particularly interesting as they highlight the need for designers, particularly around obtaining valid consent prior to man-machine interactions. This is a clear challenge for human robot interactions, of communicating sufficient information to users in a transparent, temporally sensitive manner.

There is need for operationalisation and strategies to embed such values in design. A Responsible Research and Innovation approach is important here, as it focuses on practical reflection and interaction with a range of stakeholders, to ensure stewardship for the future, going beyond high level aspirations (Von Schomberg, 2011, p. 9). Reflexivity of designers on their position, knowledge and impact is key but a sense of responsibility can depend on if designers are doing more applied or fundamental research (Grimpe et al, 2014). Thus, responsibilities within roboticist communities can be fragmented due to their role.

Drawing on its role in human computer interaction, the role for human values in design is growing, as the 'third wave' of HCI widens the field to consider cultural, societal aspects of computing, as opposed to purely functional aspects (Bødker, 2015). Authors such as Nissenbaum, (2005),Flanagan, Howe and Nissenbaum(2008), Sellen *et al.*(2009) highlight the need for bringing values into design. Sellen *et al.*, (2009, p. 66) argue for user centricity in the design process, stating, "*HCI must also take into account the truly human element, conceptualising 'users' as embodied individuals who have desires and concerns and who function within a social, economic and political ecology*". In bringing values into design, 'value sensitive design' (VSD) (Friedman, Kahn and Borning, 2008; Friedman, Hendry and Borning, 2017) has been a key framework, trying to make "*moral values part of technological design, research and development.*" (Van den Hoven, 2006, p. 67).

Within the VSD framework, values with ethical import should be brought into the design process, i.e. values that " a person or group of people consider important in life" (Friedman, Kahn and Borning, 2008, p. 70), such as those that "centre on human well-being, human dignity, justice, welfare and human rights" (Friedman, Kahn and Borning, 2008, p. 1180). Criticisms of VSD have focused on "what values", and bringing more situated, local values into design, not just high level values, such as those in the codes of ethics above (Le Dantec, Poole, E. and Wyche, 2009). Accordingly, for responsible domestic robotics, user centric design strategies such as design ethnographies (Crabtree, Tolmie and Rouncefield, 2012) and co-design (Steen, 2011) are critical to understanding the real needs and values users want in domestic robotics. There is growing recognition of the importance of these concepts in robotics too, as one prominent definition of human robot interactions states, there is need to "meet the social and emotional needs of their individual users as well as respecting human values" (Dautenhahn, 2018). Furthermore, there are already examples of use of VSD for robotics, particularly care robots (van Wynsberghe, 2013b, 2013a). Recognising the need to understand user concerns, we conducted a short survey which we now present.

7. Presenting the Survey

The small-scale pilot survey was constructed to establish views and concerns of the general public around the emergence of domestic robots. It was informed by existing literature, from a breadth of disciplines considering legal and ethical matters around robots e.g. law, philosophy, computer science, engineering science fiction. The survey adopted a broad view of 'domestic robots' to include interactive artificial intelligence, to capture existing new technology such as Alexa and other personal assistants that respondents may have experience of using. The survey was approved by University of Nottingham Computer Ethics process, ran from 6th – 28th March 2018, and was shared primarily though social media channels (namely Twitter, Facebook and Reddit). Of the 43 respondents to this survey, 18 were identifiably male and 18 female, 1 non-binary and 6 remained anonymous. There was an age spread from teenage to over 70 years old with a concentration from 20-45 years old. The survey was broken into 3 broad themes, namely, general feelings & experience with robots; trust and interaction; future thinking. This enabled us to establish current understanding and exposure to robots before exploring views on future usage, ethical guidance and trust in more depth. The findings can be summarised under the following themes.[1]

[1] As is the nature of surveys, participants sometimes omit to answer questions. We have accounted for this in any descriptive statistics presented. Any results based on less than the full 43 participants are labelled as such, and the result is recalculated to reflect this. Again, this is a small scale, explorative pilot study, but provides useful insights we present here on their own, limited terms.

General Feelings and Experiences: Existing technology such as Alexa, Google Home and other domestic robots such as Roomba (robotic hoover) had only been experienced by just over 30% of all respondents with the remainder citing cost (36.7%) dislike (23.3%) and others (50%). For those who cited others, the main recurring theme was lack of trust/privacy issues as the reasons for lack of engagement,[2] as one participant stated, "*I don't see a tremendous amount that these devices could do to improve our family life at the moment; certainly not enough to justify the cost and personal data implications."*[3]

Privacy and informational harms are major concerns[4], and when asked to state two fears from the introduction of domestic robots almost 75% of all participants cite concerns around covert listening/privacy/hacking. The challenge for the domestic robot industry will become managing the privacy trade-off for consumers. The responses made clear that people were aware of their privacy being traded for the benefits conveyed by AI/domestic robots but striking that balance where the robot's duties outweigh the loss of privacy has yet to be achieved in the majority of respondent's opinions.

On the positive side, 50% of 42 respondents were at least slightly positive about the increase in Artificial Intelligence in the home.[5] Additionally, the most cited two benefits from the introduction of domestic robots among the 43 respondents are time saving/convenience and companionship/care.[6] When all 43 respondents were asked about a range of tasks for future domestic robots to perform, among others, the top roles were cleaning (95.3%); washing/ironing (79.1%) and medical/care (69.8%). Somewhat contradictorily, in a later question asking what robots should not do, 54.8% of the 31 question respondents felt that robots should not be allowed to have childcare/parenting/care roles, which appears contradictory.[7]

Future Thinking: Respondents were wary of providing domestic robots with legal rights.[8] Only 16.3% of all respondents felt that domestic robots should have any rights protected by law although the sentience of the robot was recognised largely as the deciding factor.

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[2] Finding 1

[3] In addition to the statistics, we also present qualitative quotes or other feedback from our respondents. This provides further context and is sourced from free form boxes in the survey where they could further explain their answers.

[4] Finding 3

[5] Finding 2

[6] Finding 2

[7] Finding 4

[8] Finding 5

This implies that respondents are not yet comfortable with robots having legal rights, although by pointing to sentience as a variable for legal protection, where robots sit in relation to other species, such as animals, will be a legal challenge for the future.

Independence in ethical control for robots was key[9], with 78.6% of 42 respondents wanting an independent body to be responsible for controlling the any ethical rules driving domestic robots. Interestingly, government was the second most approved controller (57.1%), perhaps demonstrating an inherent trust in governmental control (or perhaps showing a lack of trust in other options). An interesting comment that backed this up is:

> *'I don't trust companies to regulate themselves at all, not under capitalism where they aim to make profits, see Uber evading police controls, Volkswagen messing about with the Diesel fumes, Facebook not caring about people abusing data mined from their service - it's a mess.'*

The physical form of the domestic robot matter[10], and in this survey almost 60% of 42 respondents felt that the physical form a domestic robot takes makes a difference. Some stated, "*it's still a machine regardless"* and "*they perform a function so looks are irrelevant*" whilst another stated "*the more human like it is the more users are likely to regard it as human. This can have advantages and disadvantages."* This recognises the impacts of the form domestic robots take remains an unsettled domain. However, robot form (humanoid or not) links back to discussion of robot rights, and more broadly, robot personhood, which is an ongoing debate in the EU (European Parliament, 2017) and wider academic circles (Darling, 2016; Schafer, 2016). As such personhood would also enable responsibility to be passed from roboticist to robot this remains a contested point (Delcker, 2018).

Trust and Interaction: Over 95% of all respondents either do not implicitly trust (51.2%) or don't know (44.2%) about trusting domestic robots.[11] Some felt machines can fail, errors can be made in programming and they are susceptible to hacking accurately replicates the lack of trust highlighted earlier. Surprisingly, despite the lack of trust and recognition that domestic robots are only machines, 74.4 % of all respondents felt that robots could help with feelings of social isolation.[12]

This exploratory survey whilst not large scale, provides indicative topics for further reflection, particularly around the issue of trust, which we unpack further below.

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[9] Finding 6

[10] Finding 7

[11] Finding 8

[12] Finding 9

7.4 Unpacking the Themes

Trust is key because, as Holder et al argue, "*user acceptance will be critical to uptake [of robots] and acceptance will be based on trust*" (Holder *et al.*, 2016, p. 384). Various aspects of trust are considered below, before considering safety, privacy, transparency and control.

Human Robot Interaction and Trust: To address the shift from industrial robots to domestic robots that can "communicate with environment, follow human social norms, and mimic human abilities." (Haidegger *et al.*, 2013, p. 1216), better understanding of how users live and is needed. The field of *Human—Robot Interaction (HRI)* has emerged, "dedicated to understanding, designing, and evaluating robotic systems for use by or with humans" (Goodrich and Schultz, 2007, p. 204). Mataric (2007). set out a comprehensive list of human robot interaction orientated challenges, similar to those outlined above, around safety, privacy, attachment, and trust. Attachment is interesting for the domestic environment, as users become attached to their robots. "*Roomba users already refuse to have their Roombas replaced when they need repair, insisting on getting the same one back. What happens when the robot is much more interesting, intelligent, and engaging than the Roomba?"* (Mataric, 2007, p. 285-286)

Not all users are so attached, and from an interactional perspective, the line between trustworthiness and distrust can be tenuous (Mataric, 2007). Whilst Wagner (2009), shows that studies indicate humans tend to trust and confide in robots, in contrast, Pagallo argues "personal and/or domestic robots will raise a number of psychological issues concerning feelings of subordination, attachment, trustworthiness, etc." (Pagallo, 2013, p. 502). Similarly, Holder *et al.* (2016) found that people have become more sceptical of robots as the technology advanced and capabilities increased. Hence, trust in human robot interactions has to deal with the legacy that it is normally formed between humans, but as humans & robots co-exist, metrics for trust need to adapt as "*the change in a user's perception of a robot from simply being a technology to being a social actor*." (Moran, Bachour and Nishida, 2015 p. 2)

Trust and Robot Form: One basis for trust is the *form of the robot*, ranging from non-humanoid (e.g. Roomba) to humanoid (e.g. Aeolus) or ethereal interactive AI (e.g. Alexa). This is highlighted above. Some robots may utilise more human attributes in their relationships with users "*which can help increase the perceptions of anthropomorphism, including facial features, physical expressiveness, emotions and personality*." (Moran, Bachour and Nishida, 2015, p. 1). Similarly, affective robots have abilities to "[*recognize] and [synthesize] emotional cues and response but are still largely incapable of emotional reasoning*" (Sullins, 2012, p. 399). However, given the possible emotional connection between human and robot, human psychology can be exploited and user behaviour manipulated (Darling,

2016). Hence, there legal and design-based protections for vulnerable users who could be adversely influenced are necessary.

Law and Trust: The law can support trust in robots by ensuring they are safe and respect privacy. With the legal approach, it could help set an equal playing field in the market while regulating and protecting consumers by supporting *"trust in brands, trust in functions, trust in privacy, trust in a fair market*." (Holder *et al.*, 2016, p. 384) We explore the legal frameworks around safety and data privacy below.

Safety – Currently, there is a lack of coherent legislation governing service robot safety. For example, Directive 93/42/EEC concerning medical devices (as amended by Directive 2007/47/EC) ("Medical Device Directive") and Directive 90/385/EEC on active implantable medical devices ("AIMDD") only apply to care robots in dealing with medicine but not care robots with other functions. Standards, such as ISO 13482, plug this gap. As care robots inherently deal with vulnerable populations, appropriate regulation (Holder *et al.*, 2016), is necessary, especially given the multitude of contexts domestic service robots may live in. Accordingly, whilst design can address some challenges, ensuring legal frameworks that do exist are applicable is vital to protecting user interests.

Privacy and Data Protection – As Finding 3 states, privacy is a big concern. With domestic robots, privacy risks are amplified as they are within the intimate setting of the home, collecting sensitive data from users longitudinally, and profiling their behaviour over time to provide contextually appropriate services. New European Data Protection frameworks, such as the General Data Protection Regulation 2016 (GDPR) and proposed ePrivacy Regulation, provide compliance requirements. This includes problematic requirements such as around data portability (Article 5(2) GDPR; (Urquhart, Sailaja and McAuley, 2017)), accountability (Article 20 GDPR; (Urquhart, Lodge and Crabtree, 2018)) and the right to be forgotten (Article 22 GDPR). As in many areas of IT regulation, the fast pace of technological change and slow legal landscape means there is an increasing turn to design as a regulatory tool (Lessig, 2006; Urquhart, 2017). Law and policy concepts like privacy by design and default (PbD – Article 25 GDPR) and security by design (Article 32 GDPR) provide the mandate for ensuring personal data driven technologies embed safeguards from the beginning, not just after a harm occurs. Supporting how best roboticists can do PbD in practice requires extra thought, as it does for other developers (Luger *et al.*, 2015; Hadar *et al.*, 2018). As Mataric recognises "*Privacy has to be taken seriously when the robot is designed, not after the fact, as a result of users' complaints"* (Mataric, 2007, p. 285-286). Navigating, the interface between HRI practitioners and researchers and law will be critical, as it is already for HCI and law (Urquhart and Rodden, 2017).

Transparency & Control: Linked to data protection, is questions of transparency and control. The degree of agency a robot has is a big concern as this impacts the degree of uncertainty and ability to control its actions. Oversight of autonomous decisions, and how these

are made accountable to users is as much a design issue as it is a legal one (Edwards and Veale, 2017). It is predicted that eventually robots will achieve the level of autonomy where "they themselves become the data controller and responsible for compliance with data privacy legislation" (Holder *et al.*, 2016, p. 395), a prediction also supported by Pagallo, (2013). However, for now, focus should be on establishing and operationalising the responsibility of roboticists to their users, and in particular, protecting their legal rights. Translation between legal frameworks and design guidelines is important for this (Urquhart, 2014).

8. Conclusions

The growth of smart homes is paving the way for domestic robots. There are a multitude of existing challenges around robotics that need to be dealt with. Findings from the pilot survey were numerous but highlight the relationships between robots and users with form, privacy and trust. Given the current pitfalls being experienced with emergent smart homes, there is a responsibility on roboticists to learn from these mistakes and design such robots in legally, socially and ethically responsible ways. A key dimension of this is the need to design technologies after engaging with, understanding and respecting needs of users. Whilst there are commitments to many high-level ethical principles emerging in new codes of conduct for roboticists, these need to be situated and operationalised. The current focus in HCI on values in design is one approach to doing this. Similarly, the turn in law to design for regulation means there is similar drive to consider end user interests and rights within the design process. If the roboticists creating domestic robots ensure they engage with end user interests, there is a chance they can emerge in a more responsible manner.

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Appendix 1: Example Domestic Robots.

Sector	Example and explanation	URL
Domestic Chores	- A. Vacuum Cleaner - iRobot Roomba – robot vacuum that uses intelligent sensors to move through home, adapting to surroundings and cleaning floors. - B. Mopping - iRobot Braava – Similar to above but offering wet mopping, damp sweeping, or dry sweeping. - C. Window Cleaning - Ecovacs Winbot - Cordless vertical window cleaning for the majority of window types. - D. Home Butler –Aeolus – Humanoid home assistant that can learn and develop in situ and perform basic cleaning and tidying tasks, integrate with personal assistance technology and smart devices	www.irobot.co.uk www.irobot.co.uk www.ecovacs.com www.aeolusbot.com
Gardening	- A. Lawnmower – Robomow - Automatic sensor lawn mower.	www.robomow.com
Pets & Care	- A. Litter Tray – Litterbot - Automatic self-cleaning litter box. - B. Pets – Sony Aibo dog resurrected in 2018 after original launch in 1999; more threatening Boston Dynamics dog SpotMini also emerging too	www.litter-robot.com www.sony-aibo.co.uk https://www.bostondynamics.com/spot-mini
Food & Drink	- A. Moley Robotics – robot kitchens (humanoid arms behind glass) that can cook different selected recipes. - B. Miso Robotics Kitchen Assistants – burger flipping robots that detect when reach desired temperature. - C. Starship – food delivery robots that were tested in San Francisco, but pedestrians don't like them hugely. - D. Robot Barista - Automated processing of drinks orders in a known environment trialled in Japan.	www.moley.com www.misorobotics.com www.starship.xyz www.cnet.com
Care & Companionship	- A. Care robots – 'Stevie the Robot' is a research project bot that can perform autonomously or be remotely operated by human operators e.g. for tasks such as reminding elderly to eat (and taking photos as evidence) or reminding to clean up after themselves (detecting when plates are dirty). - B. Elli-Q - Keeping older adults active & engaged, the robot suggests activities and can make phone calls for the elderly users.	www.junoassistive.com www.elliq.com

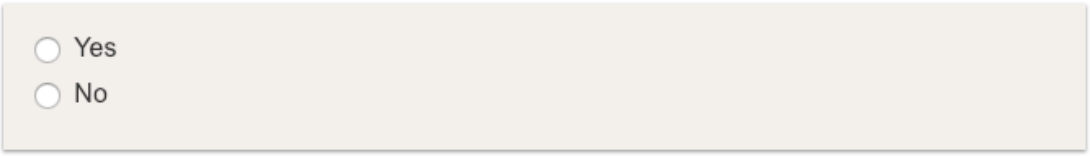
	- C. Paro Robot seal - Animal therapy has proven benefits for the elderly and this robot allows such therapy to be administered in places where a live animal may be inappropriate. - D. Pepper Robot – able to assess and react to perceived emotional state of individual it interacts with.	www.paro-robots.com www.softbankrobot-ics.com
Home Management e.g. Security, Energy	- A. UB Tech Walker – can perform basic roaming security duties and other tasks such as calendar and email management. - B. Robotex Avatar III Security Robot – fully functioning all terrain stair climbing security robot linked via wi-fi for continual monitoring. - C. Appbot Riley – Similar to above, Riley uses Wi-Fi connectivity to stream live video and audio.	www.theverge.com www.robotex.com www.ipatrol.net
Existing Interactive AI e.g. Home Personal Assistant Devices	- A. Amazon Echo - Smart speakers developed by Amazon. Uses voice-controlled intelligent personal assistant, Alexa and is capable of playing audiobooks, music playback, setting alarms, making to-do lists, streaming podcasts, and providing real-time information such as weather and rail times. It can also control several other smart home devices such as heating and lighting. - B. Google Home – Similar to Alexa, Google Home speakers enable users to speak voice commands to interact with services through Google's intelligent personal assistant called Google Assistant. Offering the same breadth of services as above. - C. HomePod – Again, this smart speaker developed by Apple Inc. uses Apple's own smart assistant, Siri, to control the speaker and other HomeKit devices. This can connect to all Apple based product such as iPhones and through to services such as iTunes. - D. Invoke – A further iteration of the smart speaker, this time utilizing Microsoft's intelligent personal assistant, Cortana. Effectively providing all of the same services but to a Microsoft user.	www.amazon.co.uk store.google.com www.apple.com www.harmankar-don.co.uk
Toy Robots	A. Luka the Owl - reads bedtime stories to children. B - Pleo Robot Dinosaur - Pleo uses a basic AI to grow and develop from a baby to an adult dinosaur taking cues from the user to develop a unique personality (within a set of predefined algorithms). C.- CHiP the smart dog - Artificial intelligence robot dog with adaptive personality. Will respond to App and wearables.	https://intl.ling.ai/pages/luka www.pleoworld.com www.wowwee.com

Appendix 2: Key Survey Results

General Feelings & Experience with Robots

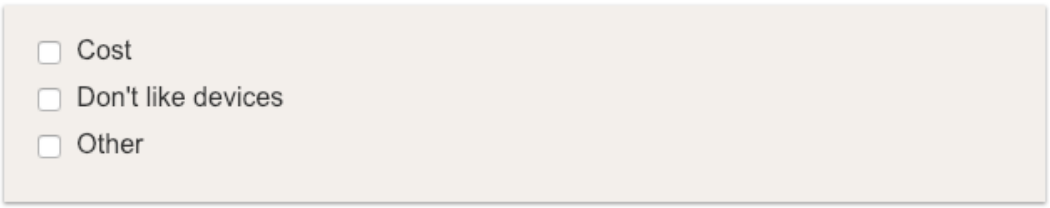
Finding 1: Q.16

16. Have you used domestic robots EG Alexa/Google Home/Roomba?



- 13 out of 43 respondents answered 'Yes' which equates to 30.2%
- 30 out of 43 respondents answered 'No' which equates to 69.8%

a. If 'No', what has prevented you to date?



**Note that respondents may tick all that apply*

- 11 out of 30 respondents who answered 'No' in Q.16 answered 'Cost' which equates to 36.7%
- 7 out of 30 respondents who answered 'No' in Q.16 answered 'Don't like devices' which equates to 23.3%
- 15 out of 30 respondents who answered 'No' in Q.16 answered 'Others' which equates to 50%

i. If you selected Other, please specify:

- 7 out of 15 respondents who answered 'others' in Q.16a cited the answer under the theme of trust/privacy which equates to 46.7%

Unique Response number	Responses	Theme
1	Don't want someone else's microphone in my home	Trust/privacy
2	Lack of interest, not that bothered, unsure of where my datas going and how being used.	
3	Have not found any that would improve lifestyle or help in a meaningful way	
4	Not researched them enough to know whether I want one	
5	I haven't really got a clear sense of what I would use them for at this point	
6	I don't see a tremendous amount that these devices could do to improve our family life at the moment; certainly not enough to justify the cost and personal data implications. Also my husband thinks that IoT tech is ridiculous and doesn't want it in the house.	Trust/privacy

7	I'm wary of networked appliances and am uncertain of 'always on' technologies.	Trust/privacy
8	I dont trust em	Trust/privacy
9	Don't see the point	
10	No interest/incentive	
11	Privacy concerns	Trust/privacy
12	Not yet comfortable with the idea of more data being collected through voice interfaces (always listening)	Trust/privacy
13	I not sure what benefits they would offer over and above being able to 'goggle' information other than being voice activated. I'm also concerened about becoming reliant upon a device and also my capacity to remember information deteriorating.	
14	Not sure how useful they actually are	
15	Privacy Concerns	Trust/privacy

Finding 2: Q.17 & Q.18

17. How does the increase in artificial intelligence in the home (eg Alexa) make you feel?

- [ ] Very Positive
- [ ] Slightly Positive
- [ ] Neutral
- [ ] Slightly Negative
- [ ] Very Negative

- 8 out of 42 respondents answered 'Very Positive' which equates to 19%
- 13 out of 42 respondents answered 'Slightly Positive' which equates to 31%
- 9 out of 42 respondents answered 'Neutral' which equates to 21.4%
- 12 out of 42 respondents answered 'Slightly Negatively' which equates to 28.6%

18. Identify 2 benefits you can see from the introduction of domestic robots?

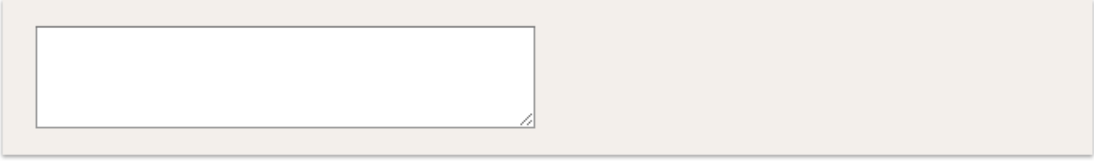
- 25 out of 43 respondents cited the benefits under 'Time saving/Convenience' theme which equates to 58.1%
- 14 out of 43 respondents cited the benefits under 'Companionship/Care' theme which equates to 32.6%
- 10 out of 43 respondents cited the benefits under 'Domestic work' theme which equates to 23.3%

Unique Response Number	Responses	Theme(s)
1	Spare time Better cleaning	Time saving/Convenience Domestic work
2	Easy use of sophisticated technology Tasks done for you which means less wasted time on your part	Time saving/Convenience
3	- Less human error / forgetfulness - Additional (physical) security	
4	Useful for people with disabilities. Potentially timesaving	Companionship/Care Time saving/Convenience
5	To save time. To make tasks easier.	Time saving/Convenience
6	Energy efficiency Ability to do new things	
7	They are fun and helpful e.g for security or heating to be controlled remotely.	
8	Easier music playing Keeping people company	Companionship/Care
9	Quick support and decisions making	Time saving/Convenience
10	Comfort Convenience	Companionship/Care Time saving/Convenience
11	Less Housework Easier to control more things at once	Domestic work Time saving/Convenience
12	Being able to create a smart home is great. The ease of using voice activation is a brilliant achievement.	
13	More time for humans to do other things. Makes chores more interesting ie can watch domestic robots at work.	Time saving/Convenience Domestic work
14	Feeding up time, can do more enjoyable stuff	Time saving/Convenience
15	Easy access to information Increased time to spend on other things	Time saving/Convenience
16	TIME SAVING HELPFUL FOR DISABLED/ELDERLY	Time saving/Convenience Companionship/Care
17	More convenient - dont have to get up to turn lights off/on Richer experience - ie, bulbs wth different colours for when watching films relaxing, having these integrated with a smart speaker eg homepod	Time saving/Convenience
18	Could improve safety for ageing population by monitoring there actions and health and contacting emergency services. Aiding disabled people to live a fuller life and improve interaction and assist in doing tasks perhaps by voice control	Companionship/Care
19	Labour savings New ways of living ones life by being presented with new ideas / approaches by AI	Time saving/Convenience
20	quicker and easier decisions	Time saving/Convenience
21	Sorry I actually don't see any benefits.	
22	1. Do the chores that I don't enjoy doing 2. Help me to remember things	Domestic work Companionship/Care
23	Entertainment (seeing what I can get it to do that it wasn't designed to do) pure laziness .	
24	Making life easier for people with a disability; being able to remotely control equipment etc. in the home when away	Companionship/Care Time saving/Convenience
25	1. Easing the burden of domestic chores. 2. Means to meet increasing care needs of aging population.	Domestic work

26	Easier to complete tasks Quicker to complete tasks	Time saving/Convenience
27	Natural integration, talking/interaction with people, pets or animate objects mostly comes easy to people Access of ease, quick and easy interaction (no need to unlock laptop, open browser, search etc.), you could just ask your "robot buddy"	Companionship/Care Time saving/Convenience
28	1. Integration of household tasks 2. making homes more accessible for those with disabilities	Domestic work Companionship/Care
29	Background performance of tedious tasks, labour saving	Time saving/Convenience Domestic work
30	Maybe beneficial to those who feel isolated. Monitoring/Assisting who need it	Companionship/Care
31	1. Reduction of domestic labour 2. Increased safety for older people	Domestic work companionship/Care
32	They can help with the automation of certain tasks and, in the case of digital assistants like Alexa/Google home, to access answers to some questions quicker than if we had to search for them on our phones or computers.	Time saving/Convenience
33	Less cleaning work Integrated systems, less to worry about	Domestic work
34	simplify the interface to the house appliances; earn people more time	Time saving/Convenience
35	1) Domestic robots have entertainment value 2) Domestic robots might have value in helping people with disabilities to live more comfortably and self-sufficiently	companionship/Care
36	Care	Companionship/Care
37	provides entertainement - it's quite funny to keep asking Alexa to play obsure tracks or be finding out answers to various questions, I used it once or twice when socialising and we all had a good laugh. Other, less advanced functions like the alarm clock are also useful.	
38	Do mundane tasks that humans are happy to miss out Free up time for other human persuits	Time saving/Convenience
39	1. Allow mundane tasks to be performed more conveniently	Time saving/Convenience
40	Automating domestic tasks. Being able to perform domestic tasks while away.	Domestic work
41	1) Being able to acccess information in an immediate, seamless (voice activated way). 2) Easier access to such information for multiple users	Time saving/Convenience
42	1. increased convenience 2. increased efficiency	Time saving/Convenience
43	1. Convenience 2. Helping people with disabilities	Time saving/Convenience

Finding 3: Q.19

19. Identify 2 fears you can see from the introduction of domestic robots



32 out of 43 responses involve covert listening, privacy and hacking which equates to 74.4%

Unique Response Number	Responses	Theme
1	Safety of pets and children Damage to possessions	
2	Disclosing your personal details Errors occurring	Covert listening/privacy/ hacking
3	- Use of data by unknown 3rd parties - Loss of control	Covert listening/privacy/ hacking
4	They could go wrong and, for example, start playing music when you're asleep. Potential to result in families spending less time together.	
5	They will make jobs redundant. The fear that we are being monitored e.g. whereabouts etc.	Covert listening/privacy/ hacking
6	Hacking Unreliable programming	Covert listening/privacy/ hacking
7	Cutting jobs. Could be dangerous e.g driverless cars.	
8	More targeted adverts played from devices People listening in on you	Covert listening/privacy/ hacking
9	People becoming over dependent on them and them lacking in 'soft' skills	
10	Lose of privacy Disruption of home environment	Covert listening/privacy/ hacking
11	Cost of repairs More things to go wrong	
12	There is a fear that people or the government can hack into these devices. The expense of kitting out your home with domestic robots	Covert listening/privacy/ hacking
13	Data they gather can be hacked. Makes humans lazy.	Covert listening/privacy/ hacking
14	Data they collect, at what point do we say gone too far	Covert listening/privacy/ hacking
15	Invasion of privacy, being continuously supervised by a robot that is relaying your personal information to an outside entity. You do not know what data is being sent, what is being stored and when it is being sent. Using the gathered data for malicious purposes	Covert listening/privacy/ hacking
16	MALFUNCTION COULD CAUSE DANGER LACK OF PHYSICAL MOVEMENT	
17	Always listening - bit weird but I can get over it, don't really think about it. Hacking - criminal activity/terrorism	Covert listening/privacy/ hacking

18	hacking into home and personal data and possible reprogramming to do harm or ignore some actions. Increase in obesity as people do less and rely on robots for manual tasks without moving.	Covert listening/privacy/ hacking
19	Cyberdyne Systems / Skynet Sloth developing in users	
20	unconsented data capture, misfunction (eg. the creepy laughter episode from Alexa)	Covert listening/privacy/ hacking
21	Domestic robots can slow down our daily routine if broken It's another task to deal with (setting them up etc) They take away spontaneity They're just creepy	
22	1. Things going wrong 2. Being listen to or watched without my knowledge	Covert listening/privacy/ hacking
23	Malfunction , being an annoyance	
24	Too much dependence on machines (lack of control); expense and hassle of keeping them working and up to date	
25	1. Unwanted/unknown surveillance and data harvesting by private companies for their own commercial gain. 2. Unemployment of human carers, cleaners, delivery couriers etc.	Covert listening/privacy/ hacking
26	Personal data issues Can be hacked	Covert listening/privacy/ hacking
27	Surveillance: Companies listening in on, government actors tapping into collected data, e.g. alexa is constantly listening to catch its wake word, so private conversations will also get processed by Amazon, feels like a breach of privacy if your "robot buddy" is just a glorified moving microphone Safety: What if your "robot buddy" gets hacked and harms/endangers you in some shape? E.g. administering wrong information, opening doors to strangers etc.	Covert listening/privacy/ hacking
28	1. data breaches caused by IoT having intimate knowledge of people's daily lives. 2. Possible issues surrounding trust and accountability within the home.	Covert listening/privacy/ hacking
29	Will be expensive for limited functionality; will be hooked into a larger data ecosystem that i dont want to be connected to	Covert listening/privacy/ hacking
30	Intrusive Harvesting data	Covert listening/privacy/ hacking
31	1. Can be vectors for stealing information about me/my household. 2. Connection to other online services (as much as possible I would like to keep internet separate from real life).	Covert listening/privacy/ hacking
32	That the networking protocols used may not be secure enough and the devices could be accessed and controlled by strangers. This, of course, may also depend on which “robot” you are acquiring and using, and how your network is configured.	Covert listening/privacy/ hacking
33	I go on holiday and they decide to do something crazy for two weeks. Data concerns	Covert listening/privacy/ hacking
34	data leaks; the device being hacked	Covert listening/privacy/ hacking
35	1) Privacy invasion - especially from devices that are "always listening" 2) Service disruption might impair system efficacy - for example, if a device relies on having a reliable internet connection, how does a user adapt when internet service is disrupted?	Covert listening/privacy/ hacking
36	privacy, misinformation	Covert listening/privacy/

		hacking
37	I am worried about the data that the robot is collecting, even things like my daily routines etc. could be used against me (by the robbers) if they would leak out. I have a little awareness of what could happen with this data, but the device like Alexa doesn't seem to have much internal storage, so it may be sending it somewhere else to store it, and we can never be sure of the safety of the information that is put on the internet. I also have this unexplained fear of relying on the technology and being unable/ forget how to carry out some tasks when I need it and the tech. is not available	Covert listening/privacy/ hacking
38	The robots knowing 'too much' about me/us The security risk of remotely accessible technology being the target of malicious attack	Covert listening/privacy/ hacking
39	1. Increased invasion of privacy by companies	Covert listening/privacy/ hacking
40	Data collected might be breached or sold on to third parties. Risk of being unable to do domestic tasks if tech fails (e.g. being locked out)	Covert listening/privacy/ hacking
41	Personal information being potentially disseminated The information being accessed / delivered to me may be biased based upon my on evolving choices and not being aware or in control of this	Covert listening/privacy/ hacking
42	1. lack of control 2. less independence	
43	1. Privacy 2. No internet connection/electricity	Covert listening/privacy/ hacking

Finding 4: Q.20 &Q.21

20. What domestic roles should robots perform (Tick all that apply)?

- [ ] Medical/Care
- [ ] Cleaning
- [ ] Washing/Ironing
- [ ] Cooking
- [ ] Entertainment/playing games
- [ ] Tutoring
- [ ] Other

**Note that respondents may tick all that apply*

- 30 out of 43 respondents answered ‘Medical/Care’ which equates to 69.8%
- 41 out of 43 respondents answered ‘Cleaning’ which equates to 95.3%
- 34 out of 43 respondents answered ‘Washing/Ironing’ which equates to 79.1%
- 24 out of 43 respondents answered ‘Cooking’ which equates to 55.8%
- 32 out of 43 respondents answered ‘Entertainment/playing game’ which equates to 74.4%
- 26 out of 43 respondents answered ‘Tutoring’ which equates to 60.5%
- 6 out of 43 respondents answered ‘Other’ which equates to 14%

21. Any tasks robots should not be allowed to perform?

17 out of 31 respondents mentioned that robots should not perform tasks related to parenting, medical or caring roles which equates to 54.8%.

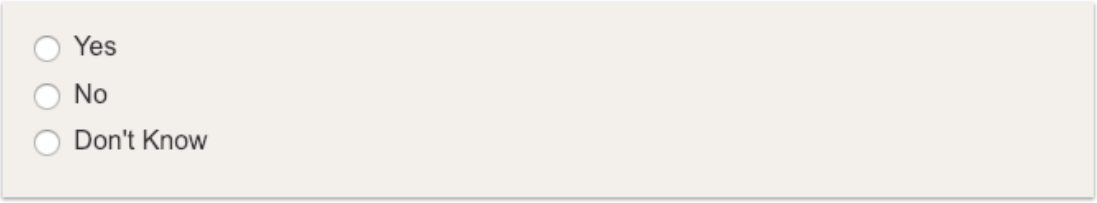
Unique Response Number	Responses	Theme
1	Parenting	Parent/medical/care
2	Anything that could cause danger/hazards if there is a malfunction	
3	Babysitting! When considering tasks like tutoring and medical care I think there needs to be a certainty that they can't get it wrong. It doesn't matter if they get the ironing a bit wrong but it does matter if they get a medical matter wrong.	Parent/medical/care
4	Mental health therapy or to replace personal care	Parent/medical/care
5	Robots shouldn't be allowed to take over job roles at the cost of self worth.	
6	No	
7	Domestic robots should not perform medical care in these early stages.	Parent/medical/care
8	Dressing and bathing	Parent/medical/care
9	Anything which involves human interaction eg medical care.	Parent/medical/care
10	Anything that makes life easier/ more efficient	
11	CHILDCARE	Parent/medical/care
12	no.	
13	Some actions concerning health and finances etc should require a human input to confirm action proposed by robot. Robots should be programned so cannot do harm even if someone trys to change this basic rule.	Parent/medical/care
14	Childcare?	Parent/medical/care
15	Medical care/ I wouldn't trust the robot to perform anything more serious than cleaning	Parent/medical/care
16	This depends on who lives in the home, a robot should not be able to spy on another human, or do anything that affects a person without their consent. This might be difficult though, where one person controls the robot in the home. Robots oughtn't be able to do anything that might go wrong without someone present, I guess, like cooking if they might set the house on fire because they didn't notice a tea towel on the stove.	
17	Not in principle but it would very much depend on how they were programmed and controlled to ensure safety, ethics etc.	
18	I suppose any role is acceptable if it supports the user's wellbeing. However, there might be psychological risks involved in robots taking on certain roles in people's lives, e.g. reinforcing risky behaviours or replacing social contact with other humans. But all this would be con-	

	text dependent and difficult to regulate. Would the sexual use of robots be preferable to the exploitation and criminality associated with prostitution?	
19	None	
20	Violence, no military robots, no justice/judge robots, no police robots, any form of policing/power-exercising robot is super scary to me because machine learning/AI tends to biased (wonky data sets, engineers not thinking about social stigma etc). These robots would and will discriminate against marginalised people.	
21	Anything that may put the public at risk. Cooking/medical / ironing/ cleaning.	Parent/medical/care
22	Standing in for parents	Parent/medical/care
23	Anything that involves a "blank cheque" (I don't want a robot spending money on my behalf)	
24	Depending on the type of robot, they should not be left alone with vulnerable people that can't notify anybody else of a potential malfunctioning/dangerous situation, or that do not understand the consequences of using such robot.	Parent/medical/care
25	Dangerous tasks	
26	babysit	Parent/medical/care
27	Education	
28	Childcare, Banking transactions, Legally binding agreements	Parent/medical/care
29	Unsure	
30	- *(considered as no response, so not counted in analysis)*	
31	They shouldn't replace human interaction, such as putting children to bed, giving them a bath etc	Parent/medical/care
32	Important Decision (e.g. which medication to take)	Parent/medical/care

Future Thinking

Finding 5: Q.22

22. Should robots have 'rights' protected by law?



- 7 out of 43 respondents answered 'Yes' which equates to 16.3%
- 18 out of 43 respondents answered 'No' which equates to 41.9%
- 18 out of 43 respondents answered 'Don't Know' which equates to 41.9%

a. Why do you belive this?

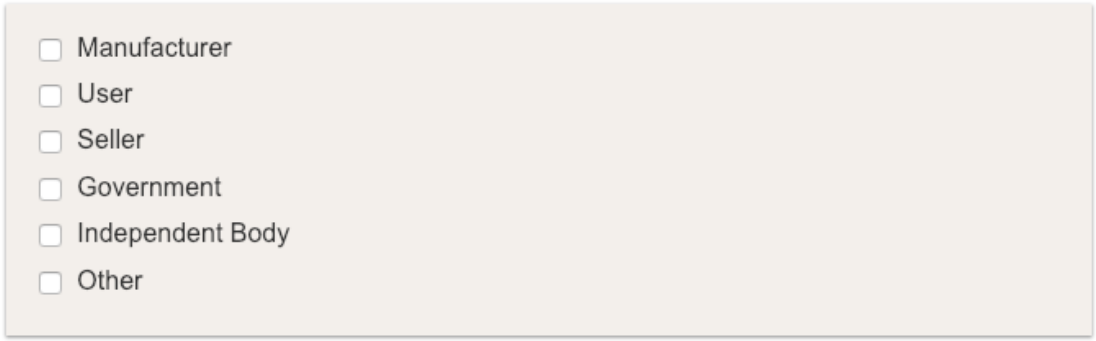
- 21 out of 35 respondents cited answer under the theme of the sentience of the robot which equates to 60%

Unique Response Number	Responses	Theme
1	Depends on level of sentience	Sentience
2	They are not ‘human’	
3	If 'consciousness' is demonstrated then yes, else no.	Sentience
4	They are not sentient.	Sentience
5	It depends how autonomous they are	
6	They should have the right to be used ethically.	
7	If artificially intelligent to a human level, why not? If they are able to not want to work then yes.	Sentience
8	Because they are not programmed with emotions/ understanding of this area	Sentience
9	If they have any kind of feelings they must be protected	Sentience
10	Assuming they aren't sentient, that would be like giving a kettle rights.	Sentience
11	Because they are automonus machines and they do not half feelings.	Sentience
12	This would give the programmers an excuse to hide behind legislation is something went wrong.	
13	Currently no as not sophisticated enough, unsure for future. Should the limit if robot AI development be that we don't create robots that should have rights?	
14	Quite honestly it depends on the level of intelligence displayed by the robot. Simple forms of intelligence are never protected by laws - an example being insects. The higher the levels of intelligence, the more laws are set to protect the creatures. In biological experiments it is much harder to experiment on a monkey than it is to experiment on a cockroach. I believe that we should not discriminate based on the type of lifeform though. If silicon based intelligence eventually develops to the levels of animal/human based intelligence then it too should be protected by laws. Technically speaking we are far away from this, and most AI applications require insect level intelligence to operate.	Sentience
15	ONLY IF THEY WERE TO BECOME SELF AWARE	Sentience
16	Its Technology, my phone doesnt have 'rights' nore my connected speaker	
17	We are at the start of artificial inteligence in the future robots could become "Human" in their outlook and should have rights not to be abused or forced to cause harm.	Sentience
18	AI improving all the time ... fully sentient robots only matter of time ...	Sentience
19	Because they are a human-made device	
20	I think it highly unlikely that robots will reach a level of consciousness that makes them more than a machine anytime soon.	Sentience
21	Because they aren't a living thing	Sentience
22	As they are not human it does not seem appropriate to give them human rights - it seems that the most relevant/appropriate laws would be related to property, safety etc.	Sentience

23	There should undoubtedly be regulation of how robots are designed and used, but whether this equates to the AI having 'rights' I'm not sure.	
24	I answered yes, but these things should be carefully negotiated... maybe not through laws? More through best practises/social treaty/community enforced rules. I don't know how that could really look like, because it could go south really quickly (e.g. companies being treated like people is a super scary thing in the states!), but I think robots should be protected from harm... I don't want people to murder or rape their robots, but I tend to anthropomorphise objects (I apologise to objects when I bump into them and have said thank you to doors), so I recognise that I am not very objective on this.	
25	This is a problematic question in that neither 'robots' or 'rights' are adequately defined.	
26	At this time there is no sense they are sentient - assuming you buy it (not hire it) it is just a tool. My washing machine does not need rights.	Sentience
27	If you mean 'rights' as in stuff I can't complain about, no (like it has a 'right' to spy on me for Amazon). There is another kind of 'rights' that are really less about the robot and more about the regulation of human behaviour. If it were possible to be cruel to a robot in a way that could be learned/normalised and transferred to people or animals, there is an argument for preventing it but I'm not sure about this owing to liberal impulses and the fact I'm not sure being mean to The Sims actually led to bad behaviour in real life (I think this is called "the media hypothesis" and is generally used in bad arguments for censoring things). Then again, maybe robots are different. It may depend on the degree to which the robot approximates a living thing, I'm not sure.	Sentience
28	This would depend on what are those ‘rights’	
29	I believe right now they are not much different from any other house hold appliances. In the distant future, if such robots become conscious (if anyone can define/prove that), my answer will be yes.	Sentience
30	I don't know enough about this topic to form an opinion.	
31	I heard about these AI programmes that managed to create their own language and were using it to communicate between themselves. As people couldn't follow what they are talking about they killed the processes by disconnecting the machines from power. One of my fiends told me about it and I remember that we had this conversation on whether it is ethical to finish the existence of another intelligence, and even though I think we shouldn't overreact (as computers and robots are not living beings), I would feel better if this type of issues was assessed by the professionals and regulated. Also there should be laws that strictly regulate the access to the data & protection of data gathered by robots.	Sentience
32	Depends on level of intelligence	Sentience
33	They're not yet sentient, just lines of code	Sentience
34	Robots tend to belong, be designed or be maintained by large corporations. Giving domestic robots legal protection would give these corporations leverage against the consumers that use the robots, e.g. you wouldn't be allowed to unplug a machine you've bought.	
35	Robots should have regulations and a legal framework within which they operate. Robots cannot be given natural or legal 'rights' (if we choose this distinction) since they are artifacts and that will contradict the definitions of the term 'rights'.	

Finding 6: Q.23

23. Who should control the ethical rules driving domestic robots (Tick all that apply)?

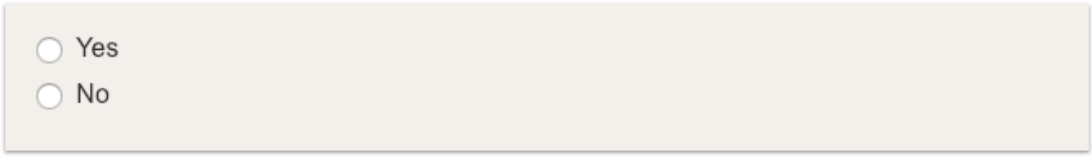


**Note that respondents may tick all that apply*

- 15 out of 42 respondents answered 'Manufacturer' which equates to 35.7%
- 16 out of 42 respondents answered 'User' which equates to 38.1%
- 5 out of 42 respondents answered 'Seller' which equates to 11.9%
- 24 out of 42 respondents answered 'Government' which equates to 57.1%
- 33 out of 42 respondents answered 'Independent Body' which equates to 78.6%
- 4 out of 42 respondents answered 'Other' which equates to 9.5%

Finding 7: Q.24

24. Does the form a robot takes (eg humanoid style/Alexa style 'home assistants) make a difference to your interaction with it

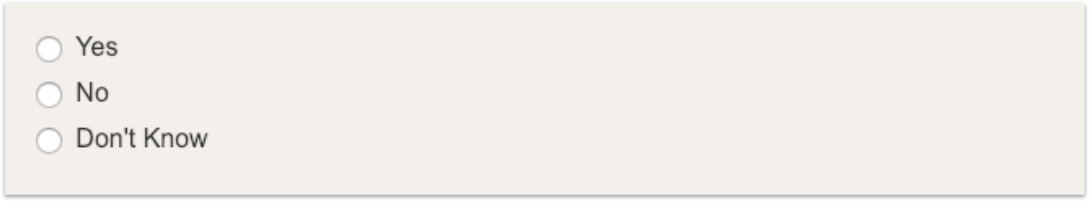


- 25 out of 42 respondents answered 'Yes' which equates to 59.5%
- 17 out of 42 respondents answered 'No' which equates to 40.5%

Trust & Interaction

Finding 8: Q.25

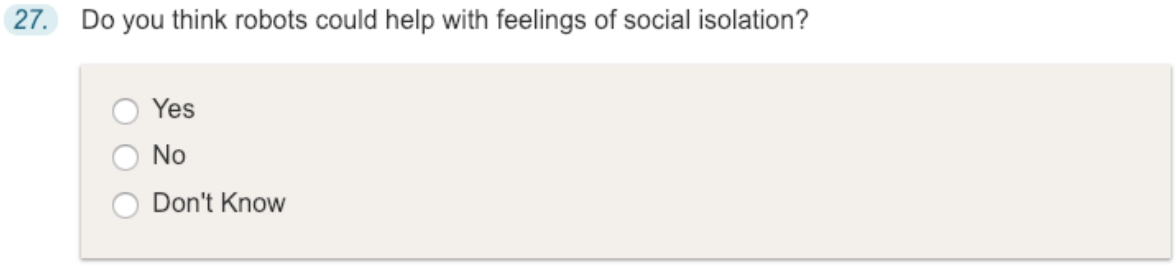
25. Would you implicitly trust a robot?



- 2 out of 43 respondents answered 'Yes' which equates to 4.7%

- 22 out of 43 respondents answered ‘No’ which equates to 51.2%
- 19 out of 43 respondents answered ‘Don’t Know’ which equates to 44.2%

Finding 9: Q.27



- 32 out of 43 respondents answered ‘Yes’ which equates to 74.4%
- 2 out of 43 respondents answered ‘No’ which equates to 4.7%
- 9 out of 43 respondents answered ‘Don’t Know’ which equates to 20.9%