A Roboethics Framework for the Development and Introduction of Social Assistive Robots in Elderly Care

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Dedication

"To the creation and evolution of human conscience…"

Acronyms

AR(s): Assistive Robots(s).

EC: European Conformity.

EURON: European Robotics Research Network.

EUROP: European Robotics Technology Platform.

EEG: Electroencephalography

FCC: Federal Communications Commission

FOV: Field Of View.

GSR: Galvanic Skin Response.

GT: Grounded Theory

GUI: Graphical User Interface

HCI: Human Computer Interaction.

HRI: Human Robotic Interaction.

IT: Information Technology

IS: Information Systems

RAE: Royal Academy of Engineering.

RSG: Relevant Social Groups.

SAR(s): Socially Assistive Robot(s).

SIR(s): Socially Interactive Robot(s).

SST: The Social Shaping of Technology.

Abstract:

There is an emerging “aging phenomenon” worldwide. It is likely that we will require the introduction of assistive technologies that can assist caregivers in the exercise of elderly care. Such technologies should be designed in ways that promote high levels of human dignity and quality of life through the aging process. Social Assistive Robots (SARs) demonstrate high potential for complementing elderly care when it comes to cognitive assistance, entertainment, communication and supervision. However such close Human Robotics Interactions (HRIs) encompass a rich set of ethical scenarios that need to be addressed before SARs are introduced into mass markets. To date the HRI benchmarks of “Imitation”, “Safety”, “Autonomy”, “Privacy”, “Scalability”, “Social success” and “Understanding of the domain” are the only guidelines to inform SARs developers when developing robotic prototypes for human assistance. However such HRI benchmarks are broad and lack of theoretical background to understand potential ethical issues in elderly care. Further, there is little guidance for either developers or those involved in the provision of care, regarding the appropriate introduction of SARs.

In this research the current HRI benchmarks are reviewed alongside the core ethical principles of beneficence, non-maleficence, autonomy and justice, together with a social care ethos. Based on such interpretation, practical robotics workshops were conducted in five care and extra care institutions with the direct participation of elderly groups, caregivers and relatives. “In-situ” robotics demonstrations, informal interviews and observations were conducted, investigating human behaviours, attitudes, expectations, concerns, and levels of acceptance towards the introduction of SARs in elderly care settings. Following a thematic analysis of the findings, a roboethics framework is proposed to support the research and development of SARs. The developed framework highlights the importance of selection, categorization and completion of relevant HRI benchmarks, HRI templates, HRI supervision schemes and ethical specifications for SARs applications.

Keywords: elderly care, SARs, ethics, roboethics, HRI benchmarks.

CHAPTER 1 - INTRODUCTION

According to the United Nations (UN) human civilization is undergoing significant demographic changes in both western and non-western cultures. As an example, in 1990 the number of British citizens over 65 years old represented (16%) of the overall UK population. From 2012 to 2020 the number of elderly people is expected to reach (20%) (UN 2011). By the year 2050, UN expects three times more people (worldwide) over 85 than exist today (UN 2011). It is understandable that a significant portion of the future ageing populations will require extra levels of physical and cognitive assistance throughout their lives. A great deal of attention and research must be directed to assistive technologies aimed at promoting ageing-in-place, facilitating living independently and promoting the wellbeing of individuals and communities. Robotics as a multidisciplinary science starts to demonstrate an immense potential to be used in social care contexts (Feil-Seifer and Matarić 2009). However in the robotics community there is still no exact definition to describe “what is a robot” or how we could classify robots Polk (2005) and Dautenhahn (2013). The word “robot” was introduced in 1920 by Karel Čapek in the science fiction play Rossum’s Universal Robots (RUR). In reality “industrial robotic arms” have been used in manufacturing and production lines since the 1950s. The efficiency and productivity of industrial robots is translated in modern life (Veruggio 2006). However, almost a century after we still don’t have a clear definition to “what is a robot” and to what extent can we classify devices as robots. In literature we find different “robotic” definitions. Joseph Engelberger the pioneer of industrial robotics states "I can't define a robot, but I know one when I see one" (BRNO 2013). The Merriam-Webster encyclopaedia provides several definitions for what is a robot: "a machine that looks like a human being and performs various complex acts (as walking or talking) like a human being"; "a device that automatically performs complicated often repetitive tasks", or "a mechanism guided by automatic controls" (Merriam-webster 2008). In reality robots are usually classified based on their abilities. In robotics academic teaching Rapp (2011) robotic classification usually includes the domain of operation, degrees of freedom, control system, level of autonomy or the goal which robots are designed to. In the domain of assistive technologies Social Assistive Robots (SARs) result from the intersection of Social Interactive Robots (SIRs) and Assistive Robots (ARs) (Feil-Seifer and Matarić 2005). The term SIRs was originally used by Fong, et al. (2003) to describe robots whose main task was some form of interaction. Such interaction could use social interaction principles typical from human beings such as speech and gestures. On the other hand the ARs term has been widely referred in the robotics community to describe robots that assist people with physical limitations or disabilities (Feil-Seifer and Matarić 2005). Feil-Seifer mentions that SARs philosophy is not based solely on the interaction itself but mainly on the outcome of the interaction for providing assistance and achieve measurable progress in terms of convalescence, rehabilitation, motivation or learning. Despite the degree of sophistication of the terminology it still doesn't translate a fundamental definition and consensus on how to classify robots. However as SARs philosophy is to provide motivation, supervision, rehabilitation or convalescence to vulnerable users we could expect scenarios where physical support and psychological assistance are required. So the physical nature and psychological nature involved in HRI takes substantial relevance. Due to a high set of possible SARs scenarios in this thesis we will consider a robot as "an electromechanical device that can be programmed through software or hardware to execute tasks automatically". We believe such definition has enough depth to cover a wide range of situations where robots could complement elderly care.

However the term "robot" might need to be expanded and possibly categorized according to its capabilities and primary objectives. In today's manufacturing robots, SIRs, ARs, entertainment robots or any other type of robots such classification takes place independently. This means robotics classification considers either the robot's degrees of freedom, control system or for example the locomotion method involved. In reality we might have a combination of robotics characteristics that might take into account both the aesthetics, level of autonomy and overall robotic objective. Due to the broad range of future robotics applications we could have robotic information cards to define levels of aesthetics, degrees of freedom, control systems, locomotion types, autonomy, level of intelligence, types of sensors, main robotic objective, serial number etc. Such robotics characteristics could also contribute to define different categories of robots. This means the continuation of ARs, SIRs and SARs families but probably we will need to categorize them at a higher level (e.g. robot category 1, robot category 2) to better identify its main objectives and human responsibilities when it comes to development and usability.

Despite the robotic definition and classification it is likely that robotic assistance with elderly groups will require technologies capable of providing motivation through entertainment, cognitive assistance, supervision and communication. Those are capabilities that could be delivered in the medium/long term by the first generation of SARs. However the introduction of SARs is likely to raise ethical challenges around independency versus human contact, privacy and wellbeing of elderly groups. Currently there is a paucity of studies that involve the use of SARs with vulnerable groups such as the elderly. As an example existing studies highlight psychological gains with the use of SARs with elderly groups but also report emerging connections formed between the elderly and robotic animals Wada and Shibata (2008) and Kidd, et al. (2006). On the same line Wada and Shibata (2008) report increases in communication and socialization of elderly groups with the use of robotic seals but also mention emerging connections between certain individuals and the robots. Beyond such acknowledgement none of these studies analyse the use of SARs from an ethical point of view. The work of Feil-Seifer and Matarić (2009) calls for attention from the robotics community to better develop SARs that can provide assistance to vulnerable groups. They propose a set of HRI benchmarks for informing SARs developments. However such benchmarks do not include an ethical analysis on its core development. Instead the current robotics development benchmarks of Kahn, et al. (2006) and Feil-Seifer and Matarić (2009) are mainly influenced by psychology. Such contributions are important and represent a starting point however we need more emphasis in the ethics associated to SARs development and potential use.

Such fact raises the following question: with the emerging demographic challenges how SARs can be used as an extension of elderly care if they are not ethically analysed? This represents a critical point to be researched as the outcome of SARs deals with the trade of between the benefits and potential harms provided to elderly groups. It is likely that we will have ethical interpretations which can provide important indicators both for users and robotic manufacturers. However due the sensitivity of elderly care we will need to visit the foundation principles of ethics. We will have to consider the ethical principles of “beneficence”, “non-maleficence”, “justice” and “autonomy” Beauchamp and Childress (2001) to analyse current SARs technologies with the presence of elderly groups. Social care ethos plays also an important role in listening to people’s opinions, rights, dignity and choices in care (Suhonen, et al. 2010). On the same perspective we believe the ethical understanding of SARs should follow the same assumption. For the moment SARs perception and its potential benefits for elderly groups has yet to be demonstrated and studied with more practical emphasis in ethics and robotics.

Despite the lack of consensus on what defines a robot in this research we are mainly considering the nature of SARs in care scenarios. SARs can be used in areas of supervision, entertainment, cognitive assistance and companionship. In general SARs are expected to move around, resemble different morphologies and communicate and interact (physically or psychologically) with humans and other systems. Such robotics nature is likely to open new opportunities unseen in care but also needs careful analysis when bringing robots to vulnerable groups. As roboethics author Veruggio mentions, "roboethics is an exercise of ethical reflection related to the particular issues that are generated by the development of robotic applications and their diffusion in society" (Veruggio, et al. 2011). In SARs it seems that we need further research that could promote active user participation throughout the robotics design, development and introduction stages. The use of SARs with vulnerable groups will represent additional challenges that go beyond the robotics technical nature. To date there is a lack of practical HRI studies in conjunction with elderly groups that could translate ethical issues and serve as basis for reflection and guidance for future research and development of SARs. Also when it comes to social assistance, the scope of previous HRIs studies is mainly confined to research labs and controlled environments that do not translate real contexts, challenges and human feedback involved in HRIs. The interaction between elderly people and robots is likely to open many questions relative to the ethics, validity and benefit of such interactions. Beyond the fact that SARs are being developed for providing potential "therapeutic" benefits for users, the crossover between the core ethical principles of beneficence, non-maleficence, autonomy, justice and social care ethos needs to be further researched. Social care is already by its nature abundant in ethical scenarios (Suhonen, et al. 2010). We believe that by interpreting and developing further HRI benchmarks according to the core ethical principles and social care ethos it is possible to shape the development of SARs and enrich the quality of HRIs that can benefit elderly groups.

When developing SARs for elderly care we could expect additional questions: How SARs could help in elderly care? What they should look like? What maps good levels of HRI? How can we supervise and read the outcome of such interactions? How can we address the ethical issues involved in the development and introduction of SARs in elderly care? Is it possible to learn and conceive ethical guidelines for developing SARs technologies?. Due the sensitivity of elderly groups further research will have to improve our understanding on the new field of roboethics (level 1). We will need to better understand how to connect theoretical considerations (ethics) with practical robotics exercises to better translate ethical issues and possible alternatives. At this point ethics and robotics seem to be separate by different routes. In reality we will need to build a common language for developers, users and stakeholders involved in design, development and introduction of SARs. Further qualitative inputs are needed to create visual representations of HRI benchmarks and try to categorize them according to relevant areas where SARs could complement elderly care. Such representations are likely to be completed by the use of ethical specifications which can involve defining human supervision responsibilities and human contact schemes to be applied. In sum we will need the development of ethical frameworks and practical tools for understanding some of the emerging ethical issues arising from the development and introduction of SARs in elderly care.

The beauty and challenges associated to the use of SARs need contributions from multidisciplinary teams arising from the fields of electronics, mechanics, computer science, artificial intelligence, social sciences, ethics, law, psychology, neuroscience, arts and others. Such exercise could help informing the potential benefits and challenges around the use of SARs with vulnerable groups. At this stage it seems plausible that the development of ethical frameworks that take into account the multidisciplinary aspects of HRIs could contribute to develop better products/services and possibly inform the creation of robotics law.

To help understand some of these questions this research conducts “in-situ” robotics workshops with the use of SARs and the direct participation of elderly groups, carers, managers and relatives in care and extra care facilities. We believe that SARs ethical issues are likely to emerge in real care settings. Such practical robotic workshops are absolutely crucial to interpret current HRI benchmarks and extend them according to the four ethical principles of beneficence, non-maleficence, justice, autonomy and social care ethos. At this point we acknowledge that there is an aging phenomenon worldwide UN (2011) and an emerging need to develop assistive technologies for expanding the quality of care. However there are critical considerations involved in the current state of the art of SARs research and development. After literature review we conclude that there is no articulation between the ethical considerations and the practical exercise of robotics when assisting elderly groups. In practical terms there are no roboethics frameworks of reference that can provide guidance during the development and introduction of SARs. In sum we lack of ethical understanding and tools that can translate a common language for developers and potential users of SARs technologies. At this stage we tried to highlight crucial points that need to be carefully researched. Thereby the following research aims and objectives were identified:

- To investigate the current state of the art of the ethics involved in developing SARs for elderly care and identify potential limitations.

- To examine how the four core ethical principles of beneficence, non-maleficence, autonomy, justice allied with social care ethos can be applied to the existing HRI benchmarks of “safety”, “scalability”, “imitation”, “autonomy”, “privacy”, “social success” and “understanding of domain” (Feil-Seifer and Matarić 2009).

- To conduct practical robotics workshops and perform a qualitative analysis to reframe current HRI benchmarks.

- To propose a roboethics framework that includes human supervision schemes, HRI benchmarks and ethical specifications for the design, development and use of SARs with elderly groups. Demonstrate the application of the proposed roboethics framework with practical case studies.

The contribution to knowledge of this thesis is to revise the current HRI benchmarks according to the four core medical ethical principles allied with social care ethos to propose a roboethics framework that can inspire the development and introduction of SARs in elderly care. Such framework involves three steps: analysis and visual representation of HRI benchmarks, the use of templates to create an ethical specification and finally a revision process. The roboethics framework represents an iterative process that provides flexible understanding on some of the SARs emerging ethical issues.

The research is decomposed into 5 main stages (**figure 1**). Stage 1 reviews the literature on the new curriculum of roboethics. Stages 2 and 3 revise Feil-Seifer and Matarić's (2009) existing HRI benchmarks according to the core ethical principles of beneficence, non-maleficence, autonomy, justice and social care ethos. Stage 4 is informed by stages 2 and 3 and it involves practical robotics workshops in care and extra care facilities with elderly groups, carers and families. Stage 5 analyses qualitatively the practical robotics workshops and proposes a roboethics framework for assisting the development of SARs for elderly groups.

This research follows an interpretivist philosophy to gain understanding of elderly people's attitudes, behaviours and concerns towards the introduction of the SARs in care/extra care scenarios. Qualitative research methods are applied. The study includes "in-situ" HRI workshops, informal interviews with elderly groups, caregivers/families and the use of practical case studies.

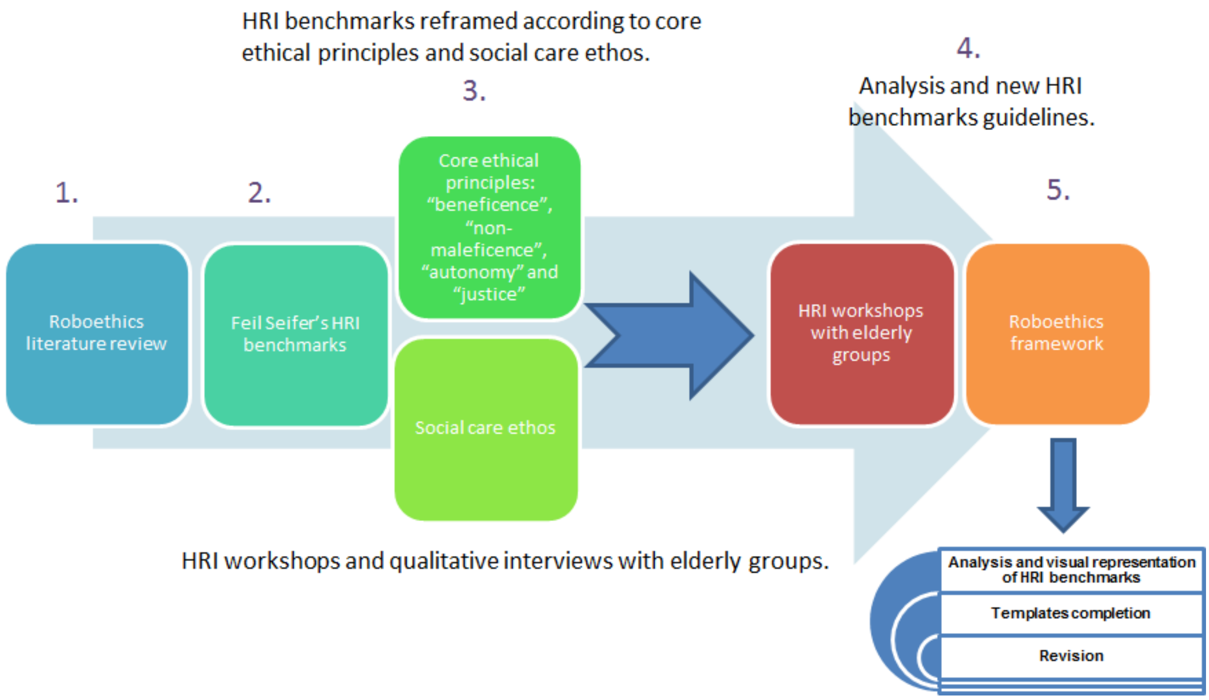

FIGURE 1 - OVERALL RESEARCH CONCEPTUAL MAP

As we saw currently there is a lack of field studies in SARs. Still within the most significant studies ((Wada and Shibata 2008), (Kidd, et al. 2006), (Tapus, et al. 2009)) there is no significant analysis, discussion and guidance towards the ethics of delivering SARs to vulnerable groups such as the elderly. It is an area that needs further attention. This research adds knowledge and practical applicability to the discipline of roboethics (level 1) by informing SARs developments and user interaction with elderly groups.

Following the structure of this thesis chapter 2 presents the literature review on the discipline of roboethics. Chapter 3 introduces SARs technologies and correlates the existing HRI benchmarks with the core ethical principles of beneficence, non-maleficence, autonomy and justice aligned with social care ethos. Chapter 4 presents the selected research methodology and robotic workshops performed during the course of the study. Chapter 5 analyses the data collected during the practical robotic workshops. Chapter 6 reframes the existing HRI benchmarks considering the analysed results with special regard to the core ethical principles of beneficence, non-maleficence, autonomy, justice and social care ethos. Chapter 7 presents the proposed roboethics framework, which includes HRI benchmarks identification, templates, and the framework process. Chapter 8 illustrates the application of three case studies using the proposed roboethics framework. Chapter 9 describes the conclusions of this study and suggests further research work.

CHAPTER 2 - LITERATURE REVIEW

2.1. ETHICS IN THE DIGITAL WORLD

Information technology (IT) is rapidly expanding to several areas of human life. The positive impact of information systems (IS) is highly noticeable in areas such as health and medicine, communications or business (Castells and Cardoso 2005). As IT becomes omnipresent in human life also the ethical considerations about the use of computer technology become more challenging. Computer ethics has been a topic of research since 1950s with prominent contributions from (Wiener 1950). Wiener was mainly preoccupied with the ethical use of computers. Such preoccupations covered aspects related with automated machines, networks, responsibility, security, artificial intelligence and more.

Today such topics are integral part of discussion in information systems and communication technologies. In addition, the growth of communications and the Internet originated new challenges in the field of computer ethics. Some of the most prominent ethical issues in contemporary computer ethics deal with intellectual property, privacy, control and regulation, censorship, computer crime and access (Bynum and Rogerson 2003).

However the definition of computer ethics in itself might involve different perspectives. According to Moor (1985) computer ethics is "the analysis of the nature and social impact of computer technology and the corresponding formulation and justification of policies for the ethical use of such technology". According to Johnson and Snapper (1985) computers didn't constitute a whole new ethical paradigm, but rather gave a "new twist" to already familiar issues such as ownership, power, privacy and responsibility. Because of the exponential growth of information systems and communication technologies authors such as Gorniak-Kocikowska (1996) even predict that computer ethics will possibly achieve the standard of global ethics. Kocikowska mentions "in the future, the rules of computer ethics should be respected by the majority (or all) of the human inhabitants of the Earth... In other words, computer ethics will become universal; it will be a global ethic".

For now we understand and feel the current and emerging importance of computer ethics in modern life however in this thesis we will consider computer ethics as an area of applied ethics that refers to the ethical development and use of computing technology. Such area involves guidance on how humans choose to conduct themselves through the use of computing programs and resources online or offline. Typically computer ethics deals with issues such as privacy rights and respect for intellectual property which are transversal to developers and users.

On another plain medical ethics is an area that studies how physicians conduct their actions in the exercise of health care. Every situation presents different questions and ethical issues in medicine should be approached carefully (Gillon 1994). Beauchamp and Childress (2001) proposed a medical ethics framework that involves the interpretation of the four core ethical principles of beneficence, non-maleficence, justice and autonomy. In health care beneficence guides health care workers towards the benefit of patients. Non-maleficence states that the physician actions should not harm individuals. Autonomy deals with the respect for patients decisions about their own care. Finally justice deals with difficult questions associated with access or rationalization of care (Gillon 1994). However how physicians will apply those same ethical principles remains a big challenge. In practical terms beneficence is not separable from non-maleficence. As an example, working towards the best interest of a patient might involve administrating a short/medium term painful treatment. On the same spectrum respecting patients' autonomy might imply stopping treatments or procedures that are considered by the medical community as beneficial for such individuals. In justice medical decisions usually take the notion of fairness, however they could be influenced by risk factors such as epidemic situations or even governmental considerations towards costs in health care. As Gillon (1994) mentions although such framework doesn't provide a set of ordered rules for every single situation, the four core principles can help doctors and other health care professionals to make moral judgements and decide the course of actions.

In the domain of information and communication technologies it is important to acknowledge that we are relying more and more on computing decisions (Castells and Cardoso 2005). Samuel, et al. (2010) report similarities between medical ethics and computer ethics. Medical devices and health care information systems are currently based on software. As Anderson and Goodman (2002) mentions software in health care could make life and death decisions. The operating system flaw of the Therao-25 medical accelerator is reported as one of the examples that originated losses of lives. Beyond such fact, ethical challenges in modern health care deal with scenarios related with safety and confidentiality. Questions around patients information as well as health professionals information comes to debate (Samuel, et al. 2010). An example deals with the use of databases with identifying information relative to patients participating in antiretroviral research programs versus their privacy and testimonials to other patients. Another example deals with doctors' access to information systems where patients' complaints are made towards health professionals and how such access impacts on care decisions. On the first example the patients' privacy has to be taken into account but on the other hand such behaviour brings inefficiency to the process of informing patients with typical disorders. The same dilemma arises with health professionals' access to patients' complaints databases. Does such behaviour improve health care or it prejudices the health care decisions? Ethics deals with deriving knowledge and guidance towards decisions that involve moral judgements. Thereby the interpretation of the ethical principles of beneficence, non-maleficence, autonomy and justice involve understanding, selecting and deciding the outcome of actions towards information systems in health care. However as in medical ethics such interpretation varies and could in same cases translate advantages and disadvantages for the stakeholders involved (Gillon 1994). The common aspects of medical ethics and computer ethics point to a classification where computer ethics involves a certain understanding of medical ethics (Samuel, et al. 2010). It is important that software developments associated to health care follow a system of verifiability and ethical discussion before entering in activity. Thereby for the scope of this thesis we will consider that computer ethics relates to medical ethics in terms of the resulting interpretation of the core ethical principles (**figure 2**).

Roboethics is defined by its author Veruggio, et al. (2011) as "an exercise of ethical reflection related to the particular issues that are generated by the development of robotic applications and their diffusion in society". Roboethics updates views on concepts such as the dignity and integrity of people, their fundamental rights and the social, legal and psychological elements involved in the development of robotics technologies (Veruggio, et al. 2011). As we saw SARs philosophy is to provide assistance through forms of rehabilitation, motivation, convalescence or coaching of vulnerable groups. Due to demographics challenges we will probably need to develop assistive technologies to extend our current levels of care. Scenarios associated to elderly groups' cognitive assistance, supervision, entertainment or companionship constitute areas where SARs could be possibly applied. The universe of SARs is likely to be vast including robots from different types of aesthetics, ergonomics, autonomy or locomotion. Robots are likely to move and resemble different physical configurations in close proximity of elderly groups. In such exercises human safety is primordial. It is important to recognise that current software architecture commands the hardware behaviour involved in SARs. Such feature could be critical when it comes to decision making that could influence the robot's interaction with users or the environment. As Anderson and Goodman (2002) mentions "software could make critical decisions in health care". Such fact constitutes in itself a fundamental challenge in computer ethics. Similarly the notion of human safety associated to robotics decision making is of primary importance. Situations where the SARs levels of displayed autonomy could be compromised by software bugs, unpredicted situations or hardware failures (e.g. sensors) could influence negatively the outcome of care actions. So in the domain of safety roboethics already shares important questions with computer ethics when it comes to controlling software in care situations. Other examples deal also with challenges associated to the privacy of HRIs. As we saw computer ethics presents examples of critical scenarios where healthcare information brings issues around privacy both for patients and health professionals (Anderson and Goodman 2002). Questions around patients' sensitive information or the nature of access to digital care complaints are in debate but not separable from a medical ethics perspective. In roboethics because SARs are likely to provide cognitive assistance and supervision to groups such as the elderly similar questions arise. Cognitive assistance involves programming SARs databases with a set of medication reminders, personal task lists and other elements that contribute for the welfare of individuals. However the access to the elderly personal and sensitive information for robot programming is not currently discussed or represented by codes of conduct. Who can access such information (e.g. caregivers, robot operators) and what are the elderly users' safeguards? Such questions involve particular interpretations of the core ethical principles of beneficence, non-maleficence, justice and autonomy.

Additionally roboethics is likely to raise more and different ethical challenges. The synthetic aspect of robots involves aesthetics and behavioural considerations (Breazeal 2002). Until this point humans having been dealing primarily with fixed terminals (computers) running software. As robots' embodiment takes place it is likely that robots could translate different levels of persuasiveness and ethical considerations. As Kidd (2008) reports there seems to be a higher level of persuasiveness arising from HRIs relatively to traditional software running on computers. Kidd (2008) mentions that participants were much more motivated by a weighting loss robotic coach than a classical software program. Results proved that globally people did consider more accurately the indications provided by a robot in order to control their diet (Kidd 2008). Interestingly some individuals didn't want to return the robotic coach to the research teams. Following the same line Wada, et al. (2008) also reports psychological gains when using robotic seals in care homes in Japan. Such robots were used as relaxing and comforting platforms to improve the communication and socialization among elderly users. Wada also reports connections formed by certain elderly individuals and robotic seals (Wada, et al. 2008). To a certain extent we should be aware that the aesthetics and behavioural nature of robots could originate new levels of persuasiveness between humans and robots. SARs nature is based on the outcome of HRI which could originate advantages and ethical challenges for vulnerable groups.

For now it is noticeable that at this stage many of the computer ethics challenges around safety and privacy are inherited by robotics technologies (**figure 2**). The sensitivity of HRIs for example in assistive care brings up the core ethical principles of beneficence, non-maleficence, autonomy and justice to discussion. Robotics by its power and persuasiveness opens new opportunities and challenges for human life. It is likely that roboethics will represent an extension and not disruption with the information technology era. The intersection between computer ethics (**figure 2**), medical ethics and roboethics is crucial to understand many of the ethical challenges associated to SARs development and use. As we saw in health care the three areas are confronted with the application of the core ethical principles of beneficence, non-maleficence, autonomy and justice. Such assumption should continue to inspire roboethics on its foundation and exercise. Thereby the contribution of this thesis arises from such intersection to possibly inform future developments and practical use of SARs in elderly care.

It is important to remember that beneficence will mean that robotic systems should be developed and used in ways that benefit human beings. Non-maleficence reinforces the notion of not harming robotic users. Such principle gains extreme importance in terms of user safety when considering for example autonomous and semi-autonomous robotic systems to be deployed in care scenarios. The ethical principle of autonomy deals with the right of users to decide the course of actions in HRI scenarios. Finally justice is related to costs, democratisation, legal issues and fair access to robotics technologies for the general public.

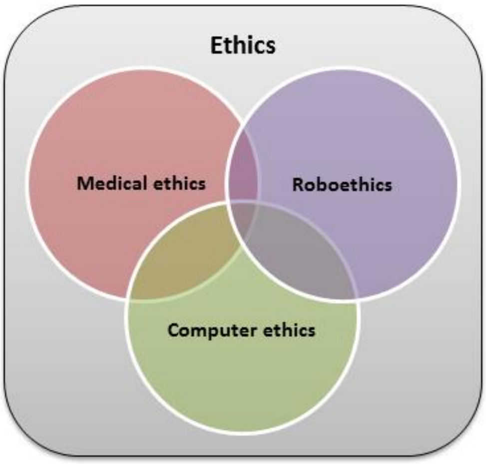

FIGURE 2 - ROBOETHICS, COMPUTER ETHICS AND MEDICAL ETHICS

2.2. EXPLORATORY WORK IN ROBOETHICS

In 1920 the Czech writer Karel Čapek introduced the word robot through his famous play entitled "Rossum's Universal Robots". In the following 93 years such vision inspired many science fiction writers and public to preconceive potential robotics and automation scenarios. Despite such "media" success however there is still no consensus in the scientific community when it comes to define "what a robot is" and which machines can be classified as robots. In reality the set of opportunities that such programmable robotic devices start to demonstrate for human life can be viewed as both fascinating and dangerous at the same time. Machines with various forms and dimensions are being equipped with sensors and computerized with AI algorithms for a wide range of purposes (Veruggio, et al. 2011). According to some of the world leading experts in robotics ((Breazeal 2002), (Brooks, et al. 2000)) it is likely that robots will be endowed with the ability to learn and process human profiles, tastes, habits, which will inevitably lead to privacy, safety and individual freedom choices. It is likely that in the near future humans will coexist with the next generation of automated machines (robots) employed alongside domestic workers, nurses and caregivers at home, hospitals and extra care facilities. For instance, in aging societies there is an urgent motivation for safe, (semi)autonomous and adaptable personal robots, also called SARs. However it is also likely that such distribution of robots will raise many completely new ethical, legal, and societal challenges.

AI is becoming more advanced and targeted to be used in a vast array of applications including SARs. Despite all the advantages that can be provided by robotics and automation

Sharkey and Sharkey (2011) have continuously warned the scientific robotics community of other types of dangers that go beyond physical safety. As robotics technology advances "roboethics" constitutes an area of primary importance to be studied and further developed. According to Sharkey and Sharkey (2010), robots can cause psychological problems, especially in vulnerable populations such as children, elderly people and hospital patients. Also issues regarding the attribution of civil and criminal liability should an autonomous robot produce damages are also arising in many debates. For instance, if we consider the civil and criminal liability of machines causing damage (physical, psychological or both) to humans or the environment, where does the responsibility lies? To robotic developers, insurers or final users? Which standards can inform law practitioners or courts?. There are also critical areas surrounding the humanitarian and international laws in the cases of brutal force used by military robotics. Such ideas have been subject to discussion since the "dawn" of robotics particularly in the works of Wiener (1950) or in the science fiction stories of Asimov (1941) where "the three laws of robotics" were introduced.

Three Laws of Asimov

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given to it by human beings, except where such orders would conflict with the first law.
3. A robot must protect its own existence as long as such protection does not conflict with the first or second laws.

The robotics laws were derived from a top-down approach where ethical theories such as utilitarianism and deontology were applied for evaluating the morality of a specific course of action (Wallach 2008). However according to Singer (2009) Asimov's laws were conceived purely for science fiction purposes. The laws seem to imply that robots have similar cognitive capabilities and behaviours as human beings. Such laws are far from being implemented into present day robotics. The current state of the art in AI is very limited Singer (2009) and such laws would imply a deeper knowledge about human conscience and ultimately its implementation on a machine.

It is only in the last few years that the debate has been progressively organized within the international robotics community and that roboethics has established itself as an emerging field of applied ethics (Veruggio, et al. 2011). Roboethics is an exercise of "ethical reflection related to the particular issues that are generated by the development of robotic applications and their diffusion in society" (Veruggio, et al. 2011:21). Because the complexity and sensitivity of the subject is enormous it is important to clarify the terminology between ethics and robotics before going further. For doing so I have analysed the perspectives of Veruggio, et al. (2011). In the article entitled "Roboethics: Ethics Applied to Robotics" Veruggio, et al. (2011) state that at least three levels of roboethics were already identified:

Roboethics levels (Veruggio)

- Roboethics (Level 1)
- Robot Ethics (Level 2)
- Robot's Ethics (Level 3)

The first level is denominated "Roboethics" and is represented by the "adopted ethical theories, developed principally by the branch of philosophy called morality, which studies human conduct, moral assessments, and the concepts of good and evil, right and wrong, justice and injustice" (Veruggio, et al. 2011:21). Such level represents an ethical reflection directly related to the particular issues generated by the "development of robotic applications and their diffusion in society. They add that level 1 "updates the various views on concepts such as dignity and integrity of a person, the fundamental rights of individuals and the social, psychological and legal aspects involved in the research and development of robotics and its diffusion in society " (Veruggio, et al. 2011:21).

A second level presented by Veruggio is currently referred to as "Robot Ethics" or machine ethics. This level represents the code of conduct that engineers and roboticists should implement in the AI algorithms of their robotic creations. It is seen as a sort of "artificial ethics able to guarantee that autonomous robots will exhibit ethically acceptable behaviour in all situations in which they interact with human beings or when their actions may have an impact on human society" (Veruggio, et al. 2011:21). Finally Veruggio presents a third level defined as "Robot's Ethics", because it is "the ethics born from the subjective morality of a hypothetical robot that is equipped with a conscience and freedom to choose its own actions on the basis of a full comprehension of their implications and consequences" (Veruggio, et al.

2011:21). This would be a scenario where robots could be deemed as moral agents involving their responsibilities or even rights.

In a certain way roboethics tries to provide answers to the scientific progress of robotics and related technical fields. Due to the high number of potential robotic applications the concepts of human dignity, integrity and the fundamental rights of the individuals, as well as the social, psychological and legal aspects become intertwined. By their nature these are elements likely to change from individual to individual or from culture to culture which makes them challenging to analyse.

What is ethically acceptable or not is a direct product of the aforementioned level 1 of roboethics (Veruggio, et al. (2011). This researcher’s perspective is that any result from robot ethics level 2 must be strongly informed by level 1.

When it comes to robot’s ethics level 3 it is still a purely speculative scenario as Veruggio states that “robots are in fact “machines”, tools that are unaware of the choices made by their human creators, which therefore we bear the moral responsibility for their actions” (Veruggio, et al. 2011:21).

Such categorization isn’t targeted specifically to SARs. Instead it tries to cover a wider spectrum of robotics applications where we have three different natures of research involved. The first one is directly related to the broad curriculum of ethics as well as considering the social impacts, advantages, disadvantages of robotics technologies. Areas such as humanities, social sciences, arts and law could well be located in this level. The second area tries to map technical solutions for practical implementations in robotics systems. I consider this to be a natural field for science, engineering, maths and technology. Lastly the third level appeals to robot’s conscience and ethical reflections on their actions towards human life. Currently this is still part of science fiction and thereby it is difficult to imagine the possible areas of human knowledge that could contribute for such research. To date all three levels of roboethics are not translating any guidance for prospective robot developers and their users. Nevertheless the levels can help us localising some of the emerging ethical questions about robotics and maybe addressing multidisciplinary teams to study and follow the evolution of robotics science.

In the perspective of this research more clarity is needed in the area of roboethics (level - 1). We have to understand and establish new paradigms and ethical frameworks to equip roboticists, engineers, computer scientists, philosophers, sociologists, lawyers and ultimately final users when it comes to decide the delivering schemes and possible applications for robotics in society. Thereby some valid questions that society might ask include: why do we want robots (motivation)?; where they should be applied (areas of human life); what do we want them exactly to do?; what should they look like?; are they threatening? if yes, what can be done to mitigate this?. Such questions have to actively involve prospective user's feedback on how machines should be designed, what kinds of usability, privacy and accessibility levels are required, what HRIs scenarios should be presented, and finally what are the relevant levels of autonomy and uncertainty for human intervention, safety or welfare.

2.2. Roboethics rules and guidance

In 2006 the EURON "EUropean *RObotics* research Network" workshop on roboethics took place in Genova (Italy) (Veruggio 2006). This was the first key conference where scientists from humanities and science were involved to debate contributions to the foundations of the human ethics applied to robotics. One of the findings of this meeting was the confirmation that the perception of robots and the definition of good and bad differ according to ages, cultures, religious beliefs, moral values, professional duties, social obligations and prohibitions. The EURON roadmap (**figure 3**) (Veruggio 2006) covers an assessment of the potential ethical issues in the design, development and use of robots and intelligent machines. It investigates potential ethical issues around the following robotics applications: advanced production systems, network robotics, outdoor robotics, military robotics, edutainment, adaptive robot servants in intelligent homes and health care and life quality. The EURON roadmap draws a broad perspective on the potential use of robotics and automation technologies by mapping its advantages and disadvantages, however the EURON roadmap is not sustained by academic studies on HRI and globally it doesn't seem to reflect practical guidelines for prospective SARs developers and users. Nevertheless the EURON roadmap marks a wake up stage for the robotics scientific community relatively to the importance of the subject of roboethics.

1. Advanced production systems
2. Network Robotics
3. Outdoor Robotics
4. Military Robotics
5. Edutainment
6. Adaptive robot servants and intelligent homes
7. Health care and life quality

FIGURE 3 - EURON ROADMAP, ROBOTICS APPLICATIONS AREAS 2006 VERUGGIO (2006)

However in the literature we also find controversial perspectives and studies that do not reflect exactly the visions of the EURON group. In 2006 a research was commissioned and recently updated in 2011 by the UK Office of Science and Innovation's Horizon Scanning Centre entitled “A.I. Law: Ethical and Legal Dimensions of Artificial Intelligence”. The article depicts a future science fiction scenario where robot calls may be made for human rights to be extended to robots (TheSgimaScan2.0 2011). At the end of 2007 the South Korean government announced the development of a robot ethics charter which to date has not been made public. However the media reported that the “robot ethics” charter will address questions such as “robot abuse of humans and human abuse of robots”. Some of the sensitive areas will cover human addiction to robots, human abuse of robots and prohibiting robots from ever hurting humans (Terry 2007). Taking a different perspective, Kim, et al. (2009) revealed a study where 230 participants (students) from the University of Hawaii (USA) completed a questionnaire which determined their concern relative to communication constraints in situations involving humans and robots. The results showed that people were more concerned with avoiding hurting the human’s feelings as well as avoiding the inconveniencing of other humans and less concerned with avoiding hurting the robot’s feelings or avoiding the inconveniencing of a robot partner.

In 2010 the UK EPSRC council gathered a team of experts from the world of technology, industry, arts, law and social sciences to discuss emerging robotics applications and their future potential for society. The outcome of this initiative was a document with five rules which can be seen as an extension of the three laws of Asimov.

Five rules of EPSRC

1. Robots are multi-use tools. Robots should not be designed solely or primarily to kill or harm humans, except in the interests of national security.
2. 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.
3. Robots are products. They should be designed using processes which assure their safety and security.
4. Robots are manufactured artefacts. They should not be designed in a deceptive way to exploit vulnerable users; instead their machine nature should be transparent.
5. The person with legal responsibility for a robot should be attributed.

The EPSRC rules represent an effort to reinforce both the role of human beings and robots in a future society. However the rules do not reflect a specific type of robotics application that they could be applied to. The rules seem to be targeted to future designers and regulators of robotics technologies but no academic reviews or references have been presented along them. The five rules seem to be generated in a “common sense” fashion and it is understandable that they try to inform both specialists and non-specialists audiences. In an ethical perspective the rules seem to be generated from a top-down approach underpinned by the ethical theories of deontology and utilitarianism (EPSRC 2010). Unfortunately the five rules are far from translating any real practical guidelines when it comes to the development of SARs with vulnerable groups.

In terms of benefits and harm, non-discrimination and privacy the works and interventions of ((Sharkey and Sharkey 2010), (Whitby 2010)) highlight the importance of understanding human ethics when deploying robots into society. Sharkey and Sharkey (2010) highlights that there are potential risks associated with the use of robot carers with elderly people when it comes to the reduction of human contact, increase in the feelings of objectification, losses of control, privacy or personal liberty. Whitby (2010) reinforces the idea of developing urgent guidelines and legal regulations for the development of robots. Both authors warn the scientific community about the lack of guidance when developing machines for taking care of vulnerable groups such as the elderly.

In terms of cultural diversity and pluralism the roboethics EURON Veruggio (2006) roadmap and Kitano (2007) emphasize the need for having general principles or adaptation mechanisms for the wider acceptability of robotics within different cultures and beliefs.

Relative to autonomy and individual responsibility, the works of Weng (2009) and Arkin (2008) appeal to a significant change in the way autonomous systems take responsibility in actions. Weng (2009) states that robots should be considered as “third existence entities” that will resemble living things in appearance and behaviour, but it will not be self-aware. Arkin (2008) proposes a “responsibility advisor” in warfare applications which can be translated as a mechanism for advising human operators in terms of final responsibility for their actions. In 2009 a document has been released by the UK Royal Academy of Engineering (RAE) entitled “Autonomous Systems, Social, Legal and Ethical issues” (RAE 2009) which highlights the benefits, liability and ethical problems arising from the use of autonomous systems in personal robotics and the transport sector. The document suggests if future robots are able to extend human care, society has to seriously question the cost of such technology, the balance between the isolation and independency of vulnerable groups as well as usability and privacy issues.

On the transport sector the report mentions that the use of autonomous systems could bring an immense set of advantages towards traffic management and increased levels of human safety. However currently there is no suitable legal framework to address issues such as insurance and drivers’ responsibility with self-driving vehicles. On other landscape we have seen tremendous progress in terms of autonomous driving vehicles over the last ten years. The Google self-driving car, or more recently the UK robot car are direct applications of such autonomous driving technology that could become a reality in the near future. However we are still lacking of academic contributions targeted to our social and legal spectrum that could accompany the reality of such progress. Such delay could result in lack of preparation and policy making when the first autonomous driving vehicles are introduced into the market. In the case of SARs we must be attentive to the current rate of progress. At the same time we have to start equipping ourselves with ethical frameworks that could inform our legal systems when such technologies are prepared to extend the levels of human care with vulnerable groups such as the elderly.

The late 2009 report entitled “Introduction to Ethical, Legal and Societal Issues of Robotics” has been issued by the European Robotics Technology Platform group (EUROP). The document emphasises the need to preserve and promote human dignity and skills by carefully weighting the introduction of new robotics technology in production processes (EUROP 2009). Mainly the report tries to analyse case studies where the urgency, novelty and social persuasiveness of robotics technology could raise ethical issues around human workers and robot workers. By doing so it raises societal concerns towards ethical studies that could be further conducted in robotics applications.

In 2009 the authors Feil-Seifer and Matarić (2009) extended the original HRI benchmarks of Kahn, et al. (2006). The contribution was specially focused on potential guidelines for the development of SARs. It presents seven HRI benchmarks entitled: safety, scalability, imitation, autonomy, privacy, social success and understanding of domain. So far this contribution constitutes the most relevant work to extend current knowledge on HRI benchmarks with special regard to emerging SARs ethical issues with vulnerable groups. The work not only identifies ethical issues in SARs but it mainly tries to move us towards a set of potential guidelines for research and development of SARs. However the HRI benchmarks don't seem to consider on its basis the four core ethical principles of beneficence, non-maleficence, justice, autonomy nor social care ethos considerations which this research believes are of primary importance to be explored in the context of SARs for elderly care. The research presented in this thesis extends Feil-Seifer's HRI benchmarks through the application of the previous core ethical principles and investigating elderly peoples' attitudes and choices towards SARs. We will discuss these in detail in chapter three.

All the presented works seem to be very generic both in terms of robotics applications and eventual guidelines for the design and development of SARs. As our ageing society progress we have to expand our own levels of care through diverse technological platforms that could include SARs. Robots that can provide supervision, cognitive assistance, entertainment and companionship could well result in increased benefits for elderly individuals and help reorganizing the quality and networks of care. However at this point, it seems we need further research involving SARs and the direct participation of elderly groups. Robots are still part of our fictional dreams and the lack of understanding, knowledge and experience when humans interact with SARs has to be iteratively researched through the coming years. The start-up participation of elderly groups in this research can reveal important cues on how people perceive the first generation of SARs. Such crossing will help us understanding the ethics of HRIs and inevitably guide us through the design and development of SARs.

2.3. "In-situ" practical workshops with SARs

I have presented the concept of roboethics and the most prominent works in this recent field. However it is also important to consider some of the existing practical workshops conducted with SARs and the participation of elderly groups.

Wada, et al. (2005) and (2008) and Wada and Shibata (2008) have presented practical studies with a SAR called PARO (a baby robotic seal). Wada conducted practical workshops during nine months in a care centre in Japan. The elderly residents interacted with PARO during their normal day care settings. Wada reports psychological gains through increased forms of communication and socialization among the elderly with PARO. Physiological tests were made to the urine of residents which concluded less stress levels in individuals. Lastly electroencephalography (EEG) tests were conducted with elderly residents that suggested improved activity in the patients' cortical region (neurological) due the interaction with PARO. This suggests potential benefits of SARs but such studies don't reveal an ethical analysis weighting or considering ethical principles with emphasis on social care ethos that could provide any guidelines for SARs development.

In 2005 Turkle (2005) presented a study that investigated the authenticity of HRIs with senior citizens. The study used "Furby", Sony "AIBO" and "my fur real baby" to investigate people's impressions and expectations towards HRIs. It questions until what point it is acceptable to provide a certain character to robots that tend to elude people during HRIs. Do robots actually mean what they were primarily programmed to? The study encourages further investigation on personalizing elements for HRIs such as: should the name of an elderly person who is in contact with the robot be included in the HRI? Could for example the robot express tenderness behaviours towards elderly people? Despite the fact that some social care elements such as peoples' attitudes and dignity were investigated, the study doesn't appeal to any ethical principles or conclude a potential set of guidelines for further SARs developments.

In 2006 Kidd, et al. (2006) presented a practical study that investigated senior citizens impressions towards HRIs. My real Baby and PARO were used. The study concluded that the use of such robotic platforms contributed to increased levels of socialization among the residents. Especially in the case of PARO the notion of touch was remarkably experienced by senior residents. A curious aspect during the interactions was that of some residents wanted to try PARO on water which raises questions about the aspect of the robot and what message it directly conveys to vulnerable groups. Despite this issue they also detected certain responses from some of the residents that mapped excessive care towards the PARO robot. The study proposed that such HRIs have to be delivered in shared contexts and that high skilled caregivers should monitor the course of HRIs periods (time). Such element is important to retain to the extent that such robots could become too much to handle for those who are frail, vulnerable or cognitively impaired. Issues about usability towards PARO are also highlighted: the robot is currently very heavy and not easy to turn ON/OFF. Despite the fact that the study reveals some of the residents' perceptions and attitudes (social care ethos) it lacks investigation of ethical principles when designing such HRIs that can provide important guidelines for future SARs developments.

By now we understand that roboethics has to be strongly informed by practical robotics workshops. The perception of vulnerable groups such as the elderly relative to early SARs developments can help developers, caregivers and families to understand the real requirements and ethics of care involved in the use of SARs. Such valuable information can positively influence the future design and development of SARs technologies targeted for elderly groups.

As a result, this research comprises practical HRI workshops where the four core ethical principles of beneficence, non-maleficence, justice and autonomy as well as social care ethos are explained, to investigate potential HRI benchmarks that could assist in the design and development of SARs technologies.

2.4. Summary

Roboethics is a novel area of research that tries to provide guidance to the scientific progress of robotics research and related technical fields. It encompasses human values and ethical theories capable of guiding humans when it comes to the design, development and use of robots and "intelligent machines". Veruggio, et al. (2011) classified roboethics into three distinct levels: roboethics, robot ethics and robot's ethics. Such categorization is conceived towards a wide range of robotics potential applications (not specifically SARs). It tries to identify potential areas of human knowledge that could be involved in each level of research. Roboethics (level 1) is intrinsically related to social sciences and humanities where robot ethics (level 2) is more related to science and technology. In my perspective there is a relationship between level 1 and level 2 as the second level is a practical result of the studies originated by level 1. Level 3 is still part of the realm of science fiction but it opens a generic space for future contributions in the area of robot's ethics.

In terms of roboethics rules and guidance we reviewed the EURON roboethics roadmap (2006). The document highlighted ethical issues resulting from implementing robotics in the following areas: advanced production systems, network robotics, outdoor robotics, military robotics, edutainment, adaptive robot servants in intelligent homes and lastly health care and life quality. Despite the advantages and disadvantages highlighted on the EURON roadmap the document is not sustained by studies on HRI and globally it doesn't provide practical guidelines for prospective SARs developers and users. On the same spectrum in 2010 the UK EPSRC presented the five rules of robotics that seem to cover a wide spectrum of robotics applications (not targeted to SARs). The rules are not sustained with references to previous and current HRI studies. It seems the rules are designed to wider audiences (non-technical) with the objective to trigger people's attention towards the importance of incorporating ethics into the design and development of robotics technologies. However the five EPSRC rules are far from translating any practical guidelines for prospective roboticists and engineers to consider throughout their robotics designing processes.

We looked to the work of (Feil-Seifer and Matarić 2009). Feil-Seifer proposes seven HRI benchmarks: safety, scalability, imitation, autonomy, privacy, social success and understanding of domain. This contribution is mainly inspired by the areas of psychology, robotics technologies and social interactions. The work tries to synthesize HRI benchmarks that could serve as guidelines when it comes to the design and development of SARs. However Feil-Seifer's HRI benchmarks do not correlate the ethical principles of beneficence, non-maleficence, autonomy and justice allied with social care ethos. In addition Feil-Seifer's work lacks an underpinning of practical HRIs workshops to test the validity of the proposed HRI benchmarks with vulnerable groups such as the elderly.

From the current "in-situ" research using SARs with elderly groups I highlight the work of Wada, et al. (2008) and Wada and Shibata (2008). Wada concludes that the use of robotic seals PARO can reinforce the communication and socialization in elderly care scenarios. Wada also reports quantitative increases in the neural activity of some elderly participants as well a reduction of stress levels. However the work of Wada lacks investigation of an ethical perspective when performing and analysing HRIs with elderly groups. Wada's work has a strong practical dimension when using SARs with the direct participation of elderly groups but it lacks of resulting guidelines that could inform future research and development of SARs technologies. It seems a qualitative landscape would be highly welcome that could encompass the four core ethical principles of beneficence, non-maleficence, autonomy, justice and social care ethos.

In sum we have looked to the current definition and categorization of roboethics. We tried to understand both the advantages and disadvantages of existing rules and guidance. The perspective of this research is that we need more emphasis on roboethics level 1. Such emphasis has to involve both an ethical dimension (ethical principles and social care ethos) allied with practical HRI workshops conducted closely with elderly groups. We need to build a bridge between such adjacent areas in order to propose ethical guidelines for assisting in the research and development of SARs.

In the following chapter we will introduce SARs technologies and analyse the existing HRI benchmarks by considering the core ethical principles of beneficence, non-maleficence, autonomy, justice aligned with social care ethos.

CHAPTER 3 - HUMAN ROBOTICS INTERACTIONS AND ETHICAL PRINCIPLES

3.1. HUMAN ROBOTICS INTERACTIONS

As we have noted above the nature of robotics is different from that of computers or other artefacts. Robots can move and have a physical effect in different scenarios. They are machines designed to physically interact with humans, animals or environments and by doing so, there are emerging ethical implications. As an example as robots are programmed to interact within different cultural environments a new set of human experiences are likely to emerge and to offer different kinds of immersion, opportunities and relationships. When considering the health and social care contexts the ethical dimensions of robotics inevitably pose high challenges for users, carers and developers. One of the biggest issues surrounding the area deals with an excessive exposition of vulnerable groups such as children and elderly groups to robotics environments e.g. leaving them fully dependent on machines Sharkey and Sharkey (2010) and neglecting human contact. There are also many ethical preoccupations around the social aspect of robots for example in terms of accessibility i.e. who can access the information stored by a robot in a third party household? In which situations and why?. Also the safety of individuals could be at risk in the case of misuse of robot information or unwanted robotic physical control.

3.2. SOCIAL INTERACTIVE ROBOTICS APPLICATIONS

Robots result from a mixture of sensory information and computing power (Veruggio, et al. 2011). However there is still no scientific consensus on what is and what can be classified as a robot. For the scope of this study we will consider a robot as ‘an electromechanical device that can be programmed through software or hardware to execute tasks automatically’. I will start by presenting the Social Interactive Robots (SIRs) category which are pre-programmed machines that can interact and communicate with humans or other systems through some form of interaction (Feil-Seifer and Matarić 2005). SIRs are important for domains in which robots must exhibit peer-to-peer interaction skills, either because such skills are required for solving specific tasks, or because the primary function of the robot is to interact socially with people. One area where social interaction is desirable is that of “a robot as a persuasive machine” (Fogg 1999), i.e., the robot is used to change the behaviour, feelings or attitudes of humans. This is the case when robots mediate human–human interaction as in autism therapy (Dautenhahn and Werry (2004); Werry (2001)). Some examples of commercially available social interactive robots are listed below:

- AIBO an interactive robotic dog (Sony 2012)
- QRIO a small humanoid robot that can entertain people (Sony 2012)
- Kismet a robotic head capable of expressing emotions (Breazeal 2012)
- Kaspar a small humanoid torso used to mediate human interactions with autistic children (Dautenhahn 2012)
- Wakamaru a prototype communication robot that can interact with humans (Mitsubishi 2012)
- NAO (**figure 4**) a small humanoid platform targeted to robotics research in universities and robotic labs (Aldebaran 2012)

FIGURE 4 - NAO ROBOT CREDIT: UNIVERSITY OF CONNECTICUT CHIP

The expectation that robots will become part of everyday life working alongside humans as assistants, teammates, care-takers and companions raises a number of issues. The long-term goal of creating SIRs that are competent and capable partners for people is a challenging task. These types of robots will need to be able to communicate with humans using both verbal and nonverbal cues. One of the biggest challenges is engagement with humans not only on a cognitive level but also on an emotional level. Sabanovic (2010) concludes that a deep understanding of human intelligence and behaviour across multiple dimensions (e.g. social, cognitive, affective, physical, philosophical etc.) is necessary in order to design robots that can successfully play a beneficial role in our daily lives. Such an approach requires multidisciplinary efforts where the design of social robotic technologies are informed by the areas of robotics, artificial intelligence, psychology, philosophy, ethics, sociology, neuroscience, industrial design, anthropology and others (Sabanovic 2010).

3.3. Socially interactive and social assistive robots applications

Social interactive robots (SIRs) are a category of robots that can interact with humans through various forms. Typically machines such as Sony AIBO (a robotic dog) that can emit sounds and perform choreographies classify as a SIR. On the other hand some elucidative examples of Assistive Robots (AR) can include machines such as HAL a state of the art robotic exoskeleton Cyberdyne (2012) or PARO the Japanese baby harp robotic seal (PARO 2012). Both are examples of AR that help humans to cope with physical limitations and can contribute to stress relief and psychological comfort (Feil-Seifer and Matarić 2005). SARs result from the intersection of SIRs and AR. However SIRs philosophy is to explore and develop close and effective interactions with humans for the sake of the interaction itself (Feil-Seifer and Matarić 2005). On the other hand the SARs goal is to create close and effective interactions with humans for the purpose of providing assistance and achieving measurable progress in convalescence, rehabilitation processes, learning and so on. This is a technical field that aims to address critical areas and gaps in care through:

- Automating the supervision of individuals
- Providing coaching for individuals
- Providing motivation and companionship of one-on-one interactions with individuals from various large and growing populations with care needs such as stroke survivors, elderly residents, children, disabled people and other vulnerable groups.

This new field of research involves several areas of expertise such as robotics, psychology, sociology, anthropology, philosophy and ethics (Feil-Seifer and Matarić 2009). Certain examples have been already used as companion robots in the common areas of nursing homes, aimed at increasing the residents' socialization (Wada, et al. 2008). These robots are designed not to provide a specific therapeutic action, but to be the focus of a resident's attention. One such example is "Huggable", a robot outfitted with several sensors to detect different types of touch. Another example is "NurseBot" a robot used to guide users around a nursing home. But perhaps the most successful SAR to date is PARO, an actuated stuffed baby harp seal that behaves in response to touch. Its goal is to provide the benefits of pet assisted therapy, which can benefit the residents quality of life (Edwards and Beck 2002) in nursing homes that cannot support pets. Initial studies have shown that PARO lowered the stress levels in residents' interacting with the robot, as well as contributed for an overall increase in the amount of socializing among the elderly (Wada and Shibata 2008).

3.4. Relevance of social groups and social care ethos

Pinch and Bijker (1987) discuss the notion of different Relevant Social Groups (RSG), arguing that if we are to understand the development of technology as a social process, it is crucial to take artefacts as they are viewed by the relevant groups since to do otherwise would imply that the technology has an autonomous life on its own. Having identified the relevant social groups for an artefact, the focus turns to the problems that each group may have in relation to that artefact. Around each problem a number of solutions can be identified. The social groups play a crucial role in defining and solving the problems that arise during the development of technology. Various social groups not only define problems differently, they also have different opinions about achievement of closure and stabilization. Hence technological development is a multidirectional and non-linear process that involves constant negotiation among different groups.

Given that social groups define problems of technological development differently there is no "one best buy" and instead there is flexibility in the way things are designed and used. Interpretive flexibility is a useful concept for understanding how problems and solutions associated with a technology present themselves differently to different groups of people (Pinch and Bijker 1987). At the moment commercial robotics devices are task oriented designed, and compliant mainly with safety principles for machinery such as ISO/IEC Guide 51, ISO14121 and ISO12100. Such standards are mainly driven by functional aspects that positively reinforce human physical safety but fail to propose guidance/support on a qualitative level.

In assistive care scenarios understanding the target groups perspectives and potential requirements is essential for developing assistive technologies. However to date this is a neglected area of research in HRIs. It is likely that we will need much more focus on the practical analysis of SARs that coexist with vulnerable groups such as the elderly in care scenarios. With the current robotics state of the art, delivering functional robots to elderly people isn't likely to work straight away. If we are to develop SARs that can extend the exercise of human care than it is essential to read and observe peoples' reactions and expectations towards such technologies. Initial studies ((Wada and Shibata 2008), (Kidd, et al. 2006)) reveal a qualitative dimension around SARs but to better understand it we need further practical studies with the direct input from elderly groups. Social care ethos deals with considering people's perspectives, attitudes and dignity involved in the exercise of care. Giving voice to elderly groups towards the first developments of SARs is important to understand the real requirements of elderly care and how such technology could respond to them. Additionally such analysis is likely to reveal ethical issues around HRIs that have to be highly weighted when guiding the development of SARs.

As it has happened with information technologies (IT) more and more products move away from the boundaries of functionality to increasingly relate to the sphere of personal experiences. As we approach elderly groups we will have to continuously learn from individual SARs experiences and try to identify possible response patterns and personalizing elements that can positively reinforce HRIs.

In sum SARs technologies will not be perfect and will not suit all possible care scenarios however they should be designed in such ways that they allow their configuration or modifications according to its potential users' requirements and environments. Thereby the role of elderly groups in SARs developments is absolutely essential to reveal meaningful roboethics guidelines for roboticists, engineers and other stakeholders involved in SARs research and development.

3.5. Core medical ethical principles in assistive care

The four core medical ethics principles of beneficence, non-maleficence, autonomy and justice (Beauchamp and Childress 2001) continue to inspire both clinicians and caregivers throughout the exercise of care. Beneficence states that caregivers should act in the best interest of the patient. However in doing so, clinicians also acknowledge the principle of non-maleficence which highlights the need of "not harming" patients. Separating beneficence from non-maleficence brings additional challenges. In medical ethics for example, acting towards the benefit of a patient could not always be perceived equally. Medication prescriptions or treatments could become painful and in some cases even rejected by patients and relatives. Other scenarios deal with patient inability to understand their condition and to fully rely on health professionals who act according to the patient's beneficence. As many treatments involve some degree of harm, the principle of non-maleficence would imply that the harm should not be disproportionate to the benefit of the treatment. The balance between the benefits and risks of treatment plays a crucial role in nearly every medical decision. Nonetheless, the potential benefits of any intervention must outweigh the risks in order for the action to be ethical (Beauchamp and Childress 2001).

The autonomy principle deals with the right for a patient to make informed decisions about care which raises questions about the level of information given to individuals and their psychological condition for assessing their own levels of care. Lastly justice is concerned with the fair distribution of scarce health resources among patients. In a practical dimension, the social care ethos involves people's choices, attitudes, rights and dignity applied to social care (Ensign 2004). In elderly care, social care ethos takes interpretations of the previous four core medical ethical principles with special regard to the individuals' autonomy. Beneficence and non-maleficence are intertwined as caregivers try to work towards the best interests of the elderly while minimizing any eventual harms arising from care. Autonomy reinforces the power of decision about individual care where enough information and elderly peoples' voices are constantly heard. Justice is associated with a fair distribution of care resources among elderly individuals which could depend more on administrative roles or even government policies. Derived from the previous ethical principles there are rules of ethical care provision such as: veracity, confidentiality and fidelity. In veracity caregivers try to provide all the possible truth to an elderly person, however there is no concise agreement to what information is considered truly beneficial or harmful to be communicated to the elderly e.g. type of diseases and conditions. Confidentiality states that patients' health records must be kept the most confidential as possible. Nevertheless in health practice there are situations where such rule might be broken to follow a utilitarianism approach. As an example in cases of epidemic threat, individual measures and actions are usually taken to minimize the risk of public health (the greatest good for the greatest number). Lastly fidelity deals with the willingness of the caregiver or family member to be responsible for the type and quality of care that the elderly needs and receives. However fidelity could also raise special issues regarding elderly ethical behaviours and lawful considerations. As an example in cases where patients demonstrate aggressivity or harassment towards their carers the type of care has to be reconsidered and responsibilities could be legally ascribed (Ensign 2004).

In the literature there is evidence that the ethical principles and their application in caring for older people present big challenges. Suhonen, et al. (2010) identify ethically difficult situations in the care of older people where there is evidence that perceptions differ about ethical issues among health professionals, patients and their relatives. The core principles of beneficence, non-maleficence, autonomy and justice could have different interpretations on what is acceptable or not within different contexts of application. Medical ethics raises questions relatively to beneficence versus non-maleficence, autonomy versus beneficence, informed consent, confidentiality, and refusal of treatments or truth telling. As an example Scott, et al. (2003) presented a study where they tried to investigate autonomy, privacy and informed consent in the context of elderly care. They reported differences in perceptions between patients and nurses relative to ethical decisions. In terms of autonomy, of 101 persons only (15%) stated that carers actually informed them about the true nature of their treatments and what it would involve. Fifty four percent of the staff responded that patients were fully informed about their treatments. Similar differences were reported towards elements such as the length of hospital stays, risk of treatment, pain relief, names and doses of medication and how to support bowel and bladder function (Scott, et al. 2003). When it came privacy there was more general agreement between the staff and the elderly. For example (100%) of elderly patients and (95%) of caregivers reported that privacy was always maintained for example when providing private access to toilets or administration of enema procedures. Lastly in terms of informed consents big discrepancies were found. Only (5%) of elderly patients acknowledged that they gave written consent before examinations or treatments, however (40%) reported that they had given their consent verbally.

Scott, et al. (2003) conclude that improvements in nursing care for elderly people seem to demand greater levels of communication between caregivers and care receivers. Communication could help ensure that the staff teams have a better understanding of what information and what level of involvement in decision making regarding the care, patients need or want. In an elderly care family typical scenario, Teeri, et al. (2006) also identify ethical discrepancies between the elderly and relatives. Examples are given where relatives sought extreme forms of treatment regardless of the patient's suffering or respecting his/her own wishes. Classical examples deal with professional health care medication prescriptions where elderly users reject such prescriptions but are forced to take them by their families. In a certain sense such cases reveal the complexity of the autonomy principle in practice, both in care institutions and in household environments. We will develop this example following our roboethics analysis when complementing human care with the use of SARs.

At this stage it is important to remark that the four medical ethics principles do not provide a method for choosing between them or their levels of implementation (Gillon 1994). In scenarios where there is a conflict of ethical principles we need further ways to morally decide the exercise of care.

3.6. Core ethical principles and SARs

There is an increasing need for assistive care. Currently societies are growing older and the human civilization will need assistive technologies that could promote dignity, and support physical and mental activity throughout the ageing process. SARs represent the first generation of machines that could provide cognitive assistance, supervision, entertainment and companionship for vulnerable groups. The number of elderly people is likely to increase over the next few years UN (2011). We could face scenarios where we will face a lack of caregivers for those who need quality care. Economic considerations also represent a challenge with pertinent questions about taxes and/or combinations of social and care contributions. Meanwhile assistive technologies such as SARs are currently under research as future forms of expanding human care to vulnerable groups. However the integration of SARs that could extend human capabilities in the exercise of elderly care is likely to raise many ethical issues in assistive care scenarios. In modern western societies we currently see a mixture of ethical theories and their inherent interpretations. Manifestations of utilitarianism take different routes (e.g. political and economic): tax payments where each citizen contributes with a percentage of its income for reinforcing social and health benefits that promote social justice for the individual and to the greater number of citizens. Utilitarianism could also take different interpretations in cases of health and safety for example in the case of epidemic diseases where infected individuals are isolated from society in order to guarantee public health and wellbeing. Following a deontological approach, philosophers highlight that human actions should not be focused on the outcomes, ends or actions. Instead deontology reinforces that there are transcendent duties that must be followed by all existing inhabitants of the planet. As a result we abide by a prescribed set of civil laws shaped in terms of human duties, rights and recommended behaviours that allow us to live in conformity with human rights and respect for each other. Deontology also points to other types of individual obligations and responsibilities such as taking care of the environment and guaranteeing the sustainability of life on planet earth. In sum all ethical theories suggest advantages and disadvantages to particular human conduct. In reality our lives are driven by a continuous mix of such ethical theories and subsequent interpretations.

Elderly care is by nature rich in ethical challenges. Caregivers and families are constantly confronted with ethical scenarios for which we still don't have answers. As we saw the rules of ethical care provision (veracity, confidentiality and fidelity) are not always linear and equally applied. Situations such as the true nature of diagnosed diseases, palliative care, general public health or weighting abnormal behaviours towards carers and other patients involve a deep analysis into each case study that originates different outcomes for those rules. So as previous studies suggested (Suhonen, et al. 2010, Scott, et al. 2003, Teeri, et al. 2006), instead of following classical ethical theories, an elderly care ethos is mapped by flexible interpretations of the four core ethical principles of beneficence, non-maleficence, autonomy and justice.

Similarly, due to the high number of expected SARs applications and contexts, we could expect that classical ethical theories such as "deontology" and "utilitarianism" will not provide enough flexibility for understanding emerging HRIs ethical scenarios and propose potential practical solutions for them. Classical ethical theories particularly result in various interpretations of the ethical principles of beneficence, non-maleficence, autonomy and justice. Such theories are constantly applied into human life however SARs contexts are likely to raise situations where e.g. deontology, utilitarianism and other ethical theories could conflict or coexist at the same time. It is likely that the process of selecting an ethical theory and what to do to reinforce HRIs with vulnerable groups such as the elderly to become extremely complex. It might be also erroneous to acknowledge that one ethical theory is always suitable for an assistive context as the number of SARs applicational contexts and social care ethos are already immensely high. As Wallach, et al. (2005) points out top-down ethical approaches are likely to be very generalist and difficult if not almost impossible to translate into every user's requirements and applications when interacting with robots. On the other hand bottom-up ethical approaches seem to emphasise a big set of individual requirements (Wallach, et al. 2005) within certain contexts of application and therefore lack generality which is part of the SARs implementation philosophy. In SARs, decisions about functionality and social interaction have to be balanced between the ethical core principles of beneficence, non-maleficence, justice, autonomy as well as social care ethos. Such balance motivates us to better understand the reality of SARs in the exercise of care. As in pure assistive human care, SARs are likely to raise many challenges that have to be unfolded to better understand the outcomes of HRIs and propose both ethical and technical solutions for future research, development and diffusion of SARs within the context of elderly groups.

3.7. SARs - ROBOTS EVALUATION

Roboethics level 1 is by definition informed by the ethical theories studied by the branch of philosophy called morality, which studies the concepts of right and wrong. Roboethics level 1 currently updates views on concepts such as the dignity and integrity of a person, the fundamental rights of the individuals as well as the social, psychological and legal aspects involved in the research and development of robotics and its diffusion in society (Veruggio, et al. 2011). But roboethics level 1 needs further exploration. It is possible that we need a more practical emphasis in researching SARs prototypes within the proximity of vulnerable groups. The increasing ageing populations and the need for assistive care build up societal challenges. In futuristic therapeutic and assistive care scenarios it is likely that SARs have to be aligned not only with the core ethical principles of beneficence, non-maleficence, autonomy, justice but also be prepared to provide their target users with tangible and hedonic experiences.

In the next section we will present and analyse the current work around HRI benchmarks of Feil-Seifer and Matarić (2009) as identified categories that try to inform the outcomes of HRIs with vulnerable groups in mind.

3.8. SARS AND HRI BENCHMARKS

Any robot is a technological platform that must be properly evaluated before it is deployed within the proximity of humans or the environment. The nature of SARs is strongly connected with their use in assistive care settings for dealing with vulnerable groups such as elderly, children or disabled people. However to date robotics science by itself doesn’t possess enough tools to judge the emerging human levels of acceptability in HRIs and consequent behaviours derived from the use of robots. On the other hand ethics isn’t equipped with enough knowledge on robotics developments and HRI experiences to derive theories that can guide roboticists, engineers and other stakeholders when developing robots. In such challenging scenarios, HRI benchmarks represent important guidance for exploring ethical issues using robotic systems within the proximity of target groups. HRI benchmarks can inform us about the advantages and disadvantages of deploying robotic systems and reveal emerging ethical issues derived from such experiences.

The existing HRIs benchmarks proposed initially by Kahn, et al. (2006) and analysed more recently by Feil-Seifer and Matarić (2009) are reviewed. Kahn's contribution points more to the evaluation of recreating humanoid robots (androids more specifically) at the image of human beings which is beyond the scope of this research. However Kahn's work introduced three benchmarks that still remain speculative but might open new research questions for the future of HRIs. The first one is entitled "moral accountability" which asks whether robots should be deemed morally responsible for their actions. This question seems to be well located in robot's ethics level 3 which studies issues related to machine conscience and inherent robot actions and possible liability. The second benchmark is "intrinsic moral value". Kahn poses the question if we are going to live in close proximity with robots how should we respond to them. If robots act like humans are we going to respond in similar ways as we respond to other human beings? do we voluntarily project our own human emotional responses towards robots, do we respond the same way to a robot moral claim? Lastly Kahn introduces the benchmark of "reciprocity" by illustrating how pervasive the concept is on human life. A young toddler learns from his parents' examples about what is acceptable in society (right and wrong) permeating to the notion of the "golden rule" which inspires him to treat people in the same way he would like to be treated. Should such ethics of reciprocity be applied to the context of robots? Despite Kahn's futuristic interpretation there are important elements to retain. According to the current robotics state of the art human beings are responsible for their robotic creations and actions. Such idea is important to be retained as robotics developers and engineers develop the first robotic prototypes targeted for social interaction. Secondly in the near future robots are likely to represent technological tools, an extension of human capabilities in the most diverse scenarios so it is likely that they will trigger different types of responses according to different robotic goals. Thirdly as it happens with computer technology today, society learns and expands their knowledge in more organized, innovative and creative ways which constitutes an important learning reference towards the use of robots.

To date Feil-Seifer and Matarić (2009) present the more centred approach in terms of HRI benchmarks in the domain of SARs and its goals which we will analyse during the course of this research.

In the area of robotics technology (**table 1**) Feil-Seifer and Matarić (2009) identify two benchmarks of safety and scalability, and in the social interaction domain they present further five; autonomy, imitation, privacy, understanding of domain and social success.

Robotics technology (HRI benchmarks)	Social interaction (HRI benchmarks)
Safety	Autonomy
Scalability	Imitation
	Privacy
	Understanding of domain (HRI Task benchmark)
	Social success (HRI Task benchmark)

TABLE 1 - HRI PROPOSED BENCHMARKS (FEIL-SEIFER, MATARIĆ ET AL. 2007)

3.8.1. Safety

Safety is the first HRI benchmark to consider: How safe is the robot, and how safe can the robot make the life for its users? A robot's safety in its given domain is currently the primary concern when evaluating a HRI system. If a robot is not designed with safety in mind, it could harm the very users it was designed to interact with. When discussing safety of a robotic platform Feil-Seifer and Matarić (2009) refer to the ability to manoeuvre in an area without unwanted contact or harmful collisions. Safety also refers to protection of the robot itself (e.g. preventing it from destroying itself in certain contexts).

Safety for AR has been studied in depth in the contexts of obstacle avoidance for guide-canes and wheelchairs Baker and Yanco (2005), Rentschler, et al. (2003), Yanco (2002). The need for safety assessment for HRI systems primary designed for vulnerable groups is a topic of growing importance as HRI systems are increasingly being developed aimed at such users (Feil-Seifer and Matarić 2009). However there are more categories that need to be studied and considered on the safety benchmark. Reading previous authors like Sharkey and Sharkey (2010), and Whitby (2005) it seems the dangers of HRI are not only confined to the physical safety of participants or its surrounding space but also related with the psychological effects originated by attachments or dependencies formed throughout periods of HRI. We will analyse and discuss this issue in chapters 6 and 7.

3.8.2. Scalability

The majority of current HRI work occurs in research laboratories, where systems are engineered for one environment and a pre-determined prototype of user population. As HRI becomes more widespread in homes, schools, hospitals, and other daily environments, the question of scalability and adaptability arises: How well will such HRI systems perform outside of a robotic lab? And, how well does a robot perform with users from the general population? The scalability benchmark of Feil-Seifer and Matarić (2009) does not imply that roboticists should design each robot for a large variety of situations where assistance is required. Rather, it is important to stress that even within a group that needs assistance there is a big difference between a “prototypical” user or environment and the range of real world users and environments. So Feil-Seifer and Matarić (2009) ask “Can the robot interact with someone who cannot move, e.g. can it accept voice commands?”; “If the robot is meant to be a companion for a user, can the robot’s behaviour or personality be programmed for different users?”. Most robotic systems to date have been tested in research labs, but it seems that more “in-situ” research would be appropriate to explore this dimension more effectively.

3.8.3. Autonomy

It is important to understand the difference between the core medical ethics principle of (autonomy) and the term autonomy used within the context of robotics. The autonomy ethical principle (autonomy) is related to the user ability to decide their own level of care provided by SARs. Robotics autonomy or displayed autonomy deals with the level of autonomy that a SAR is capable of performing within the context of elderly care.

In the context of HRI, (autonomy) is a complex issue to debate. It is favourable, when constructing a system that is designed to stand in for a human in a given situation and to have a degree of displayed autonomy which allows it to perform well in certain tasks. Autonomy can speed up applications for HRI by not requiring human input, and by providing rich and stimulating interactions (Kahn, et al. 2006). For example, HRI systems for proactive social interaction with children with Autism Syndrome Disorder (ASD) (Dautenhahn and Werry 2002) and motivational robot tools (Matarić, et al. (2007), Tapus and Matarić (2006), Wainer, et al. (2006)) require such types of autonomy. However autonomy can also lead to undesirable behaviours both from robots and their human users Feil-Seifer and Matarić (2009). In situations such as the robot causing pain or harm to a person or in scenarios such as medication dispensing and therapy monitoring (Fortescue, et al. 2003). There are also issues related with stakeholder authority that may contradict the views of users, carers and relatives towards the use of more or less autonomy in SARs.

In general, HRIs contexts require engaging and believable social interaction schemes, but the user must retain authority. For example, rehabilitation should terminate if the user is in pain or discomfort. Partial or adjustable autonomy programming on a HRI system allows for an appropriate adjustment of both user authority and robot autonomy (Feil-Seifer and Matarić 2009). However it is also important to explore the concept of 'user' (autonomy) in SARs. In the case of SARs supplementing care to elderly groups what actors and roles are involved and expected in such HRIs? How one decides or is equipped to decide about his/her own level of care provided by SARs? Different levels of robotics displayed autonomy might be technically feasible and different human intervenients with several levels of responsibility need to be investigated.

3.8.4. Imitation

Kahn showed that a robot's programmed personality can affect a user's compliance with that robot (Kahn, et al. 2006); Kiesler and Goetz (2002)). When exhibiting a serious personality, the robot could provoke a greater degree of compliance than when displaying a playful personality. It has also been shown that when the robot's extroversion/introversion personality traits matched the user's task performance seem to improve (Tapus and Matarić 2006).

While no definitive evidence yet exists, there is a good deal of theory regarding a negative correlation between the robot's physical realism and its effectiveness in HRI. Realistic robotics introduces new complications to social robot design (Duffy 2003) and it has been implied that anthropomorphism has a negative influence on social interaction when the robot's behaviour does not meet the user's expectations (Scneiderman 1989). The "Uncanny valley" theory (**figure 5**) suggests that as a robot becomes very similar in physical appearance to a human being that robot appears less, rather than more familiar Mori (1970) and actually it can produce a sense of revulsion in human beings. Also physical similarity that attempts to imitate human-like appearance and behaviour could cause discord with robotics users (Feil-

Seifer and Matarić 2009). The role of imitation in SARs could therefore become determinant when it comes to the outcome of the interaction itself. Thereby further practical research is needed to understand the imitation benchmark and its potential ramifications.

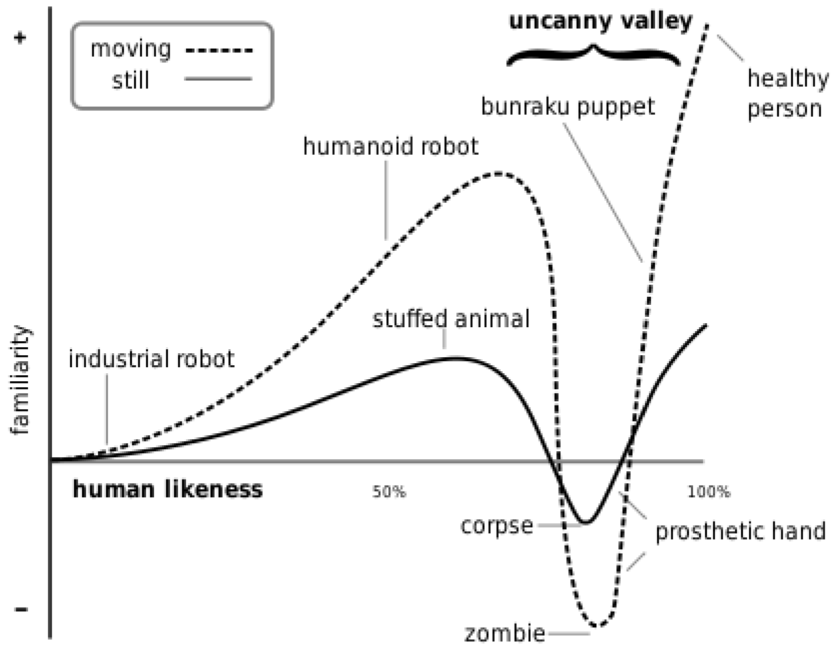

FIGURE 5 - UNCANNY VALLEY THEORY

3.8.5. Privacy

The presence of a robot can affect a user's sense of privacy (Kahn, et al. 2006). In contrast to ubiquitous systems ((Bien, et al. 2002); (Kim, et al. 2003); (Lee and Keating (1994)) where a user has no idea of when the system may be watching, robots are tangible and their perception is limited and observable. A robot can be told to leave when privacy is desired, and the user can observe when privacy is achieved. Because of its synthetic nature, a robot is often perceived as less of a privacy invasion than a person, especially in potentially embarrassing situations (Baillie, et al. 2004). Feil-Seifer and Matarić's (2009) perspective on privacy poses the following questions "does the user sense of privacy relate to better robot performance as an assistive presence?; does the user privacy impact on user satisfaction?".

Equally important is to analyse how the robot interacts and communicates with other systems. Privacy issues might occur beyond immediate physical interaction when for example SARs share vulnerable users' information with search engines or social networks. Privacy might encompass two different natures, physical nature (robotic users' identification) and information systems nature (robotic users' personal data). Thereby privacy needs to be categorized according to its objectives and weighed against the advantages and disadvantages that a SAR can offer to its users. We will discuss and extend this topic in chapter 6.

3.8.6. HRI TASK-ORIENTED BENCHMARKS

Beyond the existing HRI benchmarks proposed by Kahn, et al. (2006), Feil-Seifer and Matarić (2009) also suggested HRI task-oriented benchmarks. Since SARs philosophy is focused on the outcome of the HRI where it reinforces aspects such as rehabilitation therapy, convalescence, socialization, and tutoring the authors believe that it is necessary to add at least two task oriented benchmarks to better understand HRIs. The first one is denominated social success which is of importance when it comes to understanding "if the robot does what it is supposed to do?". In other words if the robot's role is to be funny, is it really being funny with its users or is it a mere illusion? Social success is still a very broad benchmark that consequently needs to be categorized and weighted against any emerging secondary effects of HRI. Next Feil-Seifer and Matarić add the understanding of the domain benchmark. Basically the vision is that the understanding of social dynamics is a critical component in SARs. Feil-Seifer and Matarić believe that such analysis of social understanding can be originated "from both human-oriented social perception (such as speech recognition or face recognition) or more futuristically based on non-human oriented social perception (such as galvanic skin response for evaluation of emotional state)". However to date because robotics perception is immensely limited, such interpretation of understanding of the domain is still very vague and could lead to confusion terms relative to what is actually feasible in SARs or not.

SUMMARY OF HRI:

Socially assistive robotics is a new area of research that is focused on the outcome of HRI in terms of rehabilitation, convalescence or learning. It culminates the areas of Assistive Robotics (AR) and Socially Interactive Robots (SIRs). However the introduction of SARs technologies within vulnerable groups involves the analysis of ethical issues with its potential users. To date HRI benchmarks seem to be the most effective methods to help researchers to deal and understand such reality.

Safety remains a key topic in SARs since the objective is to interact with vulnerable groups. However such safety is a complex issue especially when a robot starts to exhibit "intelligent" behaviour. The safety of users is not solely from a physical perspective as SARs might have also psychological impacts on its human users. Relatively to scalability it is important to understand how many people can be helped by such robots? Could the robotic prototypes be applied outside of research labs and be directed into people's homes and extra care facilities? Another aspect of scalability deals with the interaction methods of SARs. What kind of interfaces shall we consider for certain robotic applications so the robot fits the highest number of users?

Autonomy in robotics means the capacity of a machine to reproduce tasks without human intervention. However, autonomy can also lead to undesirable behaviours either provoked by software programming (errors), hardware failures (sensors) or even unpredicted situations originated by users. In situations such as medication dispensing and therapy monitoring, for example, autonomy is not desirable or at least demands a certain level of human supervision. Equally, autonomous systems should be capable of detecting abnormal events where the user might be in pain and stop its actions. It is noticeable that autonomy is directly related with safety policies. For those reasons I think autonomy encompasses not only an analysis in terms of technical behaviours but also establishes agreements in terms of responsibilities between developers, users and ultimately regulators.

According to the uncanny valley theory (Mori 1970) it seems that applying high levels of anthropomorphism to robots could cause a sense of revulsion in humans. Apart from this fact it has been implied that anthropomorphism can also have a negative influence on the social interaction if the robot's behaviour does not meet a user's expectations (Scneiderman 1989). In terms of imitation I feel much more investigation is needed especially in terms of aesthetics that could translate positive experiences in terms of presence which I think is a non-explored area in HRI benchmarks. Next we analysed the concept of privacy reframed by

Feil-Seifer and Matarić (2009). In HRIs, privacy could be a determinant factor to achieve smooth and comfortable levels of interactions. Because of its nature, a robot could be perceived as less of a privacy invasion than a person, especially in potentially embarrassing situations. Due to the modernity and sensitivity of the area it seems robotics users should be able to define their own levels of privacy when interacting with robots. However such a concept may need to be refined since privacy takes many forms including personal data, space and time especially when dealing with vulnerable groups such as the elderly.

We looked also to the two task oriented benchmarks of Feil-Seifer and Matarić (2009). Social success tries to analyse if the robot does what is supposed to do, e.g. entertaining people by telling jokes; is it really being playful or not?. The understanding of domain is seen as an important element for the robot's inner sense of perception. It appears that social success is still too vague to be considered and implemented in real terms. We will try to expand such benchmark through modes of engagement displayed by the user towards a robot so we can identify real behavioural cues in HRIs. At present, the understanding of domain is still purely fictional. The view of the authors Feil-Seifer and Matarić put too much emphasis on robots understanding human social dynamics. For now the question should be reframed in different terms: "how can we humans, understand more about our own dynamics when interacting with SARs?" and how can we use such knowledge to program robots?.

To date the HRI benchmarks proposed by Kahn, et al. and Feil-Seifer and Matarić are directly influenced by psychology. Such interpretation of ethical benchmarks is positive and it seems that the SARs integration into social domains has to involve new qualitative instruments. Feil-Seifer, et al. (2007) state that HRI benchmarks have to be further analysed. By now it is perceptible that much more work is needed in terms of HRIs categorizations as HRI naturally involves several levels of imitation, autonomy, safety, scalability, privacy, social success and understanding of domain. Such analysis in HRI cannot be solely theoretical and this research explores such HRI benchmarks using robotics prototypes through "in-situ" research, backed up by the core ethical principles of beneficence, non-maleficence, justice and autonomy along with social care ethos. It is expected that new indicators and dependencies will emerge. Such findings can help categorize and inform more accurately robotic developments and ultimately users when it comes to design and usability of SARs.

3.8.7. HRI BENCHMARKS, CORE ETHICS PRINCIPLES AND SOCIAL CARE ETHOS

We saw the importance of HRI benchmarks when analysing, measuring and informing decisions about ethical issues present in HRIs. In the previous analysis (Kahn, et al., Feil-Seifer and Matarić) were mainly inspired by psychology. Due to the sensitivity of elderly groups the current HRI benchmarks need further ethical analysis to be included and possibly translated into frameworks that can inform the design, development and introduction of SARs in elderly care. Such enrichment needs to be performed by interpreting the current HRI benchmarks of safety, imitation, autonomy, scalability, social success, privacy, understanding of domain according to the ethical principles of beneficence, non-maleficence, autonomy and justice aligned with social care ethos.

In chapter 2 we understood that the new field of roboethics shares common areas with medical ethics when dealing with health care situations. According to Veruggio's definition roboethics is an exercise of "ethical reflection related to the particular issues that are generated by the development of robotic applications and their diffusion in society" (Veruggio, et al. 2011). In the case of SARs when extending the levels of care delivered to elderly groups a new set of ethical issues are likely to arise. Those are valid not only on the inherent safety level but also reflected through a multitude of personal/group choices that have to be addressed by elderly residents, caregivers and relatives when considering SARs. Human dignity, contact, autonomy in care, respect and privacy guide us to the logical foundation of the core ethical principles. As a result we will review the identified HRI benchmarks in the context of the core ethical principles of beneficence, non-maleficence, autonomy, justice as well as social care ethos in elderly care. Note that such interpretation results from a subjective analysis where the core ethical principles and social care ethos are considered in every HRI benchmarks. Future SARs research is likely to unveil new interpretations of the ethical principles of beneficence, non-maleficence, justice and autonomy aligned with social care ethos.

In chapters 5 and 6 we will revise the result of the conducted practical robotic workshops in line with the following HRI benchmarks ethical analysis.

3.8.7.1. Imitation

According to Feil-Seifer and Matarić (2009), imitation (**table 2**) deals with understanding how the imitation between the human and the robot can allow for an expression of human capabilities during HRI. On the same topic the author asks if the imitation between the human and the robot reflects an effective impression of the robot capabilities. However from a critical perspective, SARs are likely to take many forms and applications that can bring much more fundamental questions for the whole understanding of the ethics of HRI and its outcome on care. It is likely that SARs imitation will be more related to the aesthetics of robots and how these could be delivered in care.

When it comes to beneficence, a SAR system should be designed to act on the best interest of vulnerable groups such as the elderly. The quality of such care could be translated by a hybrid approach between humans and machines. Supervising someone twenty four hours a day: monitoring walking patterns, reminding about taking medications or daily tasks, identifying unexpected situations, playing games and motivating people through HRI, can be seen as an extension of the human biological capabilities through the exercise of care. From a caregiver's perspective the use of SARs systems could also contribute for a better quality of the service provided during care. Staff shortages and the inability to become specialized in certain types of conditions and care allied with the constant need for improving communication between those who need care and those who provide care are extremely important to reframed within the context of SARs. Thereby the use of assistive technologies such as SARs has to be proposed in ways that promote a set of benefits for elderly users and also reinforce the work of carers (Feil-Seifer and Matarić 2011).

However to achieve such goals imitation is still too vague. In SARs beneficence states that robots and assistive technologies should act in the best interest of patients. However it is also true that the exercise of care has to take into consideration aspects of social care ethos. People's choices, attitudes, rights and dignity play such a crucial and challenging role in the context of elderly care. In SARs the principle of non-maleficence (do not harm) is also related to the perception and the realistic outcome obtained in HRIs. The question here asks if are we really helping and not harming individuals through the exercise of deploying SARs in assistive scenarios. An elderly person's perspective on a robot (including aesthetics) could be determinant for its successful use during the course of HRI. Moreover the Social Construct of

Technology (SCOT) states that technology should not have a life of its own but indeed be highly influenced and constantly interpreted by their target groups (Pinch and Bijker 1987). SARs technologies should be no exception to such argument. Imitation by itself seems incomplete and should be categorized more directly into notions of aesthetics where the anthropomorphization, zoomorphication, proxemics, FOVs, colours or ergonomics could have a determinant role.

In terms of the ethical principles selection as we saw imitation is likely to be more related to aesthetics of robots. So in the ethical principle of beneficence we will have to consider how the aesthetics of SARs could possibly translate benefits for the elderly through HRI. That said is also important to reassure that the aesthetics will not cause harms to elderly groups. Thereby the ethical principle of non-maleficence must be considered in imitation. Finally since aesthetics might vary significantly from elderly individual to individual social care ethos plays an important role to investigate people's reactions and expectations towards SARs aesthetics. Thereby in the benchmark of imitation we are considering the ethical principles of beneficence and non-maleficence aligned with social care ethos. To date the core principles of justice and autonomy pose no additional challenge in the context of imitation.

HRI benchmark	**Beneficence**	**Non-maleficence**	**Social care ethos**
Imitation	Imitation is not only confined to imitation of humans and robots (vice versus). New categories of aesthetics where the anthropomorphization, zoomorphication, proxemics, FOVs, colours or ergonomics could be determinant for the outcome of HRIs with elderly groups.	What is the perception and the realistic outcome obtained in HRIs with elderly groups?	Through practical robotics demonstrations we should listen to people's opinions and expectations towards the imitation aspects of SARs. New categories involving the aesthetics of SARs could be unveiled in imitation.

TABLE 2 - ETHICAL ANALYSIS OF THE HRI BENCHMARK IMITATION

3.8.7.2. Safety

Safety (**table 3**) is the first topic of discussion in HRIs. It brings perspectives of physical safety to mind. It is likely that further testing and analysis with SARs target groups needs to be done within the context of safety. Feil-Seifer and Matarić (2009) ask how safe is a robot and how safe can it make the life for its users? This relates directly to the ethical principle of non-maleficence in which SARs should be designed in ways that promote user safety.

In health care ethics the core principle of autonomy states that people should be able to make informed decisions about their own care. In the context of SARs this could play a similar role when deciding what type of SARs technologies could and should assist individuals (Feil-Seifer and Matarić 2011). Despite the fact that the generic notion of safety still pertains, the context of SARs is more related to the individual experiences and perceptions (including visual) of HRIs safety, which could be translated for example by the level of autonomy displayed by a SAR with a vulnerable user. In the context of elderly care this issue is aggravated by the fact that the cognitive abilities of elderly persons are reduced with time. Periodic assessments should be done to analyse the individual's ability to make judgments about the outcome of SARs technologies with special regard to elderly safety.

The robot displayed autonomy could therefore contribute for the human perceived level of safety towards SARs. In broader terms it is likely that safety is not confined solely to physical safety and further categories such as psychological safety need to be reframed to better inform the design of SARs when applied to elderly care. Social care ethos will involve talking to elderly groups and analysing their perspectives, attitudes, dignity and expectations towards safety in SARs.

In terms of the ethical principles selection as safety is related to the notion of physical safety we have to consider the ethical principle of non-maleficence. Safety should be exhaustively tested in order to minimize the risk involved in harming elderly individuals. SARs perceived notion of safety could also influence the decision about the level of care selected by the elderly thereby the ethical principle of autonomy should be considered. Lastly it is important to read people's perspectives and that such perspectives could be influenced by their limited cognitive abilities. So social care ethos reinforces the need for supervision and understanding of the elderly cognitive abilities. That is an exercise crucial to guarantee the elderly safety and better inform their decisions about SARs safety. Thereby in the benchmark of safety we are considering the ethical principles of non-maleficence and autonomy aligned with social care ethos. To date the core principles of beneficence and justice pose no additional challenge in the context of safety.

HRI benchmark	Non-maleficence	Autonomy	Social care ethos
Safety	SARs should be designed in ways that promote user safety.	Elderly people should make informed decisions about the desired level of care delivered by SARs.	Due to inherent cognitive limitations continuous assessment should be performed to analyse the elderly ability to judge SARs. We should observe carefully the elderly individuals behaviours arising from HRIs and talk to them about it. Safety might not be confined solely to physical safety and further categories need to be explored.

TABLE 3 - ETHICAL ANALYSIS OF THE HRI BENCHMARK SAFETY

3.8.7.3. AUTONOMY

In elderly care (autonomy) decisions (**table 4**) constitute a complex issue to debate. There are relevant factors that could influence the types of decisions about one's care. The fact that beyond a certain age the elderly individual cognitive capabilities are usually diminished could involuntarily reduce the individual intervention on care decisions; the financial conditions to access care might not be linear; the cultural and religious beliefs could also shape final decisions. Manifestations such as social pressure, confusion or divergences between relatives, caregivers and the elderly themselves could aggravate such problem. The ethical dichotomy between beneficence - autonomy could be coexisting from households and care settings to the more formal environments such as hospitals where medical ethical challenges constantly take place. Thereby it is likely that we will experience similar kinds of challenges when deciding about SARs displayed levels of autonomy. Despite such challenges it is important to remark that the ethical principle of beneficence should guide the development of SARs autonomy in ways that try to promote the wellbeing of their users. Subsequently, non-maleficence should be central to considerations of autonomy in ways that promote elderly users safety.

When it comes to the autonomy benchmark, Feil-Seifer and Matarić (2009) highlight the functional advantages of having more automation and higher degrees of autonomy in SARs. Task executing speed, automation of individuals' supervision and the reduction of costs are among the most cited points when it comes to the potential use of SARs in assistive care. However autonomy could also lead to undesirable situations such as medication dispensing or stopping a set of therapeutic activities deliberately (Feil-Seifer and Matarić 2009). The ethical principle of autonomy states that individuals have the right to make informed decisions about their own levels of care. However when working with vulnerable groups, users might not be capable of being fully informed about the capabilities and limitations of a specific robotic system. As an example an elderly person can have the perception that a robot is more capable than actually it is when delivering care. This raises an important ethical issue related with the description provided to vulnerable groups of the current SARs capabilities and how the robot is going to be used throughout care (Feil-Seifer and Matarić 2011). Another ethical issue with the benchmark of autonomy deals with the notion of authority in HRIs. Since SARs are deployed to deliver care, in certain situations they can conflict between the individual's autonomy and the robot autonomy (Feil-Seifer and Matarić 2011). Since SARs are programmed to primarily deliver care there is a need for certain authority and credibility arising from the robot peer. In another perspective human users still need to retain authority, especially in situations where a high level of uncertainty and unpredictability of robot actions will take place. Situations where a person might be in pain or suffering must be overridden by human input to dictate the course of actions (Feil-Seifer and Matarić 2011). Autonomy could also trigger confusion among SARs users. Due to health problems and the normal ageing process an elderly person could easily underestimate the supervising capabilities provided by a SAR and might be persuaded to reject it. Such behaviour is likely to occur, and information and guidance must be put in place to inform as best as possible the individuals choices when benefiting from robotic care. It is important to mention the role of social interaction to reinforce care through HRIs. It is unlikely that SARs will achieve its "assistive" objectives without any caregiver's intervention around them. From an ethical perspective SARs autonomy and human contact have to be well calibrated when it comes to the emerging outcomes of HRIs.

To better synthesize the objectives, bottlenecks and emerging solutions we need a more detailed exposition of the HRI benchmark of autonomy. What levels of displayed autonomy are available in SARs? How do the concepts of active or passive user and their roles influence HRIs? What human supervision levels and human contact are put in place constitute some of the fundamental questions in autonomy. The search for such answers can reinforce the ethical understanding of emerging issues and possibly translate into technical solutions when it comes to product design and usability of SARs within the context of elderly care. Social care ethos will involve talking to elderly groups and analysing their perspectives, attitudes, dignity and expectations towards autonomy in SARs.

Relative to the ethical principles selection in the benchmark of autonomy we are considering the levels of displayed autonomy in elderly care. Thereby in the ethical principle of beneficence we reinforce the fact that SARs levels of autonomy should be constructed and delivered in ways that benefit elderly individuals. On the same line in the ethical principle of non-maleficence it is important to reinforce the notion of user safety. Autonomy in SARs could originate difficult situations where users might be in pain or suffering and such levels of displayed autonomy should terminate in such cases. In the ethical principle of autonomy it is important to consider the elderly right to make informed decisions about the levels of SARs displayed autonomy. Nevertheless social care ethos plays an important role in informing elderly individuals about the advantages and disadvantages arising from such levels of displayed autonomy. In the benchmark of autonomy we are considering the ethical principles of beneficence, non-maleficence and autonomy aligned with social care ethos. To date the core principle of justice poses no additional challenge in the context of autonomy.

HRI benchmark	**Beneficence**	**Non-maleficence**	**Autonomy**	**Social care ethos**
Autonomy	Autonomy in SARs should be delivered in ways that promote the benefit of elderly users.	Autonomy should be developed and tested in ways that promote elderly users safety (do not harm). In situations where a person might be in pain or suffering SARs autonomy must be overridden by human input to dictate the course of actions. Despite SARs levels of autonomy human contact should be maintained with vulnerable users by promoting social interaction between care receivers, caregivers and families.	The elderly have right to make their own care choices relatively to the displayed SARs' autonomy.	Elderly people should be listened and provided with enough information to guide their decisions towards the displayed levels of SARs autonomy. However it is important to constantly assess elderly people cognitive abilities to decide about SARs autonomy. Periodic supervision checks should make sure that elderly users have sufficient human contact with caregivers and families. Further synthesis is needed to reveal new categories of displayed autonomy to be included in SARs.

TABLE 4 - ETHICAL ANALYSIS OF THE HRI BENCHMARK AUTONOMY

3.8.7.4. Social success

According to Feil-Seifer and Matarić (2009) the task oriented benchmark of social success (**table 5**) tries to understand if SARs accomplish their primary objectives. As an example if a robot is programmed to being funny, is it really being funny? However in ethical terms such vision might be too reductionist. Initially SARs should be designed for promoting the wellbeing (beneficence) of elderly individuals, but for example the relation between SARs success and the ethical principle of non-maleficence is extremely complex. If we consider examples where robotic animals are used as relaxation exercises to comfort elderly people in nursing homes the notion of success could become relative. Academic studies ((Wada, et al. (2008); Turkle (2005); Kidd, et al. (2006)) refer notions of attachment taking place between vulnerable groups and robotic animals such as PARO (a baby robotic seal used in care homes in Japan and USA). When attachment takes place one could argue that such phenomenon is actually an excess of success, however the opposite is also likely to happen in other social robotics scenarios through the form of deception when for example a robot doesn't meet the human user expectations in HRIs. To date the psychological repercussions of such phenomena in elderly groups is still unknown. However information about the robots capabilities and direct behavioural responses are extremely important to be clarified. As SARs have a synthetic appearance and since humans are heavily influenced by visual cues, we could expect several types of instant responses to robot appearance (Wainer, et al. 2006). In imitation we already talked about incomplete categories of exploration when considering the aesthetics of a machine designed for social assistance. However the notion of scale (size of robot), the concept of usability (how to turn it on off, how to interact with it), or even the way that the machine is "dressed" and accessorized could influence the way it is perceived by elderly groups. It is highly probable that social care ethos will play an important role in determining or not the success of HRIs. As a result personalizing elements in HRIs could arise and will need to be identified as they can positively inform future SARs developers and manufacturers.

Still in non-maleficence there is the notion of meaning and earnestness. High levels of HRI could also translate false expectations when for example a vulnerable user communicates health problems to machine and expects it to inform an agency (health care) or react like a real clinician. Sensitive information about a person's health and wellbeing might fall into such scenario that can originate ethical repercussions. The opposite effect was also mentioned in the benchmark of autonomy when humans lose the notion of earnestness associated to a machine and underestimate robots that are performing towards care. To aggravate such challenge is the fact that the loss of earnestness and machine authority during HRIs may not be instantaneous. The user might be receptive and amenable to interact with a SAR for some initial period perhaps due to the novelty of the machine, however the user might lose interest in it with time (Feil-Seifer and Matarić 2011). So to act in ways that both benefit and do not harm users, SARs systems should be constantly updated and create high expectations throughout the interaction life cycle. However the solution for such issues isn't likely to emerge solely from algorithms and robotic behaviours. We might need further engagement of caregivers, relatives, users and robots to continuously cultivate meaning to HRIs through classical social interaction. Lastly the ethical principle of justice talks about the fair distribution of resources. If SARs are going to be implemented in the near future then care institutions have to debate the fair access to such type of technology how to supervise their interactions, maintenance of SAR systems and responsibility towards them. Beyond the access challenge, justice also questions the benefit and cost of such HRIs which could become inspired by existing governmental health systems policies across nations.

In reality as with autonomy one should consider such types of researches and clarifications to be extremely challenging with vulnerable groups that frequently suffer from cognitive problems. Questions such as where is the boundary between comforting exercises and addiction to robots in elderly groups? How to act in cases of robotic attachment or losses of interest? What is the responsibility of caregivers and clinicians relative to such types of practices, and where is the line between living more independently and becoming socially isolated? All SARs four core areas of supervision, cognitive assistance, entertainment and companionship pose similar challenges that need to be further analysed. Social care ethos will involve talking to elderly groups to analyse their perspectives, attitudes, dignity and expectations towards social success in SARs.

In terms of the ethical principles selection in the benchmark of social success we are primarily concerned with the qualitative elements that can build good levels of HRIs. Thereby we are considering the ethical principle of beneficence as the HRIs should be constructed for the benefit of elderly groups. On the same line the ethical principle of non-maleficence is important to avoid potential situations where HRIs could possibly harm elderly individuals. As social success is researched a fundamental question arises with the fair access and distribution of SARs technologies that can benefit elderly groups. Thereby the ethical principle of justice should be considered. Lastly as social success represents a set of qualitative elements also elderly groups opinions and expectations towards SARs are crucial to analysed. So social care ethos is crucial here. In the benchmark of social success we are considering the ethical principles of beneficence, non-maleficence and justice aligned with social care ethos. To date the core principle of autonomy poses no additional challenge in the context of social success.

HRI benchmark	**Beneficence**	**Non-maleficence**	**Justice**	**Social care ethos**
Social success	The outcome of HRIs using SARs should promote the benefit of elderly users.	HRIs with elderly groups could result in attachment behaviours with unknown repercussions. The opposite phenomenon could also be true. Robotic deception could occur if a robot doesn't meet users' expectations. Both phenomena could counteract the predicted outcome of care. There is also the notion of meaning and earnestness in SARs. High levels of HRI could also translate false expectations when for example a vulnerable user communicates health problems to machine and expects it to inform an agency (health care) or act like a real clinician. Still in the level of earnestness SARs systems could become surprising for an initial period of time but	Justice brings notions of fair distribution of resources. If SARs are going to be implemented in a near future then care institutions have to debate the fair access to such type of technology, how to supervise HRIs, how to maintain SAR systems and what levels of responsibility are involved in such robotics practices. Despite the access challenge, justice also questions the benefit and cost of SARs for elderly groups.	Information about SARs capabilities and direct behavioural responses are extremely important to be exposed and analysed with elderly groups. There are aspects such as the notion of scale (size of robot), the concept of usability (how to turn it on/off, how to interact with it), or even the way that the machine is "dressed" and accessorized that could influence the way SARs are perceived by elderly groups. Thereby peoples' attitudes and expectations could become determinant to understand the eventual success patterns and personalizing elements that can reinforce HRIs. Social interaction between caregivers, families and the elderly is the vehicle to understand and reinforce social success.

HRI benchmark	Beneficence	Non-maleficence	Justice	Social care ethos
Social success		then decline in terms of interest, engagement and therefore credibility (problematic in health checks and supervision). Thereby SAR systems should be constantly updated to create high expectations throughout the HRI life cycle.		

TABLE 5 - ETHICAL ANALYSIS OF THE HRI BENCHMARK SOCIAL SUCCESS

3.8.7.5. Scalability

In scalability (**table 6**) Feil-Seifer and Matarić (2009) talk mainly about the types of interfaces displayed in SARs. How does a SAR respond to different users' requirements? How adaptable are the existing robotic interfaces to someone who cannot speak or cannot move? Another question raised on scalability dealt with the fact the robotics research is taking place in controlled environments such as robotic labs or hospitals. As Cairns and Cox (2008) point out, "well designed and executed controlled experiments, can give confidence in the practical results" especially in situations such as cognition or interactive behaviour. However it is also true that the "causes of success or failure of new interactive systems are commonly found in the broader context of activity rather than on the details" Cairns and Cox (2008).

In the context of SARs we could expect such typical challenges with the aggravation that robots do move and can affect directly the human perspective as well as the surrounding environment. We should ask and be critical about how do robots adapt and respond outside of such controlled environments such as robotic labs?

If we consider scenarios where interacting with the robot is essential to human beings then the nature of SARs communication between robots and humans is relevant for defining the nature of the interaction (Feil-Seifer and Matarić 2011) and the users' role in such interaction. As an example speech and body language could translate different levels of interaction between humans and machines and inspire the development of new interfaces. This is of primordial importance as scalability deals also with how SARs are able to respond to different users' requirements and environments. Such area could be determinant in complementing the outcome of the interaction itself, act towards the benefit of the user and promote non-maleficence (Feil-Seifer and Matarić 2011). When it comes to the ethical principle of autonomy one should regard that the level of care depicted in SARs isn't to date, anywhere comparable to a professional clinician (e.g. doctor or nurse). Thereby SARs represent a tool to complement elderly care.

In terms of justice the judgment that care institutions could make for example when buying a robot could be manipulated by marketing or wrongly perceived by potential users (both caregivers and elderly users) about the realistic care potential of such SAR. Scalability needs to be further research possibly also to understand how different cultures show different levels of acceptability and interest in robotics technologies and how those could influence and educate such growing industry over the next decades. Social care ethos will involve talking to elderly groups and analyse their perspectives, attitudes, dignity and expectations towards scalability in SARs.

Relative to the ethical principles selection in scalability we are considering different types of interfaces provided to robotic users. However scalability is also associated with the space where the HRIs take place. So the ethical principle of non-maleficence should contemplate the spatial context of action and also the different types of interfaces that can reinforce HRIs. In the ethical principle of autonomy it is important to consider that the level of displayed autonomy of SARs is far from the level of human care and thereby SARs selection should be informed as best as possible. On the same line it is important to highlight that the potential of SARs could be involuntary misunderstood or wrongly depicted by marketing sources so the ethical principle of justice plays an important role. Lastly social care ethos reinforces people's views and expectations towards different types of SARs and interfaces. One should be aware that as SARs are used in different cultures also the people's responses might be different. Thereby attention is needed relative to cultural elements that can shape the outcome of HRIs.

In the benchmark of scalability we are considering the ethical principles of non-maleficence, autonomy and justice aligned with social care ethos. To date the core principle of beneficence poses no additional challenge in the context of scalability.

HRI benchmark	Non-maleficence	Autonomy	Justice	Social care ethos
Scalability	Currently SARs are mainly developed in controlled environments such as robotic labs and research centres however it is required much more HRIs focus. Also the study of HRI elements such as speech and body language could inspire the development of better human machine interfaces capable of suiting different user requirements and environments.	The level of care depicted in SARs isn't to date, anywhere comparable to a professional clinician (e.g. doctor or nurse). Thereby SARs are a complement for elderly care.	The judgment that care institutions could make for example when acquiring SARs could be manipulated by marketing sources or wrongly perceived by potential users (both caregivers and elderly users) about the realistic care potential of such SARs.	SARs communication between robots and humans is relevant for defining the nature of the interaction itself and users' roles. As an example speech and body language could translate different levels of interaction between humans and machines and inspire in the development of new interfaces. Observing and talking to the elderly relative to the HRI experiences is absolutely important to develop SARs. It is also important to notice that cultural investigations should be promoted to analyse different cultures, religions and feedback towards SARs interfaces and their outcomes.

TABLE 6 - ETHICAL ANALYSIS OF THE HRI BENCHMARK SCALABILITY

3.8.7.6. Understanding of domain

In the task oriented benchmark of understanding of domain (**table 7**) Feil-Seifer and Matarić (2009) point out that the understanding of social dynamics of vulnerable users is essential to develop good HRIs in SARs. Despite the fact that I recognize such argument as valid it is still too futuristic to be part of the main technical guidance for SARs development. To date robotics technical awareness towards human users and environments is immensely reduced. In non-maleficence for example one should regard that currently robots lack the technical abilities to recognise the majority of human alarming situations which could lead to undesirable scenarios where the user is in need for urgent care (Feil-Seifer and Matarić 2011). Scenarios such as medication reminders are tremendously critical to be misinterpreted by elderly users (is the person really understanding which medicine to take and when (timetable))?. The understanding of messages delivered by SARs has an ethical dimension that has to be closely followed. As an example in health information systems and tele-monitoring technologies a recent case study revealed that the content of such monitoring has to be well understood by patients. Dar, et al. (2009) reported a decrease in hospitalizations for heart failure decompensation and a reduction in clinic and emergency room visits in 182 patients. The tele-monitoring system used involved constant intervention and understanding from health patients. Elderly people were monitoring daily their weight, blood pressure, heart rate and oxygen saturation and had to answer four questions relative to symptoms of their heart rate decompensation. The binary answers were then forwarded remotely for posterior analysis by a heart failure nurse.

From another perspective when it comes to the outcome of HRIs, Kidd (2008) demonstrated better results in coaching individuals when monitoring long diets using robots rather than using computer software or paper log methods. Both in health informatics and personal robotics we start to sense the importance of understanding of domain and the need for developing strategies that promote it.

In the domain of SARs results are unlikely to be mapped solely by delivering robots to elderly individuals. In current care homes, human contact, personal motivation and entertainment between caregivers, relatives and health professionals are of primordial importance. Next stages of potential SARs ethical research might involve how to understand, communicate and transmit meaning to elderly groups. Such challenge involves establishing good multimodal interfaces reproduced by engaging robotic behaviours that can be mapped with elements of imitation. When a SAR achieves such balance it is more likely to communicate a message, in a pleasant, respectful and yet credible way (with authority) to vulnerable users. In non-maleficence it is absolutely essential to retain the idea that the message transmitted by SARs is being well perceived by vulnerable groups such as the elderly. Social care ethos will involve talking to elderly groups to analyse their perspectives, attitudes, dignity and expectations towards understanding of domain in SARs.

In terms of the ethical principles selection the understanding of domain benchmark deals with the need for robots to understand social dynamics to better conduct HRIs. However in the ethical principle of non-maleficence we should be aware that to date robots lack of such functionality. Thereby attention is needed when elderly groups are under SARs supervision. SARs supervision might change according to the elderly physical and mental condition and it is likely to be shared with human contact. However understanding of domain might also encompass the notion of understanding SARs messages. Thereby social care ethos plays an important role to continuously supervise the elderly and assure that the messages delivered by SARs during care are perceived by their users.

In the benchmark of understanding of domain we are considering the ethical principle of non-maleficence aligned with social care ethos. To date the core principles of beneficence, justice and autonomy pose no additional challenge in the context of understanding of domain.

HRI benchmark	**Non-maleficence**	**Social care ethos**
Understanding of domain	Currently robots lack of technical abilities to recognise the majority of human alarming situations which could lead to undesirable scenarios where the user is in need for urgent care. Scenarios such as medication and task reminders are tremendously critical to be misinterpreted by elderly users (is an elderly person really understanding which medicine to take and when (timetable)?) It is likely that we need to complement medication and task reminders with human supervision schemes. It is absolutely essential to retain the idea that the message transmitted by SARs is being well perceived by vulnerable groups such as the elderly.	When using SARs for delivering care communicating with elderly groups and reading their cognitive perceptions is essential. Next stages of potential SARs ethical research might involve how to understand, communicate and transmit meaning to elderly groups. SARs should be able to communicate messages in credible, comfortable and yet respectful ways for elderly groups. Talking and sharing points of view with the elderly is absolutely crucial.

TABLE 7 - ETHICAL ANALYSIS OF THE HRI BENCHMARK UNDERSTANDING OF DOMAIN

3.8.7.7. Privacy

In privacy (**table 8**) Feil-Seifer and Matarić (2009) mentioned that robots could become more invasive experiences than ubiquitous systems (e.g. CCTV cameras with image processing techniques, microphones or other sources of surveillance) existing today. However the author also mentions that due to the synthetic aspect of robots, SARs could be in certain cases perceived as a less invasive experience than having a human being supervising individuals. Feil-Seifer poses the following questions, does the user sense of privacy relates to better robot performance as an assistive presence?; does the user privacy impact on user satisfaction?".

According to the ethical principle of autonomy, when it comes to privacy in robotics, users tend to perceive a robot's camera as having similar capabilities to human vision which represents a natural but false assumption (Feil-Seifer and Matarić 2011). It is likely that SARs users will desire to be fully informed about their levels of privacy and how to select such levels in assistive care. In beneficence it is important to highlight and demonstrate to elderly groups the advantages of being supervised by SARs. However if one imagines that SARs could supervise someone twenty four hours a day, seven days a week a question about the location of the robot in an institution/ household and its patrolling routes arises. Locations such as bedrooms, bathrooms are sensitive even for non-vulnerable groups so further discussion and information is required with potential elderly users when it comes to robotic supervision (Feil-Seifer and Matarić 2011). From a technical point of view privacy in robotics could be established with the use of 3D silhouettes, or models that resemble the human shape but do not promote the direct identification of individuals. Still in the autonomy ethical principle a robot might not have sufficient capabilities to distinguish between privileged information and information that can be shared with other systems (e.g. other robots, search engines, social networks) or simply with human users. Such inability could lead to potential unintended violations of user's privacy. A robot is also constrained when it comes to distinguish between individuals who can access and use information stored in a robot from those who don't (Feil-Seifer and Matarić 2011). The dimension of privacy in HRIs is likely to be significant. In situations such as the supervision of elderly groups when for example taking medications or monitoring walking patterns, a pleasant and respectful relationship has to be continuously searched between humans and machines. Lastly in justice if privacy agreements take place, different methods of supervision might well contribute for the benefit of elderly users by reinforcing the standards of care that they have received. Conversely high levels of supervision could also become part of jurisprudence when analysing situations such as care negligence or abuse of individuals. As a result the privacy benchmark needs to be further researched and developed in line with ethical core principles and social care ethos.

Relative to the ethical principles selection in the benchmark of privacy we saw that robots could be more or less invasive when for example supervising elderly users. The initial privacy interpretation also questions the role of the user's sense of privacy to the outcome of the HRI. In the ethical principle of beneficence it is important to retain that SARs supervision of elderly groups could contribute for the wellbeing of elderly users. However in the ethical principle of autonomy it is also important to be able to inform elderly users about their levels of privacy during care. In that area further research needs to be done to better describe new forms of elderly supervision. Privacy is a complex issue and because of its extension and advantages it might in the future involve law considerations. Thereby the ethical principle of justice should be considered. Finally in privacy, it is also important to read people's perspectives and expectations towards their levels of privacy involved in supervision. To date the core principle of non-maleficence poses no additional challenge in the context of privacy.

HRI benchmark	**Beneficence**	**Autonomy**	**Justice**	**Social care ethos**
Privacy	Advantages of the elderly being supervised by SARs during certain periods of time.	SARs users should be fully informed about their levels of privacy and how to select such levels in assistive care. New forms of supervision could encompass different technologies where the user privacy is guaranteed according to different protocols. Beyond that a SAR might not have sufficient capabilities to distinguish between privileged information and information that can be shared with other systems (e.g. other robots, search engines, social networks etc). Lastly questions around who can access (caregivers, health professionals or families) the information stored in a SAR are also pertinent.	High levels of supervision and privacy could also become part of jurisprudence when analysing situations such as care negligence or abuse of individuals.	If SARs could supervise elderly people questions about the location of robots and their patrolling routes in institutions/ households arises. Therefore we should listen elderly groups relatively to this.

TABLE 8 - ETHICAL ANALYSIS OF THE HRI BENCHMARK PRIVACY

In this section we reviewed Feil-Seifer's HRI benchmarks considering the ethical principles of beneficence, non-maleficence, autonomy, justice and social care ethos (**table 9**). It is noticeable that there are advantages and disadvantages arising from the existing HRI benchmarks. It is important to remark that beneficence guides the development of SARs towards the benefit of elderly groups. However this assumption is directly related to non-maleficence in the sense that as we develop machines for providing care we also acknowledge that they should not harm elderly individuals. Autonomy is also related to non-maleficence since it can provide a set of advantages in care. At the same time the reliability of SARs become extremely important to debate in order to find a balance between autonomy and reliability in elderly care. Justice is related to the fair distribution of care resources however justice might also be interpreted in legal terms if SARs become omnipresent in ageing societies. Social care ethos constitutes an important guide to investigate elderly people's opinions, attitudes, dignity and expectations towards the use of SARs. That is an essential exercise to better understand potential generic patterns and personalization elements to be included in SARs capable of delivering care to elderly groups.

HRI benchmark	Beneficence	Non-maleficence	Autonomy	Justice	Social care ethos
Imitation	Imitation is not only confined to the imitation of humans and robots (vice versus). New categories of aesthetics where the anthropomorphization, zoomorphication, proxemics, FOVs, colours or ergonomics could be determinant for the outcome of HRIs with elderly groups.	What is the perception and the realistic outcome obtained in HRIs with elderly groups?			Through practical robotics demonstrations we should listen to people's opinions and expectations towards the imitation aspects of SARs. New categories involving the aesthetics of SARs could be unveiled in imitation.
Safety		SARs should be designed in ways that promote user safety.	Elderly people should make informed decisions about the desired level of care delivered by SARs.		Due to inherent cognitive limitations continuous assessment should be performed to analyse the elderly ability to judge SARs autonomy. We should observe carefully the elderly individuals behaviours arising from HRIs and talk to them about it. Safety might not be confined solely to physical safety and further categories need to be explored.

HRI benchmark	Beneficence	Non-maleficence	Autonomy	Justice	Social care ethos
Autonomy	Autonomy in SARs should be delivered in ways that promote the benefit of elderly users.	Autonomy should be developed and tested in ways that promote elderly users safety (do not harm). In situations where a person might be in pain or suffering SARs autonomy must be overridden by human input to dictate the course of actions. Despite SARs levels of autonomy human contact should be maintained with vulnerable users by promoting social interaction between care receivers, caregivers and families.	The elderly have right to make their own care choices relatively to the displayed SARs levels of autonomy.		Elderly people should be listened and provided with enough information to guide their decisions towards the displayed levels of SARs autonomy. However it is important to constantly assess elderly people cognitive ability to decide about SARs autonomy that can act towards their benefit. Periodic supervision checks should make sure that elderly users have sufficient human contact with caregivers and families. Further synthesis is needed to reveal new categories of displayed autonomy to be included in SARs.
Social success	The outcome of HRIs using SARs should promote the benefit of elderly users.	HRIs with elderly groups using robotic animals could result in attachment with unknown repercussions. The opposite phenomenon could also be true in terms robotic deception (a robot doesn't meet users		Justice brings notions of fair distribution of resources. If SARs are going to be implemented in a near future then care institutions have to debate the fair access to such type	Information about SARs capabilities and direct behavioural responses are extremely important to be exposed and analysed with elderly groups. There are aspects such as the notion of scale (size

HRI benchmark	Beneficence	Non-maleficence	Autonomy	Justice	Social care ethos
Social success		expectations) and could jeopardise the outcome of care. There is also the notion of meaning and earnestness in SARs. High levels of HRI could also translate false expectations when for example a vulnerable user communicates health problems to a machine and expects it to inform an agency (health care) or react like a real clinician. Still in the level of earnestness SARs systems could become surprising for an initial period of time but then decline in terms of interest, engagement and therefore credibility (e.g. problematic in health checks and supervision). Thereby SAR systems should be constantly updated to create high expectations throughout the HRI life cycle.		of technology, how to supervise their interactions, maintenance of SAR systems and responsibility towards them. Despite the access challenge, justice also questions the benefit and cost.	of robot), the concept of usability (how to turn it on/off, how to interact with it), or even the way that the machine is "dressed" and accessorized could influence the way SARs are perceived by elderly groups. Thereby peoples' attitudes and expectations could become determinant to understand eventual success patterns and personalizing elements that can reinforce HRIs. Social interaction between caregivers, families and the elderly is the vehicle to understand and reinforce social success.

HRI benchmark	Beneficence	Non-maleficence	Autonomy	Justice	Social care ethos
Scalability		Currently SARs are mainly developed in controlled environments such as robotic labs and research centres however it is required much more HRIs focus. Also the study of HRI elements such as speech and body language could inspire the development of better human machine interfaces capable of suiting different user requirements and environments.	The level of care depicted in SARs isn't to date, anywhere comparable to a professional clinician (e.g. doctor or nurse). Thereby SARs are a complement for elderly care.	The judgment that care institutions could make for example when acquiring SARs could be manipulated by marketing sources or wrongly perceived by potential users (both caregivers and elderly users) about the realistic care potential of such SARs.	SARs communication between robots and humans is relevant for defining the nature of the interaction itself and users' roles. As an example speech and body language could translate different levels of interaction between humans and machines and inspire in the development of new interfaces. It is also important to notice that cultural investigations should be promoted to analyse different cultures, religions and feedback towards SARs interfaces and outcomes.
Understanding of domain		Currently robots lack of technical abilities to recognise the majority of human alarming situations which could lead to undesirable scenarios where the user is in need for urgent care. Scenarios such as medication and task reminders are tremendously critical to be			Communicating with elderly groups and read their cognitive perceptions towards care delivered by SARs is essential. Next stages of potential SARs ethical research might involve how to understand, communicate and transmit meaning to elderly groups. SARs should be able to

HRI benchmark	Beneficence	Non-maleficence	Autonomy	Justice	Social care ethos
Understanding of domain		misinterpreted by elderly users (is an elderly person really understanding which medicine to take and when (timetable)?) It is likely that we need to complement medication and task reminders with human supervision schemes. It is absolutely essential to retain the idea that the message transmitted by SARs is being well perceived by vulnerable groups such as the elderly.			communicate messages in credible, comfortable and yet respectful ways for elderly groups. Talking and sharing points of view with the elderly is absolutely crucial.
Privacy	Advantages of the elderly being supervised by SARs during certain periods of time.		SARs users will desire to be fully informed about their levels of privacy and how to select such levels in assistive care. New forms of supervision could encompass different technologies where the user privacy is guaranteed according to different protocols. Beyond that a SAR might not have sufficient capabilities to distinguish	High levels of supervision and privacy could also become part of jurisprudence when analysing situations such as care negligence or abuse of individuals.	If SARs could supervise elderly people questions about the location of robots and their patrolling routes in institutions/ households arises. Therefore we should listen elderly groups relatively to this.

HRI benchmark	Beneficence	Non-maleficence	Autonomy	Justice	Social care ethos
Privacy			between privileged information and information that can be shared with other systems (e.g. other robots, search engines, social networks etc). Lastly questions around who can access (caregivers, health professionals or families) the information stored in a SAR are also pertinent.		

TABLE 9 - HRI BENCHMARKS ETHICAL ANALYSIS

SUMMARY:

In this section we have discussed the current HRI benchmarks along each of the cardinal ethical principles of beneficence, non-maleficence, autonomy, justice as well as with social care ethos. Imitation seems not only related with SARs imitation of human behaviour or human imitation of SARs. Imitation in SARs is likely to expand aspects of aesthetics such as anthropomorphization, zoomorphication, colours or ergonomics. Safety involves perspectives of physical and psychological safety. The robot displayed autonomy could therefore contribute for the human perceived level of safety and the user's decision towards autonomy selection. In autonomy we understood both the advantages and dangers associated to medication dispensing, stopping therapeutic activities or robot safety issues. On other prism the ethical principle of autonomy reinforces the user's right to make informed decisions about care, however when working with vulnerable groups such as the elderly users might not be capable to understand the capabilities and limitations of a specific robotic system.

When it comes to social success the existing interpretation tries to understand if SARs do accomplish their primary objectives. However the relationship between SARs social success and the ethical principle of non-maleficence is extremely complex. Academic studies already reported notions of attachment towards robotic animals during trial periods of HRIs with elderly groups. Also the previous imitation elements presented in aesthetics could influence the way SARs are perceived by elderly groups.

In scalability the previous HRI benchmarks work talks mainly about the types of interfaces displayed in SARs. How does a SAR respond to different users' requirements? How adaptable are the existing robotic interfaces to someone who cannot speak or move. Questions about locations of such SARs research also come to place, how do robots adapt and respond outside of controlled environments such as robotic labs?

When it comes to non-maleficence, SARs communication is extremely relevant: speech, gestures, facial expressions or body language could inspire the development of better human machine interfaces capable of suiting different user requirements and environments.

The benchmark of understanding of domain highlighted the SARs understanding of human social dynamics. However in terms of non-maleficence one should regard that currently robots lack of technical abilities to recognise the majority of human alarming situations which could lead to undesirable scenarios. In non-maleficence it is absolutely important to retain the idea that the message transmitted by SARs is well perceived by its primary users (the elderly).

In privacy we examined the idea that robots could become more invasive experiences than ubiquitous systems (e.g. CCTV systems). However due to the synthetic aspect of robots, SARs could be in certain cases also perceived as a less invasive experience than having a human being supervising someone. In autonomy when it comes to the supervision of elderly groups a question about the selected location of a robot or its patrolling routes arises. Additionally a robot might not have sufficient capabilities to distinguish between privileged information and information that can be shared with other systems (e.g. other robots, search engines, social networks) or simply other users.

Lastly it is important to mention that we need more practical HRI studies that could incorporate the existing knowledge on HRI benchmarks and extend it. Such iterative journey is likely to unveil ethical issues which are unique to human history. To address such challenges we will need roboethics guidelines that can provide enough flexibility to understand the ethical issues involved in different SARs applications. In assistive care, the core ethical principles of beneficence, non-maleficence, justice, autonomy represent a base for research allied with the concepts of social care ethos. In the next chapters we will explore such paradigm through SARs “in-situ” research with the direct participation of elderly groups, caregivers and relatives.

CHAPTER 4 - RESEARCH METHODOLOGY

4.1. RESEARCH PHILOSOPHIES

Research philosophies guide researchers through the process of collecting data and further analysis. Two main research philosophies are commonly applied: positivism and interpretivism. Positivism advocates that reality is stable and can be observed and described from an objective point of view (Levin 1988). On the other hand interpretivism states that access to reality can be better explained by subjective thought (Winch 1958). Because of their nature, the current research philosophies are better suited for certain types of studies than others. As an example scientific contributions usually follow a positivist philosophy in the sense that they try to prove and quantify an hypothesis through observed elements (e.g. medical research, chemistry, physics, engineering, computer science). Social sciences and humanities use interpretivism as a vehicle to access reality. The emerging effects and human perspectives arising from a subject of study are key elements in social sciences. Additionally research philosophies also encompass a set of proposed research methods (**table 10**) (Davison 1998). In positivism, research methods usually range from laboratory experiments, field experiments, data collection through surveys and quantitative methods, case studies, theorem proof through demonstrations, forecasting based on statistics or simulation of phenomena. Interpretivism uses people's subjective/argumentative views, observations and action research to test theories, case studies to illustrate different perspectives, uses descriptive and interpretive analysis of facts and opinions, makes predictions resulting from statistics and lastly investigates the role of humans in theory and practice.

Scientific/Positivist	Interpretivist/Anti-positivist
Laboratory experiments	Subjective/argumentative
Field experiments	Reviews
Surveys	Action research
Case studies	Case studies
Theorem proof	Descriptive/interpretive
Forecasting	Futures research
Simulation	Role/game playing

TABLE 10 - POSITIVISM AND INTERPRETIVISM RESEARCH METHODS

Quantitative research methods are usually used in natural sciences to study natural phenomena. They typically use statistics to quantify data and generalize results from a sample population. From a different perspective, qualitative research is used to gain understanding of people's attitudes, behaviours, value systems, concerns, motivations, aspirations, culture or lifestyles. Qualitative research methods usually include interviews, focus groups discussions, and "in-situ" observations with specific groups.

To better synthesize research philosophies, strategies and methods Saunders, et al. (2007) present a "onion" research model which helps researchers illustrate their selected research philosophy. The model shows research philosophies (positivism, interpretivism), approaches (deductive (top-down) or inductive (bottom-up)), strategies (e.g. action research, case studies, grounded theory) and the use of research methods (quantitative and/or qualitative) to potentially collect data and analyse it.

4.2. Research methodology

As we saw qualitative studies are related to the interpretative understanding of human experience. This research (**figure 6**) follows an interpretivist philosophy with an inductive approach (bottom-up). It uses different strategies to collect data such as practical robotics workshops (experiments) and focus groups interviews. When it comes to choices mixed methods are used (qualitative and quantitative). In terms of time horizon a cross sectional period was delimited (8 months) to perform practical robotic workshops and gather data for further analysis.

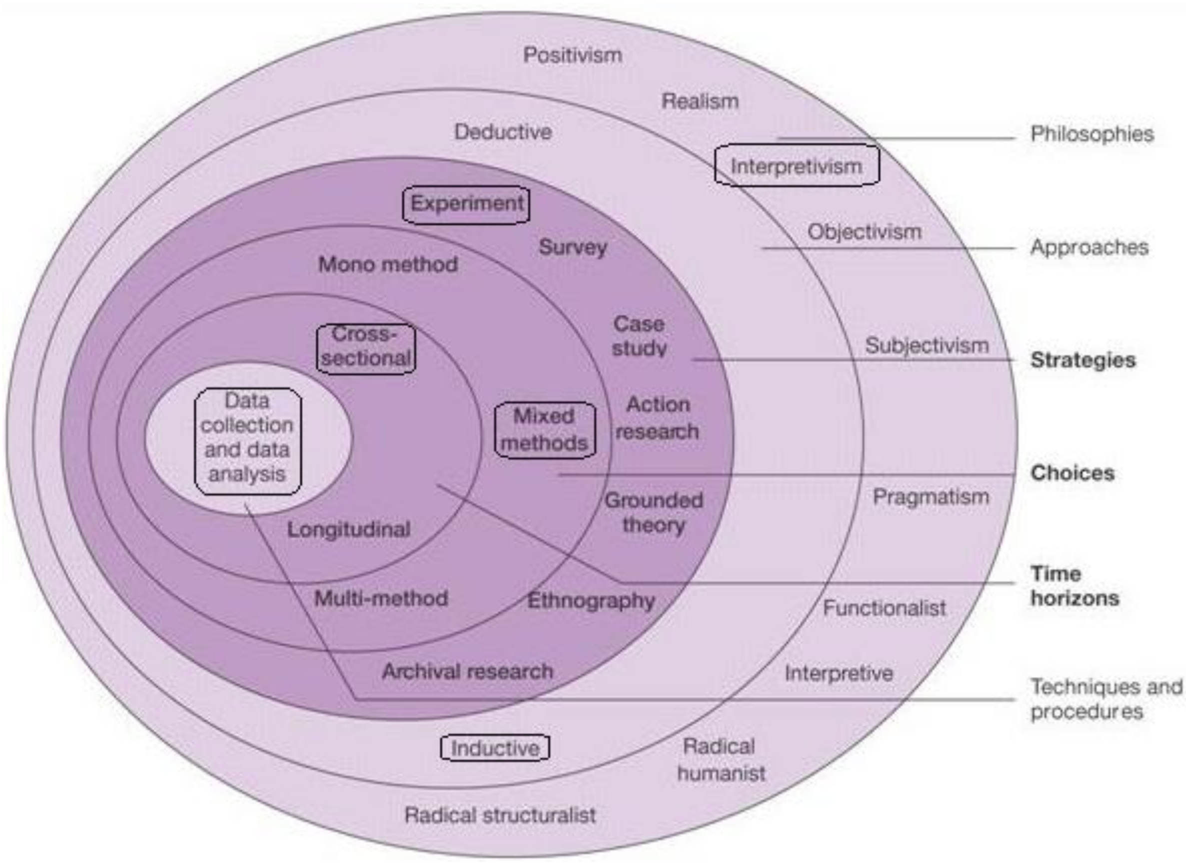

FIGURE 6 - ONION RESEARCH MODEL IN THE CONTEXT OF THIS RESEARCH

Because of the robotics practical nature, field experiments need to be performed to better understand emerging ethical issues when delivering SARs in elderly care. As we saw in the HRI benchmark of scalability robots are mainly tested and operated in controlled environments such as robotic labs which is not likely to translate the real ethical scenarios. As Cairns and Cox (2008) mention the access to reality provides a better insight of how information technologies can be used and ultimately perceived by their prospective users. On the same perspective in SARs we need to connect with target audiences to investigate the real benefits/dangers and limitations of SARs within the context of elderly care. As a result "in-situ" robotics workshops will be performed with the presence of elderly residents, caregivers and relatives in care/extra facilities. A qualitative analysis investigates limitations of the existing HRI benchmarks and contributes with a new roboethics framework for the development and introduction of SARs in elderly care.

Because of the particular sensitivity (e.g. health problems, lack of motivation etc.) of elderly groups we had to investigate innovative ways of presenting the research and therefore explore creativity as a method for data collection. Thereby the robotics workshops were originally designed through the form of a weekly “show” that involved a high immersive approach from presenter and audience. We wanted to maintain the current care and extra care settings as much as possible. The elderly residents should feel comfortable and act normally on their daily activities to keep observations valid. Great care was taken to ensure that residents understood their participation was voluntary and provided fully informed consent.

The robotic experiments were designed for approximately 45 minutes where user participation was completely voluntary and the participant could manifest the will to stop at any time. We try to minimize as much as possible the psychological pressure (it is always present in any kind of technological trial). We are constantly monitoring any signals of physical/psychological distress and ready to stop the experiments if needed. The research was granted ethical approval by the University of Salford Research Ethics Panel in April 2011 under the code REP10/144 (see appendix I).

Such innovative research will analyse the emerging outcomes of HRIs in their natural environments which is primordial to ethically inform the development and introduction of SARs. Due the high sensitivity of the subject it is probable that the proximity between researcher and participants might not be equally reproduced by other research projects. However as elderly care providers mention “working with elderly groups, requires human proximity and good communication levels” (Ensign 2004). Such premise was part of our practical robotic workshops and data collection.

4.3. Qualitative data process

As we saw the interpretivism philosophy assumes that access to reality, is possible through social constructions such as language, consciousness and shared meanings. Interpretive studies try to understand phenomena through the meanings that people assign to them. In the case of information systems Walsham (1993) states that interpretive methods of research are aimed to produce an “understanding of the context of the information system and the process whereby the information system influences and is influenced by the context”. In the case of SARs we need to understand the ethics of HRIs and its context. Such process is likely to benefit from the interpretivism philosophy. However as Benbasat, et al. (1987) have commented no single research methodology is intrinsically better than other. In fact authors such as Mingers (2001) call for a combination of research methods in order to improve the quality of research. As an example common research methods in human computer interaction involve controlled experiments, questionnaires and users interviews (Cairns and Cox 2008). Controlled experiments have been used to evaluate interfaces and to understand cognition in the context of interaction. The goal of a controlled experiment in human computer interaction is to support a theory and make predictions about human behaviour (Cairns and Cox 2008).

Questionnaires are one of the tools to evaluate subjective measures in human computer interaction. It is important to ensure the respondents can easily understand, interpret and complete the questionnaires. Questionnaires can be delivered to respondents in online or paper based formats and the number of respondents is depending on the objective of study (Cairns and Cox 2008).

In interviews the main objective is to understand the meaning of what the interviewees say (Kvale 1996). Interviews are particularly useful for getting the story behind participants' point of view. The interviewer can pursue in-depth information around a certain topic. Interviews are one of the most common methods used in qualitative research.

Another example of research methods deals with participants' observation which is commonly used in social sciences and psychology. Hargreaves (1967) mentions that the participant observation method leads the researcher to accept a role within the social situation. In such scenario the researcher participates as a member of the group while observing it. In theory, such participation in a group allows an easier entrance into the social context. As a result the researcher experiences and observes the group's norms, values, conflicts and pressures, which are fundamental to create knowledge.

All described research methods represent different ways of collecting data. In the case of SARs in elderly care we will need to collect data for further analysis. However due the sensitivity of elderly groups we will have to create an original scheme for conducting HRIs. Thereby the robotic workshops will be presented as a weekly show in care homes where data is collected in terms of observations with video/audio and notes. At the end of each month an interview is conducted with the elderly groups. So in this particular study the research methods used will involve robotic workshops, interviews, notes and on site observations with video recordings.

In the case of SARs we follow a bottom-up approach to collect data where social care ethos takes into consideration elderly peoples' attitudes, expectations and dignity during HRIs. It is also true that it is extremely difficult to generalize potential research results as in a pure positivist research philosophy. On the other we hand we believe the emerging behaviour patterns and ethical issues discovered during this study could serve as basis for creating the foundations of a roboethics framework of reference that can inform the potential development and use of SARs in elderly care.

The qualitative research (**figure 7**) involves three main stages during the data analysis process. The initial stage is the data collection where we will observe elderly participants, conduct interviews and listen to people's comments and concerns towards the introduction of SARs. Once we obtain the raw data, it needs to be stored for further processing. This should take forms of video recordings, field notes, reports and memory recalls during the conducted robotic workshops. On stage three we will start analysing the data. This is the step where we will review the data collected during the workshops and start performing some forms of classification. Once the data is classified according to the research objectives we will proceed to the coding stage. The coding indexes the processed data during the robotic workshops combined with the previous ethical analysis of the HRI benchmarks. The final step is the interpretation of the previous analysed elements to build up the research findings.

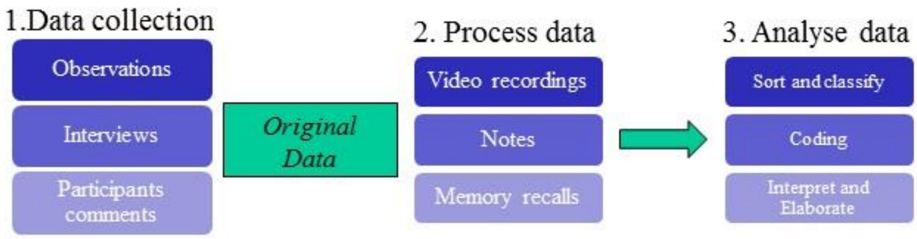

FIGURE 7 - QUALITATIVE DATA PROCESS

4.3. Qualitative data analysis

As mentioned this qualitative analysis (**figure 8**) will involve a combination between the ethical interpretation of the current HRI benchmarks according to the ethical principles of beneficence, non-maleficence, justice, autonomy aligned with social care ethos (chapter 3) and the practical findings from the robotic workshops (chapter 5). The crossing between the two will build the refined HRI benchmarks that will contribute to the ethical specification stage. It is also important to remember that due the sensitivity of the study with elderly groups some of the robotic workshops results might be discussed and advised with expertise from areas such as psychology and social work.

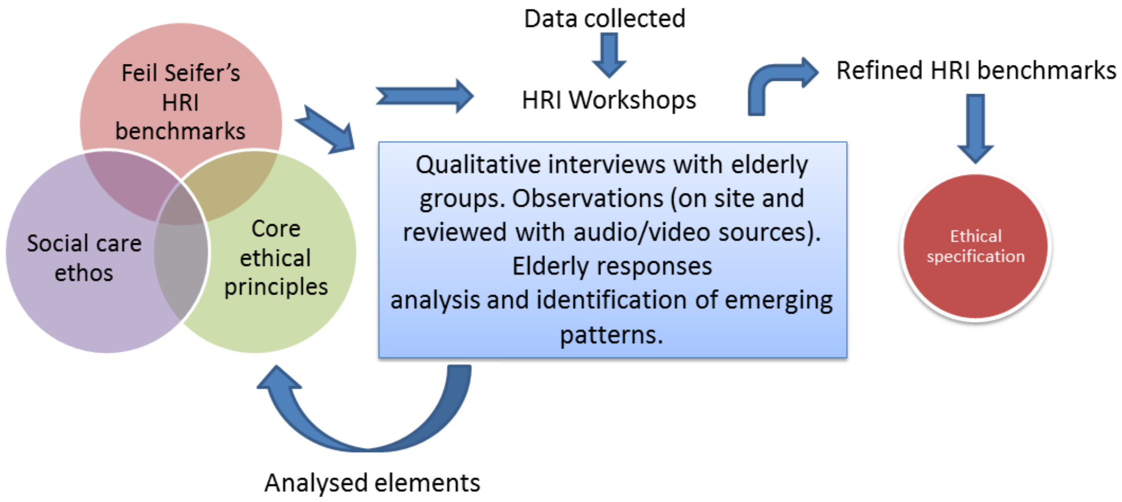

FIGURE 8 - QUALITATIVE ANALYSIS

4.4. Care home settings

In the context of this research I will visit 5 care homes (**table 11**) in UK and Portugal. I want to analyse the introduction of SARs from a cultural perspective and to identify qualitative elements, eventual patterns and differences arising in terms of user acceptability in several types of elderly care settings.

In the UK I will visit "Wallfields court" (**A**) a private day centre located in the West Midlands that provides care and extra care services. In the public sector I will visit "Rivercare" (**B**) an institution in the Northeast that provides extra care. In Portugal I will visit three institutions located in the south: ("Centro Social e Paroquial Alentejo") (**C**) (extra care); "Lar do Monte Velho") (**D**) (care; extra care) both from the private sector. In the public sector I will visit an institution belonging to the Portuguese social services entitled "Acolhimento Jardim Rosa" (**E**) (care; extra care).

Some of the technology used during the practical robotic workshops will be customised within the domain of elderly care. The humanoid robots sound system was improved to better suit hearing problems. The virtual games sessions are conducted in larger screen displays to accommodate the average elderly FOVs and sight limitations. D45 platform was developed and configured for carrying and delivering goods in care institutions. The multiplicity of robots involved and the selected delivering schemes go beyond the few "in-situ" HRI research discussed in literature. The robotic animals (seals, cats), the humanoid robots (RS Media, RS V2), the mobile robots (ROVIO, D45), the service robots (automatic vacuum cleaner, mops), the entertainment robots (roboquad) and finally the virtual games contribute to analyse different perspectives towards robots and assistive technologies. Such flexibility on different robotics scenarios is important to be considered in roboethics. The balance between the advantages and disadvantages of different robotics applications cultivates a synergetic perspective on how SARs could be developed and used to extend and complement elderly care.

In care institutions we will follow a predefined layout to deliver the practical robotic workshops. The activities are meant to take place in a common room (lounge) where participants voluntarily join in. As we see in (**figure 9**) the elderly groups are sitting on circular fashion around the researcher and the robots. The disposition is similar to a musical or theatre where the actors perform in the middle for their audiences. Such disposition is natural as the elderly could see and enjoy the show whilst we promote the idea of group activities. As a result participants can share the technological atmosphere and interact with each other and SARs (in the case of robotic animals).

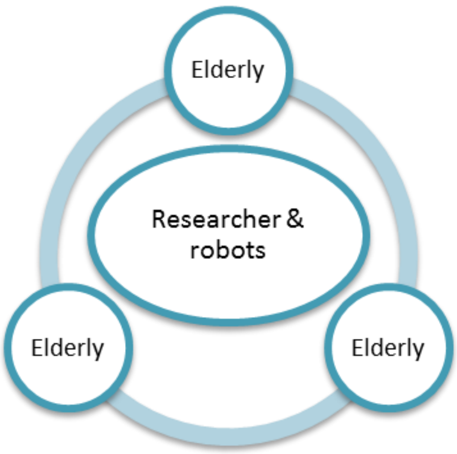

FIGURE 9 - PRACTICAL ROBOTIC WORKSHOPS LAYOUT

On the next table (**table 11**) we can find the care/extra care institutions settings.

Institution	Identifier	Country/Region	Public/Private	Care/Extra care	Approximate number of residents	Typical activities delivered by staff
Wallfields court	A	UK (West midlands)	Private	Care and extra care	30	TV, reading, bingo, domino, paper drawings/stationary, physical exercises.
Rivercare	B	UK (Northeast)	Public	Extra care	12	TV, reading.
Centro Social e Paroquial Alentejo	C	Portugal (South)	Private	Extra care	16	TV, card games (e.g. solitaire).
Lar do Monte Velho	D	Portugal (South)	Private	Care and extra care	25	TV, paper drawings/stationary, physical exercises.
Acolhimento Jardim Rosa	E	Portugal (South)	Public	Care and extra care	30	TV, card games (e.g. solitaire), physical exercises.

TABLE 11 - CARE HOME SETTINGS

4.4. Technology used in the practical workshops

In this section I describe the technologies (**table 12**) used during the 7 months and half of field work. The robotics workshops were recorded in digital format (video) for later analysis in the context of this research.

Name of the robot/technology	Activity	Used to test
1. *RS V2*	50 cm humanoid robots teleoperated to deliver robotic choreographies.	HRI benchmarks of safety, autonomy and imitation.
2. *RS Media*	50 cm humanoid robots teleoperated to tell jokes, play songs and deliver robotic choreographies.	HRI benchmark of imitation.
3. *Robotic seals*	Robotic seals used in the workshops as relaxation exercises.	HRI benchmark of social success.
4. *ROVIO*	Mobile webcam robot: practical workshops for testing communication and supervision of elderly people.	HRI benchmarks of autonomy, privacy.
5. *Automatic vacuum cleaner robot*	Robotic vacuum cleaner: cleaning workshop for demonstrating the functional aspect of robotics technologies.	Entertainment purposes with service robots.
6. *xBox 360 with Kinect system*	VEs workshops for demonstrating the potential of using virtual reality technologies with care and extra care residents.	Entertainment purposes for testing the acceptability and elderly performance when interacting with VEs.
7. *Digital tablet*	Workshop for promoting creativity (human motivation) in extra care facilities.	Entertainment purposes.
8. *D45*	Mobile robotic platform: workshop demonstrating the SARs cognitive assistance and supervision capabilities for elderly people.	Testing levels of acceptability and the HRI benchmarks of autonomy, social success and privacy.
10. *Robotic mops*	Robotic mops: cleaning workshop for demonstrating the functional aspect of robotics technologies.	Entertainment purposes with service robots.
11. *Robotic crab*	Entertainment robot for performing choreographies and sounds.	Entertainment purposes.

TABLE 12 - ROBOTICS TECHNOLOGY USED IN RESEARCH

In the next section we can see the variety of SARs used during the course of research.

1. **RS V2 - (figure 10)** Humanoid teleoperated robots (50cm) used in the robotics workshops to understand HRI benchmarks of safety and imitation.

FIGURE 10 - RS V2

2. **RS Media - (figure 11)** Humanoid teleoperated robots (50cm) used in the robotics workshops to understand cultural aspects and the imitation HRI benchmark.

FIGURE 11 - RS MEDIA

3. **Robotic seals** - (**figure 12**) Robotic seals used in the robotics workshops as relaxation exercises. Used for testing the HRI benchmark of social success.

FIGURE 12 - ROBOTIC SEALS

4. **ROVIO** - (**figure 13**) Telepresence robot used in the robotics workshops for testing communication, supervision of elderly people and the HRI benchmarks of autonomy and privacy.

FIGURE 13 - ROVIO

5. **Automatic Vacuum Cleaner Robot** - (**figure 14**) Robot vacuum cleaner used in the robotics workshops for demonstrating the functional aspect of robotics technologies.

FIGURE 14 - AUTOMATIC VACUUM CLEANER ROBOT

6. **xBox 360 with kinect system** - (**figure 15**) Kinect system used in the robotics workshops for demonstrating the potential of using VEs technologies within the context of extra care facilities.

FIGURE 15 - XBOX 360 WITH KINECT SYSTEM

7. **Digital tablet - (figure 16)** Digital tablet used in the robotics workshops for entertainment purposes. It promotes creativity (human motivation) in extra care facilities.

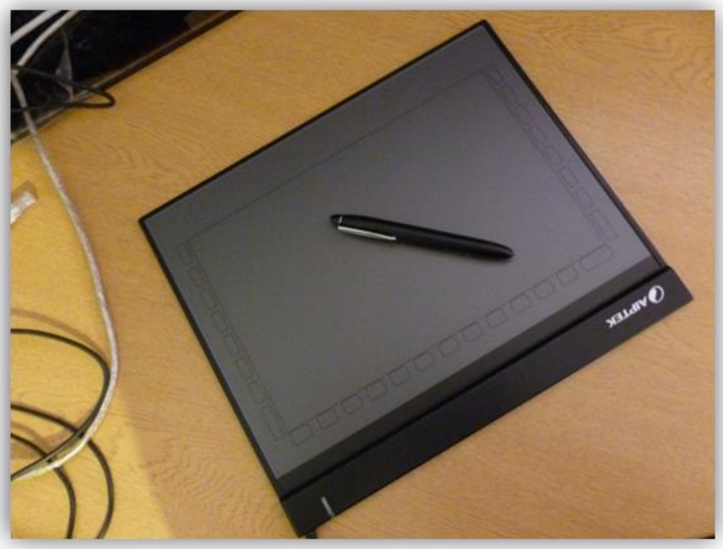

FIGURE 16 - DIGITAL TABLET

8. **D45 mobile robotic platform - (figure 17)** Mobile robotic platform used in the robotics workshops for testing levels of acceptability and the HRI benchmarks of social success and privacy.

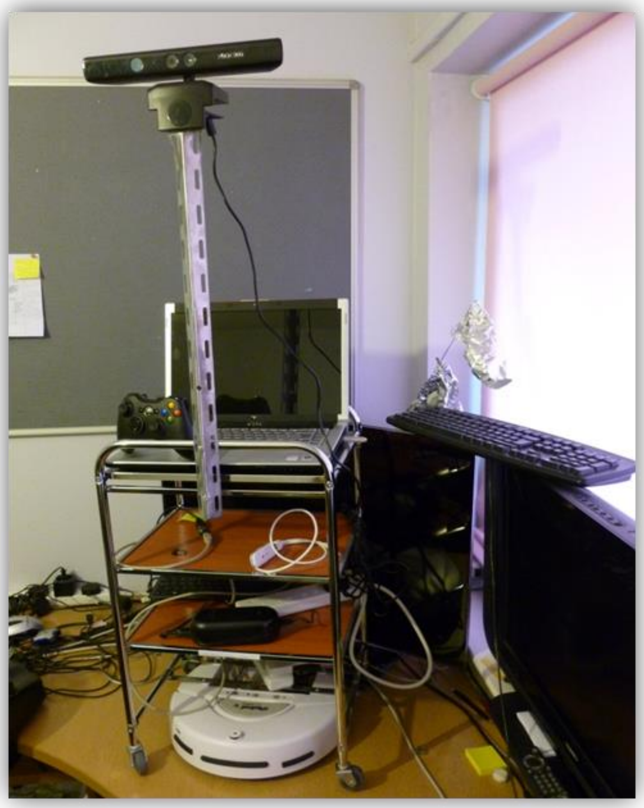

FIGURE 17 - D45 MOBILE ROBOTIC PLATFORM

9. **Robotic cats** - (**figure 18**) Robotic cats used in the robotics workshops as relaxation exercises. Used for testing the HRI benchmark of social success.

FIGURE 18 - ROBOTIC CATS

10. **Robotic mops** - (**figure 19**) Robotic mops used in the robotics workshops for demonstrating the entertainment and functional aspect of robotics.

FIGURE 19 - ROBOTIC MOPS

11. **Robotic crab** - (**figure 20**) Robotic crab used in the robotics workshops as an entertainment tool.

FIGURE 20 - ROBOTIC CRAB

4.5. Robotic workshops and activities

This research involves the use of robotic workshops (**table 13**) to demonstrate the emerging potential of SARs in elderly care institutions. I have developed an original scheme where I presented one weekly workshop in 5 different institutions. Working with sensitive groups such as the elderly is challenging so I intertwined the robotic workshops in original ways to keep high levels of motivation and promote users expectations during the course of research.

Cohan and Shires developed the theory that "meaning was only developed through the application of language through discourse" (Cohan and Shires 1996). However discourse, they say, consists not only of the spoken words of a language, but also on the nuances of verbal articulation, and of non-verbal communication such as body language. I was inspired by such premises to deliver content for example through the humanoid robots workshops. The songs, robotic choreographies and also the jokes programmed into the robots resulted in a creative form of delivering entertainment to the elderly. As a result the robotics workshops were delivered and perceived through the form of show in order to keep observations as natural as possible in familiar care settings.

In temporal terms the field work was scheduled into three evaluation periods (**table 14**) according to the nature of the robotics workshops and conducted activities. The first two interviews (1 and 2) with elderly residents were focused on the ethical issues related to the HRI benchmarks of safety, scalability, autonomy, imitation, social success and understanding of domain using SARs technologies. The third research topic (interview 3) dealt with a more in depth analysis on the benchmarks of privacy, social success, scalability and understanding of domain (although still related with the first two).

Workshop	**Activity**
Kinect system	The VEs workshops were designed for the elderly residents to interact with a virtual world using their own gestures (e.g. body language). Elderly residents could play interactive games whilst doing some controlled physical exercises. Selected activities ranged from petting virtual animals to playing Bowling or stack virtual boxes.
Humanoid robots	The objective here was to explore the entertainment feature of SARs. I programmed in advance the Humanoid robots to perform for the elderly groups. The robots were capable of telling jokes, playing songs, dancing and even playing bowling. One of the main objectives was to test human levels of confidence in very close HRI scenarios and to reveal if the robots personalities, aesthetics and colours played a big part or not in the

Workshop	Activity
	HRI itself.
Robotic seals	From a scientific point of view it is known that "Pet Therapy" is beneficial for humans Stasi, et al. (2004). However because of logistical issues it is not possible to have real animals in extra care facilities. Knowing this potential I decided to recreate an environment where I brought baby robotic seals to day centres and observed human robotic seal interaction. The robots reacted to user touch, by enacting sounds, opening and closing their eyes.
ROVIO	This is a mobile webcam robot that can act as "Skype on wheels". It allows people to remotely control it and to talk with each other. The device has potential in terms of elderly supervision and communication. It was used to demonstrate communication scenarios between the elderly, their relatives and for example GPs.
Automatic robotic vacuum cleaner	The objective of these demonstrations was to give users a perspective that robots have many forms and contexts of application. In this case we explored the functional aspect of having a robot for cleaning the floor/carpet. It served as a platform for investigating the levels of acceptability and degrees of confidence when it comes to the use and proximity of service robots.
Digital tablet	Although HCI was not the main goal of this research, IT can be an innovative way of promoting digital inclusion and creativity among the elderly. The digital tablet activity demonstrated how the residents could easily use a regular pen to write down their own stories or to draw paintings on a computer without the use of a classic keyboard and mouse.
D45	D45 is a mobile research platform that allows testing algorithms and ethical issues involved in HRI. In the workshops it was used to demonstrate medication reminders for elderly groups. The robot was also used test issues around aesthetics and user privacy.
Robotic cats	The robotic cats resemble the natural behaviour of cats. They respond to user touch by moving their head, legs, purr and meow. This was the continuation of the robotic animals' activities (robotic seals) in the extra care centres to investigate possible impacts on stress and socialization of residents.
Robotic mops	Robotic mops can clean household floors. This activity was the continuation of the "service robots" demonstrations to show the functional aspect of robots. It helped analysing the levels of acceptability when it comes to the use and proximity of service robots.
Robotic crab	The robotic crab moves like a real crab and emit sounds. It was used as an entertainment robot.

TABLE 13 - CONDUCTED WORKSHOPS AND ACTIVITIES

Institution	Date	Robots/technology	Activities	Number of elderly participants	Interview identifying number
Wallfields court (**A**)	01/09/11 20/11/11	RS V2, RS Media, robotic seals.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises.	10	1
	01/09/11 20/11/11	RS V2, RS Media, robotic seals, automatic robotic vacuum cleaner, robotic mops, robotic crab and ROVIO.	RS Media was programmed with songs, jokes, and choreographies. The automatic robotic vacuum cleaner, the robotic mops, and ROVIO were introduced. The robotic seals were used as relaxation exercises.	15	2
	01/03/12 15/06/12	RS V2, RS Media, robotic seals, robotic cats and D45.	RS Media was programmed with songs, jokes, and choreographies. D45 was presented. The robotic seals and robotic cats were used as relaxation exercises.	19	3
Rivercare (**B**)	01/09/11 20/11/11	RS V2, RS Media, robotic seals.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises.	11	1
	01/09/11 20/11/11	RS V2, RS Media, robotic seals, automatic robotic vacuum cleaner, robotic crab and ROVIO.	RS Media was programmed with songs, jokes, and choreographies. The automatic robotic vacuum cleaner, the robotic mops and ROVIO were demonstrated. The robotic seals were used as relaxation exercises.	5	2

Institution	Date	Robots/technology	Activities	Number of elderly participants	Interview identifying number
Centro Social e Paroquial Alentejo (**C**)	20/07/11 03/09/11	RS V2, RS Media, robotic seals.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises.	15	1
	20/07/11 03/09/11	RS V2, RS Media, robotic seals and ROVIO.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises. ROVIO was demonstrated.	9	2
	20/07/11 03/09/11	RS V2, RS Media, robotic seals, robotic cats and D45.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic cats and seals were used as relaxation exercises. D45 was demonstrated.	9	3
Lar do Monte Velho (**D**)	20/07/11 03/09/11	RS V2, RS Media, robotic seals.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises.	21	1
	20/07/11 03/09/11	RS V2, RS Media, robotic seals and ROVIO.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises. ROVIO was demonstrated.	21	2

Institution	Date	Robots/technology	Activities	Number of elderly participants	Interview identifying number
	20/07/11 03/09/11	RS V2, RS Media, robotic seals, robotic cats and D45.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic cats and seals were used as relaxation exercises. D45 was demonstrated.	21	3
Acolhimento Jardim Rosa (**E**)	10/11/11 18/12/11	RS V2, RS Media, robotic seals.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises.	16	1
	10/11/11 18/12/11	RS V2, RS Media, robotic seals, ROVIO.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises. ROVIO was presented.	24	2
	10/11/11 18/12/11	RS V2, RS Media, robotic seals, robotic cats and D45.	RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic cats and seals were used as relaxation exercises. D45 was demonstrated.	24	3

TABLE 14 - ROBOTIC WORKSHOPS/ACTIVITIES CALENDAR

The practical robotic workshops were scheduled to last 45 minutes on a weekly basis. They involved many activities ranging from the use of humanoid robots and robotic animals to entertain the elderly to demonstrations of supervision, medication dispensing and performing daily chore tasks with the use of SARs. Beyond the weekly observations and qualitative reports three evaluation periods were proposed for qualitative interviews. At the end of two months, informal interviews will be conducted with elderly residents relatively to the previous robotic workshops. Typically in an interview day, by the end of the workshop I will speak to the residents and register their views on the conducted workshops. Thereby, the researcher interviews the participants individually in a set of pre conceived questions during approximately 5 minutes. In the next chapter we will look to the conducted interviews and perform a critical analysis on the emerging results.

CHAPTER 5 - RESEARCH ANALYSIS AND FINDINGS

5.1. ACTIVITIES PROGRAM

In this research 7 months and half of robotics workshops were developed by the researcher in public and private extra care facilities in UK and Portugal. The study was temporally organized into 3 evaluation periods. In each set of 8 weeks one informal interview will take place with elderly residents in care and extra homes. The interviews are programmed to take place at the end of each 8th session during the last half hour of the robotic workshop. In terms of timing the experiments were run in parallel in the UK and in separated times in Portugal (see chapter 4, table 14).

For the first period 73 residents (age 60 plus), 4 relatives and 1 carer were interviewed. In the second period 74 residents (age 60 plus), 11 carers and 1 manager were interviewed. For the last period 73 residents (age 60 plus), 1 relative, 5 carers and 2 managers were interviewed. The robotics workshops took place in the UK and Portugal in extra care facilities/day centres. Uniquely I have conducted 'in-situ' research rather than asking participants to visit a robotic lab. There are several reasons for such choice: first the degree of mobility and motivation of elderly groups is generally reduced, plus it adds a sense of extreme responsibility for both researchers and staff. The logistics of such visits would also reduce the levels of immersion and the validity of the robotic workshops. Currently SARs research mainly takes place in robotic labs and research centres worldwide (Feil-Seifer and Matarić 2009). However as we saw Cairns and Cox (2008) mention that the "causes of success or failure of new interactive systems are commonly found in the broader context of activity rather than on details". By visiting these institutions with SARs we will benefit from richer observations and enable elderly peoples' choices to be maintained in familiar care and extra care settings.

5.2. Research procedures

This research involved practical robotic workshops with elderly groups in five care institutions. During seven months and half I was observing and registering people's attitudes and expectations towards the introduction of SARs. The robotic workshops involved demonstrations of several SARs platforms through the form of a show. Such activities took place once per week with duration of approximately 45 minutes per session. The activities demonstrated robotics potential in terms of supervision, cognitive assistance, entertainment and companionship. At the same time the nature of this "in-situ" research allowed to understand some of the ethical issues arising from the deployment of SARs within the proximity of elderly groups. Such understanding was essential to propose a roboethics framework of reference for the development and introduction of SARs in elderly care.

Three evaluation periods were scheduled to conduct informal interviews with elderly groups. Such arrangement would provide some familiarity with the robotic technology and build up confidence with the researcher. The delimited time periods also allowed the elderly to process the experiences lived through the robotic workshops. The interviews took place during the final workshop in each evaluation period. The first two interviews explored the HRI benchmarks of safety, imitation, social success and autonomy. The third interview investigated the HRI benchmarks of privacy, scalability, social success and understanding of domain.

Due to the fact that I was dealing with vulnerable groups I had to investigate creative and engaging ways to connect myself and the robots with elderly groups. Thereby I started by investigating what kind of songs did the elderly groups often listened. With the help of caregivers a form was passed in care institutions to get people's favourite playlists. Equally I tried to get more information about the local audiences I was working with in terms of habits, accents and jokes. The materials helped me to program such content into the RS Media humanoid robots.

I started by demonstrating the RS Media robot with songs, jokes and choreographies. The RS V2 humanoid robot was playing bowling and also performing choreographies. Both humanoid robots were delivered to entertain the elderly. I did introduce the robotic animals sessions with the robotic seals as relaxing and comforting exercises for providing entertainment and companionship. During this period we also used a Kinect system with virtual reality games for entertainment and physical exercises (bowling and stacking boxes) with elderly groups. During the workshops video recordings, observations and daily notes were taken for further qualitative analysis. After this two month period of robotic workshops we conducted the first interview with the elderly to explore the HRI benchmarks of safety, imitation, social success and autonomy.

In the second period of robotic workshops we continued to use the RS Media, RS V2 humanoids for performing choreographies. Here I introduced a more functional aspect of robots with the robot vacuum cleaner and the robotic mops. Demonstrations included how such robots could be utilized to help cleaning common household's floors. I also took the opportunity to introduce ROVIO a mobile robot tested for supervision purposes. The Kinect system was delivered for entertainment and physical exercises.

Lastly I continued to deliver the robotic seals as relaxing and comforting exercises. During the workshops video recordings, observations and daily notes were taken for further qualitative analysis. After this two month period of robotic workshops we conducted the second interview with the elderly to explore the HRI benchmarks of safety, imitation, social success and autonomy.

During the third period of robotic workshops I continued to deliver the RS Media, RS V2, and robotic seals. We also used the kinect system for entertainment and physical exercises. However in this period I introduced D45 a mobile robot for entertainment and supervision purposes. Lastly I introduced a new category of robotic animals: the robotic cats. Such cats were also used as relaxing and comforting exercises. During the workshops video recordings, observations and daily notes were taken for further qualitative analysis. After this two month period of robotic workshops we conducted the third interview with the elderly to explore the HRI benchmarks of privacy, scalability, social success and understanding of domain.

During the workshops 2 and 3 I discussed some of the emerging results from the robotic workshops with a psychologist and social work researcher. The objective was to get their perspective on some of elderly responses exhibited during the robotic workshops.

5.3. HRI WORKSHOPS, ETHICAL PRINCIPLES AND SOCIAL CARE ETHOS

The HRI workshops were inspired by a combination of Feil-Seifer's HRI benchmarks interpretation (derived in chapter 3), the four ethical principles of beneficence, non-maleficence, autonomy, justice and finally social care ethos. Such combination positively informed the design of the robotic workshops but also helped understanding some of the relevant questions to be asked within the prospective scenario of SARs in elderly care.

Beneficence

In beneficence we tried to explore robotics technologies that could benefit elderly users in their normal lives. Such benefits are correlated with four areas of HRI: supervision, cognitive assistance, entertainment and companionship. In supervision it is noticeable that a high number of elderly people are getting isolated due to their physical and psychological limitations. Thereby the supervision element of using robotics technologies could benefit elderly users, caregivers and families in the exercise of care. However questions around isolation versus living independently and with quality of life arise. As an example when supervising individuals using telerobotics one should not forget that individual carer visits are still primarily important (human contact).

When it comes to cognitive assistance it is common that elderly people suffer from dementia levels and forget about important tasks in their lives such as medications, eating, shopping etc. Again robotics technologies have the power to act as personal reminders for elderly users and thereby work towards their health benefit. On the entertainment area it is important to refer that SARs can also provide elderly users with a rich set of activities that could include cultural and physical games that can provide motivation, psychological and health benefits. Lastly companionship is a difficult issue to debate as SARs technologies could provide entertainment and companionship versus the existent/inexistent human contact with elderly groups. We should remember that SARs could recreate qualitative dimensions between humans and machines; for example when bringing robotic animals to individuals that are frail and lonely. Robotics, by encompassing supervision and entertainment features, could reinforce companionship to levels that can benefit immensely elderly users. As technology progresses the potential benefits of SARs rise. At the same time it is necessary to examine SARs "in-situ" and give voice (social care ethos) to elderly groups, carers and families for understanding impressions, attitudes, dignity and expectations towards such technology.

Non-maleficence

In non-maleficence we understood the importance of not harming vulnerable users. In literature there is a common point of interest discussed with relationships to the safety of users. However for now it is important to recognise that in current elderly care practice there exist a dichotomy between beneficence and non-maleficence (Ensign 2004). At the same time SARs benefits and harms have not yet been fully researched with vulnerable groups, but for now we should keep in mind that a balance between the four main areas of SARs: supervision, cognitive assistance, entertainment and companionship should be achieved.

Autonomy

In terms of the ethical principle (autonomy), we should consider the elderly users' choices towards care. Robotics autonomy raises questions when individuals are confronted with their preferred levels of autonomy displayed by a robot next to them. The displayed robot's autonomy and their inherent supervision levels is likely to raise challenging questions around: what the robot is really monitoring (doing?) and what sensing sources are being used towards the elderly benefit? Such answers can only gain life by presenting HRI experiences to potential elderly users and to investigating peoples' impressions, attitudes towards the first generation of SARs.

Justice

Finally it is important to talk about the ethical principle of justice. However justice in SARs is related to the democratization of SARs in society. The prices of SARs prototypes are still considerably high. However this is a question that is inherently dependent on how these machines can perform in terms of benefits offered to an ageing society. Thereby economic aspects associated to price, performance and insurance will become part of SARs business models. However in its true essence justice has to promote the fair access of SARs technologies to the highest number of people. Economic decisions about healthcare resources are currently made based on the number of patients who would benefit from such resources. The potential of rationing care to the frail, elderly, poor, and disabled creates an ethical dilemma. This is not an easy question to answer but one that has to be explored more directly with managerial teams and governments when it comes to funding schemes for implementation of SARs technologies.

5.4. Evaluation structure

This research was organized into three evaluation periods. Three interviews will be conducted with staff, residents and families following the final workshop in each evaluation period. The 8 weeks intervals between interviews will provide enough time for the elderly to become more familiar with SARs technologies and process experiences. "Acceptance" is an important issue to be considered with vulnerable groups. The robotic workshops follow a seven months and half program where robotic animals, humanoid robots and mobile robots will be presented. We will progressively introduce entertainment features, companionship, cognitive assistance and supervision for further analysis in each set of interviews. The interviews will take place in a common room/lounge where the elderly participants are usually sitting in a circular fashion. The researcher will approach each of the elderly participants with a set of informal questions to register their personal views on the conducted robotic workshops. Due to the nature of vulnerable groups, the questions involve easy terms and tend to explore the common perspectives of individuals towards the use of SARs in care/extra facilities. The first two interviews will explore the HRI benchmarks of safety, imitation, social success and autonomy. The third interview will investigate the HRI benchmarks of privacy, scalability, social success and understanding of domain. On the following sections we will introduce the set of questions included in each interview.

Interview 1 - Safety, Imitation, Social success

For interview 1 the following activities were conducted: RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises (see chapter 4 tables 12 and 14).

1. Were you comfortable with the proximity of the robot? Would you prefer if the robot kept a certain distance from you?

I wanted to understand the concept of proxemics in SARs. The first stage is to make sure that *people are not afraid of SARs and that there is an acceptable level of confidence between humans and machines. This area of research extends the HRI benchmark of* ***safety****.*

2. When the robot is playing some music do you mind if the robot is performing behind you?

Still related with the first question I wanted to understand if the residents were confident enough while having a SAR performing some type of activities outside of their Field of View (FOV). This area of research extends the benchmarks of ***safety*** *and* ***autonomy****.*

3. Did you like it when the robot talked to you? The jokes and songs were OK? Would you prefer to listen to music from a radio or from a machine such as this?

Because my show involved a lot of media programmed in the RS Media humanoid robots I did a preliminary study among the audience in order to understand the nature of the content to be programmed into the robots. Thereby firstly we wanted to understand the levels of engagement created through my innovative ways of presenting audio accompanied with robotic choreographies. Also because SARs are likely to deliver audio/video in the very near future I wanted to understand if people prefer this new form of media relatively to the classical platforms (e.g. TV, radio etc). This area of research extends the HRI task oriented benchmark of ***social success****.*

4. When I gave the ball and collected it from the robot were you afraid of it?

The objective here was to analyse people's responses and behaviours when I gave a ball to the robot and retrieved it a moment later. Beyond the functional aspect, I wanted to understand if people were afraid or not of interacting with a SAR within close proximity. This area of research extends the HRI benchmark of ***safety****.*

5. Did you enjoy holding the baby harp seal?

In this case I wanted to understand the levels of engagement displayed by the residents when the robotic seal was used in extra care facilities. I also wanted to have a perspective on the notion of attachment relatively to SARs. This area of research extends the HRI task oriented benchmark of ***social success****.*

6. From these two robots which one do you prefer?

Lastly I wanted to have people's perspective relatively to the levels of anthropomorphism displayed in SARs. I provided photographs of more and less anthropomorphized robots (of more or less human aspect) and asked residents to select from their preferences. I was also interested in investigating the concept of robotic presence in HRI. This area extends the HRI benchmark of ***imitation****.*

Interview 2 - Autonomy, Imitation, Social success

For interview 2 the following activities were conducted: RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic seals were used as relaxation exercises. ROVIO was demonstrated (see chapter 4 tables 12 and 14).

1. From the two personalities we saw this month which one do you prefer most?

The objective here was to understand if people were more receptive to certain types of personalities displayed by the humanoid robots. I have programmed the RS Media robots with different personal characteristics which included more human or robotized voices, local jokes or more formal comments. In essence we wanted to test different robot personalities and explore which ones are more successful with elderly groups. This area of research extends the HRI task oriented benchmark of ***social success****.*

2. Did you enjoy the fact that you can select the songs for the robot to play?

I wanted to understand if people would like to personalize the content of their robots. If that was the case then developers should pay more attention to such aspect. This area of research extends the HRI task oriented benchmark of ***social success****.*

3. The robot can walk by itself here in the room without crashing to any objects. Do you like that idea or do you prefer that I'm right on the corner controlling it and watching it very closely?

The objective here was to understand if autonomy is desirable within the context of SARs but I also wanted to understand the role of a human being in terms of teleoperation. This area of research extends the HRI task oriented benchmark of ***social success*** *and the benchmark of* ***autonomy****.*

4. Ok from this robot RS Media and RS V2 which one you prefer? If you had the chance of selecting the colour for it, which colour would it be?

*Here I wanted to understand if colours play or not a big role in the aesthetics of the robot. Thereby people were presented with robots of similar aspect but with different colours and asked to select one. I also took the opportunity to ask them if they had any suggestion in terms of colours. This area extends the HRI benchmark of **imitation**.*

Interview 3 - Privacy, Social success, Scalability, Understanding of domain

For interview 3 the following activities were conducted: RS Media was programmed with songs, jokes, and choreographies. RS V2 played bowling and performed choreographies. The robotic cats and seals were used as relaxation exercises. D45 was demonstrated (see chapter 4 tables 12 and 14).

1. Did you enjoy interacting with the robotic animals? Did you prefer the cats or the seals?

*The objective here was to investigate people's levels of acceptance towards the robotic cats and seals. I also wanted to understand which of these animals was preferred? This area of research extends the HRI task oriented benchmarks of **social success** and **understanding of domain**.*

2. So do you like the idea of having a machine such as D45 that can remind you about your medication and daily tasks? Such medication and daily tasks have to be programmed into the robot, would you have any problem to provide us that type of information (e.g. medication list)?

*I wanted to understand if people were supportive of having a robot that could remind them about their medications and tasks. If that was the case were residents receptive to provide their medications and tasks list to a carer to be programmed into a robot. This area of research extends the HRI benchmark of **privacy**.*

3. The D45 robot also allows that your family could contact you through the robot. In the future even your GP can contact you through the robot. Do you like that idea?

*I wanted to understand if people were comfortable with the idea of contacting and being contacted by their GPs through a robotic platform. This area of research extends the HRI benchmark of privacy and the task oriented benchmarks of **social success** and **understanding of domain**.*

4. You understand that with this type of robot you are much more contactable with your family (relatives, carers, GP etc). However the robot must be in close proximity to you. This means that the robot will be filming you in spaces such as the living room or the corridors? Are you comfortable with D45 filming in common areas?

*As part of supervision I wanted to investigate people's levels of acceptance towards having a machine filming in common areas of an extra care facility. This extends the HRI benchmark of **privacy**.*

5. Do you have any problem with the robot following you (just like it followed me before)?

*The objective here was to investigate peoples' levels of acceptance towards having a robot following them around. This area of research extends the HRI benchmark of **privacy**.*

6. When you are in your home sometimes the carer needs to check if you are taking the right medication at the right time. Instead of being there in the near future the carer can check if you are taking your medication through the robot placed for example in your living room or kitchen. Would you mind being filmed taking your medication?

*As part of supervision I wanted to investigate people's levels of acceptance towards having a machine filming them when taking their medication. This extends the HRI benchmark of **privacy**.*

7. From what I have demonstrated here over the last months, would you welcome these robots at the day centre? Do you have any concerns?

*The objective here was to investigate people's impressions relative to all the activities conducted at the day centre. This area of research extends the task oriented benchmark of **social success**.*

5.5. Qualitative analysis

During the seven months and half of robotic workshops the following data was collected: participants' interviews (see appendix I), field observations, field notes and video recordings. The data was classified and organized according to the existing HRI benchmarks of safety, imitation, autonomy, privacy, scalability, understanding of domain and social success. The data was qualitatively analysed (**tables 15, 16 and 17**) following the HRI benchmarks ethical analysis presented in chapter 3. The objective was to find emerging patterns and responses that could be translated in further HRI benchmarks knowledge. Such qualitative analysis is likely to refine or reveal missing benchmarks, categories or relationships that are crucial to consider when assisting the development and introduction of SARs in elderly care.

Categories	**Qualitative analysis**
Safety	In interview 1 the majority elderly participants were not afraid of the humanoid robots. Comments included "hey robot come here" or "do you have bigger robots?". Field observations and video reviews revealed that in terms of FOVs elderly people preferred to have the robots performing on sight. Similarly their body language didn't translate any signs of distress. Reviewing the video images it was notorious that in the humanoid robots workshops some of the elderly participants followed the robots gestures spontaneously. Such practical results are in line with the previous interpretation of the core ethical principles of non-maleficence, autonomy and social care ethos. We conclude that SARs have to be designed in ways that promote user safety and that enough freedom should be provided to elderly individuals to make their choices relatively to having or not a SAR complementing their care. However important considerations should take place relatively to elderly cognitive capabilities and how those could influence their decision towards the use of SARs. Lastly voices were given to elderly groups and their perspectives were considered during the robotic workshops.
Imitation	During interview 1 the majority of elderly participants' preferred the more

Categories	Qualitative analysis
Imitation	robotic look rather the typical android type. Comparisons were made with pictures of more or less anthropomorphized robots. In the robotic workshops elderly people asked for bigger robots. The following comment was common “do you have bigger robots?”. That was an important element that can influence the degree of importance and perceived meaning during HRIs. Thereby it seems the scale of the humanoids could play an important role in the interaction. In imitation we extended the ethical principles of beneficence, non-maleficence and social care ethos. The robotic workshops with elderly groups showed that imitation is not only related with the imitation of humans by machines or vice versa. Indeed much more emphasis was highlighted into the aesthetics of robots aligned with the notion of scale. Interview 1, field observations and video footage revealed that elderly participants were engaging well with such type of anthropomorphism presented in the humanoid robots. The investigation of aesthetics represents a fundamental step of research in SARs as we are working with vulnerable groups such as the elderly. Thereby the elderly perception of how robots look is absolutely crucial to be able to build pleasant interactions that can benefit their levels of care.
Social success	During interview 1 elderly participants seemed to prefer listening music from a humanoid robot rather than a radio. However comments were issued about the volume and tone of the humanoid robots. During the field observations and video reviews elderly participants were supportive of close HRIs. In the case where I give and retrieve a ball from a humanoid robot the elderly were supportive of such types of interactions with the robots. The robotic animals’ sessions started with the robotic seals. Such robots seem to build a fascination and interest from elderly participants. Despite the fact that the elderly had the perception they were interacting with robots, comments were issued “lovely animals” and indeed the body language observed in the field and video footage revealed that. The robotic seals seem to work well as comforting and relaxing exercises. However in certain cases they seemed to work too well. We had cases of female participants that were

Categories	Qualitative analysis
Social success	reluctant to give the robots back. Lastly during the field observations and videos we detected emerging body language signs arising from the use of SARs: eye gaze towards the robots; hands and arms following the music and rhythm; feet and walking sticks tapping on the floor were common during the workshops. Such qualitative signs constitute important references when considering the social success benchmark. Such results extended the interpretation of the ethical principles of beneficence, non-maleficence, justice and social care ethos. It was perceptible that the use of the humanoid robots and robotic seals were working towards the entertainment of the elderly and building a new qualitative dimension aligned with beneficence. However in non-maleficence one should consider that notions of “attachment” could take place when delivering SARs such as the robotic seals to vulnerable groups. Indeed balancing the level of exposition, periodicity and duration of such interactions is determinant for achieving social success in SARs. It is also important to remember that updating SARs programmable content is absolutely crucial. Caregivers do mention that elderly groups in general have a lack of motivation. Possibly cultivating dynamic activities could contribute to new levels of motivation and wellbeing. It is also important to remember the concept of justice associated to HRIs. Thereby if such robotic workshops are going to be delivered in the future than the notion of fair access and democratization of SARs technologies comes into place. Justice also has to address issues around the benefit versus disadvantages of delivering SARs with elderly groups. Finally in terms of social care ethos elderly participants’ attitudes and expectations were considered during interview 1. However it is important to consider future qualitative elements such as usability issues and aesthetic considerations that might be highlighted by elderly groups. The participants did like the humanoid choreographies and the use of the

Categories	Qualitative analysis
Social success	robotic seals.

TABLE 15 - INTERVIEW 1 QUALITATIVE ANALYSIS

Categories	Comments/Observations
Autonomy	In interview 2 we analysed the elderly perspective on having autonomous robots working in close proximity. In the robotic workshops initial comments were issued around the ability of mobile robots to avoid obstacles and work without human intervention. Comments were made "“wow it can avoid obstacles successfully”. Through field observations and videos reviews no signs of distress were identified. However in interview 2 we found that the elderly preferred to have me controlling the robots in real time not as a safety measure but because of the apparent human contact (socialization) provided. Comments were common “we enjoy the fact that you are here with us”. Equally important was the opinion of caregivers and relatives towards the guarantee of human contact arising from the use of SARs. Thereby we concluded that the level of autonomy displayed by SARs within the proximity of elderly groups could be discussed by an ethical committee that can provide meaningful insights about the elderly individual cases. The practical workshops extend the interpretation of the ethical principles of beneficence, non-maleficence, autonomy and social care ethos. Autonomy should be incorporated into robots in ways that promote beneficence and not harm elderly groups. In situations where a person might be in pain or suffering autonomy should stop and trigger the attention of a care professional. Despite the selected SARs levels of autonomy we should not forget that human contact has to be maintained in the exercise of care. In

Categories	Comments/Observations
Autonomy	social care ethos as it happened in safety it is important to balance elderly peoples' choices (autonomy) towards the desired levels of autonomy displayed by SARs. However attention should directed to the elderly cognitive capabilities that are reduced and different. This means probably we will need specific assessment and guidance towards the introduction of more or less autonomy in elderly care.
Imitation	In interview 2 we concluded that elderly groups are supportive of selecting the colours for SARs. Indeed in interview 1 we saw the importance of aesthetics. Imitation thereby extends the interpretation of the ethical principles of beneficence, non-maleficence and social care ethos. It seems selecting colours for SARs could reinforce the level of interaction between humans and machines and thereby opens space for personalization elements that could be included in SARs.
Social success	In interview 2 the majority of elderly participants preferred the more robotized voice rather than human voice. Such perspective could influence the levels of expressivity that SARs could be programmed with when

Categories	Comments/Observations
Social success	communicating with elderly groups. Before starting the robotic workshops I did investigate elderly peoples' preferences relatively to music. A paper was filled in by the elderly residents' with their favourite playlists. Such list helped me programming the musical content for the humanoid robots. Thereby we investigated if elderly participants were supportive of selecting their own playlists and have them uploaded into the humanoid robots if possible. The main answer was yes which opened space for a new personalization element that can reinforce SARs. During the robotic workshops observations and video reviews it was perceptible that the songs programmed into the humanoid robots aligned with the robots choreographies were extremely successful to entertain the elderly groups. Lastly I had the opportunity to interview caregivers and institutional managers relative to the outcome of the conducted activities. It was acknowledged that the robotic seals provide both visual and tactile feedback which makes the activity extremely motivating for elderly groups. In terms of humanoid robots the musical choreographies displayed on the humanoid robots contributed for a good emotional environment and invited younger generations to visit their grandparents. In fact one of the biggest benefits of the robotic workshops is the increase in communication between individuals in the institutions and the external world. Such results extended the interpretation of the ethical principles of beneficence, non-maleficence, justice and social care ethos. As it happened during interview 1 one should retain that "attachment" manifestations could occur during the robotic animals' sessions. The balance between the exposition of elderly groups and the qualitative dimension that the robotic seals bring has to be well analyzed. Such balance is deterministic for working towards beneficence and non-maleficence of elderly groups. The fair access of such technology continues to pose questions around the democratization of such SARs technologies and its emerging benefits versus disadvantages in elderly care. Social care ethos revealed new personalization elements to be considered in SARs such as the type of voice

Categories	Comments/Observations
Social success	to be programmed in robots and the ability to personalize SARs with songs for reinforcing HRIs.

TABLE 16 - INTERVIEW 2 QUALITATIVE ANALYSIS

Categories	Comments/Observations
Social success	In interview 3 we concluded that the elderly enjoyed interacting with both the robotic seals and cats. During the robotic workshops observations and video reviews it was visible that the elderly enjoyed the experiences provided with the robotic animals. The zoomorphism aspect of such robots associated with the touch interfaces created a new qualitative dimension in extra care. On the same line we found that the robotic cats were preferred relative to the seals. Through observations and video reviews this behaviour was noticeable. The fact that elderly people were familiar with cats during their lives and not with seals might have influenced such choice. However it was also noticeable that the notion of "attachment" already identified in interview 1 became more present with the introduction of the cats. In interview 3 female participants issued comments such as "When we will have the cats again?" or "You can leave the cats with us". The elderly body language seemed to be more reactive to the use of robotic cats. The robotic cats' behaviours (movements and miau) triggered a more expressive response in the elderly groups. Conversely the use of D45 raised different responses. In the humanoid robots, interview 1 and interview 2 it was noticeable that the elderly groups engaged well with such type of robots. However in the scenario where D45 robot was demonstrated for supervision and cognitive assistance the elderly seemed to be a reluctant to accept it. Comments were issued "What a strange machine" or "Is the robot safe?". Such responses might arise from the fact that D45 had no significant aesthetics work. Thereby a new qualitative dimension around the aesthetics of SARs has yet to be explored in order to provide the best HRIs as possible associated with the functional

Categories	Comments/Observations
Social success	aspects of care. In interview 3 we also wanted to understand the elderly perspective in terms of SARs medication reminders in terms of cognitive assistance and supervision. It seems the elderly support such system however it is also true that human contact should be maintained as we saw during interview 2. On the same perspective one of the relatives raised some issues around the level of autonomy of SARs versus the reduction of human contact. In interview 3 we also investigated the role of caregivers when using SARs. We found that caregivers support the introduction of SARs technology. Potential scenarios such as telepresence through these robots were discussed. Caregivers mention that such technology could extend their levels of care. Some caregivers had the opportunity to try both the humanoid robots interfaces and robotic seals and cats. No issues around usability were reported. Finally when it comes to the robotic workshops experience caregivers mention that the activities seem to work well with the elderly residents. Robotic animals seemed to be at the top of the scale when considering touch interfaces for motivating elderly individuals. The humanoid robots represented a new concept that allowed the elderly to perform movements and enjoy their favorite songs through a very modern concept. Special attention should be taken to the dynamics of the robotics workshops as the elderly require high levels of motivation. Such results extended the interpretation of the ethical principles of beneficence, non-maleficence, justice and social care ethos. The robotic animals seemed to trigger people's attention and provide entertainment and companionship. However attention needs to be taken to the emerging manifestations of "attachment" detected in interview 1 and comments on interview 3. Further analysis is needed in terms of SARs conveyed message, periodicity and durations of HRIs. When it comes to social care ethos we listened people perspectives towards SARs and found interesting aspects related to their preference towards the robotic cats. At the overall the elderly participants enjoyed the conducted robotic workshops.

Categories	Comments/Observations
Scalability	In the third evaluation period we concluded that the interfaces used in the robotic animals were absolutely successful. During the field observations and video revisions it was noticeable that the notion of touch and sounds produced by the animals triggered the elderly attention. Similarly the interfaces used in the humanoid robots were successfully tested by caregivers. No usability issues were detected. They also mentioned that if possible they would like to carry such type of workshops in the future. Lastly no cultural differences were detected in terms of elderly responses in Portugal or UK. Such results extended the interpretation of the ethical principles of non-maleficence, autonomy, justice and social care ethos. It is important to understand that more research is needed in care environments. Currently SARs are mainly confined to controlled environments such as robotic labs that do not translate real ethical issues. It is also important to remind that the level of care depicted in SARs is nowhere comparable to a professional clinician. Equally important is to acknowledge the real potential of SARs technologies and acknowledge also potential dangers associated with them. In scalability more research is needed in terms of HRI interfaces and how those could provide better levels of care. However social care ethos is essential to acquire the most information as possible to develop new interfaces and experiences that could contribute to the benefit of the elderly. Cultural elements should be weighted when designing HRIs with specific elderly groups. Such cultural considerations and responses could impact on the social success of such HRIs.
Privacy	In interview 3 we found that elderly people were positive about providing their medication and daily tasks to be programmed into a SAR. Similarly they liked the idea of contacting or being contacted by GPs through a robot. When it comes to having SARs patrolling and supervising common areas of day centre the majority of individuals didn't had any objections. However when it comes to filming elderly residents taking their medications issues were raised about the location where such supervision takes place. It seems

Categories	Comments/Observations
Privacy	the bedroom is a sensitive area because of privacy and dressing issues. Comments were made in interview 3 “not in the bedroom” or “yes, in the lounge”. It was also investigated if elderly participants were confident in having a SAR following them for supervision and support when transporting goods. No objections were made towards such functionality. Lastly in terms of privacy we asked the opinion of staff relative to the use of SARs for supervision and cognitive assistance of elderly individuals. Their opinion is that SARs could extend the levels of care provided in care homes. It was also mentioned that receiving advice and motivation from a robot could be seen by the elderly people as a less invasive experience. From their experience, it seems sometimes the age gaps are not well accepted when advising senior residents. Such results extended the interpretation of the ethical principles of beneficence, autonomy, justice and social care ethos. The supervision methods and cognitive assistance characteristics of SARs are being developed towards the benefit of elderly groups. Challenges around dementia or Alzheimer are increasing worldwide and the creation of assistive technologies is of primary importance. However it is also important to acknowledge that elderly people have the right to make their own decisions about privacy. It is also true that new forms of SARs supervision could encompass a different meaning in terms of supervising individuals. To date SARs don’t have the ability to select privileged from personal information that can be shared with other users or systems. It is also true that such information is essential to be acquired for medication and tasks reminders in care contexts. Such exercise raises questions about who can access such information (caregivers, relatives) for programming it into SARs and what are the elderly users’ safeguards. In terms of locations where SARs supervision might take place it is important to read people’s concerns and suggestions. Social care ethos has a determinant role for listening and advising elderly groups throughout the process of selecting their own levels of privacy.

Categories	Comments/Observations
Understanding of domain	In interview 3 we wanted to investigate if elderly people understood the message delivered by SARs. Through the conducted interviews, field observations and video reviews it was noticeable that elderly people understood that the robotic workshops had both an entertainment and functional aspect. In the robotic animals the elderly used the robots for relaxing and comforting exercises. The atmosphere created by the humanoid robots was a kind of musical where people were entertained by the robots. When it came to ROVIO and D45 the elderly understood that such robots can be used to contact their GPs or relatives remotely and reminding them about their medications and daily tasks. Such results extended the interpretation of the ethical principles of non-maleficence and social care ethos. It is important to remember that currently robots don't have technical abilities to recognize when a person is in pain or suffering. That is an insufficiency that could lead to undesirable scenarios where the elderly user is in need for urgent care. Additionally there is a primary question dealing with the understanding of the message conveyed by a SAR. In scenarios where SARs remind an elderly individual about their medications or daily tasks, does the elderly person really understands what medication to take and the timing? Thereby social care ethos plays an important role in listening, guiding and accessing elderly groups through the exercise of care.

TABLE 17 - INTERVIEW 3 QUALITATIVE ANALSYS

5.5.1. Research findings

In this section I present an analysis towards the research findings on locations (A, B, C, D and E). The detailed analysis for each individual location is in appendix I.

Locations A, B, C, D, E

5.5.1.1. **Interview 1** analysis (Table 18):

In this robotic workshop I interviewed 73 residents, 1 carer and 4 relatives. In terms of proxemics I have tested several distances (150cm, 40cm) for robots to keep from humans and I found that elderly people were not afraid when the robots got too close to them. In this case (98%) of the elders were not afraid of the humanoid robots (RS Media; RS V2).

In locations (A,B,C,D,E) participants often deliberately mentioned "hey, robot come here!" or "can you believe this? How the machine moves?". So far in terms of human behaviours (body language) I haven't observed any signals of distress relative to having a humanoid robot close to people. In terms of FOV I was interested to know if people were confident enough in having a robot performing some tasks normally around the house. I found that (87%) of the individuals prefer to have the robot performing in front of them instead of positioned behind them.

In terms of content delivering (music played by a robot) 40 people (54%) answered they definitely preferred listening music from a robot instead of a classical radio. The impressions I have is that the musical moments allied with the robotic choreographies spark peoples' imaginations when it comes to robots. People often sang and followed the rhythm of the music played by the humanoid robots. In conversation with the staff, we concluded that such performance contributes for the elderly physical and psychological wellbeing since carers and robots incentivize people to follow the rhythm with gestures (almost like gymnastics).

In the HRI context I wanted to understand if people were confident enough to interact with a humanoid robot in very close terms. Beyond the distance (proxemics) that we already tested now it was time to demonstrate to the residents how I could give or retrieve a ball from a robot. In terms of confidence displayed during the activity (94%) of the residents mentioned that they wouldn't have any kind of problem performing the same type of task with a humanoid robot.

When it comes to petting the robotic seals (81%) of the people were happy to do it. The remaining (19%) were not present during the robotic workshops or suffered from high levels of dementia. I also noticed that initially the robotic seals triggered curiosity on elderly individuals but rapidly conquered people's acceptance. In locations (A,B,C,D,E) it was common for some female participants to mention "we will keep the seal on the centre, we will take care of it".

In terms of aesthetics, the first impression that residents have from a robot could be determinant in the way they perceive the machine and without a doubt one that could influence the above answers. In literature despite the uncanny valley theory (anthropomorphization) not much emphasis is put into the aesthetics of a SAR. I found this to be of major importance as I surprisingly noticed that despite the age and subjectivity of the individuals, the elderly still identify successfully (what is generically beautiful or not). The residents (75%) tend to prefer the more robotic look instead of the typical "android" model that looks very similar to a human being. We made comparisons between the humanoid robots and pictures from other types of robots (more anthropomorphized and less anthropomorphized). It seems there are important elements of anthropomorphization that can reinforce the sense of presence and attitudes towards robots. In terms of humanoid robots having a torso including a head and arm(s) seems to capture the elderly's attention and to convey meaning to the interaction itself. Such elements should not look like too human but instead to inherit their disposition on a human body. I realized that the anthropomorphic characteristics displayed on a robot can influence the type of importance given to it in terms of robotic presence. For several occasions people commented the size of the robots especially the humanoid robots RS Media, RS V2. In locations (A,B,C,D,E) comments were commonly made on the issue of scale "do you have bigger robots?". It seems scale could become an important part of aesthetics that needs to be further researched.

In terms of engagement I discovered some emerging body language signs exhibited by the residents. Beyond the normal gestures (hands and arms) following the rhythm I saw the residents' feet tapping on the floor (listening to the robots' music) and also their walking sticks tapping on the floor when watching the RS Media robot choreography. I also observed that the eye gaze towards the robots seems to be characterized by concentration, which allows the residents to deviate from their classical problems (health, depression etc).

HRI benchmarks categories	Findings
Safety: Proxemics (distances).	Elderly participants are not afraid of the humanoid and mobile robots tested during the workshops. Distances tested varied from 150cm to 40cm.
Safety: FOV (SARs performing on sight or behind?)	Elderly participants prefer to have a robot performing on sight.
Imitation: Anthropomorphization of SARs	Elderly participants prefer the more robotic look instead of the typical "android" aspect.
Imitation: Scale of SARs	Elderly participants asked for bigger robots.
Social success: Listening music from a SAR or classical radio?	Elderly participants prefer listening music from a robot.
Social success: Confidence displayed on HRI proximity?	Elderly participants are not afraid of the demonstrated HRIs. In fact they are supportive of those.
Social success: Robotic seals exercise.	Elderly participants enjoyed the relaxation exercises delivered with the robotic seals.
Social success: Body language signs.	Through the humanoid and mobile robotics activities I detected the following body language signs: eye gaze towards the robots; hands and arms following the music and rhythm; feet and walking sticks tapping on the floor.
Extra elements:	Some elderly residents seem to engage extremely well with the humanoid robots. As soon as they realized that the robot responded to human gestures they automatically wanted to interact with it.

TABLE 18 - HRI BENCHMARKS CATEGORIES AND EMERGING FINDINGS

LOCATIONS A, B, C, D, E

5.5.1.2. **INTERVIEW 2** ANALYSIS (TABLE 19):

In this robotic workshop I interviewed 74 participants, 11 carers and 1 manager. In this second assessment I wanted to understand if there were perceived differences in the personalities that I have programmed for the humanoid robots. I found that elderly people (39%) preferred the more robotized voice programmed into the robot's personality than the complete human voice (33%). It would be equally interesting to know if the residents levels of engagement exhibited during the interactions could even become amplified in terms of content. It seems in terms of programmable content of the humanoids robots the majority of the participants (84%) would like to upload their favourite playlists to the robot if they had the chance (or someone that could do it for them).

Relatively to autonomy I wanted to see peoples' reactions in terms of acceptance when it comes to deploy autonomous robots in a common space such as the lounge. In locations (A,B,C,D,E) participants often mentioned "is the robot going to crash" or "wow it can avoid obstacles successfully". I found that (69%) of the residents preferred to have me controlling the robot as a safety measure but also because of the apparent human contact (socialization). In locations (A,B,C,D,E) comments were made: "we enjoy the fact that you are here with us" or "the robots are interesting but we also like you…".

Also I found that the staff and relatives agreed that the level of autonomy displayed on SARs has to be selected according to elements such as: the residents' respective age group, physical and cognitive abilities, medical history, psychological feedback and ultimately with people's or their families informed consent. In locations (A,B,C,E) the point of human contact was raised by carers and relatives with comments such as "even if robotics and technology becomes so advanced, we can't leave elderly people fully dependent on robots", "elderly people need human contact".

Lastly in terms of aesthetics could colours contribute significantly for the outcome of the HRI? It seems so, as the majority of the people (56%) selected the RS Media (Orange Grey) as their favourite colour but also liked the idea of selecting their own colours for the robot.

Throughout the second period of assessment the staff globally mentioned that the robotic seals seem to be very productive when it comes to people suffering from dementia (it provides both visual and tactile feedback which is extremely relevant for those groups). In terms of humanoid robots they recognize that the musical choreographies displayed on the RS Media contribute for a good environment of these groups as it also engages them emotionally in something through a common experience. The opportunity to stimulate residents to perform gestures during the humanoids activity is something highly welcome in the future.

HRI benchmarks categories	Findings
Autonomy: humanoid and mobile robots autonomous behavior. Decision about having more or less autonomy in SARs?	Elderly participants tend to prefer having humans controlling robots in real time. However one of the reasons for such choice is the emerging human contact arising from a robot operator and the residents. It was agreed by staff and relatives that the level of autonomy displayed by SARs within the proximity of elderly groups could be discussed by an ethical committee that can provide meaningful insights about the elderly individual cases. Despite technological advancements elderly residents, staff and relatives reinforce the role of human contact in elderly care.
Imitation: Colours contribute for better HRI?	Elderly participants are supportive of selecting colors for their robots.
Social success: voices displayed on the	Elderly participants tend to select the more robotized voice rather the more humanoid voice.

HRI benchmarks categories	Findings
humanoid robots?	
Social success: Selecting and uploading favorite songs to the robot?	Elderly participants are supportive of uploading their favorite playlists to the robot (or have someone that could do it for them).
Social success: staff perspective on the conducted robotic activities?	Staff mentions that the robotic seals seem to be very productive with people suffering from dementia (it provides both visual and tactile feedback which makes the activity extremely meaningful for such groups). In terms of humanoid robots the musical choreographies displayed on the RS Media robots contribute for a good emotional environment.
Extra elements:	One female participant referred that her answer relative to SARs displayed autonomy was depending on the staff decision to allow the robots to patrol the facility.

TABLE 19 - HRI BENCHMARKS CATEGORIES AND EMERGING FINDINGS

LOCATIONS A, C, D, E

5.5.1.3. **INTERVIEW 3** ANALYSIS (TABLE 20):

For the third period of assessment I have interviewed 73 residents, 1 relative, 5 carers and 2 managers. The activities conducted were mainly used for investigating the HRI benchmark of privacy around the future use of SARs. I also continued to explore the task-oriented benchmark of social success and understanding of domain. From the interviews I concluded that all participants (100%) enjoyed interacting with the robotic animals. It seems (55%) of the residents prefer the robotic cats and only (18%) prefer the seals. In locations (A,C,D,E) female participants often commented "when will you bring us the robotic cats" or "you can leave the cats with us during the week, we will keep them safe". However both robotic animals (seals and cats) seem to demonstrate high levels of persuasiveness among the residents and when it comes to social success the attachment phenomenon is still present. However I must say that the levels of persuasiveness demonstrated by the robotic cats are far superior to the seals. It is curious that the challenges associated to attachment seem to be more noticeable with the introduction of the robotic cats (as the residents immersion levels are higher when interacting with them). Some female participants got really attached to the robotic cats and were reluctant to return them back. Other cases deal with residents asking me to leave the robotic cats with them for a week until the next robotic workshop.

In terms of providing personal information for robotic medication reminders and personal tasks (including providing their medication list to a carer) (97%) of the residents were supportive of such functionality. When contacting or be contacted by their GPs through a robot (93%) of residents enjoyed such activity. Some of the residents mention that one of the problems deals with the stress of travelling to their personal GPs (e.g. it could only take 10 minutes for checking health exams etc). In terms of having a robot filming in common areas of the centre such as the living room or the corridors (93%) of the people are comfortable with such hypothesis. For robot following people as I demonstrated in the workshops (95%) of the residents were supportive of such action. An important remark to add here is the fact that at the overall the D45 robot wasn't persuasive enough as the other robots used (e.g. humanoids). D45 was an incomplete robotic platform (typical from robotic labs) full of wires and with no aesthetics work. In locations (A,C,D,E) it was common for the elderly residents to mention "what a strange machine" or "is the robot safe?". Such element points to importance of aesthetics in future SARs research and development.

In terms of the robot filming when residents taking their medications (91%) were Ok with such idea however some concerns were issued in terms of the area in which the filming takes place (the bedroom isn't really a choice because of dressing and privacy issues). In locations (A,C,D,E) comments such as "not in the bedroom" or "yes, in the lounge" were common. All the residents (100%) mentioned that they really enjoyed the activities delivered in the workshops. Lastly in locations (A,C,D,E) carers had the chance to experiment some of the humanoid and mobile robotic interfaces. They reported positively in terms of usability and acknowledged that if possibly they would like to use some of these robots in the future. Comments were "yes I can control one of these", "definitely I would like to repeat it in the future".

In terms of cultural responses towards the conducted robotics workshops no differences were detected from British and Portuguese audiences. However it is important to remember that content programmed on the robots and languages used were translated accordingly.

During this robotic workshop I had the opportunity to talk with one relative (location A) who raised the point that such "robotic medication monitoring scheme" is likely to compromise the human contact that carers have with elderly residents and it could also originate job losses.

I spoke with 5 carers that were supportive of carrying a mobile phone with them as a technological platform for receiving SMSs with emergency alarms and medications/tasks reminders sent by SARs (it would make their job more efficient). When supervising the residents for taking their medications through the robot both agreed that it would be a good idea. Sometimes one of the problems is that there is not enough staff around to supervise or take care of everybody (e.g. 50 flats on the court for 2 3 carers to supervise). In those situations the robot could become an advantage. Beyond the medication/task/emergency reminders in the future carers mentioned that these robots could be used (through teleoperation methods) either locally or remotely for example to fetch things for the residents. Staff also says that the robotic cats and the seals seem to work better with patients suffering from Dementia or Alzheimer. However they see a huge potential for the entertainment aspect of the humanoid robots and also the use of the Kinect system for the general elderly population (helps them practicing exercise in a complete different way). The staff agrees that these types of activities can approach generations. The younger audiences are persuaded to visit their grandparents since they can interact with robots or play with the Kinect system (practicing exercises). Carers also mentioned that the dynamics of the show is something very important as residents usually don't like to have continuous repetitions of the same activities for long periods of time to the extent that they can lose their interest. At this point it was perceptible that SARs were both fascinating and challenging at the same time. To better understand the nature of the robotic activities and its emerging outcome staff agrees with the potential creation of an assessment panel to supervise HRIs. Such panel could be constituted by researchers, staff and family representatives.

Lastly I had the opportunity to interview a manager at the Wallsfield court. The manager definitely agreed that these types of initiatives tend to approach generations. It is common to see grandsons and granddaughters coming to the see the robots or to participate in the Kinect workshops. He mentions that the level of acceptability of this current generation (now in the centre) is fairly high. He predicts that the next generation will become even more open and actually expecting more types of technologies to help them in the most various number of tasks.

In terms of the residents personal alarm systems one of the problems usually deals with actually finding the person (their current alarm doesn't provide a location description of the signal) and it doesn't allow the staff to talk directly with the person to investigate what is actually happening (telepresence robots "could be magnificent in that aspect"). He says that carrying a mobile phone for the residents or staff wouldn't be a problem and that it is an area that has to become more personalized in terms of alarm (locations) and methods to communicate with residents. Supervising people using a teleoperated robot could become an important tool as it is common in these institutions to have occasional shortages of staff to deliver care. The robots could allow that process to become more efficient since the carers can spend more time with the neediest residents. Finally the manager says that despite robotics is still on a "primitive" state of art, the functional and entertainment aspects shown during the activities could in a medium long term become extremely beneficial in terms of the quality of service provided to the residents. Medication/tasks reminders are definitely an area that is welcome. The robotic seals and cats for example surpass any type of activity conducted in the centre so far when it comes to deal with levels of dementia. It is a meaningful experience that makes people communicate more between themselves and socialize. One curious aspect that the manager mentioned is that the use of SARs could actually become less invasive in terms of presence and attitudes perceived by the residents. In a certain way he believes that by using a machine to convey positive messages to the residents could become more acceptable (less invasive) and a more enjoyable experience.

HRI benchmarks categories	Findings
Social success: Elderly residents enjoyed interacting with the robotic animals?	Elderly residents enjoyed interacting with both the robotic cats and robotic seals.
Social success: Which robotic animals do residents prefer?	Elderly residents prefer to interact with the robotic cats.
Social success: Attachment phenomenon.	Attachment seems to become more noticeable with the introduction of the robotic cats.
Social success: Generally speaking did the elderly residents enjoy the robotic workshops?	Elderly residents enjoyed all the robotic activities.
Social success: Robotic medication reminding system versus human contact?	Elderly people are supportive of having daily medications and tasks reminders. One relative raised the point that such robotic medication reminding system is likely to compromise the human contact that carers have with elderly residents and could even originate job losses.
Social success: carers carrying a mobile phone with them to receive medication and SMS reminders of residents.	Carers are supportive of such technology. They mention that in the future these robots could also be used through teleoperation methods to perform other tasks for the residents. Sometimes there is not enough staff around to supervise or take care of everybody and these robots could become extra help.
Social success: The objective of these robotic workshops?	Staff teams say that the Robotic activities seem to work well with the elderly residents. The robotic cats and the seals seem to work better with patients suffering from Dementia or Alzheimer. However they see a huge potential for the entertainment aspect of the humanoid robots and the kinect system. The staff says that these types of activities approach young generations to their grandparents. Carers mention that the dynamics of the show is something very important as residents usually

HRI benchmarks categories	Findings
Social success: The objective of these robotic workshops?	don't like to have continuous repetitions of activities for long periods of time (they might lose their interest). The staff adds that more assistive technologies are welcome in extra care facilities. Telerobotics and medication/task reminders could revolutionize the ways of delivering care.
Human supervision scheme: creation of an assessment panel?	The staff agrees that HRIs have to be closely supervised. The creation of an assessment panel formed by researchers, staff and families representatives was suggested.
Scalability: Interfaces used on robots and how well such robots performed outside a robotic lab? Cultural responses?	Carers responded positively to the interfaces provided (usability) for controlling the humanoid robots. The touch interfaces used with the robotic animals were successful with the elderly residents. The humanoid robots, seals, cats, rovio and D45 seem to work well outside of a controlled environment such as a robotic lab. No differences were detected in terms of cultural responses from Portugal to the UK.
Privacy: providing information relative to medications and daily tasks?	Elderly people answered positively towards providing their personal information for robotic medication reminders and personal tasks.
Privacy: contacting or being contacted by a GP through a SAR?	Elderly residents are supportive of being contacted or contact their GPs through a robot. Some residents even mentioned problems related to the stress of traveling to their personal GPs.
Privacy: having a SAR filming in common areas of the day centre?	Elderly residents are comfortable with such hypothesis.
Privacy: SAR filming when the elderly are taking their medications?	The majority of the elderly residents are Ok with such idea however some concerns were issued in terms of the area in which the filming takes place (the bedroom isn't really a choice because of dressing and privacy issues).
Privacy: a SAR following people?	Elderly residents are supportive of such action.
Privacy: invasiveness of SARs.	Staff teams say that SARs could become less invasive than human beings. There are situations where advising senior citizens through a machine could be more successful. Also in terms of privacy if a resident is monitored by a machine it could be a more acceptable and enjoyable experience for them.
Understanding of domain: in terms of meaning did the elderly groups perceived the robotics workshops well?	Elderly people understood the general idea of the conducted robotic workshops. The humanoid robots, seals and cats were perceived as entertainment activities. When it comes to the functional aspect of robots such as D45 or ROVIO elderly people understood the meaning of having medication, task reminders and access to telecare.
Extra elements:	Some of the elderly residents' relatives also engaged well in the activities and asked me if they could watch

HRI benchmarks categories	Findings
Extra elements:	and participate in some of them.

TABLE 20 - HRI BENCHMARKS AND EMERGING FINDINGS

5.5.2. Critical analysis

I this chapter we have analysed the collected data in the context of the HRI benchmarks of safety, autonomy, imitation, privacy, scalability, social success and understanding of domain. Such analysis is based on the conducted practical robotic workshops and was also informed by the four ethical principles of beneficence, non-maleficence, justice, autonomy and social care ethos. We will now consider what we have revealed about each of these HRI benchmarks.

5.5.2.1. Safety

Safety as an issue is dominant within the robotics industry since the 70s however in terms of SARs, safety has to be unfolded into new categories so we can understand its true nature and emerging dependencies. From a medical ethics perspective the principles of beneficence and non-maleficence could become critical if a SAR isn't developed within a framework of safety standards. We suggest that safety in SARs should be analysed in at least three levels: physical safety, proxemics and cognitive decline. Any robot deployed within human environments has to meet minimal physical safety standards so it doesn't harm humans (e.g. industrial standards ISO 10218-1 & 2; ISO/RIA TS 15066; ISO/DIS 13482). In technical terms this usually involves equipping robots with infrared sensors for obstacle avoidance and providing emergency interfaces and documentation for users to stop the robot or the on-going activity whenever it is required. On the second level we identify proxemics (Hall 1959) as a determinant factor for reinforcing both the first level and generally the outcome of the HRI. As it happens in VEs (Roberts and Tresadern 2008), proxemics studies distances (the use of space on human interpersonal communication). I found it particularly interesting to investigate if the residents were comfortable enough with the distances that I was applying to the robots during the practical robotic workshops. In interview 1 the responses were positive the majority (98%) of the residents did not feel threatened by the humanoid robots presence when the robots came close to them. In this case I operated the robots within 150cm to 40cm away from the residents'. In fact in interview 1 (locations A,B,C,D,E) some residents even commented: "robot come closer" or "it is amazing how it moves". Also their body language was congruent with their discourse. It was perceptible that people were supportive of getting closer to the humanoid robots. Still related with proxemics I investigated the concept of FOV. I was interested to know if people were confident enough in having a SAR performing some tasks on future household scenarios. Still in interview 1, I found that most, (87%) of the individuals prefer to have the robot performing in front (natural line of sight) instead of working behind them. As a precautionary measure I have identified a third level of safety denominated cognitive decline. Cognitive decline occurs with ageing but the term is also used interchangeably to define pre and post dementia stages (Levy 1994).

Interviews 1 and 3 revealed notions of attachment towards the robotic seals and cats. Comments were issued in locations (A,B,C,D,E); "when we will have the seals?" or "you can leave the robotic cats with us during the week…".

The work of Feil-Seifer and Matarić (2009) identifies safety as an important HRI benchmark but it doesn't inform us how to classify, measure or validate it. I do understand that such safety analysis could also become a subjective issue but for the time being the robotics community needs to be equipped with tools and knowledge that can refine safety to different levels.

5.5.2.2. Autonomy

In terms of autonomy I conducted robotic workshops based on two types of approaches: remote operation (controlling the humanoid robots in real time) and secondly functioning in autonomous mode where the robots roamed around the room without human intervention. In interview 2, I found that (69%) of the residents preferred to have me controlling the robots as a safety procedure however I did find that the residents preferred to have me in the room controlling the robots because they enjoyed my presence and artistic performance. In locations (A,B,C,D,E) comments were made "we enjoy the robots, but we will also like you", "it is good that you are here…". Thereby it seems that beyond certain autonomous robotics advantages the apparent intergenerational human contact is something extremely important for elderly residents. For the time being I interpret this as a reinforcement of human contact in the universe of SARs. Human nature is much more than a functional machine (following instructions, achieving goals), it has other dimensions that lead us to interact and socialize even in an advanced aged spectrum. In my view that has to continue to play an important role when deploying robots within the proximity of such vulnerable groups. These findings are in line with some of the recent objectivation warnings made by Sharkey and Sharkey (2011). Autonomy is an extremely complex issue to debate and the elders answers could be influenced by aspects such as social isolation and replacing any human contact by machines won't psychologically help them, secondly they might be persuaded by the way a human (in this case myself) presents the robots and they might want to keep such an hybrid contact as part of their weekly entertainment. Feil-Seifer and Matarić (2009) talk about partial or adjustable autonomy in HRIs. If we imagine scenarios where there is a shortage of carers to supervise and care for older people and even if we have robots with full autonomy, we as human beings need to provide or at least make our biggest efforts to provide human comfort and contact with such vulnerable groups. The good news is that technically the set of ARs might allow us to communicate with people in different ways. As an example in telepresence robotics we will be capable of conveying partial human presence through robots and to have a physical effect in a remote location. It is important to understand that the philosophy here isn't simply to deploy robots (even if we technically can), the question here is that we (humans) must be part of the robotic scheme itself if we are to meet high standards of human welfare and dignity.

As Gillon (1994) states, in medical ethics, autonomy requires us to consult people and their relatives (if applicable) "to obtain their agreement before take any action, hence the obligation is to obtain informed consent from patients before we do anything to try to help them". Before framing autonomy in SARs paradigm I have observed that elderly people can sometimes tend to reinforce their views beyond the views of health professionals, GPs, nurses and relatives. Scenarios such as living independently beyond their current physical and psychological capabilities without human dignity and avoiding socialization within local communities (isolation phenomenon) are commonly known. In the same way I predict that with the introduction of sophisticated SARs we will still face the same type of attitudes when it comes to supervising or autonomously providing a set of tasks that could help a person. In certain way I suspect that the decision towards SARs autonomy with elderly people could also become affected solely by relying on the individual's choice when their health condition could be unconsciously influencing their decisions. In interview 2 this issue was discussed with the staff and relatives and we agreed that part of the solution for the autonomy issue in SARs is to decide different levels of autonomy to be displayed by the robots according to the residents' respective age group, physical and cognitive capabilities, medical history, psychological feedback and ultimately people's or families informed consents. This requires a profound work from robotics developers in conjunction with elderly groups their families and carers to demonstrate and adjust the levels of autonomy possible for SARs to display.

As we analysed in the first and second evaluation periods in the HRI benchmark of autonomy elderly residents prefer to have a human being around presenting and accompanying the robotic activities. In interview 2 (locations A,B,C,E) the human contact issue was raised by carers and relatives with the comment "even if robotics and technology becomes so advanced, we can't leave elderly people fully dependent on robots", "elderly people need human contact". Similarly in interview 3 one representative of the relatives mentioned that one of the problems associated with robotic medication reminders could be the reduction of the level of human contact between human caregivers and elderly residents. However they are also preoccupied with the reduction of jobs that could occur by the introduction of such robotic systems once cost reduction policies take place. The underlying idea here is that robots shouldn't represent a cheap replacement for human interaction. What is important to consider at this stage is that SARs should represent a motivation for complementing human-human interactions and maintaining social care ethos.

Beneficence and non-maleficence in medical ethics guides health professionals to act in the best interest of the patient. Currently SARs autonomy is far from having the ability of understanding and developing such principles. However, AI systems are being developed for encompassing hybrid behaviours where machines can act with a certain degree of autonomy but humans share the conscience and morality in sensitive actions. Thereby independently from the outcome of selecting autonomy using SARs with the elderly, the wise action for now is to perform an "assessment of the current situation" in conjunction with health care professionals to try to justify the best choice for the individual's welfare. There are no easy answers on this issue and cultural and political forces might become determinant when it comes to produce standards and regulations for SARs autonomy according to the different regions of the planet. However we must also stress that such decisions are better to be informed by qualitative analysis with strong practical emphasis on real robotic workshops near elderly groups, health professionals and their families. Analysing Feil-Seifer and Matarić (2009) view on autonomy is inspiring and indeed helped us finding different elements beyond autonomy. One of the findings deals with the importance of human contact expressed by the elderly groups and the current perspectives of carers and relatives when it comes to the decision of having more or less autonomy in SARs. During the robotic workshops in locations (A,B,C,D,E) elderly residents were commenting the autonomous capabilities of SARs (interview 2) by mentioning “wow, the robot can navigate by itself” and were actually supportive of such technology towards their benefit. However it is also true that they mentioned human contact as being of primary importance for them. The same perspective is shared by staff and families. Therefore autonomy in SARs might need to be weighted according to different robotic platforms, people’s requirements and care objectives.

5.5.2.3. Imitation

We analysed the imitation benchmark of Feil-Seifer and Matarić (2009) by focusing on the aesthetics of SARs. During my interviews I spoke with residents about the physical aspect of the humanoid robots I was bringing in. We made comparisons with pictures of more or less anthropomorphic robots in order to understand which ones were preferable for the elderly. In interview 1 it was found that most (75%) of the residents tend to prefer the more robotic look instead of the android aspect that looks close to a human being. The example of D45 robotic platform revealed that elderly people are influenced by robotics aesthetics. On locations (A,B,C,D,E) during the humanoid robots we experienced high levels of persuasiveness however as D45 had no significant aesthetics work (e.g. full of wires). In interview 3, in locations (A,B,C,D,E) several people commented “what strange machine is that?”. From my analysis their normal reaction was uncertainty towards D45 even beyond the advantages that it could offer in terms of care. Previously we have made comparisons with different robotic platforms and such exercise led me to conclude that there are anthropomorphic characteristics that make SARs more acceptable than others. It seems that having a well-defined torso, head and arms looks good and also brings earnestness and meaning to the interaction itself. These findings are in some way inspired by the classical uncanny valley theory Mori (1970), however instead of localizing ourselves in the y axis (see Chapter3: 35 **figure 5**) I find much more important to retain the concepts of “torso”, “head”, “arms” and their disposition.

In terms of colours displayed on the robots I wanted to understand if they played a role or not in the interaction itself. In interview 2, I found that (56%) of the residents selected the orange and grey colours of the RS Media robot as their favourite set relatively to the white, grey, or red tonalities. However I also concluded that there is space for personalization as the residents manifested themselves positively when selecting different colours for the robots. Still related to the imitation benchmark I decided to borrow the concept of presence from VEs (Roberts and Tresadern 2008). Imagine a robot that reminds you about medications and tasks every day, provides you with entertainment (music, videos and news) definitely I would say that such functionalities have to be transmitted by a machine that has a certain presence ascribed in an environment. However the sense of robotic presence by itself depends directly on the aesthetics of the robot. As we saw the anthropomorphic characteristics can influence the type of importance given by people to a SAR. During the robotic workshops some residents asked if I had bigger robots. Aesthetics in SARs is a complex issue that might involve the notion of scale. During my conversations with the staff I found that the residents still perceive most of the robots as toys. Even beyond the functional aspect of robots demonstrated during the workshops and the perceived shared meanings the notion of scale is an element that can influence the outcome of the HRI itself.

Conveying robotic presence in SARs requires creative combinations of the previous set of elements. I have noticed that the type of presence required in HRI is different from human presence. The objective of conquering robotic presence is that robotic developers will be able to create technological entities that could complement human beings in cognitive assistance, communication, supervision, entertainment or companionship. In my mind it is crucial to perform some preliminary studies relative to the kind of physical configurations that developers could consider throughout the robot’s designing phases in order to meet such objectives. However Kahn, et al. (2006) and Feil-Seifer and Matarić's (2009) interpretation of imitation is quite different from the interpretation of this empirical research. Kahn, et al. (2006) suggest that it is likely that humanoid robots will be increasingly designed to imitate people, not only using language-based interfaces, but also through appearance on an increasing range of human like behaviours. Feil-Seifer and Matarić (2009) try to understand if the interaction and imitation between humans and robots contribute to the outcome of HRIs. However due the current robotics state of the art I consider both visions as secondary objectives since aesthetics and robotic presence can significantly constrain the imitation behaviour of humans towards machines and vice versa (why should humans imitate something that is ugly and full of wires?). For now we need to concentrate much more on analysing the robotic aesthetics issue and how to convey robotic presence.

5.5.2.4. Understanding of domain

Relative to Feil-Seifer's task oriented benchmark of understanding of domain my interpretation is different from Feil-Seifer and Matarić (2009). Feil-Seifer and Matarić (2009) state that understanding of domain shall give inputs to a SAR relatively to human social dynamics. To date I feel this is a very fictional perspective and I'm much more interested to know if the core message of the robotics workshops is perceived by the participants. In understanding of domain I was inspired by the social psychology theory of "Shared meaning" (Nelson 1985). I found that the elderly residents understood the message that I was delivering with the robots. The context of technological activities that could entertain and help older people in the future was perceived by both audiences in UK and Portugal. The shared meaning however is strongly connected to the delivering methods and the content programmed on the robots during the robotic workshops. Of major importance is the understanding of elderly people towards the messages delivered by SARs. A robot that for example advises someone to take their medication has to be well perceived by such groups. Does an elderly person really understands the medication messages (description and timetables) communicated by a SAR?. For now the SARs perceived meaning with elderly groups has to be closely supervised by carers and health professionals.

5.5.2.5. Scalability

As Kitano (2006) reports, there are cultural differences in the way robots are perceived by individuals. In this research we believe cultural traits are important to be considered in order to build good levels of HRI with elderly groups. Such cultural traits Boas (1907) might involve dialect, music or jokes. Thereby the humanoid robots content was programmed according to UK and Portugal dialects, songs and jokes. Such cultural traits contributed to the overall success of the robotic workshops.

As a result in the benchmark of scalability, no significant cultural differences where identified in UK and Portugal. Beyond that we must recognise that the cultural differences between Portugal and UK are narrow. The economical differences are relatively high but both countries live under democratic regimes; have national health systems; have more or less the same religious practices and beliefs; both promote safety and human rights among its citizens etc. Another element in scalability is how adaptable the robots were with the different elderly age groups. I had participants ranging from 60 to 111 years old and the robotic activities seemed to be well received in terms of robotic interfaces and perceived messages. Similarly carers and staff had the chance to control some of the robots in real time in terms of entertainment and supervision. Their remarks were positive and staff generally was supportive of further adoption towards SAR technologies.

5.5.2.6. Privacy

We have analysed the HRI benchmark of privacy within the context of supervision using SARs. The first two assessments looked to the information accessibility levels (who could access medication lists and tasks of elderly residents) to be programmed in a SAR. In terms of medications and tasks I found that elderly residents were happy to provide their medication lists and tasks details to a carer to program them into a robot. To better understand the robotic supervision practice I have introduced three new HRI benchmark categories in privacy: active privacy, passive privacy and hybrid privacy. Active privacy is related with real time video/audio sources such as videocameras or microphones built into a robot that could be used to establish a videoconference, surveillance or health supervision. On the other hand, passive privacy is associated with non-identifying sensing inputs that can for example provide human vital signals or human 3D silhouettes for body tracking. Passive privacy sensors are still under research and development but we could expect a vast array of sensing networks for various functions in the near future. Hybrid privacy will result in a mixture of active privacy and passive privacy in SARs.

In active privacy I started by analysing the elderly residents views on the idea of telecare. I found that the residents were supportive of being contacted or contact their GPs through a SAR. It seems that one of the challenges senior citizens occasionally face deals with distances that they have to travel to their GPs. This often involves tiredness that is problematic in advanced ages. A SAR could become a “mobile” system to contact relatives, carers or a personal GP. However such technological platform is not a substitute for GP human contact and the need for specific health diagnostics is of primary importance. Telerobotics should be perceived as an extension of clinicians practice to periodically check elders and to establish a better approach to their psychological problems. Residents were particularly fascinated with the idea of being contacted by their relatives more often with a

SAR. This envisages that if "active privacy" is well determined in SARs it could become effective in reducing the sociological effect of "Outsiders" (Becker 1963) and it can also reinforce the personal health confidence of individuals. Next I wanted to investigate the residents' opinions relatively to filming on common areas of a day centre. As I showed during the workshops it is likely that we will have this scenario in the future where robots can be teleoperated to patrol common spaces of a household. In locations (A,B,C,D,E) I found that elderly residents didn't have any objections towards such idea. Still on active privacy I asked residents their opinion about a hypothetical scenario where a robot can film them when taking their medications. The majority (93%) of senior residents were supportive of it, however there were some concerns relative to where the filming takes place. In locations (A,B,C,D,E) people mentioned that the bedroom isn't really the ideal place as it involves dressing and privacy issues.

On passive privacy I showed several examples of how a robot could follow us in a household scenario. I wanted to understand the elders' perspective on having a robot that can follow them for helping in a variety of tasks. People were comfortable with such idea however they asked me if there was some emergency or redundancy system to stop the robot in the case of a failure. They also asked if the carers would have enough training to deal with such technological platforms.

Finally staff teams mentioned that the original concepts of active, passive, or hybrid privacy could help their institutions in the future both from an institutional perspective but also from the elderly residents' perspectives and their families. Situations where there is lack of personal or the service gets quite busy the extra help of robots to monitor residents could become an important asset. They state that in some cases the use of robots could even surpass the advising techniques used by current carers and health professionals. Sometimes the age gaps between carers/clinicians and elderly residents' is high and therefore some advices are not perceived in the best way possible. The use of a machine as an advisor could reduce such effect and if used in passive privacy mode it could even be perceived as a less invasive experience for residents.

The implementation of privacy modes is at the same level of decision than the HRI benchmark of autonomy. Selecting from active, passive or hybrid modes depends on the current residents' physical and psychological condition. An assessment should be made by health professionals in conjunction with relatives and staff from care/extra care institutions. It is important to refer that the concerns about privacy must be balanced against the advantages of having such robotic systems: a robot can remind people about medications and tasks 24h a day, doesn't get bored or tired, is always ready to detect an emergency, allows residents to be contacted more times by relatives or clinicians and could even be perceived as a less invasive supervising experience. A hybrid privacy mode is still conceptual and the decision to move between active privacy and passive privacy is currently based on human input. However the hybrid mode is likely to involve more technical responsibility from the robot manufacturer and mainly from the human operator who will use the robot in active mode. Bringing SARs to the hemisphere of care means reinforcing the confidence of those who provide and receive care but no system is free of technical failures and human misuse. There is a trade-off between human confidence and the level of privacy required in a SAR. In the three levels of proposed privacy the conditions, advantages and disadvantages of such robotic system should be well informed to residents, their families and health professionals. As in autonomy, elderly care ethos constitutes a big reference and it is likely to involve many peers to decide the levels of privacy required when supervising elderly people. Whatever is the outcome of the privacy decision the correct guidance provided by assessment panels is fundamental. The use of informed consents is necessary and should become part of a SAR introduction, maturing and decline stages.

My perspective on the HRI benchmark of privacy is much deeper than Feil-Seifer and Matarić (2009) or Kahn, et al. (2006). In SARs privacy is a complex area of study that needs to be categorized. I introduced the categories of active, passive and hybrid privacy. The objective of such categorization is to help us identifying the objectives of robot supervision, human capabilities and responsibilities involved in human privacy. In the near future SARs are likely to offer different types of interfaces and systems to deliver supervision which must continue to be assessed and categorized. The HRI privacy benchmark of Feil-Seifer and Matarić (2009) tries to understand if the user sense of privacy relates to better robot performance in assistive settings or if the user sense of privacy impacts on user satisfaction. Such interpretations are too vague and don't provide consistent guidance towards the objectives of privacy when it comes to the real challenges of supervision schemes and inherited responsibilities of human users and developers of SARs.

5.5.2.7. SOCIAL SUCCESS

In terms of social success Feil-Seifer and Matarić (2009) considers that it is important to understand if SARs objectives are met or not. In locations (A,B,C,D,E) I started by understanding if the methods I used to deliver the entertaining materials through SARs were adequate and persuasive enough. In interview 1, (54%) of the residents preferred listening to music from a humanoid robot rather than on a normal radio, however some of the residents mentioned that the volume and tone of the speakers were not accurate as in a normal radio. In interview 1, it was interesting to know that (84%) of the residents were supportive of uploading their favourite playlists to the robot or having someone to do it for them. Overall, residents mentioned that the experience of watching the robot's choreographies and listening to music from it was indeed a very modern and enjoyable concept. Another item considered in interview 1 dealt with the levels of confidence perceived by the residents when I interacted directly with the RS Media robot by giving and retrieving a ball from it. I found that the majority (94%) of people were confident enough during the demonstrations and were actually positive about performing the exercise themselves. In terms of robotic personalities (interview 2) (39%) of the individuals preferred the more robotized voice whereas (33%) still preferred the more humanoid voice programmed into the robot's personality. There is evident space for investigating the personalization of voices in SARs and possibly relate it to future categories of imitation.

In these set of robotic workshops I have used robotic seals that looked and reacted like real baby seals. The objective of the activity was to use the robots as "relaxation" exercises within elderly groups and to test the outcome of such close HRI. In interview 1, the majority (81%) of the residents considered the experience extremely beneficial for them and for the groups they were involved in. Soon the robotic seals became one the most popular robots I worked with. I noticed people were often asking me to bring the seals again and remembering themselves about the past experiences they had with such robots. Overall the robotic seals are a positive experience however I found evidence that they can become too effective. I came across situations where some female participants became too attached to the seals and for two/three times didn't wanted to give them back. In locations (A,B,C,D,E) comments were typically issued "When we will have the seals", "Did you brought your cats today?". It seems such phenomenon relates to the social psychology theory of attachment. Attachment in psychological terms happens when there is a deep and enduring emotional bond that connects one person to another across time and space (Bowlby 1969). This is not exactly the case with SARs since the attachment isn't directed to a human being but indeed to a robot which could point to a derivative branch of attachment theory. From social psychology we know that attachment behaviour in adults towards a child, includes responding sensitively and appropriately to a child's needs (Bowlby 1969). Since the robotic seals look and act just like baby harp seals this was visible when residents had contact with them. I have noticed that in the most persuasive cases female participants tend to hold the robots with their face towards them. Residents usually looked to them fixedly, as though they were interacting with a real creature. It seems the robotic animals are not only successfully achieving the concept of robotic presence but indeed almost achieving the status of "animal presence". Despite the attachment phenomenon we can say that the advantages of a supervised robotic seals scheme outweigh potential disadvantages. However exercises with robotic animals need to be calibrated between the ethical principles of beneficence - action that is done towards the benefit of others and non-maleficence - action that does not harm individuals.

By talking with staff it appeared that these relaxation exercises were indeed reducing the stress of the residents and also making them much more active and communicative with each other. These results are in fact aligned with Wada, et al's (2008) research when it comes to reduction of stress and increased communication among residents resulting from using PARO (a Japanese robotic seal). Wada, et al. (2008) also performed EEG tests with 15 elderly residents in Japan and found an increased brain electrical activity of alpha waves indicating human relaxed states.

In my robotic workshops I noticed that in the majority of the cases of people suffering from severe dementia, the individuals remembered past experiences they had had with the robotic seals (e.g. three weeks to several months later). Such a result makes me believe that the robotic workshop was meaningful enough for them and the robotic interaction experience is somehow stored in the brain and can be recalled. This would be an important area to explore in dementia research.

Relative to the content of the humanoid robotic experiences I have found inspiration in the early works of human communication theory Cohan and Shires (1996) that focus on language and on how language is used to generate meaning. In the RS Media workshops it was common to have elderly people following the robots gestures and singing songs without the caregivers or researcher asked them to. Another important finding was that partial success of

SARs depends on the content programmed and such content needs to be positively informed by future ethnographical studies. As a result ethnographic studies could become an important benchmark category to be considered in social success.

Beyond the content of SARs one interesting point I found through the robotic workshops is the importance of human contact expressed by the residents. We analysed this during autonomy however it is important to reframe it after the whole research experience - the success of the robotics workshops with elderly groups results from a hybrid approach between humans and machines. In other words the ethnographic studies are an important start but the way researchers can present the show is indeed a key issue to its success. Such remark points to a possible extended category of social success denominated “SARs methods used to deliver HRIs”. In this area the social psychology theory of “Group dynamics” Lewin (1947) is an important reference. When working regularly with older adults and vulnerable groups you will notice that not every day has the same dynamics nor the audiences exhibit the same type of personal disposition for the proposed activities. As an example if there are activities where the participants are more distanced and less involved this means as a performer, I have to become more playful e.g. say a few more jokes to break the monotony of the environment or even change the type of activity with a more dynamic one. For that reason I usually scheduled two types of activities for each robotic workshop - one that required more attention usually to be delivered at the beginning of the robotic workshop (morning - when the level of concentration is high) and a second usually involving more group participation and dynamics. In this way I had available choices and knowledge for adapting my behaviour to different audiences’ responses. There is no complete answer to the delivering methods using SARs with elderly groups. However it is important to retain that reading people’s/residents body language is essential to determine the course of workshops. Because of the environment and age, elderly individuals will not be so active participants as younger research audiences (18 to 50 years old). SARs have to be delivered in a hybrid manner where robots and presenter are part of a show for entertaining frail and sensitive groups such as the elderly.

When it comes to task-oriented benchmarks my perspective on social success is gradually moving away from Feil-Seifer and Matarić (2009). In my view it is important to understand how we can provide higher levels of engagement and better overall experiences for elderly residents, staff and relatives through the use of SARs. I found that residents enjoy attending the robotic choreographies and listening to music delivered by SARs. Elderly people engaged easily with the robots by singing songs and reproducing some of the performed rhythms programmed in the robotic choreographies. It is important to refer that such experiences can be reinforced if robotics developers allow for the personalization of entertaining contents such as: music, jokes, stories and voices to be uploaded into the robots' databases. Because we already explored safety and autonomy I found that the residents displayed good levels of confidence when I interacted closely with the RS Media humanoid robots and were indeed supportive of further close HRIs. To better understand my target audiences I performed investigation on local cultures, accents, jokes and songs before programming the content on the humanoid robots thereby ethnographic studies could play a big part of specifying the content of SARs. According to the staff and relatives the delivered activities so far proved to entertain and promote communication, socialization and sharing of values and experiences among the elderly and younger generations. I recognise the importance of how to deliver robotics materials and tried to actively calibrate the show according to the audiences' responses. Such techniques were inspired by the social psychology theory of Lewin in terms of group dynamics Lewin (1947). Such findings unfold the social success benchmark into the notions of engagement which I consider to be fundamental for providing good HRI levels in SARs.

Over the second stage of social success trials I concluded that all participants enjoyed the delivered robotics workshops. Elderly residents were fascinated by the robotic animals' workshops. At the final stage (interview 3 in locations A,B,C,D,E), I concluded that (55%) of elderly people preferred interacting with the robotic cats versus the seals. People often commented "when do you bring the robotic cats again" or "can we keep them during the week, we will take care of them". However I did noticed that the introduction of the robotic cats had had a higher effect on the elderly groups. The robotic cats included more lifelike characteristics than the seals as they moved their legs, chest, head and could even meow. An important aspect here is the familiarity that these residents had with real cats. The majority of them interacted with cats during their lives so the "cat" concept was not strange for them. One curious aspect is that as the robotic animals become more lifelike and their success increases the more pronounced the phenomenon of attachment is. The number of situations where some residents didn't wanted to retrieve the robots at the end of the robotic workshops increased with the use of robotic cats. This phenomenon was particularly true with female participants, however the body language signs and periods of interaction with male participants were also substantially higher than the ones displayed with the seals. With some residents the concept of attachment inevitably led to some reluctant behaviours when we tried to collect the robotic cats from them. In certain cases there is an inconsistent behaviour in terms of human actions displayed towards the robots and the true nature of the robotic exercises (sharing of robots, having fun and promoting group participation). Such behaviour happened whenever I or one of the carers tried to retrieve the robot from some individuals to give it to others. Due to the previous situations I conceived a new system for monitoring the time that every resident had to interact with the robotic animal (Watson and Rayner 1920). Classical conditioning is currently a technique used in behavioural training that resembles an involuntary response (Ormrod and Rice 2003). One of the classical conditioning examples of Ormrod and Rice (2003) reports to a musical lecturer that was having a difficult time getting the students attention. It was a class common behaviour, so the teacher had to find an effective solution to deal with it. Visual cues seemed not to work since students were always excited looking at what their classmates were doing that they rarely noticed any signals. The lecturer decided to tap into their enthusiasm for drumming loudly by increasing both the volume and speed of the drumming when attention was needed. Students rapidly learned to recognize that a “crescendo” was a signal for silence to follow.

My original concept involved the participation of a referee, the participants and a buzzer system. The exercise was simple, whenever the elderly residents heard the sound alarm they should pass the robot to their next colleague. The idea was to bring “rules” to the robotic animals’ activity in that everyone had to abide. The deontological inspiration allied with the “Classical conditioning” contributed for a reduction of eventual attachment responses towards wanting to keep the robots for longer periods of time. Generally the system functioned well, however there were still female residents that wanted to continue interacting with the robotic cats for longer periods of time. The robotic animals offer a set of advantages never seen in the care industry however such exercise involves a deeper analysis in terms of ethical issues. From my empirical research we might be facing a derivative of the social psychology theory of attachment. Robotic attachment could resemble a fuzzy barrier between human attachment where human beings develop close connections and emotional dependencies with other humans and the use of robots for filling gaps in vulnerable groups that might suffer from emotional deficits. From literature (Stasi, et al. 2004) we know that pet therapy is a beneficial practice with elderly groups, however because of logistical issues in extra care facilities that isn’t possible at all. The advantages of robotic exercises seem to be very promising. In conjunction with the staff we identified increases in communication and socialization among the residents which are in line with Wada's, et al. (2005) findings.

Despite the identified notions of attachment I also found that the robotic animals experience constituted a meaningful experience for these groups as the majority of them even when suffering from dementia were remembering themselves of robotic past experiences.

In terms of social success with the introduction of extra gadgets in the extra care facilities, carers were completely supportive of such actions. They mentioned that medication/task reminders for the residents and carers could indeed mean a more efficient service provided. One of the inherent problems in these types of institutions deals with the sporadic lack of personnel to deliver care. Such robotic systems could in the medium to long term provide extra help.

Lastly in terms of social success benchmark the staff states that the robotic activities seem to work well with the elderly residents. The robotic cats and seals are extremely important when working with patients that suffer from Dementia or Alzheimer. In fact to date the robotic seals and cats surpass any type of activity conducted in the centres so far when it comes to deal with individuals that suffer from dementia. The staff teams also recognize a huge potential for the entertainment aspect of the humanoid robotic activities and the use of the Kinect system. It seems that these types of activities help approaching young generations to their grandparents' generations. Carers mention that the dynamics of the show is something very important as residents could get bored easily. In all locations (A,B,C,D,E) staff teams are supportive for the introduction of new technologies in their care/extra care facilities. As we saw in the benchmark of autonomy caregivers and families also recognise the importance of human contact when operating SARs (**table 19**). When confronted with such extra effects of attachment they also recognized that more attention and empirical research is needed.

My interpretation of social success brings much more depth into the origins and causes of such social success rather than following Feil-Seifer and Matarić (2009) perspective on answering if a SAR is socially successful or not. An interesting factor here is that as I brought more zoomorphism into the robotic animals the phenomena of attachment was much more present. The introduction of the robotic cats meant much more persuasive interactions and deeper experiences. However I identified that as the realism of the robotic cats increased also the attachment phenomenon increased. The notion of social success is relative here. There might exist secondary effects of unsupervised and prolonged HRIs resulting from these types of exercises that we might discover in soft or hard ways in a near future. In the HRI benchmark safety I talked about a third level of safety which was denominated cognitive decline. During the robotics workshops we have noticed certain notions of attachment displayed by some elderly individuals. Such manifestations included comments on interview 3 such as "when we will have the robotic cats again" and reluctant body language traits when returning such robots. To date such repercussions in SARs are currently unknown however when working with such vulnerable groups as the elderly we have to continuously assess the positive/negative outcome of such HRIs and decide the level of exposition of such groups to SARs.

For now we have an ethical issue where the perception of the robotic animals exercise is not perceived in the same way by carers/researchers and residents. For the time being the use of robotic animals seems promising enough however this is a process that should be delivered in a supervised manner. Ideally it would require the residents' families and clinical accompaniment to discuss the robotic animals' activities in order to analyse what those are representing for the elderly people and their future. In terms of robotic medication reminders the issue of human contact could become extremely important to consider. The scenario of introducing SARs that can remind senior citizens about their medications/tasks is attractive from both the functional and financial aspects; however such introduction raises questions of objectification and losses of human contact with elders (Sharkey and Sharkey 2010). The introduction of SARs is a complex issue that needs to involve predefined schemes of usability, resident's choices, periods of interaction, HRIs outcomes, contingency plans on secondary effects and the definition of human responsibilities involved in this process.

Another important aspect to refer is that to better understand social success researchers and developers will need to decode it. In the current and emerging HRI benchmarks I have detected some body language signs on the residents during the robotic workshops. Beyond the normal gestures (hands and arms) following the rhythm I noticed the residents' feet tapping on the floor (listening to the robots' music) and also their walking sticks tapping on the floor when watching the RS Media robot choreography. I also found that the eye gaze towards the robot seems to indicate concentration which perhaps allows the residents to deviate their attention from health and other common problems. When it comes to petting the robotic seals, it seems that in the most persuasive cases people tend to hold the robots towards their chest and look them fixedly. These are important elements especially when analysing the outcome of the robotic workshops towards the benchmarks of social success, safety, imitation and autonomy.

My vision of the HRI benchmark of social success moves away from Feil-Seifer and Matarić (2009) original perspective. We are drawing more particular objectives in social success with the use of SARs. Indeed this is a qualitative journey that has to be continuously accessed in a critical manner. Not everything in SARs is beneficial or harmful and the best way to analyse it is to equip roboticists and other robotics stakeholders with schemes and tools that allow them to conclude the outcome of their proposed HRIs.

As it happens with the previous analysed HRI benchmarks I'm currently moving from a top-down HRI ethical approach Wallach, et al. (2005) to a bottom-up approach where I try to include the four core ethical principles of beneficence, non-maleficence, justice, autonomy with elderly care ethos themes of inclusivity, values and choices when it comes to user participation and interactive design of SARs.

REENCOUNTER

One year after the robotic workshops I had the opportunity to visit the "Wallsfield court" (UK) (location A) and Centro Social e Paroquial Alentejo" (Portugal) (location C). I interviewed 29 residents on these two institutions where 27 of them (93%) still remembered the robotics activities. The reencounter was not always direct as some of the residents recognized me straight away and others didn't. The underlying and hardest question during the reencounter was "Are you coming back, are you performing with the robots again?". The managerial teams made me the same question, and it was perceptible that there is inevitably a qualitative dimension of HRI associated to elderly care. One year after, elderly people still recognized me and recalled the experiences delivered: the humanoid robots, the robotics animals or the virtual environments. My answer to that question is a difficult one, but at the same time it directly opens up new questions that continue inspiring me to research HRIs. Throughout the empirical work tried to explore the intersection between the existing HRI benchmarks of safety, scalability, imitation, autonomy, privacy, social success, understanding of domain Feil-Seifer and Matarić (2009) with the ethical principles of beneficence, non-maleficence, autonomy, justice allied with social care ethos. I have observed and given voice to elderly groups, carers and their families relatively to their impressions, attitudes and expectations relatively to the role of SARs in elderly care. It seems at this point that such crossing is possible, however it involves further research to continuously understand both the roles of humans and machines with the intent of proposing guidelines for roboticists, engineers and other stakeholders when it comes to develop robots that can extend the exercise of human care.

CHAPTER 6 - REFRAMED HRI BENCHMARKS

6.1. REFRAMED HRI BENCHMARKS

In the following section a revised interpretation and categorization of Feil-Seifer's HRI benchmarks is presented. Thereby the new interpretation of Feil-Seifer's benchmarks results from a combination of the ethical analysis involving the core ethical principles of beneficence, non-maleficence, autonomy, justice aligned with social care ethos (chapter 3) and the qualitative analysis resulting from the practical robotic workshops with elderly groups (chapter 5). Such process involved understanding the emerging results from the qualitative analysis but also revisiting the fundamental HRI benchmarks to refine and extend current knowledge on some of the ethical issues involved in the use of SARs with elderly groups.

As a result we revisited all Feil-Seifer's HRI benchmarks (7) by proposing 26 categories and 4 benchmarks.

6.1.1. HRI BENCHMARKS VISUAL REPRESENTATION

To better synthesize the HRI benchmarks a visual representation is proposed. Such diagrammatic approach represents each benchmark in a square with bold font (see **figure 21**). The identified categories of each benchmark are represented under the main benchmark (**figure 21**). Additionally HRI benchmarks relationships are identified in the visual diagram. To represent HRI benchmarks relationships a subscript is included on the right side of the main HRI benchmark. Such number identifies a correspondence to other benchmark. As an example the subscript (3) (**figure 21**) identifies a relationship between the benchmarks of human supervision scheme (**figure 21**) and autonomy. The complete details of the identified HRI benchmarks relationships are described in section 6.4.

6.2.1. HUMAN SUPERVISION SCHEME

During interview 2 I shared a common perspective with both carers and managerial staff of care and extra care institutions. The delivered robotic activities had to be closely supervised. As we saw during the assessment periods there were both advantages and disadvantages emerging from the use of SARs. Significant progress was made in the five care and extra institutions when it comes to demonstrating technological activities that aim for the improvement of communication and socialization among elderly groups. Nevertheless it is also true that we started to observe evidence of attachment in the robotic animals' sessions. A key element for the progressive ethical introduction of SARs lies in understanding advantages and disadvantages of SARs and how to deliver robotics to elderly groups. Simply introducing high tech robots will not solve the challenges of demographics, the need for care, human dignity or issues around isolation. Thereby close human supervision schemes (**figure 21**) are needed to balance the exposition of elderly groups to SARs and assistive technologies.

During the robotic workshops staff comments were issued "we can't leave elderly people fully dependent on robots, these people need human contact". Similarly elderly participants mentioned that they enjoyed the intergenerational contact provided in these types of activities. Comments were made "we enjoy the fact that you are here with us". The supervision scheme raises questions about who provides and has the responsibility for human contact and secondly who inspects and measures such levels of human contact being delivered to elderly groups. We will probably need the creation of an assessment panel formed by researchers, staff and family representatives. Another important point deals with the definition of the duration and periodicity of HRIs.

In terms of ethical principles of beneficence, non-maleficence aligned with social care ethos, it seems that the supervision of elderly groups during HRIs works towards their benefit. In the ethical principle of non-maleficence it is important to highlight the fact that human supervision could also reinforce the notion of safety when using SARs. SARs are likely to be successful but originate also situations of uncertainty where human intervention is needed. So the supervision scheme carries also precaution and responsibility towards some of the SARs activities. As part of the supervision scheme process social care ethos reinforces the communication and considerations towards people's requests and decisions during the exercise of care. In the human supervision benchmark we are proposing the categories and subcategories of assessment panel constitution and periodicity (duration of interactions).

In (**figure 22**) we see that the inner set of developed HRI benchmarks in this research must be overlaid with human supervision schemes. Beyond the crucial human contact it is recommended to have periodic interviews with elderly residents to determine their cognitive condition and acceptability towards SARs. Supervising teams and assessment panels have to continuously balance peoples' attitudes, dignity, choices and their health benefits. This will be a permanent feature of deploying SARs due to the nature of the human environment.

6.2.1.1. **Assessment panel constitution**: After interview 2 we considered the constitution of an assessment panel for supervision and assessment of HRIs. We found that the most congruent panel would be formed by carers, staff, health professionals and families. Such an assessment panel should meet periodically to discuss the outcomes and challenges associated with HRIs.

6.2.1.2. **Periodicity**: Intrinsically related with the human supervision scheme benchmark is the periodicity (e.g. daily, weekly) and duration of SARs interactions (e.g. 45m; 1.5 hours). Vulnerable groups such as the elderly usually suffer from cognitive and physical problems, isolation, depression and emotional deficits which have to be well balanced in terms of their exposition to SARs environments.

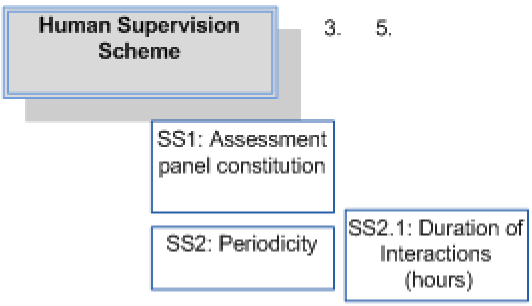

FIGURE 21 - HUMAN SUPERVISION SCHEME

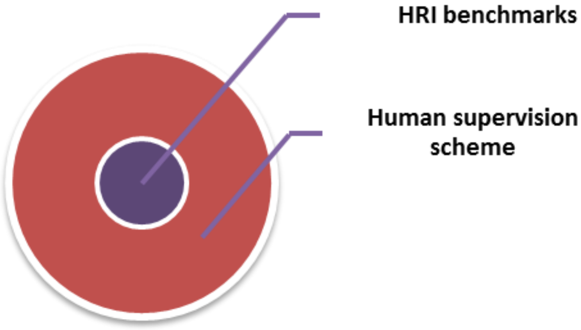

FIGURE 22 - HUMAN SUPERVISION SCHEME SET

6.2.2. SUPERVISION SCHEME

As Feil-Seifer and Matarić (2009) mention SARs safety is of primary importance. In fact the need for human supervision scheme is also mapped by promoting human contact with the use of SARs. According to this research perspective human supervision schemes rise both from the required levels of safety and human contact. Additionally it is important to understand that as SARs are equipped with audio, touch and visual features (e.g. zoomorphism) they unconsciously can trigger emotions in humans. As we have seen in the robotic workshops, the introduction of SARs brings challenges associated to the fundamental nature of HRIs and their implications for human life.

It is important to remember that when working with vulnerable groups such as the elderly there are significant challenges associated with the individual emotional and cognitive capabilities. Special attention should be placed in terms of cognitive decline, where elderly people often forget about normal day to day activities or medication prescriptions. We saw during the workshops that some elderly residents demonstrated a tendency to continuously interact with life like robotic animals. In SARs workshops, supervising teams should be attentive of any signs of cognitive decline or attachment originated from incorrect levels of exposition to robots. To reinforce these issues, we propose a new HRI benchmark denominated human supervision scheme. Such benchmark unfolds the importance of having a human supervising team and an assessment panel for consequent HRI analysis.

Even with the proposed benchmark, the medium to long term effects of SARs introduction are still unknown. More research is needed especially in familiar care and extra care settings where robotics technology is deployed within the proximity of elderly groups. The participation of health professionals and clinicians in this process is extremely relevant as they are the most qualified human resources to identify possible signs of attachment or cognitive decline. Positive or negative effects could occur after the robotics workshops take place and clinicians, carers, staff and relatives have an important role in identifying such effects and informing the future development of SARs.

6.2.3. Safety

Safety (**figure 23**) is of primary importance in any type of technological application. However in SARs safety could take several categories. In terms of proxemics during the robotic workshops and interviews the elderly participants were not afraid of the robots presented. In fact comments were made in interview 1 “hey robot come here” or “do you have bigger robots?”. An interesting point to consider is the FOV of the HRIs. Elderly participants preferred to have a robot performing in their line of sight. In terms of the ethical principles of non-maleficence and autonomy aligned with social care ethos we concluded that SARs have to be designed in ways that promote user safety. However enough freedom should be provided to elderly users when it comes to make their choices relative to having or not SARs complementing their care. It is also important to highlight that the elderly cognitive capabilities tend to get reduced with time so periodic check-ups should be made to guarantee the elderly safety (physical, psychological) and to better inform their decisions about care. Cognitive decline serves as reference for analysing elderly responses. It requires constant supervision to check if the HRIs are acceptable and don’t have visible opposite effects. Thereby in the benchmark of safety we are proposing the categories and subcategories of physical safety, proxemics (FOV, distances) and cognitive decline.

6.2.3.1. **Physical Safety**: physical safety is associated with existing technology (proximity sensors, emergency buttons) and HRI protocols to prevent a robot from harming human beings. During the robotic workshops I haven’t noticed any significant levels of distress when robots navigated around care and extra facilities. In interview 1 the majority, (98%) of the residents said that they were not afraid of the presented robots. However it is also interesting to note that some residents asked if the humanoid and mobile robots autonomous behaviour was safe enough. In interview 2 comments included “is the robot safe?” or “can it avoid obstacles?”. Also in interview 3 we got less positive reactions to the demonstrations of D45.

Comments were issued around the aesthetics of the robot “what a strange machine”, “are you sure it is safe?”.

Robotic safety systems are being developed to contemplate a wide range of scenarios such as promoting individuals physical safety and welfare. However physical safety is still related with the human ability to abide by safety standards (e.g. ISO) and to become self-aware of dangerous situations. In the case of elderly groups such capabilities are often reduced due to the aging process and thereby physical safety is a complex area in terms of technical development but also in terms of human supervision schemes. The current ISO standards are not specific about the use of SARs with vulnerable groups. The current industrial standards ISO 10218-1 & 2 describe standards towards robotic devices - “Safety requirements for industrial robots” however these do not encompass any scenarios of robots interacting with humans in social environments. In terms of ISO/RIA TS 15066 the standard aims at supplying the user with assistance for setup of human-robot-collaboration and the appropriate risk assessment procedures in industrial environments. Lastly the ISO/DIS 13482 “Robots and robotic devices - Safety requirements for personal care robots” is just starting to analyse emerging robotic devices and applications in environments that can provide services for humans beyond industrial settings. This standard focuses on safety requirements for personal care robotic applications and its publication is under development.

6.2.3.2. **Proxemics**: In SARs I have identified proxemics (Hall 1959) which studies distances (the use of space on human interpersonal communication). The distances practiced between a SAR and a human being may become essential to determine the degree of confidence resulting from such HRI. During the robotic workshops I found that almost all (98%) of the residents were comfortable with the distances that the humanoid robots were performing (15cm - 40cm). In interview 1 we heard comments such as “hey robot come here” or “that is amazing! look how the robot moves”. Conversely I had less positive responses in interview 3 when D45 tried to navigate closer to individuals. Comments were issued such as “what kind of machine is that?” or “is it really safe?”. Proxemics is therefore likely to change according to the individual’s cognitive and physical capabilities but also with the type of robotic aesthetics presented to vulnerable groups. Similarly the notion of FOV could become determinant in such HRIs e.g. having a robot performing in front, back or sideways of a user might be perceived differently. In the case of the humanoid robots (87%) of the individuals preferred to have a robot on their site instead of working behind them.

6.2.3.3. **Cognitive decline**: Lastly safety in SARs could not be confined solely to physical safety. When working with elderly groups researchers must aware of the sensitivity of such groups and thereby selecting the right SARs delivering schemes seems crucial. As an example in the robotic workshops (interview 3) we already experienced some preliminary notions of robotic animals' attachment that need to be considered in the category of cognitive decline. Scenarios were common where female participants were asking for the robotic cats or seals and wanted to keep the robotic animals for longer periods of time. Comments were made "when we will have the cats?" or "do you bring the seals today?". In certain cases female participants were even reluctant to give the robots back and we had to gently justify that this was a group exercise.

Cognitive decline occurs naturally throughout ageing however the effects of incorrect levels of SARs exposition are still unknown. At this stage we have to try to understand and balance the advantages and dangers of SARs and adapt our delivering methods to best serve elderly groups.

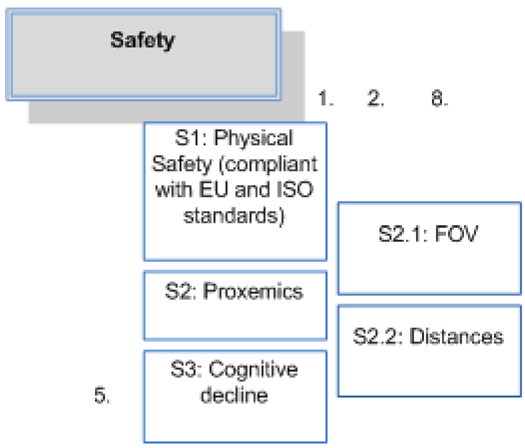

FIGURE 23 - SAFETY

6.2.4. Imitation

Imitation (**figure 24**) is directly related to the aesthetics of robots. However aesthetics is a complex issue that could involve anthropomorphism, zoomorphism, colours, ergonomics and scale. Aesthetics could become a combination of the previous elements and take different configurations that are applied into different robotics scenarios. Within SARs we might not need any anthropomorphism, or need to achieve only a few notions in order to transmit credibility and comforting interfaces when advising for example elderly people during their daily tasks. During the robotic workshops we presented robots with different types of aesthetics. The humanoid robots resembled an anthropomorphic figure with head, arms, torso and legs. During the interviews we made comparisons with pictures of more and less anthropomorphized robots. Elderly participants tend to prefer the more robotic look but still maintaining the basic anthropomorphic elements of head, arms, torso and legs. Equally we have tested several colours associated to the humanoid robots and the elderly participants did in fact respond positively to the different colours presented. Such fact points to the possible personalization of colours to reinforce HRIs. Another important qualitative element dealt with the fact that the elderly participants asked for bigger robots. Comments were made in interview 1 “do, you have bigger robots?”. It seems the result of the HRI was positive but somehow the elderly did expect a different notion of scale associated to the humanoid robots. According to ethical principles of beneficence, non-maleficence aligned with social care ethos we found that the benchmark of imitation encompasses important notions of aesthetics. From the concept of aesthetics we did found that scale played an important role. Similarly ergonomics could become determinant in SARs. We believe the elderly perception of SARs aesthetics is crucial to build pleasant interactions that can benefit their care. Additionally non-maleficence highlights the notion of not harming elderly individuals. As we saw important considerations must be taken in SARs product design. Aesthetics should be balanced to achieve good levels of HRIs with elderly groups. Thereby in the benchmark of imitation we are proposing the following categories and subcategories: aesthetics (anthropomorphism, zoomorphism, hybrid, colours, ergonomics and scale).

6.2.4.1. **Anthropomorphism**: A robot could look more or less like a human being depending on its objectives. Categories may range from non-anthropomorphic to fully anthropomorphic. In the robotic workshops we made comparisons between more anthropomorphized robots and less ones. A majority, (75%) of the residents tended to prefer the more robotic look instead of the android aspect that looks like a human being.

6.2.4.2. **Zoomorphism**: Similarly a robot could become a replica of an animal. Categories may range from non-zoomorphic to fully zoomorphic robots. In the robotic workshops fully zoomorphic robots were used (seals and cats). Interviews 1 and 3 revealed that they were both successfully with elderly groups. Comments included “lovely robots” or “when can we have the cats again?”.

6.2.4.3. **Hybrid**: It is important to retain that the levels of anthropomorphism and zoomorphism depend on the target robotics application and have to be balanced between the advantages and disadvantages emerging from their exposition to potential vulnerable users. In robotics aesthetics hybrid notions could take place and behaviours could result both pleasant and uncomfortable for vulnerable groups. The hybrid category contemplates notions ranging from machine (robotic) aspect associated to more or less anthropomorphic or zoomorphic aesthetics.

It seems aesthetics plays such an important role in HRIs. As an example during the robotic workshops (interview 3) elderly residents expressed comments around the D45 hybrid aesthetics: “what a strange machine”, “is it safe, though…”. There is no complete answer to robotics aesthetics, however the qualitative action of studying a SAR prototype within the proximity of their target groups is a plausible route to establishing desirable aesthetics for a given robotic application.

6.2.4.4. **Colours**: When it comes to colours in interview 2, (56%) of the residents selected the orange and grey colours of the RS Media robot as their favourite set. However we also found that the elderly residents manifested themselves positively when it comes to selecting a colour for their robots. The colours displayed on robots could reinforce the HRI and it could become a personalized element in the future of SARs.

6.2.4.5. **Ergonomics**: Ergonomics could be applied to robotics and the user impression on usability might be influenced by the type of physical structure or adaptability of the robotic system to the user needs.

6.2.4.6. **Scale**: Despite the target robotic application, the machine’s functionalities could be underestimated if there is a reduced or disproportional notion of scale. In interview 1 we had elderly comments such as “have you got bigger robots?” or “small robotic dolls” even beyond the perceived sense of success delivered by the use of such robots.

It seems that aesthetics and scale play a crucial role in HRIs. Such fact led me to add robotic presence in the social success benchmark. Robotic presence could result in the combination between robotics aesthetics and scale.

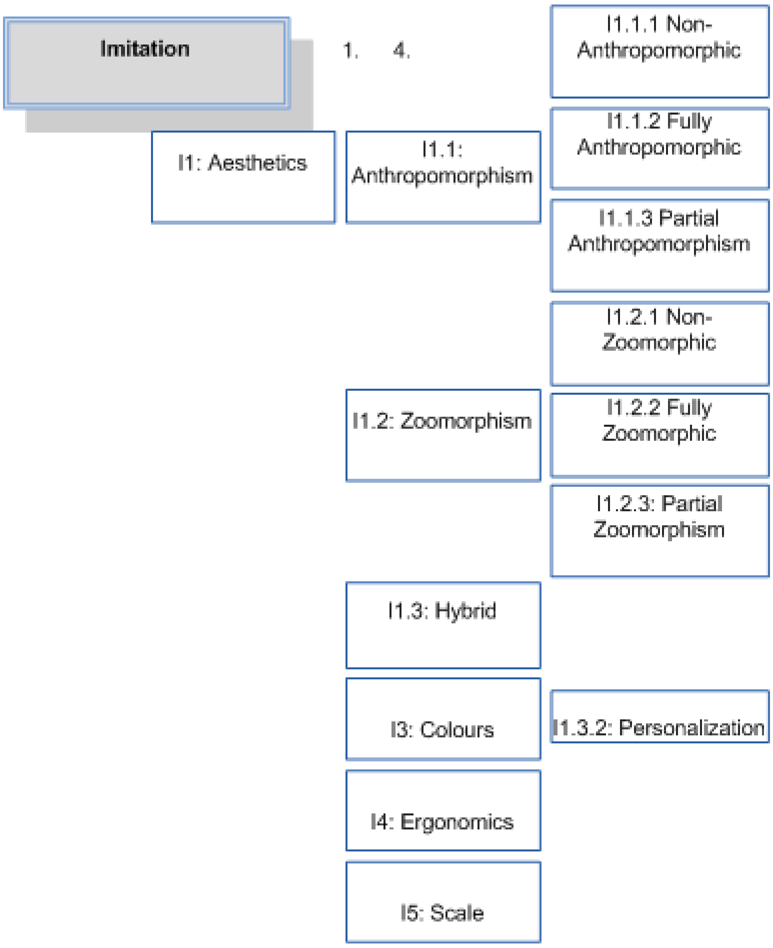

FIGURE 24 - IMITATION

6.2.5. AUTONOMY

Autonomy (**figure 25**) in robotics is a broad subject. In the context of elderly care autonomy could be classified into different categories. In autonomy we wanted to understand the notion of SARs displayed autonomy and how those could be translated in terms of elderly care. We started by investigating the elderly opinions and expectations towards the humanoids and mobile robots autonomous behaviour. We found that the elderly were supportive of such levels of displayed autonomy however the intergenerational contact was very important as well. Comments were typically made across institutions “we enjoy the robots, but we will also like you”, “it is good that you are here…”. During the conversations with staff and relatives we also agreed that the level of displayed autonomy in SARs has to be calibrated according the elderly cognitive and physical limitations. In terms of the ethical principles of beneficence, non-maleficence and autonomy aligned with social care ethos we concluded that SARs displayed autonomy should be incorporated into robots in ways that benefit and not harm elderly groups. Attention should be taken into situations where an elderly person might in pain or suffering so displayed autonomy should stop and wait for the human caregiver input. It is also important to remind that the elderly cognitive capabilities get reduced in time so periodic check-ups should highlight and better inform the role of SARs in elderly care.

A common perspective of caregivers and care receivers is that human contact has to be maintained in the exercise of care. Thereby a crossing between the possible levels of displayed autonomy and supervision schemes that involve human contact must be researched. In the benchmark of autonomy we are proposing the following categories and subcategories: displayed autonomy (autonomous systems, semi-autonomous systems, teleopereated), supervision scheme (autonomous supervision, semi-autonomous supervision, human supervision) and human contact.

6.2.5.1. **Displayed autonomy**: Autonomous systems are robots or devices that can operate fully without human intervention. To date, such type of robots are only used in industrial environments. However, future artificial intelligence developments will allow more autonomy to be implemented in SARs. On the second level I identify semi-autonomous systems which are characterized by the ability to respond autonomously to certain stimulus (inputs) and environments. Such systems are mainly teleoperated by human beings in remote locations however they can also be instructed by task driven objectives which involve a certain level of autonomy (e.g. instructing a robot to clean only a certain area of a room). Lastly we have fully teleoperated systems which are based on human control through a remote location. In the robotic workshops I have used two displayed autonomous categories. In the first example (teleoperation) I controlled the humanoid and mobile robots manually. In the second example the robots performed autonomous manoeuvres under my supervision. In interview 2, we found that most (69%) of the residents preferred to have me controlling the robot as a safety procedure however they also mentioned that they enjoyed my presence and artistic performance. Comments were made “we enjoy the fact that you are here with us”, “robots are amazing, but we also like your presence”. Such perspective reinforces the need for human contact in SARs levels of autonomy. Still in interview 2, (31%) of the individuals also expressed uncertainty and fascination towards the high degree of autonomy that SARs displayed. Comments included “the robot is going to crash” or “wow, it can avoid obstacles”.

6.2.5.2. **Supervision scheme**: As we saw above human contact and human supervision schemes are essential in SARs. In SARs one of the main objectives is to assist vulnerable groups. This topic was debated in interview 2 with staff and relatives. It was discussed that autonomy might need different levels of supervision according to each individual elderly case. So far three possible levels of robotics supervision schemes were identified in the exercise of care. The first one is denominated autonomous supervision which involves a high level of autonomy for monitoring its users. These could include scenarios such as having sensors monitoring human signals and behaviours in real time to be processed by AI algorithms. In essence the machine is completely autonomous when monitoring the patient’s activity and has the capacity to alert the competent authorities if high levels of uncertainty arise or something goes outside the programmed patterns. Next we have the semi-autonomous supervision mode which includes partial supervision of humans by machines and partial supervision by human carers. Such manifestations could include robots and devices that monitor walking gaits or detect user “falls” etc. On the other hand these are robots that can be remotely operated to supervise and interact with vulnerable groups through a machine interface that includes the robot itself. The same scheme includes e.g. regular carer (physical) visits to check if an elderly user is feeling comfortable or needs extra assistance. This is likely to be the direction that SARs will be taking during the next decades. Lastly we have the current human supervision model (non-robotic, 100% human) deployed in care and extra care facilities worldwide.

6.2.5.2. **Human contact**: despite the identified categories of displayed autonomy and supervision schemes human contact is of primary importance. In interview 2 we proposed that human contact should be agreed by the assessment panel that supervises HRIs. Similarly during interview 2 elderly residents’ comments included “we enjoy the fact that you are here with us”, “robots are amazing, but we also like your presence”. Such perspective reinforces the need for human contact in SARs levels of autonomy.

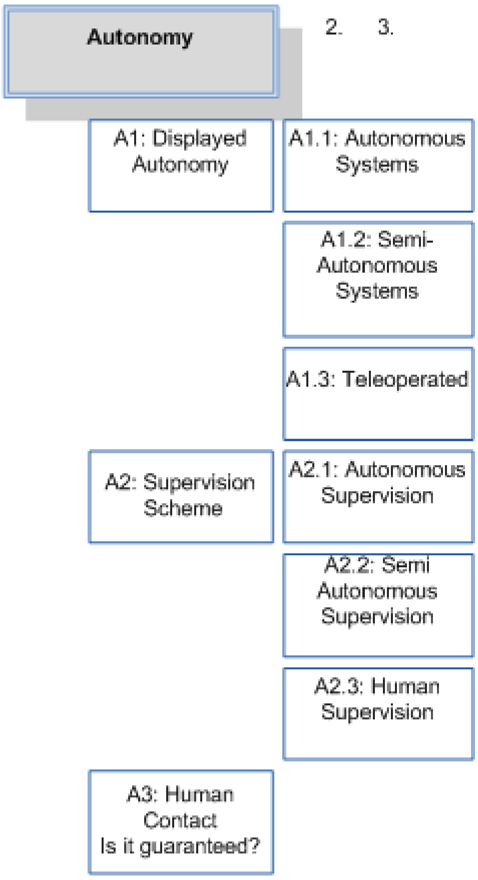

FIGURE 25 - AUTONOMY

6.2.6. SOCIAL SUCCESS

In social success (**figure 26**) we are looking to potential qualitative elements that can build and reinforce the success of HRIs with elderly groups. The first point is to try to understand what is the objective of such HRIs with elderly groups and what are the possible emerging questions (advantages and disadvantages) arising from those. In terms of users responses we started by analysing if the elderly did preferred listening music from a robot or a classical radio. They did prefer the robot however issues were raised relative to the quality of the audio on the robot itself. An enquiry was also made relative to the use of more or less robotized voices. The elderly preferred the more robotized voice used in the humanoid robots.

Equally important was to understand the users' body language when the researcher gave a retrieve a ball from the robot in close proximity of the elderly. We found that the elderly were not afraid of the robots and were in fact supportive of close HRIs. In terms of personalization elements we did investigate if the elderly were supportive of uploading their favourite songs to the robots (or have someone that could do it for them). The response was positive. On the same line it is important to mention that ethnographic considerations did play an important role in defining the content to be programmed into the humanoid robots. Across the 5 different institutions investigations were made relative to language, songs and jokes that could be programmed into the robots. Thereby such qualitative elements are likely to reinforce the outcome of the HRI. In terms of cognitive assistance we demonstrated potential scenarios where a SAR reminds the elderly about their medications and daily tasks. The elderly were supportive of such actions.

In social success we found that the notion of robotic presence could become determinant for the outcome of the HRI. In the D45 workshop elderly participants were doubtful about the potential of such robot. D45 had no significant aesthetics work and didn't had any anthropomorphic elements. In interview 3 comments were addressed "what strange machine is that". It was clear that D45 didn't achieve the notion of robotic presence among the audience. Conversely on the humanoid robots workshops they were programmed specifically to entertain elderly groups by performing choreographies and playing music. They were successful however the notion of scale could reinforce their robotic presence. In interview 1 comments were made towards the size of the robots "do you have bigger robots?".

On the robotic animals sessions robotic seals and robotic cats were used as relaxation exercises for the elderly. We did found that in the case of the robotic animals the notion of robotic presence was completely achieved. The elderly seemed to interact and engage well with the robotic seals and cats. Such success even led to situations where female participants were reluctant to give the robots back. In interviews 2 and 3 comments were common "when we will have the robotic seals" or "you can leave the cats with us until next week". Thereby considerations must be taken in terms of any signs of attachment between the elderly groups and SARs. We believe the calibration and supervision of HRIs plays a key role in the robotics exercise. It is important also to remind that the methods used to deliver SARs are important. Prior to the interactions we should try to synthesize the objectives of such interactions and how to better deliver such interactions to vulnerable groups. Elderly people often suffer from physical and cognitive limitations in which new forms of motivation and activities need to be performed by presenters and researchers when conducting HRIs.

In terms of the ethical principles of beneficence, non-maleficence and justice aligned with social care ethos we found that the humanoid robots and robotic animals' exercises were activities that contributed to build a new qualitative dimension aligned with the beneficence of elderly groups. Equally important is to consider the dynamic of HRIs as elderly groups often lack of motivation. Thereby the content programmed into SARs and the presenting methods are absolutely crucial elements to consider. In the non-maleficence principle attention should be directed to any signs of “attachment” towards SARs. We believe the exposition of vulnerable groups to such SARs technologies is possible but it needs constant supervision schemes. In terms of the ethical principle of justice if such SARs technologies could be used in the future it is important to address questions around the access of such technologies to the highest number of people. In social care ethos it is important to remember that people behaviours, opinions and expectations towards SARs can translate important qualitative elements to reinforce the nature of HRIs.

In the benchmark of social success we are proposing the categories and subcategories of: type of robotic application delivered and emerging questions, users’ responses (body language, confidence, level of communication and socialization), personalization elements, robotic presence, attachment, ethnographic studies and methods used to deliver SARs.

6.2.6.1. **Type of robotic application delivered and emerging questions:** Initially we have to clarify the type of robotic application used and what is the main objective in terms of HRI. This exercise is likely to reveal potential questions and answers that we want to expand through the form of existing HRI benchmarks. It seems the simple answer of “yes” or “no” doesn’t include enough extension for understanding some of the emerging challenges of SARs.

6.2.6.2. **Users’ responses:** social success in SARs has to try to explain why, how and when social success seems to be valid. Thereby the mechanisms by which we can qualitatively and quantitatively measure the results of HRI have to be yet researched. Such mechanisms could include analysing users’ responses in terms of body language, confidence, level of communication and socialization displayed during HRIs. It is important to stress that independently from the level of autonomy displayed and autonomous supervision schemes there are several stakeholders involved in SARs (user, robot, human supervisor (carer)). As we saw in interview 2 it is recommended that the supervised HRIs be analysed in conjunction with an assessment panel which could be formed by e.g. researchers, staff and families. Beyond that it is also important to retain the notion of content programmed and personalization in SARs. Such balance could make the HRI more or less successful. As we saw in interview 2 there are elements in HRIs such as colours or voices played that could become personalizable and contribute for higher levels of immersion during the interactions.

6.2.6.3. **Robotic presence:** Robotic presence is a result of how well imitation is perceived within SARs however it is also dependent on the aforementioned human responses resulting from the robot's behaviour. In elderly care, people are less likely to interact with SARs that do not transmit any sense of technological presence e.g. robots full of wires. This was particularly true in interview 3 when D45 was demonstrated to the elderly. Comments were made "strange machine" or "are you sure it is safe?". Conveying robotic presence in SARs is equally related on how well the human machine interfaces are available to a user and the generic HRI experience is perceived.

6.2.6.4. **Attachment:** social success could become successful but also develop notions of attachment on individuals. During the robotics workshops we identified notions of attachment when it came to the robotic animals activities. Especially in interview 3, elderly residents were constantly commenting "when we will have the robotic cats?" or "you can leave them with us". Also their body language traits demonstrated high levels of connection with both seals and cats and in some cases they were reluctant to give the robots back.

6.2.6.5. **Ethnographic studies informing SARs content**: social success also derives from the content programmed into a SAR. Thereby ethnographic studies could contribute to the overall result of SARs if there is affinity between man and machine.

6.2.6.6. **Methods used to deliver SARs**: lastly the methods used to conduct robotic activities with the participation of vulnerable groups have to be weighted also. Researcher and staff worked together towards the social success (interviews 2 and 3) of the robotic workshops. The presenting methods seemed to work well with vulnerable groups. As an example theories of communication (Cohan and Shires 1996) and groups dynamics (Lewin 1947) become extremely relevant to read the audiences responses and to adapt the presenter scheme, skills and robot behaviour for selecting the best approaches to deliver SARs with elderly groups.

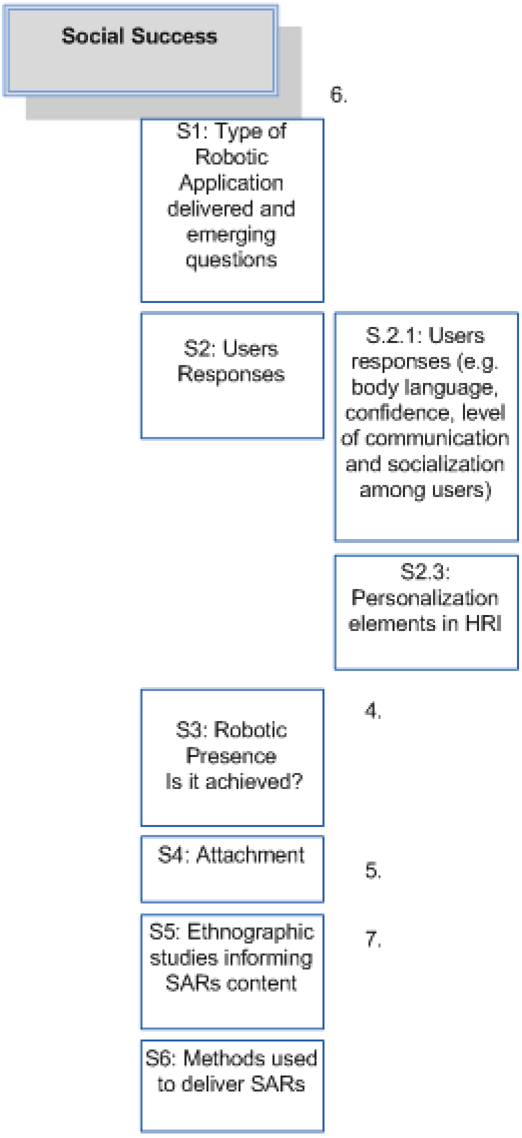

FIGURE 26 - SOCIAL SUCCESS

6.2.7. Understanding of domain

Understanding of domain (**figure 27**) deals with the need for SARs to perceive the social dynamics around them. However to date such interpretation is still too futuristic as robots can't detect accurately situations where an elderly user is in pain or suffering.

During the robotic workshops we were interested in understanding if the elderly really understood the message transmitted by the robots. Through the interviews we found that the elderly participants understood the general idea of the workshops. The humanoid robots, robotic seals and cats were perceived as entertainment activities. When it came to ROVIO and D45 the elderly understood that such robots are being developed for providing medication, task reminders and telecare applications. In terms of the ethical principle of non-maleficence aligned with social care ethos it is important to remember that to date SARs levels of care are nowhere comparable to human care. On the same line it is crucial to check if the elderly users really understand the message delivered by SARs. Scenarios such as medication reminders are crucial "does the person really understands which medication to take and the timing?". Thereby social care ethos plays an important role in listening to people's voices and understanding their real perceptions towards SARs.

In the benchmark of understanding of domain we are proposing the categories of perceived message and robotics understanding and adaptation to different users and environments.

6.2.7.1. **Perceived message**: questions such as: is the message delivered by a robotic system equally perceived by vulnerable groups? And is such message continuously perceived with aging, e.g. if a robot reminds someone to take their medication at a certain hour of the day does the person really understands that message? This involves human supervision and the delegation of such analysis to an assessment panel. During the robotic workshops we simulated some medication scenarios where a robot would remind people to take their medication. From the results in interview 3, (97%) of the residents grasped the meaning of having a machine reminding them about their medications, daily tasks and access to telecare.

6.2.7.2. **Robotics understanding and adaption**: following Feil-Seifer's perspective the robotics understanding and adaption deals with the futuristic capability of SARs to identify and adapt themselves to different human scenarios (e.g. social dynamics) and changing environments.

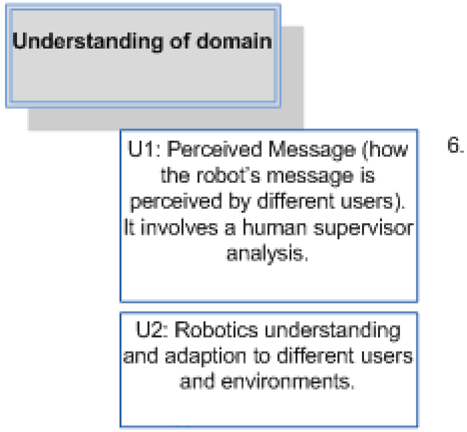

FIGURE 27 - UNDERSTANDING OF DOMAIN

6.2.8. SCALABILITY

In scalability (**figure 28**) we wanted to understand the role of SARs interfaces in HRIs. SARs are likely to offer different interfaces that could be adapted to different users' requirements and circumstances. During the robotic workshops the interfaces demonstrated during the humanoid robots, mobile robots and robotic animals were well received. In the humanoid robots and mobile robots caregivers had the opportunity to control both the humanoids and the mobile robots in real time. In interview 3 they didn't report any usability issues when operating the robots and comments were made "if possible we would like to control these robots in the future". Equally important is to highlight that SARs are currently being tested mainly in robotic labs and controlled environments. A question arises relative to the validity of such interactions with human participants. In the case of this research we conducted "in-situ" robotic workshops which translated a richer set of qualitative elements. Therefore scalability deals also with the adaptability of SARs interfaces to different users' requirements and spaces. Additionally we found that scalability might also deal with understanding cultural traits Kitano (2006) particular to the audiences and regions where HRIs take place. As Lyman and O'Brien (2003) mention the transmission of culture is complex and could be manifested in many forms. For earlier anthropologists such as Boas (1907) cultural traits represented observable elements of human culture that could be defined broadly enough to be comparable across cultures on a global scale, but were not restricted to any specific domain of culture. However as Lyman and O'Brien (2003) mention the lack of consensus towards the theoretical concept of "cultural trait" is aggravated due to the scale versus comparability of the concept. In current anthropology cultural traits are being studied as units of cultural transmission with possible properties that can be analytically discussed and considered in cultural evolution. To help conceptualize some of the cultural traits properties as units of transmission Lyman and O'Brien (2003) suggest that cultural traits could be expanded "into smaller parts" by giving the example of a "recipe" that involves ingredients and rules in its conception. At the heart of this discussion is the comparability nature that cultural traits carry across different cultures. It is important to recognize that despite the wide range of examples cited as cultural traits e.g. dialect, stories, songs, habits, skills, inventions those are transmitted from person to person or from culture to culture which brings important considerations to the domain of SARs. On the same line of thought in the context of this thesis we will consider cultural traits as dialects, songs or jokes that can reinforce the outcome of HRIs. As a result in UK and Portugal we have programmed the humanoid robots with such elements. The experiences proved to be successful and no differences were found in terms of users' responses in UK and Portugal. It is likely that we will need a new category in scalability to consider cultural elements that can be programmed in SARs.

In terms of the ethical principles of non-maleficence, autonomy and justice aligned with social care ethos it is important to highlight that more research is needed in care environments. The setups and assumptions recreated in robotic labs and dedicated scenarios are not likely to translate the real ethical issues arising from the contact between SARs and elderly groups. In terms of non-maleficence it is important to remember that to date the level of care depicted in SARs is nowhere comparable to the level of human care. So it is important to acknowledge the potential advantages and dangers arising from HRIs with elderly groups. In terms of the ethical principle of autonomy attention is needed with the type of robotic interfaces provided to the elderly groups and how those can be adapted to different users' requirements and circumstances. Such selection of interfaces could influence the elderly decision towards having or not having SARs to complement their care.

The investigation of potential cultural traits that can reinforce the outcome of the HRI should be considered and social care ethos plays an important role in understanding potential users' responses. In the benchmark of scalability we are proposing the categories of adaptability of robotic interfaces to different users and spaces and cultural elements.

6.2.8.1. **Adaptability of robotic interfaces**: the use of different interfaces that can match users' requirements could be a direction to follow. During interviews 1,2,3 we didn't found any differences in terms of elderly responses in UK and Portugal.

6.2.8.2. **Cultural elements in SARs**: scalability is inherently related with cultural elements arising from deploying robots in different cultures. Cultural traits such as dialect, music and jokes could contribute to reinforce the outcome of the interaction between SARs and elderly groups. As an example the humanoid robots were programmed with local dialect, songs and jokes both in UK and Portugal. It is likely that ethnographic studies could help to understand the content delivered by SARs and the interfaces displayed in HRIs.

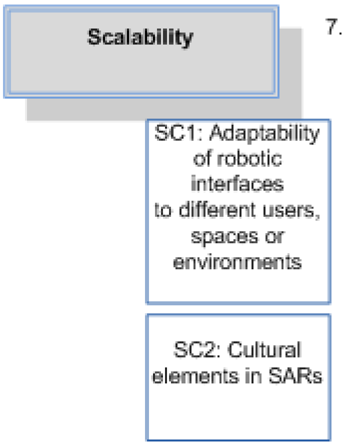

FIGURE 28 - SCALABILITY

6.2.9. Robotic information system

As we saw in privacy, SARs information systems and privacy are currently one benchmark. However that might not be case. In this research we separate robotic information system (**figure 29**) from privacy. In privacy we were primarily concerned with the identifying sources that are possible in supervision routines (e.g. video/audio). In robotic information system we are considering the elderly sensitive information that researchers, caregivers or robotic operators can have access to program in SARs. Sensitive information such as medications lists, tasks, medical history or financial background raises questions such as: who can access the elderly sensitive information and what are the elderly users' safeguards?. During the robotic workshops we interviewed the elderly on this topic. We found that the elderly participants were positive about providing their personal details, medication lists and daily tasks to caregivers to program them into the robot. When it comes to the ethical principles of beneficence, autonomy and justice aligned with social care ethos we should consider the challenges around dementia and Alzheimer. Assistive technologies such as SARs need to be developed to cognitively assist elderly groups. The introduction of SARs can provide benefits to elderly people by reminding them about their medications and daily tasks. However the ethical principle of autonomy also reinforces the right to make decisions about personal levels of care. According to this research such crossing is possible. However it is important to retain that social care ethos plays an important role in communicating and reading people's attitudes towards SARs. Access to sensitive information has to be carefully approached and must constitute a vehicle for promoting the wellbeing of elderly groups. In the robotic information system benchmark we are proposing the category of access to information.

6.2.9.1. **Access to information**: access to information addresses questions such as: what information does a robot programmer or robotic system has the right or privilege to obtain, in which conditions and safeguards? How and when information can be accessed and used? We are primarily dealing with users' personal information that can be provided to caregivers and robot operators for enriching HRIs.

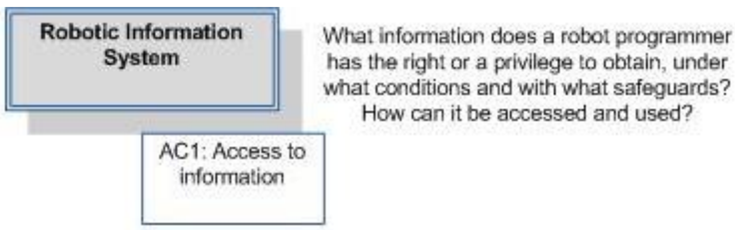

FIGURE 29 - ROBOTIC INFORMATION SYSTEM

6.2.10. PRIVACY

In privacy (**figure 30**) we were interested to investigate the current level of privacy involved in SARs supervision of elderly groups. In privacy there is a fuzzy barrier between the access to sensitive information and identifying sources. In this research we believe privacy is more related to the identifying sources available during SARs supervision of vulnerable groups such as the elderly. Thereby during the interviews we found that the elderly were supportive of contacting their GPs or caregivers through a robot itself. The notion of supervision through telecare was demonstrated with ROVIO and D45. Relatively to having a SAR patrolling common areas or following people in care homes (e.g. lounge, corridors) the elderly participants were supportive of such actions. However when it comes to personal medication reminders and remote assistance some issues were raised relative to the location where such monitoring takes place. Comments were issued the "the bedroom isn't really a choice because of dressing and privacy issues". It seems we will need different types of privacy associated to the use of SARs in elderly care. Such categorization might be associated with the nature of the supervision sources: active, passive or hybrid. Equally important in privacy is the notion of traceability in situations where SARs can trigger alarms for example when an elderly person might need help. Due to the sensitive nature of supervision it is likely that we will need operational and user logs to be able understand what is happening in the context of the robot internal system and what the human expected behaviour is. It is likely that such information must be encrypted and protected from unwanted access.

In terms of the ethical principles of beneficence, autonomy and justice aligned with social care ethos the supervision methods and cognitive characteristics of SARs are being developed towards the benefit of the elderly. It is also true that such technologies raise ethical issues around supervision versus privacy. The ethical principle of autonomy reinforces the elderly right to make their own decisions about care. Thereby in social care ethos it is important to read peoples' concerns and suggestions. The exercise of investigating privacy has to be guided towards listening and advising elderly groups when it comes to select their own levels of privacy. Thereby in privacy were are proposing the categories and subcategories of type of privacy (active, passive, hybrid, location of such interactions), traceability, operational logs, user logs and encryption methods.

6.2.10.1. **Type of privacy**: active privacy deals with scenarios where the user agrees to concede permission to be filmed or recorded by a robot for purposes of autonomous supervision and semi-autonomous supervision modes. Active privacy uses active and real time media sources audio/video that are processed by a machine to trigger actions. On the other hand passive privacy deals with the use of passive sources to determine the same type of actions. Passive privacy encompasses the use of sensing inputs that are not related with the direct identification of the human user. Examples range from sensing individual biological data to 3D silhouettes collected during the normal life of vulnerable groups. Hybrid privacy is a mixture of both active privacy and passive privacy where passive and active sources are processed by a robot. In all three privacy categories there is a common question related to the location (physical space) where such robotic supervision takes place e.g. living room, kitchen, corridor etc. As an example during interview 3, elderly residents issued comments such as "the bedroom, isn't a good location for a robot", "maybe the lounge will be better".

6.2.10.2. **Traceability**: traceability is a complex area that needs to be weighed against the advantages and disadvantages in SARs. The ability of a robotic system to trace the location of human users is something that has to be previously agreed (e.g. robotic license agreement) by its potential users or supervising teams.

6.2.10.3. **Operational logs**: Due the high complexity of robotic systems and inherent liability it is important to have log systems on all A.I decisions.

6.2.10.4. **User action logs**: Similarly it is important to have log systems on all user deliberate actions.

6.2.10.5. **Encryption methods**: Wireless communications in robotics, security protocols and encryption methods are essential to be updated for guarantying users' information and privacy.

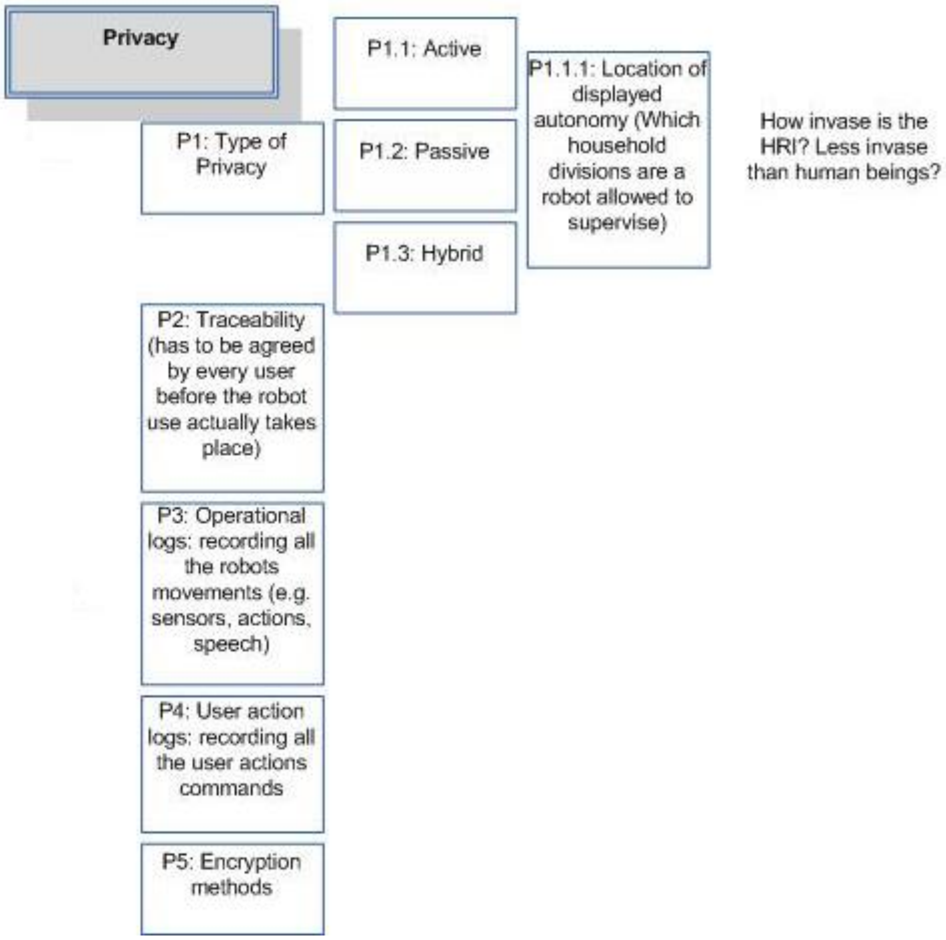

FIGURE 30 - PRIVACY

6.2.11. Usability testing

In usability and testing (**figure 31**) we reinforce the notion of testing SARs. Usability and testing could cover extensive testing exercises to see if SARs comply with safety procedures. Prior to the robotic workshops all the robotic platforms involved in this study were extensively tested. It is important to highlight that robots are complex machines involving electronics, mechanics and software. Any emerging faults both on hardware, ergonomics or software could influence its counterpart and the whole robot might not work as expected. Thereby we will probably need functional testing phases associated to the life cycle of SARs. Because SARs family is broad it is likely that interfaces and usability will play crucial roles. It is important to assure that staff and users who deal with SARs have enough preparation/training to do so. Thereby we will probably have a learning curve associated to SARs usability.

In terms of ethical principles of beneficence and non-maleficence aligned with social care ethos it is important to highlight that usability and testing works towards the benefit of HRIs. Functional testing is a crucial phase for identifying product design issues that can be dangerous for elderly users. As part of non-maleficence it is important to highlight the staff training that should occur prior to HRIs. Lastly in social care ethos it is important to reinforce the notion of reading people's attitudes and expectations when it comes to SARs usability and outcomes of HRIs. Thereby users HRIs observations and interviews are important qualitative elements that can reinforce the quality of care. In the benchmark of usability and testing we are considering the categories of functional testing, potential users' HRIs observations and interviews and learning curve.

6.2.11.1. **Functional testing**: an exhaustive functional testing of a robotic device is required as such phase can identify emerging product faults and improve product design and user safety.

6.2.11.2. **Potential users HRIs observations and interviews**: it is recommendable to test the emerging robotic prototypes in conjunction with their target groups. Such testing isn't solely a functional perspective, but indeed a qualitative journey to users' impressions and relationships formed with such type of robots that could dictate new requirements and safeguards for better robotic products and human experiences. As we saw during the course of this research, users' impressions, attitudes and expectations were crucial to uncover ethical issues that can be addressed in the research and development stages of SARs.

6.2.11.2. **Learning curve**: an important aspect to consider in robotics usability testing deals with the learning curve of the available robotic user interfaces. A SAR must become a pleasant experience to use in different scenarios including teleoperation, autonomous and semi-autonomous supervision schemes. In interview 3 we looked to how carers could adapt themselves to some of the existing robotic interfaces (humanoids and mobile robots). In the case of the humanoids and mobile robots the usability experiences were positive with comments such as "yes I can control one of these", "yes I would like to do it in the future".

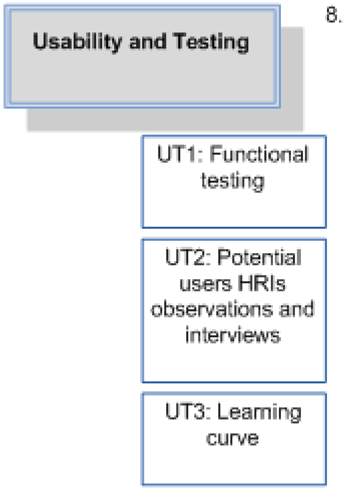

FIGURE 31 - USABILITY TESTING

6.2.12. LIABILITY

Although this study doesn't research specifically into the topic of liability (**figure 32**) we believe that at the overall it can contribute to better understand some of the liability issues involved in SARs. Due the complexity of SARs it is likely that we will need the creation of a robotic user license agreement. Such document could specify items such as the manufacturing guarantee, the conditions in which the device has been tested and warnings or disclaimers about the improper use methods that can compromise users' safety. On the same line it is likely that SARs residual risks and misuse are no different from other technologies that humans have been dealing with in the past. Thereby user liability should be contemplated by law. As SARs are likely to use wireless points and internet connections, devices and protocols should enforce the integrity of data transactions and the privacy of robotic users. Due the role of SARs in care, unwanted access or control of such robots by non-authorized personnel should be considered by law. As other types of sensitive technologies SARs are likely to involve insurance policies. Such agreements will consider a wide range of unexpected outcomes and risks derivated from the use of SARs. In terms of the ethical principles of beneficence, non-maleficence and justice aligned with social care ethos it is important to highlight the seriousness involved in SARs interactions. Liability in SARs has to be well informed both by manufacturers and developers, care staff and elderly users. Such exercise works towards the beneficence of manufacturers', caregivers and care receivers. It is equally important to highlight the notion of not harming vulnerable groups with the use of

SARs technologies. Such guarantee is far from certain but the ethical principle of non-maleficence should be part of SARs development and life cycle. Lastly it is important to address the need for more communication and information of elderly groups towards the potential use of assistive technologies in their care. Social care ethos reinforces the link between caregivers and care receivers by listening to people's concerns and expectations towards the first generation of SARs. In the benchmark of liability we are considering the categories of manufacturing guarantee, user liability, robotic system hacking and third party liability and insurance.

6.2.12.1. **Manufacturing guarantee**: Manufacturing guarantee must be presented to SARs users. It states manufacturers and users responsibilities. However due to the complexity of a robotic system, liability on manufacturing is likely to include agreements, risk analysis and possibly insurance policies.

6.2.12.2. **User liability**: It is crucial for users to understand their role in HRIs. Being able to understand responsibilities and how robotic systems work (usability) is essential. Informed consents are possible forms of acknowledgement, where signatures (physical or digital) could be collected.

6.2.12.3. **Robotic system hacking**: Hacking attacks and unwanted robotic control could become problematic and dangerous for human users. Such attacks have to be contemplated by law and prosecuted in terms of liability and torts.

6.2.12.4. **Third party liability and insurance**: because there is a residual risk in SARs it is likely that we will have insurance systems to delimitate both manufacturers' and users' responsibilities. Such insurance areas will need to use roboethics guidelines and frameworks for helping deciding the level of risk involved into different SARs applications.

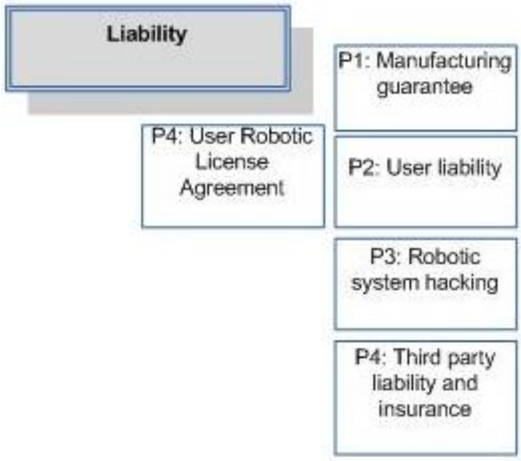

FIGURE 32 - LIABILITY

6.3. HRI BENCHMARKS DIAGRAM

This section presents a new HRI benchmarks diagram (**figures 33 and 34**). We also present possible relationships between the identified HRI benchmarks.

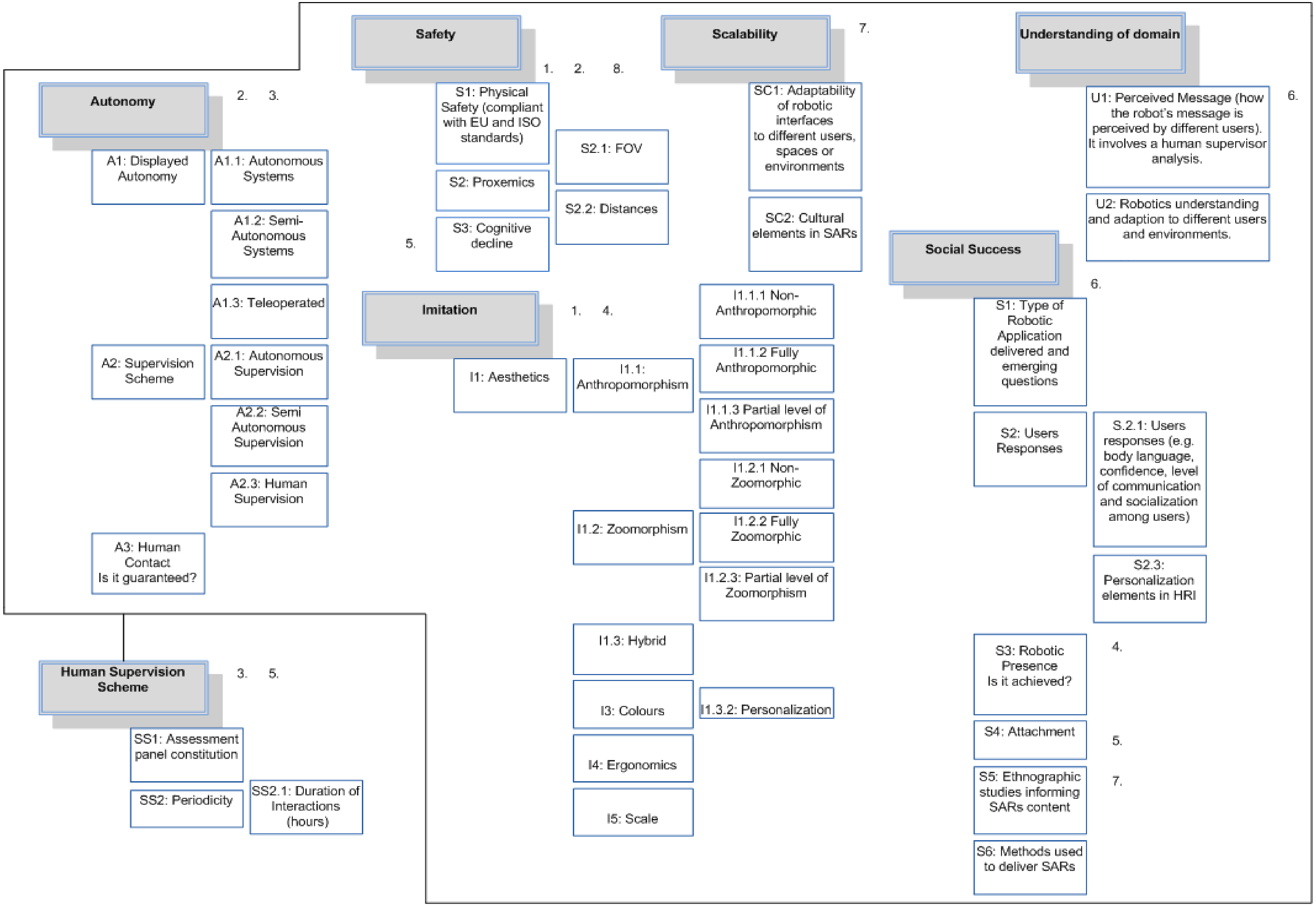

FIGURE 33 - HRI BENCHMARKS DIAGRAM

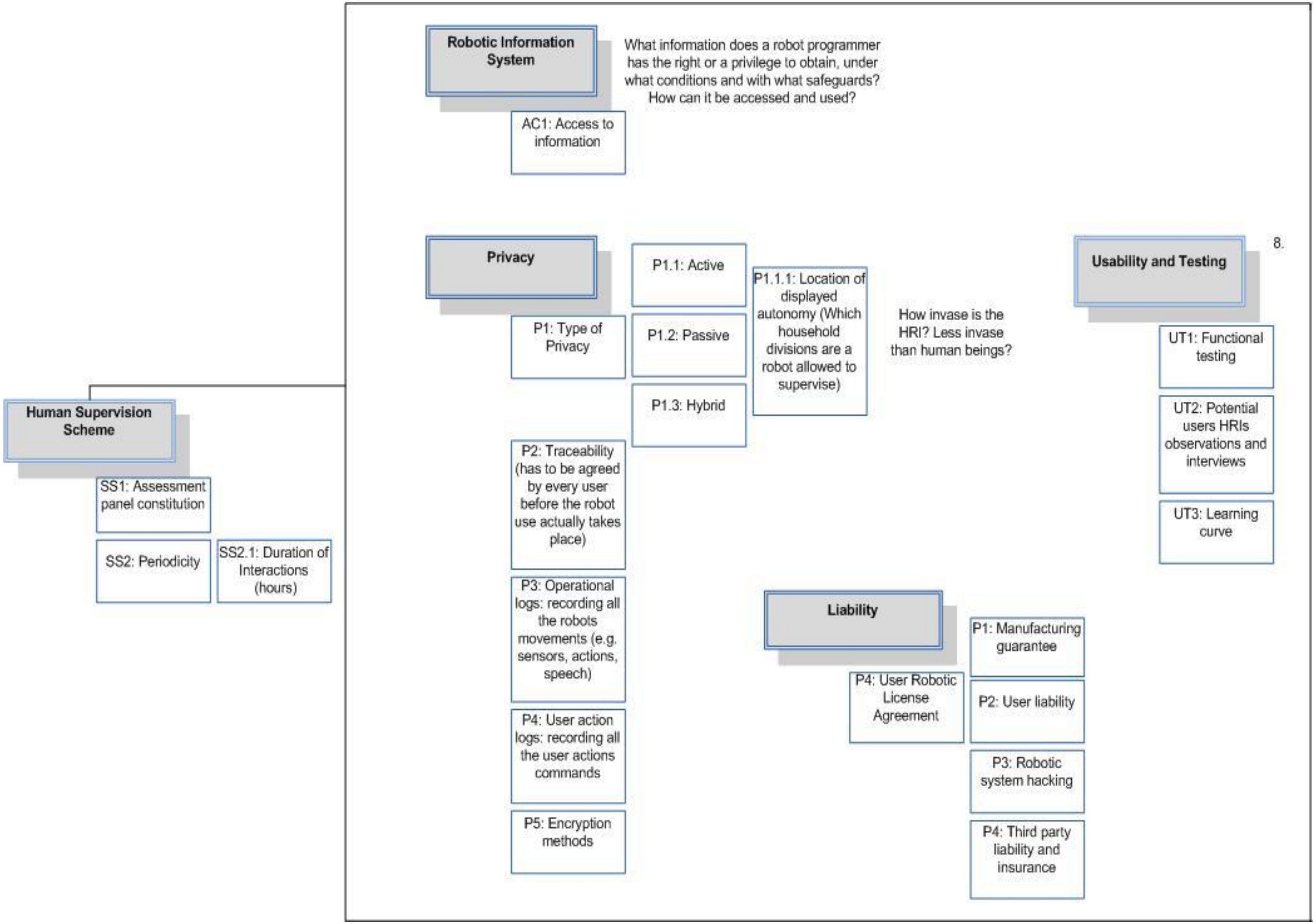

FIGURE 34 - HRI BENCHMARKS (CONTINUATION)

6.4. HRI BENCHMARKS EMERGING RELATIONSHIPS

Beyond the reframed HRI benchmarks possible relationships between them are identified. In this section we will highly some of the emerging HRI benchmarks relationships identified during the course of the robotics workshops. Such relationships emerge from the three case studies presented in chapter 8.

The HRI benchmarks relationships can be identified in the visual diagrams by following a subscript scheme 1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 7-7, 8-8. In the following example (**figure 35**) autonomy has a subscript of 1 and safety as well. This means there is a relationship between autonomy and safety. The same scheme applies for the remaining subscripts.

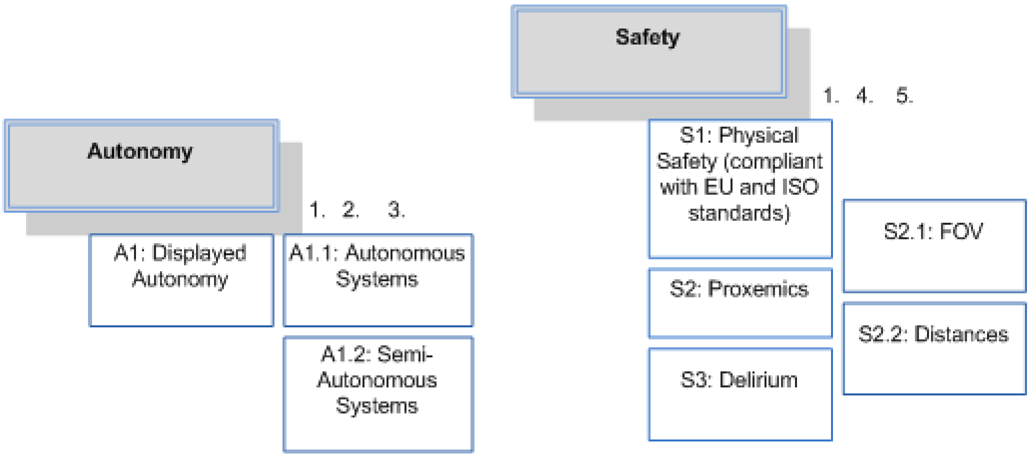

FIGURE 35 - HRI BENCHMARKS RELATIONSHIPS SUBSCRIPT SCHEME

6.4.1. IMITATION - SAFETY (1)

It is important to notice that the perceived notion of safety could be influenced by the type of aesthetics that is present on a SAR. During the robotic workshops elderly people engaged easily with the humanoid robots. Ninety eight percent (interview 1) of the people mentioned they were comfortable with the robots presence and aspect. Comments were common "hey robot come here!", "funny machine look how it is moving". However in interview 3 we detected less positive levels of engagement towards D45. Elderly people commented the strange aspect of the robot. Comments included "what a strange machine", "is it safe". The fact that D45 has no significant aesthetics work (e.g. full of wires) influenced peoples' perspectives towards the robot itself. This is an important relationship to retain since robotics technological capabilities could be easily dismissed if for example aesthetics in imitation isn't well calibrated.

6.4.2. Autonomy - safety (2)

There is always a residual risk associated with the displayed autonomy on a robotic system. A robot is designed for certain tasks and environment conditions however hardware malfunctions, software glitches and user misuse could contribute for reducing robot safety.

As an example during the robotic workshops in interview 2, (31%) of the elderly individuals expressed both fascination and uncertainty towards the high degree of autonomy that SARs displayed. Comments typically covered "the robot is going to crash!" or "wow, it can avoid obstacles". It is important to retain that the displayed autonomy encompasses advantages and disadvantages that could influence the users' notion of safety during the use of SARs. Demonstrating those to your potential SARs vulnerable users and registering their responses is essential.

6.4.3. Autonomy - human supervision scheme (3)

During the robotic workshops we saw that human contact is essential in autonomy. In interview 2, (69%) of the residents preferred to have me controlling the humanoid robot as a safety procedure however they also mentioned that they enjoyed my presence and artistic performance. The residents commented "we enjoy the fact that you are here with us", "robots are amazing, but we also like your presence". Such perspective reinforces the need for human contact in SARs levels of autonomy. The same point was expressed as care staff and relatives mentioned human contact is essential; "we can't let elderly people fully dependent on technology and robotics (even if it is technically possible)". So there is a relationship between the levels of displayed autonomy, supervision scheme and human supervision scheme. As we saw human contact is essential to be considered in SARs autonomy however it is also important to decide what level is being delivered. So there are two important questions: first, who provides and has the responsibility for human contact and secondly who inspects and measures such levels of human contact being delivered to elderly groups.

6.4.4. Imitation - robotic presence (4)

We previously saw that imitation is related with aesthetics of robots which include notions of anthropomorphism, zoomorphism, colours, ergonomics and scale. A balance between all these elements could translate the sense of robotic presence. In interview 1 we found that (98%) of elderly people engaged well with the humanoid robots but some comments were addressed on the scale of the robots e.g. “do you have bigger robots?”. It seems robotic presence could be improved if scale is reconsidered.

However it is important to remember that in interview 3, D45 was less perceived by people. Comments included “strange machine”, “is this robot safe?”. D45 had no aesthetics work, measured 70cm height, moved autonomously but it didn’t translate a notion of robotic presence. Elderly people were not fascinated and willing to interact with it as they did it with the humanoid robots activities. Robotic presence is by its nature derived from social success and intrinsically related with the perceived human experiences during HRIs.

6.4.5. Human supervision scheme - attachment (5)

In social success we analysed the “success” of the robotic workshops. In interview 3 promising results were identified by carers and relatives especially when it comes to the dynamics of the robotic show. The reduction of boredom and the increasing communication among elderly groups are results that are important to consider. It is also true that in the robotic animals’ sessions some of the elderly residents expressed what it seems to be a notion of attachment towards the robots used. The robotic seals and cats triggered comments on some female participants such as: “lovely robots”, “you can leave them with us until next week”, “when we will have the cats?”. Such comments were even more noticeable when people were reluctant to give the robots back. It seems the methods to deliver the robotic activities have to be well planned and good levels of human supervision are necessary to monitor any eventual attachment phenomena. Similarly human safety issues could occur on a psychological level with robotics influencing behaviours associated to cognitive decline. When working with emotionally sensitive groups such as the elderly close supervisions are important to be agreed and maintained.

6.4.6. Understanding of domain - social success (6)

In understanding of domain it is absolutely important to retain the idea of perceived meaning. When delivering robots with vulnerable groups we have to closely supervise HRIs. During interview 3 we demonstrated potential scenarios where a robot advertises someone to take his/her medication. Responses were positive with (97%) of elderly individuals supporting such action. However in future SARs assistive scenarios it is crucial to ask the following questions: is the group of people involved in HRI perceiving the message that a SAR is trying to deliver (e.g. entertainment, medication dispensing). At an individual level if a robot advertises someone to take their medication, does the elderly person really understands that he or she has to take a specific medication at certain hour of the day?. Conversely the lack of understanding of such messages could lead to undesirable results in HRI.

6.4.7. Ethnographic studies - scalability (7)

Researchers and manufacturers should note that the content delivered by SARs and the type of interfaces provided in HRI might differ from culture to culture. Therefore ethnographic studies play an important role in informing the content to be programmed in SARs. The types of interfaces displayed and their level of adaptability to different regions and cultures are also important to study. During the robotic workshops (interviews 1,2,3) no cultural differences between UK and Portugal were identified in terms of HRI responses or interfaces used. It is important to retain that such relationship involves reading constantly the audiences responses to reinforce HRIs interfaces in terms of usability and further research and development.

6.4.8. Usability and testing - safety (8)

The usability and testing phase of a robotic device can identify emerging product faults and improve product design and user safety. Such testing must also take a qualitative analysis involving users' impressions, learning curves and relationships formed with such type of robotic prototypes. As an example in interview 3 we end up finding that D45 was not being well perceived by elderly residents. Comments were issued "what a strange machine", "are you sure it is safe?". Aesthetics issues and the lack of robotic presence are probably behind the uncertainty towards the prototype's safety.

6.4.9. Summary of the proposed HRI benchmarks

In this section I proposed a new categorization for the existing Feil-Seifer's HRI benchmarks based on the conducted robotics workshops with the direct participation of elderly groups. In human supervision scheme it is proposed the constitution of an assessment panel for supervision and assessment of HRIs with elderly groups. Such panel would be formed by the representatives of carers, staff, health professionals and families.

Safety was categorized into three different areas: physical safety tries to prevent situations associated to dangers common in electrical equipment. Proxemics in robotics studies the impact of distances and FOVs in HRIs. Thirdly we proposed cognitive decline which deals with understanding and preventing situations such as HRI attachment or other phenomena that can lead to ethical repercussions in elderly care.

According to this research imitation is directly related with the aesthetics of SARs. In aesthetics we identified three possible categories: anthropomorphism, zoomorphism and hybrid. HRIs colours and ergonomics could reinforce the outcome of such interactions. It is also important to retain the notion of scale relative to the ways humans formulate their impressions and commit themselves to HRIs.

In terms of autonomy we have displayed autonomy, supervision scheme and human contact. Displayed autonomy deals with the demonstrated levels of autonomy of a robot whereas the supervision scheme deals with the type of autonomous supervision that is implemented. The guarantee of human contact is absolutely crucial to retain in the autonomy benchmark.

Social success starts by understanding the type of robotic application delivered and identifying the primary objectives that need to be fulfilled. The audiences' responses (e.g. body language, confidence, level of communication and socialization) are extremely relevant to positively/negatively inform researchers about the outcome of HRIs. Based on such responses there are personalizing elements in SARs that can reinforce the outcome of such HRIs. Robotic presence is a result of how well imitation is delivered in SARs however it is also dependent on the aforementioned human responses depicted in social success. Attachment deals with the propensity for elderly groups to start interacting too much with

SARs. To date such levels are unknown but it is important that researchers and developers are aware of possible psychological effects on elderly groups.

Ethnographic studies could contribute for building affinity between man and machine thereby the content to be programmed and delivered by SARs has to be investigated in advance according to different target audiences. The delivering methods used to conduct entertainment robotic activities with the participation of vulnerable groups becomes extremely relevant especially when considering the audiences responses and the level of adaptability of a presenter/performer in conjunction with the robots to meet such audiences dynamics.

In understanding of domain there are two levels. The first perceived message deals with the capacity of vulnerable groups to understand the robotic message delivered. Is the message delivered by a SAR really understood by an elderly person? The second level robotics understanding and adaption deals with the futuristic capability of a SAR to adapt to different users and environments.

Scalability in SARs deals with the ability of a robotic system to be adapted to different users, social spaces and environments. In SARs it is important to provide different robotic interfaces that can match users' requirements. Scalability is also related with the cultural responses that arise from deploying robots in different areas of the globe.

In robotic information system we are dealing with what information does a robot programmer or robotic system has the right or a privilege to obtain. In privacy we consider the users wish to remain unnoticed or unidentified in a robotic environment especially in the case of SARs supervising individuals. Traceability in robotics deals with the ability for a robotic system to trace the location of human users. Due the high complexity of robotic systems and inherent liability it is important to have logs: on an A.I level operational logs and on a user level user action logs. Wireless communications in robotics, security protocols and encryption methods are essential to be updated for guarantying the users' information and privacy.

Usability and testing involves an exhaustive functional testing of a specific robotic device that can identify emerging product faults. Testing might also include a qualitative journey into people's attitudes perspectives and expectations of SARs. Usability and testing might also provide an insight about the learning curve for prospective SARs users.

In terms of liability we looked to the categories of safety, accessibility, privacy and usability testing. It is inevitable that as SARs become more sophisticated there is an emerging level of complexity towards responsibility. Despite the likely exhaustive robotics testing scenarios required the user robotic license agreements have to encompass a mixture of the previous described categories. Situations such as defining the manufacturers product guarantee, user liability, third party liability and insurance as well as hacking attacks have to be contemplated by law.

Beyond the new HRI benchmarks some potential relationships were also identified in the course of research. Imitation - safety is relevant in the sense that if the aesthetics of imitation isn’t well calibrated users might be doubtful about the level of reliability of SARs. Autonomy - safety exists in the sense that there is always a residual risk associated to the displayed levels of autonomy that might compromise certain levels of human safety. In autonomy - human supervision scheme we highlight the importance of human contact when it comes to HRIs with elderly groups. Imitation - robotic presence deals with how well elements such as aesthetics and scale are presented to final SARs users and therefore transmits a notion of robotic presence. In human supervision scheme - attachment it is important to consider the possibility that some vulnerable users might develop a type of attachment behaviour towards certain SARs. Understanding of domain - social success highlights the importance of guaranteeing that elderly groups do understand the message delivered by SARs (e.g. medications, tasks). In ethnographic studies - scalability it is important to retain that the content programmed in SARs and the types of interfaces displayed might differ according to different regions and cultures around the world. Usability testing - safety reinforces usability and testing to identify potential SARs faults and also highlights the importance of reading users perspectives and levels of usability towards SARs technologies.

CHAPTER 7 - ROBOETHICS FRAMEWORK

7.1. OVERVIEW

The proposed roboethics framework provides guidance on how stakeholders involved in the development and introduction of SARs can use the revised HRI benchmarks to develop an ethical specification. The framework includes the revised HRI benchmarks, templates for ethical specification and guidance on process.

7.2. HRI BENCHMARKS ANALYSIS

In chapter 6 we proposed a re-interpretation of Feil-Seifer's HRI benchmarks based on the robotic workshops and their reframing according to the cardinal medical ethical principles and social care ethos. As a result we consider 11 HRI benchmarks with extended categories. A visual representation of the HRI benchmarks (diagrams) (**figures 36 and 37**) and templates is proposed to help identify ethical issues around the specific areas of HRIs. Due the complex nature of SARs possible HRI benchmarks relationships are also identified to illustrate interactions which may influence the outcomes of HRIs.

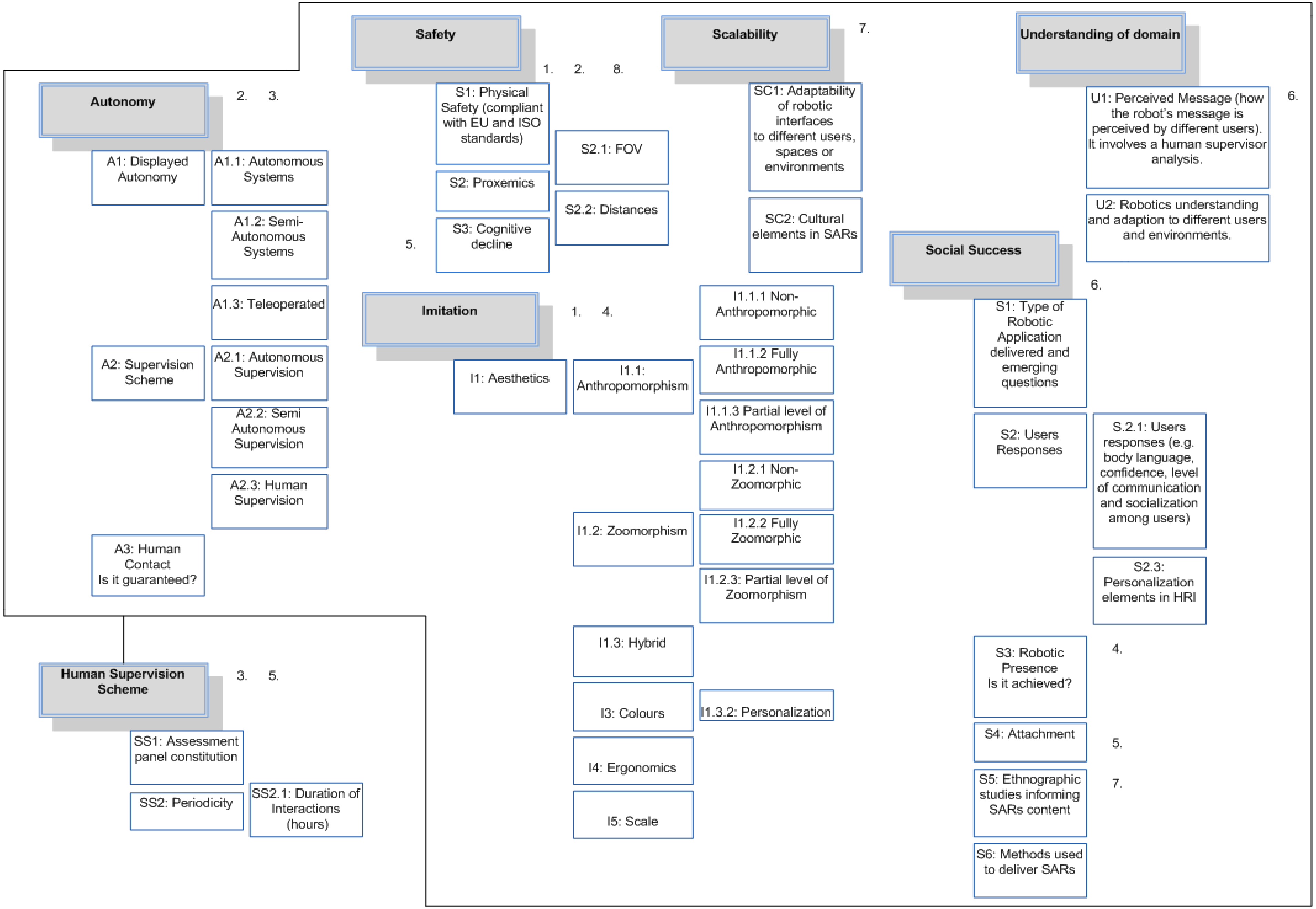

FIGURE 36 - HRI BENCHMARKS DIAGRAM

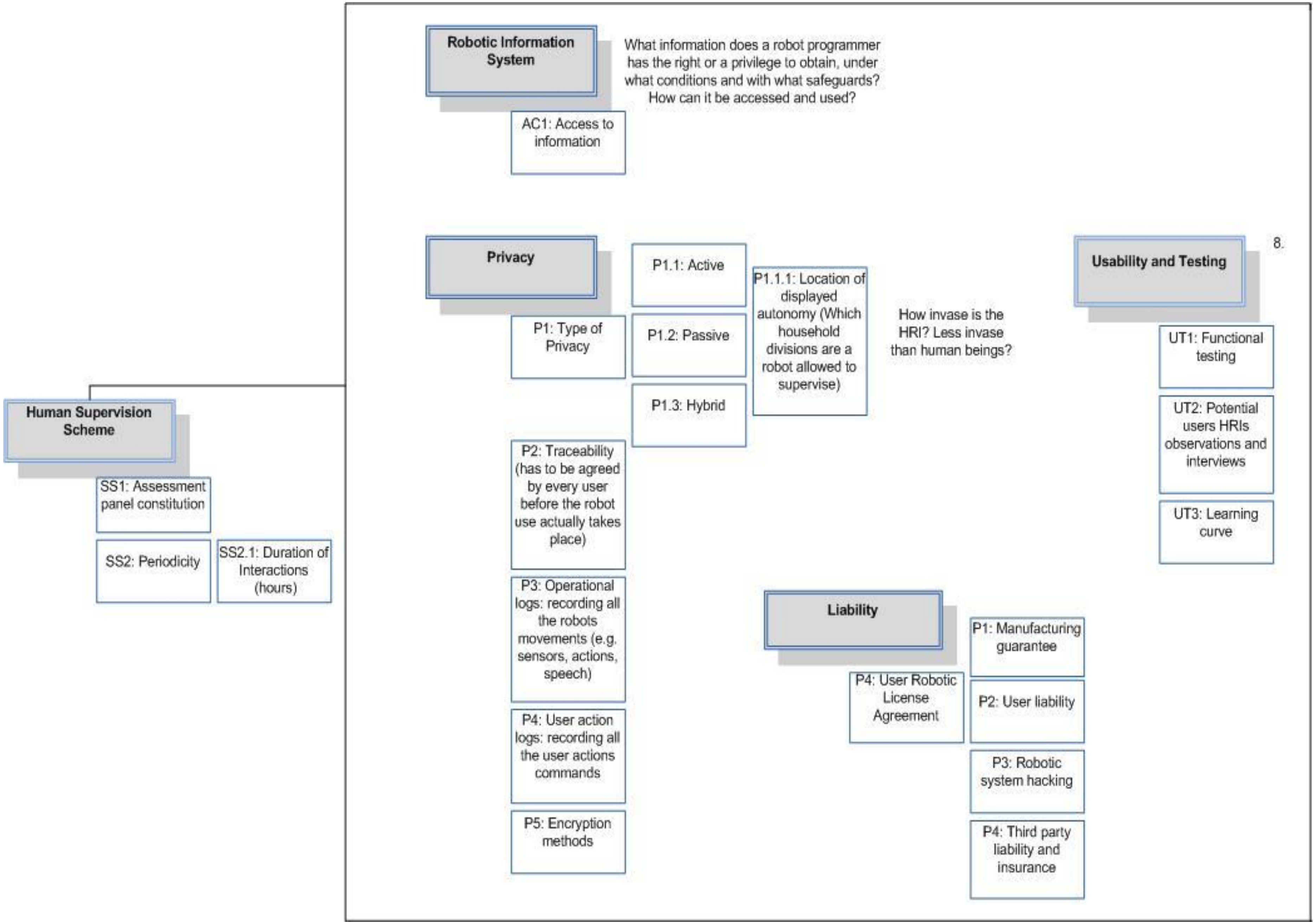

FIGURE 37 - HRI BENCHMARKS DIAGRAM (CONTINUATION)

A visual representation (diagrams) of three case studies will be presented in chapter 8.

7.3. HRI BENCHMARKS TEMPLATES

It is suggested to fill in the generic robotics application template and a template for each HRI benchmark selected. Template forms are provided to record relevant information from the ethical analysis. The completed set of templates provides an ethical specification.

Generic robotics application template

Name of the robot:	***Write the name/title of the robot/device that will be used.***	
Main SAR objective:	***What is the main objective of using this particular SAR application?***	
Location where the HRIs will take place:	***Location where the robotic activities will take place (care/extra care, institution name and address).***	
Main HRI benchmarks involved:	*Relevant:* ***If possible add the main HRI benchmarks involved in this HRI.***	*Not Relevant (why):* ***Add the not relevant HRI benchmarks together with explanation.***
Supervision team:	**Add the names and pre-determined roles of the selected supervision team.**	
Supervision scheme:	*Periodicity:* ***How often the HRIs are likely to occur (daily, weekly, monthly?)***	*Duration:* ***How long are the HRIs? E.g 15m, 45, 3 hours?***
Stakeholders involved in the HRIs:	***Who is involved in the robotic activities: institution representatives, elderly associations, relatives' representatives, governmental or companies/industrial partners?***	
SARs owner:	***Name all parties involved in supply.***	
	Extra elements to consider.	

Additional comments:	

HRI benchmark template:

HRI benchmark:	***Write the HRI benchmark title.***
Iteration number and date of revision:	***Iteration number (review) for this particular benchmark (e.g. 3rd). Also include the revision date.***
Main robotic objective:	***What is the main objective of using a particular SAR application with elderly groups?***
Description:	***Generic description of the benchmark. What it is trying to investigate and guide in terms of development and introduction of a particular SAR to elderly groups.***
Categories and subcategories identified:	***Write down the identified categories and subcategories for this benchmark in a particular SAR scenario.*** **Category A** **1. Sub Category A1** **1.a. Sub Sub category A1.1** **2. Sub Category A2** **3. …**
Possible new categories:	***If new categories are found and relevant add them here.***
Emerging relationships with other HRI benchmarks:	***Write down the potential/identified relationships between HRI benchmarks.***
Expected responses:	***Expected elderly groups responses relative to the current benchmark.***

Observations:	***Add observations.***
Additional comments:	***Extra elements to consider in this benchmark.***
Detailed description:	

The SARs research team (manufacturers, care institutions or academic body):

HRI benchmark: add the HRI benchmark	**Revised:** add date
Name	**Signature**
Person A	
Person B	
Person C	
Person D	

7.4. Framework process (steps)

The framework process includes the following steps:

1. HRI benchmarks analysis: in a specific SAR context the most relevant HRI benchmarks and emerging relationships are selected and represented in a diagram.
2. HRI benchmarks templates: in this step both the generic and individual HRI benchmarks templates are completed. Detailed supervision scheme information is obtained at this stage.
3. Revision: revise the process to improve SARs.

7.5. Ethical specification

Due to the high complexity of robotic systems and human requirements it is important to complement any ethical analysis with full documentation. The proposed HRI benchmarks selection through visual representations (diagrams) and templates is essential to be included in any SARs application. The ethical specification plays an important role in informing ethical issues around HRIs, and is a potential tool for legal reviews regarding robot's manufacturers, insurers and users' responsibilities.

7.6. Iterative framework process

The proposed roboethics framework aims to provide sufficient flexibility to understand the ethical issues around SARs developments for elderly care. The roboethics framework is an iterative process (**figure 38**). As SARs are introduced the human supervision scheme with elderly groups is always present and contributing for the ethical specification itself. Such sequence of stages tends to infinite (n) as it improves robotic products and services using this roboethics framework of reference.

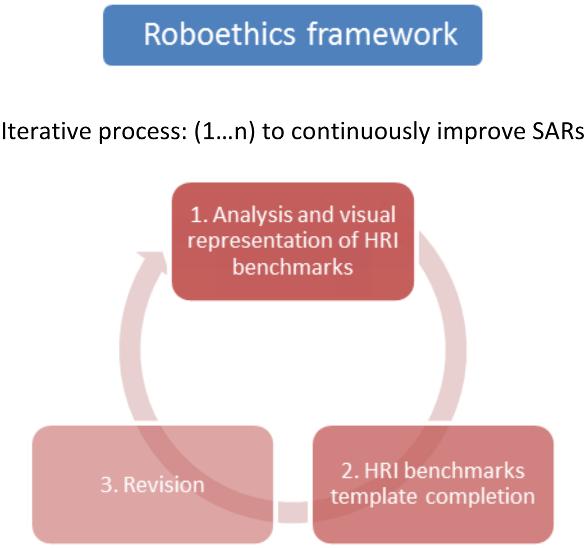

FIGURE 38 - ROBOETHICS FRAMEWORK CYCLE

The use of the proposed roboethics framework is demonstrated in the next chapter through presentation of three case studies.

CHAPTER 8 - CASE STUDIES

8.1. HRI BENCHMARKS: CASE STUDIES

In this section we will present three case studies that emerge from the delivered robotic workshops with SARs. In future implementations this might be done through lab or field testing. The case studies result from the application of the derived HRI benchmarks analysis and consequent visual representation (chapter 6) and also the completion of both the generic robotics application template and the HRI benchmarks templates presented in chapter 7.

The humanoid robots, robotic animals and D45 are illustrative examples of SARs supervision, cognitive assistance, entertainment and companionship. According to this research those are areas of primary importance for elderly care during the next decades.

1. Humanoid robots (entertainment)
2. Robotic animals (entertainment, companionship)
3. D45 (supervision, cognitive assistance)

Each case study represents a different interpretation of the proposed HRI categorization model. The presented relationships are derived from each case study (1, 2 and 3).

8.2. HUMANOID ROBOTS (FIGURES 41, 42)

This section presents the humanoid robots case study. In (**figures 39 and 40**) we can see the initial visual selection process from the generic HRI benchmarks diagram. In (**figures 41 and 42)** we see the HRI benchmarks final selection (framework step 1).

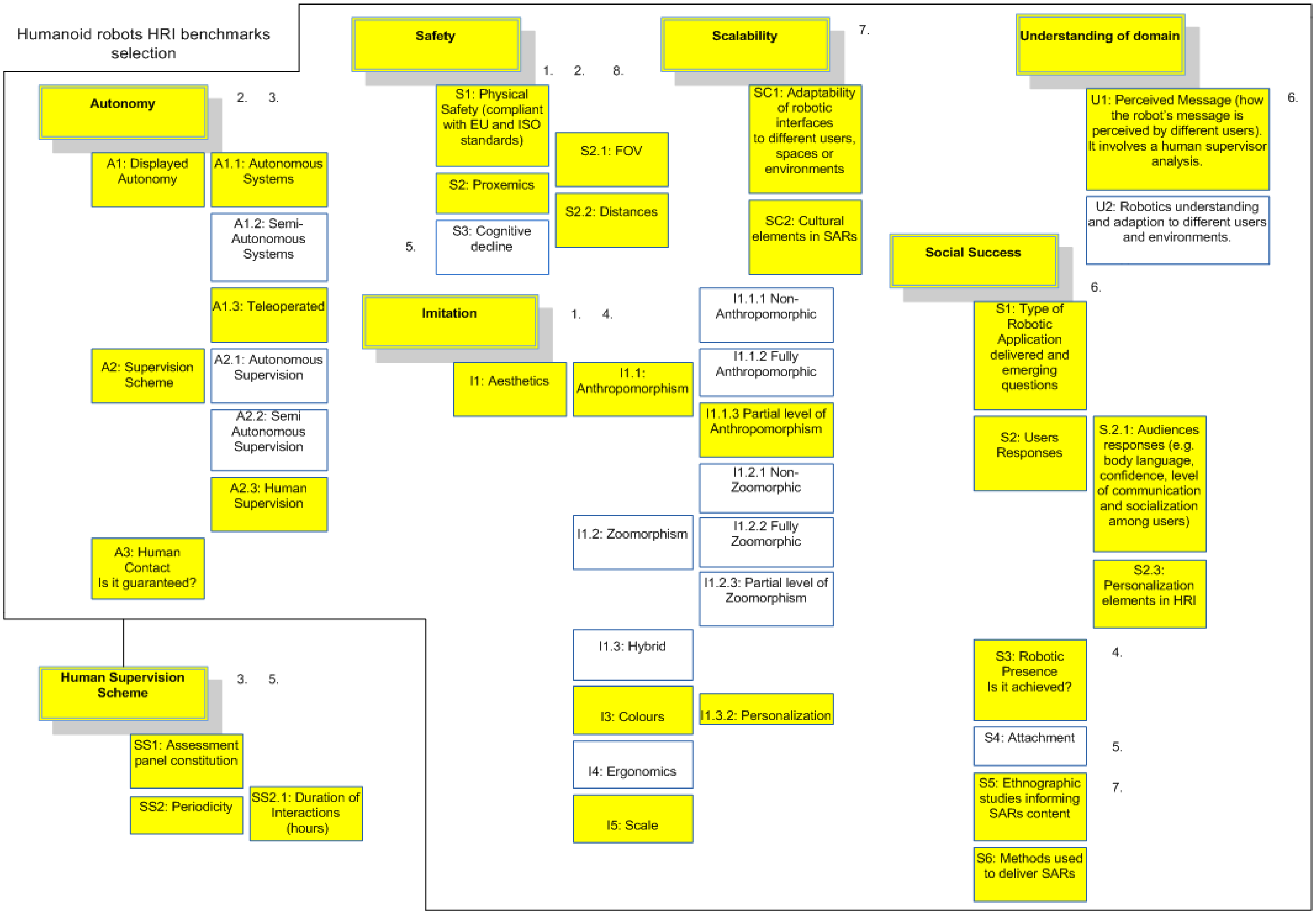

FIGURE 39 - HUMANOID ROBOTS - HRI BENCHMARKS VISUAL SELECTION

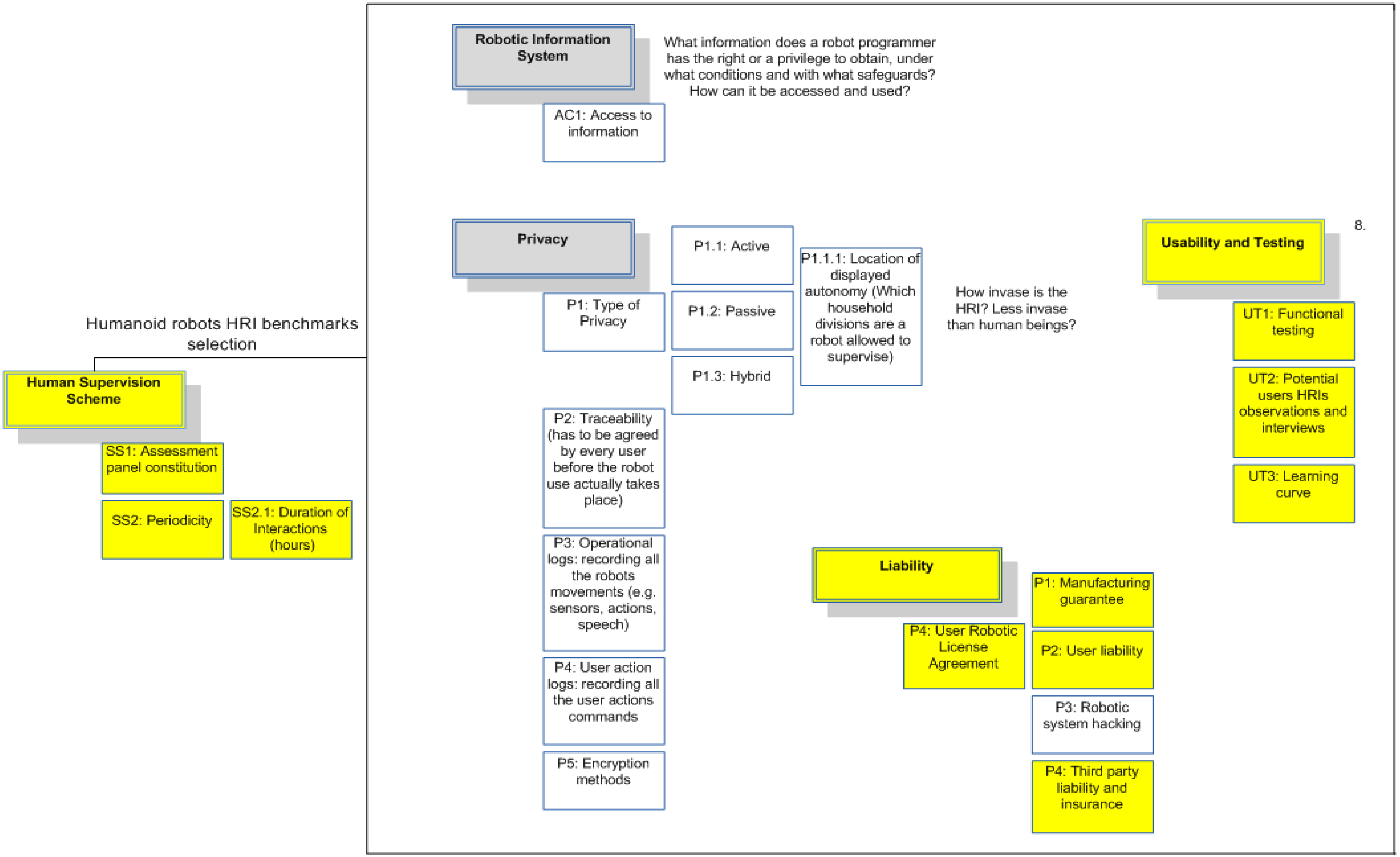

FIGURE 40 - HUMANOID ROBOTS - HRI BENCHMARKS VISUAL SELECTION (CONTINUATION)

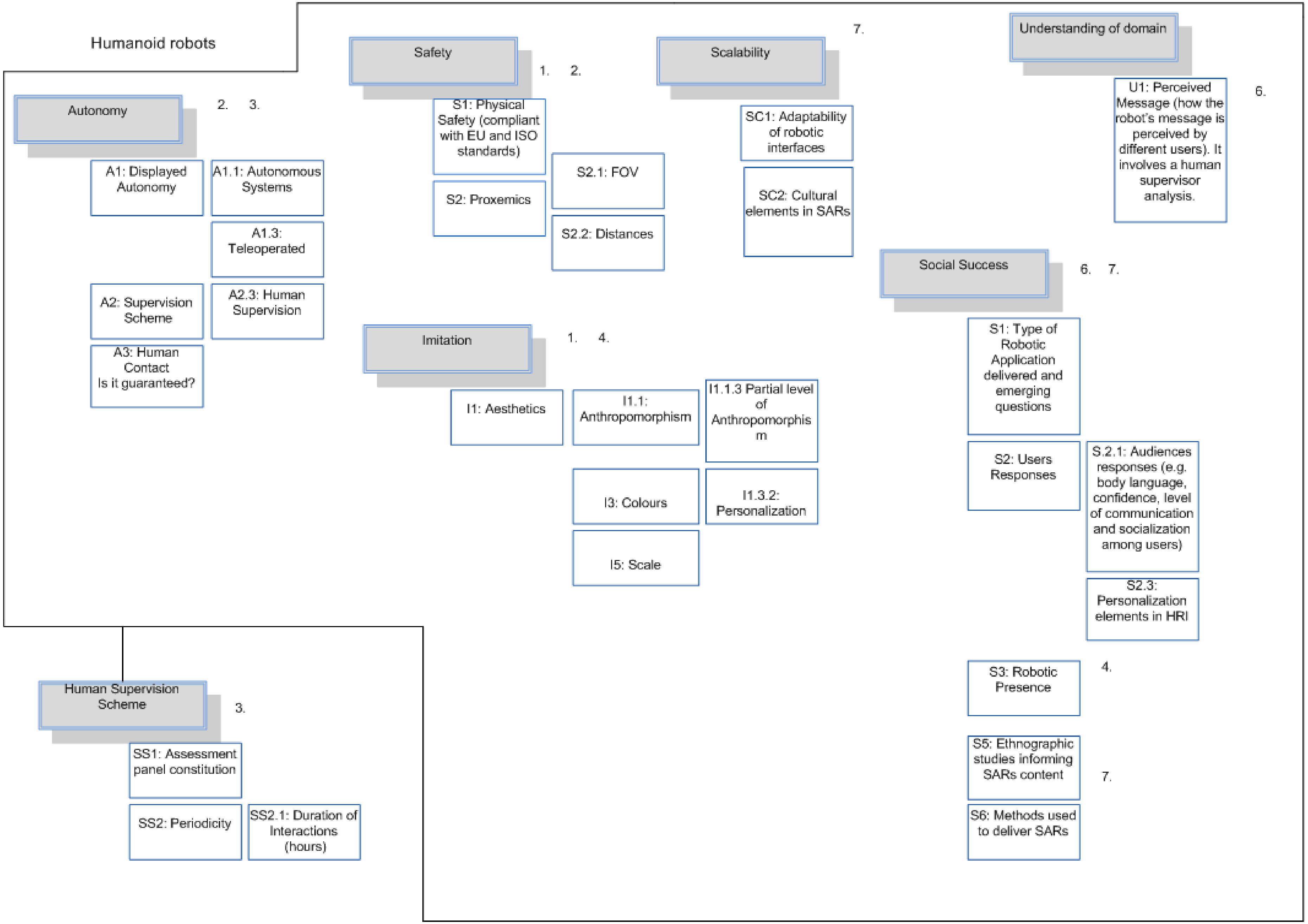

FIGURE 41 - HUMANOID ROBOTS DIAGRAM

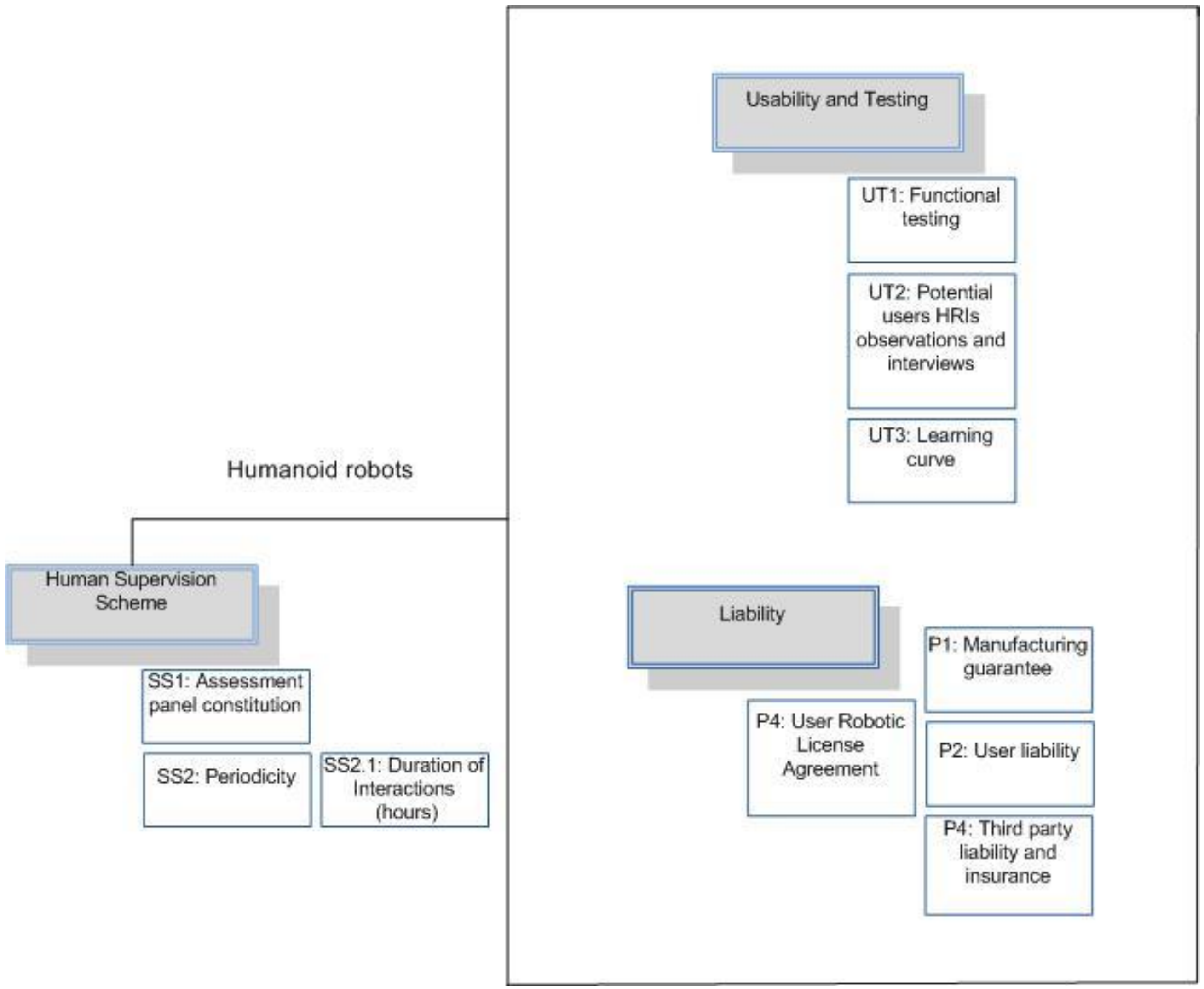

FIGURE 42 - HUMANOID ROBOTS DIAGRAM (CONTINUATION)

On this section we present the framework step 2 which includes filling in the HRI benchmarks templates.

Humanoid robots: generic robotics application template

Name of the robot:	***RS Media and RS V2.***	
Main SAR objective:	***The objective of these SARs is to entertain elderly people by performing choreographies and playing music/sounds.***	
Location where the HRIs will take place:	***Locations:*** *Wallfields court (A), Rivercare (B), Centro Social e Paroquial Alentejo (C), Lar do Monte Velho (D), Acolhimento Jardim Rosa (E).*	
Main HRI benchmarks involved:	*Relevant:* ***Human supervision scheme, imitation, autonomy, safety, social success, scalability, understanding of domain, usability and testing, liability.***	*Not Relevant (why):* ***Robotic information system and privacy: no information about participants will be collected or stored in the robots/cloud. No identifying elements (audio/visual) are collected during the workshops.***
Supervision team:	**Location A: Assistant 1, Manager 1, Antonio Espingardeiro** **Location B: Manager 2, Antonio Espingardeiro** **Location C: Manager 3, Antonio Espingardeiro** **Location D: Assistant 4, Antonio Espingardeiro** **Location E: Manager 5, Antonio Espingardeiro**	
Supervision scheme:	*Periodicity:* ***Once per week during a period of 7 months and half.***	*Duration:* ***45 minutes sessions.***
Stakeholders involved in the HRIs:	**Location A: Assistant 1, Manager 1 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location B: Manager 2 (public care/extra care sector), Antonio Espingardeiro (researcher)** **Location C: Manager 3 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location D: Assistant 4 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location E: Manager 5 (public care/extra care sector), Antonio Espingardeiro (researcher)**	

SARs owner:	***SARs used for research purpose and owned by Antonio Espingardeiro.***
Additional comments:	***None.***

Autonomy HRI benchmark template:

HRI benchmark:	**Autonomy**
Iteration number and revision date:	**Number 2 (07/07/2013)**
Main robotic objective:	**RS Media and RS V2 are programmed to entertain elderly groups. The robots perform choreographies and sing.**
Description:	**In autonomy we are analysing people's responses to different levels of autonomy displayed. RS Media and RS V2 are controlled through teleoperation and autonomy modes in the context of elderly care.**
Categories and subcategories identified:	**1. Displayed autonomy (autonomous systems, teleoperation)** **2. Supervision scheme (human supervision)** **3. Human contact**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Autonomy - safety: high levels of autonomy have to be well tested in terms of users' safety.*** ***Autonomy - human supervision scheme: human contact and close supervision must be promoted throughout the robotic workshops.***
Expected responses:	***Positive.***
Observations:	***The robots were operated at distances 150-40cm away from elderly residents. Elderly participants' do not seem to be afraid of the humanoid robots. Further analysis details are described in appendix I.***

Additional comments:	***None.***
Detailed description:	**Displayed autonomy**: mainly controlled by teleoperated methods. A performer will be controlling the robots in real time. **Supervision Scheme**: human supervision. A researcher will be paying close attention to the audiences' responses and ready to intervene. **Human contact**: must be promoted. In autonomy we considered the ethical principles beneficence, non-maleficence and autonomy.

Safety HRI benchmark template:

HRI benchmark:	**Safety**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**RS Media and RS V2 are programmed to entertain elderly groups. The robots perform choreographies and sing.**
Description:	**In safety we want to make sure that SARs are compliant with EU/ISO electrical equipment safety regulations. We are also interested to understand elderly people's perspectives on the distances and FOVs practiced in the humanoid robotic workshops.**
Categories and subcategories identified:	**1. Physical safety (compliant with EU/ISO regulations)** **2. Proxemics (distances, FOVs)**
Possible new categories:	***Not found yet.***
Emerging relationships	***Autonomy - safety: high levels of autonomy have to be well tested in terms of users' safety.***

with other HRI benchmarks:	***Imitation - safety: aesthetics notions could impact on the user's sense of safety.***
Expected responses:	***Positive.***
Observations:	***No safety issues were detected. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Physical safety**: the humanoid robots are currently considered as a class B digital device and compliant with FCC (USA) part 15 directive. The corresponding European conformity is translated by the European electrical equipment safety regulations and assigned the EC logo. Both directives on USA and Europe are targeted to provide reasonable protection against harmful interference in a residential installation. Such electrical devices generate, use and can radiate radio frequency energy and, if not installed and used in accordance with the instructions manual, may cause harmful interference to radio communications. However such definition of physical safety is still conceived for a wide spectrum of electrical devices that can generate, use and can radiate radio frequency energy. **Proxemics**: the following operating distances are selected 150cm and 40cm. In terms of FOV the robots will perform in front of elderly residents. In safety we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Imitation HRI benchmark template:

HRI benchmark:	**Imitation**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**RS Media and RS V2 are programmed to entertain elderly groups. The robots perform choreographies and sing.**
Description:	**In imitation we want to understand aspects related to the aesthetics of the humanoid robots, personalization elements and notions of scale.**

Categories and subcategories identified:	**1. Aesthetics (Anthropomorphism; partial level)** **2. Colours (personalization)** **3. Scale (50cm)**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Imitation - safety: aesthetics notions could impact on the user's sense of safety.*** ***Imitation - robotic presence: scale could be related to the users' perceived notion of robotic presence.***
Expected responses:	***Positive.***
Observations:	***The elderly seem to like the RS Media/RS V2 aesthetics. However comments were addressed towards the scale of the humanoid robots (too small). Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Aesthetics**: in the case of the humanoid robots a partial level of anthropomorphism will be presented to the elderly residents. The robots encompass a humanoid shape (head, torso, two arms, and two legs). **Colours**: several colours will be tested for the humanoid robots e.g. grey, red, white, and orange. **Scale**: the humanoid robots are 50cm height. In imitation we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Scalability HRI benchmark template:

HRI benchmark:	**Scalability**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**RS Media and RS V2 are programmed to entertain elderly groups. The robots perform choreographies and sing.**
Description:	**In scalability we wanted to understand the RS Media/ RS V2 adaptability in terms of interfaces provided. In several locations caregivers had a chance to experiment controlling the robots in real time. The input on the control methods (joystick and buttons) was positive.** **Scalability also deals with cultural responses. No significant differences were found in UK and Portugal.**
Categories and subcategories identified:	**1. Adaptability of robotic interfaces** **2. Cultural elements in SARs**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Ethnographic studies - scalability: it is important to understand that the content programmed into the humanoid robots has to be studied according to different cultures. In this case adjustments were made in terms of local accents, songs and jokes.***
Expected responses:	***Positive.***
Observations:	***In terms of responses no cultural differences were found between UK and Portugal. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Adaptability of robotic interfaces:** the robots will be programmed with songs, choreographies and

	jokes. **Cultural elements in SARs:** during the course of the robotic workshops we will be investigating the elderly residents' responses in UK and Portugal. In scalability we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Understanding of domain HRI benchmark template:

HRI benchmark:	**Understanding of domain**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**RS Media and RS V2 are programmed to entertain elderly groups. The robots perform choreographies and sing.**
Description:	**In understanding of domain we wanted to know if the robots delivered message was perceived by elderly residents.**
Categories and subcategories identified:	**1. Perceived message (how the robot's message is perceived by different users)**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Understanding of domain - social success: it is important to understand if the elderly residents do understand the message delivered by robots. Throughout the robotic workshops the elderly understood that the robots were performing for entertainment purposes.***
Expected responses:	***Positive.***
Observations:	***The elderly seem to understand the entertainment message delivered by the robots. Further analysis details are described in appendix I.***

Additional comments:	***None.***
Detailed description:	**Perceived message:** in conjunction with care and extra staff we will try to understand if the message transmitted by the humanoid robots is successfully perceived by the residents. In understanding of domain we are considering the ethical principles of beneficence, non-maleficence.

Social success HRI benchmark template:

HRI benchmark:	**Social success**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**RS Media and RS V2 are programmed to entertain elderly groups. The robots perform choreographies and sing.**
Description:	**In social success we want to unfold some of the aspects for the success of the humanoid robotic workshops.**
Categories and subcategories identified:	**1. Type of robotic application delivered and emerging questions** **2. Users' responses (users' responses in terms of body language, confidence, level of communication and socialization among residents; personalization elements in HRI)** **3. Robotic presence (is it achieved?)** **4. Ethnographic studies informing SARs content** **5. Methods used to deliver SARs**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Understanding of domain - social success: it is important to understand if the elderly residents do understand the message delivered by robots. Throughout the robotic workshops the elderly understood that the robots were performing for entertainment purposes.***

Expected responses:	***Positive.***
Observations:	***The elderly seem to enjoy the humanoid robotic workshops. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Type of robotic application delivered:** the type of robotic application delivered are humanoid robots. The objective of such demonstrations was to entertain elderly individuals. When working with sensitive groups such as the elderly, some questions arise: what builds or prevents success, and how we are going to achieve it?. **Users' responses:** the users' responses will be recorded in video/audio formats for further analysis. **Robotic presence**: we will try to investigate if the humanoid robots achieve "robotic presence". **Ethnographic studies**: a small ethnographic research will be performed to understand cultural elements to be programmed into the humanoid robots. **Methods used to deliver HRIs:** in the humanoids activities we will explore several delivering methods. In social success we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Human supervision scheme HRI benchmark template:

HRI benchmark:	**Human supervision scheme**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**RS Media and RS V2 are programmed to entertain elderly groups. The robots perform choreographies and sing.**
Description:	**In human supervision scheme we want to clarify a human supervision team for monitoring the HRIs with elderly residents. We also want to define the periodicity and duration of HRIs.**

Categories and subcategories identified:	**1. Assessment panel constitution** **2. Periodicity and duration of the HRIs**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Autonomy - human supervision scheme: human contact and close supervision must be promoted throughout the robotic workshops.***
Expected responses:	***Positive.***
Observations:	***A supervision team was closely following the robotic workshops. Further details of analysis are described in appendix I.***
Additional comments:	***Due to the sensitivity of elderly groups the human supervision scheme is extremely important. Such supervision is also important in promoting human contact.***
Detailed description:	**Assessment panel**: small assessment panel constituted by the researcher, one representative of the carers and relatives. **Periodicity:** in terms of the robotic workshops duration periods we have decided that the workshops should not exceed 45 minutes of weekly robotic workshops and especially should be held during the mornings. In the human supervision scheme benchmark we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Usability and testing HRI benchmark template:

HRI benchmark:	**Usability and testing**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**RS Media and RS V2 are programmed to entertainment elderly groups. The robots perform choreographies and sing.**

Description:	**In usability and testing we want to test the humanoid robots in different conditions/scenarios to ensure their safety. We are also interested to get users' perspectives on robots and possibly learning curves to use them in the future.**
Categories and subcategories identified:	**1. Functional testing** **2. Potential users HRIs observations and interviews** **3. Learning curve**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Not identified yet.***
Expected responses:	***Positive.***
Observations:	***The humanoid robots were tested in lab before the practical robotics workshops. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Functional testing:** before the robotic workshops an exhaustive testing to the humanoid robots will be performed. **Potential users HRIs observations and interviews**: during the course of research people's attitudes, points of view and expectations were investigated. **Learning curve**: we will investigate if care staff can cope with the humanoids interfaces. In usability testing we are considering the ethical principles of beneficence, non-maleficence.

Liability HRI benchmark template:

HRI benchmark:	**Liability**
Iteration number and revision	**Number 2 (07/06/2013)**

date:	
Main robotic objective:	**RS Media and RS V2 are programmed to entertain elderly groups. The robots perform choreographies and sing.**
Description:	**In liability we want to have a perspective on the robotic manufacturers' liability, user liability/ third party liability or insurance. The objective is to clarify the user license agreement which will be part of SARs in the future.**
Categories and subcategories identified:	**1. User robotic license agreement (manufacturing guarantee, user liability, robotic system hacking, third party liability and insurance).**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Not identified yet.***
Expected responses:	***Positive.***
Observations:	***No liability issues detected. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Manufacturer guarantee:** 90 days guarantee (free from defects). **User liability**: the liability of the humanoid robots is a fusion between physical safety and disclaimer policies. On both humanoids the use of the robot is not recommended for children under 4 years old. The manufacturer recommends continuous supervision as it happens with the majority of electrical equipment to prevent any electrical shocks. The manufacturer states that the use of the robots do not convey a license nor imply any right to distribute the content created with their products on revenue-generating broadcast systems (terrestrial, satellite, cable) or other distributions channels such as audio and video stored in any physical devices such as computers or shared applications via internet, intranets and/or other networks. An independent license for such use is required.

	Third party liability: in technical terms the manufacturer states that any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In liability we are considering the ethical principles of beneficence, non-maleficence and justice.

The SARs research team (manufacturers, care institutions or academic body):

HRI benchmarks template	**Revised:** 07/06/13
Name	**Signature**
Person A: Antonio Espingardeiro	Antonio. Espingardeiro.
Person B	
Person C	
Person D	

8.2.1. HUMANOID ROBOTS HRI BENCHMARKS RELATIONSHIPS

These are the identified HRI benchmarks relationships in the humanoid robots' workshops. For more information see detailed analysis on appendix I.

Imitation - safety (1): during the robotic workshops elderly people engaged easily with the humanoid robots. Ninety eight percent (interview 1) of the people mentioned they were not afraid of the humanoids. The aesthetic of machines seems to trigger pleasant reactions on elderly individuals. Comments were common "hey robot come here!" "funny machine look how it is moving".

Autonomy - safety (2): despite the fascination towards the humanoid robots in interview 2, (31%) of the elderly individuals expressed uncertainty towards the high degree of autonomy that the humanoids displayed. Comments typically covered "the robot is going to crash!" or "wow, it can avoid obstacles".

Autonomy - human supervision scheme (3): during the robotic workshops (interview 2) we saw that human contact is essential in autonomy. As an example in interview 2, (69%) of the residents preferred to have me controlling the humanoid robots as a safety procedure however they also mentioned that they enjoyed my presence and artistic performance. The residents commented “we enjoy the fact that you are here with us”, “the robots are amazing, but we also like your presence”.

Imitation - robotic presence (4): In interview 1 we found that (98%) of elderly people engaged well with the humanoid robots. However in terms of aesthetics some comments were addressed relative to the scale of the robots e.g. “do you have bigger robots?”. In imitation it seems the notion of scale could be improved to build a higher notion of robotic presence.

Understanding of domain - social success (6): in interview 3 carers and relatives agreed that the elderly residents grasped the idea of care and extra care “entertainment” using a robotic platform such as the humanoid robots. In interview 1 staff mentioned that elderly people easily sang and followed the rhythm of the music played by the humanoid robots. At the end we think such performance contributes for the elderly physical and psychological wellbeing.

Ethnographic studies - scalability (7): The small ethnographic studies performed prior to the robotic activities were important to understand the content to be programmed in SARs. Songs, jokes and comments were investigated according to the different target audiences to be programmed into the humanoid robots. During robotics workshops (interviews 1,2,3) no cultural differences (UK, Portugal) were identified in terms of HRIs. In interview 3 when it comes to scalability of the humanoid robotic interfaces tested by carers were positively used. Comments included “yes we can control such robots” or “we would like to do it ourselves in the future”.

Finally framework step 3 includes a revision on the previous steps.

8.3. Robotic animals (seals and cats) (Figures 45, 46)

This section presents the robotic animals' case study. In (**figures 43 and 44**) we can see the visual selection process from the generic HRI benchmarks diagram. In (**figures 45 and 46)** we see the HRI benchmarks final selection (framework step 1).

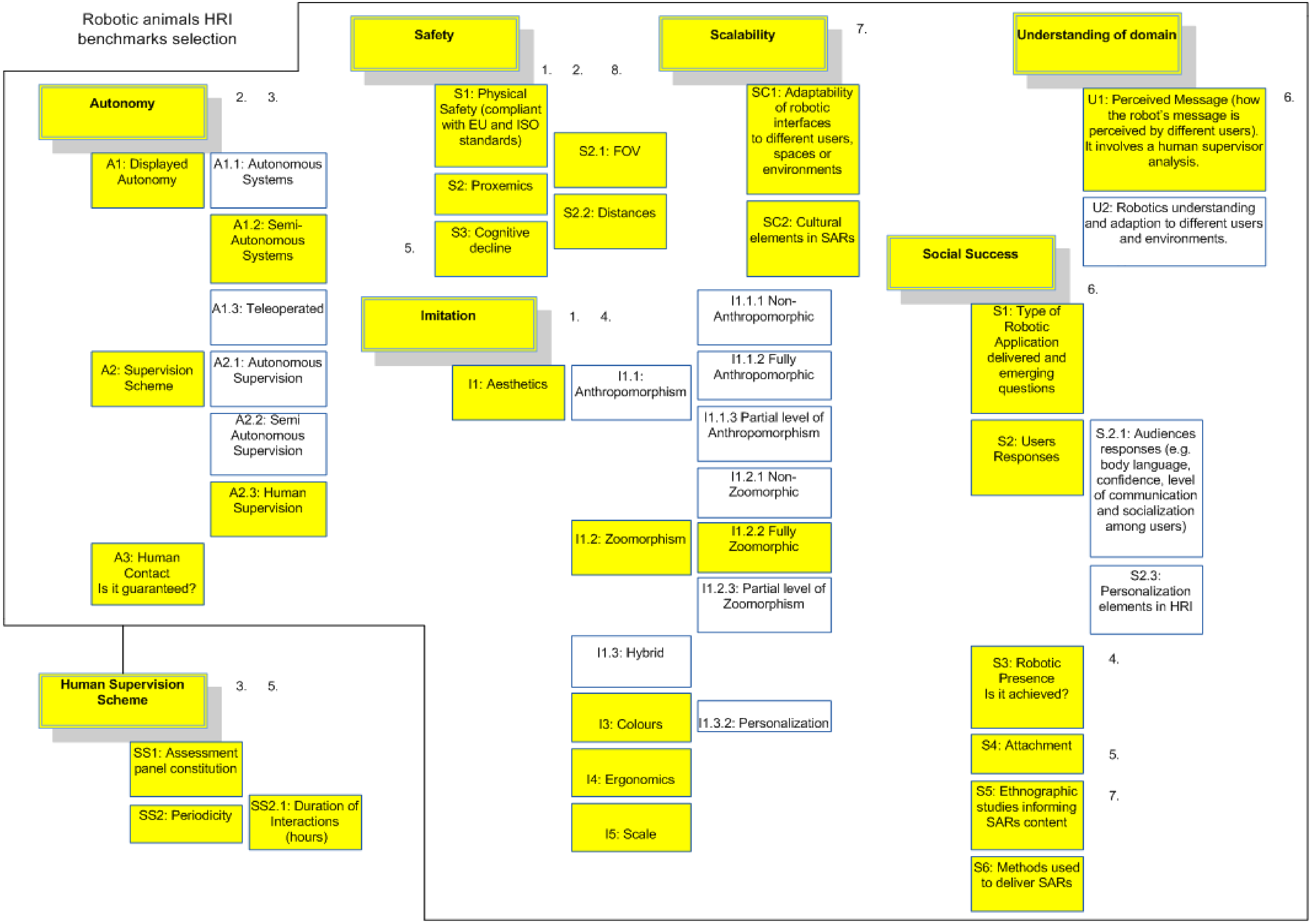

FIGURE 43 - ROBOTIC ANIMALS HRI BENCHMARKS SELECTION

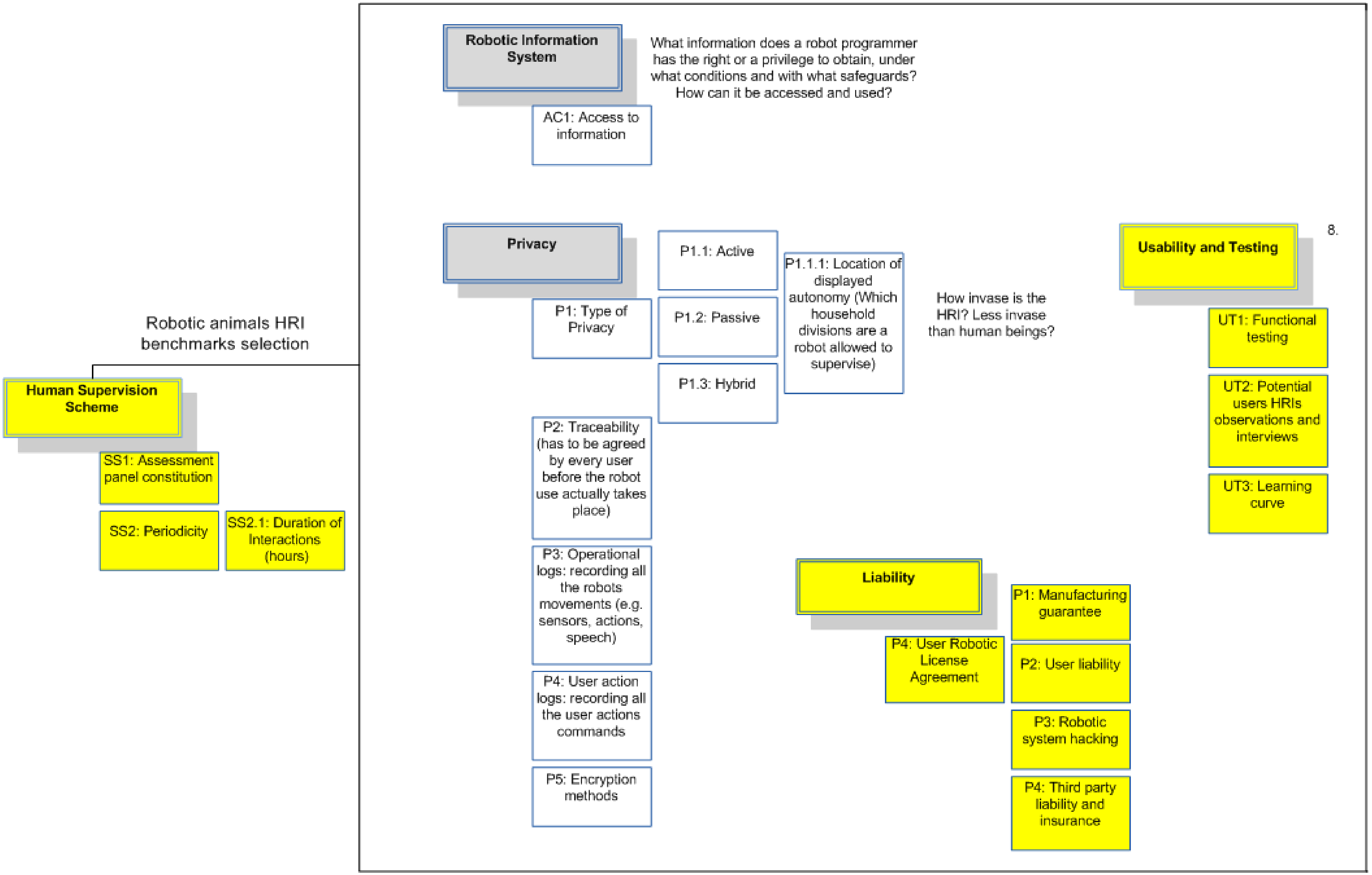

FIGURE 44 - ROBOTIC ANIMALS - HRI BENCHMARKS SELECTION (CONTINUATION)

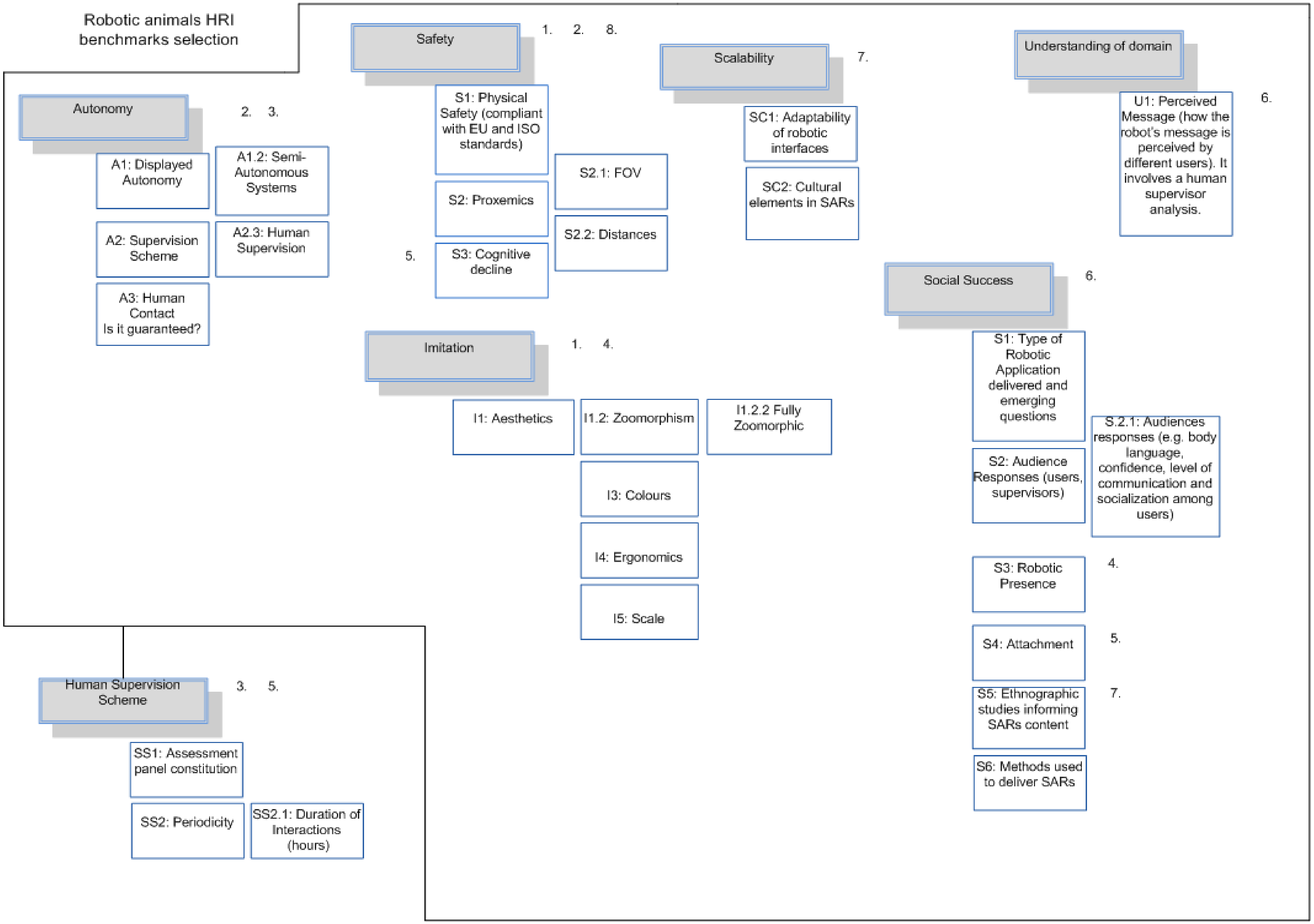

FIGURE 45 - ROBOTIC ANIMALS DIAGRAM

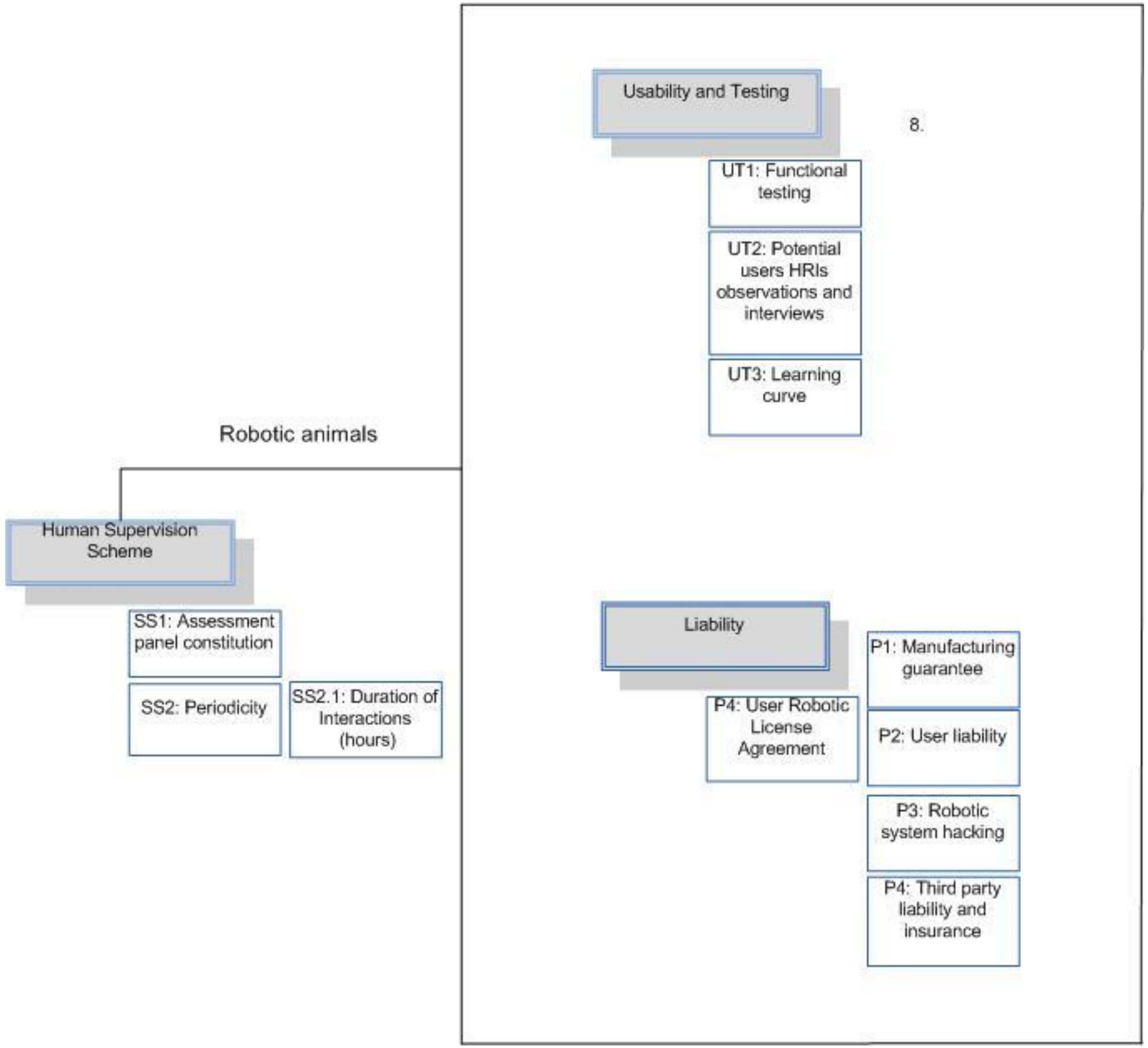

FIGURE 46 - ROBOTIC ANIMALS DIAGRAM (CONTINUATION)

On this section we present the framework step 2 which includes filling in the HRI benchmarks templates.

Robotic animals: generic robotics application template

Name of the robot:	***Robotic seals and robotic cats.***	
Main SAR objective:	***The objective of these SARs is to entertain elderly people by delivering robotic animals.***	
Location where the HRIs will take place:	***Locations:*** *Wallfields court (A), Rivercare (B), Centro Social e Paroquial Alentejo (C), Lar do Monte Velho (D), Acolhimento Jardim Rosa (E).*	
Main HRI benchmarks involved:	*Relevant:* ***Human supervision scheme, imitation, autonomy, safety, social success, scalability, understanding of domain, usability and testing, liability.***	*Not Relevant (why):* ***Robotic information system and privacy: no information about participants will be collected or stored in the robots/cloud. No identifying elements (audio/visual) are collected during the workshops.***
Supervision team:	**Location A: Assistant 1, Manager 1, Antonio Espingardeiro** **Location B: Manager 2, Antonio Espingardeiro** **Location C: Manager 3, Antonio Espingardeiro** **Location D: Assistant 4, Antonio Espingardeiro** **Location E: Manager 5, Antonio Espingardeiro**	
Supervision scheme:	*Periodicity:* ***Once per week during a period of 7 months and half.***	*Duration:* ***45 minutes sessions.***
Stakeholders involved in the HRIs:	**Location A: Assistant 1, Manager 1 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location B: Manager 2 (public care/extra care sector), Antonio Espingardeiro (researcher)** **Location C: Manager 3 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location D: Assistant 4 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location E: Manager 5 (public care/extra care sector), Antonio Espingardeiro (researcher)**	

SARs owner:	***SARs used for research purpose and owned by Antonio Espingardeiro.***
Additional comments:	***The use of touch is extremely important with elderly groups.***

Autonomy HRI benchmark template:

HRI benchmark:	**Autonomy**
Iteration number and revision date:	**Number 2 (07/07/2013)**
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**
Description:	**In autonomy we are analysing people's responses to robotic animals, human supervision levels and guarantee of human contact.**
Categories and subcategories identified:	**1. Displayed autonomy (semi-autonomous systems)** **2. Supervision scheme (human supervision)** **3. Human contact (is it guaranteed?)**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Autonomy - safety: since the robots respond to human touch (semi-autonomous system), special attention is required to prevent harming elderly users (e.g. fingers trapped and/or causing someone pain).*** ***Autonomy - human supervision scheme: human contact and close supervision must be promoted throughout the robotic workshops. As in any other type of robotic workshop human contact is absolutely essential between human supervisors and vulnerable groups.***
Expected responses:	***Positive.***
Observations:	***The elderly residents accepted the robots straight away. An interesting aspect is that the robots seem to trigger a natural connection between the elderly and the robots. On some occasions female participants wanted to keep the robots for longer periods of time. Further analysis details are described in appendix I.***
Additional	***None.***

comments:	
Detailed specification:	**Displayed autonomy:** the robotic animals could be considered semi-autonomous devices. They require human input through "touch" sensors to trigger a specific set of animal behaviours. **Supervision scheme**: human supervision scheme was selected for the robotics workshops. Researcher in conjunction with carers or relatives will supervise the elderly groups during the course of HRIs. **Human contact**: human contact must be promoted. In autonomy we considered the ethical principles beneficence, non-maleficence and autonomy.

Safety HRI benchmark template:

HRI benchmark:	**Safety**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**
Description:	**In safety we want to make sure that SARs are compliant with EU/ISO electrical equipment safety regulations. We are also interested to understand elderly people's perspectives on the distances and FOVs practiced in the robotic animals' workshops.**
Categories and subcategories identified:	**1. Physical safety (compliant with EU/ISO regulations)** **2. Proxemics (distances, FOVs)** **3. Cognitive decline**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Autonomy - safety: since the robots respond to human touch (semi-autonomous system), special attention is required to prevent harming elderly users (e.g. fingers trapped and/or causing someone pain).***

	Usability testing - safety: the robotic animals were exhaustively tested to detect any abnormal situations that could compromise human safety. We did pay attention to the learning curve of vulnerable groups, carers and relatives and their level of confidence when operating the robotic animals.
Expected responses:	***Positive.***
Observations:	***No safety issues were detected. Further analysis details are described in appendix I.***
Additional comments:	***Special attention should be taken towards the category of cognitive decline. Close supervision and pre-determined robotic animals timetables should be discussed among the stakeholders to assess the elderly progress.***
Detailed description:	**Physical safety:** in terms of physical safety the robotic animals follow both the European (EC) and the USA (FCC - part 15) directives. These are electrical equipment that generate, use and can radiate radio frequency energy and, if not installed and used in accordance with user instructions, may cause harmful interference to radio communications. **Proxemics**: in the robotic animals' sessions the robotic seals and cats will be sitting on the residents' lap. In terms of FOV elderly residents will establish eye contact with the robots. **Cognitive decline**: in the robotics animals sessions we will be aware of any signs of cognitive decline. In safety we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Imitation HRI benchmark template:

HRI benchmark:	**Imitation**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**
Description:	**In imitation we want to understand aspects related to the aesthetics of the robotic animals, personalization elements, ergonomics and scale.**
Categories and subcategories identified:	**1. Aesthetics (zoomorphism; fully zoomorphic)** **2. Colours (standard)** **3. Ergonomics** **4. Scale**

Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Imitation - robotic presence: the high levels of zoomorphism presented in the robotic seals and cats contribute positively for the notion of robotic presence.***
Expected responses:	***Positive.***
Observations:	***The elderly residents accepted the robots straight away. An interesting aspect is that there seems to be a natural connection between the elderly and the robotic animals. In certain occasions female participants wanted to keep the robots for longer periods of time. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Aesthetics:** in imitation the aesthetics category had full zoomorphism. **Colours**: the robotic seals were white whereas the robotic cats had two models: white or ginger. **Ergonomics**: the robotic seals and cats resemble a typical offspring. The robots are an exact replica of baby seals and junior cats. Synthetic fur is available in both devices. Touch is something very important in elderly care. **Scale**: the robotic seals and cats had the exact measurements of a real animal (baby seals and junior cats). In imitation we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Scalability HRI benchmark template:

HRI benchmark:	**Scalability**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**

Description:	**In scalability we wanted to understand the robotic animals acceptance in terms of interfaces provided. Scalability also deals with cultural responses.**
Categories and subcategories identified:	**1. Adaptability of robotic interfaces** **2. Cultural elements in SARs**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Ethnographic studies - scalability: the robotic animals touch interfaces were well accepted by elderly people in the UK and Portugal. However it seems that both European cultures show more affinity with the robotic cats than the seals.***
Expected responses:	***Positive.***
Observations:	***No significant cultural differences were found in UK and Portugal. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed specification:	**Adaptability of robotic interfaces:** we will investigate the adaptability of individuals to the robotic animals' interfaces. **Cultural elements in SARs:** we will investigate cultural perspectives in UK and Portugal. In scalability we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Understanding of domain HRI benchmark template:

HRI benchmark:	**Understanding of domain**
Iteration number	**Number 2 (07/06/2013)**

and revision date:	
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**
Description:	**In understanding of domain we wanted to know if the robots delivered message was perceived by elderly residents.**
Categories and subcategories identified:	**1. Perceived message (how the robot's message is perceived by different users)**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Understanding of domain - social success: it is important to understand if the elderly residents do understand the objective of the robotic animals' workshops. In essence they did, however we noticed strong connections from certain female participants towards the robotic cats and seals.***
Expected responses:	***Positive.***
Observations:	***The elderly residents understood the robotic message. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Perceived message:** in conjunction with the institutions we will try to understand if the message transmitted by the robotic animals is successfully perceived by the elderly. In understanding of domain we are considering the ethical principles of beneficence, non-maleficence.

Social success HRI benchmark template:

HRI benchmark:	**Social success**
Iteration number	**Number 2 (07/06/2013)**

and revision date:	
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**
Description:	**In social success we want to unfold some of the aspects beyond the apparent success of the robotic animals' workshops.**
Categories and subcategories identified:	**1. Type of robotic application delivered and emerging questions** **2. Users' responses (users' responses in terms of body language, confidence, level of communication and socialization among residents; personalization elements in HRI)** **3. Robotic presence (is it achieved?)** **4. Attachment** **5. Ethnographic studies informing SARs content** **6. Methods used to deliver SARs**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Understanding of domain - social success: it is important to understand if the elderly residents do understand the objective of the robotic animals' workshops. In essence they did, however we noticed strong connections from certain female participants towards the robotic cats and seals.***
Expected responses:	***Positive.***
Observations:	***The elderly residents accepted the robots straight away. An interesting aspect is that there seems to be a natural connection between the elderly and the robotic animals. In certain occasions female participants wanted to keep the robots for longer periods of time. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed specification:	**Type of robotic application delivered:** robotic animals will be used. The objective of such activities is to recreate relaxation exercises to be performed by elderly groups. When working with sensitive groups such as the elderly, some questions arise: what builds or prevents success with them, and how we are going to achieve it?. **Users' responses:** the users' responses will be recorded in video/audio formats for further analysis. **Robotic presence**: we will investigate if the robotic animals achieve robotic presence. **Attachment**: the human supervision team will be constantly monitoring for any signs of attachment towards the robotic animals. **Ethnographic studies**: a small ethnographic research will performed to understand potential

	reactions to two different types of robotic animals: seals and cats. **Methods used to deliver HRIs:** we will explore current methods for delivering the robotic animals with elderly groups. In social success we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Human supervision scheme HRI benchmark template:

HRI benchmark:	**Human supervision scheme**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**
Description:	**In human supervision scheme we want to clarify a human supervision team for monitoring the HRIs with elderly residents. We also want to define the periodicity and duration of HRIs.**
Categories and subcategories identified:	**1. Assessment panel constitution** **2. Periodicity and duration of the HRIs**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Autonomy - human supervision scheme: human contact and close supervision must be promoted throughout the robotic animals workshops.***
Expected responses:	***Positive.***
Observations:	***A supervision team as closely following the robotic workshops. Further analysis details are described in appendix I.***
Additional comments:	***Due to the sensitivity of elderly groups the human supervision scheme is extremely important. Such supervision is also important in promoting human contact.***

Detailed description:	**Assessment panel**: small assessment panel constituted by the researcher, one representative of the carers and relatives. **Periodicity:** in terms of the robotic workshops duration periods we have decided that the workshops should not exceed 45 minutes of weekly robotic workshops and especially should be held during the mornings. In the human supervision scheme benchmark we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Usability and testing HRI benchmark template:

HRI benchmark:	**Usability and testing**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**
Description:	**In usability and testing we want to test the robotic animals in different conditions/scenarios to ensure its safety. We are also interested to get users' perspectives on the robotic animals and possibly learning curves to use them in the future.**
Categories and subcategories identified:	**1. Functional testing** **2. Potential users HRIs observations and interviews** **3. Learning curve**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Usability and testing - Safety: prior to the robotic animals sessions the robots were exhaustively tested to see if there was any safety issue. No problems were detected.***
Expected responses:	***Positive.***
Observations:	***The robotic animals were tested in lab before the practical robotic workshops. Further analysis details are described in appendix I.***

Additional comments:	***None.***
Detailed description:	**Functional testing:** the robotic animals will be tested in advanced to check for any potential dangerous responses or hardware faults. **Potential users HRIs observations and interviews:** we will observe and interview elderly people relative to the use of robotic animals. **Learning curve**: we will consider the learning curve in the robotic animals' sessions. In usability and testing we are considering the ethical principles of beneficence, non-maleficence.

Liability HRI benchmark template:

HRI benchmark:	**Liability**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	**Robotic seals and robotic cats were used to entertain elderly people in care/extra care homes. It investigated new opportunities in terms of human pet companionship in elderly stages.**
Description:	**In liability we want to have a perspective on the robotic manufacturers' liability, user liability/ third party liability or insurance. The objective is to clarify the user license agreement which will be part of SARs in the future.**
Categories and subcategories identified:	**1. User robotic license agreement (manufacturing guarantee, user liability, robotic system hacking, third party liability and insurance).**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Not identified yet.***

Expected responses:	***Positive.***
Observations:	***No liability issues found yet. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Manufacturer guarantee:** normal 90 days guarantee (free from defects). The robotic animals abide by the European electrical equipment safety regulations and are assigned with the EC logo. As in other type of electrical equipment such policies try to prevent any eventual electrical shocks. **User liability:** the use of the robotic animals is not recommended for children under 4 years old. **Third party liability and insurance**: the manufacturer states that he is not responsible for any damages caused by accidents, negligence, improper service or use or other causes not arising out of defects in materials or workmanship. In liability we are considering the ethical principles of beneficence, non-maleficence and justice.

The SARs research team (manufacturers, care institutions or academic body):

HRI benchmarks template	**Revised:** 07/06/13
Name	**Signature**
Person A: Antonio Espingardeiro	Antonio Espingardeiro
Person B	
Person C	
Person D	

8.3.1. Robotic animals HRI benchmarks relationships

These are the identified HRI benchmarks relationships in the robotic animals' workshops. For more information see detailed analysis on appendix I.

Autonomy - Safety (2): The robotic animals react to touch and then display an autonomous behaviour. Since the machines are designed to work on the participants' lap a certain attention is required to prevent any abnormal situations where the robot might trap the user hands and compromise human safety.

Autonomy - Human supervision scheme (3): It is important to understand that the robotic animals' activities result from a hybrid approach where the interaction between humans and machines takes place. Three actors are proposed, vulnerable users, robots and supervisors. As in any other type of robotic workshop human contact is absolutely essential between supervisors and vulnerable groups to both reinforce and supervise the level of interaction with the robots.

Usability and testing - Safety (8): Prior to the workshops the robotic animals were exhaustively tested to detect any abnormal situations that could compromise human safety. Also during the robotic workshops a high level of attention was dedicated to analyse the learning curve of vulnerable groups, carers and relatives and their level of confidence when operating the robots. However there is always a residual risk in technology and usability and testing is a crucial phase to both detect faults from hardware and user behaviour which can contribute positively to safety.

Imitation - Robotic presence (4): Imitation is highly influenced by the aesthetics of the robots. In the case of the robotic animals a high level of zoomorphism was used. In part I found that such robotic animals' aspect and natural behaviour were responsible for conquering a high level of robotic presence. Such justification could take philosophical and anthropological routes where human beings seem to constantly establish good relationships with certain mammals. With the robotic animals we are reactivating such relationships using high levels of zoomorphism that convey not real presence but indeed robotic presence.

Human Supervision Scheme - Attachment (5): The robotic seals and cats triggered comments on some female participants such as: “lovely robots”, “you can leave them with us until next week”, “when we will have the cats?”. Such comments were even more noticeable when people were reluctant to give the robots back. It seems the methods to deliver the robotic activities have to be well planned and good levels of human supervision are necessary to monitor any eventual attachment phenomena.

Understanding of domain - Social success (6): In the robotic animals activities we made an effort to understand if the vulnerable groups understood the objective of such HRIs. The robotic animals achieve a higher level of robotic presence and are capable of triggering positive emotions on their users. I found that people understood the robots as machines that were designed and programmed for entertaining them which is in line with our primary objectives. In HRIs social success depends also on the level of understanding of the interaction itself. The notion of what is the role of humans and machines has to flow spontaneously during the interaction and the key element to achieve such result lies on the threshold between robotic presence and human reality.

Ethnographic studies - Scalability (7): Despite the fact the robotic animals were not programmable there are some relevant elements when it comes to understand the local cultures and how well such robotic animals could be received in communities of vulnerable groups. In Japan seals are popular, in Europe people coexist daily with cats and dogs and that was their favourite animal. Despite such cultural pet choices I found that the “touch” interfaces seems to work remarkably well both with UK and Portuguese elderly groups.

8.3.2. Robotic animals attachment

During the robotic workshops I have identified human behaviours associated to attachment theory (Bowlby 1969). Such behavioural manifestations were particularly true in females during the robotic seals and robotic cats workshops. Comments were common in interview in 1 and 3, “we will keep the seal on the centre, with us”; “when we will have the cats?”, “you can leave the cats with us until next week!”. It seems elderly residents established a strong relationship with robots that resembled a certain animal behaviour. This effect seemed to be amplified with higher levels of robotic zoomorphism brought in through the form of robotic cats. In certain cases the experience was so meaningful for certain females that they didn't wanted to stop petting the robotic animals and pass them to other members of their group. I detected some traces of attachment once I or one of the carers tried to retrieve the robots from people. In terms of understanding of domain elderly residents were aware that I was bringing in these robots for their relaxation and contentment. The robotic workshops were initially created to be group exercises where everybody should had the opportunity to interact with robots. Such behaviour occurred in weekly robotic workshops during the period of 6 months and half with the same magnitude both in the UK and Portugal. Such behaviours lead us to question the periods and timetables of such interactions.

8.3.3. Robotics animals attachment procedures

We are currently introducing the concept of SARs with vulnerable groups such as the elderly. During the robotic animals workshops I have promoted a non-informal setup where elderly people would sit normally on a recreational room or lounge. Typically the disposition of the audience would form an elliptical or oval shape surrounding myself with the robots. We wanted to recreate the most natural possible scenario as it was important for the participants to feel comfortable and to perceive the robotics workshops as any other type of show (e.g. musical, theatre, cinema etc). The objective of "in-situ" research was to observe the natural reactions of elderly people relatively to SARs in familiar care settings. The scenarios of robotic attachment lead me to rethink the way I was presenting the robotic animals' workshops and what guidance could be provided for future research. I was inspired by the psychological theory of "Classical conditioning" (Watson and Rayner 1920). The phenomenon of classical conditioning resembles an involuntary response that is "sometimes referred to as signal learning, where stimulus occurs just before the expected behaviour is to occur" Ormrod and Rice (2003: 57). The idea was to bring "rules" to the workshop that could lead the activity in a fair and ethical manner. Thereby I invented a hybrid scheme involving the participation of a referee, the participants and a buzzer system. When I pressed the buzzer the elderly residents would pass the robot to their next colleague and so on. Thereby all the elements of the group would have the opportunity to share the robot within the 45m scheduled period. Unconsciously this scheme imposed "rules" to the robotics animals whilst I could better monitor the outcome of each individual HRI. This deontological inspiration allied with the classical conditioning theory was designed for the reduction of eventual attachment responses towards the robotic animals' exercises. Despite the friendly and comfortable environment created by robotic animals in care and extra care facilities researchers have to think about emerging contingency plans to deal with situations of extreme attachment or breakdown/loss of robots. In "human-pet attachment" studies there is no complete answer to guide the elders through the process of losing a pet (Sharkin and Knox 2003). In a remote future if we consider that each individual in an extra care facility will have the opportunity to have its own SAR then it is likely that such individual will form a close relationship with that robot even when such robotic exercise is delivered according to a scheduled plan.

In situations of robotic animals' attachment the substitution of robots by other types of activities that have a high level of importance for elderly individuals could be an alternative. At the present there are no known solutions for robotic attachment but it is important that awareness sessions towards robotic workshops should take place periodically as an extension of the informed consents for staff teams, relatives and friends. The dissemination of information as well as discussing the risks of close HRIs with elderly residents have to be balanced between advantages and disadvantages and always keeping in mind that rarely we will find a solution for all the cases. Indeed the robotic animals bring new forms of relaxing and contentment in care and extra care facilities but it also reinforces the fact that this is a process that involves a continuous supervision scheme and responsibility of carers, relatives and residents.

Framework step 3 includes a revision on the previous steps.

8.4. D45 (FIGURES 49, 50)

This section presents the D45 case study. In (**figures 47 and 48**) we can see the visual selection process from the generic HRI benchmarks diagram. In (**figures 49 and 50)** we see the HRI benchmarks final selection (framework step 1).

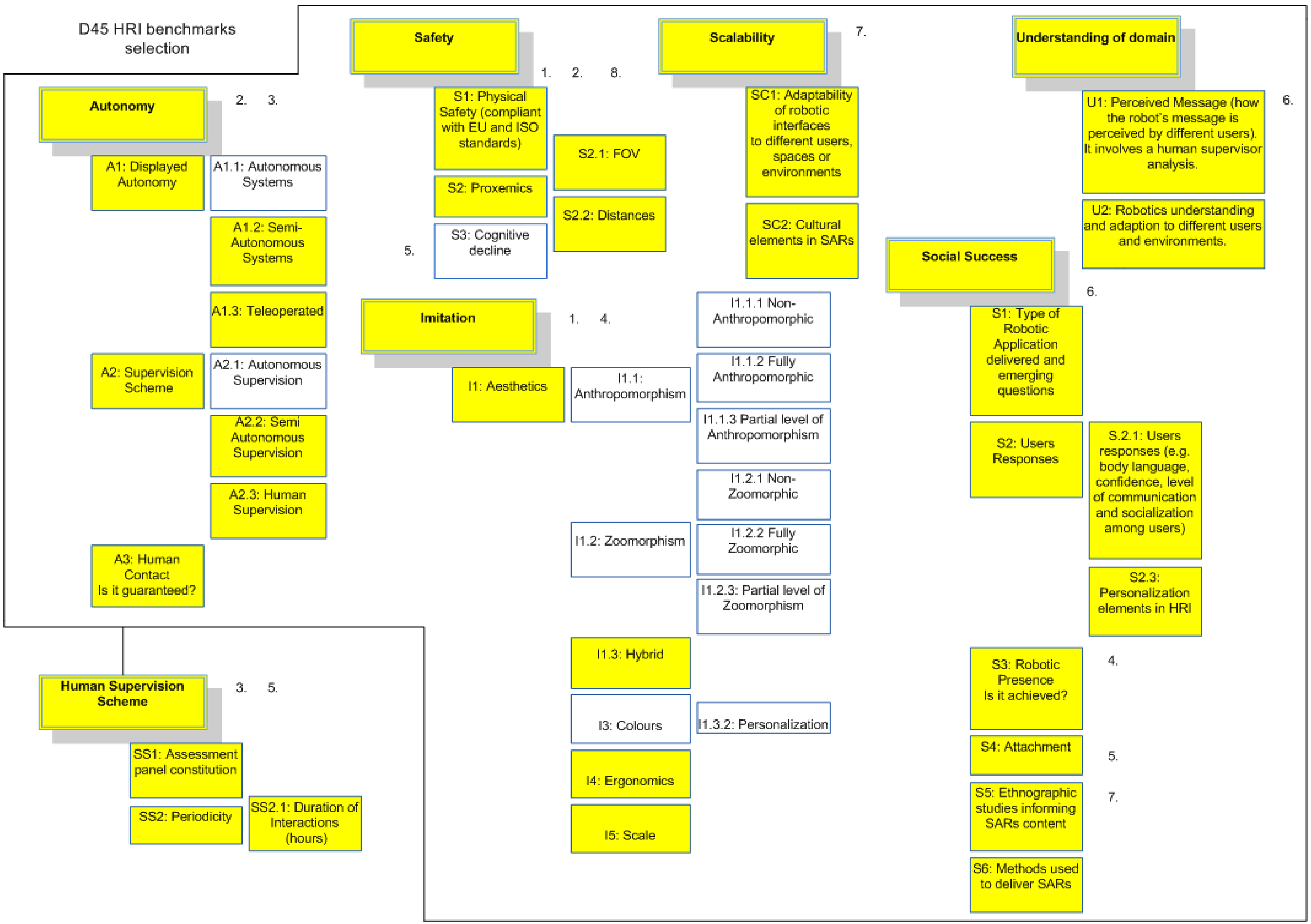

FIGURE 47 - D45 HRI BENCHMARKS SELECTION

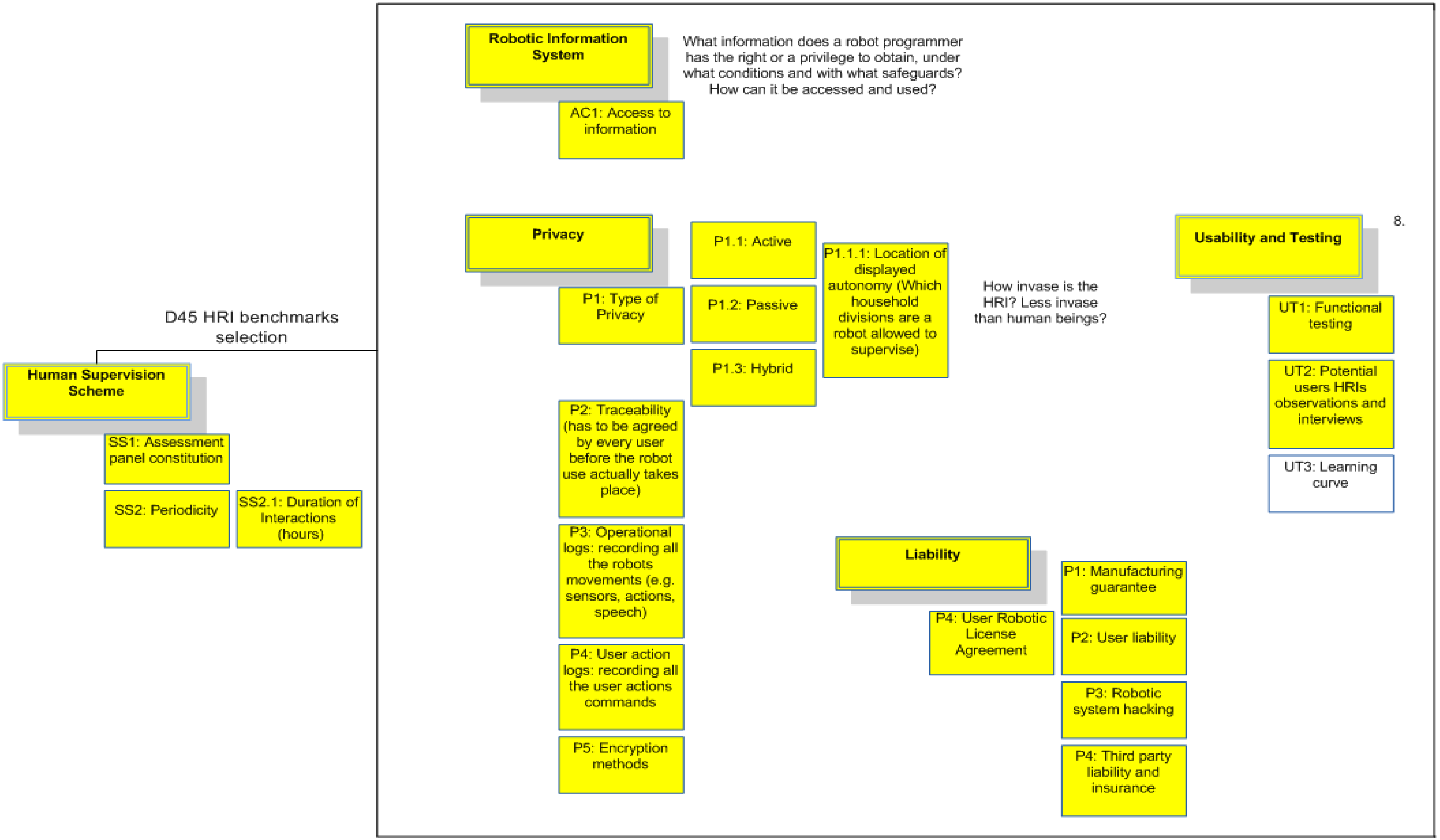

FIGURE 48 - D45 HRI BENCHMARKS SELECTION (CONTINUATION)

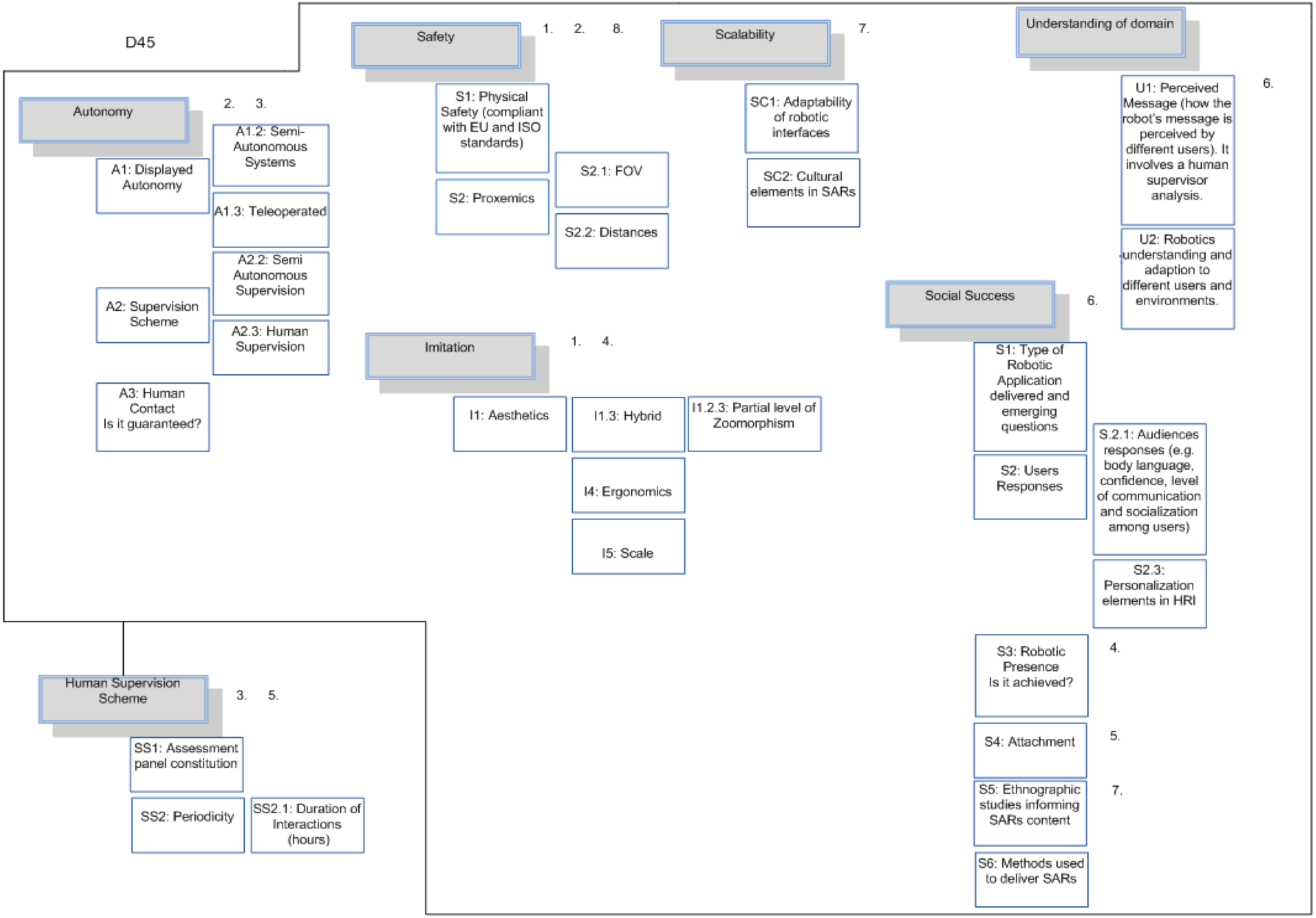

FIGURE 49 - D45 DIAGRAM

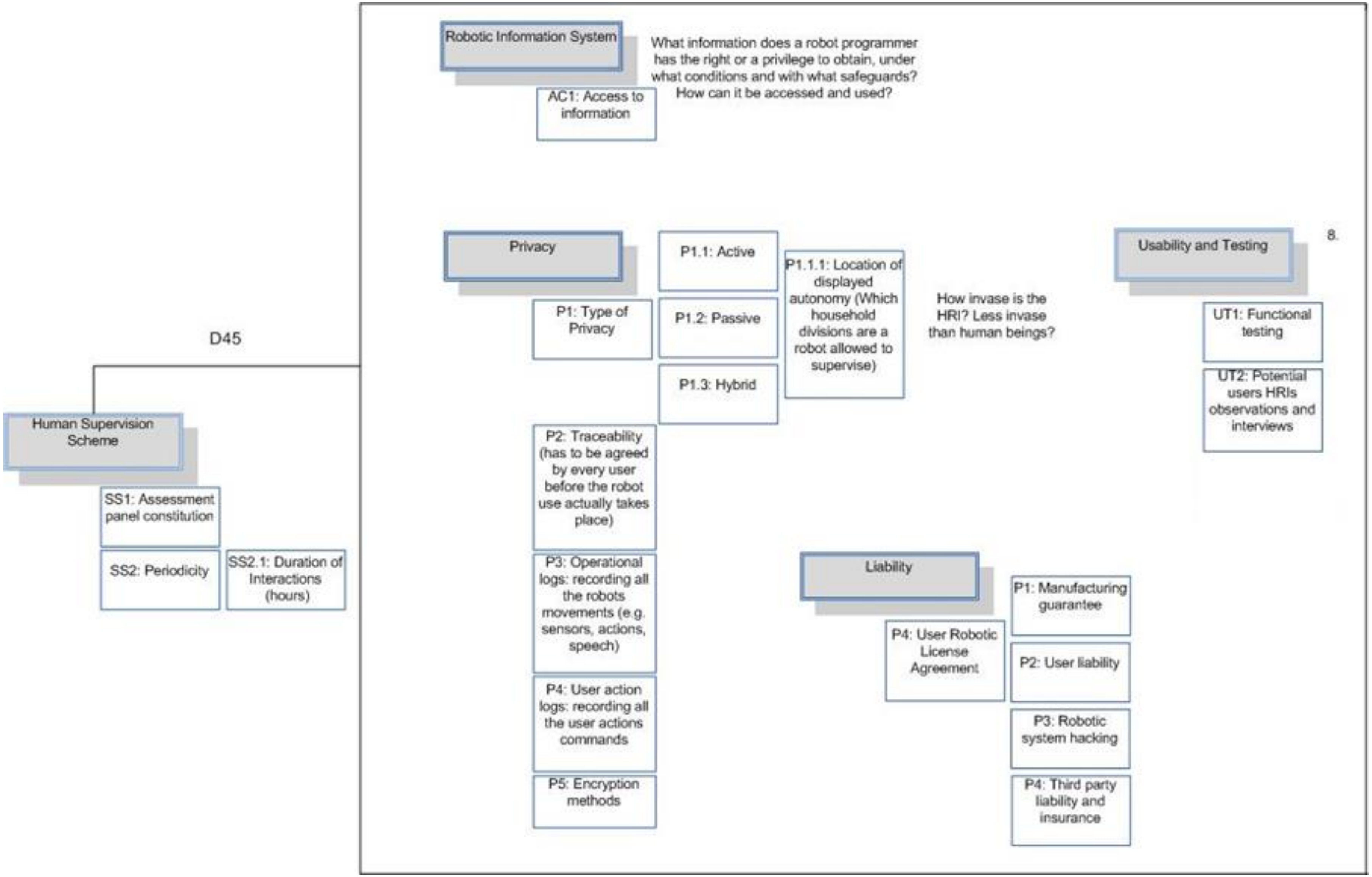

FIGURE 50 - D45 DIAGRAM (CONTINUATION)

On this section we present the framework step 2 which includes filling in the HRI benchmarks templates.

D45: generic robotics application template

Name of the robot:	***D45.***	
Main SAR objective:	***The objective of this SAR is to demonstrate supervision and communication capabilities in elderly care.***	
Location where the HRIs will take place:	***Locations:*** *Wallfields court (A), Rivercare (B), Centro Social e Paroquial Alentejo (C), Lar do Monte Velho (D), Acolhimento Jardim Rosa (E).*	
Main HRI benchmarks involved:	*Relevant:* ***Human supervision scheme, imitation, autonomy, safety, social success, scalability, understanding of domain, usability and testing, liability, robotic information system, privacy.***	*Not Relevant (why):* ***All relevant.***
Supervision team:	**Location A: Assistant 1, Manager 1, Antonio Espingardeiro** **Location B: Manager 2, Antonio Espingardeiro** **Location C: Manager 3, Antonio Espingardeiro** **Location D: Assistant 4, Antonio Espingardeiro** **Location E: Manager 5, Antonio Espingardeiro**	
Supervision scheme:	*Periodicity:* ***Once per week during a period of 7 months and half.***	*Duration:* ***45 minutes sessions.***
Stakeholders involved in the HRIs:	**Location A: Assistant 1, Manager 1 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location B: Manager 2 (public care/extra care sector), Antonio Espingardeiro (researcher)** **Location C: Manager 3 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location D: Assistant 4 (private care/extra care sector), Antonio Espingardeiro (researcher)** **Location E: Manager 5 (public care/extra care sector), Antonio Espingardeiro (researcher)**	

SARs owner:	***SAR used for research purpose and owned by Antonio Espingardeiro.***
Additional comments:	***Approaching care givers and care receivers is an important topic in elderly care.***

Autonomy HRI benchmark template:

HRI benchmark:	**Autonomy**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In autonomy we are analysing people's responses to different levels of autonomy for supervision of elderly groups.**
Categories and subcategories identified:	**1. Displayed autonomy (Semi-autonomous system, teleoperated)** **2. Supervision scheme (Semi-autonomous supervision, human supervision)** **3. Human contact (is it guaranteed?)**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Autonomy - safety: since D45 is 60cm height mobile robotics platform, high levels of autonomy have to be well tested in terms of users' safety. Hardware failures or software glitches have a residual risk in HRI.*** ***Autonomy - human supervision scheme: D45 was mainly demonstrated for supervision purposes (semi-autonomous supervision and human supervision modes). However human contact must be promoted throughout the robotic workshops.***
Expected responses:	***Positive.***
Observations:	***In terms of aesthetics D45 wasn't accepted so well. However in general terms the robot message and capabilities was well accepted by the elderly groups. Further analysis details are described in***

	appendix I.
Additional comments:	***None.***
Detailed description:	**Displayed autonomy**: D45 could be considered a semi-autonomous device. For most part of situations the robot is teloperated by a human operator. However it can also follow people autonomously. **Supervision scheme**: human supervision scheme was selected during the D45 workshop. The researcher in conjunction with carers will supervise the elderly groups during the course of HRIs. It is important to add that in robot following mode passive sensing methods were used to identify a 3D human silhouette for the robot to follow. At the overall a semi-autonomous supervision mode is selected. **Human contact**: human contact must be promoted. In autonomy we considered the ethical principles beneficence, non-maleficence and autonomy.

Safety HRI benchmark template:

HRI benchmark:	**Safety**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In safety we want to make sure that SARs are compliant with EU/ISO electrical equipment safety regulations. We are also interested to understand elderly people's perspectives on the distances and FOVs practiced with D45.**
Categories and subcategories identified:	**1. Physical safety (compliant with EU/ISO regulations)** **2. Proxemics (distances, FOVs)**

Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Imitation - safety: aesthetics notions could impact on the user's sense of safety. In the case of D45 the robot was full of wires and had no significant aesthetics work. In the robotic workshops elderly people were doubtful about the robot safety.*** ***Usability testing - safety: D45 was exhaustively tested in laboratory; however there is always a residual risk associated to hardware and software faults. Researchers must be attentive to situations that might compromise elderly safety.*** ***Autonomy - safety: since D45 is 60cm height mobile robotics platform, high levels of autonomy have to be well tested in terms of users' safety. Hardware failures or software glitches have a residual risk in HRI.***
Expected responses:	***Positive.***
Observations:	***No safety issues were detected. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Physical safety:** in terms of physical safety D45 was developed according to electrical regulations (EC). **Proxemics**: in terms of distances the robot will be tested in the range of (150-40cm) away from individuals. In safety we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Imitation HRI benchmark template:

HRI benchmark:	**Imitation**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In imitation we want to understand aspects related to the aesthetics of D45, ergonomics and**

	scale.
Categories and subcategories identified:	**1. Aesthetics (Hybrid)** **2. Ergonomics** **3. Scale (70 cm)**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Imitation - safety: aesthetics notions could impact on the user's sense of safety. In the case of D45 the robot was full of wires and had no significant aesthetics work. In the robotic workshops elderly people were doubtful about the robot safety.*** ***Imitation - robotic presence: aesthetics and scale could be related to the users' perceived notion of robotic presence. In the case of D45 elderly residents didn't accepted the robot so well. It seems aesthetics needs more work for achieving the notion of robotic presence.***
Expected responses:	***Positive.***
Observations:	***In terms of aesthetics D45 wasn't accepted so well. However in general terms the robot message and capabilities was well accepted by the elderly groups. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Aesthetics:** in imitation the aesthetics category selected is hybrid. D45 was designed as robotic research platform. It has a square shape with a long neck and a Kinect system on its head. **Ergonomics**: underneath the CPU the robot had a few drawers which were used to store candy whilst the robot helped distributing it among the residents. **Scale**: D45 is about 115cm height. In imitation we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Scalability HRI benchmark template:

HRI benchmark:	**Scalability**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In scalability we wanted to understand the D45 robotic platform adaptability in terms of interfaces. In autonomy D45 used a semi-autonomous supervision mode to follow humans. In scalability we also wanted to explore the emerging cultural responses.**
Categories and subcategories identified:	**1. Adaptability of robotic interfaces** **2. Cultural elements in SARs**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Ethnographic studies - scalability: it is important to understand that the content programmed into robots has to be studied according to different cultures. In this case no cultural differences were found between the UK and Portugal.***
Expected responses:	***Positive.***
Observations:	***No significant cultural differences were found in UK and Portugal. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Adaptability of robotic interfaces:** in the robot following mode D45 has a passive supervising system that allows it to follow any humans. **Cultural elements in SARs:** we will investigate cultural responses in UK and Portugal.

	In scalability we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Understanding of domain HRI benchmark template:

HRI benchmark:	**Understanding of domain**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In understanding of domain we wanted to know if the robots delivered message was perceived by elderly residents.**
Categories and subcategories identified:	**1. Perceived message (how the robot's message is perceived by different users)** **2. Robotics understanding and adaption to different users and environments**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Understanding of domain - social success: it is important to understand if the elderly residents are happy with the atmosphere recreated by the robots. Despite the aesthetics issue the elderly understood that D45 was performing for supervision purposes.***
Expected responses:	***Positive.***
Observations:	***The elderly understood D45 as a supervising machine. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Perceived message:** we will try to understand if elderly residents do understand the message delivered by D45 e.g. medication reminders, task reminders.

	Robotics understanding and adaption: D45 has a semi-autonomous behaviour however in robot following mode it can detect human 3D silhouettes and follow them in a certain location. In understanding of domain we are considering the ethical principles of beneficence, non-maleficence.

Social success HRI benchmark template:

HRI benchmark:	**Social success**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In social success we want to unfold some of the aspects beyond the success/in success of the D45.**
Categories and subcategories identified:	**1. Type of robotic application delivered and emerging questions** **2. Users' responses (users' responses in terms of body language, confidence, level of communication and socialization among residents; personalization elements in HRI)** **3. Robotic presence (is it achieved?)** **4. Attachment** **5. Ethnographic studies informing SARs content** **6. Methods used to deliver SARs**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Understanding of domain - social success: it is important to understand if the elderly residents do understand the message delivered by robots. Throughout the robotic workshops the elderly understood that D45 was performing for supervision purposes.***
Expected responses:	***Positive.***
Observations:	***In terms of aesthetics D45 wasn't accepted so well. However in general terms the robot message***

	and capabilities was well accepted by the elderly groups. Further analysis details are described in appendix I.
Additional comments:	***None.***
Detailed description:	**Type of robotic application delivered:** the type of robotic application delivered is a mobile robot. The objective of such activities was to create a good environment where D45 is demonstrated as a robot helper for carrying goods and as a medication reminder tool. When working with sensitive groups such as the elderly, some questions arise: what builds or prevents success with them, and how we are going to achieve it?. **Users' responses:** the users' responses will be recorded in video/audio formats for further analysis. **Robotic presence**: we will investigate if D45 achieves robotic presence. **Ethnographic studies**: in the UK the D45 medication reminders will be demonstrated in English. In Portugal the medication reminders are translated to Portuguese. **Methods used to deliver HRIs:** we will explore delivering methods for the D45 robot. In social success we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Human supervision scheme HRI benchmark template:

HRI benchmark:	**Human supervision scheme**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In human supervision scheme we want to clarify a human supervision team for monitoring the HRIs with elderly residents. We also want to define the periodicity and duration of HRIs.**
Categories and subcategories	**1. Assessment panel constitution** **2. Periodicity and duration of the HRIs**

identified:	
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Autonomy - human supervision scheme: human contact and close supervision must be promoted throughout the robotic workshops.***
Expected responses:	***Positive.***
Observations:	***A supervision team was closely supervising the elderly responses. Further analysis details are described in appendix I.***
Additional comments:	***Due to the sensitivity of elderly groups the human supervision scheme is extremely important. Such supervision is also important in promoting human contact.***
Detailed description:	**Assessment panel**: small assessment panel constituted by the researcher, one representative of the carers and relatives. **Periodicity:** in terms of the robotic workshops duration periods we have decided that the workshops should not exceed 45 minutes of weekly robotic workshops and especially should be held during the mornings. In the human supervision scheme benchmark we are considering the ethical principles of beneficence, non-maleficence and autonomy.

Usability and testing HRI benchmark template:

HRI benchmark:	**Usability and testing**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In usability and testing we want to test D45 in different conditions/scenarios to ensure its safety. We are also interested in getting users' perspectives on the use of D45.**

Categories and subcategories identified:	**1. Functional testing** **2. Potential users HRIs observations and interviews**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Usability testing - safety: D45 was exhaustively tested in laboratory; however there is always a residual risk associated to hardware and software faults. Researchers must be attentive to situations that might compromise elderly safety.***
Expected responses:	***Positive.***
Observations:	***In terms of aesthetics D45 wasn't accepted so well. However in general terms the robot message and capabilities was well accepted by the elderly groups. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Functional testing:** D45 has been technically tested in lab to identify possible faults. **Potential users' observations and interviews**: D45 will be tested in close proximity with elderly individuals. Their responses, attitudes and points of view have to be taken into consideration. In usability testing we are considering the ethical principles of beneficence, non-maleficence.

Robotic information system HRI benchmark template:

HRI benchmark:	**Robotic information system**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***

Description:	**The robotic information system investigates what elderly users' personal information can be obtained by a programmer or robotic system (e.g. name, birthdate, medications, diseases etc). Such information is targeted to facilitate the levels of care provided by SARs such as D45.**
Categories and subcategories identified:	**1. Access to information**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Not identified yet.***
Expected responses:	***Positive.***
Observations:	***In terms of personal information provided to a robot no objections were made by the elderly groups. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed description:	**Access to information:** in robotic information system we are primarily concerned to understand what information could a robot or robot programmers obtain from its human users and how can that information be used (e.g. medication lists, personal information etc). In robotic information system we are considering the ethical principles of beneficence, autonomy and justice.

Privacy HRI benchmark template:

HRI benchmark:	**Privacy**
Iteration number and revision date:	**Number 2 (07/06/2013)**

Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In privacy we want to explore the concept of invasiveness using SARs such as D45. The notions of traceability, identification of elderly users and logs (records) come into question.**
Categories and subcategories identified:	**1. Type of privacy (Active, passive, hybrid)** **2. Traceability (has to be agreed by every user before the robot use actually takes place).** **3. Operational logs (e.g. recording all the robots movements e.g. sensors, actions, speech).** **4. User action logs: recording all the user action commands** **5. Encryption methods**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Not identified yet.***
Expected responses:	***Positive.***
Observations:	***Elderly were supportive of D45 supervision modes, including remind people about their medications, tasks and being able to establish a video conference with their doctors in a remote location. In terms of D45 patrolling routes the elderly had no objections for its use in corridors and common areas such as the lounge or the kitchen etc. However personal bedrooms are not suitable option because of dressing a privacy issues. Further analysis details are described in appendix I.***
Additional comments:	***In SARs defining privacy is absolutely important. Such options inevitably influence the possible levels of care delivered to vulnerable groups such as the elderly. A trade of must be achieved between levels of privacy and supervising features in D45.***
Detailed description:	**Type of privacy:** D45 will demonstrate the concept of passive privacy in the sense that it has sensors for detecting 3D human silhouettes without exactly identifying a person. D45 can also be used in active privacy mode in which it can film a person for example in telecare applications. **Traceability**: in traceability we will explore users' permission for a robotic system to trace elderly individuals in care settings. **Operational logs AI**: D45 will register all A.I decisions when operating in robot following or medication reminder modes. **Operational logs user**: D45 will register all user deliberate commands. **Encryption methods**: in terms of confidentiality and security of information state of the art encryption methods will be used to protect the robots' database.

	In privacy we have considered the ethical principles of beneficence, autonomy and justice.

Liability HRI benchmark template:

HRI benchmark:	**Liability**
Iteration number and revision date:	**Number 2 (07/06/2013)**
Main robotic objective:	***D45 is used to demonstrate supervision and communication capabilities in elderly care.***
Description:	**In liability we want to have a perspective on the robotic manufacturers' liability, user liability/ third party liability or insurance. The objective is to clarify the user license agreement which will be part of SARs in the future.**
Categories and subcategories identified:	**1. User robotic license agreement (manufacturing guarantee, user liability, robotic system hacking, third party liability and insurance).**
Possible new categories:	***Not found yet.***
Emerging relationships with other HRI benchmarks:	***Not formally identified yet. However it is likely that the selected levels of SARs privacy and access to elderly users' information could inform legal frameworks and insurers. Such bodies can review/consider manufacturing, supervision and user choices when deciding risks and liability issues.***
Expected responses:	***Positive.***
Observations:	***No liability issues were detected. Further analysis details are described in appendix I.***
Additional comments:	***None.***
Detailed	**Manufacturing guarantee**: normal 90 days guarantee (free from defects). D45 abides by the

description:	European electrical equipment safety regulations and is assigned with the EC logo. As in other type of electrical equipment such policies try to prevent any eventual electrical shocks. **User liability**: there are important elements that should be stated in the user robotic license agreement. D45 users should be aware that D45 uses a passive privacy mode where no personal human identification is made. However D45 can also be operated in active privacy mode which films (audio/video) an elderly individual for example in telecare applications for contacting his/her personal GP. Deciding when such modes will be used has to be positively informed by an assessment panel with input from users or relative representatives. D45 is mainly designed as an extension of care in terms of carrying goods and helping managing medication reminders. Carers and possibly robot operators are the main actors on controlling the robot. D45 will be tested in care settings where operational logs are recorded on A.I level and user level. It is likely that courts could use such records to help identifying manufacturers or user liability in the case of accidents. **Robot system hacking**: unwanted access and robot control should be considered by law. **Third party liability/insurance**: it is likely that insurers need to be informed as most as possible towards the residual risks involved in D45. Advantages and disadvantages should be presented and discussed between manufacturers and insurers. It is likely that such SARs will have insurance policies associated with their lifecycle. In liability we are considering the ethical principles of beneficence, non-maleficence and justice.

The SARs research team (manufacturers, care institutions or academic body):

HRI benchmarks template	**Revised:** 07/06/13
Name	**Signature**
Person A: Antonio Espingardeiro	Antonio Espingardeiro
Person B	
Person C	
Person D	

9.4.1. D45 HRI BENCHMARKS RELATIONSHIPS

These are the identified HRI benchmarks relationships in the D45 robotic workshop. For more information see detailed analysis on appendix I.

Imitation - Safety (1): we should regard that safety could be influenced by the type of aesthetics that is presented on a SAR. In D45 no significant aesthetics was developed. Elderly people responded with uncertainty by commenting “what strange machine is that?”, “is it safe?”. Such relationship is important to retain since robotics technological capabilities could be easily dismissed if for example aesthetics in imitation isn’t well calibrated.

Autonomy - Safety (2): the displayed autonomy in D45 encompasses semi-autonomous behaviours and teleoperation. On teleoperation the potential operators (carers, relatives, GPs) can control the robot in real time. There is a reduced risk in terms of compromising the physical safety of vulnerable groups. In semi-autonomous mode D45 can follow users. Despite the exhaustive testing in terms of hardware and software D45 is like any other type of technology invented by humans and it is prone to fail. The main types of failures associated to semi-autonomous modes are associated with hardware problems such as sensors malfunctions (e.g. wrong readings). Such behaviours are likely to trigger wrong software functions and generate deadlocks which could be translated into robots behaviours that can compromise human safety at a certain level.

Autonomy - Human supervision scheme (3): D45 was mainly developed as a SAR prototype for supervision of vulnerable groups. The philosophy behind it, is translated by a “hybrid” approach where interaction takes place between humans and machines. In the case of D45 the researcher, carers and relatives were supervising the activities and promoting a good environment when watching the robot’s capabilities. As in any other type of SARs interactions human contact is absolutely essential between supervisors and elderly groups.

Imitation - Robotic presence (4): the aesthetics of imitation could become crucial to the notion of robotic presence. That is exactly what happened with D45. The elderly residents' responses were not positive towards D45. In interview 3, elderly residents comments were made "what strange machine", "is it safe?". It seems the aesthetics of D45 isn't well calibrated (e.g. full of wires). Such relationship is important to consider as the aesthetics of the robot can block its potential users' acceptance.

Understanding of domain - Social success (6): despite the aesthetics of D45 in interview 3, we found that elderly people perceived the robot as a technological attempt to provide extra help when it comes to medication and task reminders. When working with vulnerable groups it is important to understand if SARs messages are perceived by the target groups. It is important to remember that this relationship is likely to become aggravated as the human cognitive level decreases with the ageing process.

Ethnographic studies - Scalability (7): in interview 3, no differences were identified in terms of cultural responses.

Usability and testing - Safety (8): D45 has been technically tested in lab to identify possible faults. However there is always a residual risk associated to hardware faults and human misuse of robots. We tested D45 in close proximity of elderly groups. In interview 3 comments were identified "what strange machine is that?", "are you sure it is safe?".
For now D45 aesthetics needs to be improved. A new aesthetics could reinforce its capability to convey robotic presence and provide extra help to elderly groups.

Framework step 3 includes a revision on the previous steps.

8.5. ROBOETHICS FRAMEWORK TOOLS DEVELOPED

A template has been developed in Libre Office 4.0 for maximizing the use of the proposed roboethics framework. In **figures (51, 52 and 53)** we see examples of the framework GUI during the selection of the relevant HRI benchmarks and templates completion.

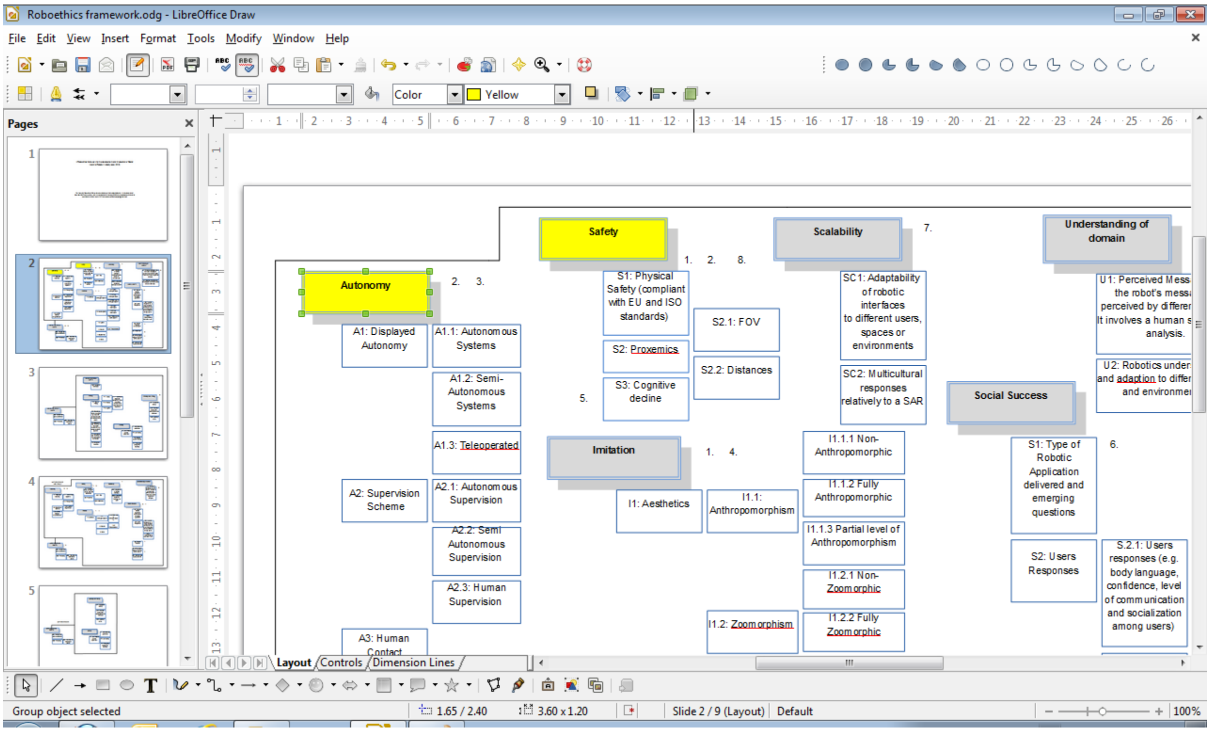

FIGURE 51 - ROBOETHICS FRAMEWORK GUI - HRI BENCHMARKS SELECTION 1

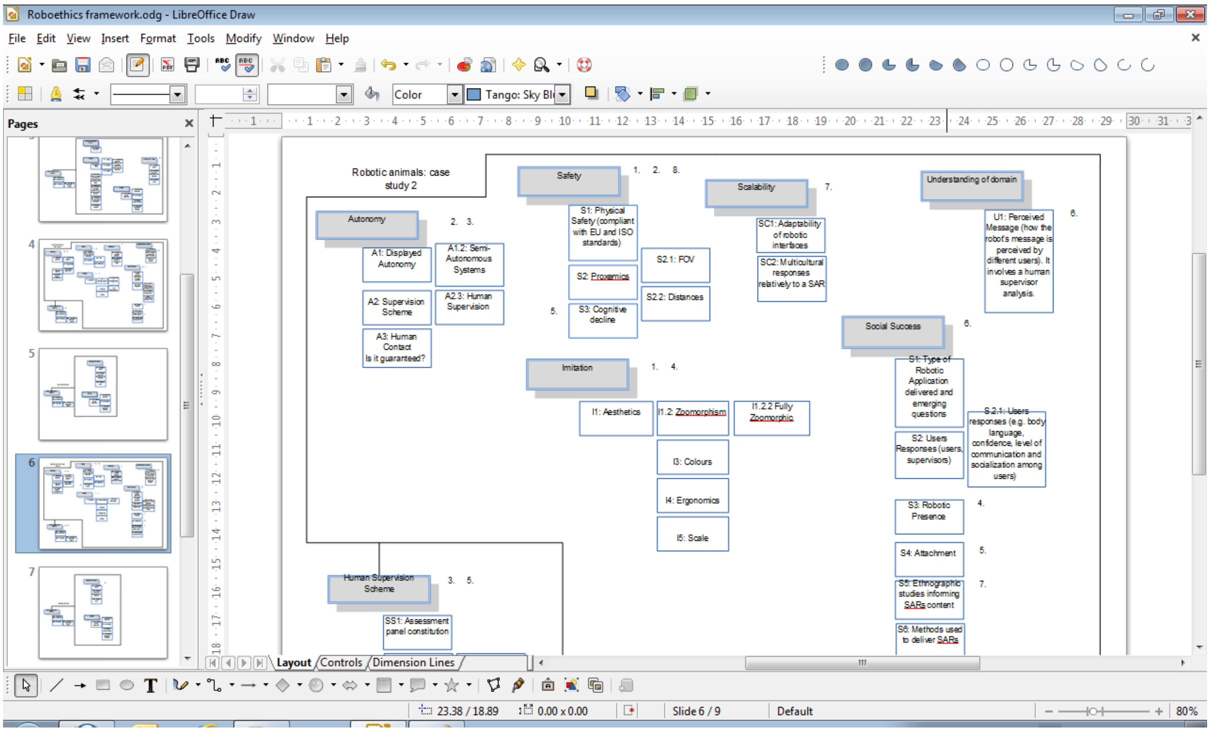

FIGURE 52 - ROBOETHICS FRAMEOWORK GUI - HRI BENCHMARKS SELECTION 2

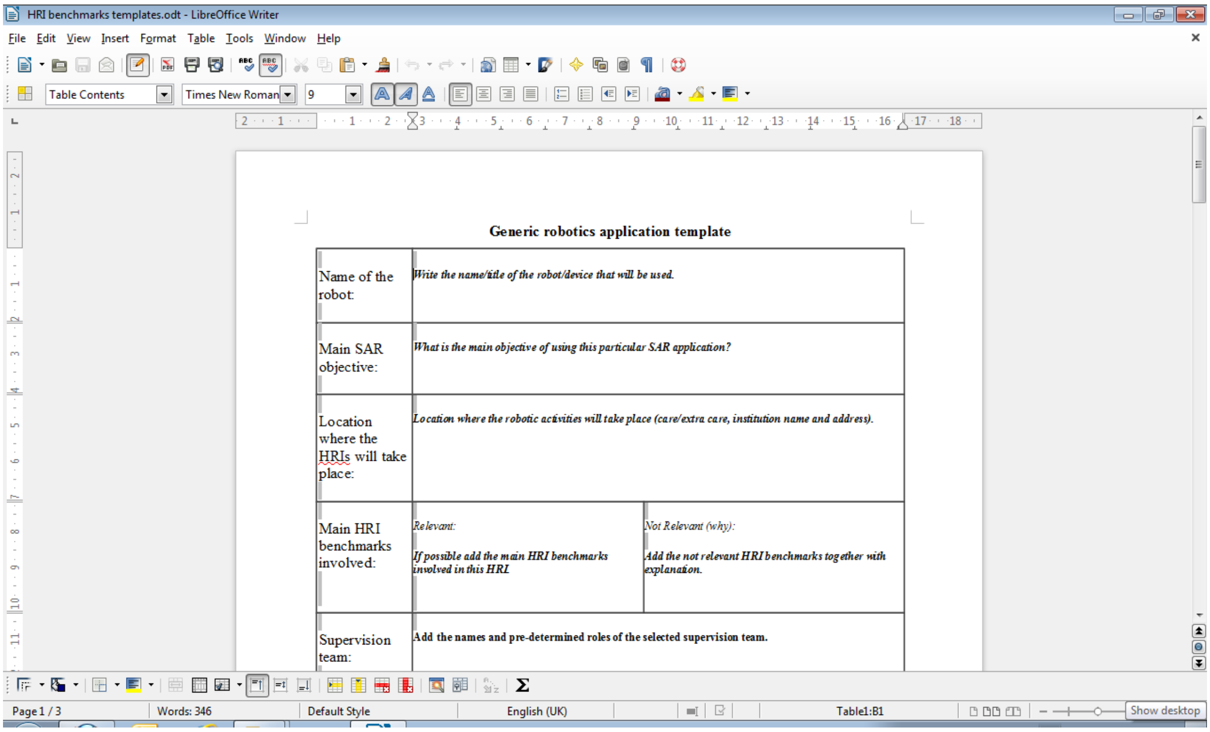

FIGURE 53 - ROBOETHICS FRAMEORK GUI - HRI BENCHMARKS TEMPLATES COMPLETION

8.6. Robotics prototypes developed

As a practical result of implementation of the proposed roboethics framework two robotic prototypes for elderly care were developed. On this section two robotic prototypes are introduced. P37 S65 (**figure 54**) is a SAR developed to provide cognitive assistance, supervision and entertainment for vulnerable groups. S15 Alpha (**figure 55**) is a SAR that resembles the form and behaviour of a cat and it is meant for entertainment and companionship.

FIGURE 54 - P37 S65

8.6.1. P37 S65

P37 S65 (**figure 54**) was designed and developed based on the lessons learned from practical workshops and ethical specifications derived during the case studies. In the imitation benchmark (aesthetics) I tried to inspire myself in elements of anthropomorphism to convey a message of technological assistance targeted for vulnerable groups. I tried to fuse the humanoid elements of RS Media e.g. head, arms and torso with the functionality of a machine such as D45. In terms of the benchmark of scale I created the robot with 5.4 feet (my height). We learned in the past that elderly residents were not happy with the scale of the humanoid robots (RS Media/V2 were too small) which definitely affected its notion of robotic presence. In terms of personalized elements P37 S65 is available in several colours however the user can request specific customizations in terms of colours. In P37 S65 I was extremely careful in terms of product design in order to transmit robotic presence. In terms of the benchmark of privacy I implemented the concepts of active privacy and passive privacy. In terms of autonomy benchmark P37 S65 is mainly used as a teleoperated robot to supervise vulnerable groups however it can operate with a higher level of autonomy for processing passive sources and provide a higher level of supervision for human users.

P37 S65 features:

- Medication Reminders (Send SMS to elderly and carer) (Programmable)
- Task Reminders (Send SMS to elderly and carer) (Programmable)
- Informs the user about the time
- Informs user about the weather forecast
- Provides the latest news to the user
- Plays music
- Tells jokes
- Tells stories
- Plays cultural games - makes programmable questions and waits for the user answer.
- The robot can incentivize physiotherapy exercises by interacting with elderly residents (e.g. lower and raise arms move hips).

- Speech recognition (all menus available).
- Face recognition (it can recognise different people).
- Object recognition with bar code technology (e.g. medication, daily objects).
- It can follow people for example to help serving meals or carry recycling garbage in a household.
- Telepresence robot - used as communication tool between the elderly, carers and GPs.
- It can also alert the authorities if the person is not feeling well.
- Anti-fall prediction system.
- All functionalities available on Wireless keyboard or joystick.

8.6.2. S15 Alpha

S15 Alpha (**figure 55**) was developed during the final stage of the robotics workshops. I understood that the robotic animals were indeed a very successful concept among the elderly. However we have experienced notions of attachment among the elderly participants. This led me to develop new qualitative and technical solutions for reducing such phenomenon during HRIs. In S15 Alpha an AI system was developed to monitor and constrain long periods of HRIs.

FIGURE 55 - S15 ALPHA

S15 Alpha functionalities:

- Real cat behaviour: legs, neck, head, eyes and tail movements, sounds (meow, purring).
- Human voice response.
- Touch sensors and vibrating motors displaced around the body (haptic feedback)
- Different personalities programming.
- Artificial Intelligence on board to monitor and constrain HRIs.

8.7. Summary of case studies

Three case studies were presented in this chapter. In the humanoid robots we highlight the immense potential when it comes to entertain vulnerable groups. The humanoid robots provided special entertainment moments to the elderly by playing their favourite songs and dancing. The elderly engaged naturally in this type of HRI. However such robots did fail in robotic presence. In imitation - robotic presence (4) it was identified that the notion of scale isn't proportional to the full potential of such machines to entertain people. Relative to the robotic animals, the seals and cats encompassed high notions of imitation where aesthetics took forms of full zoomorphism allied with the successful scalability of touch interfaces. The robotic seals and cats were very popular among the vulnerable groups since they responded to the elderly touch and resembled a natural animal behaviour. However in some of the cases the robotic animals were too successful. In social success traces of attachment were identified during the robotic workshops. In reality the robotic animals achieved such a high level of robotic presence that some of the female participants were reluctant to give the robots back. In the robotic animals workshops it is important to highlight the human supervision scheme - attachment (5) relationship, in which the role of the human supervising teams becomes absolutely essential to supervise and reinforce HRIs.

D45 was developed to provide supervision and cognitive assistance for elderly groups. However D45 fails immensely in terms of robotic presence. In imitation - robotic presence (4) we see that there are huge deficiencies in terms of aesthetics (D45 is full of wires and doesn't show any type of product design effort). Such aesthetic characteristics complicated tremendously its level of acceptance with elderly groups.

As a result of the implemented proposed roboethics framework, two robotic prototypes were developed in the context of this research. P37 S65 is a SAR developed for supervision, cognitive assistance and entertainment of elderly individuals and S15 Alpha is a robotic cat targeted to promote HRI through entertainment and companionship.

Chapter 9 - Conclusions and further work

According to the UN there is an ageing phenomenon worldwide (UN 2011). It is likely that the human civilization will need assistive technologies to extend the level of care required on the next decades. Socially assistive robotics is a relatively new area of research focused on the outcome of HRIs in terms of rehabilitation, convalescence or motivation of individuals. SARs are beginning to demonstrate high potential for delivering cognitive assistance, communication, supervision and entertainment for vulnerable groups such as the elderly. However ethical questions around the cognitive capabilities of elderly individuals to perceive and accept robotics technologies; the concepts of isolation versus living independently and the new qualitative dimension of care using SARs have to yet be fully explored. A review of the literature revealed a paucity of guidelines to develop SARs for vulnerable groups, with the benchmarks proposed by Feil-Seifer offering the most appropriate guidance. However the benchmarks appeared incomplete, with a lack of ethical interpretation and practical guidance for SARs developments.

In this research we reinterpreted the current HRI benchmarks through theoretical analysis drawing on the core medical ethical principles along with social care ethos. We conducted practical robotic workshops to observe the benchmarks in care/extra care field settings.

The contribution to knowledge of this thesis is to revise the current HRI benchmarks according to the four core medical ethical principles allied with social care ethos for proposing a roboethics framework that can inspire the development and introduction of SARs in elderly care. The framework process involves an analysis against the HRI benchmarks and the development of an ethical specification using the templates provided followed by a revision process. An important component of the specification is the provision of a supervision scheme. As a result the proposed roboethics framework aims to provide sufficient flexibility to understand the HRI benchmarks in the practical domain of elderly care.

9.1. Reframing HRI benchmarks

We revisited Feil-Seifer’s 7 HRI benchmarks of safety, imitation, autonomy, scalability, privacy, social success and understanding of domain by considering the HRI benchmarks ethical analysis and conducted robotic workshops. As a result 26 new categories and 4 benchmarks are included in the proposed roboethics framework.

9.1.1. Safety (3 categories added)

Feil-Seifer states that physical **safety** is of primary importance in robotics. However in safety we propose three new categories: physical safety, proxemics and cognitive decline. Physical safety deals with the level of integrity, accuracy, and performance standards displayed by SARs within the proximity of human beings (does the robot abide by safety standards?). Next we investigated proxemics, the use of space on interpersonal communication (Hall 1959) between humans and robots. During the robotics workshops we found that elderly residents were comfortable with the distances that the robots kept from them but they also preferred having a robot performing in front of them (FOV) instead of behind them. In the third category we considered cognitive decline which raises awareness relative to cognitive losses often manifested in elderly stages. Thereby a balance between the individuals' cognitive abilities and SARs delivering schemes should be achieved.

9.1.2. Autonomy (3 categories added)

Feil-Seifer reminds that **autonomy** in SARs is desirable, however autonomy could also lead undesirable situations such as stopping taking medications, therapies, or inability to identify human "pain" or "suffering".

In the benchmark of autonomy we propose three new categories: displayed autonomy, supervision scheme and human contact. Displayed autonomy deals with the autonomous capabilities of SARs e.g. autonomous navigation. Supervision schemes deals with the level of autonomous supervision possible during HRIs with elderly groups. During the workshops we found that elderly residents enjoyed the levels of SARs displayed autonomy but also highlighted the importance of human contact. This led us to propose a new category entitled human contact which emphasizes the promotion of human contact between caregivers, families and elderly groups. In addition staff and relatives agreed that an assessment should be made in conjunction with health professionals, residents and families when it comes to decide the level of autonomy used by SARs in elderly care.

9.1.3. Imitation (5 categories added)

Feil-Seifer introduces **imitation** by questioning if the interaction between the human and the robot helps expressing human capabilities or in the case of SARs does it reinforce performance.

Relative to imitation we unfolded the categories of aesthetics, colours, ergonomics and scale. More attention is needed relative to the robotics visual impact and how it can influence the elderly perception of SARs. In terms of humanoid robots aesthetics the residents tend to prefer the more robotic look rather than a typical "android" aspect. However there are anthropomorphic characteristics that seem to reinforce the residents' perception of SARs (torso, head and arms). A curious aspect is that some residents asked if we had bigger robots. By talking to the staff we found that the residents still perceive SARs as toys. In the robotic workshops, this fact didn't alter the entertainment and functional aspect of the robots but indeed it could influence the concept of robotic presence and therefore its acceptance/outcome in elderly care. Scale seems to play an important role in aesthetics however this is an area that needs further research. Elderly people also seem to be open to the idea of selecting their own colours for robots (personalization) so it could play an important part of HRI in the near future. Lastly in imitation, ergonomics deals with interfaces and shapes available for elderly users to interact with SARs. During the robotic workshops the robotic animals were successful in terms of aesthetics and interfaces used. The robotic behaviours associated with touch sensors and soft furs were well received by elderly groups.

9.1.4. Social success (6 categories added)

Feil-Seifer identifies **social success** as a task oriented benchmark. He asks "does the robot does what it was supposed to do"? Is it being successful in HRIs?

In the social success benchmark we introduced the following categories: type of robotic application delivered, audiences responses, robotic presence, attachment, ethnographic studies and methods used to deliver SARs. The type of robotic application delivered identifies the primary objectives of HRI and emerging questions in such interaction. The users' responses (e.g. body language, confidence, level of communication and socialization) are extremely relevant to positively/negatively inform researchers about the outcome of

HRIs. Robotic presence is a result of how well imitation is delivered (aesthetics) and perceived by elderly groups when using SARs. Attachment deals with the propensity for elderly groups to interact excessively with SARs. To date such levels are unknown but during the robotic workshops we already experienced some signs of attachment associated to the robotic animals' activities. In ethnographic studies we investigate eventual cultural issues/differences that can inform the content programmed in SARs and map its success. Also the delivering methods used by a researcher/performer to deliver entertainment robotic activities with elderly groups is an important step to be considered. In the case of the conducted robotic workshops we acknowledge that the high levels of communication and presentation skills of the researcher may have influenced in part the outcome of the workshops.

9.1.5. Understanding of domain (2 categories added)

In the task oriented benchmark of **understanding of domain** Feil-Seifer states that SARs should have the ability to understand aspects such as social dynamics and be capable of extracting useful information within human environments. He asks "does the social understanding of human behaviour helps task performance?".

In understanding of domain we considered two levels. The first, perceived message deals with the capacity of vulnerable groups to understand the robotic message delivered. Is the message delivered by a SAR really understood by an elderly person? In the case of the conducted robotic workshops the answer was positive.

The second level, robotics understanding and adaption relates to SARs adaptability to different users and environments.

9.1.6. Scalability (2 categories added)

Feil-Seifer mentions that the **scalability** benchmark is related to the adaptability of SARs interfaces to different users' requirements (e.g. how does a SAR respond to someone who cannot see or speak?).

When it comes to scalability we consider the ability of a robotic system to provide alternative interfaces that can match different users' requirements and environments (e.g. outside a robotic lab). Scalability also adds questions around the cultural perspectives that arise from deploying robots into different countries/regions. In the conducted robotic workshops the robotic animals were an example of how the "touch" interface was easily perceived and accepted by different cultures.

9.1.6. Robotic information system (new benchmark, 1 category)

In the **robotic information system** benchmark we are dealing with the level of information that a robot programmer or robotic system has the right or a privilege to obtain from elderly users. In the conducted robotic workshops no objections were made towards providing medication lists and personal information to be programmed in SARs such as D45.

9.1.7. Privacy (5 categories added)

Feil-Seifer states that SARs can become more or less invasive experiences than our current surveillance systems. He questions "does the user sense of privacy relates to better robot performance as an assistive presence?".

In the benchmark of **privacy** we consider the users wish to remain unnoticed or unidentified in a robotic environment especially in the case of SARs supervising individuals. During the robotic workshops elderly users were asked about locations where the SARs supervision could take place. No problems were raised in common areas such as the living room or kitchen. However the bedroom seems to be a sensitive area because of dressing and privacy issues.

To better understand privacy we added three new levels of privacy: active privacy, passive privacy and hybrid privacy. Active privacy uses active sources (audio/video in real time) to monitor individuals. Passive privacy uses passive methods such as 3D sensors to track individuals' without identifying them. Hybrid privacy is a mixture of the two modes. Traceability deals with the ability for a robotic system to locate human users. Due the high complexity of robotic systems and inherent liability it is important to have logs: on an A.I. level - operational logs and on a user level - user action logs. Encryption methods should be applied to guarantee personal users' information and privacy.

9.1.8. Usability and testing (new benchmark, 3 categories)

In the **usability and testing** benchmark we consider functional testing of a specific robotic device as primordial stage to identify emerging product faults. The robotics technology used during the workshops was exhaustively tested to identify any potential faults that could compromise users' safety.

Usability and testing should also include a qualitative journey into people's perspectives and learning curves when using SARs.

9.1.9. Liability (new benchmark, 1 category)

In terms of **liability** we are considering the HRI benchmarks of safety, robotic information system, privacy and usability testing. User robotic license agreements have to encompass a mixture of the previous described categories. Such categorization could help informing manufacturers guarantee, user liability, third party liability/insurance and robotic law. During the robotic workshops no liability issues were identified.

9.1.10. Human supervision scheme (new benchmark, 2 categories)

In the **human supervision benchmark** we propose an assessment panel constitution where a supervising team is assigned to supervise the conducted HRIs. Important information must also be clarified relative to the periodicity and duration of HRIs. During the robotic workshops it was shared by both caregivers and researcher that the HRIs with elderly groups have to be closely supervised. The conducted robotic workshops took place once per week with duration of 45m. The supervised team was formed by the researcher and caregivers/assistants in the care/extra institutions.

The assessment panel should gather regularly to discuss the outcome and progress of such HRIs.

9.1.11. HRI IDENTIFIED RELATIONSHIPS

Beyond the reframed HRI benchmarks some potential relationships were also identified in the course of research. Imitation - safety is relevant in the sense that aesthetics could have a positive/negative impact in the way people perceive robots. Autonomy - safety is important since there is always a residual risk associated to the displayed autonomy that might compromise human safety (e.g. hardware, software glitches). In autonomy - human supervision scheme, human contact is central to HRIs with elderly groups. Imitation - robotic presence reinforces how aesthetics and scale are presented to final SARs when it comes to convey robotic presence. In human supervision scheme - attachment it is important to be aware that some vulnerable users might develop a type of attachment towards certain SARs applications. In understanding of domain - social success it is important to understand (supervision teams) if the SARs messages transmitted to elderly groups are fully understood (e.g. medications, timetables, tasks). In ethnographic studies - scalability the content programmed in SARs and the types of interfaces displayed might differ according to different cultures. The usability testing - safety reinforces testing SARs to possibly identify faults and stresses the importance of reading users perspectives and levels of usability. Such HRI relationships were identified in the context of this research by considering the three case studies: humanoid robots, robotic animals and D45. However further research is likely to reveal more HRI benchmarks and potential relationships.

9.1.12. ROBOETHICS FRAMEWORK

A roboethics framework has been proposed to improve understanding on some of the ethical issues around the development and introduction of SARs. The framework includes the following steps:

1. HRI benchmarks analysis: in a specific SAR context the most relevant HRI benchmarks and emerging relationships are selected and represented in a diagram.
2. HRI benchmarks templates: in this step both the generic and individual HRI benchmarks templates are completed. Detailed supervision scheme information is obtained at this stage.

3. Revision: revision process to improve SARs.

The proposed roboethics framework attempts to provide enough flexibility to understand potential ethical issues in different SARs scenarios. However the framework itself does not represent a complete solution for all challenges involved in elderly care. It represents a framework of reference that should be applied in an iterative fashion: each step is a movement towards the improvement of SARs in elderly care.

As robotics technology advances, further HRI benchmarks, visual representations and revisions need to be performed. The ethical principles of beneficence, non-maleficence, autonomy, justice and social care ethos should be considered when developing SARs. Balancing those constitutes a continuous challenge for successful HRIs in elderly care.

9.1.13. Reflection on aims and objectives

In this research the following aims and objectives were identified:

- To investigate the current state of the art of the ethics involved in developing SARs for elderly care and identify potential limitations.

  ✓ In literature review we concluded that no significant contributions were made to the new curriculum of roboethics. The ethical design and development of SARs for vulnerable groups revealed fragilities.

- To examine how the four core ethical principles of beneficence, non-maleficence, autonomy, justice allied with social care ethos can be applied to the existing HRI benchmarks of “safety”, “imitation”, “scalability”, “autonomy”, “privacy”, “social success” and “understanding of domain” (Feil-Seifer and Matarić 2009).

  ✓ We revised the current work on HRI benchmarks. We have analysed it according to the four medical ethical principles and social care ethos. Such interpretation revealed limitations on the existing HRI benchmarks.

- To conduct practical robotics workshops and perform a qualitative analysis to reframe current HRI benchmarks.

✓ We have conducted HRI workshops considering the previous ethical analysis with social care ethos. We proposed an extension to such HRI benchmarks.

- To propose a roboethics framework that includes human supervision schemes, HRI benchmarks and ethical specifications for the design, development and use of SARs with elderly groups. Demonstrate the application of the proposed roboethics framework with practical case studies.

✓ A roboethics framework of reference was proposed. The framework involves three steps: analysis and visual representation of HRI benchmarks, templates completion and revision process. Three case studies illustrate the application and flexibility of such framework when guiding the design and development of different SARs applications.

At this point all aims and objectives seem to have been accomplished. This research investigated the current state of the art of the ethics involved in developing SARs for elderly care and identified limitations. It examined the existing HRI benchmarks according to the four cardinal medical ethical principles of beneficence, non-maleficence, autonomy, justice allied with social care ethos. A set of practical robotics workshops were prepared to qualitatively analyse the existing HRI benchmarks. After the analysis we reframed the current HRI benchmarks considering the theoretical and practical dimensions of SARs. As a result, this study proposes a roboethics framework that provides flexible understanding on some of the ethical issues involved in elderly care.

9.1.14. Self-critical analysis

It is important to remind that the theoretical analysis of the current HRI benchmarks resulted from a subjective interpretation of the ethical principles of beneficence, non-maleficence, justice and autonomy aligned with social care ethos. I tried to cross the advantages and disadvantages of the potential use of SARs within the context of elderly care. Such crossing seems possible but not always providing the certainty and answers that fit every situation and parties (caregivers and care receivers). In fact the emerging flexibility of the proposed roboethics framework represents a mechanism for understanding and balancing both the opportunities and challenges around the introduction of SARs in elderly care. Special focus should be placed in terms of any signals of distress or attachment demonstrated through future robotic workshops. In the case of the robotic seals and cats high levels of interaction were identified between the elderly and the robots. We will need more input from health care, psychology and social work to be able to construct theories and practical knowledge to deal with those.

It is also important to recognise that during the practical workshops the researcher's performance and communication skills may have influenced some of the perspectives of elderly residents towards SARs. It is also true that this represented a unique and complex experience for those who research and those who need care. Therefore high levels of communication between parties were needed to build the necessary confidence and motivation. Future researchers should understand that the experiments depicted in this study might not be exactly reproduced when bringing robots to care and extra facilities. In fact, the magic behind them lies in the delivering methods, supervision and engagement between elderly groups, researcher, caregivers and robots.

This research followed an interpretivism philosophy. We believe this was appropriate to try to understand some of the emerging ethical issues with the introduction of SARs. We conducted "in-situ" research which meant richer qualitative elements for further analysis. It is also true that we had to accommodate our research methods according to the sensitivity of the elderly groups. The robotic workshops were presented as weekly "shows" where observations and notes were collected. The qualitative interviews were conducted after 4 weeks of workshops in a total of 3. Such timing gave space for the HRIs to be processed and built up motivation for the next stages.

It is important to mention the limitations and effectiveness of this research. This qualitative study involved 74 elderly participants plus caregivers and relatives. It tried to investigate the reality of elderly care and how SARs technology could be applied ethically to extend human levels of care. However it is difficult to generalize the results. Both the qualitative analysis and roboethics framework result from a subjective analysis of the reality and time in which the study took place.

In a reflective perspective it is important to recognize that there is an emerging ageing phenomenon worldwide. By other hand we are living in a time of rapid technological progress. The creation of assistive technologies could contribute to extend the levels cognitive assistance, supervision, entertainment, communication and companionship. The first generation of SARs are one example of possible technologies that could encompass such characteristics. Nevertheless SARs development and introduction will have to be followed by ethical frameworks that can provide indicators to reinforce moral judgments when using such technologies to complement elderly care. A key element here is to understand where humans perform better than machines and in which conditions robots offer advantages beyond human limitations. Such exercise can open doors to new developments and improvements in technologies that can significantly improve the quality of life.

9.1.15. Contribution to knowledge

The contribution to knowledge of this thesis is to revise the current HRI benchmarks according to the four core medical ethical principles allied with social care ethos for proposing a roboethics framework that can inspire the development and introduction of SARs in elderly care. Such framework involves three steps: analysis and visual representation of HRI benchmarks, the use of templates to create an ethical specification and finally a revision process. The roboethics framework represents an iterative process that provides flexible understanding on some of the SARs emerging ethical issues.

9.1.16. Future work

More “in-situ” research using SARs and the participation of elderly groups is required. SARs developments need to be more related with their prospective users and surrounding environments. In terms of scalability SARs prototypes are still confined to robotics labs and research centres. However the true analysis of ethical issues is likely to emerge from the deployment of robots in real world scenarios. The application of roboethics frameworks could determine the pace between precautionary approaches and technological benefits for providing better quality of life.

It is important to remember that as SARs technologies evolve more HRI benchmarks/relationships are likely to be identified and reframed in the context of elderly care. Thereby the roboethics framework has to be revisited and expanded in the future.

The creation of multidisciplinary teams is an important step in SARs research. As an example further projects could investigate the use of SARs with elderly groups and correlate prospectus results in terms of dementia or Alzheimer. Improvements, drawbacks or a complement to current therapeutic procedures could be unveiled with expertise from health care, social work, psychology and neuroscience.

As we saw during this study an area of primary interest deals with studying SARs aesthetics and how can we create more persuasive and engaging HRIs with elderly groups. Other areas might need to explore the relationships formed between elderly groups and robotic animals and how supervision teams should guide the interactions. Such projects would possibly involve expertise from areas such as robotics, ethics, healthcare, social work, product design, arts and psychology. Being able to construct and improve the category of robotic presence represents a big challenge related to the visual impact of SARs and its possible behaviours for complementing elderly care. Lastly, the continuation of robotics "in-situ" research with the culmination between the ethics and robotics science is a vehicle for reinforcing both the role of technology and humans when facing the rising challenges of demographics. Such projects are likely to implement, critic and expand the proposed roboethics framework and contribute to better inform the design, development and introduction of SARs in elderly care.

9.1.17. Summary

This research proposed a roboethics framework for helping understanding some of the ethical issues around the development and introduction of SARs. The framework includes three steps: analysis and visual representation of HRI benchmarks, the use of HRI templates to create an ethical specification and finally the revision process. The framework is an iterative process that is used to improve SARs and related outcomes. Uniquely the framework provides flexibility to understand some of the ethical issues present in SARs. As we saw in chapter 8, the framework implementation raises different types of questions and results according to different types of SARs applications. Such flexibility is essential to better understand SARs creations and its potential for extending human care. To date we already identified increased forms of communication, socialization and entertainment arising from the use of SARs in care settings. It seems possible that SARs could contribute to build a new functional and qualitative dimension in elderly care. However it is important to remember that social assistive robotics is a multidisciplinary area that will need contributions across disciplines. Examples of further research involve the study of SARs within the thematic of dementia and Alzheimer and the study of SARs aesthetics to build improved notions of robotic presence for complementing elderly care. Finally the proposed roboethics framework represents an exercise to help understanding potential ethical issues and inform the development and introduction of SARs in elderly care. Such exercise is continuous and constitutes an integral part of the evolution between humans and machines.

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References of Images

Figure 1.0 - Credit: University of Connecticut CHIP: http://news.cnet.com/8301-17938_105-20013657-1.html

APPENDIX I - INTERVIEWS ANALYSIS

Detailed robotic workshops analysis in locations (A, B, C, D, E).

Interview 1 - Safety, Imitation, Social success

Location : "Centro Social e Paroquial Alentejo" (Portugal) (**C**)

In this robotic workshop I had 15 participants (12 women; 3 men). In terms of safety and proxemics 2 people (13%) have mentioned that the robot (RS Media) scared them initially, but after 5/10 minutes of the robotic workshops they were confident with the proximity of the machine. In terms of being close to the robot (myself giving and retrieving a ball from the robot) no one mentioned fear when dealing with the proximity of the machine (40 cm). Some residents mentioned "robot come here!" or deliberately expressed body language to call the robot close to them. People also asked "do you have bigger robots?".

In terms of FOV the residents mentioned (100%) that they prefer to have the robot in their sight instead of working behind them. Nine participants (60%) mentioned that they were supportive of listening to music from a robot instead of a radio. Participants sang and followed the rhythm as the robot played choreographs. In terms of robotic animals all participants (100%) enjoyed petting the robotic seal. In certain cases some female participants mentioned "I will keep the robot with me, don't worry".

In terms of aesthetics, 3 participants (20%) said that they preferred the more human aspect of the robot (anthropomorphization) in the picture I presented them instead of the RS Media. Nevertheless 12 (80%) voted the RS Media as their preferred design.

In this robotic workshop 2 carers were interviewed as they had watched the show from a certain distance. Also 4 relatives attended the activities and reported positive thoughts on it. In both cases it was mentioned that the robotic seal and the RS Media kept the audience active and promoted human communication and socialization among the elderly. In this set of robotic workshops I have noticed the specific case of a female participant who seemed fascinated with the robotic seal "Branquinha". The puppet completely hypnotized the participant as she kept tracking every movement of the seal whilst it was passing through the other residents. When she finally got the opportunity to pet the "robotic animal", she did hold it very tight and kept it with her for a long period of time. After the end of the robotic workshops the carers gave the seal back to her and she hugged it until I had to finally collect it and leave the facilities.

Interview 1 - Safety, Imitation, Social success

Location : "Lar do Monte Velho" (Portugal) (**D**)

Group A: In this robotic workshop I talked with 10 residents (6 women; 4 men) and also had the chance of talking to their local entertainer (staff). In terms of safety and proxemics from these 10 people none of them seemed to be afraid of the robot RS Media (100% confidence) either when watching it on the floor or on the top of the table (when it collected the green ball). However one of the residents mentioned that he was a little bit doubtful about the kind of gripper used by the robot. He asked "is it safe for my fingers?". Also one resident mentioned that the distance was not really important for him in terms of generating confidence with the robot, however he mentions that if the robot was too far that it could be difficult for his/her level of perception. Some residents mentioned "robot come here" and were supportive of getting closer to the machine. People even asked "do you have bigger robots?". When it comes to FOV all residents mentioned (100%) that they prefer to have the robot on their site instead of having it working behind their back.

In terms of entertainment (social success) all the residents (100%) enjoyed the kind of jokes that the robot have been programmed with. However when asked if they would prefer a radio or the robot to listen to music the opinions diverge: Five people (50%) claimed that they definitely preferred listening to music from the robot itself as it was a modern and exciting concept. From those one person told me that the radio still gives her more freedom do change the volume levels (usability) than the current robot (RS Media).

4 residents (40%) mentioned that they loved listening to music through any form and thereby having a robot or a radio didn't make any difference for them, however 1 person mentioned that she would still prefer the classical radio.

Lastly in terms of aesthetics 10 residents (100%) preferred the RS Media type of robot instead of the more anthropomorphic one. All participants and entertainer enjoyed petting the robotic seal (100%) and some of the residents asked "can we keep it?".

In terms of interactions I noticed several interesting scenarios such as people tend to give names to the robotic seals and attribute typical behaviours of a real baby "is it sleeping?", "is it going for a wee?" etc.

In this group I highlight two events where an educated participant and apparently physically fit was initially a little bit reluctant to interact with the baby robotic seal. Nevertheless 40 seconds later, he started to bend over the robot and hugged it pretty much like the other people in the group. The robotic seal was now triggering an emotional response and he seemed to enjoy interact with the puppet. Another example that shows of how personality affects the way residents perceive the robotic seal was a man that was a big football supporter and started to attribute certain athletic characteristics to the robot (such as you are fit, e.g. you are just like Cristiano Ronaldo).

Lastly people enjoyed the RS Media robot playing the choreographies. In this robotic workshop we encouraged the residents to follow the robots movements (rising, lowering their arms, turn left, turn right) and to follow the rhythm of the music. Most of the residents were participative by singing songs and following the robots' rhythm.

Such activities were followed with much interest from their entertainer there who mentioned that such exercise definitely promotes the spirit of the group and contributes to their individual wellbeing.

Group B: In this robotic workshop I had 11 participants with 9 men and 2 women. From the 11 residents no one mentioned they were afraid of the robot (either on the floor on the top of the table) (100% confidence) however one male participant said "for now". I interpreted that as a comment that reflects his uncertainty about the future of robotics. Generally the residents were asking the robot to come closer to them by mentioning "robot come here!". Some residents also mentioned "the robots are small but very interesting machines".

In terms of FOV they all mentioned to me (100%) that they prefer to have the robot on their site instead of working behind their back.

In terms of jokes all the residents (100%) enjoyed the content of the robot and 6 of them (54%) preferred the RS Media compared with the traditional radio. Four people (36%) mentioned it was irrelevant for them to listen music from the RS Media or radio as music is always welcome for them. However there was 1 resident that deliberately preferred the radio when it comes to listening to music. Other resident mentioned that he/she preferred the RS Media because "it was a more modern technology than the radio". During the humanoids activity most of the residents were singing and following the robots' rhythm.

In terms of aesthetics 9 persons (81%) preferred the RS Media robot but one resident still preferred the more anthropomorphic example. One resident mentioned that the design was irrelevant for him/her.

All participants (100%) enjoyed petting the robotic seal and I have found that some of the residents started to domesticate the robotic seal by saying expressions such as, "we will keep it", "we will definitely have to give it a name" etc.

As it happened with the previous group A, one of the residents exhibited a colder body language towards the robotic seal. However this was valid only for the first 30 seconds and after that the male participant started to lean towards the robotic seal and becoming more interested in the animal. One of the female participants (95 years old) suggested her own name for the seal, which I think it shows a strong self-confidence from the person herself. Another interesting aspect here is that another male participant took the opportunity to suggest his own nickname for the robotic seal (and that caused the whole audience to laugh). The male participant also suggested an interesting name for the seal "Eusébio followed by the resident's surname", Eusébio was a great football player in the 70s, a hero for this man. Finally I found extremely curious that a male participant who was an ex-army officer (parachutes regiment) at the "Ultramar war" really enjoyed interacting with the robotic seal (from the first moment he saw it). Maybe because of his past and army personality he was also trying to disturb the robot (forcing the seal to close the eyes etc). By doing so other residents mentioned to him "don't do that to the baby seal, it won't like that". It seems that the robot soon conquered the confidence of the other residents and they all started to like it in some way (e.g. some of them were even worried about the seal's wellbeing).

Interview 1 - Safety, Imitation, Social success

Location : "Wallfields Court" (UK) (**A**)

In this robotic workshop I had 10 residents (8 women 2 men). During the interviews I concluded that all the residents (100%) were OK with the distance that the robot kept from them (both on the floor and on the top of the table) (proxemics). Actually one participant mentioned that she would like to have the robot even closer to her (because of her hearing problems). Other residents mentioned "robot come here" or "what a fascinating machine you have there". People also asked me "don't you have bigger robots?", "I mean bigger ones". Relatively to the FOV when having the robot in sight or behind, 9 people (90%) told me that they preferred to have the robot in front of them (on site) and only one person told me that she had no problem in having the robot performing some tasks on her back. All participants (100%) enjoyed the jokes programmed into the robot (social success). When it comes to selecting music from the robot or from the radio the opinions diverge. Five people (50%) mentioned they would prefer hearing music from the robot however one female particpant told me she still likes to hear music from a radio as she can hear it better (increase/decrease volume (technical aspect)). Three people (30%) still preferred the radio and two people (20%) had no preference. It seems to me the sound of the robot has to be improved as some people might be answering this question influenced by the fact that they couldn't hear the robot well.

In terms of "fear" none of the participants mentioned to me that they were afraid of the robot (RS Media). On the overall residents were singing and following the humanoid robots' rhythm.

When it comes to petting the baby robotic seals 7 people (70%) said they remembered the experience and really enjoyed doing it. One person interviewed wasn't there when we had that robotic workshop. Two persons (20%) couldn't really remember themselves because they suffered from dementia. Such cases suffered from severe dementia as I understood this not only by talking to the staff but also through personal observation. However some female participants mentioned "can we keep the robotic seals?", "we will take care of them? don't worry".

In terms of Aesthetics I had 7 people (70%) preferring the RS Media type of robot and 2 persons mentioned the more anthropomorphic one. One person told me both were OK.

I got really surprised when the staff brought the oldest person in the institution (111 years old). This female participant came very close to me and I demonstrated how RS Media could collect a ball and return it back, I also made the robot talk and play music. I could understand by the body language and expressions that the she was amazed with such a robot. For two times, she said to me “marvellous machine” and I replied yes, it is the future.

Interview 1 - Safety, Imitation, Social success

Location : “Rivercare” (UK) (**B**)

In this robotic workshop I had 11 participants (10 women, 1 man). Relatively to distances (proxemics) displayed by the robot all the residents (100%) said that they were comfortable with the distance kept from the machine itself. Some residents were asking the humanoid robots “come closer to me…”. Some residents commented “the grey and orange robots are small”, “can they also clean the house?”.

In terms of FOV, 4 residents (40%) said they would prefer having the robot on their site and 5 people (50%) told me they preferred on site but they didn’t had any problem with the robot working behind them. One person didn’t give me her opinion because she was not feeling well at the time. All residents (100%) mentioned that they enjoyed the robot talking especially the jokes (social success). Four people (40%) preferred listening music from the robot and only 1 mentioned the radio instead. Again I suspect this has to do with the technical capabilities of the robot (the radio has better volume) but in this case nobody mentioned me such factor. Five people (50%) told me it was no different for them to listen to music from a robot or a radio since they enjoyed music through any form. On the overall residents were singing and following the humanoid robots’ rhythm.

In terms of confidence 9 residents (90%) mentioned to me they wouldn’t be afraid of giving or collecting the ball from the robot. The same participant that told me she wasn’t feeling well during question 2 (robot FOV) couldn’t answer the question properly.

In terms of experience with the robotic seals 3 people (30%) mentioned that they really enjoyed that experience. Six people (60%) mentioned they were not present in such robotic workshop so they couldn't really comment on that. 1 person seemed to suffer from severe levels of dementia and she couldn't really answer the question because she couldn't remember. Some female participants often asked "can we keep the seal?".

Finally in terms of aesthetics 7 people (70%) selected the RS Media as their favourite robot. 2 people (20%) mentioned they were both nice machines and 1 person said she would prefer the more anthropomorphic robot because it looked far more advanced than the RS Media.

Interview 1 - Safety, Imitation, Social success

Location : "Acolhimento Jardim Rosa" (Portugal) (**E**)

In this robotic workshop I had 16 participants (15 women; 1 man). In terms of proxemics no one mentioned that they were afraid of the RS Media robot (100% confidence). Actually some of the residents were calling the robot to come close to them "robot come close". Residents also commented "good machines, do you think they can became bigger?". All residents (100%) mentioned that they preferred to have the robot working on their FOV (in front of them).

In terms of content all participants mentioned that they enjoyed the jokes and songs played by the robot (social success). 11 people (73%) mentioned that they definitely preferred listening to music from a robot, 3 people mentioned that they liked both and 2 persons couldn't really answer. When it comes to music the majority of the residents sang songs and followed the humanoid robots choreographies. In terms of giving and retrieving the ball from the robot 14 people (87%) wouldn't be afraid of the robot at all. 1 person said she was afraid initially but that was just for a moment, after that she was comfortable with the machine. Lastly 1 person mentioned that she couldn't really tell (dementia).

With regarding to petting the robotic seal 14 people (87%) enjoyed doing it, 1 person wasn't present in the morning and 1 person couldn't really answer (high level of dementia). Some residents mentioned that they would like to keep the robotic seal for them "leave it with us; we will take care of it".

In terms of aesthetics 11 people (73%) preferred the RS Media type of robot whereas 5 people (32%) preferred the more anthropomorphic one.

Interview 2 - Autonomy, Imitation, Social success, Understanding of domain

Location : “Centro Social e Paroquial Alentejo” (Portugal) (**C**)

In this robotic workshop I had 9 residents (7 women; 2 men) and 3 carers participating. In terms of personalities 4 persons (44%) preferred the more robotized voice and its types of jokes and 3 persons (33%) enjoyed the more human voice. Two individuals (22%) mentioned that they enjoyed both (not having a preference). All residents (100%) were supportive of selecting the songs for the robot to play. Relatively to Autonomy displayed by the robot 5 persons (55%) were supporting the idea that the robot could walk autonomously on the room (it didn’t pose any threat for them). Three persons (33%) mentioned that they would prefer that a human would supervise the process and intervene if necessary. One person mentioned it didn’t make any difference to her. Residents comments were often based on “where is the robot going?” or “can it avoid obstacles?”. They also commented my performance “we like your show” or “it is good that you are around”.

In terms of aesthetics 6 persons (66%) responded that they preferred the RS Media colour (Orange and Grey) instead of having a total grey robot such as RS V2. One person claimed that the colour wasn’t important for her but still seeing the two robots he/she preferred the RS Media colours (orange and grey). One person said to me that she would like to have the RS V2 color (grey) as the robot seemed more formal with that colour. Another resident mentioned that she would like to select a pink robot. An interesting remark point here was the fact that the resident mentioned that he/she could be scared when finding an RS Media silhouette in the dark room with such red eyes.

I had the chance also to talk with three carers there. They all confirmed to me that with certain training and adaptation they could cope with the remote interface of RS Media (very similar to the RS V2). They all agreed that these types of activities contribute for making the elderly more active. However they also mentioned that the residents need to socialize more with other people with comments “yes we feel these people need more human contact, perhaps intergenerational contact”. Having this exercise two times per week would probably be a good timetable to start with.

Interview 2 - Autonomy, Imitation, Social success, Understanding of domain

Location : "Lar do Monte Velho" (Portugal) (**D**)

Group A: In this robotic workshop I had 11 participants (7 women; 4 men). Relatively to personality, 2 residents (18%) preferred the more humanoid voice, 3 (27%) the more robotic voice and 6 (54%) said they liked both. All residents agreed (100%) with the possibility of selecting their own songs to be played on the robot. In terms of the autonomy demonstrated by the RS Media robot, residents understood that the machines could perform some tasks autonomously or being controlled in real time by a human operator (in this case myself). Five residents (45%) mentioned to me that they would prefer to have a human as a safety backup to control the robot even if the robot is capable of performing some autonomous tasks. Four residents (36%) said that they actually liked the autonomy mode and they didn't saw it as problem for them. However one of the residents pointed out the fact that even if the robots have autonomous capabilities the human contact should not be discarded at all. In other words this man was conveying to me that having an autonomous robot isn't the complete solution for the elderly. Two residents (18%) said that they were indifferent to the autonomy mode. Residents comments' on autonomy included "that is amazing the robot avoids obstacles", "I see, it can make a safe journey around the house" or "we like you controlling the robots".

Lastly in terms of aesthetics (color), 7 residents (63%) preferred the RS Media colour instead of the V2 classical grey. 1 resident preferred the grey RS V2 and 3 people (27%) were indifferent (liked both). It is also curious to notice that when I asked people which colour they would order for themselves, some of them came up with white, cream, green, red or deep blue.

Group B: In this robotic workshop I had 10 participants (7 men; 3 women). In this robotic workshop 5 people (50%) mentioned that they didn't had a favourite personality (both voices presented were great). Two persons (20%) preferred the more human voice and 3 persons (30%) the more robotized voice. All residents agreed (100%) with the possibility of selecting their own songs to be played on the robot. Relatively to the Autonomy issue 7 people (70%)

preferred that I was in control of the machine. It seems in this group only 2 persons (20%) were supportive of having full autonomy. One person said it was indifferent for her. Comments were made “wow the robot is intelligent”, “look at that, the robot is avoiding obstacles” or “it is such a good environment with you and the robots”.

In terms of aesthetics 6 people (60%) preferred the RS Media typical colour (Orange Grey) and 1 person preferred the grey tone of the RS V2. 3 people (30%) mentioned to me that the colour was indifferent to them. In terms of suggested colours we had brown, red, a lighter grey colour and also grey and blue.

Lastly I had the opportunity to interview the local entertainer that helped me on the robotic activities. In the overall, she mentions that the robotic activities could have a positive impact by reducing the levels of isolation of these groups. She also said to me that being able to personalize some characteristics of the robot, such as colour, aesthetics; voices or interfaces could make the HRI even more persuasive.

Interview 2 - Autonomy, Imitation, Social success, Understanding of domain

Location : “Wallfields court” (UK) (**A**)

In this robotic workshop I had 15 participants (12 women; 3 men). Relatively to the two personalities we saw over the last months, 10 people (66%) preferred the more human voice, 4 people (26%) selected the more robotized voice and one person was indifferent. In terms of audio content, 10 people (66%) told me they would like to select the songs for the robot to play. However 5 people (33%) mentioned to me that they would prefer to have the robot with the average content (non personalizable). In terms of autonomy 11 people (73%) preferred to have a human on site controlling the robot, 2 people (13%) mentioned they were absolutely OK with autonomy and 1 person was indifferent. Also 1 person mentioned that she was OK with the autonomy issue but still she would like to have a human controlling the robot as part of the show (as the residents enjoyed the human contact). Typical residents comments’ were based on “Is the robot driving ok?”, “that is amazing”, “we like to have you controlling these robots”.

Lastly in terms of Aesthetics 9 people (60%) told me they preferred the RS Media type of Robot, 4 people (26%) mentioned the RS V2 and 2 (13%) didn’t had any preference. When it comes to select any colour for the robot the opinions diverge: 4 people (26%) still prefer the RS Media Orange Grey colour, 4 people (26%) selected the White of RS V2, 3 people (20%) mentioned green, 2 people (13%) red, 1 blue and 1 purple.

In this robotic workshop I also wanted to have the feedback of some of the staff that followed my robotic workshops over the last months. I talked with 3 members of staff who enjoyed the experience and think that generically it fits the needs of their tenants by entertaining them (it does a good job). They mentioned that the robotic seals seem to be very productive when it comes to people suffering from dementia (it provides both visual and tactile feedback) which allows them to remember the positive experience. In terms of humanoid robots they recognize that the musical choreographies of the machines contribute for a good environment of these groups as it also engages them emotionally in something through a common experience. The staff also mentioned that the vacuum cleaner robot was also a very popular motive of discourse among the residents. They even state that some of the residents were looking forward to have one of these robots in their flats as they could clean autonomously the floor.

In terms of autonomy the staff acknowledges that human contact is absolutely essential to be maintained with elderly residents. Comments were made by carers and managers "These people, need the most human contact as possible"; "we can't leave them fully dependent on machines". They also mentioned that the activities were well presented. The performer was able to engage with the Wallfields communities and to speak without using technical terms during the exercises. The staff recognises that their involvement is equally important in order to translate and to provide comfort, stimulation and support to the residents during the robotic workshops. Lastly they point out that if they had the chance to have some of these machines in their court they would be happy to control them and to deliver the experience themselves.

Interview 2 - Autonomy, Imitation, Social success, Understanding of domain

Location : "Rivercare" (UK) (**B**)

In this robotic workshop I had only 5 participants (women). In this robotic workshop we had 8 interviewees (4 residents, 4 elements of staff). In terms of residents 3 people (60%) preferred the more human voice and 1 person selected the more robotic one. One person told me that robotic voice wasn't perceptible at all for her and that was one of the reasons that influenced her choice. In terms of media content 2 persons (40%) answered yes, they "would like to select their favourite songs for the robot to play", 1 person preferred to have songs uploaded by default and 1 person didn't had any preference at all. In terms of autonomy 3 people (60%) answered they still would prefer to have a human controlling the machine there and one person said she was fine with the robot performing autonomously. Still on the autonomy issue one of the youngest female participants (60s) told me that she would also like to learn how to control the robot by herself. Elderly people also commented on the fact that the robot move autonomously by stating "wow that robot is smart", "it knows its way home", "but we also enjoy the fact that you are here with us".

Finally in terms aesthetics and selected colours 2 people (40%) selected the Orange and Grey of RS Media as their favourite colour, 1 person mentioned the white and 1 person didn't had any preference. When it comes to select any type of colour, people suggest pink, green, or the RS V2 type of colour (white cream).

In terms of staff I had the opportunity to talk with 2 administrative people that have been accompanying my robotic workshops over the last months. Relatively to the course of the activities they mentioned that they had an increase of people showing up at Thursdays (to their coffee shop) because of the robotics show. They also notice that some of the people in the cafeteria (non-residents) are attracted to the robotic activities even if they don't get closer to me (presenter) or the residents (it seems the show creates a good environment for the whole institution). Also they mentioned that the activities were interesting and anything that promotes the residents participation (interaction with systems) and socialization among them is welcome (these people are already too stopped every day). The robotic seals are very popular among the residents and the staff thinks it is an interesting way of stimulating them through visual and tactile cues. They suspect that holding the "seals" is a productive way to mitigate the dementia disorder as the experience is really meaningful for them. Relatively to comments after I finished the robotic workshops the staff says that the residents commented the show among them, so it can be considered already a victory as it promotes human communication and socialization among them. Two managers mentioned the fact that elderly people need more visits from younger generations "They definitely enjoyed visits, and we see human contact and initiatives like this as the future". In terms of robotics itself they mention that the residents loved the music and the dancing of the RS Media robot. The choreographies seem to be a very stimulating activity that makes the residents to perform gestures and sing.

Lastly and not least they also suggested that the versatility of the timetable is something that usually makes their traditional types of activities very successful. So in the future it might be something that can be explored to meet the best moments for delivering the robotics show.

Interview 2 - Autonomy, Imitation, Social success, Understanding of domain

Location : “Acolhimento Jardim Rosa” (Portugal) (**E**)

In this robotic workshop I had 24 participants (20 women; 4 men). In terms of personalities 14 people (58%) preferred the more robotized voice used during the interactions, 5 people (20%) selected the more human voice, 4 people (16%) didn’t had any particular choice as they enjoyed both. 1 person couldn’t really hear the robotic workshop. Relatively to choosing the songs 22 (91%) people answered yes (they would like to do it), 1 person mentioned that she was OK with the current songs and 1 person couldn’t really answer (dementia disorder).

In terms of autonomy 20 people (83%) mentioned that they preferred to have me controlling the machine in the room, 2 residents (1%) were OK with full autonomy however if there was a hardware breakdown I should be around to intervene. Two people (1%) didn’t have any particular choice. In terms of autonomy elderly comments were based on “so the robot can drive itself around the room, “that is amazing” or “we prefer having you controlling these robots”.

Lastly in terms of aesthetics 17 people (70%) mentioned that they preferred the RS Media robot whereas 7 people (29%) preferred the RS V2 robot. When asked the residents about suggested colours the opinions diverge as always. The RS Media colour is still one of the favourite among red, green, blue and pink.

Finally I had the opportunity to speak with the day centre director at “Acolhimento Jardim Rosa” (Portugal). In terms of the activities conducted she mentioned that despite the fact that the majority of these people had low level qualifications they rapidly grasped the essence of the robotics show. The director mentions that it would be good to have these types of activities in the future as the residents felt encouraged to continue them. He says “human contact with younger generations is absolutely crucial, family visits, friends etc”. I understand that “robots could gather everyone”. The director still mentioned that such exercises reduce the levels of isolation of people (promote human communication) and it might reduce the progress of mental illness that affects such vulnerable groups.

Interview 3 - Privacy, Social success, Scalability, Understanding of domain

Location : "Centro Social e Paroquial Alentejo" (Portugal) (**C**)

In this robotic workshop I interviewed 9 residents (7 women, 2 men) and 3 carers. All participants (100%) enjoyed interacting with the robotic animals. 6 persons (67%) preferred the robotic cat whereas 3 persons (33%) selected the robotic seal. Some female participants commented "when will we have the cats again".

In terms of robot medication reminders 7 people (77%) were supportive of such idea (including providing their medication list) while 2 people (22%) mentioned that they were doubtful. Similarly 7 people replied that they would like to contact their GP through a robot. One resident claimed that even beyond having a robot capable of such task he/she would still prefer to have the institution carers to remind him/her about his/her medication and wouldn't like to contact his/her GP using the robot. The second resident was OK with using the robot with medication reminders but also mentioned that he/she wouldn't like to contact the GP using the robot. In terms of the robot filming in common areas and being filmed while taking medications 7 people (77%) were supportive of such task and 2 people (22%) objected. Some comments addressed the location where such supervision takes place "here in this room, no problem at all".

In terms of robot following 7 people (77%) were supportive of such task and 2 people (22%) couldn't really answer the question. A point to remark is the low level of acceptability towards D45. The robot was full of wires and it was often commented by the elderly residents "what kind of machine is that?". Two carers tried out the humanoid and mobile robots. They reported positively in terms of interfaces: "fascinating, I could have one of these", "definitely I would like to control it in the future".

At the end all participants (100%) confirmed to me that they enjoyed the set of activities delivered. In terms of carers they agreed that these types of activities contributed for making the elderly more active and communicative. The use of supervision robots is an asset that they would like to have in the future as it shortens distances between people and would allow them to focus on the most serious cases of care.

Interview 3 - Privacy, Social success, Scalability, Understanding of domain

Location : "Lar do Monte Velho" (Portugal) (**D**)

Group A: In this robotic workshop I interviewed 11 participants (7 women, 4 men) and 1 element of staff. In terms of robotic animals all people (100%) enjoyed the activities where 9 persons (81%) preferred the robotic cat while 2 (18%) preferred the robotic seal. Some residents often commented "where are your robotic cats".

Relatively to having a robot with medication reminders all participants (100%) agreed (including providing their medication list) that it would be beneficial for them. Similarly all residents (100%) agreed that by contacting their GPs through the robot would be a good idea. Some of them mentioned that sometimes they have to travel long distances to see their doctors (according to certain expertise). It seems the robot apparently would provide them with a more generic solution for regular check-ups (exams reviews etc). In terms of the robot filming in common areas and filming while the residents were taking their medications all residents (100%) were supportive of such hypothesis. However some female participants asked me "where the robot will be?", "we don't want it in the bedroom".

Similarly no objections were made towards having the robot following the residents however D45 responses were not persuasive as with other robots (e.g. humanoids). Comments were made around the aesthetics of the robot such as "wow, don't get too close!". In this session 1 carer had the chance of controlling the humanoid and mobile robots. She commented "yes, I can control them, it is just a question of training".

At the end all participants (100%) enjoyed the activities delivered and were very supportive for more in the future.

I had also the opportunity to talk with one element of the staff that mentioned that the medication reminders provided by the robot are an interesting solution and if allied with the entertaining aspect that I'm currently developing in telerobotics it could have a positive impact by reducing the levels of isolation of such vulnerable groups.

Group B: In this robotic workshop I interviewed 10 participants (7 men, 3 women). In terms of robotic animals all people (100%) enjoyed the activities. 9 persons (90%) preferred the robotic cat while 1 person preferred the robotic seal. Robotic cats were preferred with typical female comments based on “can we have the robotic cats again” or “they are so lovely”.

In terms of the robotic medication reminder system (including providing their medication list) all participants (100%) were supportive of such idea. Similarly they all agreed (100%) that contacting their GP through the robot would be a good idea (it would save them time, money and human effort). In terms of filming in the common areas of extra care facilities and being filmed while taking medications, 9 people (90%) mentioned to me that there was no problem at all and only 1 person said that it was better if we could consult the residents individually before implementing such functionality on the robot. Again some uncertainty was detected towards the locations of robot filming with comments such as “here, in the lounge yes no problem”, “I don’t know about the bedroom”.

No direct objections were made towards having the robot following the residents however in the D45 session typical comments were made “what kind of machine is that?” or “is it safe?”. Two elements of staff had the chance to control the humanoid and mobile robots. They mentioned that it requires a little bit of training with the control pad (joystick) but they were positive about doing it in the future.

On the overall all participants (100%) enjoyed the activities delivered and where very supportive for more in the future.

Interview 3 - Privacy, Social success, Scalability, Understanding of domain

Location: Wallsfield court (UK) (**A**)

In this robotic workshop I had 19 participants (15 women, 4 men). I had also the chance to interview 1 carer, 1 relative and 1 manager. All participants (100%) enjoyed interacting with the robotic animals. 9 people preferred the robotics cats (47%), 5 people preferred the robotic seals (26%), 4 people (21%) replied that they enjoyed both (no preference at all) and 1 person couldn't really answer. Some female participants commented on several occasions (even outside of robotic workshops), "when will we have the robotic cats again" or "such lovely machines aren't they".

Everyone (100%) was supportive of having robotic medication reminders and providing their medication list to a carer for programming it on a robot. Relative to contacting (or be contacted) by a GP through a robot 16 people (84%) were supportive of such idea. Some of them recognised that sometimes the journeys to the GP take a long time just to know the result of some exam (something that the GP can tell them in 10m). 2 persons (10%) were perhaps influenced by the personality of their current GPs and replied that it wouldn't really fit their current GPs methods. One person couldn't really answer the question.

In terms of filming in common areas of the centre such as the living room or the corridor 17 people (87%) were supportive of that. One person didn't knew the answer and only 1 person objected to the idea. Comments were made "no, in the bedroom I wouldn't like it", "because of dressing and privacy issues".

In terms of having the robot following the residents on the room, 18 people (94%) were supportive of such idea. However 2 people (10%) were not sure. Lastly 1 person couldn't really answer.

Relatively to being filmed while taking their medication 16 people (84%) were comfortable with that idea. However one person raised concerns about the area in which the filming takes place (the bedroom isn't really a choice because of dressing and privacy issues). Still 2 people (10%) said they wouldn't want the robot to be filming them taking their medication. One person raised the point that such scheme is likely to compromise the human contact that carers have with elderly residents and it could originate certain job losses. One person couldn't really answer the question (wasn't sure about that). D45 was not so well perceived as other types of robots e.g. humanoids. Some residents commented “that machine is strange; don’t get to close to us”.

In terms of overall experiences 19 people (100%) were satisfied with the activities and really enjoyed those moments over the last 4 months. Some of them even mentioned that despite having physical limitations they were really engaged in the exercises I presented. One person mentioned everything that is entertainment for the elderly is welcome in the day centre. Finally 1 carer had the chance to control the humanoid and mobile robots. She mentioned “it was an interesting experience; I could do it in the future”.

I had the opportunity to interview 1 carer and 1 relative. They both agreed that the software interface on D45 was easy enough to use for the medication and task reminders however it would require some training provided by the software developer with the carers. In terms of carrying a mobile phone with them as tool for receiving SMS (emergency alarms and medications/tasks reminders) they were 100% supportive of such use (it would make their job more efficient). In terms of the idea of supervising the residents when taking their medications through the robot they also agreed that it would be a good idea. One of the common problems is that there is not enough staff around to supervise or take care of everybody (e.g. 50 flats on the Wallfields Court for 2 3 carers to supervise). In those situations the robot could become an advantageous tool that can allow them (not being busy all the time) to focus and allocate more resources on more serious cases whilst they check other residents through the robotic system (the service provided could become more efficient).

The staff mentioned that in terms of acceptance towards these robotic technologies the residents still see them for now as “toys”. However they are supportive of the medication/task/emergency reminders demonstrated through the workshops and in the future they expect that some of these robots could be used (through teleoperation methods) either locally or remotely for example to fetch things. Staff also says that the robotic cats and the seals seem to work better with patients with dementia or Alzheimer. However they see huge potential for the entertainment aspect of the humanoid robots and also the use of the Kinect system for the general elderly population (helps them practicing exercise in a complete different way).

Generally the staff agrees that these types of activities can approach generations. The younger audiences are persuaded to visit their grandparents since they can interact with robots or play with the Kinect system. Lastly the staff mentions that the dynamics of the show is something very important as residents usually don't like to have continuous repetitions of the same activities for long periods of time to the extent that they can lose their interest.

Finally I also had the opportunity to interview one of the managers at location A. The manager definitely agreed that these types of initiatives tend to approach generations. It is common to see grandsons and granddaughters coming to the see the robots or to participate in the Kinect workshops. From that point of view that is already a victory. He also says that the level of acceptability of this current generation (now in the centre) is fairly high. He predicts that the next generations will become even more open and actually expecting such types of technologies to help them in the most various number of activities.

In terms of alarm systems the manager says that the wallfields residents already carry an alarm system with them (if they don't feel well they just press it and it will alert the carers). However one of the problems usually deals with finding the person (their current alarm doesn't provide a location of the signal) and it doesn't allow them to talk directly with the person to investigate what is actually happening (Telepresence robotics "would be wonderful in that aspect"). He says that carrying a mobile phone for the residents or staff wouldn't be a problem and that it is an area that has to become more personalized in terms of alarm (locations) and methods to communicate with the residents. Supervising people using a teleoperated robot could become an important tool as it is common in these types of institutions to run out of available staff to deliver care. The robots could allow that process to become more efficient since the carers can spend more time with the neediest residents. Finally the manager says that despite robotics is still on a "primitive" state of art, the functional and entertainment aspects shown during the activities could in a medium long term become extremely beneficial in terms of quality of the service provided to the residents. Medication/tasks reminders are definitely an area that is welcome. As I had the opportunity of experiencing the levels of isolation and mental illness (dementia) are high so the entertainment aspect of robots could mean new tools that can help residents from a psychological and physical levels. The seals for example surpass the outcome of any type of activity conducted in the centre so far when it comes to reducing the levels of dementia. It is a meaningful experience that makes people to communicate more between themselves (socialize) and become more active in their lives. One of the evidences of such effect is that the residents comment the experience several days sometimes weeks after it happened both between themselves and also with the staff.

One curious aspect is that the manager mentioned that the use of SARs could actually become less invasive in terms of presence and attitudes perceived by the residents. As an example he mentioned that when he started working in elderly care at the age of 23, because he was so young elderly people sometimes didn't paid too much attention to his professional skills and advices. In a certain way he predicts that by using a machine to convey positive messages to the residents could become more acceptable (less invasive) and a more enjoyable experience to follow advices from.

Generally speaking all robotic and VEs demonstrated over the last 4 months were welcome as they prove to be beneficial for elderly people.

Interview 3 - Privacy, Social success, Scalability, Understanding of domain

Location: "Acolhimento Jardim Rosa" (Portugal) (**E**)

In this robotic workshop I had 24 participants (20 women, 4 men) and interviewed 1 manager. In terms of robotics experience with the robotic cats and seals 10 people (41%) couldn't really tell the difference since they missed the robotic seal workshop; however they did mentioned the fact that they enjoyed the robotic cats. Some female participants commented "will you bring your robotic cats next time?" or "such interesting machines you have".

From the usual participants 7 people (29%) said they preferred the robotic cats, 2 persons (8%) chose the seals and 3 people (12%) mentioned both. 2 people (8%) couldn't really remember themselves since they suffered from severe dementia.

In terms of medication reminders 24 people (100%) mentioned that they agreed with such device and providing their medication list for programming into the robot however one person was not sure about providing his/her medication list. In terms of communication 24 people (100%) mentioned that they enjoyed the idea of being contacted or talking to their GPs through a robot. An interesting aspect here was that one person told me that they didn't really wanted to disturb their GP as an analogy with a regular "call centre" call.

Relatively to filming in common areas and being filmed taking their medications 24 people (100%) said they had no problem. Some comments addressed the location where such supervision takes place “here in this room (lounge), no problem at all” or “not in the bedroom”.

For robot following all participants (100%) were Ok with such idea as long as the robot didn’t stopped working and became a physical threat to them. All participants (100%) enjoyed the roll of activities delivered and mentioned that any initiatives that promote human contact among residents and the outside world is very welcome. D45 triggered elderly residents’ comments such as “strange machine isn’t it?”.

Two carers also had a chance to control the humanoid and mobile robots. They mentioned that controlling the robots was indeed a “pleasant experience”.

Finally I had the opportunity to speak with the day centre manager from “Acolhimento Jardim Rosa” (Portugal). In terms of the activities conducted she mentioned that despite the fact that the majority of these people have a low level of qualifications they rapidly grasp the essence of the robotics show.

She believes the robotic medication reminder systems could be implemented in the future as they proved to be a highly beneficial tool when delivering care. Lastly the director says that it would be good to continue these types of activities in the future as it mitigates the levels of isolation and it might reduce the progress of mental illness that affects the elderly groups.

University of Salford Research Ethics Panel - Ethical approval memorandum (REP10/144)

Academic Audit and Governance Committee

Research Ethics Panel
(REP)

MEMORANDUM

To	Antonio Espingardeiro
cc:	Dr S Nefti-Meziani, Dr H Richardson, Ms J Mulhall
From	Jayne Hunter, Contracts Administrator
Date	18th February 2011

Subject:	Approval of your Project by REP
Project Title:	A Roboethics framework for human robotics coexistence
REP Reference:	REP10/144

Following your responses to the Panel's queries, based on the information you provided, I can confirm that they have no objections on ethical grounds to your project.

If there are any changes to the project and/or its methodology, please inform the Panel as soon as possible.

Regards,

Jayne Hunter
Contracts Administrator

For enquiries please contact
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Appendix II - Research impact

Research impact: Antonio Espingardeiro's list of interviews/citations and public engagement since 2009 (in the context of this research).

In January 2014 I was interviewed by "**Intel"** relative to the future of SARs https://communities.intel.com/community/itpeernetwork/blog/2014/01/13/robotic-technology-a-growing-it-career-field.

In January 2014 I was interviewed by "Planeta Sustentável" about my new robot P37 S65 "Elderly care bot" http://planetasustentavel.abril.com.br/noticia/atitude/engenheiro-cria-robo-auxiliar-idosos-770482.shtml.

In December 2013 I was cited by the British Alzheimer's society about my new robot P37 S65 http://www.alzheimers.org.uk/site/scripts/news_article.php?newsID=1886

In November 2013 I was cited by "**BBC** news technology" about my new robot P37 S65 http://www.bbc.co.uk/news/technology-24949081.

In November 2013 I was cited by "Click Manchester" about my research with SARs and elderly groups http://www.click-manchester.com/news/local-news/1219449-salford-to-become-dementia-friendly-university.html.

In November 2013 I was cited by "Hot digital news" about my new robot P37 S65 "Elderly care bot" http://hotdigitalnews.com/can-robots-care-for-the-elderly/.

In October 2013 I was cited by "The Solanes's Corner" about my new robot P37 S65 http://www.solanes1.com/en-la-vejez-tu-cuidador-sera-un-robot-y-podrias-encarinarte-con-el/.

In October 2013 I was cited by "Health wellness.co.uk" about my new robot P37 S65 "Elderly care bot" http://www.healthwellness.co.uk/health/robot-designed-to-take-care-of-elderly/.

In October 2013 I was cited by "th24.net" about my new robot P37 S65 "Elderly care bot" http://th24.net/news/Khoa-hoc/Robot-P37-S65-tro-thu-dac-luc-cho-nguoi-cao-nien-117/.

In September 2013 my research was cited by "SCL - The IT Law Community" http://www.scl.org/site.aspx?i=ed32369.

In September 2013 I was cited by "Vietmymagazine.net" about my new robot P37 S65 "Elderly care bot" http://vietmymagazine.net/cms/view/6745.

In August 2013 I was cited by "Columbus Nursing and Rehabilitation Center" about my new robot P37 S65 "Elderly care bot" http://columbusnursingandrehabilitation.com/can-a-robot-take-care-of-another-person/.

In August 2013 I was interviewed by "Super Interessante - Brazil" about my new robot P37 S65 "Elderly care bot" http://portaldoenvelhecimento.org.br/noticias/tecnologias/robo-cuidador-de-idosos-e.html.

In August 2013 I was interviewed by "Super Interessante" about my new robot P37 S65 "Elderly care bot" http://www.nerdmundo.com/tag/carebot/.

In August 2013 I was cited by "Khahoc" about my new robot P37 S65 "Elderly care bot" http://www.khoahoc.com.vn/congnghemoi/phat-minh/48664_Robot-P37-S65-tro-thu-dac-luc-cho-nguoi-cao-nien.aspx.

In July 2013 I was interviewed by **CNN** "what is next: Robots the future of elder care?" http://whatsnext.blogs.cnn.com/2013/07/19/robots-the-future-of-elder-care/.

In July 2013 I was interviewed by “Correiro Braziliense” about academic robotics contributions in the domain of SARs http://www.pernambuco.com/app/noticia/tecnologia/45,24,46,2/2013/10/30/interna_tecnologia,471024/cientista-brasileiro-cria-software-que-torna-os-aspiradores-mais-inteligentes.shtml.

In July 2013 I was interviewed by “Bdaily business news” about the new landscape of Robotics applications http://bdaily.co.uk/opinion/11-07-2013/artifical-intelligence-and-the-need-for-rd/.

In July 2013 I was invited to join the “Creative Skills for Life” advisory panel organized by “Creative England” and the “NHS commissioning board”. I will be assessing prototypes of digital technologies and social media that will promote the inclusion of youngsters with long term life threatening conditions.

In July 2013 I was cited by “Dinamo blog” about my new robot P37 S65 “Elderly care bot” http://dinamoeditora.com.br/dinamo-recomenda/.

In May 2013 I was cited by “Robotics.ua Russia” about my new robot P37 S65 “Elderly care bot” http://robotics.com.ua/news/service_robots/1720-robot_carebot_p37_s65_from_the_university_of_salford_will_take_care_of_the_elderly.

In April 2013 I was cited by “Business Today” about my new robot P37 S65 “Elderly care bot” at http://www.businesstoday.com.tw/v1/blog_content.aspx?id=1048.

In April 2013 I was cited by the “Institute of Art, Science and Technology” about my new robot P37 S65 “Elderly care bot” at http://waag.org/en/blog/robots-are-coming-help-us.

In April 2013 I was interviewed by “Nikkan Kogyo Shimbun” (Japan) about the future of SARs in Europe. http://www.ieee.org/about/news/2013/%5C05-17-2013_nikkan_kogyo_shimbun_antonio_espingardeiro.pdf.

In March 2013 I was cited by “Well Sphere” about my new robot P37 S65 “Elderly care bot” at http://www.wellsphere.com/healthcare-industry-policy-article/salford-phd-student-develops-revolutionary-elderly-care-160-robot/1898335.

In March 2013 I was cited by “Tech Orange” about my new robot P37 S65 “Elderly care bot” http://techorange.com/2013/03/22/robot-to-care-for-elderly-made-at-university-of-salford/.

In March 2013 I was interviewed by “AZoRobotics” about my new robot P37 S65 “Elderly care bot” http://www.azorobotics.com/article.aspx?ArticleID=100.

In March 2013 I was cited by “Cyprus mail” about my new robot P37 S65 “Elderly care bot http://aspects.duckdns.org/cyprus/Archive_2013/1303/Cyprus-Mail_PDF/20130301_Cyprus-Mail.pdf.

In March 2013 I was cited by “Guardian High Education Network” about my new robot P37 S65 “Elderly care bot” http://www.guardian.co.uk/higher-education-network/2013/mar/07/research-in-brief-universities.

In March 2013 I was interviewed by “PALOP news” about my new robot P37 S65 “Elderly care bot”

In March 2013 I was cited by “New Zealand Herald” about my new robot P37 S65 “Elderly care bot” http://www.nzherald.co.nz/technology/news/article.cfm?c_id=5&objectid=10869285.

In March 2013 I was cited by “Limbotech” about my new robot P37 S65 “Elderly care bot” http://www.limbotech.net/robo-revolucionario-destina-se-a-prestar-cuidados-aos-idosos/.

In March 2013 I was cited by “Carehomefunding advocates” about my new robot P37 S65 “Elderly care bot” http://www.carehomefundingadvocates.co.uk/?s=carebot&x=0&y=0.

In March 2013 I was cited by “CanadianContent” about my new robot P37 S65 “Elderly care bot” http://forums.canadiancontent.net/technology/114466-japan-robot-suit-can-help.html.

In March 2013 I was cited by “Voip service providers” about my new robot P37 S65 “Elderly care bot” http://voipservicesproviders.com/2013/02/robot-designed-to-care-for-elderly/.

In March 2013 I was cited about my new robot P37 S65 “Elderly care bot” at http://www.magtheweekly.com/09-15mar2013/techno-bytes3.asp.

In March 2013 I was cited by “Thiis” about my new robot P37 S65 “Elderly care bot” http://www.thiis.co.uk/news-snippets/care-robot-designed-by-student.aspx.

In March 2013 I was cited by “MedIndia” about my new robot P37 S65 “Elderly care bot” http://www.medindia.net/news/a-robot-to-care-for-your-parents-115171-1.htm.

In March 2013 I was interviewed by “**BBC Radio 5**” (Live) about my new robot P37 S65 “Elderly care bot” http://www.youtube.com/watch?v=UnI13_Q2HI4.

In March 2013 I was cited by “Aids for Daily Living” about my new robot P37 S65 “Elderly care bot” http://www.nrs-uk.co.uk/news/are-robots-the-future-of-care-homes/.

In March 2013 I was cited by “DailyTimes” about my new robot P37 S65 “Elderly care bot” http://www.dailytimes.com.pk/default.asp?page=2013\02\27\story_27-2-2013_pg9_3.

In March 2013 I was interviewed by “**Quays News TV**” about my new robot P37 S65 “Elderly care bot” http://www.youtube.com/watch?v=--dkG79ZnDU.

In March 2013 I was cited by “Binary Health” about my new robot P37 S65 “Elderly care bot” http://binaryhealthcare.wordpress.com/page/2/.

In February 2013 I was cited by “world news” about my new robot P37 S65 “Elderly care bot” http://article.wn.com/view/2013/02/26/Carebot_could_boost_elderly_care/#/video.

In February 2013 I was cited by “Humsa” about my new robot P37 S65 “Elderly care bot” http://www.humsa.com/enews/robot-to-care-for-elderly-made-at-university-of-salford-3477#.UWUypzeReCM.

In February 2013 I was cited by “Totallywp” about my new robot P37 S65 “Elderly care bot” http://totallywp.com/2013/02/26/robot-designed-to-care-for-elderly/.

In February 2013 I was cited by “High Tech Centre” about my new robot P37 S65 “Elderly care bot” http://www.hi-techcentre.com/2013/02/27/robot-designed-to-care-for-elderly/.

In February 2013 I was cited by “Britain News” about my new robot P37 S65 “Elderly care bot” http://www.britainnews.net/index.php/sid/212854699/scat/415361b06433ee08.
In February 2013 I was cited by “**Yahoo** India” about my new robot P37 S65 “Elderly care bot” http://in.news.yahoo.com/robot-care-elderly-developed-093919231.html.

In February 2013 I was cited by “Patron” about my new robot P37 S65 “Elderly care bot” http://patron.org.uk/4340/internet-news/robot-designed-to-care-for-elderly/.

In February 2013 I was cited by “Perspicacious” about my new robot P37 S65 “Elderly care bot” http://www.perspicacious.co.uk/content/robot-designed-care-elderly.

In February 2013 I was cited by “Cambodian Times” about my new robot P37 S65 “Elderly care bot” http://www.cambodiantimes.com/index.php/sid/212861540/scat/e390506bcb297536/ht/Robot-to-care-for-elderly-developed.

In February 2013 I was cited by “IndiaVision” about my new robot P37 S65 “Elderly care bot” http://www.indiavision.com/news/article/lifestyle/401422/robot-to-care-for-elderly-developed/.

In February 2013 I was cited by “Technophile” about my new robot P37 S65 “Elderly care bot” http://technophile.miskatonic.co.uk/robot-designed-to-care-for-elderly/.

In February 2013 I was cited by “This is Devon” about my new robot P37 S65 “Elderly care bot” http://www.thisisdevon.co.uk/Elderly-care-gets-modern-twist/story-18264528-detail/story.html#axzz2MD7gnvZU.

In February 2013 I was cited by “TopNews” about my new robot P37 S65 “Elderly care bot” http://topnews.in/law/robot-care-elderly-developed-2132754.

In February 2013 I was cited by “Big News Network” about my new robot P37 S65 “Elderly care bot” http://www.bignewsnetwork.com/index.php/sid/212854699/scat/54761d1c174d3e31.

In February 2013 I was interviewed by “**BBC** China” about my new robot P37 S65 “Elderly care bot” http://www.bbc.co.uk/ukchina/simp/uk_life/2013/02/130227_life_robot_elder.shtml.

In February 2013 I was cited by “connectinnovativeuk.org” about my new robot P37 S65 “Elderly care bot” https://connect.innovateuk.org/web/ras-sig/articles/-/blogs/salford-develops-robot-to-care-for-elderly;jsessionid=6E108F702BEB3BF7252B223F9B7DC1CD.c6e65d2a570.

In February 2013 I was cited by “Housingcare” about my new robot P37 S65 “Elderly care bot” http://www.housingcare.org/news.aspx.

In February 2013 I was cited by “Latest Digitals” about my new robot P37 S65 “Elderly care bot” http://www.latestdigitals.com/2013/02/27/uk-makes-robot-for-elderly-people/.

In February 2013 I was cited by “Shock Radio” about my new robot P37 S65 “Elderly care bot” http://www.shockradio.co.uk/2013/02/salford-phd-student-develops-revolutionary-elderly-care-robot/.

In February 2013 I was cited by “RedOrbit” about my new robot P37 S65 “Elderly care bot” http://www.redorbit.com/news/video/technology_2/1112792751/antonio-develops-p37-s65-elderly-care-bot-022713/.

In February 2013 I was interviewed by “**BBC Manchester**” radio (Live) about my new robot P37 S65 “Elderly care bot” http://www.youtube.com/watch?v=FzEZEWisH8Y.

In February 2013 I was cited by “Kenya Star” about my new robot P37 S65 “Elderly care bot” http://www.kenyastar.com/index.php/sid/212890125/scat/e974f944f2e7496e.

In February 2013 I was cited by “Stair Lifts Doctor.co.uk” about my new robot P37 S65 “Elderly care bot” http://www.stairliftsdoctor.co.uk/the-cost-of-ageing/.

In February 2013 I was cited by “Truthdive” about my new robot P37 S65 “Elderly care bot” http://truthdive.com/2013/02/27/Robot-to-care-for-elderly-developed.html.

In February 2013 I was cited by “Malaysia Sun” about my new robot P37 S65 “Elderly care bot” http://www.malaysiasun.com/index.php/sid/212861540/scat/e974f944f2e7496e/ht/Robot-to-care-for-elderly-developed.
In February 2013 I was cited by “100.com” about my new robot P37 S65 “Elderly care bot” http://story.100.com/?sid=212861540.

In February 2013 I was cited by “MSN” about my new robot P37 S65 “Elderly care bot” http://news.uk.msn.com/odd-news/carebot-could-boost-elderly-care.

In February 2013 I was cited by “Google Press Association” about my new robot P37 S65 “Elderly care bot” http://www.google.com/hostednews/ukpress/article/ALeqM5h_9lAByKagTJ4Eid_mjirk_DHTWA?docId=N0554171361880161464A.

In February 2013 I was cited by “UK Metro” about my new robot P37 S65 “Elderly care bot” http://metro.co.uk/2013/02/27/gallery-window-on-the-world-27-february-2013-3517081/ay_104736015-jpg/.

In February 2013 I was cited by “Belfast Telegraph” about my new robot P37 S65 “Elderly care bot” http://www.belfasttelegraph.co.uk/breakingnews/offbeat/carebot-could-boost-elderly-care-29095914.html.

In February 2013 I was cited by “UK News” about my new robot P37 S65 “Elderly care bot” http://www.newsrt.co.uk/news/robot-to-care-for-elderly-made-at-university-of-salford-1440649.html.

In February 2013 I was cited by “News India” about my new robot P37 S65 “Elderly care bot” http://news.webindia123.com/news/Articles/India/20130227/2164148.html.

In February 2013 I was cited by “**BBC**” about my new robot P37 S65 “Elderly care bot” http://www.bbc.co.uk/news/uk-england-manchester-21590186.

In February 2013 I was cited by “Manchester Gazette” about my new robot P37 S65 “Elderly care bot” http://manchestergazette.co.uk/archives/12889.

In February 2013 I was cited by “simplyhealth” about my new robot P37 S65 “Elderly care bot” https://www.simplyhealth.co.uk/sh/pages/media-centre/health-news-article.jsp;jsessionid=56E1A140D715A26A3DAB7B3431044A14.SHInstanceTwo?articleId=801790002.

In February 2013 I was simply by “This is Plymouth” about my new robot P37 S65 “Elderly care bot” http://www.thisisplymouth.co.uk/Elderly-care-gets-modern-twist/story-18264528-detail/story.html#axzz2M5EpZfOy.

In February 2013 I was cited by “IET Engineering & Technology magazine” about my new robot P37 S65 “Elderly care bot” http://eandt.theiet.org/news/2013/feb/elderlycare-robot.cfm.

In February 2013 I was cited by “ANI news” about my new robot P37 S65 “Elderly care bot” http://www.aninews.in/newsdetail7/story101120/robot-to-care-for-elderly-developed.html.

In February 2013 I was cited by “Yahoo” about my new robot P37 S65 “Elderly care bot” http://uk.news.yahoo.com/carebot-could-boost-elderly-care-123609273.html.

In February 2013 I was interviewed by “mancunianmatters” about my new robot P37 S65 “Elderly care bot” http://mancunianmatters.co.uk/content/26028929-life-size-robot-could-revolutionise-care-elderley-says-salford-researcher-%E2%80%93-yet-bra.

In February 2013 I was cited by Urban Times relatively to my new robot P37 S65. I also spoke about my current research with SARs for elderly groups http://urbantimes.co/2013/02/robots-for-elderly-care-memory-cvs-las-vegas/.

In November 2012 part of my qualitative research with elderly groups was presented on the UK “National Dementia Congress” in Brighton. Robotic seals were exposed on the housing21 stand.

In September 2012 I was cited by **Care Talk**. The article talked about some the emerging results of my research with SARs for elderly people http://www.caretalk.co.uk/magazine/issue15/Care-Talk-Issue-15.pdf.

In September 2012 my research was presented on “GoStudyUK” http://www.gostudyuk.com/study.jsp?id=LIFE_NEWS_UNIVERSITY_OF_SALFORD#robots_visit_old_peoples_homes.

In September 2012 I was interviewed by the West Midlands newspaper Sunday Mercury. The article “Singing and dancing robots brought in to entertain OAPs even tell jokes” talked about my work with Social Assistive Robots with elderly people in Birmingham http://www.sundaymercury.net/news/midlands-news/2012/09/02/singing-and-dancing-robots-brought-in-to-entertain-oaps-even-tell-jokes-66331-31745503/.

In August 2012 my research using SARs in care and extra care facilities was presented in the housing21 magazine “My Time South” http://www.housing21.co.uk/files/8913/4786/7913/My_Time_south_August_2012.pdf.

In August 2012 I was cited by the website “FindAPhd”. The article described my work with SARs http://www.findaphd.com/student/news.aspx?id=00264.

In August 2012 I was cited by “**The Carer**” an online care information system for care institutions across the UK. The article my work with Social Assistive Robots in care and extra care facilities. http://thecareruk.com/robots-on-a-mission-to-visit-old-peoples-homes/#more-1955.

In August 2012 I was cited by "Manchester EveningNews" relative to the qualitative results of my research with Social Assistive Robots with elderly people.
http://menmedia.co.uk/manchestereveningnews/news/business/innovation/s/1586102_university-of-salford-researcher-develops-animal-robots-to-comfort-the-elderly.

In August 2012 I was interviewed by the "**The Sun**" newspaper. The article "Grans in robot joy" talked about my research with social assistive robots with elderly people.

In August 2012 I was cited by the local Salford Online news relatively to the use of Social Assistive Robots with elderly people "Robots on a mission to visit old people's homes". http://www.salfordonline.com/educationnews_page/37533-robots_on_a_mission_to_visit_old_people%E2%80%99s_homes.html.

In August 2012 I was cited by "mancunianmatters" on the use of Social Assistive Robots for the elderly "Robots on a mission to visit old people's homes" http://www.salfordonline.com/educationnews_page/37533-robots_on_a_mission_to_visit_old_people%E2%80%99s_homes.html.

In August 2012 I was interviewed by the "Humans Invent" magazine where I talked about P37 S65 - the socially assistive robot (one of my inventions). The article talked about emerging demographic challenges and how SARs could help to assist elderly people http://www.humansinvent.com/#!/8437/antonio-espingardeiro-building-a-robo-nurse-for-the-elderly/.

In August 2012 I was cited by the University of Salford relatively to my research with Social Assistive Robots with elderly people http://www.salford.ac.uk/home-page/news/2012/robots-on-a-mission-to-visit-old-peoples-homes.

In August 2012 my research profile was added to the University of Salford College of Science and Technology http://www.facebook.com/media/set/?set=a.347880061961474.84108.196405647108917&type=1.

In July 2012 I was interviewed by "**Urban Times**" magazine about the future of SARs http://www.theurbn.com/2012/07/robots-up-close-and-personal/.

In June 2012 I was interviewed by the Londoner magazine "International Life". I was interviewed by the fashion photographer and luxury brand expert Yves Contades. I talked about the future of Personal Robots and how my social assistive robots are being developed to meet the XXI demographic challenges http://www.internationallife.tv/Robots-%E2%80%93-close-and-personal.

In May 2012 my research was presented on the top UK management magazine for the care sector "**Caring Times**". The article was entitled "the future role of robots" and it covered the potential use of SARs in extra care facilities http://www.careinfo.org/emagazines/Caring-Times-May-2012/#/0/.

In March 2012 my research was cited on the housing21 press release entitled "Robots come to life in Walsall" http://www.housing21.co.uk/press-room/news/news-archive-2012/robots-come-to-life-in-walsall/.

In February 2012 my research with social robots was cited by the Portuguese Social Services on their newsletter "Pinheirinho". The work was regarded as a contribution to human values, social cohesion and elderly care.

In October 2011 housing21 cited my research in the "Care and Dementia Digest" magazine. http://www.google.co.uk/url?sa=t&rct=j&q=housing%2021%20espingardeiro&source=web&cd=1&ved=0CCEQFjAA&url=http%3A%2F%2Fwww.housing21.co.uk%2Findex.php%2Fdownload_file%2Fview%2F667%2F&ei=r0TvTv2tNc2h8gP50-yVCg&usg=AFQjCNEomwus7PORz1SYvtdJ4JjuNoFxFw&cad=rja). My project was presented in the context of their strategy for mitigating the dementia levels of individuals. This partnership allowed me to understand and conceive ethical strategies for dealing with "social assistive robots" in extra care facilities.

In July 2011 I was cited by "Centro Social e Paroquial de Sao Pedro da Gafanhoeira" on the topic of SARs research http://paroquiagafanhoeira.weebly.com/outras-fotos.html

In July 2011 I gave a talk at "Santa Casa da Misericórdia de Vimieiro" (Portugal) entitled "Robotics for elderly people, the new paradigm".

In July 2011 I gave a talk at Arraiolos (Portugal) entitled "Robotics for elderly people, the new paradigm".

In July 2011 I gave a talk at “housing21”, Birmingham (UK) entitled “Robotics for elderly people, the new paradigm”.

In June 2011 I was cited by the “Linux Blog” relatively to potential use of Robotics in the following areas: energy, environment, transport and health care http://www.linuxblog.ro/tag/lastest/page/8/.

In June 2011 I gave a talk at “Housing21” Beaconsfield (UK) entitled “Robotics for elderly people, the new paradigm”.

In August 2010 I was invited to write an article about social robots at “**The Times**” online. The article “A Robot in your house by 2020... Are you prepared?” The article was published in the Eureka blog (a space provided by “The Times” scientific magazine).

In September 2009 I wrote an article the British Computer Society (**BCS**) entitled “Assistive robotics, the new challenge”. This article highlighted the importance of robotics in health care by giving many examples of technologies that were already being used.

Appendix III - Gifts/notes

List of gifts/notes offered by elderly residents during the robotics workshops to Antonio Espingardeiro.

Wallfields court (United Kingdom 2011)

To Antonio

With thanks from all the
Residents & Visitors of
Alrewych Court

Wallfields court (United Kingdom 2011)

Many thanks from Adele (Day Centre).

Many thanks [illegible] Jess x.

Thank you very much Kim x

Many Thanks Sue(J) x.

Many Thanks Keith

"Thank You" Antonio

Callum

Thanks for all your hard work I know all of the participants Love it SuzL x.

Thank you very much [illegible] Noris Court Manager x

To Antonio

Many thanks for the games and robots you presented to us over the past few weeks.
The residents and visitors from the Day Centre enjoyed seeing and taking part in the activities.
They found it most enjoyable.
We wish you a safe journey back home to Portugal.
We wish you and your family a Very Merry Christmas and look forward to seeing you in the New Year.

On behalf of everyone at Alrewych Court
John Genders

Wallfields court (United Kingdom 2012)


CERTIFICATE OF APPRECIATION
PRESENTED TO
ANTONIO ESTINGARDEIRO
FOR THE INSIGHT GIVEN TO US
OF HIS WORK WITH ROBOTS.
WITH A VIEW TO IMPROVE
THE WELLBEING OF
ELDERLY & DISABLED PEOPLE
IN THE FUTURE.
WE WISH YOU EVERY SUCCESS WITH
YOUR STUDIES & THAT ONE DAY,
YOU WILL SEE ALL THE ADVANTAGES
OF YOUR HARD WORK
DONE AT THIS PRESENT TIME.
FROM ALL THE RESIDENTS & STAFF
OF
ALREWYCH COURT
RESIDENTS ASSOCIATION
& DAY CENTRE
MONDAY 23RD APRIL 2012
SIGNED CHAIRMAN VICE CHAIRMAN

Lar do Monte Velho (Portugal 2011)

Eu Mário Rosa Garcia Piteira. Utente do Centro
de dia do lar da Santa C. da M. do Vimieiro sou
beneficiário de vários cursos de animação
cultural menistrados pelos monitores - -
coadjuvados pela nossa muito querida meni
na Dra Ana aqui presente venho por este meio
agradecer a vossa disponibilidade e a competencia
profissional aqui demonstrada assim como o
carinho dispensado a este grupo de jovens
com muita idade que eu estou a representar
mesmo sem ter sido mandatado para tal to-
mei a iniciativa e tenho ainda a coragem
de vos dedicar uma quadra da minha
autoria porque outra coisa não vos posso
oferecer.

Precisamos de Distração.
que estamos ficando sós
agradeço-vos aos três
o que fizeram por nós

Mário Piteira
16/08/11

Translation (Portuguese to English)

I Mário Rosa Garcia Piteira resident at the day centre of “Lar do Monte Velho” have attended several cultural animation courses delivered by António Espingardeiro, Mariana Valério and co-authored by our kind local entertainer Ana Barrosinho. I would like to thank your availability and professional competence demonstrated here at the day centre. We are also delighted by your affection and attention dedicated to this “young and aged” group that I’m leading even without being formally appointed to do so. I had the courage to perform this act and even composed a poem of my own as I cannot give you anything more.

We need distraction,

Because we are getting lonely

I thank you all three

For what you have done for us,

Signed by Mario Piteira 16/08/11

Acolhimento Jardim Rosa (Portugal 2012)

Pinheirinho

Robots em forma de gato ou de foca, que reagem ao toque e pedem mimos com "grunhidos", olhares e trejeitos dos corpos fofinhos.

Humanóides que respondem e pedem resposta a quem se dirigem.

Jogos que lêem e projectam num ecrã os gestos das pessoas e permitem desenvolver actividades estimulantes.

Um "cão" electrónico de companhia, que capta e emite imagens e sons, que ajuda a controlar rotinas diárias, que relembra compromissos e que liga a pessoa presente a uma central de vigilância com quem se pode comunicar ou que pode accionar meios em caso de emergência.

Este o mundo maravilhoso dos Robots Sociais que nos foi trazido pelo Dr. António Espingardeiro. Ele é um investigador da Universidade de Saltford, Lancanshire, em Inglaterra. Está envolvido num estudo que procura avaliar as dimensões éticas da aplicação destas novas tecnologias ao trabalho social. Mede níveis de satisfação, ganhos e perdas na privacidade, o apoio e os efeitos das interacções conseguidas.

O estudo continua. Para nós foram momentos de grande animação. Obrigado Dr. António. Sucesso nos seus trabalhos.

Vox pop:

Manuela "- O Dr. António foi muito simpático e gostei muito da Foca."

Luísa "- Aquelas máquinas são mesmo engraçadas."

Maria José "- O meu neto havia de gostar de ter um gatinho destes."

Filipe "- Ganhei a todos no Bowling"

António Costa "- Muita Fixe!"

Edmundo "- Isto foi muito bom"

Translation (Portuguese to English)

Robotic cats, robotic seals,
humanoids who respond and ask for response,
Virtual games that read people’s gestures and stimulate physical activity,
a robot that captures images and sounds for helping controlling daily routines,
and links people
to a central emergency point.
This is the fantastic world of Social Assistive Robots that was brought by Antonio Espingardeiro.
He is a researcher at the University of Salford, Lancashire,
United Kingdom. He is involved in a study that seeks to assess the
ethical dimensions on the application of these new technologies for social care. He is measuring satisfaction levels, gains and losses of privacy
through human robotic interactions.
The study continues.

Thank you Antonio. All the best for your research.
“Pinheirinho”

Vox pop:
Manuela "- Antonio was very friendly and I enjoyed the robotic seals." Philip "- I have beaten everyone in the Bowling"
Luisa "- Those machines are very funny." Antonio Costa "- Cool stuff…"
Jose Maria "- My grandson should have a kitten like these." Edmundo "- These were very good activities…"