Assistive technologies for people with disabilities

Part III: Perspectives, needs and opportunities

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Assistive technologies for people with disabilities

Part III: Perspectives on assistive technologies

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Abstract

This report focuses on assistive technologies (ATs) for people with disabilities covering perceptions and specific needs related to ATs, as well as complementary measures by the public sector. Three comprehensive empirical studies were carried out: a quantitative European-wide online survey addressed impaired people directly. In addition, two qualitative studies were performed with experts on ATs at European level. The research focus was on three types of disability: 1) blindness and visual impairment; 2) deafness and auditory impairment; 3) autism spectrum disorders (ASD).

The main research findings are:

1) Perceptions and needs on ATs vary according to the type of disability. This variety of perceptions and needs on ATs affects not only concrete technological solutions and fields of applications but also specific measures for a more effective use of devices. Furthermore, the labelling of ATs as medical or mainstream device is still contested. This has consequences not only in terms of the perceived 'value' of a device but also in terms of regulative measures and accessibility to them.
2) Recently, on an international level, important legislative steps put forward ATs in general. However, the effective implementation of the goals politically agreed upon still needs to be improved. This concerns, from a technology development perspective, the goal of universal and user-driven design. Furthermore, in employment the inclusion of people with disabilities and the use of ATs should be improved. As for the field of education, there are specific training needs on ATs for people without disabilities, mainly in the areas of health related professions, public services, and web accessibility.
3) In general, our studies indicated that people with disabilities have an open and optimistic attitude towards new and emerging technologies. However, future research should focus not only on the technical development as such, but rather on a sound implementation, social embedding and evaluation of technological solutions which already exist.

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List of abbreviations

ASD	Autism Spectrum Disorder
ATP	Assistive Technology Professional
ATs	Assistive Technologies
BCI	Brain-Computer Interfaces
BMI	Brain-Machine Interfaces
EAA	European Accessibility Act
EASPD	European Association of Service Providers for Persons with Disabilities
EBU	European Blind Union
EUD	European Union of the Deaf
ICTs	Information and Communication Technologies
ILO	International Labour Organization
ISSA	International Social Security Association
IT	Information Technology
UN	United Nations
UNCRPD	United Nations Convention on the Rights of Persons with Disabilities
WHO	World Health Organisation

Executive summary

This report focuses on assistive technologies (ATs) for people with disabilities; it covers perceptions and specific needs related to ATs as well as complementary measures by the public sector. Three comprehensive empirical studies were carried out: a quantitative online survey addressed impaired people directly. In addition, two qualitative studies, focusing on ATs and regulatory issues respectively, were performed with experts on ATs at European level. The research focus was on three types of disabilities: 1) blindness and visual impairment; 2) deafness and auditory impairment; 3) autism spectrum disorder (ASD). The quantitative and qualitative surveys shed light into the challenges of ATs in terms of access, acceptance and awareness, with regard to the relevance of independent living, education and employment as well as for the process of technology design and development. The empirical studies focused on the needs and perceptions on ATs as well as on complementary measures of the public sector, both from the perspective of people with disabilities as well as with reference to experts' opinions.

Overall research findings

- Perceptions of and needs for ATs vary according to the type of disability. The variety of perceptions and needs on ATs affects not only concrete technological solutions and fields of applications but also specific measures for a more effective use of devices. Furthermore, the labelling of ATs as "medical" or "mainstream" device is still contested. This has consequences not only in terms of the perceived 'value' of a device but also in terms of regulative measures and accessibility to them.
- Recently, on an international level, important legislative steps have been taken to foster the use of ATs in general, especially the UN convention on the Rights of Persons with Disabilities (CRPD). This international human rights treaty has been an important driver to a changed social view on people with disabilities as full and equal members of society. However, the effective implementation of the goals put forward by the UN and agreed upon by many countries still needs to be improved. This concerns the goals of universal and user-driven design, and the inclusion of people with disabilities in the workplace. As for the field of education, there are specific training needs on ATs also for people without disabilities, mainly for professional groups in the fields of health care, public services, and web applications.
- In general, our studies indicated that people with disabilities have an open and optimistic attitude towards new and emerging technologies. However, future research should focus not only on the technical development as such, but rather on a sound implementation, social embedding and socio-technical evaluation of technological solutions also of already widely established technologies.

Insights from the Quantitative Online Survey: Perception and needs of people with disabilities

The results of the quantitative online survey: "Perception and needs of people with disabilities" revealed that people with disabilities are still confronted with a wide variety of barriers to full inclusion in social life. These barriers vary according to the type of disability and include all kinds of barriers like physical and transportation barriers, communication, information, and social as well as attitudinal and policy barriers; these barriers are relevant for all three groups of impaired persons.

On a daily basis, the actual use of ATs is especially important for people who are blind or visually impaired and deaf or hard of hearing. The use of ATs is significantly less central for respondents with ASD. Frequently ATs are regarded as a necessity for the fulfilment of everyday tasks like reading and writing, being mobile or accessing information. Blind or visually impaired respondents have the highest dependence on support by ATs, followed by deaf or hard of hearing people, and by

respondents with ASD. There are, however, several reasons for the non-use of ATs: for blind or visually impaired people the main reason is that they obtain support from another person. For deaf or hard of hearing people, the main reason for not using ATs is that they do not meet their needs. Persons with ASD report a lack of information concerning ATs. The relatively high cost of ATs is stated as an important reason for its non-use by all three groups who also share very similar expectations as to which requirements an ideal AT should fulfil. The most important are: ease of use, flexibility, adaptability and affordability.

In terms of regulation of ATs, respondents from all three disability groups share the view that ATs should be provided by the national health system and paid for by social security funds. A majority is dissatisfied with the current regulatory situation. According to respondents from all three disability groups regulation needs to be improved to facilitate access to employment, education, financial support and everyday help and assistance.

Insights from expert interviews

Two sets of expert's interviews focussing on the "needs and perceptions on ATs" and on "complementary measures of the public sector" revealed that the very basic definition of ATs is still contested. Until now, there is no common agreement on the definition of ATs, even within disabilities groups: Two ways of defining ATs may be distinguished: the first definition relates to a more formal approach where the term refers to specific devices for people with disabilities only. The second focus includes also mainstream technologies in the understanding of ATs.

Independent Living, Education and Employment

Focusing on the role of ATs with regard to "independent living", the identified needs for and perceptions of ATs vary according to the type of disability. Of specific relevance is the case of ASD. Here, ATs are required to support personal communication and social interaction as people with ASD in particular are currently up against many challenges in everyday life e.g. when interacting with the health system or with public services. For this specific area research into the need and possibilities of further development of technical solutions is especially recommended, taking the variety and complexity of requirements by people with ASD into account.

In the field of education, ATs play an important role which has to be considered from two perspectives: 1) ATs in the education process of people with disabilities; 2) ATs in the training of professionals who support people with disabilities;

1) Experts underline the high importance of education for people with disabilities. ATs can support overcoming existing barriers at an individual level, e.g. to be fully included in regular school education. For example, in the case of visual impairments, the access to web platforms has strongly boosted learning opportunities for people with disabilities. At later stages of life, a good educational standard is a precondition to empower users with disabilities to use (also mainstream) ATs responsibly.
2) Further trainings for professionals are recommended in the field of web accessibility, health occupations and public services.

There is general agreement on a strong need for a better integration of people with disabilities particularly in the workplace, as well as for the use of and access to specialised devices. All three different types of disabilities have specific needs for ATs in the workplace. In the case of blindness or visual impairments, access to IT applications is reported as crucial. In the case of deafness or hearing impairments, web-based sign language interpretation is regarded as a supportive tool. For ASD, augmented reality applications are highlighted to support people with ASD in order to train for real-life situations in the workplace. However, according to the experts, there are still many non-technical

barriers towards the employment of people with disabilities. These include attitudinal barriers towards disabilities in general or simply missing knowledge on the part of companies on how to employ a disabled person. Experts strongly recommend to place greater emphasis on the function of ATs with regard to the goal of "reasonable accommodation in the workplace" anchored in the UN convention. Moreover, there is a huge lack of information and knowledge in the field of employment in two distinct ways: The first lack of knowledge relates to the actual situation of people with disabilities and their needs for ATs with regard to a better integration in the workplace. The second refers to information for companies on available measures to integrate people with disabilities in the workplace with the aid of ATs. Finally, yet no less important, experts underline that the strategic benefit that is connected to an ageing workforce has to be used as a door opener for people with disabilities and the use of ATs in the workplace.

Accessibility, acceptance and awareness of ATs

As regards access to ATs, experts agree that accessibility, despite political agreements on its high relevance, still needs to be improved, especially in terms of access to relevant infrastructures and services, both material and virtual, e.g. transport and access to knowledge. In addition, costs associated with ATs are highlighted as one major barrier to the equal access to devices, which can induce social inequality. It is emphasised that purchase costs not only include the price of a device but also costs for services and training needs associated with the technology – an aspect often overlooked.
With regard to the acceptance and awareness of ATs it is stated that specific devices usually associated with "disability" can lead to feelings of stigmatisation by the users, e.g. hearing aids. In order to overcome such stigmatisation caused by ATs, defining and understanding ATs as a mainstream product – rather than a specific (medical) device – is regarded to be a viable strategy. Labelling ATs as mainstream products promises to raise the perceived "value" of ATs, as the devices can be then regarded as "normal" rather than exceptional. This consequently can lead to a higher level of acceptance. Such labelling might also support the producers of ATs since companies face several challenges when producing ATs, ranging from small markets sizes and high costs of devices due to strong medical regulation requirements. One approach to overcome these challenges is to highlight the general benefit of ATs also for non-disabled when they are considered as 'mainstream devices', because technology development for people with disabilities may contain a specific innovation potential beyond assistance for disabled people. In fact, people without disabilities can benefit from several ATs. In order to increase awareness and acceptance of ATs the user's age needs to be taken into account. For children (and parents) ATs often have a high acceptance level as they are considered to be an important support for children with disabilities in order to participate in society, especially education, in as 'normal' a manner as possible. Users getting their disability at old age often show serious unease and reluctance to apply ATs in their everyday life.

Future development of ATs

According to the experts, development principles for ATs, already generally agreed upon politically like the goal of universal design anchored in the UNCPRD, still need a stronger implementation into development processes of mainstream technologies. Besides, it is requested to integrate the needs of people with disabilities more strongly already in the technology development process. This would imply a participation of people with disabilities in the design process.
It is highlighted that the future focus of technology development should not only be on new devices but also on improved implementation of existing ones. Thus, the need for an evaluative overview of existing devices and applications as well as the need for an improved connection between technologies and services is highlighted.
The experts identified several relevant future technologies. Advancements in IT, especially facial recognition, are regarded as supportive in the case of blindness and visual impairments as well as ASD. Brain-Computer Interfaces (BCI) have been discussed as a promising development for a couple of

years. Although practical applications are still not available for everyday support, it is regarded as a promising future AT. Technology development of ATs in the field of ASD is still at an initial stage characterised by 'bottom-up' developments. The need for quality assessment of current technological applications is stressed in this context. In general, a very positive attitude towards new and emerging technologies prevails. It is expected that people with disabilities will benefit significantly from the use of such technologies in the future.

Legislative issues

With regard to the legislation of ATs, the CRPD is of high political importance when it comes to the future integration of ATs. However, at the present stage further national implementation strategies with regard to ATs in different societal fields (education, employment, independent living) are crucial and should be further developed. Follow-up legislation of the CRPD encompasses the European Accessibility Act (EAA). It is suggested to induce further legislative measures, e.g. on web accessibility. ATs covered by the Medical Device Directive are integrated in the health system in terms of reimbursement. However, medical devices are characterised by high costs, long development times, and high market barriers, whereas ATs which are not covered by the Medical Device Directive currently lack regulation. This is particularly evident for current technology development in the case of ASD where a quality assessment of technical devices is not yet implemented. A specific legislative approach directed towards ATs in terms of classification and regulative measures for people with disabilities should possibly be implemented to overcome the shortcomings of the current legislation on ATs. The sound integration of already existing ATs in the health care system is regarded as a huge challenge. A "holistic approach" towards the integration of ATs at community level, including a stronger connection between technological solutions and connected services, is proposed. Moreover, the support by professionals at community level should be increased. In this regard best-case examples of rules and regulations especially from the USA are available.

Social context matters

All in all, given the trends on a political, social but also technical level, ATs for people with disabilities will play an increasing role in the future. In order to shape this role in a positive manner in the best interest of people with disabilities, their social context should receive special consideration. The need for social embedding of technology development in the field of ATs can be identified on three levels.

- First, still more emphasis is needed on the co-creation of technologies with technicians and people with disabilities working together to make sure that future technologies truly meet the needs of people with disabilities and are well-perceived by them.
- Second, there should be a stronger public focus on existing technological solutions. The development of sound strategies and approaches to evaluate as well as to connect existing, often medium-tech, devices with related services, and also continuous training of occupational groups are much needed. This is of particular relevance with a view to the financial problems of health systems in many European countries that result in spending cutbacks in this area. Focusing on questions such as "What is already there?" and "How can the existing technology be implemented most efficiently?" might be a way to respond to these economic challenges in a constructive manner.
- Third, the role of ATs as such should be considered in relation to the wider societal context of people with disabilities. Many problems people with disabilities are confronted with do not originate from the quality of ATs. Instead, there are many socio-political challenges to address in order to improve the lives of people with disabilities across Europe, such as overcoming the strong attitudinal barriers that still exist towards people with disabilities.

1. Introduction

This report focuses on the role of Assistive Technologies (ATs) for the inclusion of people with disabilities and, more specifically, looks at how people with disabilities themselves perceive ATs and what complementary measures from the public sector are needed in order to further enlarge the spread and use of ATs for people with disabilities. It follows on from two other stocktaking papers from this project, respectively dealing with "Current trends of assistive technologies" (Mordini et al. 2016) and a "Regulatory framework for the inclusion of people with disabilities, and health and demographic drivers of visual and hearing impairments as well as autism" (Bratan et al. 2016). Assistive devices undoubtedly serve an important purpose for people with disabilities today, yet at the same time many challenges with regard to ATs still remain. These range from economic questions with regard to the costs of ATs, their availability for the people that need them and the technological design and development process. Even the term "assistive technology" is not as clear and uniform as appears at first glance. It should be regarded as "living terminology" with the kinds of technologies that can be classified as ATs subject to societal debate, and the field of disability being very varied, so that these technological solutions also need to address a broad spectrum of different needs. Thus, the development and use of AT differs very much when it comes to specific types of disabilities.

This report focuses on three different types of disabilities: blind and visually impaired, deaf or hard of hearing and autistic spectrum disorder, and presents the results of three different empirical studies. These three studies analysed quantitatively as well as qualitatively how ATs are perceived by people with disabilities as well as by representative organisations at EU level and how the development and use of ATs can be further complemented by public sector measures.

This report starts with a brief overview of the scientific debate on relevant issues on the perceptions of ATs (section 2). In a second step, the empirical studies will be presented by first giving an overview of the research strategy and the research methods (section 3). In section 4, the main results of the quantitative online survey will be summarised. Following this, the findings of the two expert-based studies on the needs and perceptions on ATs (section 5) as well as complementary public sector measures (section 6) will be presented. In a third and final step, conclusions that are based on the empirical studies will be drawn towards a future outlook on ATs (section 7).

2. The scientific discussion of ATs – brief overview

The United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) addresses assistive technologies in at least nine articles[1] (United Nations 2006). Also the recent launch of a priority assistive products list by the World Health Organisation (WHO), focusing on stronger spread of and an equal access to ATs in developing countries shows the importance of ATs at political level for people with disabilities (WHO 2016a). However, there are still many challenges related to the use of ATs by people with disabilities. These comprise factors like their costs, the access to them, or the implementation of adequate design principles. Subjective factors from the perspective of people with disabilities such as the fear of being judged by society by (not) using an AT as well as striving for "normality" through ATs in order to meet the demands of society also have to be taken into account (see e.g. Greenhalgh et al. 2015, Kylberg et al. 2015).

Moreover, ATs as such are very varied and comprise many different types of devices. On the one hand, ATs can be very specific and expensive, particularly if produced especially for people with disabilities. On the other hand, today, "ordinary" consumer technologies such as computers, telephones and smartphones are in some cases also highly suitable to assist people with disabilities and are often also considered as ATs (Kylberg et al. 2015). The very definition of ATs is still very much contested, e.g. in relation to the field of human enhancement where there is a debate about whether a device which transcends a human beyond the 'normal' can be still considered as an AT (Wolbring 2011). However, the decision on the definition of an AT – as medical or mainstream device, or even as enhancement technology – can have important consequences for the individual with disabilities. If an AT comes with a "medical label", its user might be reimbursed through the social system whereas when an AT is defined in terms of general needs the user may well have to pay the cost privately (Kylberg et al. 2015). Starting with these first examples of challenges surrounding ATs and their practical consequences, we will in the following sections highlight in more detail some of the factors relevant to understanding the opportunities, needs and perceptions of ATs in relation to disabled people.

2.1. Access to ATs

Access to ATs is a basic but still crucial factor not only in relation to existing ATs but also with regard to envisioned and emerging ATs.[2] The issue of accessibility is of high relevance within the European context as the figures from the Eurobarometer on Accessibility show (European Commission 2012). The figures show that for example the huge majority (93%) of respondents acknowledged that the present lack of accessibility impacts disabled people in all areas of life ranging from education and employment to leisure and social participation. In addition, a high proportion (72%) of respondents regarded an increase in accessibility of goods and services as a way of improving the lives of people with disabilities. Even more (84%) respondents held that an increase in the accessibility of products would improve opportunities for industry to sell products to people with disabilities. In addition, more than two-thirds (66%) of respondents would buy, or pay more for, products that are designed in a way that makes them are accessible to all (European Commission 2012).

On a general political level, the UNCRPD demands accessibility to ATs. However, although many countries – representing 70% of the world population – have ratified the UNCRPD so far, there is still a large implementation gap. This gap not only concerns specific laws and policies, but also

[1] These are the articles 2, 4, 9, 20, 21, 24, 26, 29, and 32.

[2] Access or accessibility entails in our view different forms of access to ATs such as information, financing or availability from suppliers.

governmental programs, which are needed to raise awareness of or provide training about ATs (Gould et al. 2014).

2.2. Acceptance and awareness of ATs

Another challenge faced by people with disabilities is the acceptance of ATs. Acceptance of ATs by people with disabilities themselves depends on many parameters, including actual utility, need, cost, and ease in accessibility, maintenance and use, and lastly the satisfaction with the interaction of the AT with the user's environment (Ahmad 2015, Carver et al. 2015, Hocking 1999). Parental choice of ATs for their children is linked to information offered to parents, opinions from professionals and educational staff as well as the quality and accessibility of support services (Dettman et al. 2013). When it comes to the scientific understanding of product acceptance, there is a gap in the common theories applying to disability. Many models have been developed to predict product acceptance such as the consumer theory, innovation diffusion model and others (Wolbring et al. 2013). However, although these models were developed to predict the acceptance of a product in a reliable way, our searches reveal that these models are hardly applied to ATs in general.[3] This suggests that academic literature faces a lack of rigour in trying to understand what disabled people think about products designed for them, and what makes a product acceptable to them. This is problematic because disabled people have different contexts and needs with regard to ATs and consumer goods in general compared with non-disabled people. For this reason, there is a scientific need to modify existing instruments of models of acceptance used for the 'normal' consumer, as they currently cannot address the choice and priority dilemma needed in specific cases.

Generally, there are two models to understand the role of ATs in the context of disabilities. First, following the 'medical model' of ATs the use of an AT by a disabled person can be described as a need to 'fix' a person's 'deficiency'. Second, following the 'social model' of ATs, the role of ATs can be seen instead as advancing the social inclusion of disabled people, contributing to satisfy their fundamental human rights as set out in the UNCRPD. The academic field of disability studies which focuses on the social contexts of disabled people criticises the medical model and expresses a sceptical position towards the use of technologies in a medical sense of ATs because of the

> *"fear that technology becomes another way to 'fix' impairments, perpetuating and reinforcing the outdated medical approach to disability, which identified disability with impaired invalid bodies that needed to be cured, helped, assisted, 'supplemented'" (Ferri, Giannoumis, and Edward O'Sullivan 2015, 81).*

Although this represents quite a strong position against the medical understanding of ATs, various academic studies actually show that ATs are often marketed with a negative perception of disabled people. In these studies, a medical approach towards the disabled person is evident with deficiency terms such as patient, disorder, disease and others (for examples covering social robotics, cognitive enhancement and exoskeleton see Breen 2015, Yumakulov, Yergens, and Wolbring 2012) being used. Dealing with ATs within a purely medical model is generally seen as problematic (Newell 2003). Aas and Wassermann argued e.g. prominently that:

> *"funding motivated by a vision of biotechnological rescue may well divert attention from alternative and more immediately effective means of increasing the social participation of mobility-impaired people – by environmental and social modifications rather than by high-tech gadgetry" (Aas and Wasserman 2016, 40).*

Others see the medical focus as leading to separate market segments for assistive and mainstream technology and that "designers of assistive technology tend to think of the people for whom they are

[3] Between 0.01-1% of the articles found on Google Scholar cover a given model and hardly to not at all (0-0.1%) cover ATs in combination with people with disabilities.

designing not as 'users' or 'consumers', but as 'clients' or 'patients', and the true 'customer' as a government agency" (Newell 2003, p.174, see also Costello 2014).

Whether an AT is accepted or not also depends on the stigmatisation that a person with disabilities experiences[4]. Experiences of stigmatisation of disabled people in connection with ATs can occur at two levels: first, a stigmatisation of the disabled user him- or herself, and second, a stigmatisation caused by the AT itself. A hierarchy of 'worthiness' of certain ATs can cause the second form of stigmatisation. The wheelchair is one example of an AT, of a liberation device, which is stigmatised by the use of terms such as "wheelchair bound" and "confined to the wheelchair" (Haller, Dorries, and Rahn 2006). We have recently seen an increase in the stigmatisation of this AT in relation to other devices because by promoting another device, namely the bionic artificial leg, negative portrayals of the wheelchair have emerged (Panesar and Wolbring 2014). Scholars from the field of disability studies argue that:

> *"ATs should allow people with disabilities to transcend their socially constructed 'disabilities' and create fluid identities that are subject to a combination of their bodies and the assistive technology they choose to use" (Chandra and Jones 2015, 4).*

However, given the reality of stigmatisations prevalent in society for disabilities as well as ATs, what is envisioned here as essential features and preconditions for ATs still seems a distant goal.

To give a concrete example: Brain-Machine Interfaces (BMI) or Brain-Computer Interfaces (BCI) are seen as useful for many disabled people including people having ASD, visual impairment or hearing impairments (Friedrich et al. 2014, Rutkowski and Mori 2015, Sarwar et al. 2010). In addition, the BMI/BCI academic literature overwhelmingly covers disabled people as a user within a medical framework (Wolbring and Diep 2016).[5] However, the bias evident in the imagery of disabled people is particular revealing in the BMI/BCI example because BMI/BCI are also created for non-disabled users, e.g. in gaming applications. Both disabled and non-disabled users are seen in need of BMI/BCI to gain abilities; however, disabled people are covered within a medical framework while the non-disabled person is portrayed quite differently. Indeed, disabled people are not mentioned at all in the consumer gaming application (Wolbring and Diep 2016). Aas and Wasserman suggest the most optimistic scenario in "the widespread adoption of BCIs [that] will eventually replace the tyranny of the normal with 'morphological diversity'" (Aas and Wasserman 2016, 37). However, given that we see two different discourses around BMI/BCI, a 'medical model' and a 'consumer model', it is uncertain that this outcome can eventually be achieved. Indeed, the authors also express concern that "getting to that point may actually have an adverse effect on people with disabilities" (Aas and Wasserman 2016, 39).[6] Nevertheless, the medical perspective on BMI/BCI is still often used for strategic reasoning as it is in part motivated by the need to obtain funding for research. A further connected argument is that ATs should link to medical needs in order to be covered by healthcare insurance plans or government programs instead of the user him- or herself (Aas and Wasserman 2016, Kylberg et al. 2015).

[4] Prejudice, stereotyping and discrimination are three facets of stigmatisation. Stigmatisation can have many consequences on the individual level such as being seen responsible for one's victimhood, not being worthy of help, and being rejected and avoided. These negative experiences can lead to psychological problems such as low self-esteem or poor physical health and well-being in general. On a societal level, stigma appears as a form of social interaction and hence as a tool to create social inequality (Coleman 1986, Crandall 2000, Powell 2003).

[5] The same findings are evident for the AT of social robots (Yumakulov, Yergens, and Wolbring 2012).

[6] Interestingly one study investigating the use of BMI/BCI in special education found that the special education teachers interviewed felt that invisibility of the brain machine interface is a valuable aspect because they were afraid that those of their students who would wear the device would be stigmatised (Diep and Wolbring 2013).

2.3. The role of ATs in independent living, education and employment

Gaining autonomy and independence in daily life as well as the ability to perform in the spheres of education and employment is often mentioned as an important goal of ATs. However, what does it mean to be independent? The understanding of exactly what 'independence' means is not as clear as it seems at first sight, since the term 'independence' lends itself to different interpretations.[7] For instance, 'independence' can be understood in a way that someone is able to do things 'on their own' with the support of ATs. An alternative understanding would be that someone is in control of a situation – deciding what to do – while not necessarily needing to do this 'on their own'. The term 'self-determination' is often used to highlight the second meaning: the control aspect of independence.[8] Just being guided by the goal of doing things 'on their own', on an individual bodily basis, can be problematic from a societal point of view. There is a risk of assuming that bodily independence can be "solved" by ATs by achieving independence as such, in the sense of "doing it on its own", since it may open the door to the disempowerment of other people as they may have only limited choices to ATs. These choices are directly related to those devices they have actually access to and which they might be able to afford or will receive. The way these specific ATs are regulated and thus made accessible to the individuals by the government can also contribute to limited choice and inequality (Chandra and Jones 2015). Moreover, the focus on "bodily independence" bears the risk of connecting the function of an AT too strongly to the individual, rather than stressing the social function that an AT could also have. As an example, accessible public transportation may be regarded as an AT which is not about having independence of mobility "on their own" but actually offers increasing mobility opportunities for people in general.

The limits of the concrete impact ATs can have also become visible when it comes to the support of individuals in specific societal fields such as education and employment. The field of education is traditionally an important focus of AT developments for people with disabilities (Ahmad 2015, Hersh 2016, Quek, El-glaly, and Oliveira 2016). However, by itself, it does not guarantee a good education experience for the disabled persons. The danger of stigmatisation by using specific ATs such as BMI/BCI and the still prevailing issue of bullying of disabled people are just two issues that might have a strong adverse effect on the personal education experience[9] (Diep and Wolbring 2013, National Children's Bureau 2007, Sherry 2016).

On the employment side, recent research highlights the general limitations of an individualised approach of providing ATs to support people with disabilities in employment. There are indeed many challenges and barriers for people with disabilities to be faced, and discrimination in the field of employment often starts in the recruitment phase already (Johnston et al. 2014). In addition, other

[7] The understanding of the term "independence", especially in its relation to "interdependence to other persons", is discussed in both ways in scientific literature, with and without a disability angle as well as in relation to ATs and disabled people (see e.g. Carnaby 1998, Foley and Ferri 2012, Gibson E., Carneval A., and King 2012, Nye 1976, Reindal 1999).

[8] In general, the term "independence" should be used carefully. In some public debates, it seems that the term is linked with ATs because it goes in line with a prevailing view that disabled people are a burden. This would imply that people with disabilities "need" ATs to gain independence in order not to be a "burden" for other people or society anymore. Rather ATs should be framed as technical support within a societal system.

[9] Social experiences of discrimination also exist in academic education, e.g. in how language is used to highlight the needs of disabled people and non-disabled people in official documents (Hutcheon and Wolbring 2012). When looking at the narrative of accommodation for disabled people, terms such as "undue hardship" and "reasonable accommodation" are used to describe equity efforts for disabled students. In contrast, other documents highlighting accommodation for non-disabled people such as "washroom accessibility for males, females, families with children, and transgender individuals" use terms such as "inclusion" and "support" (Hutcheon and Wolbring 2012, 9).

studies highlight the various attitudinal barriers to the employability of people with disabilities (Perkins-Dock et al. 2015).

From a historical perspective, figures from the US labour market speak for themselves: in 1906, an official publication stated that at least 20% of blind people and nearly 40% of deaf people had some gainful occupation (Department of Commerce and Labor, 1906). These numbers are similar to today's statistics where for Europe a gap of over 40% between people with and without work limitations can be observed in actual employment rates. [10] These figures are similar in the US: according to the July 2016 US Bureau of Labor Statistics, only 18% of persons with a disability were employed, while the employment-population ratio for those without a disability was more than three times as high (66%). These figures suggest that the past development of ATs has not considerably helped disabled people to be employed (Bureau of Labor Statistics 2016).

2.4. Technology design and development for ATs

In the previous subsections, we have already outlined that ATs are often labelled with a "medical" rather than with a "consumer" perspective of people with disabilities. Moreover, we have highlighted the often not reflected risk of stigmatisation when certain ATs are used. Finally, a reflective and social use of the term "independence" might further improve the potential of changing the societal reality disabled people encounter through ATs. It is also worth mentioning that many scholars and disabled people themselves question the medical narrative of disabilities. This also relates to an understanding of disabilities that questions prevailing definitions of 'normality' as such. In this context such standpoints are also very critical towards the use of technology to reach 'normality', see for example the debates on deaf culture or the discourses dealing with neurodiversity (Jaarsma and Welin 2012, Norbury and Sparks 2013, Sparrow 2005).

Whether ATs for people with disabilities are seen through a medical or a consumer lens also has an impact on the technological design and development process. The negative consequences of the lack of involvement by disabled people in the design of products tailored to disabled people and of mainstream products have been already addressed in many studies (Allen 2005, Ferri, Giannoumis, and Edward O'Sullivan 2015, Frauenberger 2015). Recent studies indicate that, with digital technologies, the system of exclusion of people with disabilities from the technology development process continues (Goggin and Newell 2006). Indeed, if digital communication is becoming more and more commonplace in modern societies or if most webpages still do not follow formats of accessibility, many disabled people are being excluded and denied the opportunity of communicating in this "new way" (Gambino, Pirrone, and Di Giorgio 2016). Taking a historical perspective, technologies for modern forms of communication have often discriminated against disabled people. The ordinary telephone disabled deaf people because lip reading was taken out as a means of communication, and now cell phones are also seen as disabling for deaf people, as are certain developments involving Twitter or other social networking services for the blind (Baertschi 2013, Morris et al. 2016, Voykinska et al. 2016). Here, further technological solutions need to be developed as an add-on to re-include people with disabilities in the modern forms of communication which were introduced without consideration of the specific needs of these groups.[11]

Newell (2003) suggests that "good" technical development processes for ATs should consider questions such as how they could 'delight' the user (and their friends and companions), how they could be marketed to a wider group (maybe even reaching out beyond disabled people) and how to obtain accurate feedback from current users (including but not exclusively their professional carers).

[10] See: http://ec.europa.eu/eurostat/statistics-explained/index.php/Disability_statistics_-_labour_market_access (Accessed: 12.10.2016).

[11] See also recent legislative steps towards the need for universal design.

Designers of assistive technology need also to consider what compromises should be made between aspects such as costs and quality, institutionalised versus personalised design, and of specific requirements of the user rather than the service provider. Moreover, applications designed to benefit disabled people do not necessarily benefit all disability groups in the same way.

However, even if the user is involved in the design process and acceptance surveys are performed beforehand, this still does not demonstrate the usefulness of a certain device. In the field of robotics, for example, many studies focus on the acceptance of robots, while various studies look specifically at the usefulness of robots for people with disabilities (Hoppenot and Colle 2000, Graser et al. 2013, Tay et al. 2013). However, no research ensures that using robots will be making the life of people with disabilities better in the end (Wolbring 2016): There might even be unintended social effects of the introduction of robots, such as the replacement of human carers.

Many parameters therefore need to be met in order to develop and apply ATs in such a way that they truly support and benefit people with disabilities. Finally yet importantly, it seems crucial that ATs are put and framed in a broader societal and political context.

3. Research design and methods

Starting from the challenges identified above, the results of one quantitative survey as well as two qualitative studies on the needs and perceptions of disabled people as well as complementary measures by the public sector will be presented in this section. In the data, the challenges of ATs outlined above in terms of access, acceptance and awareness are covered. Moreover the role of ATs in the fields of employment and education as well as technology design and development are taken up, both from the perspectives of the disabled people as well as with reference to the experts' opinions.

In this research paper, quantitative and qualitative data were collected in order to cover questions from the following three areas:

- Disabled people's perceptions of ATs;
- Disabled people's specific needs for ATs;
- Complementary measures by the public sector.

A mixed method was adopted, comprising quantitative and qualitative data and designed to obtain the best benefits from these two methods (Creswell 2015). Quantitative data were gathered by a European-wide online survey, addressing impaired people directly; in addition, two qualitative interview series consisting of in-depth expert interviews at European level focusing on 1) the perceptions and needs regarding ATs and 2) complementary measures from the public sector, formed the core of the qualitative research. The following sub-chapter describes the process of data collection.

3.1. Quantitative online survey

The main aim of the online survey was to identify the perceptions[12] and needs of deaf and hard of hearing, blind and visually impaired persons, and people with autistic spectrum disorders, both in general terms and specifically in relation to ATs. Making the online questionnaire survey accessible to people with very different forms of impairment posed several challenges. The questionnaire was designed using the SurveyMonkey© tool. The decision to use SurveyMonkey was influenced by the fact that SurveyMonkey provides section 508-compliant[13] and Web Content Accessibility Guidelines (WCAG2)[14] conformance surveys. It was of utmost importance that the design of the survey took into account the specific needs of impaired people[15], their relevant experiences (Evans and Mathur 2005) and methodology (Sue and Ritter 2012) as well as general limitations of online research concerning the time required to respond or the number of textbox questions. Eleven pilot tests, covering at least two responses for each type of impairment, were conducted to ensure that the survey addresses the research questions in an accessible, adequate and understandable way. In particular, the detailed feedback from blind pilot testers was very helpful to improve accessibility.

The questionnaire is composed of the following sections: a) demographics, b) type and degree of impairment and experienced barriers in everyday life, c) current use of ATs and their importance for

[12] We define perception from two perspectives. On the one hand we aim to identify the view on the surrounding "ecosystem" i.e. personal perception of barriers in everyday life or the perception of legislative environment. On the other hand we try to identify the self-perception of the respondent and how the affected person is assessing the relation to ATs or the support by another person.

[13] The section 508 compliance is a US federal law that all electronic and information technology used by the federal government be accessible to people with disabilities. For further details see http://help.surveymonkey.com/articles/en_US/kb/508-Compliance (Accessed: 12.10.2016).

[14] Web Content Accessibility Guidelines (WCAG2) describe recommendations for making the web content more accessible. For further details see: https://www.w3.org/TR/2008/REC-WCAG20-20081211/ (Accessed: 12.10.2016).

[15] E.g. https://www.soscisurvey.de/help/doku.php/en:create:barriers_visual (Accessed: 12.10.2016).

support in different areas, d) personal perceptions and future demands, e) usefulness of specific ATs, e) importance of non-technical assistance and f) regulatory situation. Similar sets of questions were applied to different types of impairments to make it possible to relate the results to each other. Some, questions were adjusted to different impairments or the ATs available for the specific impairment. The number of questions ranged from 57 for blind visually impaired participants to 49 for persons with autistic spectrum disorder (ASD). Most of the questions were closed, using a Likert-scale for responses. Comment boxes and qualitative textbox questions provided opportunities for the respondents to add qualitative information and dimensions regarded as relevant by the respondents. The questionnaire was designed to be answered within twenty minutes.[16] Responses were collected anonymously.

A snowball sampling approach was used to distribute the invitation to the survey. About 150 European and national umbrella associations, and organisations representing the disability groups included in our survey were contacted via email and asked to disseminate the questionnaire within their member communities (see 9.2). In parallel, the request for participation in the questionnaire survey was distributed by the STOA office, contacts of the qualitative interviewees, personal contacts, and social media such as Facebook and Twitter. The questionnaire survey started in last week of June 2016. Friendly reminders were sent out to all contacted organisations in mid-July of 2016 and again in the last week of July of 2016.

The responses were analysed using descriptive statistical and text analysis methods using the built-in analytical tools of SurveyMonkey and standard analytical and statistical software (Excel and SPSS for Windows Version 23). Please refer to sections 9.3 and 9.4 for further information on the methodological challenges as well as the composition of the sample.

3.2. Sets of qualitative expert interviews

Two different qualitative studies, first on the perceptions and needs on ATs and second on complementary measures by the public sector were conducted. In both studies, semi-structured expert interviews in the field of ATs and disabilities were conducted at European level. The expert interviews were based on interview guidelines.

3.2.1. Needs and perceptions on ATs

The first set of interviews covered experts' opinions on the needs and perceptions of disabled people on ATs. The interviews focused on practical experiences with ATs, as well as specific needs for ATs in relevant societal fields, namely independent living, education and working life. In addition, perceptions and attitudes towards ATs were covered. The interview concluded with a reflection on the roles of ATs in a broader societal and political context as well as present and future challenges.

Five interviews with experts from three European disability organisations as well as cross-European user groups were conducted in total. Between May and August 2016, four videoconferences took place, each lasting approximately 60 minutes. One interview was conducted by e-mail, as it was the only way to overcome the language barrier with the expert, given that none of the interviewers is able to sign and there were no resources for sign language interpretation. The list of the interviews containing information on the experts is summarised in 9.5. All five interviews were recorded and transcribed. The analyses followed the qualitative content analysis (Mayring 2000): The written content of the interviews was coded in line with the framework set out in the interview guidelines. The coding was done with software support using MAXQDA Version 11.

[16] These twenty minutes did not take into account the additional time needed for blind or visually impaired persons using screen readers to answer the question.

3.2.2. Complementary measures by the public sector

The second set of interviews focused on complementary measures by the public sector in order to improve the inclusion of people with disabilities into society. The questionnaire encompassed experiences with political measures on ATs for people with disabilities in relevant societal fields, such as independent living, education and working life. In addition, the need for further political measures with a specific focus on the UNCPRD was covered. The interviews concluded with a reflection on ATs in the current political context and an outlook to future developments.

Seven expert interviews were conducted in total. These included representatives from relevant stakeholder groups: one each with experts from three European disability organisations, as well as with a medical expert, a researcher on ATs, an industry representative, and an expert from a social security provider. During the course of the study it was decided to also integrate the institutional perspective of the International Labour Organisation (ILO), specialised agency of the United Nations (UN) and the WHO, as they appeared to be of high relevance for the political discussion on ATs. These two expert interviews were conducted additionally, as they were not part of the original research brief. Between May and August 2016 a total of eight videoconferences took place, lasting approximately 60 minutes each. One interview was again conducted by e-mail, as it was the only way to overcome the language barrier with the expert, as none of the interviewers is able to sign and there were no resources for sign language interpretation. The complete list of the interviews and additional information on the experts is summarised in 9.7, the interview guidelines may be found in 9.8. All nine interviews were recorded and transcribed. The analyses followed the qualitative content analysis (Mayring 2000): The written content of the interviews was coded, in line with the framework set out in the interview guidelines. The coding was done with software support using MAXQDA Version 11.

4. Results of the quantitative online survey

The following section presents the main results of the quantitative survey based on the perceptions of the respondents across the three surveyed disability groups. The results include also comments and feedback of qualitative nature received from the participants.

4.1. Key results

Perceived barriers in everyday life

- People with disabilities are confronted with a wide variety of barriers to accomplishing tasks in their everyday life. Blind and visually impaired people face physical and transportation barriers. For people who are deaf and hard of hearing, and for people with an ASD condition, communication, information, and social barriers are particularly important. Attitudinal and policy barriers are nearly equally faced by all three groups of impaired persons.

Use and non-use of ATs

- The use of assistive technologies (ATs) on a daily basis is more important for blind and visually impaired and deaf and hard of hearing people (90% each indicated the use of ATs), and significantly less important for respondents with ASD. For the majority of persons who do use ATs, the use of these technologies is indispensable to them.
- The respondents indicated that the use of ATs is a necessity for their fulfilment of everyday tasks such as for example reading and writing, being mobile, accessing information, going to school and to work, independent housekeeping, personal care and engagement in social, leisure, sports and cultural activities. Respondents who are blind and visually impaired have the highest dependence on the support by ATs, followed by deaf and hard of hearing people, and respondents with ASD.
- The dependence on ATs is higher for people with ASD who live with others compared to those people with ASD who live alone. A possible explanation for this observation could be that ATs help respondents with ASD in their social interaction. The use of ATs therefore becomes more important when living and interacting with others.
- Those persons who currently do not use ATs have different reasons for not using them. The main reason for not using ATs by blind and visually impaired people is that they obtain support from another person. For those persons who are deaf and hard of hearing, the main reason for not using ATs is that they do not meet their needs. Persons with ASD state a lack of information concerning ATs as their main reason for not using them. The relatively high cost of ATs is stated as an important reason by all three groups.
- A slight majority of those persons who use ATs stated that they feel exceptional in a positive manner. A positive self-perception concerning the use of ATs dominates over neutral or negative opinions for respondents from all three disabilities.
- Assistance from family members and friends is an important form of support for all the three disability groups. When comparing across the three groups, those persons with ASD place higher importance on support from family and friends than respondents who are visually or hearing impaired.

Requirements of ATs

- Concerns were raised by the respondents as to whether the use of ATs makes their disability more noticeable. The majority of respondents in all three disability groups stated that ATs either should not make the disability of a person visible or have a neutral stance towards whether the AT makes the disability visible or not. The large number of neutral responses to the question whether ATs should make the disability visible or not indicates that people are unsure about the relationship between ATs and visibility of impairment. In some situations, an increased visibility of

impairment can make it easier for people to interact with one another. In other situations, people may be afraid of discrimination by others due to their disability.

- All three disability groups have very similar expectations as to which requirements an ideal AT should fulfil. The most important are: ease of use, flexibility, adaptability and affordability. The similarity in responses across all three groups for this set of questions implies that some requirements of ATs are independent from the disability itself.
- When asked about the perceived usefulness of existing and future technologies, visually and hearing impaired persons rate technical advancements of already existing technologies such as canes, cars, cochlear implants and mobile phone apps more highly than those that are not yet readily available such as devices which convert sound into tactile information or implantable miniature telescopes. For respondents with ASD the results are nearly equal for all four proposed future technologies.

Regulation

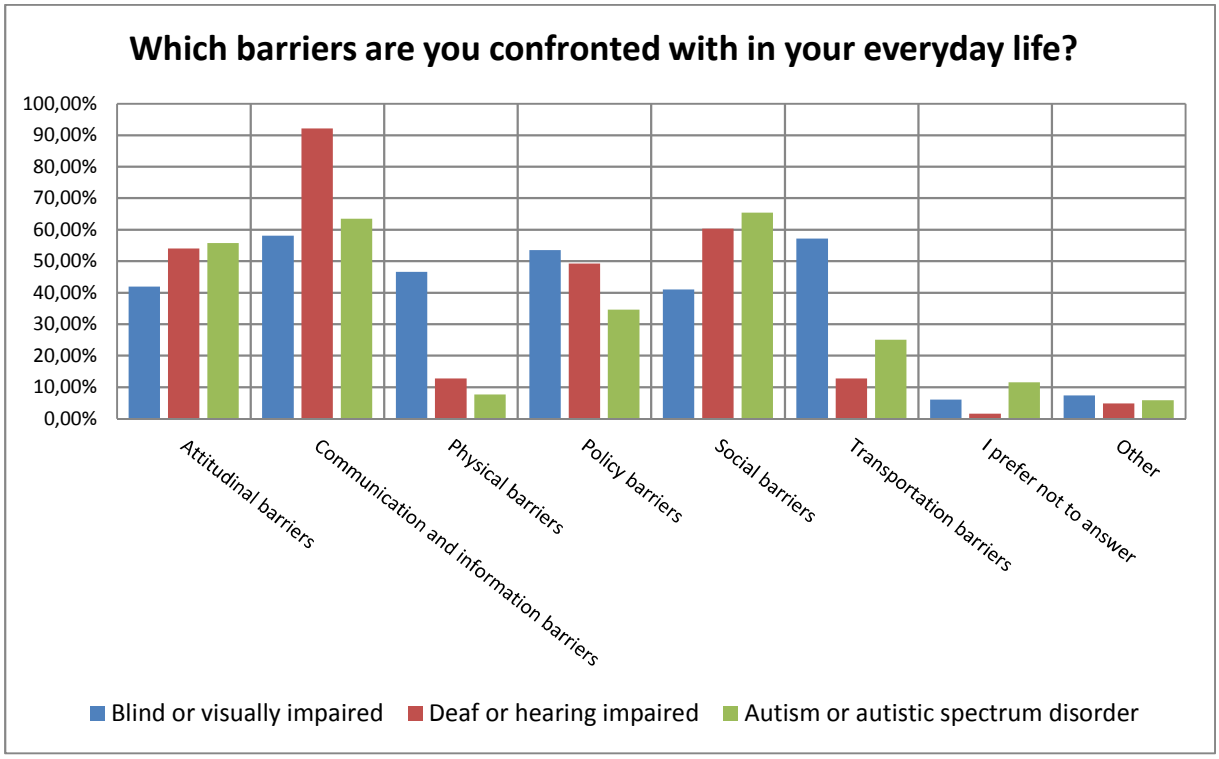
- Respondents from all three disability groups share the view that the ATs should be provided by the national health system and paid for by social security funds.
- A majority of the respondents are dissatisfied with the current regulatory situation. Regulation needs to be improved to facilitate access to employment and education, financial support and help and assistance according to respondents from all three disability groups.

In the following sections, the results of the survey are presented in detail.

4.2. Perceived barriers in everyday life

The responses to the question which barriers the respondents are confronted with in everyday life (see Figure 1) reveal striking differences, both in the relative importance of different barriers and in the general level of perception of barriers in relation to their impairment.

Figure 1: Barriers experienced in everyday life



Blind and visually impaired respondents:

The main barriers the respondents are encountering in everyday life are communication and information barriers (58%), transportation or physical barriers (57% and 47%), policy barriers (54%) and attitudinal and social barriers (42%). The respondents also had the opportunity to write comments concerning the barriers they are confronted with. Some comments to this question describe the situation of blind and visually impaired persons from their point of view. Several comments addressed mobility or transportation barriers, e.g.:

> *"Lack of boundaries between sidewalk and street (blind persons need a border of minimum 2cm!) It happens very often, that we accidently swing off the sidewalks, if these borders are missing, which could be extremely dangerous" (Respondent from Austria)*

or

> *"Mobility barriers: poor public transportation + limited individual transportation (walking, cycling on well-known paths)" (Respondent from Italy)*

Additional barriers mentioned concern inaccessible technologies such as electronic information displays or higher costs due to the impairment:

> *"Financial barriers - increased costs of daily living due to high priced assistive technology aids and costs associated with being a guide dog handler - NECESSARY for an independent life of comparable quality to non-disabled peers" (Respondent from Ireland)*

The perceived barriers and the needs seem to be interwoven. A barrier free environment allows for increasing autonomy and independent living.

Deaf and hard of hearing respondents:

Similar to blind and visually impaired respondents, deaf and hearing impaired persons have stated that communication and information barriers (91%) are the primary barrier reported. The next three most often named categories are the following: social barriers (61%), attitudinal barriers (53%) and policy barriers (48%). Physical or transportation barriers are less often experienced with only slightly more than 10% of the respondents who chose these options. Nevertheless, they are still relevant, especially with public transport as the following comment underpins: "*Only announcements of delays in speakers on rail stations and inside busses and train, No texts at all what so ever if transport delays …"* (Respondent from Denmark)

Respondents with autism spectrum disorder (ASD):

Physical barriers were in general less important for autistic people than they were for other surveyed groups. For them, the main reported barriers were communication (65%), social (65%) and attitudinal (56%). Access to further formal education, due to a lack of *"100% online programs"*, is mentioned as an example of additional barriers by persons with agoraphobia or problems to communicate in person; autistic persons may also be confronted with different kinds of barriers: *Sensory barriers like bright lights, intense smells, loud or grating sounds.*

Notable results across for the three groups:

The perceived barriers seem to be different for the three groups of the sample. All three groups encounter a wide variety of barriers in their everyday lives. Physical barriers are more "relevant" for blind and visually impaired people, communication and information barriers are our highest relevance for deaf and hard of hearing respondents and respondents with ASD have to cope most with social and communication barriers. In particular, the results for communication and information barriers are surprising: 92% of deaf and hearing impaired participants reported communication and information barriers, which is substantially higher than reported by visually impaired (58%) and ASD

(63%) respondents. They indicate that IT-based access to information and support of communication, which has increased extremely in the last decades, has not significantly contributed to reduce communication and information barriers for hearing impaired respondents.

Taking all six categories of barriers addressed in the survey into account, visually impaired respondents appear to be confronted most with these barriers with an average value of 50%, followed by deaf and hearing impaired participants with 47% and ASD with 42%.

4.3. Use of assistive technologies

The following three figures provide an overview about the use and non-use of assistive technologies among the three groups, the perceived necessity to use them and the frequency of use.

Figure 2: Current use of assistive technologies

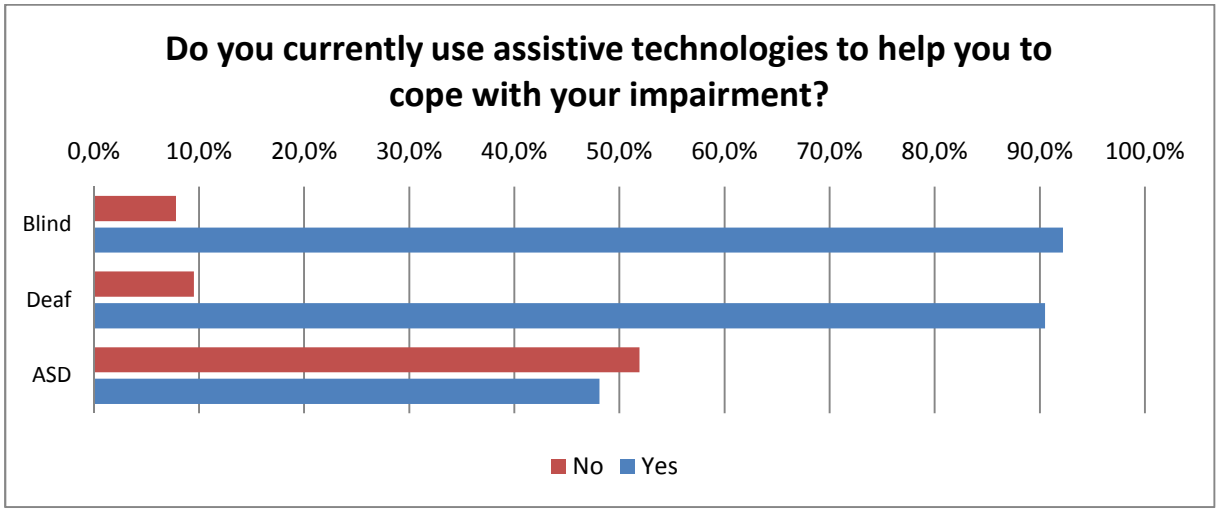


Figure 3: The necessity to use assistive technologies among the three disabilities

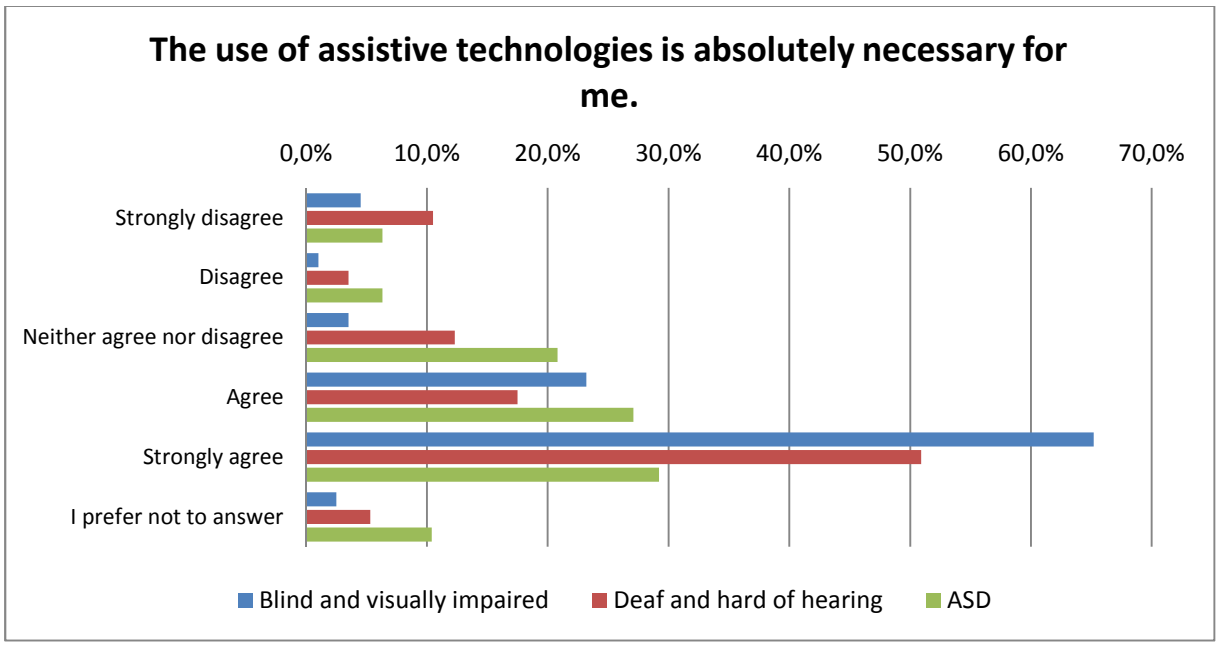
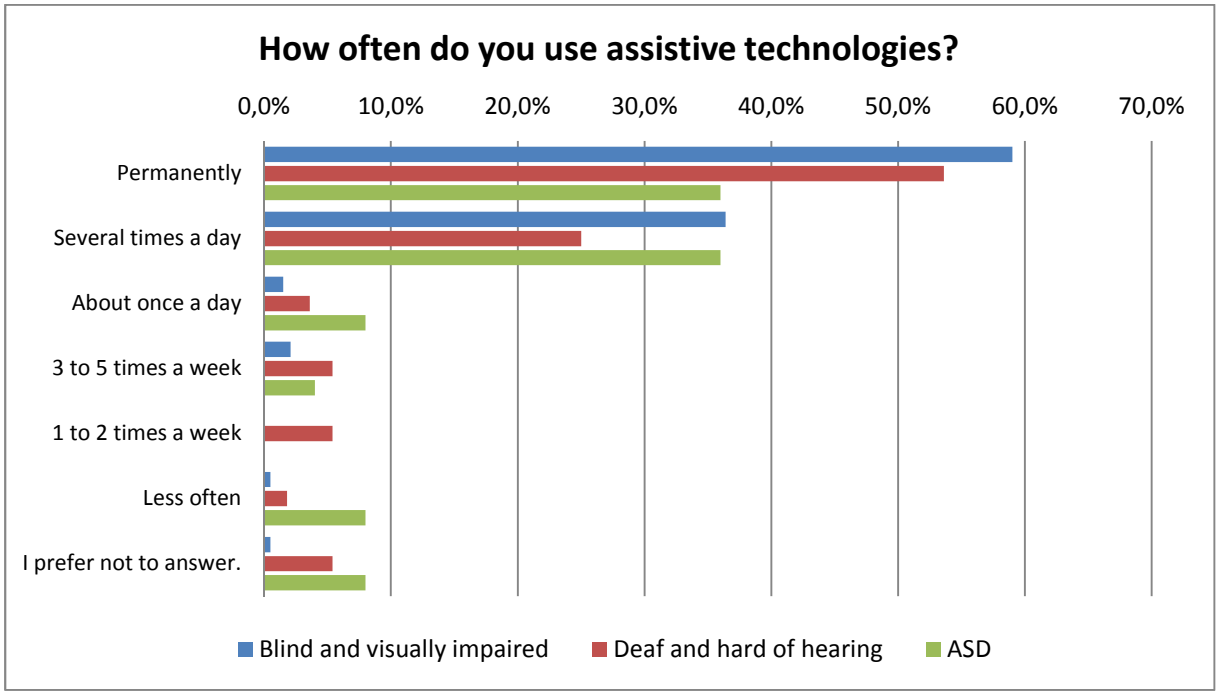


Figure 4: Frequency of the use of assistive technologies among the three disabilities



Blind and visually impaired respondents:

Technology seems to play an important role for the blind respondents. In order to answer the online questionnaire the blind respondents already needed some kind of AT or personal assistance in order to do so. More than 90% of the blind persons in our sample use assistive technologies permanently or on a daily basis (see Figure 4). These technologies include mainly information and communication devices. This is also understandable as one of the main barriers for blind and visually impaired persons is communication and information retrieval. Used technologies include text to speech systems (Voice over, JAWS and other screen readers), braille displays, magnifiers and also "general non-specific mass-technologies" like mobile phones or tablets. Low tech devices like canes were also mentioned several times (16x).

There are also blind respondents, who are currently not using ATs. The main factors reported for not using ATs are the availability of personal support, that current ATs do not meet own personal needs or financial reasons. Another interesting question which arises is how ATs can help people with multiple disabilities as shown in the quote below: *"I am both visually impaired and moderately to severely deaf and current assistive technology do not competently meet my specific needs"* (Respondent from Ireland)

Multiple disabilities may play an even higher role in the future as age related disabilities will increase due to the demographic change.

Deaf and hard of hearing respondents:

Slightly more than 90% of the respondents are currently using ATs. The used ATs are hearing aids like cochlear implants, vibrating alerts and FM systems[17]. These technologies are used by more than 80% of the respondents permanently or on a daily basis. The technologies are either used to "restore" the function of hearing (i.e. hearing aid, cochlear implant) or technologies for communication

[17] Personal frequency modulation (FM) systems are miniature radio stations operating on special frequencies. They are assistive hearing devices that enhance the use of hearing aid(s), cochlear implants and also assist people who are hard of hearing but do not wear hearing aids, in particular over distance and in noisy environments.

purposes in sensu stricto (i.e. door bell, speech to text). This is also understandable as one of the main barriers for hearing impaired persons is communication and information retrieval. The respondents also utilise general technologies like mobile phones as ATs.

The deaf and hard of hearing respondents, who currently are not using ATs do this mainly because "current ATs do not meet their needs" or because they have "too little information concerning ATs". Another additional reason one respondent mentioned was:

> *"The assistive technology makes me tired. After ten hours of wearing assistive technology and lipreading, my energy level is gone. That's the reason I stopped wearing them." (Respondent from the Netherlands)*

Respondents with autism spectrum disorder (ASD):

With about 48% positive responses, the use of such technologies is much lower than in the total sample with about 92% using ATs. The percentage of users of ATs within the whole sample of autistic persons is probably considerably lower as about one quarter of the respondents skipped the question[18] whether they are using ATs. Similar observations hold for the frequency of use; here about 70% of the respondents to this question use ATs permanently or several times a day, however, about two thirds of the autistic respondents skipped this question entirely. The technologies used are mainly the Internet and smartphones/tablets, in many cases equipped with specialised software or apps to support the specific needs of the users. According to the various representations of ASD the forms of assistance sought by technologies are also very diverse, comprising the support of non-verbal communication or communication in a protected manner, e.g. using the Internet or email instead of personal communication, assistance in the interpretation of emotions or social behaviour, applications for self-organisation, or protection against ambient noise or light. Other technologies that were named by the respondents are Picture Exchange Communication System (PECS), augmentative alternative communicative tablets (AAC) or text to speech devices.

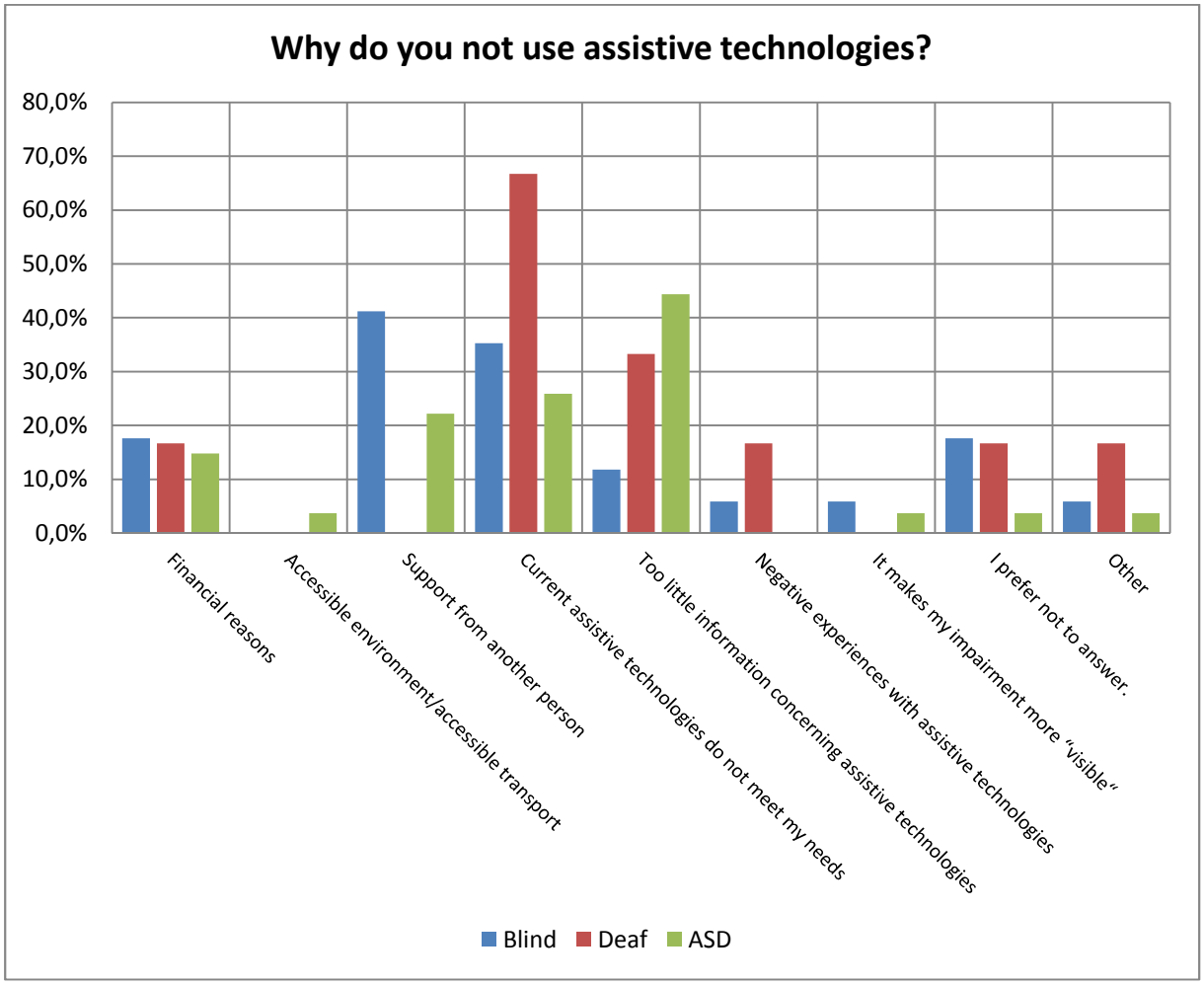
Too little information was the most frequently mentioned reason for not using ATs, followed by not meeting the needs, availability of personal assistance and financial restrictions.

Notable results for the three groups:

The ATs the three groups are using differ from each other to a certain degree. Blind and visually impaired respondents mainly mentioned technologies for information retrieval, communication and mobility, deaf and hard of hearing respondents named technologies to restore function of hearing and ASD respondents mentioned communication technologies. Widely spread and common technologies like internet, mobile phones or tablets are relevant for all three groups. An interesting picture is revealed when looking at the reasons for not using ATs. Financial barriers are more or less equally relevant for all three groups as can be seen in Figure 5 below. The main reason for blind and visually impaired persons in our sample is the support from another person. The main reason for deaf and hard of hearing persons is that current ATs do not meet their needs. The main reason for respondents with ASD is too little information concerning ATs.

[18] High dropout rates for individual questions make interpretation difficult. Whereas 25 out of 52 respondents who answered this particular question in total declared to use ATs, 18 participants skipped this question. It is not possible to include these missing votes automatically into the non-user group; however, there is a reasonable high probability that the reason for not voting in this case and in several other technology related questions is non-use.

Figure 5: Reasons for not using assistive technologies



4.4. Importance of ATs for the support of different activities

The respondents were asked to indicate the importance that assistive technologies possess for nine different activities and spheres of everyday life (reading and writing, mobility and orientation, access to information, support in school and work, independent housekeeping, personal care, social activities, leisure and sport activities, cultural activities).

Blind and visually impaired respondents:

According to the blind and visually impaired respondents answers ATs seem to be necessary in all areas of everyday life. For the participants ATs are most important for the areas reading and writing, school and work, the access to information, goods and services and for mobility and orientation. The results show that visually impaired persons need support by assistive technologies in all areas of everyday living, however with considerable differences between the diverse areas as can be seen in Figure 6. More than 90% of the people who currently use ATs answered that these technologies are extremely important or very important for them for reading and writing. The respondents had to use ATs to some extent for the completion of the questionnaire.

The respondents also had the opportunity to list other important areas where ATs could or should provide support. They named ATs which provide access to health and medical care, governmental services, voting or travel and transport. The technologies, which were named, have in most cases the

function to support access in particular. Following quotes give some examples concerning the aspect of "access":

> "Access *to public transport, being able to use it more independently.* Access *to e-government. E-voting." (Respondent from Germany)*

> *"More* accessibility *on booking website for instance: to book flights in particular since most of the web sites and apps are absolutely inaccessible. More attention on all other websites of hotel booking, bus and train tickets booking." (Respondent from Italy)*

Further comments by the respondents listed below give additional impression of potential areas in which technologies could provide support or where improvements are desired. Some of the responses address when specific needs like talking devices in healthcare or better navigation:

> *"health care: talking glucometer, talking insulin pump, talking blood pressure meter, etc." (Respondent from Slovakia)*

> *"indoor navigation, better OCR[19]" (Respondent from Austria)*

> *"There are a number of GPS and way finding apps but none of them that I have found brings all the pluses together in one app" (Respondent from Ireland)*

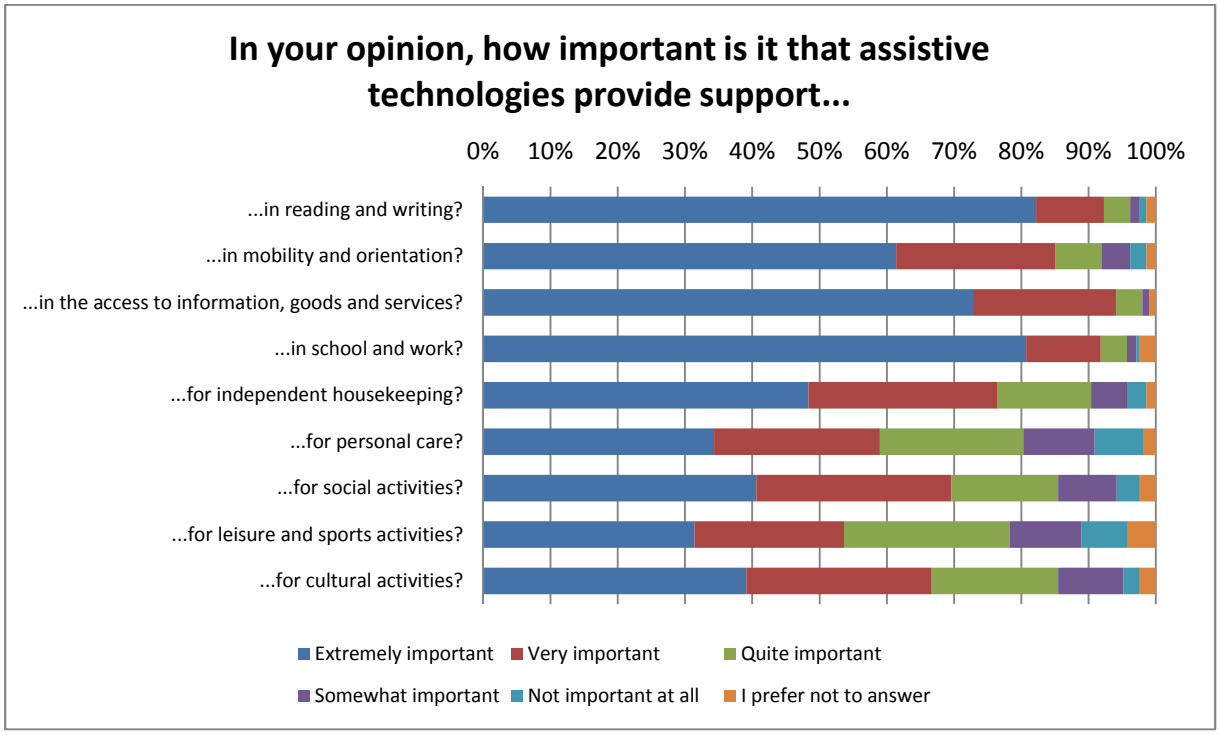
Other comments request for support from ATs in a broad range of services or raise issues of modern technology in general or of expensive products on low incomes of disabled people.

> *"Mobility, medical, public transport, shopping, social media, help lines, peer support, emergency alerts." (Respondent from Ireland)*

> *"There is a problem with modern technology because some of the creators of new technology are building it to help people with disabilities. But these components are for the common people and are not assistive technology. Therefore the help centrals more and more points to the common products which is expensive for people with disabilities because of lower income because of their disability." (Respondent from Sweden)*

[19] OCR stands for optical character recognition, which is a method for the conversion of images of typed or written texts into machine encoded texts.

Figure 6: Relative importance of assistive technologies for blind and visually impaired

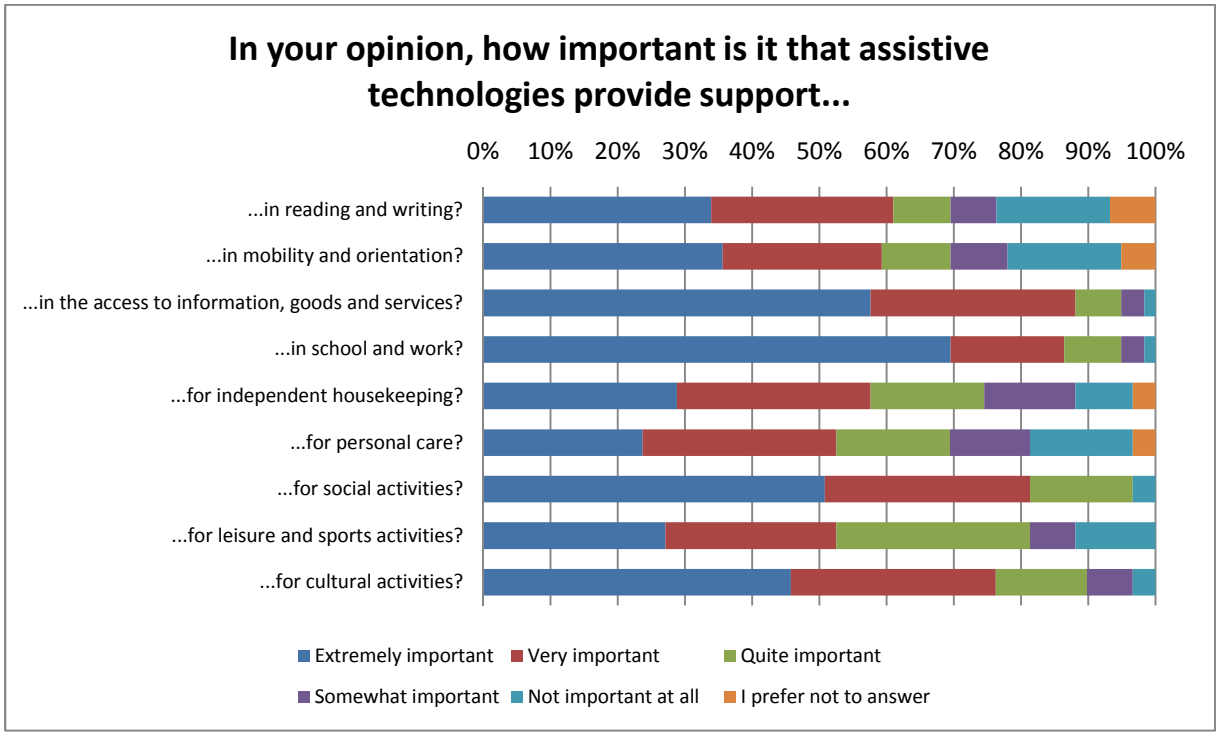


Deaf and hard of hearing respondents:

Similar to the blind and visually impaired respondents the support by ATs in everyday life seems to be important in each area. Salient areas (i.e. high values of the answer option "extreme important") are (school and work, access to information, goods and services and social and cultural activities) independent housekeeping, personal care, social activities, leisure and sport activities). Figure 7 shows the results to this question. For the hearing impaired respondents ATs are of great importance. More than 65% indicate that the use of ATs is absolutely necessary for them. Nevertheless more than 10% of the respondents strongly disagree that ATs are absolutely necessary for them. Comments on other areas where ATs should provide support are e.g.:

> *"Communication with people in my family who don´t know sign language" (Respondent from Sweden)*
>
> *"assistive technologies for "normal" people so they understands how important clear information is. Learning to articulate?" (Respondent from Sweden)*
>
> *"Railway and public transportation" (Respondent from Sweden)*

Figure 7: Relative importance of assistive technologies for deaf and hearing impaired



Respondents with autism spectrum disorder (ASD):

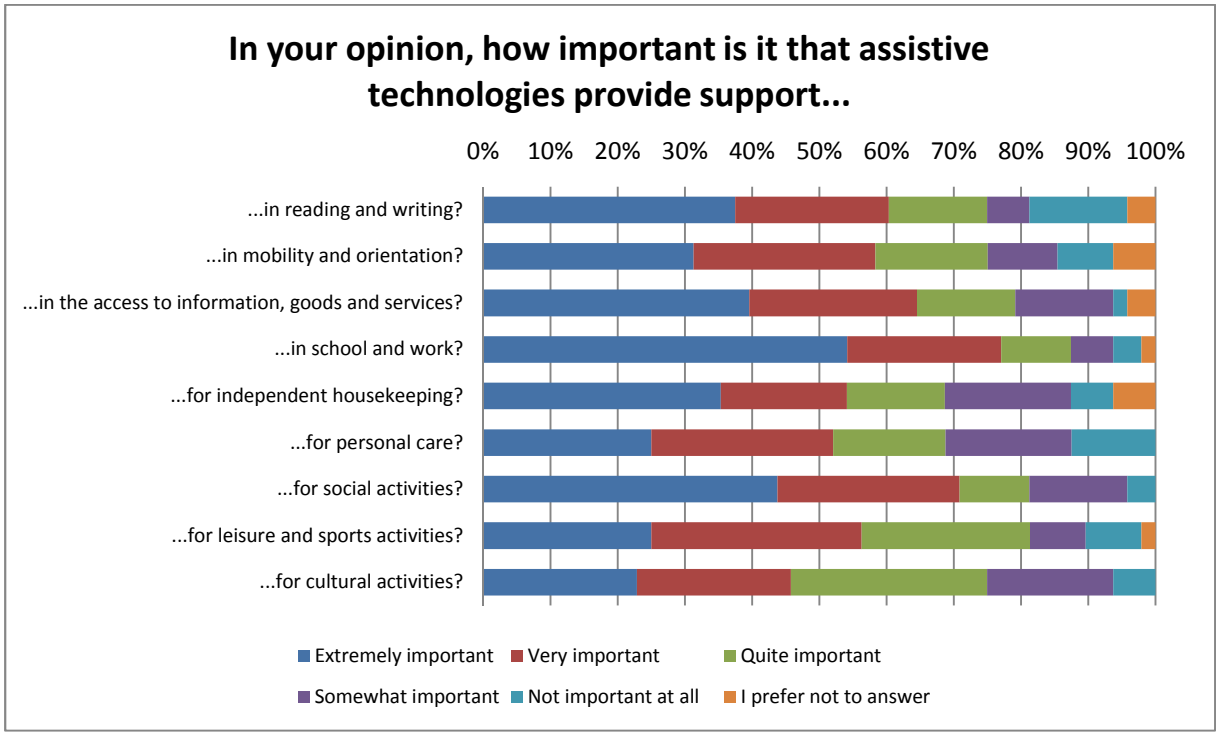
For most of the scanned areas of support (reading and writing, mobility and orientation, access to information, goods and services, …) a slight majority between 50 and 60% of the respondents regard ATs as extremely or very important, remarkably higher is the importance for support in school and work and for social activities with corresponding 77% and 70%, for the least important function - support for cultural activities - the corresponding figure is 46%.

The assessed importance of ATs for autistic people is in general much lower than for the other two investigated kinds of impairment were corresponding figures in some cases are above 90% and never fall below 50% (extremely or very important).

The relatively low level of importance for and of the use of ATs by autistic people can partly be attributed to the wide range and diversity of needs, for which assistive technologies do not (yet) exist. Additional areas named for which support should be provided comprise communication, also non-verbal, understanding of emotions, social behaviour and relationships, sexuality, reducing anxiety by emergencies services and support against the "dangers of the street", finding jobs respectively income opportunities or general services like the delivery of groceries to the home.

Asked whether the use of assistive technologies is absolutely necessary, the confirmation rates for autistic people are considerably lower than for visually or hearing impaired persons. For persons with ASD this share is 56% (29% strongly agree and 27% agree) in comparison to 68% (50% and 18%) for hearing impaired and 88% (65% and 23%) for visually impaired participants.

Figure 8: Relative importance of assistive technologies for ASD



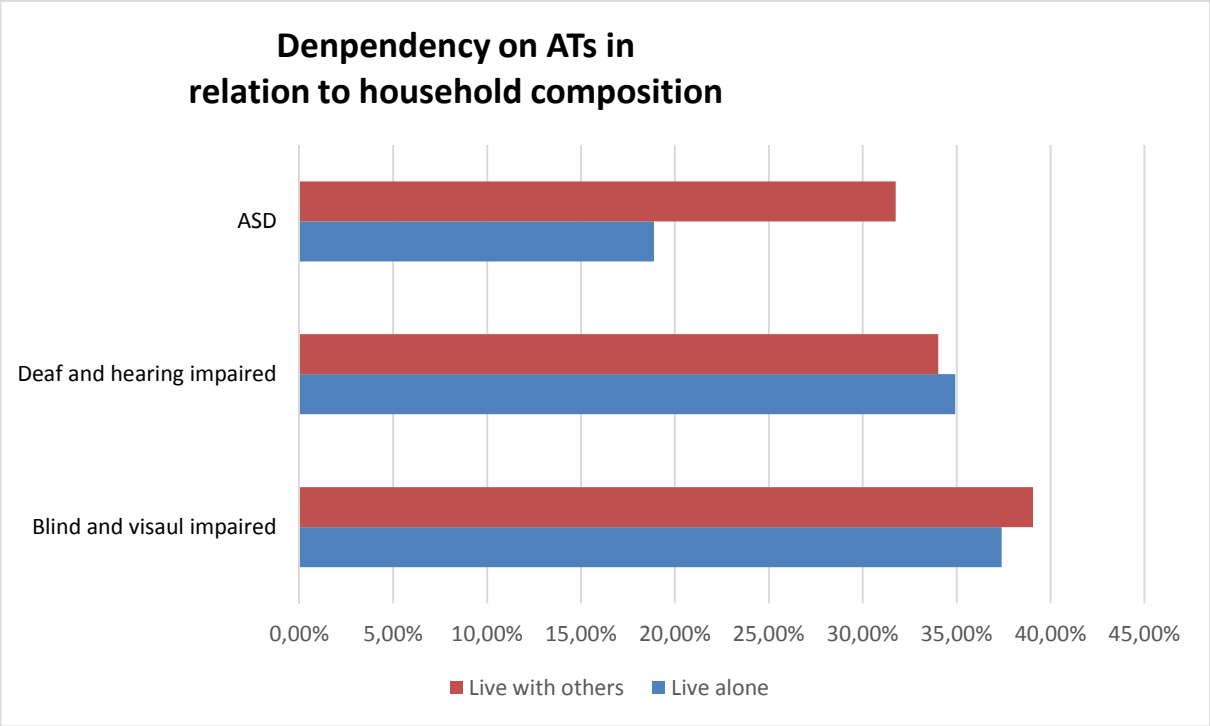
Notable results for the three groups:

The support by ATs in the nine areas of everyday life is relevant for all the three groups. Differences are identified in the level of importance (i.e. extremely important up to not important at all). The level of importance can be put on a level with dependence on ATs. Blind and visually impaired persons seem to have the highest dependencies on the support by ATs followed by deaf and hearing impaired respondents and respondents with ASD. Deaf and hearing impaired respondents, compared to blind and visually impaired persons, have a higher dependency on ATs for social and cultural activities.

For all three groups support in school or at work and in the access to information, goods and services rank very high (i.e. are seen as extremely important). The comparison of Figures 7, 8 and 9 also shows the decreasing importance of support by ATs across the three groups of disabilities. Looking at the sums of the answer categories "extremely important" and "very important" together for all nine areas, then the average decreases from 77% for blind and visually impaired people, 68% for deaf and hearing impaired people down to 60% for respondents with ASD. This trend confirms the responses regarding the necessity of assistive technologies in general for the three groups of impaired persons.

We have also investigated whether there are differences concerning the dependency on ATs in relation to the household composition of the respondents, comparing people who live alone and people who do not live alone. For each disability group the answers "extremely important" and "very important" were summed up for the nine areas (see Figure 6 to Figure 8). Figure 9 shows the aggregated results. Surprisingly the dependence upon ATs is much higher for respondents with ASD who live alone, compared with those from the same group who live with others. This difference was not observed in the other disability groups. A possible explanation for this could be that respondents with ASD have difficulties with social interaction. Therefore, the use of ATs becomes more important when living with others. It needs to be mentioned that this interpretation is to be treated with caution due to the low sample sizes in the two groups of hearing impaired respondents and respondents with ASD.

Figure 9: Dependency on ATS and household composition

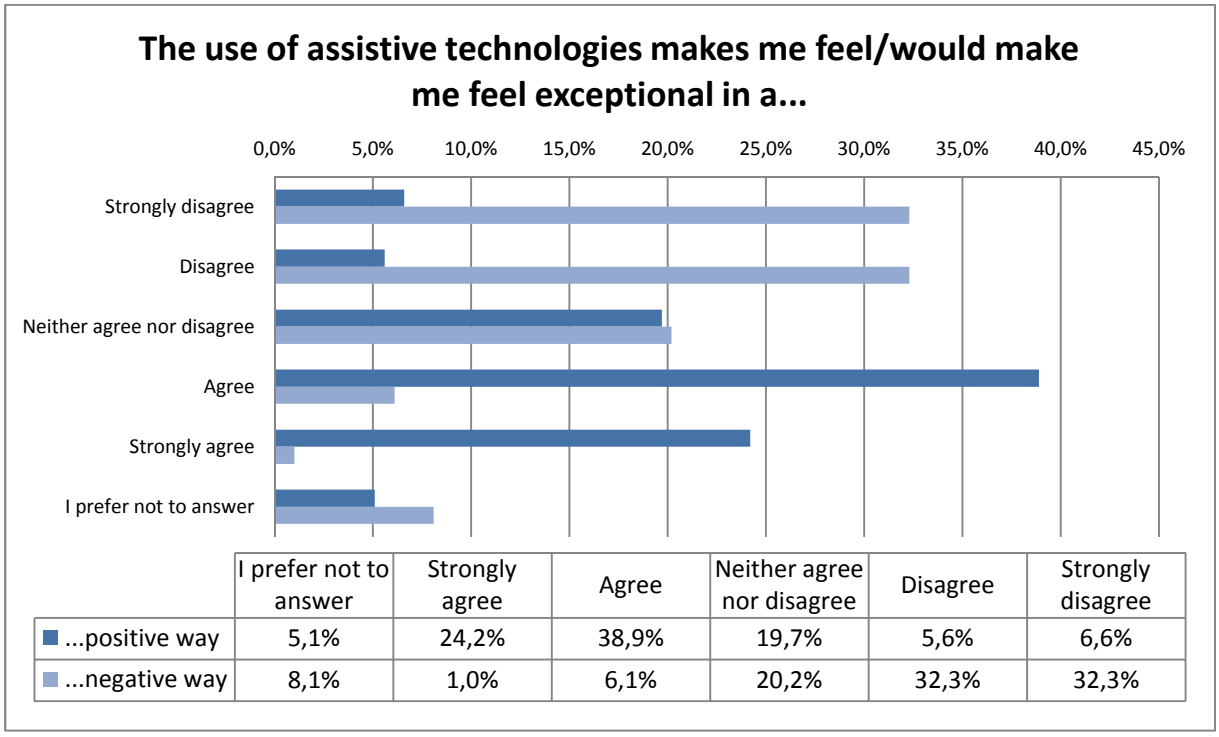


4.5. Self-perception regarding the use of ATs

Blind and visually impaired respondents:

In general, the use of assistive technologies is clearly connoted in a positive way by the majority of respondents; more than 60% strongly agree or agree to the statement, that the use of ATs makes them feel exceptional in a positive way. The pattern of answers to the opposite question (i.e. ATs makes me feel exceptional in a negative way) confirms this assumption (Figure 10).

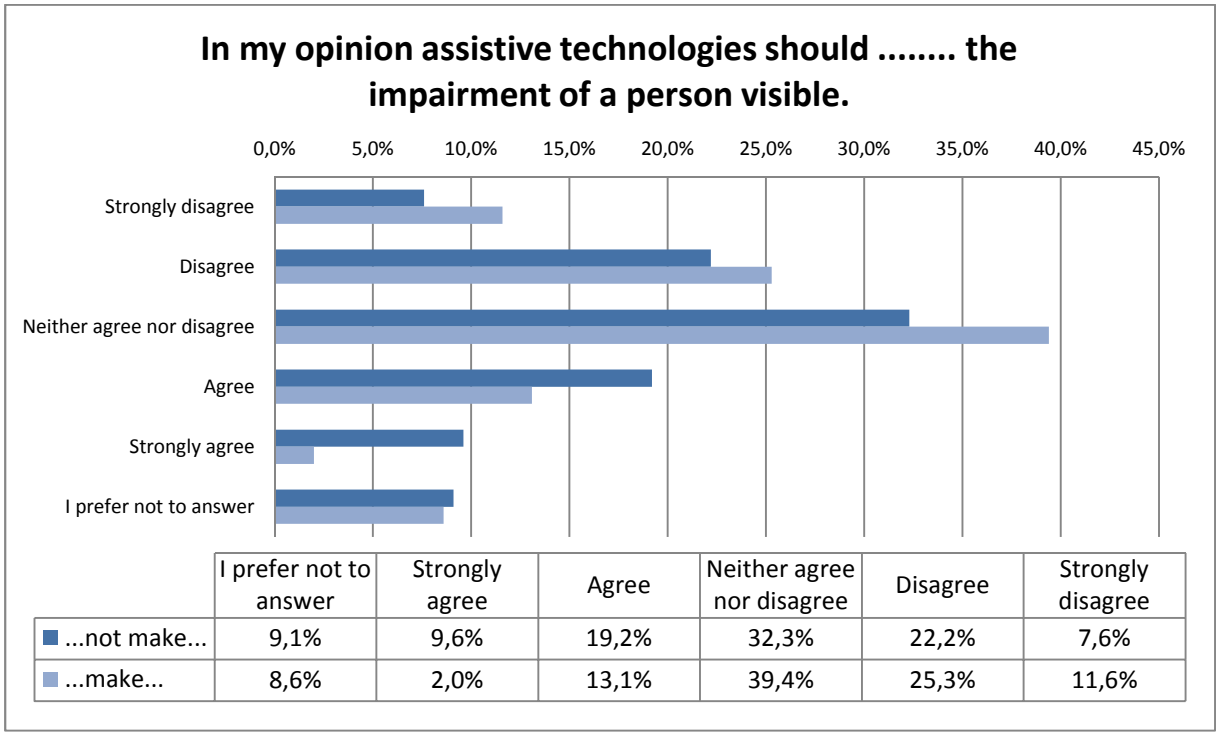
Figure 10: Use of assistive technologies and exceptionality - blind and visually impaired



	I prefer not to answer	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
...positive way	5,1%	24,2%	38,9%	19,7%	5,6%	6,6%
...negative way	8,1%	1,0%	6,1%	20,2%	32,3%	32,3%

The tendency is less pronounced concerning the visibility of the impairment due to the use of ATs. A relative majority neither agrees nor disagrees with the questions related to the visibility of ATs. Interestingly, more respondents disagree with the statement that ATs should make the impairment of a person visible (Figure 11). These results suggest an interpretation that among the respondents the wish dominates that ATs should be neutral in this respect; they should neither actively hide nor disclose the impairment.

Figure 11: Visibility of assistive technologies - blind and visually impaired



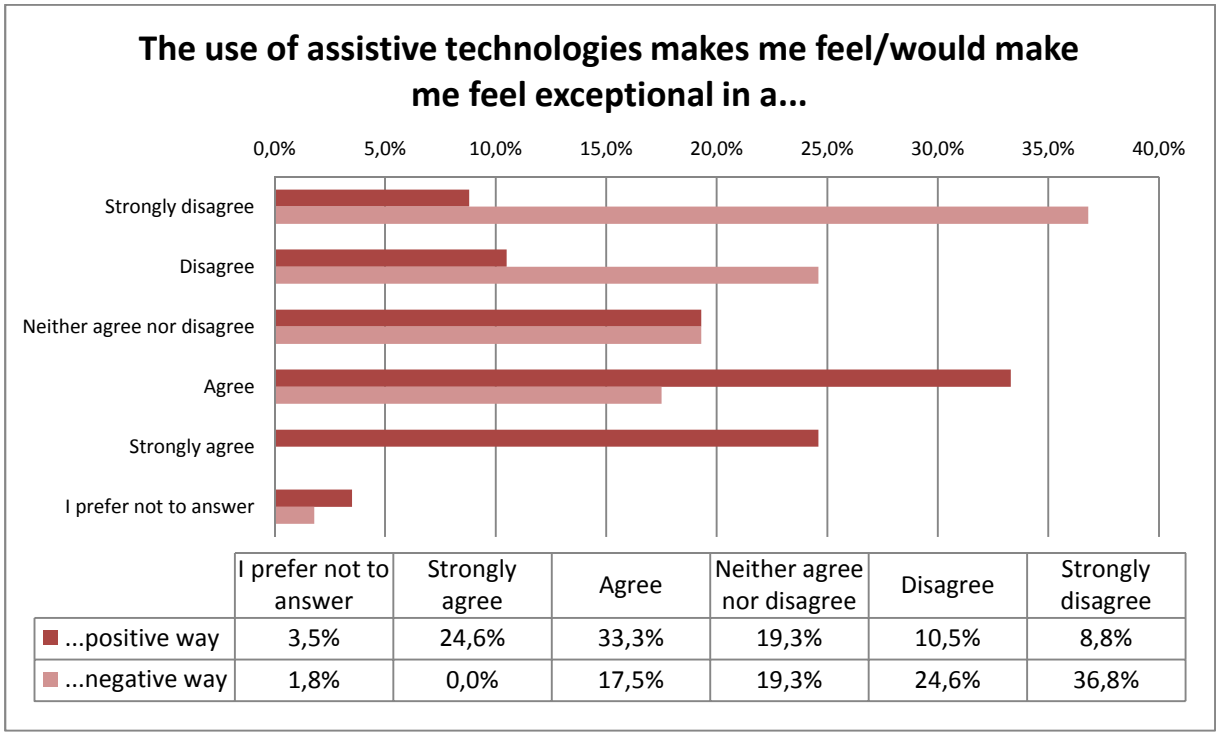
	I prefer not to answer	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
...not make...	9,1%	9,6%	19,2%	32,3%	22,2%	7,6%
...make...	8,6%	2,0%	13,1%	39,4%	25,3%	11,6%

Deaf and hard of hearing respondents:

Concerning the personal attitude towards ATs, more than 55% of the respondents have the opinion that ATs make them feel exceptional in a positive way (sum of strongly agree and agree). On the other hand almost 18% of the respondents have a "negative" feeling when ATs are used (i.e. makes them feel exceptional in a negative way). Nearly 20% of the respondents neither agree nor disagree to the statement. There is a clear tendency among the respondents of the survey to have a positive association with ATs, although a considerable share of the respondents show a neutral or negative stance.

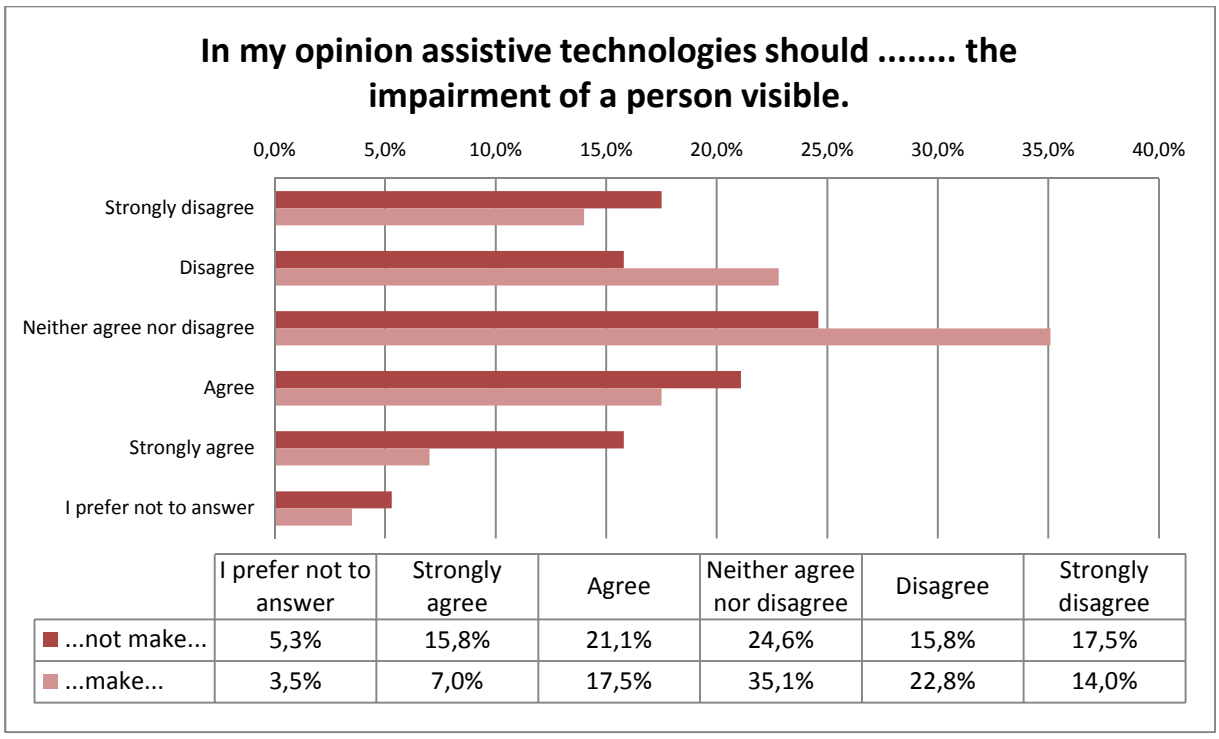
Regarding the question if ATs should make the impairment of a person visible, the results are not that distinct. One third of the respondents think that ATs should make the impairment of a person visible, nearly another third neither agrees nor disagrees and another third disagrees to the statement that ATs should make the impairment visible. This result is more ambiguous than in the question asking for the exceptionality (Figure 12 & Figure 13)

Figure 12: Use of assistive technologies and exceptionality - deaf and hearing impaired



	I prefer not to answer	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
...positive way	3,5%	24,6%	33,3%	19,3%	10,5%	8,8%
...negative way	1,8%	0,0%	17,5%	19,3%	24,6%	36,8%

Figure 13: Visibility of assistive technologies - deaf and hearing impaired



	I prefer not to answer	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
...not make...	5,3%	15,8%	21,1%	24,6%	15,8%	17,5%
...make...	3,5%	7,0%	17,5%	35,1%	22,8%	14,0%

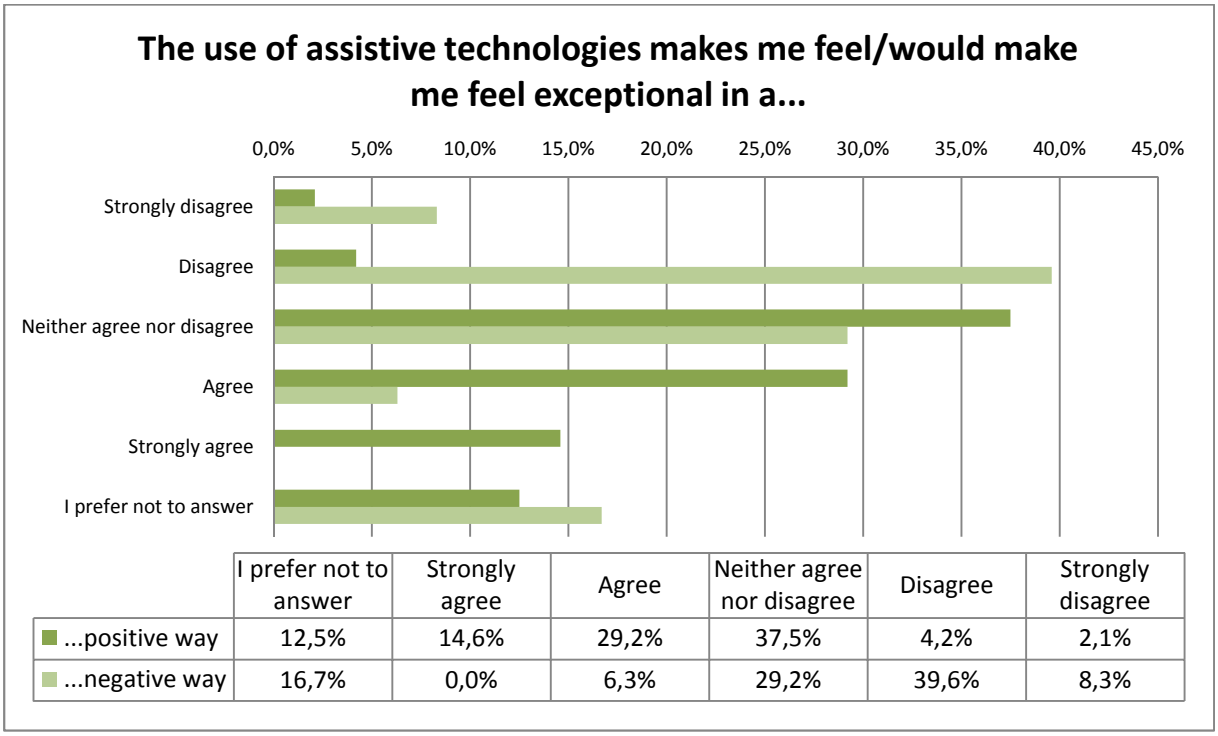
Respondents with autism spectrum disorder (ASD):

Slightly more than 44% of the responding participants agree to the statement that ATs makes them feel exceptional in a positive way (sum of strongly agree and agree). Nearly 38% neither agree nor disagree and only 6% disagree to the statement that the use of ATs makes them feel exceptional in a

positive way. A similar pattern resulted from the opposite question i.e. when asking if the use of ATs makes them feel exceptional in a negative way. Slightly more than 6 % agree or strongly agree to the statement that the use of ATs makes them feel exceptional in a negative way or put in another way nearly 48% disagree or strongly disagree to the statement that the use of ATs makes them feel exceptional in a negative way.(see Figure 14).

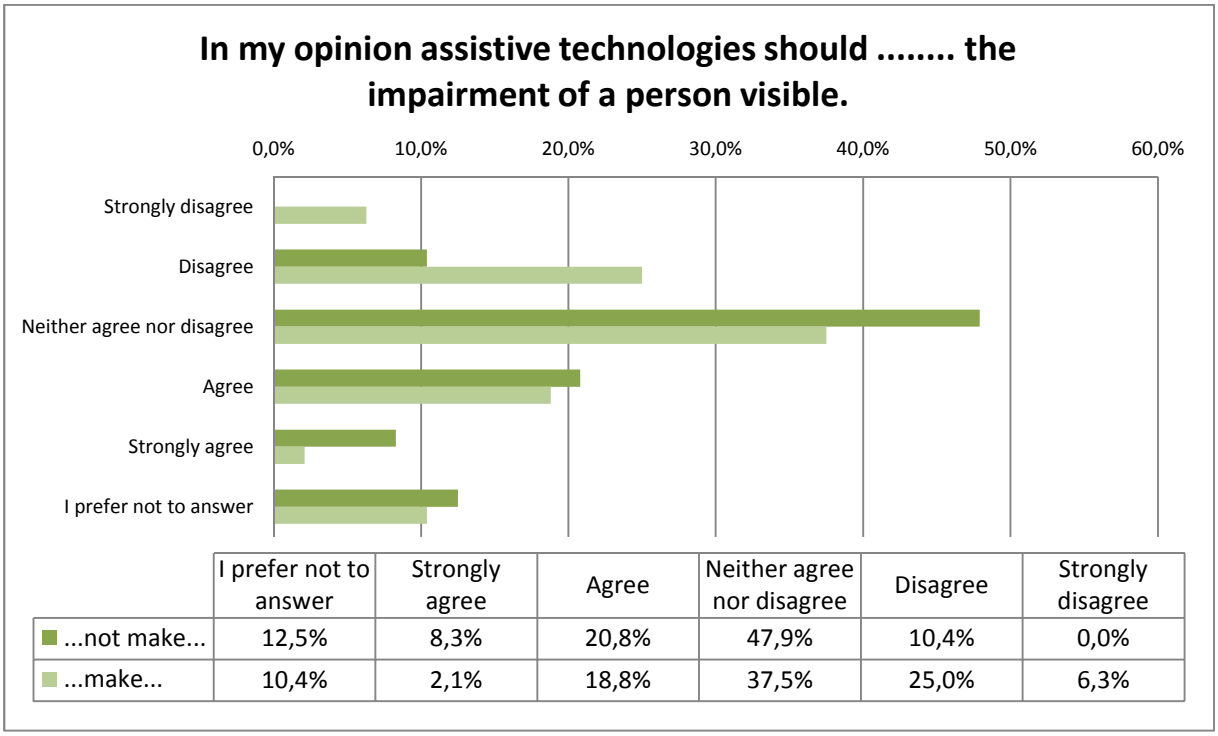
When asked whether assistive technologies should make the impairment visible or not, the answers are more balanced. Regarding the questions "In my opinion assistive technologies should make/not make the impairment of a person visible" in both cases a relative majority of the respondents chose the neither agree nor disagree option. About 29% agreed that ATs should not make the impairment visible. Slightly more than 10% disagree to the statement that the use of ATs should not make the disability visible. For the opposite question (i.e. the use of ATs should make the impairment visible), about 21% agree and about 31% disagree to this statement. In summary, it can be said that there seems to be a difference between the feeling of exceptionality and the visibility of the impairment due to the use of ATs.

Figure 14: Use of assistive technologies and exceptionality - ASD



	I prefer not to answer	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
...positive way	12,5%	14,6%	29,2%	37,5%	4,2%	2,1%
...negative way	16,7%	0,0%	6,3%	29,2%	39,6%	8,3%

Figure 15: Visibility of assistive technologies - ASD



	I prefer not to answer	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
...not make...	12,5%	8,3%	20,8%	47,9%	10,4%	0,0%
...make...	10,4%	2,1%	18,8%	37,5%	25,0%	6,3%

Notable results for the three groups:

In general, we may conclude that the self-perception of the three different groups of impaired persons does not differ to a great extent. All three groups report that the use of ATs makes them feel exceptional in a positive way. This is also confirmed by the opposite question when asking that the use of ATs makes them feel exceptional in a negative way. Concerning the visibility of the impairment due to the use of ATs a more ambiguous picture is prevalent. A majority of the respondents either thinks that the AT should not make the disability visible or have a neutral stance. This result could indicate that the respondents are cautious concerning statements to the visibility of their impairment. A possible explanation may be the aspect of negative stigmatisation due to the use of ATs. One question which arises based on these results (i.e. exceptionality and visibility) is how ATs could fulfil on the one hand the requirement of making the user feel exceptional in a positive way and on the other hand not necessarily making the disability visible.

4.6. Responsibility for the provision of ATs

The following section provides insights on the responsibility for the provision with ATs from the respondents´ point of view. Although the respondents had the possibility to choose more than one answer, a clear tendency concerning the provision of ATs can be identified across all three disabilities (Figure 16).

Blind and visually impaired respondents:

A vast majority of the blind and visually impaired respondents think ATs should be provided by public actors. Many of them, however, also attribute responsibility to specific interest groups or themselves. Over 80% of the respondents felt that the national health system should be responsible for the provision of adequate ATs. More than 50% of the respondents indicated that organisations representing impaired persons should do this and over 40% that it should be the impaired persons or their relatives.

Deaf and hard of hearing respondents:

Deaf and hearing impaired respondents show similar results to the blind and visually impaired. Slightly over 80% of the respondents think that the responsibility for the provision with ATs lays at the national health system/social security fund. Slightly more than 20% of the respondents think that organisations representing hearing impaired persons should provide ATs. This is also a major difference compared to blind and visually impaired persons, where more than 50% of the respondents think that organisations representing impaired persons should do this. Approximately 30% of the deaf and hearing impaired respondents think that impaired persons or her relatives should be in the responsibility to provide ATs.

Respondents with autism spectrum disorder (ASD):

Roughly 83% of the respondents attribute responsibility for the provision of ATs to the public sector. This is a similar result to the other two groups of impairments One third of respondents name the impaired person or her relatives and another third name organisations representing impaired persons to have responsibility for the provision of ATs. Specific comments provided by the respondents ask for more differentiated approaches, taking into account the costs of technology, the specific needs and financial situation of the concerned person. In addition, some of the respondents also requested that the private sector should contribute with accessible and affordable products and services.

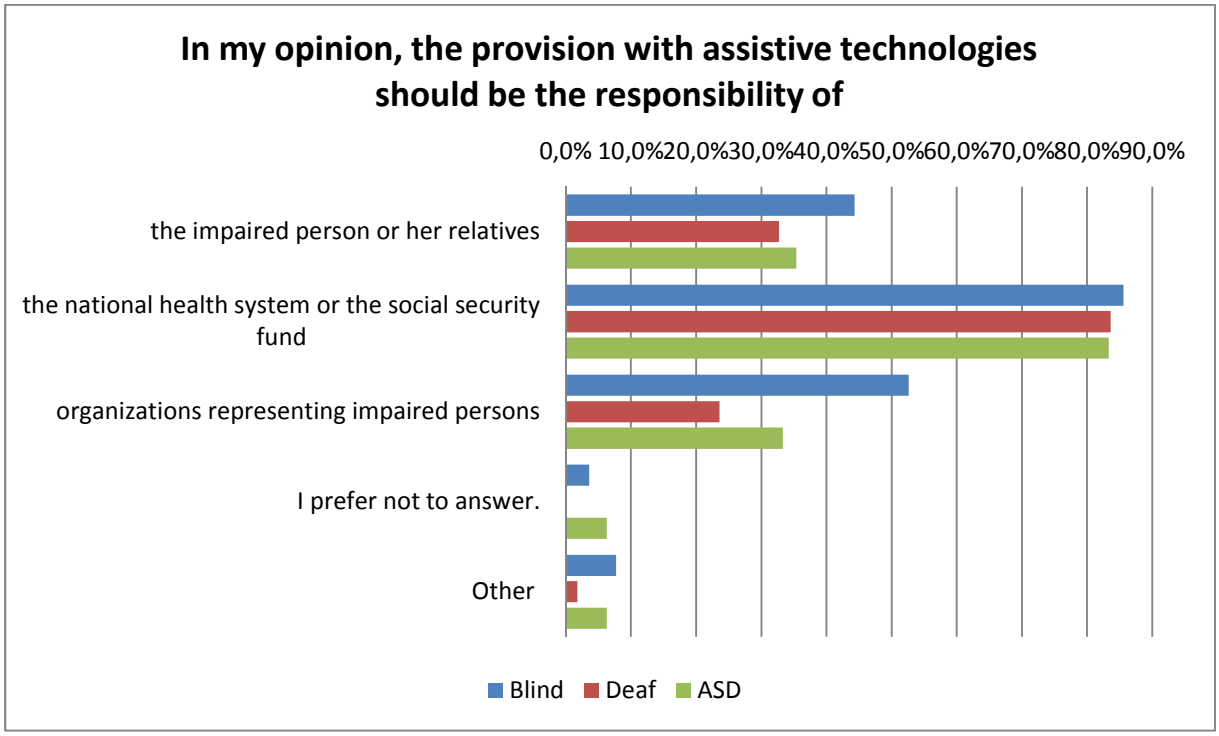
Notable results for the three groups:

Respondents had the option to indicate which entities should be responsible for providing ATs. Most stated that the national health system or social security funds should have the main responsibility. A smaller subset of these advocated that other entities (organisations representing impaired persons, the impaired person themselves, or their relatives) should also hold some share of this responsibility. The following statements given by respondents underline this view:

> *"Persons with a disability has not earned his/hers disability. Therefore the responsibility should be at the nation. No person should be responsible to pay for assistive technology to be able to live as a person without a disability." (Respondent from Sweden)*

> *"Funding should come through the national health system or the social security fund, impaired person should have a say in what products they want to use." (Respondent from Germany)*

Figure 16: Responsibility for the provision of assistive technologies



4.7. Requirements of ATs

Blind and visually impaired respondents:

The most important requirements of an AT for blind and visually impaired persons are accessibility, price, easy to use, flexible, multi-functional, customisation, simplicity, security, comfort and autonomy.

Deaf and hard of hearing respondents:

The requirements of the deaf and hearing impaired respondents are similar to those of blind and visual impaired respondents but also present some additional requirements. Devices should be easy to use, accessible and affordable for everyone, they should be mobile, handy and reliable. Standardisation was also mentioned as an important requirement because currently different standards seem to proliferate, which is not constructive in the sense of inclusiveness. Another important requirement is that ATs should aim to increase the independence of the person who uses it. One respondent also mentioned that the development of ATs should be done in close cooperation with the affected people: *AT developed based on user experience and include them in product development - like "nothing about us without us".*

Respondents with autistic spectrum disorder (ASD):

Main general requirements stated by the respondents encompass easiness to use, flexibility, adjustability to own needs, mobility and reliability. Apart from supporting communication, gaining independence is a frequently raised request. Independence also includes the ability to learn and study or to participate in the labour market. Responses range from very concrete need of assistance for specific activities to doubts or missing information on how ATs could be applied to ASD at all.

Notable results for the three groups:

The requirements across all three groups are similar. In total almost 150 responses were received on this question. The single most important aspect was ease of use, mentioned in almost 50 of the responses, followed by flexibility and adaptability needs with about 25 mentions and costs respectively affordability with about 20 entries. The technology level was regarded as less important with about 10 answers indicating high-tech solutions. In the same range were requests for technologies that can be used in the discreet or unnoticeable way and for accessibility being integrated by design into mainstream products or services. There was no clear preference concerning whether the assistive technology should mitigate an impairment or provide compensation. From blind and visually impaired participants the translation of visual information into voice was a bit more frequently mentioned than improving vision directly (nine versus six entries), whereas for deaf and hard of hearing respondents both features, improving hearing capacity or translating speech into text or sign language were equally often mentioned.

In general, the results imply that the range of requirements is mostly independent from the disability. A general framework of requirements that is flexible enough to take into account specific needs and based on the strong involvement of impaired persons is desired.

4.8. New technologies and promises of future ATs

The following section presents the results on questions regarding which potential future technologies could be of relevance for the respondents. For each of the three groups we proposed different ATs. These technologies are currently in development or at an early stage of market introduction. Besides the proposed technologies, the respondents had also the opportunity to name technologies per se or areas in their everyday life, where additional technologies could help them.

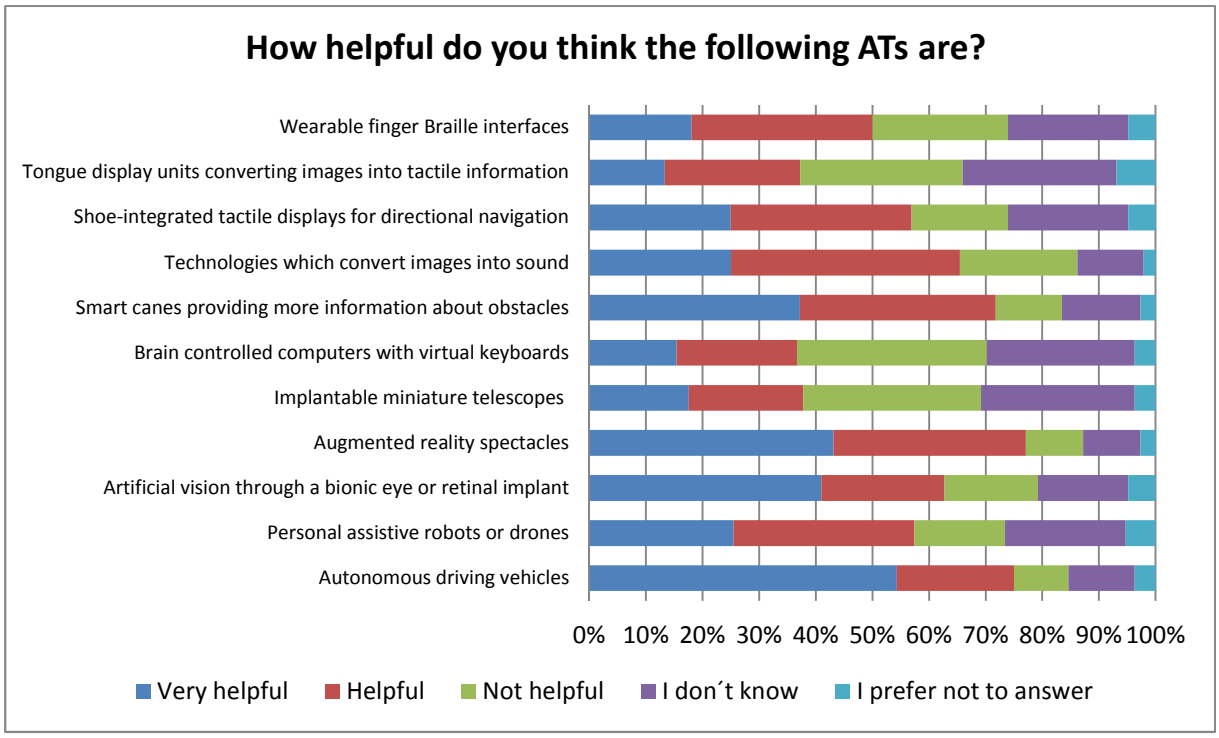
Blind and visually impaired respondents:

Although nearly all of the blind respondents are already using ATs, roughly 60% can imagine additional ATs for their personal support. This indicates that there is still a demand for additional ATs. The result of the open question concerning such additional technologies is as follows: the respondents express a strong demand for technologies which provide access in general or which have their focus on mobility or transport. This includes navigation (reading maps), orientation but also reading technologies or simply talking household appliances like washing machines and air conditioning. The main function these technologies should serve for is the ability to live more independently and to have better access to information. Other technologies include devices for swimming, housekeeping in general (cooking), shopping, television (keeping informed about society), medical devices (blood pressure, pregnancy test), access to LCD and touchscreen displays, personal safety while moving in unknown areas or solutions for better orientation and mobility indoors.

In the questionnaire we proposed 11 different ATs which are currently developed and may have an impact on the life of impaired persons (like autonomous driving vehicles providing mobility and independence). The respondents call for technologies, which improve mobility and independence. Therefore it is not surprising that more than 70% of the respondents state that autonomous driving vehicles would be helpful for them. Also navigational devices (such as shoe integrated tactile displays for navigation) are rated highly. This result confirms the respondents demand for technologies, which increase mobility and therefore also the independence of the individuals. Technologies which aim to restore the function of seeing (retinal implants, augmented reality glasses) or technologies which are already used (like canes) but newly developed (such as smart canes) are estimated as promising technologies for the future. A smart cane – an advanced version of the white cane – is a helpful AT for more than 70% of the respondents. Assistive robots and drones are also estimated to be helpful in everyday life (by more than 50%). Technologies which convert images to sound are regarded as

helpful for more than 65% of the respondents. In summary, we may conclude that augmented reality spectacles with multiple functions (magnification, audio feedback) yield higher rates than the restoration of the vision sense itself. Furthermore devices which substitute vision (image to sound) or devices which can be seen as advancements of already existing ATs were also rated higher as technologies which restore the sense of vision.

Figure 17: Future assistive technologies for blind and visually impaired persons



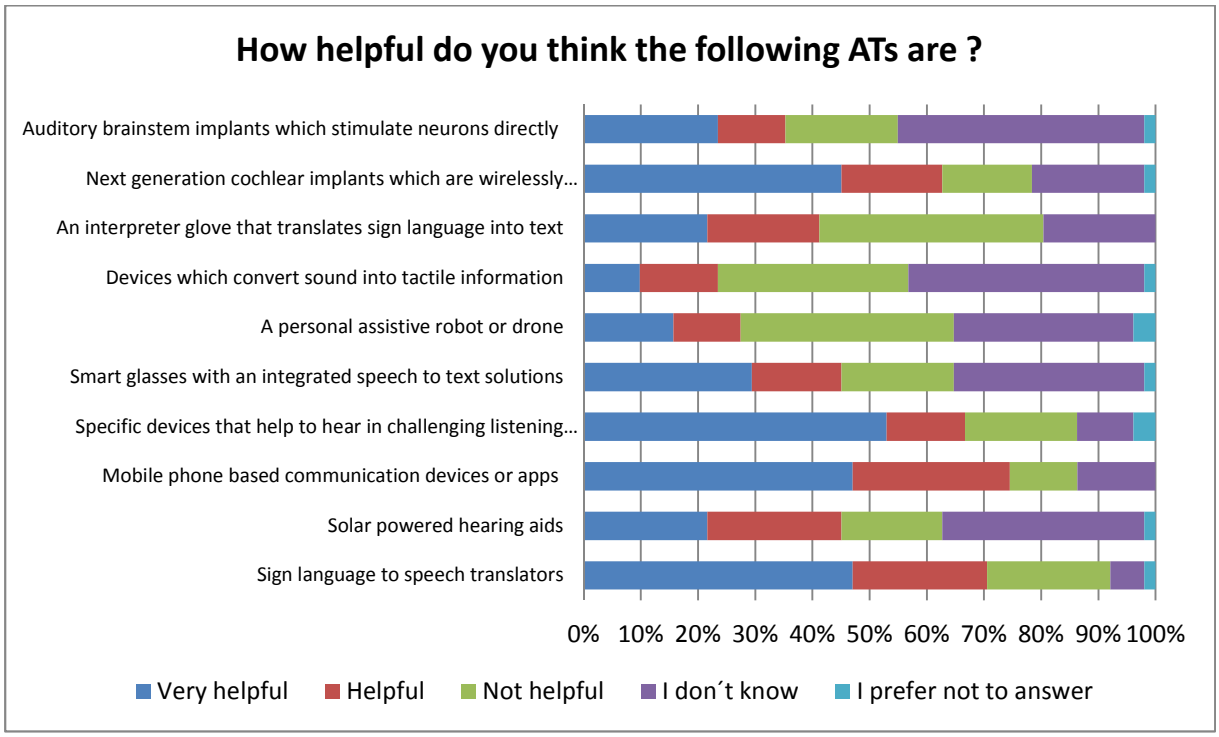
Deaf and hard of hearing respondents:

Nearly 70% of the respondents can imagine additional ATs which could help them in their everyday life. Suggestions for such technologies are devices that recognize sign language, smart glasses which produce visual information based on audio information, different sound substitution technologies (like vibrating alarms) or new generation hearing aids. In general, technologies for communication and access to information are of high importance.

In the questionnaire we proposed ten different ATs, which are currently developed and may have an impact on the life of impaired persons (like sign language to speech translators providing the ability for better communication). About 70 % of the respondents state that ATs which translate sign language to speech and vice versa would be a helpful technology to them (sum of values helpful and very helpful). Also mobile phone based translation apps are rated to be very helpful for the deaf and hearing impaired persons. This may be due to the fact that they already use mobile phones and therefore they can estimate the benefits of this technology better. About 45% of the respondents regard a solar powered hearing aid as a helpful AT. Challenging listening situations are still a problem for current hearing aids. About two thirds of the respondents therefore think that specific devices designed for such situations would be a helpful device. Personal assistive drones or robots seem not to be as relevant as they are for visually impaired people. Smart glasses, which provide a translation from speech to text, are estimated by nearly 50% of the respondents to be helpful. An ambivalent result is revealed concerning an interpreter glove which converts sign language into text. 40% say that it would be helpful and 40% say that it would not be helpful at all. Next generation technologies (i.e. cochlear implants with better sound processors) are estimated to helpful by almost 65% of the respondents. This technology is familiar to some of the respondents as some of them use it

already. Technologies which are abstract (i.e. where no previous experiences exist) are difficult to evaluate for the respondents. Examples for this are sound to tactile devices or auditory brainstem implants (high rate of "don´t know" answers).

Figure 18: Future assistive technologies for deaf and hearing impaired persons



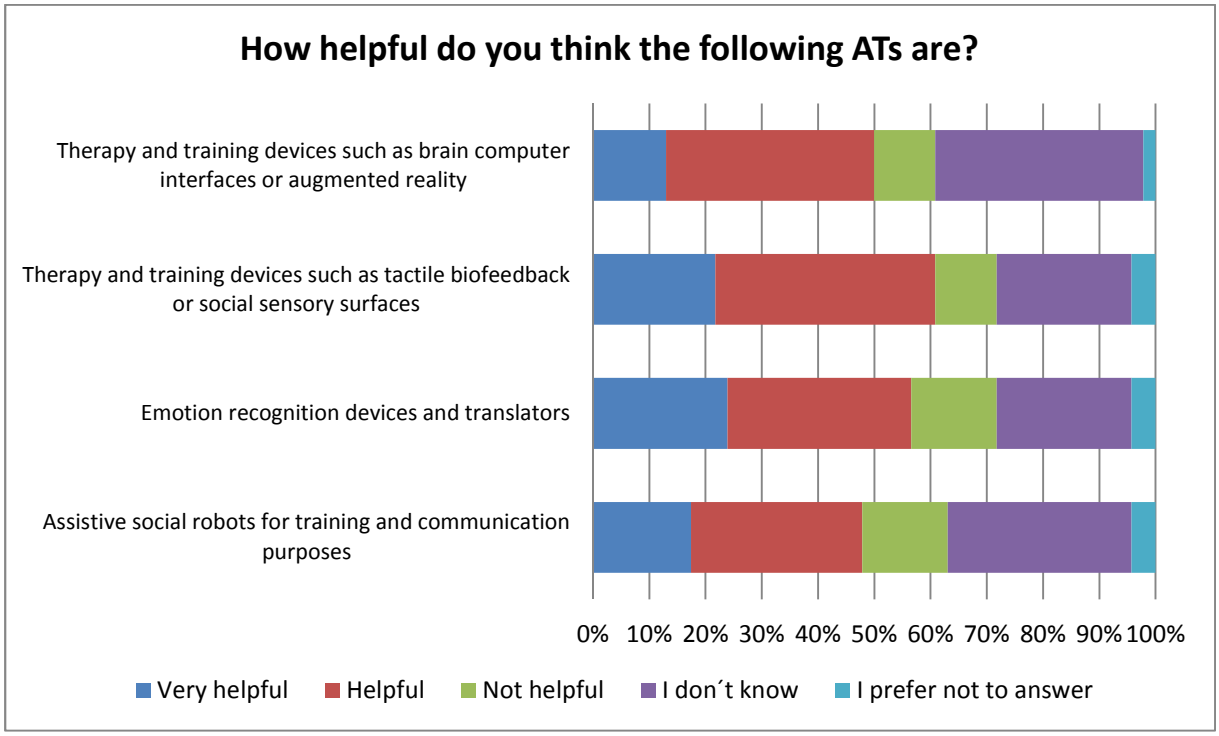
Respondents with autism spectrum disorder (ASD):

Only about 45% of the respondents with ASD can imagine additional ATs which could help them in their everyday life. The same amount of respondents cannot imagine additional ATs. Suggestions for technologies were primary for communication purposes or for situations in which social interactions are obligatory (job applications, understanding different social settings).

For none of the four investigated future technologies (assistive social robots for training and communication purposes, emotion recognition devices and translators, therapy and training devices such as tactile biofeedback or social sensory surfaces, therapy and training devices such as brain computer interfaces or augmented reality) the category "very helpful" was selected most frequently. For the two ATs with the most distant relation to currently applied technologies, social robots and brain computer interfaces, the category "I don't know" is the most often provided answer. For emotion recognition devices and for therapy and training devices the answer option "helpful" dominates (values below 40%). A considerable number of participants (between 10 and 15%) regard none of the presented ATs as helpful.

These results, however, do not necessarily imply that assistive technologies are per se less useful or relevant for autistic people. It is plausible that these lower rates are also a consequence of the much more diverse forms of impairments prevalent within ASD, requiring a corresponding diverse set of assistive technologies. In comparison, the core aims of the two other investigated impairments are much clearer and focused. Another reason could also be the possibly short history in the development of ATs for ASD in comparison to the other two groups.

Figure 19: Future assistive technologies for ASD



Notable results for the three groups:

A tendency can be identified concerning ATs for visually and hearing impaired persons. Technologies, which in some sense are already familiar (canes, cars, cochlear implants, mobile phone apps etc.) are rated to be more helpful than devices where no specific experiences exist or put in other words technologies which are abstract (i.e. where no previous personal experiences exist) are difficult to evaluate for the respondents

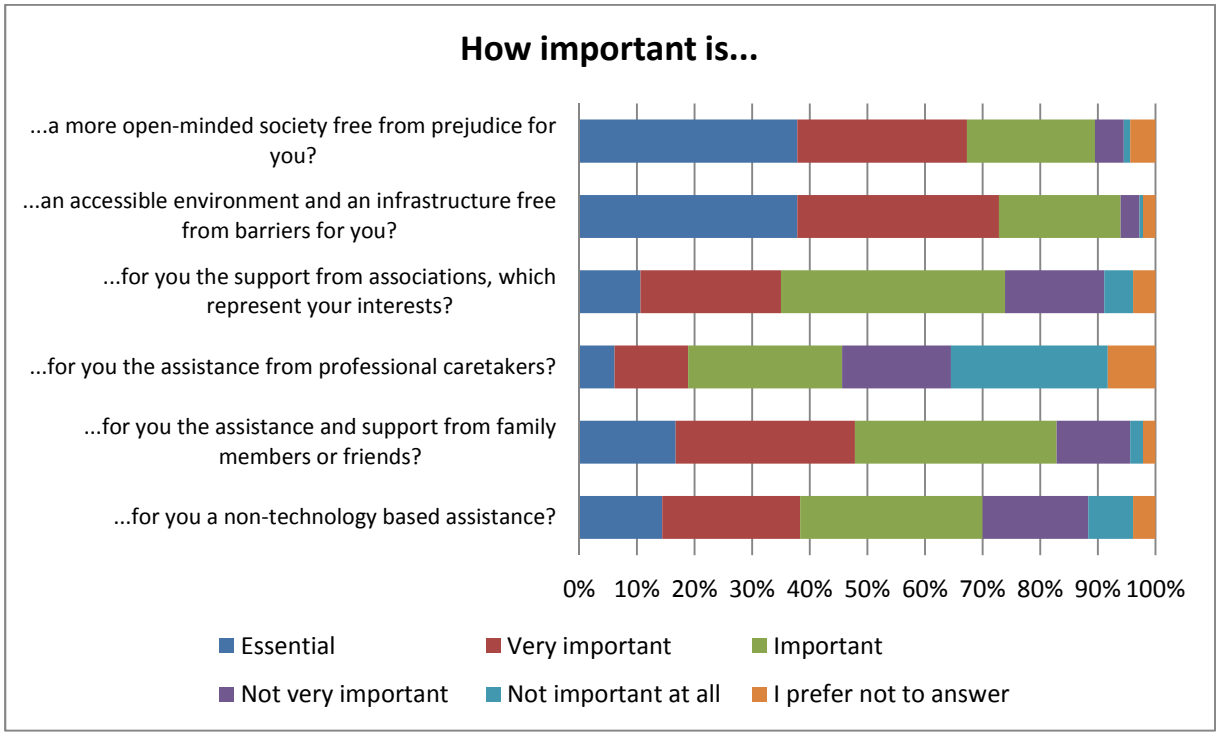
For respondents with ASD the result is more homogenous than for visually and hearing impaired persons. All four technologies which were proposed are nearly equally evaluated. All four technologies are estimated to be helpful (sum of very helpful and helpful) by around 50% to 60% of.

4.9. The role of non-technical factors

Blind and visually impaired respondents:

About 40% of the respondents also benefit from non-technical assistance (e.g. personal assistant, guide dog or assistance by family members). Assistance, which is not based on any technology, is seen as important by nearly 70% of the respondents. This includes especially assistance by family members and less the assistance by caregivers. Associations for visually impaired and blind persons have an important supportive role for the respondents (more than 70%). A clear position can also be identified concerning an accessible environment and an infrastructure free from barriers. More than 90% of the respondents estimate that these factors will be important in the future. Similar results are achieved concerning an open-minded society. An open-minded society is important for about 90% of the respondents.

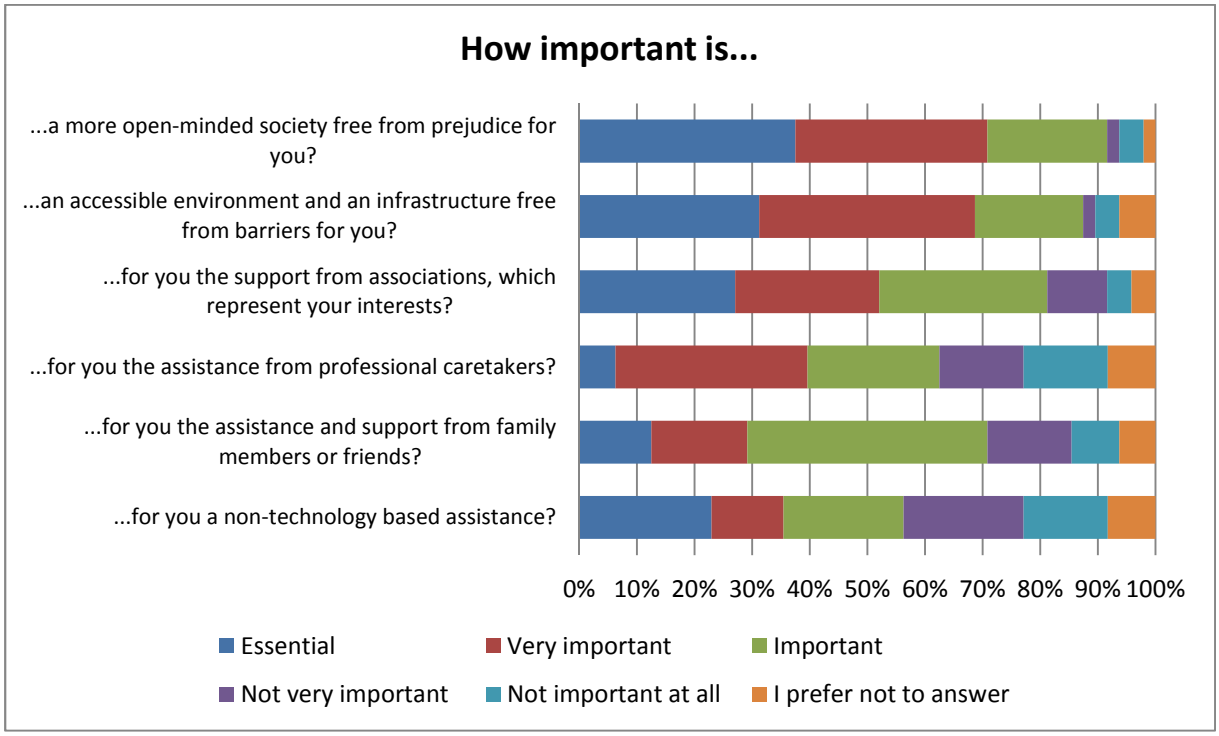
Figure 20: Importance of non-technical factors for blind and visually impaired persons



Deaf and hard of hearing respondents:

Non-technical assistance is important for more than 55% of the respondents. Family members play a central role in this context. In addition, professional care plays an important role for the majority of the respondents. Associations for hearing impaired and deaf people also play a decisive role. Non-technical assistance are sign language interpreters or special educated dogs giving signs when the doorbell rings. Similar to the results for blind people, an accessible environment and an infrastructure free from barriers are premises to guarantee inclusiveness for disabled people. Again, a society free from prejudices is estimated to be of central importance.

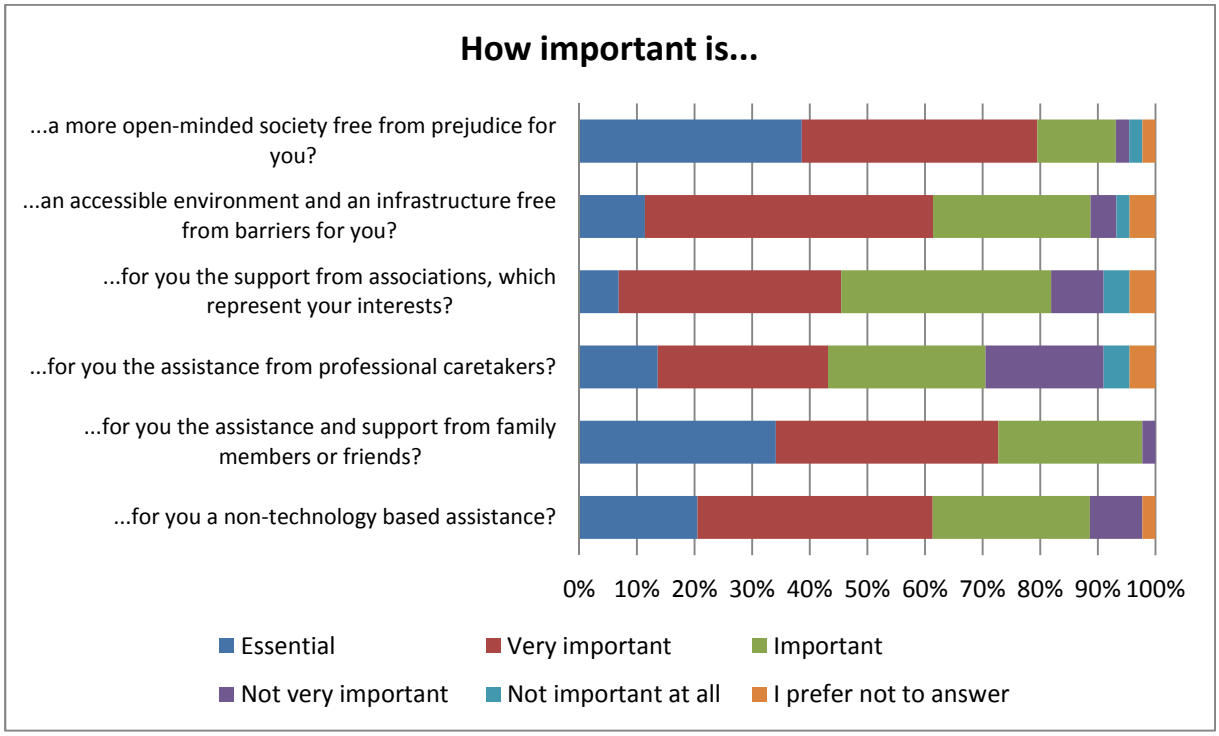
Figure 21: Importance of non-technical factors for deaf and hearing impaired persons



Respondents with autism spectrum disorder (ASD):

Only 40% of the responding participants report to have or to use non-technical assistance. In contrast to this low rate, about 60% regard non-technology-based assistance as essential or very important, if the category "important" is included, the figure increases to about 88%. About 73% of the respondents regard assistance and support from family members or friends as essential or very important; the same figure amounts to about 43% for assistance from professional caretakers or from associations representing people with ASD. The striking gap between reported use and attributed importance of non-technical assistance provides strong indication for an undersupply of personal assistance. For respondents with ASD the openness of the "mental infrastructure" is more important than the accessibility of the physical environment. About 40% each regard an open-minded society as essential or very important, compared to a value of 11% for essential and 50% for very important in the case of accessible infrastructures.

Figure 22: Importance of non-technical factors for persons with ASD



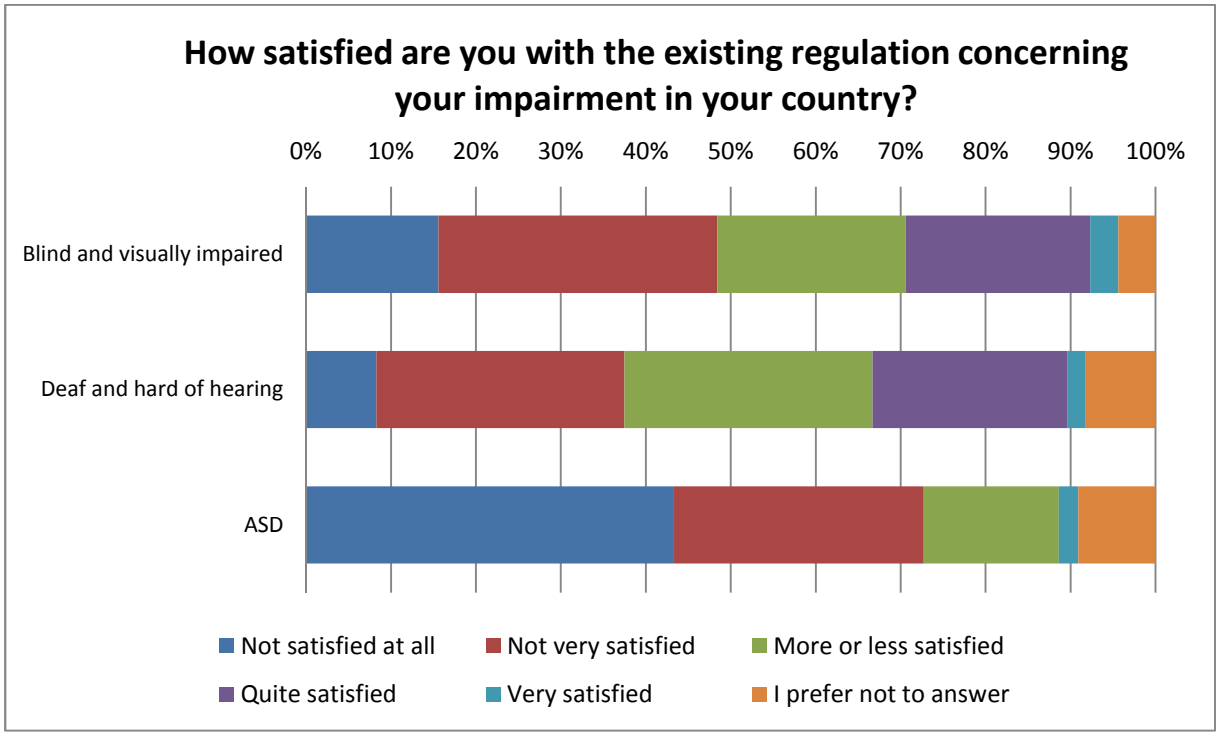
Notable results for the three groups:

Although technology plays a very important role (for hard of hearing, and visually impaired persons more than for respondents with ASD, see Figure 3), non-technology based assistance seems also to have an important role for the respondents in the sample. This seems to be especially true for respondents with ASD. Nearly 90% of them indicate that non-technical factors are important (i.e. the sum of responses essential, very important and important). The group of visually impaired respondents also attribute relatively high rates of importance to non-technical assistance, although less pronounced than compared to the ASD-group. For 70% of them non-technology based assistance is important (i.e. the sum of responses essential, very important and important). For the deaf respondents in our sample the figure is with slightly over 55% the lowest. It is also interesting that the importance of assistance by family members and friends is much higher for people with ASD (almost 100%) compared to blind and visually impaired (80%) and deaf and hearing impaired (70%) respondents.

4.10. Regulation

In this section the satisfaction and opinion concerning national regulation is presented. Furthermore the respondents had the opportunity to give feedback, which aspects of regulation they are satisfied with and with which they are not satisfied with. The latter aspect is presented with quotes from the respondents.

Figure 23: Satisfaction with national regulations among the three disabilities



Blind and visually impaired respondents:

The respondents see a clear potential for a better regulatory framework concerning their impairment. Only 3% of the respondents are very satisfied with the current regulatory situation, whereas nearly 50% of the respondents are not very satisfied (32%) or even not satisfied at all (15%). The answers to the question which aspect of regulation in their country the respondents are either satisfied with or not satisfied with, are quite diversified. This result is not surprising as the different countries have different forms of implementations and executions of disability laws. In general, the negative responses prevail over the positive ones. The result was a heterogeneous landscape of answers. It was positively noted that companies are "*forced to take handicapped employees*" (respondent from the Netherlands). At the same time, when addressing employment issues, respondents stated in several comments that it is extremely difficult for them to find a job and get employed like stated by a respondent from Sweden "*…I seem to be unable to get an employment, in spite of high education…*". A respondent from Italy stated that "*…over 70% of working age blind people are unemployed, and many of these are not in education either…*".

Another aspect which was mentioned several times was the financial assistance or the provision with ATs. A respondent from Ireland stated positively he receives "*VAT return on IT items purchased to aid general accessibility*". A respondent from Italy is not very satisfied with "*…regulation … related to the provision of assistive technology which are often very expensive and people cannot afford them.*" The results seem to indicate a high diversity on financial assistance or provision with ATs, depending on the country of residence. A respondent from United Kingdom has negatively remarked that "*Products are not currently required to be accessible because EU law prevents accessibility from being stipulated*". Looking at this comment in the context of the main requirements of ATs, namely being products and service being accessible underpins this critique.

Further comments from The Netherlands and Italy were addressing the build environment and public transport, with which they are not currently satisfied.

Deaf and hard of hearing respondents:

Concerning regulations, more than 50% of the respondents are at least more or less satisfied with the current situation in their country (sum of more or less satisfied 29%, quite satisfied 23% and very satisfied 2%). Nevertheless, more than a third of the respondents see a potential for improvements (not very satisfied or not satisfied at all). When replying to the question which aspect of regulation in their country the respondents are either satisfied with or not satisfied with the results are similar to the blind and visually impaired respondents. The positive aspects which were mentioned concern the financial assistance for e.g. sign language courses, ATs, cochlear implants (CI) or the possibility to attend special sign language courses or deaf schools for children. A respondent from Switzerland stated positively that the *"Social security pays for education, for sign language interpreters (limited volume), for many assistive equipment"*. A respondent from Slovenia stated that *"…we have a right to operation of CI covered in our healthcare, if we do have both basic and advanced health insurance paid and are candidates for CI."*

On the other hand, respondents remarked that the areas of education and of employment are still problematic. For example: One respondent from Sweden said that he has difficulties *"…finding employment because the employer must pay the interpreter costs (costs that the community paid earlier)"*. A respondent from Portugal mentioned that *"…although we have many good laws, they are not enforced in practice…"*Other problematic aspects which were mentioned addressed information retrieval (e.g. no sign language interpreter for government communication in television, or insufficient amount of subtitled TV shows.). Concerning ATs one respondent mentioned that a long waiting list exists for getting a hearing aid.

Here an example of a very comprehensive comment, describing in detail the problems with which the respondent is confronted and including requests for improvements of regulations:

> *"Personally, employment part of the regulations. Even when we are hearing disabled and thus counted under invalids, we don't get monetary recompense for suffering the disability. Because employers don't take hearing-impaired job seekers into consideration seriously most of the time, and we are still expected to pay for the basic health care out of our own pockets, we struggle with payments after our funds run out. We can, of course, ask for the monetary help from the services, but as we are indebting ourselves that way, it's not really preferable option. However, having a health insurance is a must, and thus we are forced to rely on external sources to pay for it. Additionally, there is no law for the prospective employers NOT to ignore the hearing-impaired candidates when they candidate for the job post. As a graduate myself, I experienced that personally. Very rarely I got an answer back that I am not a viable candidate for the position, despite my qualifications. It's not really good to mention that I am hearing impaired in my CV or through the talk over the phone when I am contacting the prospective employer. Also, when we are students, we are not entitled to getting the hearing devices like SCOLA system through the national health services like we used to when we were in primary, secondary and high school. Which is a shame, because in university, listening is crucial to gather the information at the lessons. Additionally, if we want to have such a system, we have to pay it out of our own pockets, and they are quite pricey. We can, of course, request for an one-time monetary help from the appropriate national institutions, but very few of us actually knows that information, because doctors don't pass it to us - either they don't know or they knowingly clamp down on it. In each case, we are being proverbially shot in our foot, so to speak. In conclusion, the regulations are in some aspects good, but they are not perfect, and it's taking time to change it according to the trouble I've described herein. If there would be Europe-wide law on the issue that would cover those troublesome areas to the benefit of hearing-impaired and deaf people, I believe it would be warmly received." (Respondent from Slovenia)*

Respondents with autism spectrum disorder (ASD):

The autistic persons, who participated in the survey, are much less satisfied with existing regulations in comparison to visually or hearing impaired respondents. About three quarters are not at all or not very satisfied, only one out of six is more or less satisfied. Essentially none of the respondents are quite or very satisfied, whereas the corresponding rates are around 25% for the respondents of the two other impairments.

When asked about positive aspects of regulations in their own country most responses referred to education or to support from the health or social system in general. However, even for this question about 50% of the answers are negative like "*I thought about it deeply and none.*"

Concerning negative aspects of regulation and suggestions for improving the situation in the following main issues are raised:

- Access to assistance or services. Specific problems mentioned are long waiting times, financing depending on available funds instead of on existing needs
- Access to the labour market, which requires flexibility, understanding and the provision of (personal) assistance if needed.
- Lack of adapted services or of specifically trained assistants.
- Creating awareness about neurodiversity to reduce stigmatisation and social exclusion.

Additional comments addressed the lack of information about existing regulations, wishes for more therapy or financial support. Some comments also express hopelessness and desperation in view of the economic and financial crisis or of stricter regulations with regard to access to social support. Several request address the wish to be included in the development of regulations as it is expressed in the following example of a respondent from Estonia describes:

> *"They would need to start listening to us, not to make decisions on their own. The only experts on their everyday needs are the disabled people themselves, not some government officials who have usually not even seen a person with invisible disability, less know how to meet their needs."*

Notable results for the three groups:

Among all three groups there are the similarities concerning the legislative aspects the respondents are not satisfied with. Access seems to be one common denominator for most of the respondents. First of all, the access to employment and education, secondly the access to help or assistance, be it technical-based or non-technical based and thirdly the access to financial support. Comparing the results of the three groups, the respondents with ASD are least satisfied with the current regulatory situation in their country. This may be due to the quite young history[20] of ASD, possibly having a negative effect on the representation of the interests of people with ASD in legislative processes.

4.11. Conclusions: Needs and perceptions of ATs by people with disabilities

The EU-wide online questionnaire survey on assistive technologies (ATs) for people with a disability (visual impairment, hearing impairment, or autism spectrum disorder (ASD)) reported here reveals valuable information for technology options and policy-making that can improve the inclusion of disabled people in society

Disabled people are confronted with specific barriers in their everyday life and in fulfilling basic needs. For blind and visually impaired respondents, physical and transportation barriers are much more relevant than for individuals with the other two types of disability. For people who are deaf and hard of hearing, and for people with an ASD condition, communication, information, and social

[20] http://www.autismuk.com/home-page/history-of-autism/ (Accessed: 12.10.2016).

barriers are particularly important. Attitudinal and policy barriers are relatively equally important for all three groups of impaired persons. ATs serve as important, but not as exclusive means to eliminate or mitigate these barriers. The dependence on the support of ATs to fulfil basic needs or to overcome certain barriers is highest for blind and visually impaired persons; followed by deaf and hard of hearing people and respondents with ASD. In general, the use of these technologies is indispensable for a majority of current AT-users. Most of the respondents perceive themselves in a positive way when using ATs.

In contrast to these observations, the results on increased visibility of the impairment due to the use of ATs are less clear. The majority of respondents stated that ATs either should not make the disability of a person visible or have a neutral stance towards this aspect of ATs. The large number of neutral responses concerning the visibility indicates that people are unsure about this relationship, indicating that the fear of discrimination may play an important role.

Although ATs play an important or essential role for many disabled people, other groups do not use technologies due to different reasons. The main reason for blind and visually impaired people not to use ATs is that they obtain support by another person. For deaf and hard of hearing persons, the main reason for not using ATs is that the products do not meet their needs or are not functioning well (for example, the spoken language that is heard with the help of hearing aids or cochlear implants is not sufficiently clear). For respondents with ASD, a lack of information about ATs is the main reason for not using them. For all three groups of individuals, an important barrier to AT use is their high cost. Assistance from family members and friends is important for all respondents. When comparing the results across the three groups, persons with ASD place higher importance on support from family and friends than respondents who are visually or hearing impaired.

All three groups of respondents had very clear and similar expectations about the requirements that ATs should fulfil. These generic demands are ease of use, flexibility, adaptability and affordability. Respondents were also asked to rate present and future technologies in relation to one another. In terms of the usefulness of currently emerging and future assistive technologies, visually and hearing impaired persons rate technical advancements of already existing technologies such as canes, cars, cochlear implants and mobile phone apps more highly than technical advancements expected from emerging technologies. For respondents with ASD, virtually all proposed future technologies are rated equally; in contrast to visually and hearing impaired people they make no difference between existing and future technologies.

The results concerning satisfaction with the current regulatory situation were highly heterogeneous across respondents and groups, possibly due to the different regulatory circumstances in each country. Some respondents are quite satisfied, but in total, dissatisfaction prevails over positive responses. Many respondents noted discrepancies between existing disability laws and their lack of implementation and enforcement. The main areas causing dissatisfaction are access to employment and education, financial support (e.g. for ATs) and help and assistance for the disabled person and for their family. In this context, concerns were raised about the impact of the persisting economic crisis and austerity policies, reducing employment opportunities and financial support for disabled people at the same time.

5. Set of expert interviews I: Needs and perceptions on ATs

The first qualitative study focuses on the understanding of ATs as well as the role ATs can play in different societal fields such as independent living, education and employment. Moreover, the experts identified needs, challenges and barriers for the present and future use of ATs.

5.1. Key results

The key results of the study are presented below. These comprise the contested definition of ATs, needs of persons with disabilities in the fields of independent living, education and employment, as well as perceived challenges in research and innovation of ATs. Moreover, the needs for improved access, acceptance and awareness of ATs are highlighted.

Definition of ATs

- There is no common agreement on the definition of ATs, as they are perceived differently, even within disabilities groups.
- Two types of definitions may be distinguished: the first definition relates to a more formal approach where the term refers to specific devices for people with disabilities only. The second focus is broader and includes mainstream technologies in the understanding of ATs.
- It was highlighted that the common meaning and understanding of "disability" should be challenged. Often the environment plays a role in disabling a person, rather than it being an individual malfunction.

Societal fields

- *Independent living*: In order to be able to live an independent life, the identified needs and perceptions for ATs vary according to the type of disability. In the case of visual impairments, this mainly concerns the lack of universal design in everyday technologies where touchscreens are used. In the case of ASD, ATs are required to support personal communication and social interaction. Further developments are also needed to make Internet applications fully accessible for people with all three kinds of disabilities.
- *Education:* ATs play an important role, especially in overcoming existing barriers at an individual level, to be fully included in regular school education. In the case of visual impairments, access to web platforms gave a strong boost to learning opportunities.
- *Employment:* There is general agreement that ATs are very important in the workplace. However, and particularly in the workplace, there is a strong need for a better integration of people with disabilities and connected with that for the use of and access to specialised devices. All three different types of disabilities have specific needs for ATs in the workplace. In the case of visual impairments, access to IT applications is reported as crucial. In the case of hearing impairments, web-based sign language interpretation is regarded as a supportive tool. For ASD, augmented reality applications are highlighted to support people with ASD to train for real-life situations in the workplace.

Research and innovation of ATs

- It is proposed that the needs of disabled people be integrated in the technology development process. In addition, the participation of people with disabilities in the design process is recommended.
- According to the experts, the goal of universal design anchored in the UNCPRD still needs a stronger implementation into development processes of mainstream technologies.
- The experts identified several relevant future technologies. In the case of visual impairment, the field of mobility (autonomous cars) is put forward. In addition, advancements in IT, especially facial

recognition, are regarded as supportive in the case of visual impairments as well as ASD. Although BCI has still been at an emerging stage for many years, it is regarded as a promising future AT.

- In general, a very positive attitude towards new and emerging technologies prevails. It is expected that people with disabilities will benefit from the use and the access to such technologies in the future.

Challenges

- *Accessibility:* Experts agree that, despite political agreements on its high relevance, on a practical level, accessibility still needs to be improved, especially in terms of infrastructure, both material and virtual. In addition, costs associated with ATs are highlighted as one major barrier to the equal access to devices, in the end leading to social inequality. It is emphasised that costs not only include the price of a device but also costs for services and training needs associated with the technology – an aspect often overlooked.
- *Acceptance and awareness:* Specific devices usually associated with disability often lead to feelings of stigmatisation by the users. In order to overcome such stigmatisation by ATs, defining and understanding ATs as a mainstream product – rather than a specific device – can be regarded as a strategy. Labelling ATs as mainstream products promises to raise the perceived "value" of ATs, which consequently can lead to a higher level of acceptance. In order to increase awareness and acceptance of ATs the user's age needs to be taken into account. On the one hand, users getting their disability at old age often face serious barriers towards ATs. On the other hand, for children (and parents) ATs often have a high acceptance level as they are considered to be an important support for the disabled child in order to participate in society, especially education, in as 'normal' a manner as possible.

In the following sections, the study findings on "needs and perceptions on ATs" are presented in detail.

5.2. Definition of ATs

At first sight, one could assume that there is a unified understanding within the community of persons with disabilities when it comes to the understanding and perception of ATs. ATs might be simply perceived as "*just products that help them to do things that otherwise they would not do*" (Torena-Cristóbal, ILUNION, 44)[21]. However, within the several communities in the field of disability there is no such uniform perception of ATs. The group of people with disabilities is represented by a broad variety of subgroups having different needs, different perceptions and different interests, since "*the only thing that is common among people with disabilities is the fact that they have the disability, for the rest they are of course the same diversity as all the people*" (Simons, EBU, 42). This diversity is also prevalent in the case of ATs: "*also in people with disabilities you find technologies haters, like you find in general society*" (Simons, EBU, 42).

Such a diversity of perspectives is also prevalent when it comes to the definition of what exactly an AT is, which at first glance seems to be simply a question of proper definition. However it is "*a very hard question because there is a lot of discussion about it*" (Torena-Cristóbal, ILUNION, 16).

The experts interviewed expressed several views on this question. One view which is oriented in existing definitions and is thus based on a formal and legal approach, understands the meaning of AT in line with the classification of ATs as defined in ISO 9999:2011[22] (Torena-Cristóbal, ILUNION, 16). In

[21] Direct quotes from the experts interviewed are given. The numbers refer to the paragraphs of the interview transcripts.

[22] ISO 9999:2011 establishes a classification of assistive products, especially produced or generally available, for persons with disability (further information: http://www.iso.org/iso/catalogue_detail.htm?csnumber=50982, (Accessed 07.10.2016)

this sense, an AT is a technology used only by persons with a disability. If the technology is a mainstream technology or is used by everyone, then it should not be designated as an "AT". This means in turn that the application SIRI in Apple devices or ramps for physical accessibility are seen as examples of mainstream technology that should not classified as ATs (Torena-Cristóbal, ILUNION, 52).

An alternative perception of 'what an AT is' takes the environment in which ATs are used into consideration. Here the understanding of ATs is much broader and does not exclude mainstream devices. An AT in this definition can "*help people with their disabilities to overcome their impairments, from our society and interaction with society*" (Cirrincione, Autism-Europe, 16). In other words, ATs are perceived as an "*interface*" (such as a piece of hardware or a software) (Simons, EBU, 14) or an "*add-on*", used to "*improve the personal capability in a given environment and task*" (Raike, EUD, 17). So even if a given "*environment is disabling*" (Raike, EUD, 48), a person may, with the help of ATs, improve their access to that environment.

In the interviews it is argued that there should be a relational view on the understanding of disabilities as such. So what is regarded as "normal" and what is perceived as "exceptional", in our case as "disabled", is a matter of understanding and societal agreement and not a bodily factor. For this reason, one understanding of "disability" is that "*people with disabilities have disabilities because of the environment*" (Torena-Cristóbal, ILUNION, 34). Thus, it is also important to reflect which conditions are needed to feel "normal" and fully included in society. Here ATs have the potential to play a role for persons with disabilities, as they can be an important support to "*close the gap between a declaration of the Human Rights and enjoying Human Rights in real life*." (Zelderloo, EASPD, 35).

5.3. Needs associated with and perceptions of ATs in societal fields

In general, the participation and inclusion of people with disabilities in society depends mainly on their inclusion in three main societal fields: independent living, education and working life. It is generally assumed, e.g. prominently by the WHO, that this participation can be attained by means of technology or assistive products. In the words of the WHO: assistive products enable people to "live healthy, productive, independent and dignified lives" in order to "participate in education, the labour market and civic life" (WHO 2016b, 1).

Feeling independent, and not relying on others to perform tasks on a daily basis as well as to take part in education and employment, is an important criterion for persons with disabilities to feel fully active, able to participate and included in society. ATs are seen as an important support to gain this independence:

> "*Being able to integrate in society, do what you need to do, independently […] and it's what assistive technologies brings us, independence - not having to ask help for specific tasks, to friends or family.*" *(Simons, EBU, 44)*

5.3.1. Independent living

To take part in all kinds of activities on a daily basis and on an equal footing is something that can be understood as leading an "independent life". The interviews showed that different groups of people with disabilities have specific needs with regard to ATs.

In the case of ASD, these needs are mainly in the field of communication. For some persons of the spectrum the expression of language needs to be supported by technologies, for others being socially active is a matter of concern. There are technological solutions, which help the individual to express him- or herself through the means of a technology interface:

> "*So for people without verbal language, assistive technology should help to communicate and to understand the communication. The others, for people like me, I don't have problems with verbal*

language but with social barriers. So technologies should help me to overcome social barriers." (Cirrincione, Autism-Europe, 69)

Thus, for persons with ASD, computer science, augmentative and alternative communication supported by information technology play a vital role. Using such tools verbal communication can be substituted by non-verbal, e.g. by replacing words by symbols, or even translating symbols into voice (Cirrincione, Autism-Europe). For instance, this helps children communicate:

"Computer science is very adapted to people with autism, you can see people with autism without verbal language, intellectual disabilities able to use tablets and smartphones very easily. They are very comfortable with technologies in spite of being intellectually disabled because to touch, to use images, to use symbols... it is adapted to our cognitive style." (Cirrincione, Autism-Europe, 77).

Nevertheless, despite these positive experiences with ATs, people with ASD perceive several barriers in communicating with others on a daily basis. Just as communication is a two-sided process, so the 'others', when communicating with persons with ASD should be aware of such technological solutions and how they could be integrated in social interaction. However, this currently is not the case, as is reported with reference to the example of public services. Here, usually the employees do not have knowledge on how to address a person with ASD or on how to take advantage of technology to communicate with them more easily:

"Because in public services we need to go in a public space, to look for information. It's difficult for us to ask people... and .... so it could be trained staff to help it, would be useful." (Cirrincione, Autism-Europe, 123).

In the case of blind and visually impaired people, it is reported that basic needs in order to take part in daily activities are sometimes not considered in recent technological developments. Although there are different kinds of technologies already available for this group of disability, some of these technologies do not match their needs. An example is a braille display that does not show a full graph or chart due to a limitation in the number of text lines that can be presented. In the future, the development of such braille readers with increased functionalities is considered very helpful (Simons, EBU, 29).

Moreover, it appears that the issue of accessibility currently cannot be taken for granted when it comes to the development of new technologies. One prominent example is the cash machine where, as part of new technological developments, buttons were removed and replaced by a touchscreen display. In this specific case, *"you totally depend on the manufacturer to make it accessible; you cannot install your third party app on the ATM to make it accessible..."* (Simons, EBU, 31). Also new developments of TV sets are excluding visually impaired persons because accessibility features are no longer integrated: *"there are almost no TVs that have speech built in them"* (Simons, EBU, 31).[23] Therefore, there is a strong need by visually impaired persons to keep such kinds of everyday technologies accessible.

Another everyday technology of growing importance is the Internet as it can be used for various activities in daily life like buying groceries, clothes, tickets for events, dinner, etc., while at the same time becoming an important 'place' for social interaction. On a general level, the Internet is given a very important role in the life of persons with disabilities:

"I think people with disabilities are on the cutting edge of technology. The Internet it's maybe even more important for us than it is for people without disabilities." (Simons, EBU, 36).

Connected to this, the question of social integration is also a question of being integrated in virtual worlds today. However, blind persons nowadays cannot use popular social media applications like

[23] Torena-Cristóbal, from ILUNION, reported from an ongoing research project focusing on the development of a mobile phone application that replaces the screen of the cash machine and allows money withdrawal.

Instagram or Facebook since they cannot "see" pictures. However, there are currently developments underway, e.g. Facebook has developed software that can interpret and describe pictures and images:

> *"they developed artificial intelligence software to check what's on the picture and to speak it so again, the things in the beginning you would think it's impossible… at least we are researching how to make it possible." (Simons, EBU, 83).*

Mainstream applications like the use of a navigation system on a smartphone would assist them to "*provide information with regard to accessibility, on accessible parking places, restaurants that have accessible access and so on*" (Zelderloo, EASPD, 15). This is an example of how mainstream technologies can be adapted to the needs of disabled people.

5.3.2. Education

Traditionally, ATs play an important role in the field of education. Currently there are several national attempts to include people with disabilities fully in regular schools. People with disabilities tend to support such a development as this affords them better educational opportunities. However, the support of technologies is seen as essential for this development.

> *"I went to mainstream school, I could study Latin but in the school for the blind they had no Latin teacher, so you would be limited in your options and also in your future career, possibly. Again, this integration is only possible thanks to assistive technologies." (Simon, EBU, 50)*

Having options, being able to choose and not feeling limited are important issues for students with disabilities, which are provided by learning possibilities. At a very practical level, technologies can make an important contribution as the following example shows:

> *"I follow now a language course, and we just have a shared Dropbox folder with the teacher and she puts in her notes or her presentations, 5 minutes before we start and I have it on my computer […] and it hardly costs any extra time or energy from anyone […]. So it helps again integrating in normal education because indeed, before we had assistive technologies we had schools for the blind." (Simon, EBU, 50)*

The use of ATs also boosted the possibilities for disabled people to access e-learning platforms and therefore be able to do on-line courses or to be able to attend a seminar that is taking place in a different country, or even to develop business skills (Zelderloo, EASPD). However, these options look very promising on a theoretical level, while on a practical level quite often 'the devil is in the detail', as there are many aspects which need to be considered to make such electronic platforms for education truly accessible, as the expert form ILUNION explains:

> *"Many parts of the current education are provided through computers […]. They need to have these assistive technologies but the content and the platform have to be accessible. I mean a screen reader does not work in the platform and the content has not been designed following the criteria... so.... you try hard that these devices in the university or in the college make their material and platforms accessible, otherwise they will have a barrier" (Torena-Cristóbal, ILUNION, 50).*

Overall, the access to information improved a lot for people with disabilities as they became able to get onto the Internet. Today, most information is gathered in Internet platforms or even in digital libraries. Compared with traditional libraries, this digital collection of information is seen as a great advantage – if accessible –, at least for people who are visually impaired.

> *"I'm extremely happy with something like the Internet because it's my accessible library, which 20 years ago, if you would have looked up something, I would have had to ask somebody to come with me to a special building with information, now I can do it independently, as long as the websites are accessible." (Simons, EBU, 36).*

In the specific case of ASD and education, where, for instance, children are not always able to use verbal language to communicate, ATs have the function to provide alternative ways of

communication. More specifically, words can be expressed by symbols and therefore a child who does not communicate verbally can use an assistive device to point to a picture or a symbol and thereby overcome communicational barriers (Cirrincione, Autism-Europe, 43).

5.3.3. Employment

In the field of employment ATs are also generally considered to be of very high importance. Technological solutions in the workplace can help people with disabilities overcome existing barriers and to be a productive part of the labour market (Bodine 2013). The expert from the European Association of Service Providers for Persons with Disabilities (EASPD) highlights this potential of AT:

> *"Technology can be very useful in the employment world, where technology can help make the labour market more disability friendly." (Zelderloo, EASPD, 33).*

At the level of the workplace, people with visual impairments need, for instance, to access ICT applications, e.g. a screen reader, or a voice control software (Torena-Cristóbal, ILUNION) to be fully capable of accomplishing their tasks. Persons who are deaf or are have hearing impairments would profit greatly from a "*Sign language interpreter over the net*" (Raike, EUD, 3785) for a rewarding participation in the workplace.

People with ASD again have different needs in the workplace. Here it was demonstrated that augmented reality applications could assist people with ASD to come to terms with social interaction in the workplace. By means of a "computer simulation", these applications can play a role even before these people encounter a real life situation. Such upfront training of critical situations in a social environment is regarded as very helpful:

> *"There is a simulation by a computer to understand the workplace. Like a video game, you can start your day, you go to your office or your laboratory and you say 'Good morning' to your colleagues. You walk to your table, you wait for your boss or you can do your activities and you can simulate your working task. And so you can prepare when you meet your real colleagues in person, because social interaction is really hard." (Cirrincione, Autism-Europe, 71).*

5.4. Needs and perceptions in research and innovation of ATs

According to the WHO, the industrial development of ATs is "currently limited and specialized, primarily serving high-income markets" while lacking "user-centered research and development" as well as a "context-appropriate product design" (WHO 2016b, 4). Thus, "an urgent need to change the way we have traditionally perceived, designed, produced, manufactured, distributed, serviced and financed assistive products or devices" is expressed by the WHO (WHO 2014: 1).

The analysis of the interviews revealed that the experts share this critical WHO assessment of the state of the art.

5.4.1. Participatory development and universal design

Many studies have already pointed out that reasons for the non-use of ATs are often due to the lack of user involvement during the development process of an AT, or even in offering them selective choices reflecting their opinions and preferences when they have to choose between different ATs (Kaye, Yeager, and Reed 2008, Wielandt and Scherer 2004). On this basis the best scenario of a technology development from the perspective of persons with disabilities is to already integrate the needs and the perspective of the affected user group into the design and testing process of a technology, or as Raike points out: *"Bad design of ATs disables, good design of ATs enables!" (Raike, EUD, 71).* Others express the urgent need that the specific requirements of disabled users be integrated into the product, especially before it goes to the market.

> *"While they are developing something and not waiting until it's coming to the market, having to complain as a person with disabilities to the manufacturer 'hey, you forgot me! Hey you have to do something for me!'" (Simons, EBU, 60).*

Technological development of ATs is most effective and successful when all types of stakeholders collaborate: "It is crucial that industry, the authorities, the people themselves and the support providers work together to make sure that technology works person-centered" (Zelderloo, EASPD, 27). Such an approach is not only of relevance for specific AT applications, such an approach is also relevant when it comes to the development of mainstream technologies which should also reflect the special accessibility needs persons with disabilities have. Otherwise the industry might risk producing a technology which in the end does not fulfil its role and has "to go back" and be re-engineered (Simons, EBU, 36). However, one has to keep in mind that it is just not feasible to "mainstream all the assistive features" (Torena-Cristóbal, ILUNION, 40) in new technologies, so even with the attempts to universal design there will be some specific needs of people with disabilities left that have to be addressed in specific assistive devices.

The need for universal design is anchored in the UNCPRD. There is general agreement also at the WHO that a universal design approach is needed in order to ensure that products, environments, services and programs are usable to the greatest extent possible by all people without the need for adaptation or specialized design (WHO 2015). This opinion is echoed by one of the experts:

> *"We need universal design. So if a device is studied and projected for universal design, it should be adapted for every type of person with or without disabilities" (Cirrincione, Autism-Europe, 79).*

Following this principle, when universal design does not exist, people with visual disabilities cannot use certain technologies with new technological features such as touchscreen washing machines or ATMs. The EASPD maintains that developing and bringing accessible mainstream technologies to the market is far more desirable than to develop specific ATs or add-ons for specific disability types because in practice it can be very difficult to integrate a disability-focused add-on to the technology at a later stage.

> *"Before we are going to use assistive technology we have to make sure that the mainstream technology is adjusted in such a way that everybody can enjoy, can use it, can benefit from it. Therefore, we strongly believe in a co-production approach where the industry sits together with organisations of persons with disabilities themselves and then act as go-between with the social services support provided to make sure that things are developed in such a way that nobody is excluded from using this technology. So first of all, the accessibility of mainstream technology is absolutely essential" (Zelderloo, EASPD, 9).*

Also Raike from the European Union of the Deaf (EUD) highlights that there is an increase in value if a technology is not only for people with disabilities but instead is a mainstream technology which can be used by all consumers: "*AT used by all people is not anymore AT, it is only part of the consumer technology, which is good*" (Raike, EUD, 53).

5.4.2. Emerging technologies – wished-for technologies?

When it comes to future technology developments wished for by people with disabilities, several societal fields were mentioned where a crucial role of technologies was identified.

At first, the field of mobility and navigation was regarded as an important topic for the blind and visually impaired persons but also from the perspective of people with ASD. Future emerging technologies should focus strongly in this field as current technological solutions are not precise enough:

> *"I think mobility is still one of the biggest challenges we have. Things like GPS, but it's not accurate enough to move totally independent and when you walk the street there can always be obstacles which are put there by... cars on pavement" (Simons, EBU, 74).*

Simons envisioned a way towards independent mobility for the blind with the use of autonomous cars which still need to be carefully assessed though especially with regard to their security and accessibility:

> *"The autonomous car - it's a dream of course that one day as a blind person you can have your own car and it would drive you where you want. […] I'm not so sure if it will really happen, if we can really trust the thing that it can work even without sighted intervention. I think we are far from this. But it's true that people with disabilities are not afraid of technology and even embracing the possibilities that are coming. So yes, I think we have nice things to look forward to, also challenges, again if the car can only be operated with a touchscreen, again the same thing: if there is no speech or no accessible interface it would be the same problem" (Simons, EBU, 36).*

For persons with ASD the use of autonomous cars is also regarded as being basically useful in the future. However, in the case of ASD this depends on the impairment, since only "*people with intellectual disabilities need assistance to travel, to move so they can be helped by automatic travel*" (Cirrincione, Autism-Europe, 53).

Currently technologies able to replace a malfunctioning organ are being further developed, like the bionic eye for blind or visually impaired persons. Although this technology looks promising on the surface, Simons from the European Blind Union (EBU) raises a concern: "*[blindness as such] is not solved by giving a person a working eye*" (Simons, EBU, 38). This means that it is not enough to replace an organ by a technology for the person to be fully functional, given that the integration of such technology in the human body is a very complex process. For instance, before a person is able to use or fully take advantage of a bionic eye, a long path of knowledge and adaptation to this sighing function is required:

> *"Changing the person, technically is probably doable, but you also need to learn to see […] a young child takes seven years to grasp these notions of seeing and measuring distances, colours, and moving issues. So has a blind born person who would have to learn seeing like a baby. So it's much more than technology here, it's psychology, it's..." (Simons, EBU, 38).*

Another field where technological innovation is making fast progress is the field of IT. Here very different technological solutions are mentioned as needed and wished for. At first, technology that allows facial recognition is highlighted. Such a technology would be welcomed especially by the visually impaired despite possible negative side effects concerning privacy issues:

> *"As far as I hear, technology can do much more than what is at the moment... for instance facial recognition. There are countries that don't like this idea, in the sense of privacy, but for me it's just a description, the picture is there, it's public so your face is there anyway" (Simons, EBU, 88).*

In addition, a mainstream use is envisioned as such applications can also be applied in other contexts:

> *"I heard that some Google software, if you import your picture library and you say find the pictures of my son, it will present you with a list of pictures where this person is included. So, it's very interesting" (Simons, EBU, 88).*

The group of ASD also regards the use of facial recognition software as relevant. In connection with cyber-physical systems, for instance with the use of robots, such an application that can recognise facial expressions for autistic children could be used in the classroom:

> *"A real child is very complex, very difficult to understand but with the robot you can forecast its behaviour. It is easy to understand the behaviour, so it is a tool to train social communication. It can be useful." (Cirrincione, Autism-Europe, 45).*

A second major area highlighted is that of brain-computer interfaces. However, there is some reluctance when it comes to their use by people with ASD since the technology is still in an emerging state. Hence there is not much knowledge available yet about how it could benefit a person with ASD. The expert from ILUNION, however, predicts a great potential for brain-computer interfaces in the field of ATs:

> *"I think it would be great to have it [brain computer interface], I don't know when, because this technology has to be researched for several years already, but I know it's extremely difficult, but it will be one of the future assistive technologies." (Torena-Cristóbal, ILUNION, 60).*

In general, also from the perspective of the deaf and hard of hearing, a positive view with regard to further technological development is envisioned: in the future, "*drones, robots etc. will be normal products available for all*" (Raike, EUD, 30). Therefore, in general a positive attitude towards the future of technological development prevails: "*Everything related to smart cars, drone technology and so on […] will make life much easier. […] it's difficult to look at, but for sure it will go beyond our imagination.*" (Zelderloo, EASPD, 25).

5.5. Challenges regarding the needs and perceptions of ATs

The main challenges of ATs focus on the topics of "accessibility" and "acceptance".

5.5.1. Improving accessibility of ATs

The UNCRPD identifies accessibility (article 9) as one of the fundamental rights for people with disabilities by outlining measures that need to be taken in order to ensure that people with disabilities have access, on an equal basis with others, to the physical environment, transports, information and communication (including information and communication technologies and systems). According to the UNCRPD, the access to mobility aids, assistive devices and technologies is considered as a human rights obligation, implying that every Member State is obliged to improve accessibility for people with disabilities (United Nations 2006). The need to remove such barriers is also an objective stated by the WHO. This "removal of barriers" also encompasses, in the view of the WHO, informational barriers and communication difficulties which cause social barriers e.g. to healthcare services (WHO 2015).

Although the need of accessibility for disabled people is highly recognised at a legislative level and enacted by two leading international organisations (UN and WHO), the experts maintain that on a practical level the aims of "accessibility" are still not achieved. It shows that accessibility cannot simply be enacted but has to be approached in a common effort by all players of society, or as EBU puts it: "*accessibility is a process not a project*" (Simons, EBU, 77).

Currently there are many practical fields where accessibility is still an issue: e.g. cash machines, banking services as well as public transport. Also website accessibility of public authorities has still not been achieved, either because these websites are not "*accessible*" or not "*understandable*" for different disability groups (Zelderloo, EASPD, 23). In public buildings there are also "*minimum requirements for accessibility*" (Simons, EBU, 66) like doors or lifts that have to be taken care of. The virtual infrastructure also needs to be accessible: occupational groups in charge like architects or programmers should be made aware of and trained in accessibility requirements.

Another aspect important to consider when it comes to the needs of people with disabilities in order to access certain kinds of technology is the issue of costs. Often the costs of certain technologies and hence their affordability are mentioned as a severe barrier to the access of technologies:

> *"We have to make sure that the technology is not only accessible and developed to co-production, but also affordable, because we see that there is a widening gap, a fast widening gap between those who have the resources and those that live in poverty and they cannot benefit from this technological*

development. We should try to keep this gap as narrow as possible; if possible, we should even try to avoid that there is a gap. […] So we have to work also on the affordability of the new technology." (Zelderloo, EASPD, 27).

This quote highlights the fact that the price of an AT can cause unequal access to the technology, promoting social inequalities. Moreover, people with low financial resources might not be able to purchase such technologies and therefore cannot benefit from them. Such an inability to access technologies due to the high cost of the devices can cause a vicious circle for the affected person, as the expert from ILUNION outlines:

"It is true that some of these technologies are rather expensive, so it can be a barrier to obtain them because specially if you don't have a job, you don't have too much income, you cannot pay for the assistive technology which in turn affects.... you cannot have a job, so it's a circle." (Torena-Cristóbal, ILUNION, 79).

What is sometimes overlooked is that the cost of a technology is not only related to the purchase price but also involves further costs such as training to use it, e.g. in the field of hearing impairments:

"Cochlear Implants needs to be 'trained' for a person… and in Finland, Sweden, Norway etc. you get the whole package [Technology and learning to adopt and use the technology]. In the US you have to pay for everything yourself, thus poor people don't get the same results as rich people" (Raike, EUD, 639).

These questions of social inequality also make it even more difficult to reach the goal of "accessibility". To meet the needs of people with disabilities it is therefore crucial to focus on the societal embedding of equal access. As is stated in section two, equal accessibility cannot be 'solved' on the individual level by only providing technological solutions on a personal level. Accessibility must therefore be understood as a duty for society in general:

"There is the impairing condition a person has and if we can bypass that through technology, and of course we should do it, but of course parallel with that we have to look at society" (Zelderloo, EASPD, 21).

ILUNION gives a positive example for the issue of accessibility, referring to a business organisation that was successful in providing accessibility to their employees enabling a high share of employees with disabilities to work with them:

"In our case, we are not assistive technology providers. We are accessibility providers. This is very related because the assistive technology has to be compatible with the accessibility, that's why we are also interested in assistive technologies. In our organisation, there are large amounts of people with disabilities, say... 35% of the 32.000 if we focus on all the business groups. If we focus on our organisation: we are around 130 right now and 55 persons of them with disabilities, so there are many employees with disabilities here, and they have the assistive technologies that they need" (Torena-Cristóbal, ILUNION, 21).

This example shows that striving for accessibility is really an issue that involves the active setting of priorities that focus on the needs of people with disabilities.

5.5.2. Improving acceptance and raising awareness for ATs

Although the positive connection between people with disabilities and the high value of the use of technologies is often made quickly, not every person with a disability enjoys using it. Thus, despite their possible usefulness, abandonment rates that usually occur within the first three months of use (see Bodine 2013) can be very high. Moreover, some AT products are seen in a negative light by disabled people as they appear to be "designed for the invalid" (WHO, 2014: 7). Such a judgement naturally has negative effects on the acceptance of ATs.

In some cases, the use of AT can be experienced as a stigma by the affected person. A "classic example" from everyday technologies concerns the comparison of glasses and hearing aids. While glasses are regarded as a "*fashion item*" (Khasnabis, WHO, 22), hearing aids are negatively associated with disability: "*Many of my friends in Europe […] don't wear their hearing aid, because they don't want to see themselves as disabled*" (Khasnabis, WHO, 22).

One strategy to make ATs less stigmatising is making them as invisible and "mainstream" as possible.

> *"The issue of the stigma is always there so, when someone is trying to design any device […] they try to make it look as standard or mainstream as possible, because in some cases we have found that some users don't want to wear a specific item because of their stigma." (Torena-Cristóbal, ILUNION, 46)*

This strategy of making products "mainstream" however does not depend on the technology only. Indeed several factors will determine whether a product can be placed on the market successfully or whether it has negative connotations. A very prominent example is of course the case of cochlear implants. The introduction of this technology to the market in the 1990s met with strong initial resistance from deaf and hard-of-hearing groups. To a great extent these controversies shaped the perception of the technology and the acceptance of it within the disability group. In the end, the controversy seems to be have been resolved over time, as "*only lately young Deaf people have realised it's just another device which does not prevent Sign Language per se*" (Raike, EUD, 3068).

The difficulties of assessing such a process and evaluating the acceptance of a product beforehand – when the technology is still in development – are explained in the case of ASD for smart glasses:

> *"According to the test we did, […] in the case of a virtual assistance, they [people with ASD] love the smart glasses because it was very funny to use. It will depend on where the market goes. I mean... if smart glasses become a mainstream product it will be great. If not, some users may think that it is a stigma for them and they will be reluctant to wearing it, because nobody else is wearing it." (Torena-Cristóbal, ILUNION, 63)*

A vision, expressed by several experts, that would create a more positive perception of technology would be a modified understanding and higher recognition of ATs by seeing them as a universal mainstream product even though they are specific devices.

> *"AT should be mainstreamed so that white sticks, hearing aids, wheelchairs etc. would be like bicycles, watches or skateboards: Part of a person's activity in doing something meaningful." (Raike, EUD, 45).*

In the interviews, this reluctance to the use of technologies was particularly prominent in cases when a disability occurs at a late age. Very often, elderly people who acquire a disability or impairment at a later age, especially blindness and low vision, experience difficulties coming to terms with the 'new reality' of being disabled. Moreover, and this aspect is connected, it is difficult for them to accept and integrate ATs in their daily life, partly also because they are not very used to technologies.

> *"Because first, when you have a disability the first thing that you think is 'oh, my life is over, I can't do this, I can't drive, I can't read my newspaper anymore'. It's not true because there are many solutions but if no one tells you, you might think 'there is nothing for me' so, yes, the environment is very important in stimulating and also in giving information" (Simons, EBU, 46).*

Thus, when assessing the technology needs and perceptions of people with disabilities, the age of the person affected also has to be taken into account. For senior citizens in particular specific efforts need to be made to overcome possible barriers to accepting the technology. Reasons for these barriers include a lack of information on the benefit and use of specific technological solutions as well as an absence of learning opportunities in order to be more open to the adaptation of the technology:

> *"The major difference is... I think... the awareness and the understanding of technology. I think that seniors over 75, 80 years old might have more difficulties using technology than a young very active*

person with a disability, who grew up with technologies. So there might be a sort of a barrier in terms of willingness, acceptance of certain types of technology. So we might have to invest a bit more for seniors in awareness and understanding of technology. As far as I see, young persons with a physical disability or people with sensorial disability they embrace technology, they love technology. This might be different for seniors." (Zelderloo, EASPD, 29)

Turning to the other end of the age scale we need to consider the perception of technologies by young people. As Simons (EBU) reports, parents play a very important role when the technology user is still a child. Parents therefore can assume a role of providing confidence and stimulus or they can slip into an overly protective role[24]:

"That's a very important issue about the environment of the person. Even for me, as a blind child, I was very lucky that my parents were stimulating to do things as normal as possible. To do things with others, the same things that sighted kids could do. But there are other parents who for some reason can't... they are overwhelmed with the disability of their child and they are not able to guide and to learn or to give this independence or to motivate the child, they are more caring than stimulating." (Simons, EBU, 46)

Especially in the field of education, technologies are perceived as very useful. A child might use the technology to be "as normal as others" e.g. by preparing in advance so as not to delay the class, since people with disabilities may well take more time to access information. Therefore, these strategies can help the child to feel more integrated in the normality of the classroom: *"You don't want to be the exception and you don't want to give the teacher the double amount of work, just because you are there"* (Simons, EBU, 50). So, as Simons puts it, feeling more "normal" is also an important outcome which can be reached with the support of AT: *"We don't want to be the exception and thanks to assistive technology we are getting relatively close to being there"* (Simons, EBU, 52).

5.6. Conclusions: Needs and perceptions towards ATs

As far as the needs and perceptions towards ATs are concerned, many of the needs that are expressed by the experts of our study, e.g. the right to participate on an equal footing in education and working life as well as the need for universal design of technological products, are already addressed in official documents by the UN and the WHO. However, although the needs regarding ATs are well known, it is the everyday experience of people with disabilities that an effective implementation is still lacking.

The experts' opinions have shown that, on the one hand, there is strong agreement on the need for further technological development and on the benefit of universal design and participatory technology development processes taking into consideration the needs of disabled people. On the other hand, starting from these overall goals, it becomes apparent that different disability groups and actors in the field express a diverse set of needs and perceptions towards ATs in the areas of independent living, education and employment. In the case of blindness and visual impairment, access to mainstream technology is still an area where improvements need to be made. For ASD, mainstream devices are mainly used to support communication and social interactions. In the case of deaf and hearing impairment, web-based sign language translation was highlighted.

[24] According to Cirrincione (Autism-Europe) not only parents should express their view on the situation of their disabled child, but also the grown-ups, as they often express a distinct position. This development of having "self-advocates", people from the spectrum, speaking out for themselves instead of parents speaking for them was especially important for the societal representation of people with autism in recent years: "Parents are very protective of their children and children want to be autonomous. So a different point of view is important […] in real participation and representation" (Cirrincione, Autism-Europe, 98).

The experts recommend that the field of employment should be strongly focused on in the future. This refers not only to a better support for and integration of ATs in the workplace, but also to an improved integration of people with disabilities in the workforce in general.

In terms of future development the experts were very optimistic and open towards future technological applications for people with disabilities. Visions for the future development of ATs range from the potential of autonomous cars and the progress in facial recognition to BCI.

The experts also stated that needs and perceptions are strongly related to the age category. If a disability occurs in old age, there are high attitudinal barriers and often a lack of knowledge by the person affected. External support would be needed to overcome these barriers. By contrast, the acceptance and awareness of ATs seems to be much higher at a younger age. Here, technologies are seen as a necessary support to gain an equal access to society in terms of education, followed up by employment.

6. Set of expert interviews II: Complementary measures by the public sector

The second qualitative study focuses on the political side of the regulation of ATs at different political levels as well as in different fields. It sets out the status quo as well as further measures needed in order to improve the embedding and use of ATs from the perspective of the public sector.

6.1. Key results

The key results of the study are presented below. These comprise current challenges in legislation at EU level, such as the UNCRPD, the EAA, and the Medical Device Directive. The main challenges for political measures in the fields of independent living, education and employment will then be described. Finally, political challenges relating to economic factors as well as research and innovation of ATs are highlighted.

Legislation

- The UN convention is of high political importance when it comes to the future integration of ATs. However, at the present stage further national implementation strategies with regard to ATs in different societal fields (education, employment, independent living) are crucial and should be developed further.
- Follow-up legislation of the UN convention encompasses the WHO GATE-initiative as well as the EAA. It is suggested that further legislative measures, e.g. on web accessibility, are still needed.
- ATs covered by the Medical Device Directive are integrated in the health system in terms of cost coverage; however, these are characterised by high costs, long development times, and high market barriers. Modifications of the Medical Device Directive e.g. towards risk-based approaches are proposed particularly for the case of ICT.
- It is proposed that ATs not covered by Medical Device Directive currently lack regulation. This is particularly evident for current technology development in the case of ASD where a quality assessment of technical devices is not yet implemented.
- A specific legislative approach directed towards ATs in terms of classification and regulative measures for people with disabilities should possibly be implemented to overcome the shortcomings of the current legislation on ATs.
- The sound integration of already existing ATs in the health care system is regarded as a huge challenge. A "holistic approach" towards the integration of ATs at community level, including a stronger connection between technological solutions and connected services, is proposed. Moreover, it is recommended that specific professionals for ATs at community level be established.
- The experts set out best-case examples of rules and regulations from the USA.

Societal fields

- *Independent living*: People with ASD in particular are currently up against many challenges in everyday life e.g. when interacting with the health system or with public services. For this specific area the need for the further development of technical solutions is recommended taking the variety and complexity of ASD into account.
- *Education*: The role of ATs in the field of education has to be considered from two sides: 1) ATs in the education process of people with disabilities; 2) training of professionals in ATs.

3) Emphasis is placed on the high importance of education for people with disabilities especially with regard to the use of ATs: a good educational standard should be considered as the basis to enable users with disabilities to choose and responsibly use ATs.

4) Training in skills and competences are recommended in the field of web accessibility, health occupations and public services.

- *Employment*: According to the experts, there are many barriers to the employment of people with disabilities. These range from attitudinal barriers to simply a lack of information on the part of companies on how to employ a disabled person. It is recommended to place greater emphasis on the function of ATs within the goal of "reasonable accommodation in the workplace" anchored in the UN convention. Moreover, the point is made that there is a huge lack of information and knowledge in the field of employment in two distinct ways: The first lack of knowledge relates to the actual situation of people with disabilities and their use of ATs in the workplace. The second refers to the need for better information for companies on measures to integrate people with disabilities in the workplace with the aid of ATs. Finally yet no less important, there might be a strategic benefit in making the connection to the ageing workforce in order to make the workplace more accessible for people with disabilities.

Role of the economy

- Companies face several challenges when producing ATs, ranging from small markets sizes and high costs of devices to strong medical regulation requirements. One approach to overcome these challenges is to highlight the benefit of ATs when they are considered as 'mainstream devices', because technology development for people with disabilities may contain a specific innovation potential, e.g. the successful mainstream use of talking devices.

Technology design and development

- It is proposed that development principles for ATs, already generally agreed upon politically, like their universal design, still need to be better implemented in technology development processes.
- It is highlighted that the future focus of technology development should not only be on new devices but on an improved implementation of existing devices. Thus, the need for an evaluative overview of existing devices and applications as well as the need for an improved connection between technologies and services is highlighted. The development of such socio-technical approaches on ATs would also be useful to countries outside the European Union.
- Technology development of AT in the field of ASD is still at an initial stage characterised by 'bottom-up' developments. The need for quality assessment of current technological applications is stressed in this context.

The results of the study on "Complementary measures by the public sector" are presented in detail below.

6.2. Approaches to the legislation on ATs

6.2.1. UN Convention on the "Rights of Persons with Disabilities"

With regard to legislative efforts for people with disabilities, the UNCRPD plays a central role. At a general level, all interview partners agree on the importance of this convention, a fact that can best be summarised by the following quote: "*The convention is really a game changer*" (Tromel, ILO, 43). Currently the convention is still in an early stage. Its impact however is regarded as huge, on the one hand with regard to legislation and policies attributable to the convention, on the other hand with regard to a higher visibility of people with disabilities in society, or in other words: "*a heightened awareness in society about disability*" (Tromel, ILO, 45).

However, the implementation of the convention on the European as well as national level is still ongoing. "*It's a great convention. It's a convention, great hope… but you know, convention is convention. The challenge is implementation*" (Khasnabis, WHO, 60). Therefore, the real impact of the convention on the lives of people with disabilities remains to be seen (see also ST 1.2). However, as experience with

other regulative instruments shows, on a practical level we need to carefully assess how e.g. financial restrictions on certain issues may *"impede your ability to fully respond … to the full aspirations of […] the Convention."* (Cudd, University of Sheffield, 27).

When it comes to the role of ATs in the convention, compared with other articles of the convention like e.g. the one on legal capacity, which was regarded as a very complex and sensitive issue to agree on, extensive negotiation processes did not accompany the inclusion of ATs between states and among disability organisations. However, ATs are not very specifically described in the convention. Rather the convention makes a reference to ATs, which can act as starting points for further initiatives that have been taken up already. There are at least two major initiatives deriving from the UN convention, namely the WHO GATE initiative, developing a catalogue on assistive devices[25] as well as the proposal for a directive on the accessibility of products and services, that is the European Accessibility Act (EAA).

The explicit reference to ATs in the UNCRPD is generally welcomed by disability organisations, as is stated, for instance, for the field of ASD:

> *"We like the fact that communication technologies are mentioned because as you know autism is a disability which affects communication skills. For us it's very important that it is really mentioned black and white. And we see […] effect already now, the added value of having new technologies, so we are very happy that the U.N. convention is really promoting these aspects" (Baranger, Autism Europe, 65).*

There are similar statements from the EUB and EDU. Moreover, the role of disability organisations as such is strengthened by the UNCRPD.

6.2.2. European Accessibility Act

Currently the EAA is still in its negotiation phase. Several disability organisations have commented on the status of the Act. In this report, no detailed comment on the EAA itself will be given. However, we will convey the general views on the EAA as revealed by the expert interviews. Generally speaking the disability organisations are of the opinion that the EAA will form a very important instrument to support accessibility issues for people with disabilities, or as the representative of the EBU puts it:

> *"If those changes that we, as European Blind Union, suggested, if those changes would be applied, then, I believe that we would have something that would cover lots of things, we haven't covered right now." (Percinic, EBU, 61).*

The main idea of the Act is that manufacturers of all kinds of devices will be obliged to take care of the accessibility of their products and services. From the perspective of the blind, there are currently lots of societal fields that still need an improvement in terms of accessibility, e.g. the field of public services or banking:

> *"And when I am talking about e-government, I'm talking about the improvement of the accessibility of all public websites, and all public facilities, which are related to ATs, such as improvements of the ATMs, the accessibility of the ATMs, or the accessibility of banking, like e-banking systems." (Percinic, EBU, 32).*

[25] An important achievement of the WHO GATE initiative in its preliminary stage by now is the establishment of a list of 50 assistive technology devices regarded as the minimum requirement for delivering AT to people with disabilities across the world. This initiative is of particular importance for developing countries, as the AT listed there can be considered as standard in all European countries already. (For more information: http://www.who.int/phi/implementation/assistive_technology/phi_gate/en/ (Accessed: 06.10.2016)).

Other directives e.g. on Web accessibility will, however, still be needed in the future to address the full accessibility of IT products, like website or apps.[26] In the case of ASD, accessibility again is an important issue, specifically with regard to accessible communication. For this disability group, *"having access to alternative or augmentative formats of communications whenever services or products are designed"* (Baranger, Autism Europe, 40) is seen as crucial, e.g. to make sure that pictograms are available to ease communication for people with ASD.

Finally, it is important to be aware of the fact that there are huge differences when it comes to the concrete implementation of accessibility requirements for different disability groups. Recent measures to provide accessibility have taken place particularly for people with sight loss. It is therefore possible to build upon experiences of how to achieve accessibility for this group of disabled people. However, the accessibility for other types of disability still has to be operationalised: *"most cognitive or learning disabilities are far more challenging"* (Cudd, University of Sheffield, 35).

6.2.3. ATs as medical devices

As outlined above (section 4.2.1) the definition of "what" an AT is, is still very much contested. On a general level, two different types of devices can be distinguished: ATs that specifically respond to a disability and ATs that are of general use also. Classification of ATs as medical devices only is evident e.g. in the organisational perspective of the International Social Security Association (ISSA) and MedTech (trade organisation):

> *"My personal view, or let's call it my personal overview, is, that assistive technologies are only considered as a treatment. So either you prescribe drugs to […] heal you, or you are prescribed some device" (Treichel, ISSA, 71).*

The advantage of the fact that an AT is classified as a medical device is that costs for the device can be covered and distributed by national health schemes through the prescription by medical doctors. For this kind of AT, classified as "medical", the European directive concerning medical devices is binding. In the case of the WHO GATE initiative, it was e.g. a crucial step when these devices were included as a medical device in the minimum catalogue of ATs, thereby ensuring that they are funded by the respective national health schemes:

> *"The WHO has listed assistive technology now as an assistive health technology. The inclusion of the word 'health' was extremely important because by doing that in many developing countries this would automatically mean an allocation of funding, so that people, populations who just weren't getting any AT suddenly would be able to significantly increase the chances of getting what they need." (Cudd, University of Sheffield, 19).*

On the flipside there is the high regulative effort and the rigorous application of the medical device directive. There are important, also historical, reasons for that, as *"in the health sector there's a high risk of anything, we still need highly regulated products"* (Albrecht, Hannover Medical School, 61), e.g. when it comes to questions of insurance and responsibility as well as in terms of secure and safe products. However, concerning new technologies, specifically IT, the strictness of the medical device regulations is also called into question being very time-consuming and not useful for every type of product.

> *"Nowadays it is easy to develop software with a medical purpose. And if you want to bring a medical device to the market it takes you a lot of time and money and effort. And with the dynamic market on software, especially in apps, when you start to follow the regulation and you pass the process, then the application is then old and others are at the front, right? […] And those applications are not dangerous in that sense, so for many applications it is overregulated." (Albrecht, Hannover Medical School, 15).*

[26] http://europa.eu/rapid/press-release_IP-16-1654_en.htm (Accessed: 06.10.2016).

In addition, the medical device directive introduces greater challenges into the development process of new technologies.

> *"There is a fundamental problem when any organisation is thinking of developing a new app or potentially some kind of website that this is more than just an information resource, this is actually operating as a piece of … database […]. They have to think about is this going to be a medical device as defined by that directive or not […] because if you immediately from the start assume that this will be a medical device that places far greater obligations on the process of development." (Cudd, University of Sheffield, 23).*

Sometimes "*tricks*" are used in order to circumvent the medical device regulation stating that an application is "*not for medical purposes [but] for learning purposes only*" (Albrecht, Hannover Medical School, 29). However, if the app is meant to serve medical purposes, with such procedures the responsibility for the use of the application is given back to the user, which is considered as "*unfair*" to the users (Albrecht, Hannover Medical School, 29).

The question of how to regulate medical devices implies a conflict between fostering innovation and reducing 'time-to-market' while at the same time ensuring patient safety. Not only do new companies today have difficulties assessing the medical device market, but new products also need several years (4-5 years, according to Khasnabis, WHO, 34) for the journey "*from the innovation lab to the market*". This bears the risk that medical devices are then already out-dated. Currently there are some proposals underway to deal with this area of tension, as the situation can now be characterised as 'black-or-white': either a product for medical purposes is strictly regulated by the medical device directive or else there is "*no-regulation*" of the product at all (Khasnabis, WHO, 34). Two experts have therefore voiced the need to develop alternatives to the existing 'black-or-white' regulation landscape concerning medical technologies, namely to find solutions to "*come somewhere in-between*" (Khasnabis, WHO, 34). This need is especially expressed when it comes to IT.

> *"We need new methods to deal with new opportunities, with new technology and new ideas of technology. The regulatory processes at the moment are too conservative in a way that they are not…they are touching the character of new technology, […] so they are not respecting the new kind of technology" (Albrecht, Hannover Medical School, 53).*

Thus, there are proposals e.g. to develop specific regulative instruments for medical apps, or introduce a "*risk-based approach*" (Albrecht, Hannover Medical School, 15). Such an approach could differentiate applications according to the risk that they imply for the patients. Thus "*low-risk-applications*" could be brought to the market more easily. Another proposal, which is of special interest here, is the proposal that AT "*should come with their own classification and regulative system*" and thus get their device directive, no longer tied to medical devices (Khasnabis, WHO, 34). In the view of Khasnabis, WHO, such a fundamental reform of the regulation of ATs, not being "*stuck*" (Khasnabis, WHO, 9) as a medical device, would also imply an 'upgrade' of ATs as such.

> *"So we see this sector as an emerging sector, and there is a lot of myth about this sector, and people think AT is only for disabled people. And we are trying to break that myth. We are saying: 'no, it's not at all, it's […] for everybody whoever has had any functioning disabilities, like you and me. […] So we are de-stigmatising, or delinking a little bit AT from disability, only disability and, at the same time, as a medical device. […]. So we are trying to take it more on the social model of the devices, not a typical, medical model of the current assistive system." (Khasnabis, WHO, 9).*

An example of a field where new technologies are applied in the absence of regulation is the field of ASD. In consequence new technologies are introduced and used, e.g. apps or robots, yet there are no particular assessment and evaluation procedures to gauge the usefulness or harm of these developments for the affected group (Baranger, Autism Europe, 14). Hence quality assessment of such technical tools for ASD is not currently in place. Moreover, in the case of ASD, people very often stand little chance to get a reimbursement of the costs incurred for AT, as there are mainly

mainstream devices for AT which in some cases though are too expensive for individuals to afford. Cost coverage therefore would *"help people to have access to these devices"* (Baranger, Autism Europe, 34). However, it should be noted that the field of technology applications for ASD is a new and emerging field, with many challenges yet to be solved, as may be gathered from the statement that: "*it's difficult to regulate tools that do not yet exist and we know that it evolves very fast"* (Baranger, Autism Europe, 42). However, for the future it is important that there are mechanisms in place to make sure "*that there is no abuse*" (Baranger, Autism Europe, 48).

6.2.4. A systemic approach in health care

Another facet illustrating the diverse field of needs and measures for people with disabilities comes into view when disabilities are treated within the health care system, either when they originate from illnesses, like diabetes, or when they occur after a work accident or exist from birth. According to the experts it is particularly that systemic approaches towards the inclusion of ATs in the health system are very important. Also in all other cases affecting disabilities, the way in which ATs are included in the respective system have to be taken into account with caution. In the case of cochlear implants, which normally are implanted before the age of two, such a "*holistic approach*" (Davis, MedTech, 22) is described as follows:

> *"There is the device, but there is also a team to walk with, so not just a doctor […] but in this case it would be an audiologist, a speech therapist and so forth" (Davis, MedTech, 22).*

However, such *"holistic approaches"*, where not only medical solutions need to be identified but where there is also a need to embed and accompany the use of a technical device within the social support framework, have to be cautiously taken care of. Currently, the transition of these two areas (medical and social) is often still challenging. In addition there is the risk that the relation between these two areas deteriorates further due to cost issues:

> *"The medical teams are very focused on doing an appropriate medical job, almost they get to the point of 'I've done everything I can medically for this patient, and this patient should go home', and they are no longer interested in kind of the rest of the process. And this disconnection which exists in a lot of European countries causes tremendous problems. And particularly so with the current financial and economic crises that the European Union is going through, because what's being tending to happen is that the medical side of care continues to be pretty well or proportionally more well supported than the social care. So you have ostensibly an individual who is well, yet he is really struggling to access assistive technology services and this is equally true for people with disabilities" (Cudd, University of Sheffield, 31).*

The need for such an integration of ATs in the "system" of medical and social care is mentioned also in the case of workplace accidents. Here, the "*case managers*"[27] (Treichel, ISSA, 74), who ideally should accompany an employee in an early intervention model right after the accident in order to achieve the professional re-integration, should know of the medical but also of the social side of the rehabilitation process. They should also be very much aware of adequate ATs to support the affected individual.

A far-reaching proposal in order to improve the integration of ATs at community level is provided by the expert from the WHO (Khasnabis, WHO, 41-45). He refers to the US system where ATs are not prescribed by medical doctors but by so-called Assistive Technology Professionals (ATP). Under the US system certain occupational groups, e.g. a physical therapist, would certify as ATP and prescribe

[27] The ISSA promotes the concept of a case management, where a case manager is accompanying a person from the moment a disability occurs. A case manager takes care of the medical aspects, but does also communicate with the employer to reemploy the person and with the family to explain the importance of emotional support (Treichel, ISSA, 7).

ATs, which are then reimbursed by the insurance. This model allows reaching out to more people, if more occupational health groups other than just medical doctors may prescribe assistive devices.

6.2.5. International perspectives on the regulation of ATs

Compared with other countries around the world, Europe seems to be rated 'average' with regard to dealing with ATs. On the one hand, there are countries like the US, characterised by one of the interview partners as *"leading"* (Percinic, EBU, 34) in this field. The US has a much longer tradition when it comes to the inclusion of ATs into state affairs. This involves not only legislation (especially "section 508"[28]), but also the provision of ATs as well as occupational training systems including official certificates e.g. on web/ software accessibility. Moreover, US-based global players invented accessible IT solutions that have since become successful "mainstream" products.[29] On the other hand, however, there is the perspective on developing countries, where there is huge lack of legislation of ATs and also where, on a more general level, the situation of people with disabilities is "*pretty bad everywhere*" (Tromel, ILO, 13).

When it comes to differences between individual countries in Europe, nearly all interview partners point out that there is a large not only national but also regional diversity in dealing with disabilities and ATs in Europe (see Stocktaking paper 1.2). The heterogeneity at national levels is also something highlighted when it comes to the implementation of the UN strategy. It seems that as a rule there is a gap between high-income and low-income countries: European countries with a higher welfare level tend to create better solutions for the disabled in their country. This also applies to better education and employment opportunities. When it comes to "best case" strategies, the UK is often mentioned for the ways in which it deals with diversity in society; moreover, specific governmental strategies exist for the case of ASD.[30]

6.3. Complementary measures for ATs in societal fields

In the following sub-section, the role of ATs in societal fields of particular relevance, namely independent living, education and employment will be set out.

6.3.1. Independent living

When it comes to the question of how to lead an independent life as a disabled person with the support of ATs, there are major differences between the different levels of needs of different groups of disabilities. In the case of blindness and visual impairment, the main challenges lay in the accessibility of public e-services, like banking or e-governance (Percinic, EBU, 92). When it comes to ASD, the situation is even more complex. This is also due to the broad variety of the disability ASD was first diagnosed in many European countries only thirty years ago, so today we have a "first" adult generation of persons with ASD. In the case of Asperger, this has since also led to a generation of adults who want to speak for themselves. In some cases they claim that ASD should not be "cured" but that it should instead be regarded as a legitimate part of human diversity: "*I mean they strongly support the fact that they have autism, they are proud to be autistic and they say it's just part of the diversity of*

[28] "Section 508" derived from the Rehabilitation Act (amended 1998) and required federal agencies to make their electronic and information technology accessible to people with disabilities. It was enacted to address and eliminate barriers in IT and encourage technological innovation in this direction. The law is binding for all federal agencies, which develop, procure, maintain, or use electronic and information technology. Furthermore, federal agencies must allow public access to people with disabilities that is comparable to the access others have.

[29] E.g. the invention of a digital assistant controlled by natural language

[30] In the UK, the Autism Act was adopted in 2009. In 2014, a new national strategy for people with autism was launched.

human nature" (Baranger, Autism Europe 63).[31] Another case are adults who have for a long time lived undiagnosed, but who nonetheless have a need for life-long support in order to be integrated into the community. Moreover, the health system is not accessible for all people with ASD, as Baranger (Autism Europe, 54-56) impressively explains:

> *"AB: People may for example display challenging behaviour when they are in pain. And it's not necessarily picked up by the health professional, or they don't have the tools to communicate with a person with autism in the health services. So it could also be a place where assistive technologies to communicate can also help to, or accessible means of communication can really help not to miss any signal for the people trying to access health care. At the moment we see that people with autism they die on average twenty years younger than the rest of the population.*
>
> *LN: Do you think it is maybe because doctors do not rightly diagnose them?*
>
> *AB: Very often they are not rightly diagnosed, they don't have access to the health care, some of them live, they live alone, live in poor conditions because of comorbidities, it can be a mental health issue, so it is also extremely important that they receive support in their community and that they are really supported throughout their life."*

Finally, it should be noted that, that in the case of ASD the access to diagnosis should be available as early as possible in childhood. Early intervention allows communication difficulties to be addressed and this is the best way of achieving inclusion into the community (Baranger, Autism Europe, 61). The case of ASD therefore is very complex and diverse and forms a major challenge not only in the development of accessible ATs but also for dealing with it in society especially in cases when this disability seems to be 'invisible' (Mordini et al. 2016) at first glance:

> *"So, as one of the experts at the Council of Europe said, that a society that is able to address the need to care for people with autism is able to care for everyone in society. So we are well aware that it is challenging, that it's not straightforward, it's complex, it is more complex than with a person in a wheelchair. But we are trying to voice this complexity, to explain how it can be done and it requires a variety of approaches, adapted to the diverse needs of the people and for people to be aware of this diversity. It is an on-going challenge that we face but with these common difficulties that everyone faces we want to leave, let's say, no one behind. To make people aware that even if people, for example, speak for themselves it doesn't mean that they do not face difficulty in their everyday life. Because in that case it is really an invisible disability and it's easy to dismiss their difficulty and to say 'wow, they are perfectly clever and able to find a job and to have a normal life'. But very often their difficulties are more important than what people assume when they see them and when they interact with them" (Baranger, Autism Europe, 58).*

In addition, technological solutions have to respond to the variety and complexity of ASD. However, currently there is a strong focus on technology development for education, while there are fewer technological solutions to allow people with ASD to live independently (Cudd, University of Sheffield, 39).

6.3.2. Education

As the interviews show, two different perspectives have to be taken into account when reflecting on the role of ATs in the field of education: first, the role of ATs in the education process of people with disabilities and, second, how people working with people with disabilities can be trained properly in dealing with ATs for people with disabilities.

With regard to the first perspective, the interviews highlight the importance of ATs to be used in school education. There are several special devices available for all three kinds of disabilities to

[31] This refers to the "neuro-diversity movement" see e.g. Mauldin, 2016.

support pupils with disabilities in school, which have partly been implemented in the education system for many years by now (see also stocktaking paper 1.1). For children with ASD, for example, tablets with specific apps are an important device that is provided in school.

However, if one goes a step further, a good school education is crucial as it allows people with disabilities to shape their lives also with the help of technologies. A good education would enable a person with disabilities not only to rely on special devices but also to make own choices and use mainstream devices. As Percinic from the EBU states:

> *"I believe that it's much more efficient for people to have a good education and where they can learn how to use all the goods from the available technologies, which is becoming something that's mainstream and something that's luckily accessible, than to have to buy separate devices which really cost a lot of money." (Percinic, EBU, 120).*

The high importance of a good educational system is also highlighted for the case of ASD, where it is stated that the role of education is especially crucial: "*education for people with autism that is more than mere education, it will help to really understand the world better*" (Baranger, Autism Europe, 54). Such an understanding of "*the world*" is also important when it comes to ATs. As for new technologies the use of apps involves complex decisions, e.g. on sensitive personal information or data protection, that have to be taken by the users themselves as other regulative instruments are often not yet in place. Thus, as a general approach, the responsibility still rests with the user (Albrecht, Hannover Medical School, 25).

From the perspective of the EBU it is also emphasised that a good education also relies on the accessibility of relevant material for educational purposes, an issue that is addressed in the Marrakesh Treaty which will come into force in September 2016.[32] The treaty is however still not signed by the European Union, a fact criticised among others by the EBU.

With regard to the second perspective, the training of people without disabilities, three different areas of training needs can be identified. First, there is a lack of qualified personnel for web accessibility, which is regarded as a serious problem. According to Cudd, recent official reports state that "*90% of European web and app developers lack the skills […] to develop effective interfacing for people with disabilities*" (Cudd, University of Sheffield, 23). In addition, official certificates to demonstrate knowledge and provide incentives to learn about issues on how to achieve web accessibility are either not widespread or indeed non-existent in Europe to date. In the USA, such certification programs already exist and this currently is the only way of proving one's expertise in web accessibility in Europe also (Percinic, EBU, 56).

The second field with training needs identified affects occupational profiles in the health care sector. It is stated, that in many health and care professions, technology issues are not part of the "*traditional expertise or requirement in their training*" (Cudd, University of Sheffield, 47). Today the people actually affected (patients or people with disabilities) are "*far more open to the use of new technologies as part of the solutions than the practitioners*" (Cudd, University of Sheffield, 49). So this reported lack of skills and knowledge in the field of ATs could be another argument for a specialised AT profession mentioned earlier, namely the Assistive Technology Professional (ATP).

[32] The Marrakesh VIP Treaty (formally the Marrakesh Treaty to Facilitate Access to Published Works by Visually Impaired Persons and Persons with Print Disabilities, colloquially MVT) is a treaty addressing copyright. It was adopted in Marrakesh, Morocco, on 28 June 2013. The treaty allows copyright exceptions when this facilitates accessible versions of books or other works for people with visual impairment. Fifty-one countries signed the treaty in Marrakesh; so far, the treaty was ratified by twenty states allowing it to come into force on 30 September 2016.

The last major field when it comes to training needs that the experts mention concerns public services. This is particularly evident in the case of ASD. As Baranger explains, there is a lack of knowledge in public services on how to deal with people with ASD. This can have severe consequences:

> *"For example training of the police […]. Because we see sometimes reports in the media of people getting shot because they were displaying challenging behaviours. But the thing is that they had autism, it was not they were being confrontational with the police on purpose. It's just their disabilities that they don't always understand social norms, social communication, and they can at times be very, very stressed and react in an unusual way to some situation. So people need to be aware of that. So it starts indeed with the police force, with the civil servant, with the teachers, throughout society as we said earlier on. That we need more inclusion of people with autism and more understanding so that all of these professions that can be in contact with people with autism should be made aware and trained to recognise autism and to know how to interact with people with autism." (Baranger, Autism Europe, 81).*

There is a chance that ATs can also play a role here as they support people with ASD to improve their communicative abilities with others; however, this cannot replace a better understanding of the specifics of disability by society as a whole.

6.3.3. Employment

A good educational system is generally regarded as the precondition for the inclusion of people with disabilities in the labour market. A high level of knowledge and skills as well as knowledge of how to use technologies in order to improve one's own knowledge base is regarded as an important factor for the employability of people with disabilities. Technologies are seen here as crucial to support this inclusion on a general level:

> *"If people with disabilities have not been able to take part in education or have not been able to benefit from education in the same way as non-disabled children because of the lack of adjustments including technologies, then the end result is, that the person with the lower level of education and skills will have more difficulties to find a job. Not just because of the disability but mainly because of the lower level of education and training […]. Let's say, the general access to information society, all that nowadays has an impact. Nowadays and before, has an impact on the employability of people. So the more people have access to technology that allows them to take part in all aspects of life that also has a positive impact on their capacity to be effectively included in the labour market" (Tromel, ILO, 45).*

However, knowledge and skills is only one piece of the puzzle when it comes to employment. There are still large "*attitudinal barriers*" (Tromel, ILO, 27) and negative perceptions *"from all players of society: government, employers, trade unions, disabled people, their families, media"* (Tromel, ILO, 35) towards people with disabilities having the capacity to work on a similar basis as non-disabled people. Such barriers are already prevalent at the recruitment stage. In the case of ASD, for example, the standard job interview process is already very challenging for people with ASD. However, it is possible to adapt these procedures for people with ASD, e.g. using a test in a real situation where skills can be demonstrated (Baranger, Autism Europe, 54). Such an adaptation to facilitate access to the labour market could already serve as an example of how to achieve the goal of *"reasonable accommodation"* that is anchored in the UNCRPD (see below). In the case of ASD, further mechanisms that could be introduced on the one hand take the form of social measures, like mentoring systems or job coaches. On the other hand, they concern the way the working environment as such is designed. People with ASD can be oversensitive to light or sound, so lighting has to be adapted or else a quiet room needs to be set aside with little interaction with other people: *"so there are lots of rather simple and easy accommodations that can be made to include people in the workplace"* (Baranger, Autism Europe, 54). Overall, what is specific to people with ASD, is that due to the diversity of the spectrum, a *"proper individualized approach"* (Baranger, Autism Europe, 52) is required. Single support programs have already proven successful in that they allow people with ASD access to the labour market. However,

due to their regional and national specifics they are not always available for the people that need them.

In order to incorporate AT into the workplace the obligation of "reasonable accommodation"[33] contained in the UNCRPD may be regarded as a starting point: *"I think that is where assistive devices come in at least from a workplace perspective"* (Tromel, ILO, 87). However, there are still many measures needed to improve the situation of people with disabilities in the labour market: *"Even if many countries now have legislation that mentions that the denial of reasonable accommodation is a form of discrimination that is not resulting really in any sort of huge changes"* (Tromel, ILO, 39). The current situation can be characterised by a huge lack of knowledge on the part of the companies (Baranger, Autism Europe, 54) of how to employ people with disabilities. Government must also be urged to provide more information on legislative steps or practical adjustment measures in a way that is easy to understand:[34]

> *"Companies need to know where to go to say: 'ok, I have recruited this person for this specific job and I'm now trying to understand what adjustments are needed, I would like to know who can help me to identify the most reasonable or the best solution that exists in the market, for this specific person in this specific job.' And that's largely missing. […] There's nobody who can help you and […]this leads either to non-recruitment or to recruitment which might not be successful at the end because the person might not get the adequate support and might then not be able to sort of perform in the best possible way" (Tromel, ILO, 39).*

Ways to improve the current situation would include better information on how to employ people with disabilities. What is needed is guidance for employers as well as easier access to funding for workplace related ATs. However, as experience shows, this also depends on the willingness of the individual employer to improve the situation for people with disabilities:

> *"But my general experience is that employers are looking to minimise the costs to their organisation whatever form that cost takes, not as purely financial, and only in some cases they are doing that while also trying to do the best they can. So it can actually in reality vary a lot from a reaction which is 'ok, we've got to do this for do that', so it's the minimum we can and not much considerations are given to whether what they do is the best or not. Whereas in others, they at least try to consider what's the best they can do without destructing their operations too significantly." (Cudd, University of Sheffield, 27).*

This is also confirmed by what is often mentioned as the limited impact of penalties that companies have to pay when they have failed to employ people with disabilities (Percinic, EBU, 44 referring to the case of Croatia). However, as the expert of the ILO states, although there is still a long way to go, it seems that the UNCRPD has started to have some impact on companies:

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[33] Reasonable accommodation in the workplace is introduced in Article 2 of the UN convention. "'Discrimination on the basis of disability' means any distinction, exclusion or restriction on the basis of disability which has the purpose or effect of impairing or nullifying the recognition, enjoyment or exercise, on an equal basis with others, of all human rights and fundamental freedoms in the political, economic, social, cultural, civil or any other field. It includes all forms of discrimination, including denial of reasonable accommodation." And: "'Reasonable accommodation' means necessary and appropriate modification and adjustments not imposing a disproportionate or undue burden, where needed in a particular case, to ensure to persons with disabilities the enjoyment or exercise on an equal basis with others of all human rights and fundamental freedoms." See: http://www.un.org/disabilities/convention/conventionfull.shtml (Accessed: 06.10.2016)

[34] From the perspective of the social security association they come into action for disabilities only if these occur after an accident. According to current procedures they would then support affected employees by providing a rehabilitation coverage or disability pension or covering ATs only if they are medically prescribed (Treichel, ISSA, 4).

> *"I mean at least the companies that we work with, they are realizing that the whole attention to disability, to persons with disabilities is much greater right now than it was ten years ago. That is leading to better legislation, and not only legislation but also just more heightened awareness in society about disability. And that companies can no longer overlook that aspect if they want to be leaders in their sector, if they want to be well-seen by their employees and their clients, they need to do more on disabilities than before." (Tromel, ILO, 45).*

Nevertheless, further steps at European level would include on the one hand a *"proactive strengthening of the reasonable adjustment legislation"* but also a better governmental support for workplace-related ATs. The connection to the general trend towards an *"ageing workforce"* (Tromel, ILO, 89) might be strategically helpful in this context as this reinforces the need for ATs at the workplace. On the other hand, there is still a general lack of knowledge about the situation of people with disabilities in the labour market including how ATs are used at the workplace. The ILO is currently developing a module to be included in labour-force surveys in order to improve the knowledge about availability and further needs of ATs at workplace level as well (Tromel, ILO, 101-107).

6.4. Role of the economy

In the context of ATs, companies have different roles. First they have a role as employer (see sect. 4.3.2), and second they have a role as technology producer. This chapter will focus on the second role companies have.

A crucial challenge, which has to be addressed in the field of ATs from an economic perspective, is the size of the market for products for people with disabilities. Very often it is claimed that people with disabilities should to be regarded as normal "*market consumers*" (Percinic, EBU, 95). However, the market size in the field of ATs is in many cases very small. In addition there is a commonly held view that the "*majority of disabled people cannot […] afford*" (Khasnabis, WHO, 27) the products developed for them. This was echoed by a comment made by a university-based app developer in the field of hearing impairments. He developed the "iSignIT"[35] app, which is designed for use in hospitals and in medical practices and which provides basic communication in sign language:

> *"So I got to this community [deaf and hard of hearing] and with the development of the application I got much closer to them and learnt a lot from them and the situation is not quite good and there was no company interested in developing for these target group, because there's no money in it" (Albrecht, Hannover Medical School, 5).*

One way of responding to the small size of the market would seem to be the high cost levels for ATs once these are classified as medical devices. This poses problems as mentioned above (Khasnabis, WHO, 51, see sect. 4.3.1). Even without this classification, costs are generally higher if a product is specifically developed for people with disabilities: *"when products appear on the market, just because they are adapted for people with disabilities, they cost five times more than a regular washing machine. And that's something that we need to overcome"* (Percinic, EBU, 144).

Another approach is to focus on devices which people with disabilities can use but which also benefit all 'other' people. In this way *"bigger markets"* (Khasnabis, WHO, 27) as well as a larger consumption level can be achieved. Moreover, this approach comes with a specific innovation potential, if technologies developed as ATs originally became successful mainstream products thanks to their accessibility features. Examples of this include the scanner or speech devices used in smartphones (Percinic, EBU, 145). Interestingly, according to the EBU, the talking function implemented now in smartphones was invented due to the pressure of legislative accessibility requirements in the USA. Today, when it comes to accessibility issues, Apple is often mentioned as a 'best-case-model' for accessible products (Tromel, ILO, 13). Although Google, too, has recently come up with

[35] For further details please visit: http://isignit.weebly.com/english.html (Accessed: 06.10.2016)

improvements making their products accessible for the blind, e.g. Google Drive which has been accessible for five years, or Google docs which has been accessible since last year (Percinic, EBU, 123). In the field of sight loss, open source products are also available that are of good quality, e.g. the NVDA screen reader (Percinic, EBU, 131).

6.5. Complementary measures in technology design and development

Turning to the technology perspective, it is important first to highlight that there is a "*twin-track-approach*" (Tromel, ILO, 55) in the field of ATs: on the one hand, specialised technologies have to be developed serving the very specific needs of people with disabilities. On the other hand, it must be ensured that mainstream devices are developed with a universal design approach or alternatively that devices can be compatible with specialised devices.

To improve the design, development, production and availability of accessible mainstream devices of good quality at reasonable cost, approaches like "universal design" as stipulated by the UNCRPD are very important. Although for several years now we have seen political attempts to bring about universal design and universal accessibility, these approaches are still not embedded in the usual technology production process. An example is the accessibility of washing machines: "*right now we have a washing machine which is touchscreen-based and I cannot do anything with it, because it doesn't have any technologies that would give me the speech back or tactile feedback*" (Percinic, EBU, 141). This example shows that it is still of major importance to "*ensure that the mainstream systems that companies purchase are being designed […] on the universal design principles*" (Tromel, ILO, 95).

The development process of technologies also has to be considered. Here the experts point to the importance to take "*the opinion and the experiences of the target group into account*". It is suggested that the affected users should be included in the development process from the outset (Albrecht, Hannover Medical School, 5). Only in this way may a technology become a "*success*", meaning that the target group is "*happy with using the application*" (Albrecht, Hannover Medical School, 27). Experiences from other groups, e.g. senior citizens, have shown that the involvement of users in a participatory technology development process is very useful in principle. At the same time such processes, however, are very time-consuming and challenging. Often they include learning processes on both sides (users and technology developers), as the following example illustrates[36]:

> *"Especially with those hard of hearing, I've got a negative experience that if you have got these men in the middle there, they are defending their interests at a very high level, not in the favour of the hearing impaired, but in their favour. And this is... I've got real barriers built up from the translators, interpreters; because they thought the application we built is a threat to them. But this is a complement as well because then they thought it is really an aid for their client. We became no... it was not possible to include interpreters into the project so we had to... we got those hard of hearing with us so the native speakers of their own language and develop with them but not with the interpreters." (Albrecht, Hannover Medical School, 31)*

However, it is not just the user involvement in the development process that is important. There is also a need for a "*proper evaluation testing*" (Baranger, Autism Europe, 42) with the cooperation of users once a technical device is established. In the interviews, this is not only highlighted in the case of ASD but also with regard to accessibility issues in the field of sight loss.

The case of ASD is again of special interest, because the development of technological solutions is still in an initial phase; however, for the past few years it has been developing very quickly. University-business co-operations are seen as an important step here, as they tend to reflect the complex needs of the users and to achieve good product quality (Baranger, Autism Europe, 42):

[36] This intention is already well described in the literature with approaches such as participatory technology development or user-led design; see e.g. Weinberger, Krings, Decker, 2016.

> *"So it's really important that clinicians and people with autism are involved in the research and development of such tools and such devices" (Baranger, Autism Europe, 18).*

Moreover, the field of ASD has very specific challenges for the technology development, which interestingly started its boom with mainstream devices:

> *"When it comes to autism, assistive technology, we don't really refer so much to assistive technology as to new technologies for autism, meaning that for several years now there is really an explosion of technologies for autism being the use of iPad or apps on the phones, computer games and so on." (Baranger, Autism Europe, 14)*

The focus of technology development in this field, which started with devices like tablets, is placed firmly on facilitating communication, e.g. with the support of pictures or type-to-speech or with apps supporting time organisation (Baranger, Autism Europe, 14). Interestingly the technology development in this field is highly individualised, with "*a lot of parents for example creating their own apps for their children*", so technology is "*made at home when they have a bit of knowledge of new technology*" (Baranger, Autism Europe, 14). Added to which, it seems that the use of apps is also highly contextualised: "*sometimes it can be really one family, one app*" (Baranger, Autism Europe, 26), so that as it stands no 'best-technology-solutions' can be easily identified. Nevertheless what would be urgently needed right now for the field of technology use in ASD, but is also reported as being helpful for other disabilities, is an evaluative overview of existing technical devices and IT products. This is not available at present (Baranger, Autism Europe, 2; Albrecht, Hannover Medical School, 9).

> *"Well, it gives a freedom to innovate in a way. But one of the main problems we are facing at the moment is that there are lots and lots of things out there and basically parents and even people on the spectrum are a bit lost, because there is so much available that it is difficult to know which apps are working or not, and which devices are the most efficient." (Baranger, Autism Europe, 16)*

With regard to new technologies in the field of ASD, there is also a debate on the pros and cons of specific devices, e.g. on the value of robots. They are seen as "*efficient for children with autism*" because "*they tend to like a predictable system-based environment and it makes them more active, and they trust more a robot for a therapy, for example, or for them it is less intimidating than another human*" (Baranger, Autism Europe, 18). In the case of apps, it was noted that they support communication and social interaction. However, these experiences can encourage "*their tendency to prefer machines and robots to interaction with real people*" (Baranger, Autism Europe, 94) or make them focus too much on computers or tablets. Finally yet importantly, the individuals with ASD still need to 'translate' the experiences they learned from technologies such as robots or applications into "*real life*" (Baranger, Autism Europe, 46).

A last stream of arguments put forward by two experts is that a future perspective of technology development should refrain from the ever-new innovating character of new technologies. This sounds like a paradox at first. However, it is evident especially for the field of AT that the implementation and social and organisational embedding of existing devices is sometimes an even greater challenge than the renewed development of technical devices:

> *"Obviously I am a researcher. I'm interested in research and development and I think still even under Horizon 2020, there is too much emphasis on trying to gain a new knowledge in states of the art, around the innovative underlying technologies and not about effective implementation of services. And with effective I would include training and support for the person with disabilities and the people delivering that support and the whole kind of infrastructure." (Cudd, University of Sheffield, 37)*

In other words, the social integration of people with disabilities does not depend on a high-level innovative technical product, but rather on the infrastructure and services put in place, or to put it differently: the technological solutions must be embedded in a societal system:

> *"The number of times you see so much money being invested in... well, take robotics for example, it's the agenda of having to have this forever innovating and highly paced innovation in the electronics industry that is really driving the agenda. And even within the assistive technology field, we would love to take advantage of some of these wonderful new technologies. If we don't fully invest in working out how best to use them, how to put appropriate infrastructure in place, we are not going to ever realize a really quality integration of people with disability into life generally and being able to be living as independently as they could. Because if we are forever playing catch up in trying to take advantage of the latest 'toy', that the engineers want to create. So I really think there needs to be some kind of policy or direction that is going to push that." (Cudd, University of Sheffield, 37)*

According to Cudd, investments in technical innovation would only pay off with more commitment and investment by research funds, not only "*in the creation of the technology [but also] in the creation of services*" (Cudd, University of Sheffield, 37). It shows that currently the "*track record*" of the integration of new technologies into societal fields is "*very poor*" (Cudd, University of Sheffield, 37). Thus, there should be a much stronger "*financial commitment to implementing solutions*". Additionally, there is a huge gap in research devoted to technology compared with that into related services: "*We are actually desperate to have much more information about how best to use technologies that we already have*." (Cudd, University of Sheffield. 41).

Such an implementation and integration perspective on existing technologies can also be connected to the needs of countries outside Europe. From a developing country perspective, there should be a much stronger focus on "very basic solutions". Such solutions could be adapted to the situation of many countries, which generally have wide-ranging technologies, as is stated by the ILO:

> *"I mean if you just look, see for instance the amazing coverage of mobile phones in some African countries, I mean, I think this sort of low cost assistive technologies for people with disabilities in developing countries, I think much more focus needs to be given there" (Tromel, ILO, 95).*

In addition, the focus on highly specialised technology bears the risk of creating greater social inequality, because high-tech devices are usually associated with high costs and can therefore only be used by a small number of privileged persons:

> *"We just look at the amount of research that might go into specific issues that may solve the situation for a rather small number of people versus the very little funds if any that are going into making the lives of people with disabilities in developing countries better. We're again having a huge gap there and a huge inequality situation." (Tromel, ILO, 95)*

6.6. Conclusions: Complementary measures by the public sector

To sum up, the results of the study "complementary measures by the public sector" indicate that there are many challenges for people with disabilities to be dealt with when it comes to ATs. Although legislative efforts were seen to be on a good track, e.g. the UNCRPD or the planned EAA, having the political system implement the rules and standards into the economy as well as the daily life of people with disabilities is still a challenge. As the results have shown, even a concept like universal design, which already has a long history, is not yet fully implemented in the daily practice of technology development in Europe.

In order to improve the utility, availability and use of ATs the experts put forward new proposals for the legislation of ATs, e.g. a specific legislation on ATs with regard to the classification of devices as well as regulative measures or new provision channels for ATs which should not only depend on the prescription by medical doctors but by medical professionals specialising in ATs (ATP).

Although there are high expectations for further technological developments of ATs, it also becomes apparent that currently there are still many challenges to address, especially with regard to the inclusion of people with disabilities into the labour market. Thus, according to the experts, there should be a much stronger focus in future on the implementation and evaluation of existing

technological solutions into relevant fields like health, education and employment. Future research and development of ATs should thus not only focus on the technical side of 'development' but should rather take the socio-technical setting of ATs into account. Thus, much greater emphasis should be placed on the connection between the technology and its actual implementation and practical use rather than on technology development and use 'alone'.

Last but not least, the success of ATs to improve the life of people with disabilities was seen to be a question of recognition and of reducing the disregard of people with disabilities in society. This is a precondition for a sound future development and diffusion of ATs for people with disabilities.

7. Conclusions – main findings and challenges regarding the future developments of ATs

In this section of the report, the main conclusions from the empirical studies will be drawn in a first step (7.1). Section 7.2, will then be dedicated to the future outlook on ATs. Based on the e results, first ideas on future trends and developments as well as their effects on the use of ATs with regard to possible policy impacts are elaborated here. The summary of these ideas along the STEEPED frame is meant to serve as a first step towards the "envisioning workshop", following the "horizon scanning" phase. Finally, section 7.3 highlights the importance of the social context in the future development of ATs.

7.1. Putting ATs in context – overall conclusions from the empirical research

The empirical results summarised in sections 4.1, 5.1 and 6.1 show the empirical complexity with regard to the availability, use and regulation of ATs. To sum up, ATs have an important function to support people with disabilities in general, including the three groups analysed. However, there are differences in AT use and availability depending on the type of disability. ATs have been used by people with visual impairments for a long time. The main concern voiced by this group is the lack of access to mainstream devices as well as to further technical advancements in the field of mobility and web accessibility. In the case of people with hearing impairments, it seems that many ATs are very well integrated into daily life, like different kinds of hearing devices for instance. This group expressed a further need for ATs, particularly in the development of web applications for sign language translation. In the case of ASD, interest concentrated on promising new technologies, such as augmented reality applications, robotics as well smaller apps for tablets directed e.g. towards time planning. While in the case of visual and hearing impairments, the development and use of ATs can look back on a longer history of using ATs, ATs have only quite recently been introduced in the field of ASD and are still in their infancy. Moreover, technology development for this type of disability in particular is challenging in view of the wide spectrum of the disorder. In some conditions of ASD, ATs are not crucially required, although they can of course have a supportive function, e.g. in Asperger. In more severe cases of ASD, no communication or social interaction would be possible without technical support. The diversity of the spectrum of impairments therefore challenges technical solutions and requires a carefully considered approach to the promotion of further technology development.

In terms of accessibility to AT in general – and this comprises information, financing as well as availability – the classification of the devices involved is crucial. On the one hand, once a device is classified as 'medical' and 'specialised' it is covered by medical regulation and will be assessed with regard to security or efficacy aspects while costs will be reimbursed by the public health or social system. On the other hand, the development process becomes more complex and time-consuming due to the high requirements that medical regulation entails. The result of these high "entrance barriers" is that in the case of ASD new and emerging technologies still await classification under present (medical) regulations. This has implications for the coverage of costs as well as for the quality control of the emerging devices.

From the perspective of people with visual and hearing impairments, it is argued that the definition of ATs should not be based solely on medical attributes. Indeed, mainstream devices that have an assistive function for people with disabilities should also be included in the definition of ATs. This at first only relates to the "labelling" of a device. Yet in a second step this might also be the starting point for a change in the way ATs are embedded in the regulatory system. Proposals are being discussed to change the legislative classification of ATs and to establish an amended classification of

ATs which would combine medical as well as mainstream devices in just one "AT-classification".[37] It is thought that this would provide improved openness of integration, quality assurance and cost coverage of different technologies, even in the case of "mainstream" devices. This could provide the added benefit of a lower price level for ATs.

Remarkable efforts have recently been made to support the development and appropriate application of ATs for the benefit of disabled people by means of regulatory and legislative intervention, especially by the UNCRPD. This could be taken as a starting point for legislative follow-up activities. However, when it comes to the practical implementation of the goals politically agreed upon, e.g. universal design or reasonable accommodation at the workplace, further efforts are still needed. One possible approach to support appropriate implementation of ATs is to ensure that people without disabilities also receive training in the technical and social aspects of using ATs, especially in the fields of health, public services, and virtual infrastructure.

In general, our studies indicate that people with disabilities have an open and optimistic attitude towards new technologies.[38] Nevertheless, the usefulness of ATs for people with disabilities could be fostered by accompanying further technological advancements with supportive legal and organisational frameworks. Technology 'alone' is not sufficient to bring about the integration and inclusion of disabled people. Additional efforts are still needed to raise awareness of the attitudinal and social barriers experienced by people with disabilities. ATs should not be regarded as a technical fix in itself. Instead, their role in their respective socio-technical context should be considered carefully to enhance their use and usefulness for people with disabilities.

7.2. Future outlook on ATs

The present report as well as in the related stocktaking papers (see Bratan et al. 2016, Mordini et al. 2016) covered the complex state-of-research on ATs for people with disabilities, not only from a technical, but also from a political and societal perspective. The following sections lead into the 'STEEPED' phase of the foresight process (see Woensel and Vrščaj 2015). This should allow the transformation of the project findings into a widely facetted picture of possible future developments, problems and demands as well as complementary policy measures in the field of ATs for people with disabilities. The categories of the STEEPED framework applied here include the differentiation into social, technological, economic, environmental, political/legal, ethical, and demographic aspects.

7.2.1. Social factors

There is a multitude of different social factors in relation to ATs for people with disabilities. Generally speaking, raising awareness of the special needs of people with disabilities as well as arriving at an open-minded society free of prejudice is essential across all specific societal fields. In line with the focus of the present report, the main challenges for 1) independent living, 2) education and 3) employment will be set out below.

1) The main future goal of ATs is to help disabled people lead an independent and autonomous life. When looking into the future, the trend towards individualistic lifestyles and decreasing solidarity in society presents a particular challenge when it comes to independent living. The traditional role of the family as a support network which today is decreasing and the trend

[37] Such a proposal was put forward by the expert of the WHO, taking an international perspective. This might, however, also serve the European context (see Sect. 6.2.3).

[38] Our empirical studies focused on the opportunities and needs for ATs in the context of people with disabilities. Our sample reveals a generally optimistic view towards technologies in all three studies. However, given the specific research focus and online-based methodological approach, people with disabilities who do not use or even oppose the use of technologies might not be represented in our studies.

towards single-households might be especially challenging for people with disabilities, as human support is at stake. Thus, the implementation of ATs in the future might imply a continuous development towards the decrease in human support for people with disabilities. The emergence of new ATs as a technological fix for disabilities might serve as an excuse to not engage with disabled people on a personal level. Thus an extensive use of technologies might even lead to social deskilling and emotional isolation in the end. Such social and emotional implications of ATs should be monitored e.g. by the health system. In terms of legislation, it is important to take care that the further development and use of ATs does not imply a cut-back of financial support related to human support for people with disabilities. Nevertheless, the motivation for developing and using ATs currently is to support people with disabilities to find ways to engage with others in daily life, e.g. to overcome mobility barriers (in the case of visual impairments), to circumvent communications barriers (in the case of hearing impairments) or to train and facilitate social interaction (in the case of ASD). It is, however, unlikely that these effects will be induced by technologies alone. In the future, special attention might be given to the human relations, also with the social environment of people with disabilities, in order to counteract possible trends towards the decrease in social relations directly attributable to the increasing availability of technological devices in everyday life.

2) ATs play a central role in the field of education, not only as devices that allow people with disabilities to learn in the first place and to take part in the educational system. Education in turn also helps people with disabilities to learn how to deal with technical devices in their everyday life. A main future trend concerning the educational sector is the increasing need of lifelong-learning and having the ability to continuously adapt to the challenges posed by the digital knowledge economy. A high level of education and professional skills therefore plays an important role in preparing individuals for an "independent life" not only with regard to e.g. employability in later stages of life, but also with regard to a self-determined and responsible use of technologies as such. It is likely that in future ATs will further support people with disabilities in learning by providing means to communicate with others or by allowing better access to knowledge resources necessary to learn throughout life ("lifelong-learning"). On the other hand this potential of ATs can only be effectively exploited if disabled people and their social environment know about the opportunities and problems of ATs in the digital knowledge economy. On a general level, political regulation is currently inadequate in dealing with the present challenges of digital devices, e.g. data protection and privacy, which are of particular relevance where health data are involved. The responsibility to comply with regulations is generally placed with the individual. This kind of responsibility also concerns people with disabilities. Education is therefore crucial for them in that it enables them to take active decisions for their rights in using digital devices in the digital knowledge economy.

   Finally, a perspective on the future trend of lifelong-learning and the digital knowledge economy should also take in people without disabilities. Some of them will be increasingly confronted with ATs in their professional lives. In this context, health-related occupations, public services as well as web-specialists in particular will need training. New certification programs as well as the further development of occupational profiles (e.g. the Assistive Technology Professional (ATP)) might be a first step towards a better integration of ATs into the lives of people with disabilities.

3) ATs are likely to play an important role in the field of employment in future. This is due to the fact that the inclusion of people with disabilities into the workforce today still appears to be highly challenging because of the high attitudinal barriers towards people with disabilities. Given the future employment trends, including the fact that the increasing global economic competition will demand a highly flexible workforce as well as a high-skill level on the part of the employees, this integration could in future become even more difficult to accomplish. Although there are many promising ATs for each of the different types of disabilities that could potentially support

the integration of disabled people in the workforce, it is crucial, in light of the trends mentioned, that ATs are integrated at workplace level in the most efficient manner conceivable. These might then be positively connected to the more flexible forms of working that we will see in the future. In view of the challenges that lie ahead in the field of employment, the following steps might contribute to improving the knowledge base on ATs at the workplace: First, research in the field of employment might provide a better understanding about the role, the needs and the use of ATs for people with disabilities at the workplace. Second, policy makers might focus specifically on companies: apart from the need to raise companies' awareness of UNCRPD and the concept of "reasonable accommodation"[39], incentives for as well as better access to relevant knowledge for companies are needed which comprise the specific requirements and needs to employ people with disabilities and the role of ATs herein. Moreover, the strategic connection to an aging workforce might be established (see 7.2.7).

7.2.2. Technological factors

When thinking of the technological future of ATs, the strong focus on high tech devices is particularly apparent. It is highly likely that research in the field of neurosciences, augmented reality and BMI will bring about new developments that also provide beneficial options to improve the quality of life of disabled people through technologically advanced ATs. Although we are able to a certain extent to identify major technological trends, it is not possible to predict whether they will have "positive" or "negative" effects in the future. It is most likely that these high-tech devices will be targeted at a technological fix of a malfunction of the human body and brain. However, we cannot be certain that these high tech devices can be embedded into the social environment of persons with disabilities in a simple or direct manner.

Generally, the results of our studies indicate that the majority of people with disabilities have a high openness towards technical solutions. However, their needs and expectations with regard to ATs are quite diverse and also very specific depending on the particular disability. Regardless of existing differences, what is common to all three groups considered in this report (visual and hearing impairments as well as ASD) is that the development of technical solutions targeted at a specific impairment, even by technologies focusing on the enhancement of bodily or cognitive functions, has to be accompanied by additional efforts directed towards the social adequateness and embedding of technological solutions.

To ensure that future technological development is guided by the needs and expectations of the disabled while also contributing to a modification of a 'disabling' environment, both concerning the actual environment as well as the virtual one, social aspects of future technology development have to be taken into account. Moreover, it would be helpful to strengthen the integration of universal design principles and participatory design in the development of ATs as well as of mainstream technologies. To this end, the support by legislative and regulatory frameworks is still needed, although important legislative steps have already been taken (UNCRPD, EAA). It might be helpful with respect to the integration of mainstream and AT development that the development of accessibility features of IT such as adding voice, as well as visual and tactile interfaces, has also proven to be beneficial for everyday applications for people without disabilities.

In general it is suggested that the concept of "technical development" in the field of ATs should switch from a pure (high) technology development perspective to giving greater consideration to the

[39] As already explained in footnote 32, 'Reasonable accommodation'" means necessary and appropriate modification and adjustments not imposing a disproportionate or undue burden, where needed in a particular case, to ensure to persons with disabilities the enjoyment or exercise on an equal basis with others of all human rights and fundamental freedoms."
See: http://www.un.org/disabilities/convention/conventionfull.shtml (accessed 06.10.2016).

interrelation of ATs within the social context they are directed to. Thus, for ATs, apart from the developments referred to above, a closer look at the actual spread and diffusion of existing technological solutions into the social context seems warranted. An evaluative inventory based on a quality assessment of existing devices, or a sound analysis of the embeddedness of existing devices into the system of social services, health care and employment would be helpful in this context.

7.2.3. Economic factors

Due to recent global economic trends, the European social model and its economic sustainability is currently greatly under pressure. This is also reflected in recent cutbacks in the health system in some European countries.

This trend is very likely to have negative effects on achieving the beneficial potentials of ATs, since the growing costs of AT are regularly addressed by disability groups as the main barrier for getting access to and making use of supportive devices. Today, ATs are regulated only inasmuch as they are categorised as medical devices. High costs very often occur for medical ATs, because the products are highly regulated by the Medical Device Directive. Production is therefore restricted to large companies, specialised in the field of medical technologies as well as long innovation cycles (time-to-market). Added to which, there are a lot more costs connected to ATs than just the purchase price. Training and connected services should also be considered within a "full-cost-model" of ATs. Hence there is the risk that high costs for ATs, which might not even be fully transparent at first glance, could further widen the gap between disabled and non-disabled people as well as between people with disabilities living in different countries across Europe, depending on that country's economic strength. Joint strategies for the efficiency and cost-transparency of the different health systems in Europe might be needed to prevent such disparities in Europe.

The high costs for ATs as medical devices is the reason why disability groups plead for a stronger consideration of ATs not only in a medical sense, but rather as "consumer goods" or "mainstream devices", since this would lead to lower costs of the devices. This in turn would allow more disabled people to benefit from ATs ("economies of scale"). On a political level, a renewed classification of ATs that does not focus exclusively on medical devices in terms of financial support would be a helpful in this respect. Yet even when ATs are regarded as a mainstream device it is by no means certain that companies will make the accessibility of new products a priority. In the future, there might also be a stronger focus on the economic benefit of accessibility solutions. There are interesting examples where the need to meet accessibility demands has eventually also led to successful innovations and benefits for other societal groups, e.g. digital voice control. Here, an innovation took place which was "successful" in economic terms, while at the same time meeting the special needs of people with disabilities. Such an approach towards innovation would also be in line with the European paradigm of Responsible Research and Innovation (RRI) as set into practice for the current EU research framework programme Horizon 2020. A guideline for research and technology development in terms of fostering the development of AT and research on ATs in relevant aspects of the development of mainstream technologies could be included in research funding programmes.

7.2.4. Environmental factors

The destruction of the environment and overuse of resources presents major challenges for the future. This is particularly clear when we consider the future development with regard to climate change. The relation of ATs to environmental factors has not been explicitly explored to date. ATs have an effect on the environment in a number of ways namely in terms of energy and resource use: However, these are on a par with the environmental impact of technical devices in general. In terms of energy use, the energy efficiency of devices should be taken into strong consideration. Moreover, there is also a need to analyse whether energy consumption rises with the increasing use and application of ATs. In terms of resource use, ATs, e.g. communication devices, are built using raw materials like rare

earths elements. Here, the impact of such resource use on the environment should be carefully considered.

The future development does not necessarily include more high-tech or low-tech devices that might be either very energy or resource intensive (high tech), or the opposite (low tech). Further research is needed into this area because it also appears to be possible that high-tech might also mean intense in terms of human resources, but with a lower consumption of energy and natural resources. Instead it is expected that "medium tech" devices will be developed and integrated further. Environmental factors like energy and resource use should be integrated when applying universal design principles.

7.2.5. Political factors

The future integration of the UNCRPD into national law and compliance will be a major challenge for the future, requiring political activity in the next few years to improve the framework conditions for ATs in different aspects of life. National implementation of the implications of the convention as well as the improved integration of ATs into everyday life, education and employment still need to be promoted. There is political agreement that continuous efforts are needed to ensure that the use of ATs can support the inclusion of people with disabilities in fields such as the field of employment where ATs make a significant contribution to the goal of "reasonable accommodation". However, limited public resources might increase the competition for public support from different topics interest and stakeholder groups. In future, the political willingness to invest into research on ATs and in a barrier-free, enabling environment, as well as in education and employment programmes might be affected by this trend. As economic costs will matter a lot, it seems likely that the limited financial leeway will favour quick-fix technological solutions rather than complex solutions that require organisational reform and the joint effort of a wide spectrum of different actors.

An area where new legislation is proposed concerns the regulation of devices. Currently ATs either fall under the Medical Device Directive, or else they are largely unregulated. This applies to the quality assessment of an AT as well as the coverage of costs, which is particularly relevant to the field of ASD. A new legislative approach towards ATs that aims to overcome the distinction between "medical" and "mainstream" devices by building up a sound classification of ATs as well as specific regulative measures might also help to alleviate the current shortcomings on the regulation front.

Generally speaking, it is crucial that there is continuous political awareness of the topic of ATs and disabilities even after the implementation phase of the UNCRPD has been finished in a first round. A regular evaluation of the success and impact of political measures derived from the UNCRPD in a comparative European perspective in a five year-cycle might be a measure not only to test the effectiveness of the implementation but also to keep the topic on the political agenda.

7.2.6. Ethical factors

The technological progress towards high-tech devices increasingly directed towards their integration into the human body and brain as well as the enhancement of human functions greatly challenges ethical considerations on the limits of the physical integration of technologies into the human body and brain as well as the enhancement of human function beyond what is considered 'normal'. This implies a range of ethical considerations set out below.

Several ethical questions are likely to arise if further investments are made leading to ATs that are progressively integrated into the human body and brain (embodied ATs). In what way(s) do embodied ATs limit personal autonomy? What is 'seen' through a bionic eye? Is this 'reality' or do ATs 'modify' reality? Do embodied ATs eventually alter intellectual functions? In what way(s) can those technologies be misused or abused by others, e.g. to manipulate users of embodied AT (e.g. in the case of BCI-technologies).

Another train of thought on embodied ATs deals with problems of human enhancement. What happens to society if ATs enhance the abilities of people (with disabilities) beyond the 'normal' level? And what does this imply for the future understanding and definition of 'normality'? Moreover, with the advancement of devices which substitute 'malfunctions' on a body-basis, there is the risk that social measures to foster an enabling environment for people with disabilities, are cut back because people might think that human weaknesses can be 'fixed' on an individual body basis simply by using technology. In turn, it will be more and more difficult for people with disabilities to decide to opt out of ATs that interfere with their body or brain as they might then be stigmatised and denied access to employment and social activities (see e.g. the ongoing controversies on cochlear implants).

On the one hand, ethical considerations concerning the future would be an important topic for public discourse to deal with such developments. On the other hand, more specific measures are also needed to properly integrate ethical factors on ATs. Ethical monitoring should therefore become an integral part of the development and design process of ATs. Moreover, ATs that give rise to public controversies should be subjected to an ethical Health Technology Assessment. In terms of the development of a future research agenda on ATs, people with disabilities as well as their representing organisations should also be involved when it comes to setting guidelines for research and implementation.

7.2.7. Demographic factors

The ageing population will pose enormous future challenges in economic and political terms, not only in terms of rising costs to public retirement funds but also due to their increasing demands on the health and care sector as well as their needs in the fields of independent living and employment.

Added to which, from a health perspective, it is reckoned that the ratio of disabilities in society will increase overall, since more disabilities occur in old age. Thus, in terms of demography, the connection between ATs for an ageing population as well as disabilities is often made. At first glance such a co-use of the technologies for the elderly seems very appealing. However, closer examination shows that old-age-users have needs with regard to ATs that are very different from users who were born with disabilities. Users, who get a disability at old age, often face more barriers in respect of ATs than disabled users who have familiarised themselves with ATs since childhood. In addition, age often coincides with multiple impairments that present a modified demand for 'multifunctional' ATs. Moreover, devices for the elderly focus mainly on independent living and, depending on the age, partly on workplace support, while devices for people with disabilities are targeted at the whole spectrum of supporting social integration.

Nevertheless, from a strategic perspective there are good reasons to see both fields – ATs for elderly and ATs for disabled people – as being connected, e.g. in order to raise public awareness of the availability and benefits of ATs. This might be especially helpful in the area of employment. If workplace adjustments are developed to serve an ageing workforce, the specific needs of people with disabilities might well be included here. This connection at workplace level seems to be especially important as the main barriers to employ people with disabilities are reported to be attitudinal barriers, followed by a lack of knowledge about ways in which to include ATs and people with disabilities. Increased general awareness of specific needs of workers and employees on the part of both the public and private employers might also help people with disabilities to be integrated into the workforce.

7.3. Shaping ATs and the social context

Given the trends on a political, social but also technical level identified above, ATs for people with disabilities will play an increasing role in the future. In order to shape this role in a positive manner in the best interest of people with disabilities, their social context should receive special consideration.

The need for social embedding of technology development in the field of ATs can be identified on three levels.

- First, still more emphasis is needed on the co-creation of technologies with technicians and people with disabilities working together to make sure that future technologies truly meet the needs of people with disabilities and are well-perceived by them.
- Second, there should be a stronger public focus on existing technological solutions. The development of sound strategies and approaches to evaluate as well as to connect existing, often medium-tech, devices with related services, and also continuous training of occupational groups are much needed. This is of particular relevance with view to the financial problems of health systems in many European countries that result in spending cutbacks in this area. Focusing on questions such as "What is already there?" and "How can it be implemented most efficiently?" might be a way to respond to these economic challenges in a constructive manner.
- Third, the role of ATs as such should be considered in relation to the wider societal context of people with disabilities. Many problems people with disabilities are confronted with do not originate from the level or quality of ATs. Instead, there are many socio-political challenges to address in order to improve the lives of people with disabilities across Europe, such as overcoming the strong attitudinal barriers that still exist towards people with disabilities.

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9. Annex: Explorative scenarios for the future of AT

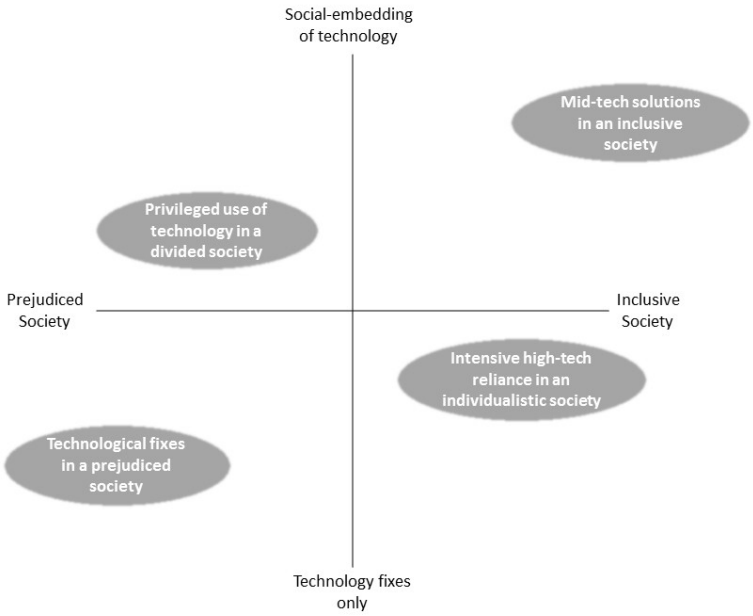
Scenarios are consistent and plausible images of the future (Schirrmeister and Warnke 2013; Schwartz 1991; van der Heijden 1997). They are mental models of different possible futures that enable reflection on upcoming opportunities and risks. Scenarios can be a very helpful tool for robust policy design and decision-making. In Jean-Claude Juncker's paper "White Paper on the Future of Europe" (European Commission, 2017) for example, different ideas are set out for a course of action to take in time for the European Parliament elections in June 2019, against a backdrop of uncertainty regarding the future of the European Union.

This annex presents four explorative scenarios regarding the situation of people with disabilities and the role assistive technologies (AT) play as a tool for inclusion in 2050. Their purpose is to provide a broad European picture on the potential attitude towards disability and technical innovations, the availability of technical and human support and other important factors for the use and non-use of AT with regards to inclusion, which can then reveal the developments that need to be monitored in order to adapt political strategies at a European level.

The scenarios presented here are based on the key findings from the three stocktaking papers to explore important issues around AT and inclusion: "Current trends of assistive technologies" (stocktaking paper 1.1), "Regulatory framework and health and demographic perspective" (stocktaking paper 1.2) as well as "Perceptions, needs and opportunities" (stocktaking paper 1.3). The scenarios are designed to contain the most important insights from the study. They were developed in an iterative process: As a first step, a 360° envisioning meeting with experts from all participating institutions, the Scientific Foresight Service of the EP as well as invited external experts took place at the European Parliament on 31 January 2017. The main social concerns of AT were assessed along the STEEPED framework of social, technological, economic, environmental, political/legal, ethical and demographic aspects. This allowed us to reflect on the insights already generated and to consider them with regards to possible long-term impacts. The outcomes provided a valuable basis for a dedicated scenario-building workshop on 1 February, also in Brussels. Here the entire project team brainstormed on aspects of different possible futures. Four distinct scenarios were developed and written up following the workshop. These drafts were then discussed in several meetings and refined further.

Two key influencing factors emerged, which were used to orientate the scenarios (see Figure 1.1, below). First, the openness of society towards the "other", i.e. people who do not conform to what is considered "normal", and second the extent of technical advances and their social embedding. The economic situation, access to the welfare system, prevalence of disability and the situation regarding specific areas of life (employment, education, living situation and public spaces) were also considered as important impact factors. While the titles of the scenarios are structured along the two axes, it is important to consider that the selected pairs are not necessarily co-dependent. Economic factors emerge as critical but not determining factors, as different consequences regarding the availability and reimbursement of AT are possible. In order to manage complexity, we do not include reference to the differences between Member States of the European Union. In each of the scenarios, the state plays a slightly different role: In scenario 1, politics has mostly been guided by society while in scenario 2 a primacy of economics is present. In scenario 3, the state is liberal and in scenario 4, it takes on a redistribution role.

Figure 1-1: The four scenarios along the axes of society and technology



The scenarios are ultimately speculative. They are not predictions of the future. Their purpose is rather to explore opportunities and challenges, to stimulate reflection and debate, to communicate important issues around the role of ATs in the field of disabilities and to contribute to shaping a desirable future through anticipatory policy making today.

Scenario 1: Mid-tech solutions in an inclusive society

By 2050 European societies have overcome tendencies towards marginalising minorities such as people with disabilities that were particularly present during part of the 2010's. Societies have matured into being fully inclusive and very accepting of deviations from the "norm", to the extent that no clear distinction is being made any more between "disabled" and "non-disabled people", rather viewing everyone as being on a spectrum of ability and taking on different positions on this spectrum throughout life. Low- and mid-tech AT are widely used to enable inclusion.

During the 2010s, the disconnect between politics and people, the rise of populist nationalism across many European countries and a very real threat of disintegration of the European Union, eventually led to a strong democratic counter movement and reactivated many European citizens' interest in politics. Attempts of marginalising minorities were fiercely opposed by many Europeans, and the governments that had successfully defeated anti-democratic and discriminatory movements gave special emphasis to societies becoming more inclusive. The view that every individual should be able to realise their potential and be able to contribute towards society (whether economically, socially, intellectually or artistically, etc.) gained strong momentum. Participation in the welfare system shifted from allowing certain opt-outs, e.g. due to alternatives such as private pension funds or healthcare insurance, to becoming obligatory for all citizens.

Economically, the effects of climate change led to a shift away from economic growth regardless of ecological impact towards reaching climate goals and promoting sustainable growth. This has led to a reduced growth-rate across Europe.

Increasing life expectancy in combination with a low birth rate have meant that a significant proportion of people have continued working well into their 70s and individuals, including people

with disabilities and older people, have become more valued for their skills and experience. With a higher prevalence of disability in the older age groups, far-reaching measures are in place to accommodate the needs of these groups. These include both human and technical support as well as a favourable regulative framework that aims to strengthen diversity and prevent discrimination.

In compliance with the Convention on the Rights of Persons with Disabilities (CRPD), new legislation has been passed to ensure that employers do take inclusion seriously and funding has been increased to allow and promote participation of people with disabilities in all aspects of life. Children with disabilities mostly attend mainstream schools and are encouraged to enter further education. Their inclusion is seen as valuable and important not only for them, but also for children without disabilities because it helps both groups to develop skills in interacting with a wider range of people. Sign language is being taught in the majority of medium-size and large schools. Educational institutions make extensive provisions for students with disabilities, allowing an increasing number of people with disabilities to acquire the necessary skills to enter gainful employment. Except in rare cases of people with certain mental impairments who benefit from accommodation and support in specialist institutions, throughout Europe people with disabilities now live in the community. Independent living is supported and encouraged through funding to adapt housing and to receive human support. New buildings are constructed to cater for people with all levels of ability. As part of smart city developments and mindfulness towards the different needs of citizens, using public spaces has become much easier for people with disabilities. However, collaboration and negotiation in designing solutions between different groups has become increasingly important because of conflicting views and needs. For example, while textured pavements are essential for blind/ visually impaired people, they can be inconvenient for wheelchair users, and vice versa.

Automation and digitalisation of industry have advanced the development of more personalised AT. Many devices are now tailor-made according the individual measurements, characteristics and needs of the user. As a result, the market for AT has increased and costs of many AT have fallen. This applies mainly to mid-tech solutions such as augmented reality travel devices (providing additional sensory information to normal navigation devices), with advanced high-tech solutions (e.g. personal robots) only being available through the welfare system in exceptional circumstances. The need to make AT available to an increasing number of people means that priority is given to affordable devices. This has led to regional variations in terms of access almost disappearing. Meeting the needs of people with disabilities through the right mix of human and technical support has been helped through certified AT advisors being available to people with disabilities and their families.

Key scenario characteristics:

- Inclusive society with comprehensive welfare system and regulation for diversity and against discrimination of vulnerable groups.
- High prevalence of disability due to ageing society.
- Ability and disability are being considered along a spectrum on which different positions can be occupied at different stages of life, "normalising" disability.
- Good level of participations of disabled citizens in all aspects of life.
- Widespread use of low-tech and mid-tech AT solutions for inclusion.

Opportunities, challenges, dilemmas:

- Increased market size of AT.
- Measures for different disabilities in the public space can conflict each other.
- Inclusion as a positive counter-movement for tendencies towards fear and rejection of the "other".
- Economical cost of fully inclusive society is unknown.

Scenario 2: Technological fixes in a prejudiced society

Fears surrounding immigration and terrorism have led to European societies becoming increasingly inwards-focused and intolerant of people not conforming to a "norm". A superiority of able-bodied people over people with disabilities is seen as natural and inevitable. Medical advances and technological fixes have greatly reduced the prevalence of disability. Those who do live with a disability have been at the receiving end of budgetary cuts and discrimination. Access to AT that do not cure AT is limited and there is little innovation in this field.

Several European countries have left the European Union and ties between those remaining have been reduced. The single market still does exist but movement of people is restricted. European solidarity is no longer seen as a successful and desirable concept and instead there is a general view that countries and individuals are best off if they guard their own interests and are responsible for their own welfare. As a result, the welfare system has been drastically reduced. While employees can manage in this model due to the savings they are required to set aside for healthcare and retirement, the unemployed often struggle.

Economic performance is strong, with European countries reaping the benefits of their investments in "industry and services 5.0" (i.e. automation of industry and services) and being at the forefront of new developments. With the need for human workers drastically reduced, side effects include higher unemployment rates, especially among low-skilled, elderly or disabled workers. Measures to counter climate change have also been cut back. While not welcomed, these effects are mostly seen as a worthwhile price of continued prosperity.

Overall, the number of people with disabilities has decreased due to medical and technical advances. Genome sequencing is routinely available to couples planning to start a family and extensive foetal screening detects any genetic and other defects, drastically reducing the number of new-borns with disabilities. The majority of existing disabilities with a known genetic origin have been cured through genome editing, and many disabilities with degenerative origin can now be treated though advanced medical technology such as smart eye and ear implants and regenerative medicine. Other forms of so-called human enhancement include advanced brain-computer interfaces to repair cognitive, sensory or motor functions. As a result of these "fixes" and preventative measures, there is high social and economic pressure to "repair" disabilities and there is little societal acceptance of people who, despite these advances, live with disabilities. Consequently, the number of people requiring AT is much lower than before. However, not all people can afford the often costly technologies, and "fixes" are not always available. However, there is little funding for social, healthcare and other support, including funding for non-curative AT. People with disabilities are required to make extensive co-payments if they wish to use or require AT that exceed very basic functions. Their participation in society through AT therefore is strongly dependent on their financial status, which is usually linked to whether a person with disabilities is able to work or not. As a result, those who cannot afford human enhancement or whose disability so far cannot be "fixed" can easily become outcasts in this "survival of the fittest" society. A small number of NGOs is trying to cover the most serious shortfalls of the welfare system.

Regulation previously passed to further equality and inclusion of people with disabilities has been partially reversed and violations are rarely penalised. R&D funding is focused on curative AT and there is little activity and innovation in non-curative AT.

Educational establishments are now heavily geared towards competition and identifying the most successful students. Pupils and workers without disabilities who can afford it, even utilise human enhancement to improve their performance in education and work. Schools generally make little accommodation for the small number of students with disabilities. Most disabled children therefore attend special schools, and this is seen as the most efficient way of educating them. Gaining a university education can be difficult to impossible for students who require special arrangements.

Accommodation in institutions has also experienced an increase and there is little support for enabling people with disabilities to live independently. While public spaces are now much more accessible than they were in the first few decades of the century, this is mainly a side effect of practical considerations, such as accessibility of buildings for the transport of goods, rather than the inclusion of disabled people.

With the rise of digitalisation, the gig economy and new models of remote working, people with disabilities can succeed in some professions, especially if they are freelancers. For knowledge workers who work remotely, there can be good opportunities regardless of disability. However, due to the often unstable nature of their work, remote workers are not always able to put aside sufficient means for healthcare and retirement. However, this has allowed a sub-group of people with disabilities to participate in employment without their disability interfering or even being known. Especially people at the high functioning end of the autism spectrum have benefitted from remote working and in some professions they are thought to make up a significant proportion of workers. People with more noticeable disabilities who are not able to benefit from the possibilities of remote working often experience discrimination. Their level of societal inclusion is poor and they often experience financial hardship and emotional difficulties as a result.

People who are able to compensate their disabilities through human enhancement sometimes have an advantage in the job market because they were able to acquire skills not usually possessed by those not enhanced. In this race of constantly improving oneself, those who cannot compete due to the type of their disability or lack of resources for enhancement are being left behind.

Key scenario characteristics:

- Prejudiced society with limited welfare system.
- Low prevalence of disability due to medical and technological advances and little social acceptance of living with a disability.
- Reduced demand for human workers due to automation, increasing competition in the workplace, which can disadvantage people with disabilities.
- Limited participation of citizens with disabilities in all aspects of life.
- The AT market is focused on products that can "cure" disabilities by more or less fully restoring functions while there is little development in terms of non-curative AT.

Opportunities, challenges, dilemmas:

- Technical and medical advances have prevented and cured many disabilities.
- A race for self-enhancement in a very competitive world could have various unintended consequences.
- With much reduced numbers of people with disabilities, these are being left excluded and disadvantaged.

Scenario 3: Intensive high-tech reliance in an individualistic society

Technological advances have contributed to good economic performance of most European societies because of efficiency gains and exports. Population ageing has continued and the prevalence of persons with disabilities has increased. With technologisation being pervasive in most areas of life, the medical model of the compensation of deficits has regained prominence and disabilities are often expected to be "fixed". The onus of inclusion tends to be on the individual rather than on society.

Technological progress has brought many benefits to European societies, among them continued prosperity, medical advances and a reduction of accidents in manual labour. However, technology is also often seen as a panacea for many problems, and self-enhancement to counter perceived

intellectual, physical or social shortcomings is popular. Its use is wide-spread in education, employment and social life.

The cure of disabilities with a genetic origin through gene therapy was banned for humans because of unpredictable risks. However, availability of effective AT as well as good welfare coverage mean that people with disabilities have the opportunity to reduce or compensate the effects of many disabilities through technical solutions. High-tech AT are available on the welfare system because they have proven to be cost-efficient. At the same time, this has also led to the expectation that people with disabilities do use these solutions and there is an implied hierarchy of AT over human assistance, meaning that people are expected to compensate their disability primarily with the help of AT. Funding for human assistance has been cut back and is only available in exceptional circumstances. In general, there is a lack of focus on non-technical services.

In education and the workplace, a good infrastructure for the use of AT has been established, allowing people with a wide variety of disabilities to participate. While younger people can benefit from this focus on self-sufficiency because they are able to gain more independence through technology, especially for older people with multiple disabilities and who are not able or not willing to use AT and already suffer from a lack of social contacts, this can increase social isolation.

Public spaces are also well equipped to cater for the needs of people with disabilities. Again, this is mainly of a technical nature and can be too taxing for some, especially for elderly people. Homes are generally built to accommodate a wide variety of ability and disability and funding is available to upgrade older buildings to the same standard. This contributes to the majority of people living with disabilities being able to reside in the community. However, those who cannot manage with only technical aids need to either rely on family support or go through a lengthy process to be granted additional personal assistance.

AT have largely lost their stigma because of their association with self-enhancement through technology and in some aspects have even become "fashionable", especially those at the high-tech end. People with disabilities are sometimes seen as being at the forefront of technological progress. With society's appetite for more technological advances, people with disabilities can however be at risk of becoming guinea pigs for "first use in human" before the technologies eventually trickle down into mainstream consumer goods. In general, there is a high level of convergence between the mainstream market and the market for AT, leading to further innovations. Some AT such as powered exoskeletons, which can support those wearing them lifting heavy weights, are widely used in professions such as nursing and construction and are spreading to other fields. The AT market also benefits from good standardisation and compatibility across different European countries.

Most AT are networked and there is heavy reliance on the power and ICT infrastructure. Incidents of cyber crime involving AT have continued to plague users and developers alike. There is also an increasing convergence between AT and medical devices, opening up new opportunities but also increasing the risk of criminal activities and threats to people with disabilities.

Key scenario characteristics:

- Individualistic society with a welfare system that is focused on self-sufficiency through technology.
- Self-enhancement is common and people with disabilities can be at the forefront of technological advances, AT have lost their stigma.
- The high-tech environment interfaces well with AT, resulting in a good inclusion of people with disabilities in all aspects of life, as long as they use technology.
- Risk of a lack of human encounters for those who are elderly or less mobile.

Opportunities, challenges, dilemmas:

- Good availability of high-tech AT due to demand.
- Neglect of the social embedding of technology.
- Convergence between the AT and mainstream market.
- Reliance on networked technology comes with an increased risk of cyber crime.

Scenario 4: Privileged use of technology in a divided society

European societies have become socially and economically more divided, partially as a result of economic hardship and now follow a US-style system. While one part of society has access to the welfare system and supports the principle of solidarity, another part has either opted out by their own choice or fails to qualify for access. While those who are well off or who are covered by the welfare system are privileged in terms of access to AT, the economically deprived have very little access. People with disabilities often fall into the latter group.

A struggle between opposing concepts of solidarity and individualism has led to an increase in societal division in terms of attitudes, political beliefs and participation as well as access to the welfare system. As this could not be resolved, existing divisions increased and became reflected in the European social model. Broadly speaking, most European societies consist of three quite distinct socio-economic groups with little social mobility: The elite, which is affluent, often globally mobile and does not wish to contribute to a national welfare system; the middle class, which is the main contributor and beneficiary of the welfare system, being able to rely on a safety net with relative comfort in case of hardship caused by illness, disability, unemployment or other difficulties; and the lower class, which has failed to secure access to the welfare system and has only limited access to state support. Poor economic performance means that there is mostly little prevention and cure of disabilities. The number of people with disabilities has therefore increased overall due to ageing, with people in low-skilled jobs at particular risk because of the often manual nature of their work. This group as well as the younger disabled are most likely to end up in a financially precarious situation.

Societal division is also reflected in the way disability is viewed. While one group believes in a society based on competition and performance and sees few opportunities for people with disabilities, another group believes in an inclusive society that offers opportunities for all. Access to AT is strongly affected by this paradigm and a distinction can be made between the technology-privileged and the technology-poor. The technology-privileged elite is able to acquire the most high-tech devices and can also afford extensive human support, allowing for very personalised solutions to cope with disability. They are early adopters of advanced AT, giving them a strong influence on the market. Eventually, some of the AT pioneered by the elite trickle down to the other groups; however, this occurs with a significant delay. The technology-privileged middle class benefits from some AT being adopted early by the elite but in general only has access to more established solutions. In terms of coverage, there is also a slight prioritisation according to people's contribution to society, meaning that employed people with disabilities have better access to AT than those who are unable to work or are retired. The lower class is mainly technology-poor, having access to only basic AT and little influence on the AT market. In contrast to the other two groups, the lower class relies more heavily on family support and charitable institutions. NGOs are very active in this field and their efforts counter-balance the lack of state support to some extent. The AT industry also offers them some options for trade-offs, e.g. access to advanced AT in return for extensive data sharing. People who could otherwise not afford AT are therefore effectively forced to surrender important aspects of their privacy or to act as volunteers for testing new devices. This is seen as an exploitative business model by some but is also quite popular.

Some people are retired and have age-related disabilities or mild impairments and are able to work. These fall into the technology-privileged group, while a significant proportion of people with more severe or uncommon disabilities are technology-poor.

Societal division can also be observed in education and the living situation of people with disabilities. Faith-based educational establishments, for example, support the inclusion of people with different levels of (dis)ability and have sufficient means available to provide AT necessary to achieve this. With state-run establishments there is greater variation, also depending on the regional political situation. For those who are part of the welfare system there is good support for living in the community, whereas for the underprivileged this can only be achieved if sufficient family support is available, otherwise there are few alternatives to institutional housing. Public spaces feature a minimum of accessibility but there is great regional variation.

Key scenario characteristics:

- Poor economic performance has caused societal division, which has also become embedded in social structures such as the welfare system.
- View on the inclusion of people with disabilities varies greatly.
- Wide variation in terms of inclusion in public life.
- Use of AT only available to the privileged.

Opportunities, challenges, dilemmas:

- Despite economic hardship, a proportion of society favours an inclusive approach towards people with disabilities.
- The situation of people with disabilities, including their access to AT, varies greatly.

Conclusions on the explorative scenarios

The scenarios described above have outlined four different futures for the inclusion of people with disabilities and the role of AT. In order to exploit the scenarios for policy options at EU level, it might be useful to identify areas which are of particular relevance for the future in terms of inclusion and the use of AT:

- Awareness-raising of the value of societal diversity and promoting tolerance for people who deviate from the "norm",
- Measures for social inclusion in terms of AT reimbursement, standardisation, regarding employers, educators, public transport, ICT accessibility, etc., promoting social embedding of technology,
- Benchmarking between countries and imposing penalties for non-compliance with European legislation.

The focus of this report is the outlook for assistive technologies for people with disabilities. It comprises three comprehensive empirical studies: a quantitative Europe-wide online survey of people with disabilities, a set of interviews with experts on the subject, and a stakeholder workshop. The report also proposes a set of explorative scenarios for the future of assistive technologies.

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