Chapter 3
Obtrusiveness Considerations of AAL Environments

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3.1 Introduction

The word *obtrusive* is being used increasingly to describe new technologies, including information technology, automation and robotics. Despite the importance of the attributes of the term obtrusive in these technological fields, there is still no clear definition. The term becomes even more confusing when there are no equivalent terms in other languages and should be introduced as an Anglicism. This term is used as an adjective for something too 'apparent/prominent' with a 'striking' or 'conspicuous' no way acceptable or obstructive manner. It means something undesirably prominent, undesirably bulky. The term can refer to something undesirably prominent physically, psychologically or both.

In relation to the field of ambient assistive living (AAL) environments, obtrusiveness can be related to either hardware or software aspects of the system. In case of a robot or another assistive device, obtrusiveness can be used to describe the occupation of the discreet space of the users, either in physical, mental or psychological form. In other instances, unobtrusiveness is used as a synonym to ease of use, user-friendliness, etc. As pointed out by Hensel [1], obtrusiveness follows four rules: (1) it is the result of an addition of features (multicomponent), (2) it depends where the technology applies, (3) the user will not be the only subject that could be affected but also others living around and (4) it is subjective.

Obtrusiveness depends heavily on the subjective perceptions and the prioritization of needs of each user [2]. Older adults will not adopt a health-related technology if it does not fulfil their current levels of need, such as security and

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safety, no matter how unobtrusive, smart, affordable or powerful the technology is [3, 4]. Demiris and colleagues conducted a series of focus groups to assess older adults' perceptions and expectations of specific smart home technologies. The results showed that most participants acknowledged the need for a balance between the benefits of monitoring, determined by level of need, and the perceived intrusion into their privacy [5]. Home robots, alone or in combination with a limited set of sensors embedded in the home environment, have the potential to achieve effective monitoring of individuals in a rather unobtrusive way and with very limited likelihood of generating privacy concerns [6].

In order to approach obtrusiveness aspects in a global way, in RADIO we adopted Hensel and colleagues' conceptual framework [1] for the definition of 'obtrusiveness', which is, to our knowledge, the most complete framework so far in this field. In this framework, obtrusiveness is described by eight subcategories. In the following sections of this chapter, we present literature related to each dimension and describe what aspects of the RADIO system are pertinent to each dimension.

3.2 Physical Dimension

The physical dimension of obtrusiveness is related to functional dependence, discomfort or strain, excessive noise, obstruction or impediment in space, aesthetic incongruence [1]. The physical dimension is affected significantly by the morphology of the particular setting where the elderly person lives, and of course by the presence of the equipment as functioning part of this setting. Moreover, in terms of the robot use, excessive noise and proximity to the user during operation must be considered. The issues in RADIO system related to the physical dimension of obtrusiveness concern: the use of environmental (smart home) sensors versus wearable sensors, the existence of a robot and the environment itself (institutional vs. private).

A striking example of physical dimension obtrusiveness is wearable sensors, which can result in discomfort and inconvenience for the users [7]. The form and aesthetics of the device should not affect normal daily behaviour [4]. If not carefully designed, wearable sensors can take a central role in the user's attention and concerns, jeopardizing accuracy and consistency in the measurements [8]. For these reasons, sensors installed in the environment (smart houses), provided that they do not impact on the user's privacy, are an acceptable solution that assumes no extra burden for wearing and maintaining the sensors.

However, elderly people express concerns about the appearance of technology (for the prominence or interference) when they find it in their homes [9]. This highlights the importance of the environmental dimension (home vs. institution) regarding obtrusiveness [1]. Some technologies could be implemented in an institutional scenario because the space in the nursing home is greater than in a private home. Moreover, this is also related to the concept of ownership. This can be phrased as follows: 'In my home I would not like to have obtrusive, prominent things around (because of aesthetics and potential damage), however in the Nursing Home I do not care, it is not my territory'.

Elderly people do not seem to consider a domestic robot equipped with sensors as a possible source of intrusion/disturbance in personal life [10]. Moreover, they show more positive reactions and evaluations when having the opportunity to know what a robot can actually do in the domestic environment. However, discomfort or strain could be experienced when interacting with socially intelligent robots. A relevant survey [11] showed that the majority of the subjects disliked the robot moving behind them, blocking their path or moving on collision path towards them. The majority of subjects experienced discomfort when the robot was performing a task within the social zone reserved for human–human face-to-face conversations (closer than 3 m). Proximity between the robot and the user raises substantial questions about safety, and that is why safety and dependability of the physical interaction have to be evaluated considering all the different components of a robot, from mechanisms to actuators, and from sensing to control [12].

3.3 Usability Dimension

The usability dimension of obtrusiveness is related to lack of user-friendliness or accessibility, additional demands on time and effort [1]. ISO 9241[1] guidelines refer to usability as the 'extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use'. In the RADIO environment, the usability of the system (or lack thereof) concerns the interaction between the user and the robot or the smart home via the use of mobile devices (smartphones or tablets). A user-friendly and easy to access graphical user interface (GUI) guarantees uninterrupted interaction with the system and thus sufficient opportunities for monitoring.

The attitude of older people towards technology can be a major constraint regarding the usability of a system. '*Computer anxiety*' can have a significant negative impact on the perceived ease of use and thus on the behaviour and performance of the user [13]. According to Hirsch et al. [14], user perceptions of their own abilities are often out of step with their actual capabilities causing them either to be fearful of attempting relatively safe tasks, or in case of overestimation of their capabilities to undertake risky tasks. On the other hand, Giuliani et al. [15] put under dispute the widespread stereotype that elderly people would be hostile to changes, even more when it comes to the introduction of technological devices. They argue that technological devices clearly go unused only when they appear to be unrealistic or in conflict with the main goal of their action.

[1]ISO 9241 Ergonomics of Human System Interaction, Part 11: Usability: Definitions and concepts

It thus becomes clear that the design of assistive technologies is extremely significant as a factor contributing to disparity between perceived and actual capabilities, promoting easiness of usage. For this reason, it is an absolute priority that the actual needs of stakeholders including end users, caregivers and clinical professionals should be the first to be taken under consideration for the design and implementation of AAL technologies and not the functional capabilities of the technological advancements [16]. Researchers and technology developers are responsible for considering how they will address the needs and limitations of older adults with regard to their interface with technology [17].

Moreover, we also consider in this dimension the notion of utility[2] and usefulness. An important precondition for the elderly to accept the technology is that they are be able to recognize and agree with the benefits it promises to provide [18]. Elderly population demonstrates a priori a less perceived need and limited usefulness of technologies than adult population generally [19]. However, they will adopt a new IT system if they perceive it useful, even if they dislike it. Thus, perceived need and usefulness of the system to maintain independence and prevent being relocated to a more restrictive environment are key to acceptance, and AAL technologies need to be customized to the concerns of the key stakeholders in order to promote adoption and buy-in [20].

Scopeliti et al. [21] found that elderly people in comparison with younger ones are the most fearful at the prospect of having a robot at home, and they try to ward off their anxiety by attributing features to robots like small size, slow motion or feminine voice. They also showed some mistrust towards machines that are likely to be unsafe by preferring to limit the autonomy of the machine, being pre-programmed in a fixed way and not free to move at will inside the house. The same study argues that the mistrust shown by the elderly people is mostly due to an emotional difficulty with technology and absence of stimulation, rather than on a well-founded assessment of how technology can or cannot improve their life.

Appreciating the importance of the usability dimension, RADIO pilot studies explicitly investigated the usability of the RADIO system. More specifically, the formative phase of RADIO pilots tested an existing graphical user interface (GUI) to get feedback on usability requirements for designing RADIO's GUIs. Based on the results, RADIO GUI was designed satisfying several requirements such as larger text fonts, more intense colour contrast and more straightforward navigation though several functions offered. The intermediate and summative phases of RADIO's pilot studies further investigated the usability of the RADIO prototype, regarding aspects of usability of the overall system in two settings (FZ—home environment and FHAG—institutional care) with the engagement of older people from different social and cultural backgrounds.

[2]I SO. Ergonomics of human-system interaction. Part 210: Human-centred design for interactive systems. ISO International Standards; 2015; Available from: http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=52075.

3.4 Privacy Dimension

The privacy dimension concerns not only the invasion of personal information but also the violation of the personal space of home [1]. In RADIO, both of these aspects are relevant and analysed below.

Privacy is considered inherent to the human nature and for this, it has been thoroughly analysed from legal, ethical and philosophical point of view. The first milestone in the legal definition of privacy goes back to 1890 when Warren and Brandeis defined privacy as '*the right to be alone*' that is the right to protect one's private sphere against interferences from others [22]. In 1967, Westin defined privacy as 'the individuals' right to control the circulation of information concerning him or her' [23]. According to Schoeman [24]: '*A person has privacy to the extent that others have limited access to information about him, the intimacies of his life, or his thoughts or his body*'. Rochelandet [25] identified three dimensions of privacy. The first dimension, defined as the secret, is the individual's capacity to control collection and usage of his/her personal data. The second dimension regards the tranquillity or «the right to be left alone» and therefore does concern the accessibility to a person. The third dimension concerns the autonomy, which is the individual capacity to take the decisions for own self.

As technology progresses, the rapidly evolving capacities of AAL systems to monitor, access and store personal data will always be under close and meticulous inspection as to how much they affect the end user's right to privacy. In terms of the research data collection and usage, RADIO strictly complied to the Data Protection Directive (1995/46/EC) and the Privacy and Electronic Communications Directive (2002/58/EC), which were currently addressing data protection, privacy and to a certain extent, security. It should also be noted that the data collection procedure followed during RADIO adhered to strict ethical requirements which suffice to cover the requirement imposed by the new General Data Protection Regulation (GDPR).

In terms of the foreseen management of private data during an eventual production deployment, the RADIO architecture provides two modes of access: aggregated for research purposes and detailed for medical purposes. In aggregated mode, the RADIO system integrates the RASSP Protocol [26] through which statistics that are useful for medical research can be computed over the RADIO users' sensitive data without disclosing individual data points. In the detailed mode, conventional authorization, access control and encrypted transmission protocols are used so that authorized users have access to private data. What should also be stressed is that in either mode of operation, the RADIO system emphasizes that raw audiovisual content is always analysed on-site and immediately discarded, and it is only abstract information that is within the scope of the data management discussed above.

The privacy dimension goes further than the psychological dimension; it points actually to human dignity. This is particularly relevant in the field of measurement techniques throughout external non-wearable sensors because they are undetectable by the subjects. In this regard, we must bring special attention to 'awareness or acceptance of measurement' because without this element of a user's approval, we could violate the privacy or intimacy of the individual. Being 'invisible' does not mean that the subject is not aware that a measurement is being taken.

Regarding the tranquillity and the autonomy, older adults' perceptions of smart home technologies depend on the trade-off between individual preferences and needs. While the continued 24 h/7 days a week monitoring can cause loss of privacy and threaten one's dignity, at the same time, it is as a way to ensure safety and security [27]. This is also extended to the place where monitoring takes place; the most evident example regards monitoring in the bedroom and bathroom, areas where highly private yet risky activities take place [28]. Moreover, the strong aversion to institutionalization and the increased sense of safety and security can result in no concerns related to privacy [4].

The use of assistive robots in the AAL environments also raises issues of privacy, related to both their movement in the private space and their monitoring capabilities (where and what they monitor). However, if the user can control robot's circulation within the living environment, this can safeguard privacy and its use may even be perceived less of a privacy invasion compared to having a caregiver around, especially in potentially embarrassing situations [29]. In case of physically assistive robots, care must also be taken with protocols for touching, something that is a standard part of human caretaker training [30].

3.5 Function Dimension

The function dimension is related to malfunction or suboptimal performance, inaccurate measurement, restriction in distance or time away from home, and perception of lack of usefulness [1]. In the context of RADIO, this dimension is applicable both in the sanity and accuracy of ADL measurements and in the perception of lack of usefulness by its primary and secondary users.

Concerns regarding the usage and functionality of the assisted living devices as well as system reliability are an important issue for all users, and it becomes even more crucial considering the possible frailty and less resilience of an older user [27]. Especially in the home environment, the level of autonomy of the users may threaten—to a lesser or greater extent—their safety.

In a human–robot interaction (HRI) system, suboptimal performance can also come as a failure to complete a task due to the unpredictable nature of the interaction (e.g. unexpected changes of humans' behaviour or preferences). Such failures cannot be ruled out, in principle, but can be managed with suitable policies [12].

3.6 Human Interaction Dimension

This dimension refers to the threat to replace in-person contacts, lack of human response in emergencies and detrimental effects on relationships [1]. In RADIO, this dimension comes relevant because of the presence of the assistive robot.

Human contacts are particularly valued in supporting the ageing process. In general, the need to quickly establish human contact on a daily basis is especially important for elderly people, and caring is an essential factor for enhancing the feeling of security for them [31]. Technology advancements while searching to satisfy the versatile nature of the older people's needs should always leave space for the beneficial contribution of the personal contact either through the physical presence of the caregiver or even through the human–machine interface. In many articles, worries are expressed that the usage of assisted living technology might lead to loss of human contact [28, 32–37]. Thus, the future success of AAL environments will depend in large part on the human–machine interface, where the individual's needs and expectations will be adequately addressed [38]. Technology should be designed with ease of use by older adults, and it should provide opportunities for more social contact. Social contact is a sign of health in older adults, and monitoring systems should be designed with this concern in mind and not as a substitute for skilled caregivers [39].

The loss of human contact and social interaction always comes as a major concern to researchers in HRI. The loss of social interaction can result in increased stress and cognitive decline. It seems that reduced social interaction can have a measurable impact on the health and well-being of the elderly, and reinforces the idea that depriving them of such contact is unethical [40]. Especially in the case of physically assistive robots, where users could be both vulnerable and dependent, the main concerns are as follows: (a) the involvement of robots in particularly intimate activities such as bathing and sanitation, (b) direct physical contact between robots and humans and (c) the high probability of user's forming emotional bonds with robots in environments that otherwise may be lacking in human companionship [30].

Older people have different preferences, between robotics and human assistance, when they have to receive care. In case of personal care tasks and leisure, elder people seem to prefer human caregiving, while they prefer robotics for more basic tasks such as manipulating objects or information management [41, 42]. In various cases, even if people are happy to adopt a new technology and do not feel that it will replace in-person contact, they would still prefer a human response in the case of a crisis [43].

The robot's physical embodiment, form and level of anthropomorphism, and the simplicity or complexity of the design are some of the key research areas needing further attention. Human-like robots might appear 'unnatural' and evoke feelings of repulsion in humans [11]. Cesta et al. [44] reported that elderly people clearly indicated their preference for a faceless robot, hardly resembling a human being, as better integrated into the home setting and more valued as a source of advantages in the management of everyday life. Naturally, robot's image preferences are influenced by the cultural background of the users as well. Nevertheless, the formation of emotional bonds might be inevitable regardless of the morphology of the platform and the direction of the design process towards encouraging or discouraging this [45].

3.7 Self-concept Dimension

This dimension of obtrusiveness is related to symbols of loss of independence, due to embarrassment, or stigma [1]. This construct is closely related to the concept of psychological obtrusiveness. It is interesting that some specific technologies for elderly contain stigmatizing symbols that can backfire at the adoption of these 'gerontotechnologies' [19]. Elderly people feel concern about dependency; their self-esteem is compromised when they reveal assistive aids in public, and they try to avoid the use of those aids in a paradoxical mode. For instance, they are frequent fallers but they are reluctant to use zimmer frames or walking canes. The more prominent the presence of a device is (obtrusiveness), the more negative its symbol is and the greater the impact on self-esteem. Naturally, the RADIO system could trigger feelings of stigmatization as it is a product targeted to elderly.

A significant barrier to technology adoption is the perception elderly people have about themselves and their abilities [21, 27]. The adoption of an assistive or monitoring technology is considered by many an acknowledgement of their frailty, and thus, older adults who might benefit the most from it might be the persons least likely to adopt it [46]. Older adults found it difficult to ask for help and moving from being independent to becoming a service user is considered a life-changing step, strongly associated with the idea of 'giving up' or of admitting defeat [31]. Monitoring devices may cause users to feel ashamed and powerless and pose a stigmatizing aesthetic that leads older people to avoid using them outside their homes or in limited environments because of their embarrassment of being relied on assistive devices [14].

Aesthetic considerations in product design and early adoption of technology can be crucial for the acceptance of assistive systems. The size and form of devices as well as product function and underlying technology are essential components of the assistive technology design. Especially, the minimization of the size and the visibility of a solution are seen as important aspects for reducing stigmatization [35, 36]. Moreover, employing technology before it is actually needed and presenting it as a useful and helpful solution that promotes safety could delay the changes associated with the onset of disability and avoid stigmatizing older persons [39]. This is in line with the fact that the lack of enthusiasm of older people, in contrast to that of their family members, to adopt a monitoring system is presented often as a need for pragmatic justification than as an a priori rejection of the concept [47].

It is true that as elderly people grow old, they constantly assemble and redefine their own attitudes towards ageing. Therefore, the preconceptions of the elderly held by service providers do not correspond to the reality. In reality, fixed conception definitions of the elderly that would embrace all elderly people are impossible [31].

3.8 Routine Dimension

This dimension refers to interference with daily activities and the acquisition of new rituals [1]. Questions relevant to this dimension are whether users have to set up the system (on daily basis) and how this affects their daily life; whether they have to alter their daily schedule (e.g. the waking up time), etc. The RADIO system by design was built to minimize interference with daily routine by excluding from the solution wearable devices, ensuring maximum autonomy of the robot and pursuing monitoring opportunities on the basis of the interaction with the user rather than the on the basis of a predetermined schedule.

Another source of obtrusiveness in terms of interruption of one's routine comes from the automatization of tasks in the context of the smart home, such as the automatic control of lights, temperature, etc. The design and automation of such routine tasks must take into account the level of control retained by the user, which routine tasks can be automated and how user's attention is attracted if necessary for the accomplishment of certain tasks [48].

An alarming issue in the development of smart homes is that of viewing users as dependent patients instead of enhancing their engagement, social inclusion and independence [33]. Again, the design of such environments must be driven primarily by the needs of older adults and not by the features of current technology. Failing to do so can lead to disempowerment of older people and discourage them from staying active, physically and possibly even mentally [49]. The trade-off between assistance and autonomy lies in allowing older people to use their competence. Otherwise, autonomy might negatively impact their self-efficacy, since too much support may lead to a loss of autonomy or even decline of capability [50].

3.9 Sustainability Dimension

The sustainability dimension of obtrusiveness is related to concerns about affordability, future needs and abilities [1]. In other words, it describes the hesitation to make a commitment to a technology that is expensive to acquire and maintain or that might solve only short-term problems but would require a complete replacement to address future needs and abilities. Sustainability dimension is well within the scope of RADIO. Specifically, affordability is one of the core objectives and has influenced several key decisions in system design. Moreover, extensibility for future use cases and needs is also accommodated by establishing software and hardware components that can be reused by other systems to satisfy further clinical requirements pertinent to different medical conditions and user needs.

Monitoring technologies need to be customized to the concerns of the key stakeholders in order to promote adoption and buy-in [20]. There is an obvious shift of the elderly care services from the hospitals to homes, where the provision of the services can be provided more efficiently and tailored to the different needs and particularities of each individual. There is a strong belief that the user-centred, home-based system will become the basis of health care in the future. However, assisted living technological innovations tend to be dominated by suppliers providing a technology push, rather than a demand-pull approach, causing user disappointment resulting from inadequate comprehension of user needs and poor demands for products and services to be used in smart homes [51].

Thus, stakeholder participation is critical to usability and adoption, particularly to accommodate the needs of older adults [52]. Nevertheless, the design method can be a universal design or 'design for all' approach to create barrier-free designs for the widest audience possible while the alternative perspective is that the large degree of variability in the overall health, functional status and cognitive status of older adults precludes such an approach.

Naturally, the cost of any technology is a crucial factor for the adoption of it [13, 18, 27]. Considering the average income of the target population during the design phase and securing financial support from the government or health insurance companies in the uptake phase are both crucial for the diffusion of AAL technologies. Nevertheless, the large-scale implementation of AAL technologies could contribute to cost reduction, allowing them to become available for everyone, and by this annihilating any problems of equity related with the financial capabilities of each user, and the phenomenon of stigmatization [53].

3.10 Obtrusiveness and RADIO Home Visitors

The monitoring of ADLs, especially in a private residence, can be obtrusive not only to the residents but also to their visitors. Interestingly, this highlights the concept of obtrusiveness itself: subjective, multifactorial, environment dependent and multi-target (individual vs. group).

To the best of our knowledge, there is no literature related to this topic. The only relevant information we were able to spot is included in Cortney et al. [43] and actually comments on aesthetic incongruence:

> …one participant described how distracting she found the assistive technologies in another resident's apartment: '[it] concerned me in M's room when I saw those things [motion sensors]. I thought that would—I would always be looking at them. And they said they could put it up higher on the wall. It's still there. You're still going to look at it'.

From a data privacy perspective, the following directives are related to monitoring by CCTV and phone call recording. Data Protection Directive (95/46/EC) imposes broad obligations on those who collect personal data and confers broad rights on individuals about whom data are collected. Personal data is defined as any information relating to an identified or identifiable natural person [Article 2(a)]. The Directive does not apply to the processing of personal data by a natural person in the course of a purely personal or household activity [Article 3(2)].

3.11 Conclusions

Obtrusiveness is a subjective, multidimensional related to primary users' perceptions, needs and psychology, to functional characteristics of software and hardware components of a system, to clinical requirements as well as sustainability factors. It is obvious from the previous analysis that the different dimensions of obtrusiveness might conflict each other. The magnitude of the obtrusiveness is heavily affected by the self-perception of need of the user, and thus, in each case, it should be examined under the subjective conditions that exist in each user's micro-environment and in accordance to personal perceptions.

As an example, the dimensions of *privacy* and *usability* appear to be weighted by each individual's *self-concept* of need and independence. Elderly might accept a technology with significant privacy implications given its overall value for sustaining a more independent lifestyle [50]. Compromises in privacy are most likely to happen and to be accepted when there is a clear benefit for the users [27]. For instance, the privacy lost from accepting video cameras could only be acceptable if it prevented transfer to a long-term care facility which represents the greatest loss in autonomy [54]. Usability of a given technological infrastructure for elderly people might well be affected by the lack of perceived need as being a reflection of current health status [28]. Moreover, social, emotional and environmental factors can also compromise usability. Elders might reject a device that does not match their environment or makes them feel embarrassed even if it useful for them [14].

For acquiring the best possible result for the users, and for exploiting the full potential of the technology's capacities, it seems very likely that the compromise of some aspects of obtrusiveness for the accomplishment of the best possible safety and monitoring conditions for a user will result in a trade-off between needs and obtrusiveness [40]. It is very important for the assisted living infrastructure to be able to treat obtrusiveness concerns without compromising the quality of the necessary functions and services, and the healthcare principles [55].

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