

## Assistive technologies: Their development from a technology assessment perspective

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This paper highlights some major challenges involved in the research and technology development process for assistive technologies. Referring to a research project conducted by the authors, the outcomes include an analysis of goals and concepts of assistive technologies as well as the context of their application. Trade-offs that include the risk of substituting human assistance by technology, a threat to privacy or unintended side effects regarding their use should be considered at the outset of the research and technological development process. As far as funding schemes are concerned, programmes need to include an evaluation of the impact of assistive technologies in a broader socio-economic, cultural and socio-political context. Hence the underlying normative assumptions need to be scrutinised before the process begins.

**Keywords:** Ambient Assisted Living (AAL), participatory technology assessment

In most European countries the proportion of older adults in the population is expected to rise over the next decade<sup>1,2</sup>. This raises important issues regarding increasing costs for social and health care and the associated burden placed on health and social care systems<sup>3-6</sup>. National and European initiatives concerning research and technology development (RTD) for Ambient Assisted Living (AAL) seek to tackle this societal challenge by encouraging the use of information and communication technologies, with the aim of improving the quality of life of older adults and providing more support to health and care services<sup>7-11</sup>. The goal of AAL is to provide services and technologies that improve the well-being, autonomy and security of older adults, as well as their health and social integration. AAL initiatives therefore support older adults and allow them to age in place.

At the same time, these initiatives contribute to the development of European Union (EU) markets for assistive technologies (ATs). We refer to AT in a broad sense according to Doughty et al.<sup>12</sup> who use the term AT for home-based systems or devices that support diverse activities of older adults. These may be mechanical or electronic, fixed or portable, visible or fully integrated, manual or fully automated. Similarly, Cowan and Turner-Smith<sup>13p325</sup> define AT as 'an umbrella term for any device or system that allows an individual to perform a task they would otherwise be unable to do or increases the ease and safety with which the task can be performed'. Other classi-

cations start from 'device types' and 'archetypical applications'<sup>14</sup>.

### Suitability

Notwithstanding a clear European interest in fostering AAL and the use of ATs, listening to older adults and those persons whose daily business it is to assist them reveals that there is much to be done to make technologically designed environments suitable for older adults<sup>15</sup>. In the course of the development of ATs, choices between technology-led innovation and human-led innovation are made<sup>16</sup>. Developing ATs that really assist and account for their users very needs seems imperative, not least to avoid yet another contribution to an ever-growing stock of useless devices, which were developed ignoring the main stakeholder: the affected user him or herself<sup>17</sup>. 'What emerges is a need for socially dependable systems, which take account of social context, the need for sociability and the principle of open access for all' state Blythe et al.<sup>18p674</sup>. Their concept also highlights the importance of the human being at the centre of the technology development process as opposed to a strategy that adapts existing technology solutions to a certain user group. This notion is affirmed by different approaches, such as 'user-centred design'<sup>19</sup>, 'co-design'<sup>20</sup> or 'co-construction of lifespan technology'<sup>21</sup>, or the 'Living Lab' concept<sup>22,23</sup>.

RTD programmes for AAL, however, also form part of the economic potential of so-called 'silver-markets', and these economic factors may over-

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ride social, cultural or other relevant contexts. Moreover, the challenges of multiple legitimate needs, and the 'plurality of legitimate perspectives'<sup>24</sup> imply that the decision-making processes within technology development should incorporate other aspects in addition to the knowledge and skills of engineers. Specific strands of technology assessment aim at organising and accompanying technological research and innovation processes in terms of a reflexive approach (for instance, constructive technology assessment<sup>25</sup> or real-time technology assessment<sup>26</sup>.) In a research project conducted by the authors, the needs of potential users and the benefits of information and communication technologies in their daily lives were addressed by applying a participatory technology assessment approach. This approach acts 'as a facilitator to reconfigure the interface between decision maker and affected (mode of inclusion) next to its capacity of delegating trust to those who participate (mode of delegation) and revealing different views (mode of mediation)'<sup>27p575</sup>.

## Background and aim

The project 'Participative approaches for technology and autonomous living (pTA)' aimed at supporting Austrian solutions in the area of autonomous living<sup>28</sup>, and was commissioned by the Austrian Research Promotion Agency to serve as a pool of information on future topics, relevant

actors and potential pitfalls to be avoided at both the level of the funding programme and the funded projects. pTA Ageing was conducted between December 2007 and May 2008. An explorative methodology<sup>29</sup> seemed promising, as technical innovations cannot be regarded as either isolated phenomena or unique solutions to problems. On the contrary, technical innovations may also create new problems. Rigby<sup>30p325</sup> criticises that more means and emphasis are given to 'molecular and technological research than to organisational and societal effects' of technical solutions. But AAL and RTD for ATs are deeply rooted in real life scenarios<sup>31,32</sup>.

The project started by identifying potential users of AT (for instance, their diversity, needs, and different meanings of well-being or autonomy) rather than focussing on technology itself. We focussed on the social needs and perspectives of users in terms of technical solutions that facilitate autonomous living. To achieve this objective, we addressed those areas of life that may be affected by ATs and the questions of who should be involved in what way and at what stage of the research and (product) development process. Furthermore, the aim was to identify critical contextual aspects, which could be incorporated within an RTD programme for ATs and services before technological ideas appear and respective pathways are defined.

*Table 1. Actors in development, implementation and application of assistive technologies for independent living and ageing well, and the 26 participants interviewed in 5 groups with some participants belonging to two or more different sections of subgroups*

Section	Subgroup	# interviewed
Individual users (>50 yrs)	Actual end users	6
	Potential end users (explicit future users)	4
	Informal social and health services: family, community, etc.	2
Organisations	NGOs	1
	Representatives of citizen groups	3
Commercial and not-for-profit service providers	Institutional, social and health services	4
	Social and health: hospital, nursing facility, assisted living residence, long-term care community, senior-citizen housing, adult day care, home and community-based services	11
	Consumer goods: shops	1
	Transport, infrastructure, security: taxi, bank, home services, fire brigade etc.	3
	Content: education, consultancy, sales, media	3
	Services for the aged	4
Industry	Large companies	1
	Small and medium enterprises	3
Researchers and academia	Universities: Interdisciplinary work on aging, ICT	4
	R&D institutions	4
Ministries and public authorities	Local	3
	National	1

## METHODS

Including lay persons, experts and intermediary persons, the participatory technology assessment project at hand deployed a transdisciplinary methodology<sup>33</sup>. Thereby, it aimed to shed light on perceptions of different actors, each of whom could be considered an 'expert from the practice', and who is an 'assessor and discussant' at the same time<sup>34p7</sup>.

After identifying the key actors in Austria, five explorative group interviews (of 3-8 participants/group, 26 experts in total, two hours/interview) were held between January and March 2008. These interviews addressed the opinions of different users and intermediary persons regarding the everyday life and needs of older adults and the barriers to using technology (*Table 1*). The aim was to explore the needs and problems of users, their living contexts, the relationship between ageing and technology and the information exchange between technology developers and users.

'Social and health care providers' as well as 'actual users' attended all five group interviews. 'Researchers' were present in four out of the five group interviews. 'Technology developers' were present in two groups. 'Representatives of public authorities' and 'representatives from public relations agencies' targeted to older adults, as well as 'journalists', participated in three group interviews. 'Potential users' are persons who actually attended in another function but during the interviews also emphasised their own experiences and perceptions as users of future ATs. Participants in three groups explicitly referred to themselves as 'potential users'. The majority of the participants shared their own experiences as family members of persons who use ATs. The different composition of the group interviews served to integrate perspectives of various user groups and to foster discussion.

Potential participants were contacted via e-mail and telephone. In total, approximately 400 relevant persons, institutions (including societies, university departments, and research institutes) enterprises and companies were approached<sup>29</sup>. To invite 'actual users' and hence older adults who live on their own and have no explicit stake in any organization, we were assisted by institutions that provide services for older adults (for instance, sheltered accommodation, food delivery services, and home care providers). They asked potential participants who then, if they were interested, contacted us. Hence all participants who were actually attending the group interviews firstly responded to our invitation and secondly were available at one of the scheduled

meetings. Before the group interviews started it was made clear that any statement would be treated according to strict rules of confidentiality and anonymity. During the group interviews the language used by the researchers was continuously reflected. This served to avoid incomprehensibility and facilitate participants' active contributions (for instance, for the introduction of the topic or when rephrasing participants' statements).

Additionally, seven experts from different fields (psychology, sociology, gerontology, medicine and care sciences, social work, education, and consumer policy) were interviewed in seven separate interviews (approximately one hour/interview). To identify potential pitfalls, a review of seven projects topically related to ageing (all participatory approaches relating to AAL for older adults) was performed. The respective projects were selected according to their content and according to their funding by the European Parliamentary Technology Assessment-Network and the EU. The results of the group and expert interviews were synthesised with the results of this review.

## RESULTS

### Contextual issues

In order to develop socially dependable ATs, it is important to identify the context in which ATs and AAL are applied and to ' [...] ask whether we really understand the needs of older people at a higher level than simple ergonomics, that is, to set out higher level requirements for a class of systems that use technology to support older people living independently'<sup>18p674</sup>. The respective results are listed in the following paragraphs.

### Surroundings

The environment of older adults can be divided into the overlapping components of working, living, leisure time and mobility (*Figure 1*). Working life is regarded here in a broad sense of the word 'work' including unpaid labour and voluntary activities. The use of ATs affects all of these areas, and they are highly interconnected, comprising psychological, physical, social and economic aspects. Mobility is thereby defined as the personal ability to move from A to B - and to choose how and when to go to a chosen place by which vehicle (taxi, bus, car, car-sharing, etc.). ATs may help to access different forms of mobility (for instance, by interactive services of ordering a taxi, or devices that help you to operate a car or make use of car sharing services). Moreover, the actual use of ATs is strongly influenced by the availability and quality of health and care services, security, safety and privacy, information and learning and, last but not least, communication and social in-

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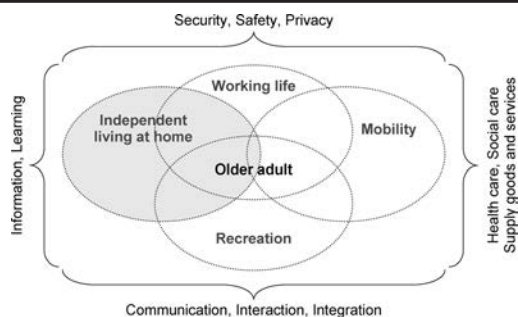


Figure 1. Activities and corresponding areas in the life of older adults with key determinants

clusion. Although strongly interconnected, each area implies special needs and solutions.

Key issues regarding the use of information and communication technologies in the light of different surroundings were mentioned by experts and by the participants in the group interviews (Table 2). Possible negative impacts were reported, as well as the measures that were identified to avoid them.

## Actors

In the context of using ATs, the multiplicity of actors involved must be considered. This is important in regard to the integration and social inclusion of older adults. Moreover, it is important to identify ways of organising and improving the information flow between AAL developers, potential users and intermediary groups. Therefore, it is important to know who is able to provide insights about the environments of older adults (Table 1).

## Technological requirements

On the level of actual technology development we found relevant aspects for (i) the planning

phase of developing and designing products or services, (ii) the testing phase, (iii) the development of markets for ATs, and (iv) aspects relevant on a policy level.

Not surprisingly for (i), the group interviews put forward simple solutions and the development of devices with few, but clear features that address all senses. The modular design of products was recommended as an appropriate strategy to allow cheap production without impairing high individual adaptability of products. Examples mentioned were universal platforms in a smart environment that can be adjusted for special needs.

For (ii), the testing phase, it was considered to be of crucial importance that the time to test products should be optimised. Critical situations, as for example emergencies, should also be taken into account. Other challenges that should be taken into consideration in the context of test settings are individual habits, values, worldviews and cultural differences. For testing procedures, being sensitive to the users' situation also implies compliance with ethical standards. Additionally, it was seen as crucial that half-developed products might over-challenge users, resulting in improper use and possibly frustrated users, especially during long testing phases.

In terms of (iii), the market development, a comprehensive exchange of information on technologies between the developer, distributor and user was claimed to be of utmost importance. An improvement in coordinated information-provision and decision support-sources to help older adults choose, purchase, install and properly use new devices was also identified. In Austria, coordinating this information would require a decoupling of information providers or consultants and

Table 2. Key issues in the surroundings of older adults as addressed by AAL (Ambient Assistive Living)

Impact area	Need	Technology impact	Measure
Working life	Facilitation	Excessive or low demands	Early-age training
	Motivation	Monotony	Life-long learning Better design
Living at home	Security	Surveillance	Consultation
	Safety	Threat to privacy	Information
	Autonomy	Undesired dependency	Training
	Memory support	Cost	Mentoring
Recreation	Entertainment	Decrease of social contact	Social inclusion by ICT
	Personal contact	Isolation	Personal training
	Saving and filling time	Cost	Group activity
	Communication		Knowledge transfer by a useful activity
Mobility	In-house/out-house mobility and accessibility	Deactivation	Organisation
		Paternalisation	Coordination
	Autonomy	Cost	Design
	Social inclusion		

producers of ATs, who have their own economic interests.

Affordability was another important issue identified, and one that affects the market conditions for ATs. (iv) On a policy level it was stated that the combination of technological innovations with conventional (organisational and social) structures might lead to failures. Hence, beyond the technological compatibility of systems, the coordination and adjustment of technological systems to social or institutional routines needs to be considered.

### *Attitudes and behaviour*

A number of individual attitudes and behaviour patterns that are important for a satisfying use of ATs were identified in the group interviews. These were related to trust, experience, self-perception, the influence of intermediaries and the perception of one's ageing in society. Additional requirements included the importance of users becoming familiar with ATs before they find themselves in a critical situation that renders self-reliant use difficult to impossible. Especially, taking into account the experience-based skills and abilities of older adults, for instance, possible physical deficiencies can be successfully compensated by applying special (experience-based) techniques. In this context, the fact that ATs are not under-challenging or over-challenging seems important for the user. Another issue that might affect users attitude towards ATs is that certain images are often (unwanted) by-products of ATs. For example, ATs coined as 'medical devices' produce associations ranging from 'safe but expensive' to 'I am weak and I have to admit that I need help'.

### *Trade-offs*

The use of ATs that older adults encounter in everyday situations as well as in the context of professional care also raises ambivalent or even contradictory issues. This ambivalence is not necessarily solvable and therefore it is most important to be aware of trade-offs, which may arise in the context of ATs. One important trade-off identified was that between support and social isolation. ATs were regarded as supporting tools that should not replace human assistance and contact, nor lead to a decline in the physical activities of older adults. Although many ATs are designed to save time for care-givers, this saved time should be earmarked for social contact instead of reducing the total available labour time.

Another trade-off was that between more security and less privacy. Sacrificing privacy was often mentioned as a trade-off for higher security. On the one hand, a frequent argument was 'As long

as I don't need it, I am against privacy affecting technology – but if I need it, I take privacy affecting aspects into account (for instance, the linking of personal medical data that might prevent me from getting a medication that I am allergic to)'. Generally, the surveillance aspect of ATs was viewed negatively, and conflicts of interest between care-takers and those who receive care, as well as potential generational conflicts were seen as critical here (for instance, between parents and caring children). The dangers of monitoring and unauthorised data use were evoked, especially when the ATs involved the transfer of personal medical data (for instance, telemedicine). The use of technologies for monitoring implies provision of explicit information and education about all the functions of monitoring systems on behalf of the producers and those who introduce ATs to older adults as, for instance, business distributors and care-takers. Both should be able to explain the functions of technical systems to older adults. The differences between actual and perceived security need to be addressed, as the limits of security technologies are usually not communicated. Security promoting an 'illusion of omnipresent technology' was criticised. There would always be 'missing links' or extreme situations, which could be even more dangerous if they occurred totally unexpected.

Concerning visibility of technologies, a balance needs to be maintained between being over-apparent and thus frightening to users and giving a minimum sense of security. Also, if the respective technology fails to prevent or even causes an accident, legal issues need to be addressed. A further trade-off involved that between support and threat of perceived autonomy: it is often important for older adults to make their own decisions concerning who provides help. A perceived decrease in decision power may prevent older adults from using various supportive services. Autonomy is also about having control over what is done (for someone), by whom and when. Finally, a trade-off between mobility and potentially under-challenging situations was mentioned. ATs may undermine activities that contribute to physical activity and fitness. For example, walking without help can contribute to greater fitness (if adequate conditions are given, for instance, the barrier-free crossing of streets). Nevertheless, supporting options (for instance, a stairlift) need to be introduced early enough to ensure continued mobility following the onset of disability. In day-to-day situations, health care personnel face trade-offs between efficiency on the one hand and bureaucracy and control for legal security on the other. Traceability and time efficiency of actions play a crucial role here<sup>29</sup>.

## Goals of ATs and AAL

Generally, ATs should contribute to supporting older adults and enabling them to age in place and live autonomously. They also play a role in promoting autonomy in institutional settings such as residential homes. Therefore, ATs are necessarily part of a broad scope of technology applications. This makes it necessary to review the normative assumptions underlying these applications as well as raise questions so as to identify and/or achieve target knowledge (how should it be) from a technology assessment perspective.

Within AAL documents a pronounced economic reasoning guides the normative assumptions that are inherent in the AAL RTD programmes:

- (i) In terms of cost-effectiveness it may be desirable for older adults to stay at home as long as possible.
- (ii) ATs alleviate the economic burden placed on national social and health care systems.
- (iii) ATs may help to develop new markets.

The terminology as used in the AAL RTD programmes often remains unclear. For example, the term 'ageing well' as used in the title of the so-called i2020 Initiative and therein the 'well-being elderly person'<sup>7p65</sup>. The latter is used to describe someone who is deliberately paying attention to his or her well-being. But what exactly does this mean? Risks to personal well-being are identified as physical and cognitive impairment. This concept therefore assumes that a person is well integrated into society, well informed and able to cope with the challenges of ageing. Furthermore, such individuals are mostly independent, well housed, in good health and have access to social and health care if needed<sup>7</sup>.

As we found in the project, normative aspects or assumptions may also arise in terms of the questions raised by AT development and application – what is assumed to be good or bad, desirable or undesirable, and eligible or ineligible (for whom)? How much are power relations affected? Who controls the development of ATs? Who has access to ATs? Who can afford them? Furthermore, according to the interviewees, an analysis of power structures that are affected and an identification of obstacles to access helping technologies seem important.

## Practical consequences

According to the interviewees, there is an urgent need to improve the exchange of information in order to better understand the needs of potential users. Hence realising technical improvements requires better coordination between technology developers and those who are affected, but

usually not actively included: the (potential) users. The various suggestions that were made represent different modes of interaction and imply increasing influence of the user.

Three modes occur: (i) a predominantly informative mode: market analysis, consumer research and classical user testing and integration, (ii) a consultative mode: user testing, user needs analysis<sup>35</sup>, and (iii) a decisive mode: user needs analysis and improving the developers' perspective by participating in people's lives<sup>36</sup>. The group interviewees and the experts both proposed a mode of research that implies that developers and technicians spend a certain amount of time together with the target group (persons in need of assistance). These activities were also referred to as 'participatory observation at institutions' or 'internships spent in institutions', or simply 'accompanying care personnel'.

Generally, it was considered of high value to participate in the real lives of persons in need. The added value of this approach was ascertained in terms of human and technological dimensions. Spending extended periods of time together may enable an understanding of those problems that otherwise remain unseen (for instance, a person may have gotten used to a complicated routine to fulfill a certain need – an observer may uncover how an existing assistive device could facilitate the problem or how a new AT would need to be, to succeed in the respective situation).

From a technological perspective, the bringing together of developers and users can reveal different rationalities in everyday problems and may trigger creative potentials as well as avoid undesired consequences. The interviewees thought that cooperation with older adults in institutions would display some advantages. Routines to ensure the dignity, privacy and security of the older adults could be developed together with the personnel (for instance, that they could withdraw whenever they wanted; informed consent etc.); for older adults living at their own homes it might be more of a challenge to withdraw, or to trust in the compliance of certain rules of cooperation is what they assumed. It was not the framing of the researchers to focus on institutions.

## DISCUSSION Contextual aspects

### Needs

Developing ATs that neglect the underlying and varying needs of older adults is considered an overall pitfall<sup>37</sup>. According to McCreadie and Tinker<sup>38p105</sup> it is important to take into account potential inconsistencies between 'objectively or professionally assessed and "felt" needs'. An

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analysis of the potential impact of ATs has to take place in the context of basic needs or (instrumental) activities of daily living<sup>39,40</sup>. Based on our results, we also include the dimension of a positive approach to life and fulfilling (and pleasing) activities as a precondition for living autonomously, social inclusion, and most importantly, for successfully using technologies<sup>15,41,42</sup>. McCreddie and Tinker<sup>38</sup> also recognise the importance of incorporating older adults into the decision-making process concerning the choice and use of ATs.

## *Technological requirements*

The recommendations of the interviewees for the development process of ATs on the level of concrete technical design can be seen as a clear message that the currently common paradigm of multifunctional devices should be overcome and replaced by simple and plain technology. The frequent change of features, products or technologies is predominantly perceived as negative. Also, the turnover in personnel of those who introduce older adults to the practical use of ATs should be rather low. Moreover, concrete details were addressed, such as the importance of the proper labelling of products to make them attractive. Lastly, co-construction of ATs was seen as promising to develop appropriate ATs and ensure the optimisation of production costs as, overall, the costs of ATs and their affordability for a broad range of potential users are considered important<sup>43</sup>.

## *Personal attitudes and behaviour*

Some aspects were identified that predominantly rely on personal behaviour patterns and individual backgrounds of potential users which may affect the application of ATs. Frequently, the users seem to be simplified to a homogenous group without personal opinions and beliefs<sup>31</sup>. A strong influence of a rather negative attitude towards ageing could be observed. Some issues referred to a lack of communication and individual abilities to orientate oneself in the abundant world of ATs and their functions. Stereotypes such as the assumption that older adults exhibit a general reluctance to learning to deal with new content were found to be prevalent among potential users as well as among those who develop ATs<sup>44</sup>. Other factors that inhibit a successful use of ATs were social power structures. The older adult doesn't consider himself or herself "to be worth a significant investment – the children are more important" and they need the money. Also important is a limited access to ATs; generally referred to as 'digital divide'<sup>45</sup>.

## *Trade-offs*

Potential drawbacks as perceived for ATs mainly concern the risk of reduced human support, interaction and contact as a consequence of

ATs<sup>46,47</sup>. Individual mobilisation – which is at the same time regarded as an important precondition for active ageing in terms of communication and interaction – is perceived to be potentially at risk if ATs are implemented in a way that reduces the motivation for mobility<sup>48</sup>. The controversy concerning support by ATs, such as monitoring at the cost of privacy, stems from the dilemma that these technologies 'cannot deliver context-dependent, value added, pro-active services without containing historical and current data about an individual's preferences and activities', says Punie<sup>31p161</sup>. This trade-off was debated in the group discussions predominantly following the rationale of personal concern: if AT addresses a clearly perceived need, people are less reluctant to accept a certain loss of privacy. Access to proper information (for instance, labelling of products) as a preliminary condition for conscious decisions along the delivery chain of ATs plays a crucial role, and includes the broad issue of proper product communication<sup>49</sup>.

## **Socio-economic issues**

### *Who is benefitting?*

The overall question of 'who is benefitting?' is crucial and requires an analysis and definition of what is perceived to be positive for whom. Selwyn<sup>15p382</sup> emphasises that 'in its present form ICT is not universally attractive to, or universally needed by, older adults'. Another important issue is to critically analyse power structures as 'the home of the future' and hence AAL 'takes place where the power relations and inequalities are fought out' (Punie<sup>31p160,17</sup>). In this context, the digital divide needs to be addressed as older users have less access and are even less optimistic about information technology and the options to use it for societal integration<sup>45</sup>.

### *Desired social values*

Closely related to the analysis of what is perceived as positive or negative by whom, terminological clarity is important. Often normative assumptions are made, but they remain unaddressed. This is also the case for well-being and autonomy. Overall, well-being reflects a positive attitude towards life, which is all the more important considering that recent studies suggest that ageing is largely perceived as negative in Western societies and that older adults have increasingly faced discrimination in recent years<sup>50,17</sup>. There are theories that identify well-being<sup>51-58</sup> by indicators such as social interaction, purpose of life, self-acceptance, personal growth, environmental mastery, and autonomy.

The concept of quality of life as defined by the WHO refers to similar categories including the dimension of past, present and future for 'activi-

ties<sup>55,56</sup>. A framework for the concept of well-being by conceptualising quality of life from a constructivist perspective that considers individual historicity is provided by Bond and Corner<sup>57</sup>. Economic well-being based on the distribution of available income and standard of living is considered by Zaidi<sup>58</sup>, who employs a multidimensional perspective on well-being by taking the interdependency of health with economic issues into account as well as the respective dynamicity of income in the context of ageing.

Whether ICT can contribute to raising the quality of life of older adults is a difficult question. The emphasis on teaching older adults how to use something should be replaced with asking what its purpose is, what the perceived added value is or what pleasure is associated with using a certain technical device<sup>59</sup> as cited by<sup>15p381</sup>. While the use of specific ATs may well contribute to the enhancement of individual well-being<sup>60</sup>, Gilhooly et al.<sup>41</sup> criticise the unquestioned assumption that the use of ICT is considered equal to a better quality of life rather than the other way round. Moreover, they say that the concept of the quality of life is too imprecise and they see the digital divide as a serious obstacle to profound and comparable data for overall assessments.

## *Autonomy*

Autonomy is not merely perceived as a function of well-being but as an ethical principle. It is influenced by being accepted and integrated into society, having the information and training to deal with the challenges of life and is sometimes compared to 'environmental mastery'. The most important ethical principles that need consideration are beneficence, non-maleficence and justice<sup>61</sup>. Therefore, the usability of AT, which is a key factor for independent living without being over-challenged by technical systems, seems an important driver<sup>62,63</sup>. Kinder et al.<sup>64p287</sup> found that the social context (which they refer to as organisation culture) is essential to determine whether a certain technology supports 'technology paternalism' or empowers the user.

## *Economically relevant targets*

Considering AAL and the use of ATs it is important to identify the economic assumptions. The assumed fact that older adults prefer to stay at home as long as possible is only legitimate if certain criteria are met (sufficient support, social contact, adequate architecture, etc.). As Greve et al.<sup>65</sup> argue, AT can, under certain circumstances, contribute to fostering social networks. An important limit though is the affordability of ATs. Especially as the economic power of the target group is often overestimated<sup>18</sup>. The scenario of persons staying in their own homes is definitely

an appealing approach not only from a (national) economical perspective. Nevertheless, questions of ageing are often discussed merely from an economic perspective, which is not sufficient as the ageing society is a genuinely interdisciplinary and dynamic challenge<sup>66,17</sup>. The societal and media focus on the increasing costs for elderly care is also controversially discussed<sup>3-6</sup>. Lastly, also an often negative tone of media reports is discriminating and inhibits a positive framing of the issues at stake.

## *Participatory activities*

To put the needs and not the technological options at the centre of the development of ATs necessitates a shift from theoretical to practical questions. This involves organising participatory activities and applying specific communication and process skills and continuous supervision of the researchers in their new roles<sup>67</sup>. Participation does not necessarily provide equal benefit for everyone. On the contrary, it can be a risky endeavour especially for participants with special needs during the process or afterwards<sup>68,69</sup>.

## **RECOMMENDATIONS**

An unquestioned optimism as for the assumed merits of technology use in older adults' life requires careful examination. We showed that a human-centred innovation approach is preferable in the development of ATs. This captures new views that need to be reflected on as well as trade-offs that may arise. Rather than trying to teach older adults how to use certain devices, there should be a focus on what the perceived added value of the devices might be and whether they can contribute to raising the quality of life of the end-user. This requires the dismissal of the stereotype of the user unable to handle a device. Opposed to common conceptions the affected users are able to assess what they want and to properly operate a device, once convinced of its usefulness.

While ATs may be analysed in terms of their impact at the individual level, such analyses should also consider a broader societal context, for instance, what is the meaning of ageing that is referred to and what is the role of institutions or the state. Ageing well is hardly possible, if there is no broader societal debate regarding the social values of fairness and respect between generations. This implies a social obligation for public and private institutions to integrate the potential of, as well as the needs of, older adults into their planning and services, and for individuals to actively express and integrate themselves. Such a broader approach may help to overcome the tendency that currently technological solutions are seen as unique solutions. By perceiving them



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as isolated phenomena there is a high risk to ignore their societal context and effects.

Also on a technological level the social context (or organisational culture) needs to be consciously considered to make sure that a certain technology supports and empowers the user rather than fosters 'technology paternalism'. Another issue concerning a technologies context is the lack of coordination and communication on marketing and distribution levels, which may lead to inadequately informed users who are not the beneficiaries of technological possibilities, but rather victims. Hence, an individual's needs must also be seen in the light of societal needs and rights<sup>70</sup>. These issues – including adequate access to relevant information - are related to power structures and hence need careful consideration. They are systematically embraced within the approach of 'ethical technology assessment'<sup>71</sup>.

To structure the RTD process and proactively address potential trade-offs and risks, normative, analytical and operational questions have to be posed within each RTD process. In terms of an extended research team, active subjects of research – the participants – may contribute to these insights. Considering the importance that the interviewees of the project assigned to participation as being relevant to the successful development of ATs, participation may be identified as a method to develop better and contextually embedded ATs. In this context, the provision of platforms for stimulating dialogue among actors who need to exchange views, knowledge and experiences is important. When involving users strict ethical standards are needed for both user integration (for instance, dynamic informed consent) and technology application contexts (for instance, privacy enhancing technologies). The mental capabilities (appreciation, respect, etc.) and the availability of sufficient physical resources (time, personnel, space and money, etc.) also need consideration.

But there is another aspect of this outcome that is worth examining. Our findings make a strong claim for participatory approaches, which also implies a demand for a democratisation of technologies – this involves three dimensions. Firstly, the integration of norms and values that are brought in by different actors; secondly, the integration of relevant issues that are addressed by different actors; and thirdly, the co-determination and/or involvement of actors, other than the researchers and engineers, in the decision-making in the technology development processes. This should take place throughout the whole process from the initial phase (formulation of the research question or issue at stake) until the final

phase (user testing of, for instance, prototypes of concrete devices) and within the necessary loops of repetition.

In this context, also the development of a clear common language is important to avoid misunderstandings and to attract those persons who are meant to participate, as well as to clarify underlying concepts such as AAL, ATs, well-being or autonomy. Merely mentioning the term 'technology' in an invitation text could discourage people from participating, because they might assume that they need technological expertise. Emphasising the real world context, which is of interest (such as problems and needs), might help prevent this bias.

Vedder and Custers<sup>72</sup> differentiate between the responsibility to identify adverse consequences of technologies and the responsibility to integrate these (and respective solutions to them) into the RTD process. According to our results, both processes are closely interlinked and may need to be addressed within a participatory approach. But it is important to consider Jasanoff<sup>73</sup> who stated that participation is not yet a sufficient answer to the call for more democratisation of technology. In fact, the relations between RTD entities, science, policy and the public have to be redefined and 'context-situated technologies' should be preferred to technologies that claim unique validity.

Participatory activities within RTD processes exhibit certain features regarding their setting, timing and transparency. They are not occurring in isolation - heterogeneous user groups and different perspectives are identified and evaluated - and they are not merely occurring at the end of the process but from the onset. Therefore, results need to be treated transparently and the way advice is considered has to be made transparent, too. These are important differences to 'traditional user testing' as often applied in research and innovation processes in technical industries.

Important parts of how AAL should be are already predefined within the RTD frameworks. In particular so-called mission-oriented research programmes, which aim to contribute to alleviating societal problems and therefore conceptualise what is desirable for individuals as well as society, predetermine to some extent what is good and desirable for individuals and society. The legitimisation of mission-oriented programmes in the area of AAL is also supported by a societal and media focus on ever-growing costs for elderly care – nevertheless, controversial discussions show that clear differentiations are of utmost importance: between different contexts (for instance, social security, health care, distribution

of economic stocks, costs of informal and formal care), assumptions (for instance, on the demographic development, on the absolute need of care per person), and other important key factors (for instance, public health, prevention, family structures, etc.). Accordingly, the conclusions that are drawn in terms of societal necessities will vary.

It is not sufficient to adopt assumptions as stated in RTD programmes which frame research activities. It may not even be enough to analyse these assumptions recursively after the constituting foundations of a research process were decided (for instance, in terms of the participatory activities). It is worthwhile to take a closer look at major underlying concepts and assumptions before and continuously during the research process. These feedback loops reflect the principles of recursivity and reflexivity as postulated for multidisciplinary research processes. A linear research process reduces procedural open-

ness instead of fostering reflexivity and learning processes. Although this provides another constraint for researchers to find financial support and to be in line with support frameworks, especially projects in mission-oriented RTD programmes should consciously reflect normative goals. Major assumptions of programmes that are not explicit, need to be clarified. This could happen, if project proposals were encouraged to reflect upon the question on how well a respective project refers to the normative goals of the programme; on what is the conception of the normative goals they refer to, and what are the expected effects. These issues, besides scientific quality, innovation potential, etc., should serve as additional selection criteria for funding. Nonetheless, the process character is important for these questions so recursive research settings should allow modifications during the research process.

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