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Widening the interpretation of assistive devices – A designer's approach to assistive technology

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Abstract
Assistive technology (AT) has traditionally focused on being ergonomic, functional and useful. The main aesthetic design maxim has been discretion, as in disguising or hiding the device. However, abandonment and non-use of acquired assistive device (AD) among people with disabilities is also a documented problem within the 'discretion' approach. A recent approach is to make the assistive technology products more 'mainstream'. This paper explores various approaches to design of assistive devices. We suggest a widened interpretation of AT that can be categorized into 'enhancing assistive devices (EAD)' and 'restorative assistive devices (RAD)'. The presentation gives an outlook on AT suggesting that designers should choose an appropriate strategy rather than limit themselves to a (mainstream) dogma. Its contribution lies in examining what impairment is (in and for design) and how the designer should approach some of the challenges of this design field.

Keywords: Assistive technology, stigmatization, inclusive design, human factors, visibility

1 Introduction
Design of assistive technology (AT) is a sensitive field. It provides the developers with complex design challenges with respect to functionality, usability and emotional aspects. There has also been, as seen in the history of hearing aids [1], an apparent consensus that AT should be as discreet as possible. However, many people in need of assistive products or devices (AD) choose to not use them [2], [3] due to perceived stigma and negative associations. So other aspects are just as, or in some cases even more, important than functionality. New ways of thinking about these products have appeared, and an increasing, yet today still insufficient, amount of research has been carried out, suggesting new approaches for design of ADs.
This article explores the 'mainstreaming' design approach towards disability by examining literature on assistive technology and stigmatization. Based on the literature the article will present main terms and concepts of AT. Mainstreaming is found to be a good approach in many cases. However, mainstreaming is a relatively vague term and the success of mainstreaming depends on many factors. Thus, we suggest a broader interpretation of the

term assistive devices that can be divided into enhancing assistive devices (EAD) and restorative assistive devices (RAD).

1.1 Methods

This article is based on an integrative literature review, i.e. it summarizes and analyses literature of a specific field [4]. The review is based on literature searches done mainly in the database Scopus and in Google Scholar. Search words used (table 1) have mostly been chosen aiming at newer design approaches to assistive technology products. Emotional aspects related to the design of the ADs, such as stigma related to AT, are important motives for these new approaches, and literature about stigma and AT has also been used. These design approaches are mainly of a relatively newer date, and because of this most of the literature is from the last decade (2000-2012). However, important older sources have been found by looking through citations.

A great deal of literature was found on design of AT, usage of AT, stigma related to AT, design of medical devices, robots and smart house technology. The paper reviews articles covering AT design and/or stigma related to AT in general, while its main objective was to investigate how a designer can reduce stigma associated with AT. Medical devices, robots and smart house technology can be seen as types of AT and probably sources to stigmatization as well. However, the focus on the more general AT that is worn and used more or less all the time, also outside the home, and in public spaces was motivated by the insight that stigma might be most obvious through such 'daily' products and by the ambition to get holistic overview of the field. The field is mainly viewed from a western cultural perspective.

Literature from designers' perspective and from health workers' and other perspectives was included, to get a holistic overview. Reviews of the topic and more original articles have been used. The book "Design meets disability" by Pullin (2009) [5] was analysed, as it is an interesting contribution to this field of design.

Table 1: Search words used in various combinations in literature search.

Assistive technology	Assistive device
Design	Stigma
Aesthetics	Appearance
Emotions	Use of …
Medical device	Inclusive
Universal	Health care
Use	Abandonment
Process	Development

2 Definition of Assistive Technology and Devices

Assistive technology (AT) has existed as long as human beings have created objects to aid them in various tasks. However, in the western world today AT is associated mainly with software, services and assistive devices (AD), all products that help people with some sort of impairment in the performance of various everyday tasks otherwise made difficult by their disability(ies). A frequently cited definition of AT is from the 1988 passage of Public Law 10-407 (USA), "The Technology-Related Assistance Act for Individuals with Disabilities".

AT devices are here defined as "any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities" [6].

This definition relates mainly to the terms ‘impairment’ and ‘disability’, and the differences between them. Disability is defined by the International Classification of Functioning, Disability and Health as “a negative state when an impairment, activity limitation or participation restriction exists, preventing execution of a specific task or action” [7]. Impairment is here interpreted as an individual source of disability. Impairment can further be explained as “an injury, illness, or congenital condition that causes or is likely to cause a loss or difference of physiological or psychological function” [8][9].
Ripat and Woodgate present a definition from “a social model of disability perspective”. Here “disability resides outside of an individual and is a result of oppressive societal practices and environments that create disabling conditions” [10][7]. Within the social perspective the motive of AT can be seen as a part of modifying society and aid the user in overcoming barriers, and thus remove such barriers. The disability is here seen as caused by the situation. A disability related to impairment will also depend on context. For example, a person with impaired hearing experiences no disability while reading a book, whereas communicating with others might make him feel disabled. Pullin [11] takes this further, and suggests that we might all perceive or experience our self as disabled in certain situations: “If we already have our hands full, our ability to carry out a task demanding dexterity is affected”. On the other hand, the international definition opens up for AT taking on a restorative purpose; it is not only about removing barriers, but also about reducing the effect of the impairment.
The ideological discussion of these approaches is important in relation to the change in acceptance and attitudes towards disability in society. However, a designer should attempt to embrace a holistic approach and acknowledge disability as caused by both impairment and by barriers created by society.

3 Emotional Aspects

3.1 Who are the “users”?

The terminology in the field of AT is a potential mine field of political correctness and can be a stigmatizing factor in itself. As Pullin points out, the word ‘user’ can be a misguiding word, especially to the designer, as it implicates that an AD is merely used [12]. He emphasizes that an AD is also owned, worn and carried, with all the various ways in which this affects the person and people around. However, this article refers to people using, wearing, owning and carrying ADs as ‘users’.
Finally, AT design challenges the designer with some user aspects that are not necessarily an issue in regular product design. The potential user groups are many and varied, and often consist of heterogeneous populations with different sets of beliefs, values and behaviours regarding disability and AT [13]. Moreover, people do not necessarily buy these products because they want to but because they have to, which leaves designers with a special responsibility to ensure that products and services are well adapted to a wide variety of users.

3.2 AT and stigma

3.2.1 Stigma

Crocker, Major, and Steele [14] define stigma as: "the possession of, or belief that one possesses, some attribute or characteristic that conveys a social identity that is devalued in a particular social context”. Stigma may have different effects, such as: “(a) less than ideal treatment; (b) disrupted social relations; (c) person avoidance, anxiety, and depression; and (d) a distorted self-image and resulting poor self-esteem” [15].

3.2.2 AT's effect on stigma

The abandonment, non-use or avoiding/postponing acquisition of a beneficial AD is a documented problem [16, 17]. In some cases, stigma is the most important factor for this [18]. So how may an AT give a person a feeling of being stigmatized? Smith and Kent claim that "inherent in stigmatization is a perception of normality and, by implication, the risk of being identified as not normal" [19]. Thus any AT that contributes to the user's feeling of not being normal may make the user feel stigmatized. Some specific areas that may contribute to stigmatization are "device aesthetics and cosmesis, gender and age appropriateness, social acceptability" [20].

Reluctance towards using AT is often based on the added negative and unwanted attention it attracts [21]. In many cases the AD might be the only factor revealing a person's disability, such as hearing aids. However, the added attention to or awareness of a disability may be experienced as constructive and positive [22], leading to positive social interactions in forms of discussions, relations and awareness. A person's perception of this added attention and its nature is affected by a number of factors, such as the appearance and aesthetics of the AD, as mentioned by Parette and Scherer [23], and the context in which it is used. Globalization and the increasing multi-culturality of many nations challenge the designer with users with potentially very different values, beliefs and perceptions of AT and disability. People may also accept various levels of attention towards their disability depending on the context, and this might call for AD's with different levels of noticeability.

Summarizing, stigma related to AD is mainly a social issue, and is a feeling of being "unusual" in a negative way. So how can a designer meet these challenges in the light of the multitude of user needs and various emotional aspects?

4 Designing Assistive Devices

Design of ADs has traditionally been focused on functionality and usability. However, other aspects are apparently just as, or in some cases even more, important than functionality. Newer research addresses the emotional aspects related to AT, and the role design, including appearance and aesthetics, plays. A review of some of this literature follows.

4.1 A tradition of discretion

The main approach to the aesthetics and appearance of the ADs is to create discreet products that do not attract attention. This is seen in traditional skin-coloured hearing aids. The ADs are often nonetheless noticeable and sometimes such attempts even increase the stigma [24].

4.2 Inclusive and universal design

The decades following WWII saw an increase in focus on inclusive and universal design. Inclusive design is said to have its origin in "barrier free design" [25], and the environment was increasingly modified with solutions specially adapted for the disabled. As the design field developed, various guidelines and models were created. The seven principles of universal design from 1997 [26] are popular guidelines. However, these focus almost exclusively on usability and functionality. The overall aim of inclusive design is to target and make the product usable by as many users as possible. The design process is often based on Benktzon's capability pyramid model [27] with "severely disabled people" at the top (figure 1, see p. 5). One either designs for the top of the pyramid, trying to include as many users as possible downwards (top-down), or the other way around.

Figure 1: Benktzon's capability model [28]

4.3 Design against stigma

As the emotional aspects have attracted more attention, new ways of approaching design of AT have appeared. These focus mainly on making the AT more "mainstream" [29, 30] and "socially acceptable" [31]. Shinohara and Wobbrock (2011) suggest a new approach to the design of AT, "Design for social acceptance (DSA)", "considering not only functionality and usability, but perception, misperception, stigma, affect, and aesthetics to maximize a device's social acceptability" [32]. Pullin (2009) refers e.g. to glasses as a perfect example of an AD gone mainstream. In the 1930s glasses were prescribed as a medical device and users were often stigmatized [33]. This has changed, and glasses are not only socially accepted today, but also by many regarded as a fashion accessory. Looking at the user disability pyramid (figure 1), we can place most sight impairments in the lower part of the pyramid, as "minor impairments". As the mainstream market can be located in the bottom of the pyramid [34] glasses as an AD are very close to this field.

Pullin [35] stresses fashion as an interesting and possibly fruitful way to go to make an AD more socially accepted. He refers to Aimee Mullins with her prosthetic legs as a good example regarding AD and fashion. Mullins has appeared on the cover of fashion magazines and works as a model, "highlighting" her prosthetics rather than hiding them. In the case of glasses, these have also been "promoted" by various contemporary idols during the process of mainstreaming (for example John Lennon). "Promoting" ADs through celebrities may be one ingredient in trying to mainstream an AD.

Few literature sources address the content of the design process regarding emotional aspects of Næss and Øritsland [36] do this by presenting a design approach focusing on affordances (possibilities of use) and analogies. By finding existing mainstream products with affordances equivalent to the ones needed for the AD, one could use this instead of a specialized AD: the use of walking poles instead of a regular cane changes the peers' perception of the user from "old and fragile", to "old and sporty". If a fitting analogy is not found for the AD in question, a "styling approach" is suggested. The intention is to "design for life style rather than disability".

As stigma is highly related to the unusualness of an AD, making the AD "mainstream" would seem to be a good approach. However, many factors contribute to making an AD appear unusual, one of these being age appropriateness. This relates to both the impairment itself (impaired sight is more common among older people), and the related AD (glasses are more common among older people). Many of the issues that make an AD stigmatizing must be addressed to make an AD mainstream. Based on the findings in this chapter, these include:

- Age appropriateness.
- What product category it is presented as to the consumers.
- The size of the potential market.

- Available resources in the developing process.
- "Promotion" of the AD.
- Cultural aspects.

It is tempting to add "functional similarity to existing mainstream products" to this list, based on the suggestions from Næss and Øritsland. However, this is also a question of context and appearance, as will be addressed in the following chapter.

5. Discussion: Implications for designers

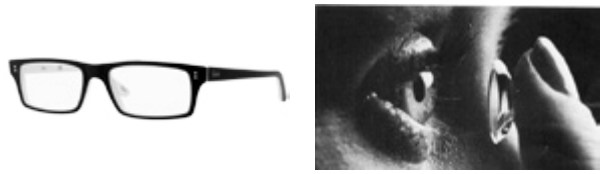
5.1 Mainstreaming or not?

'Mainstream' is in many dictionaries synonymous with 'normal'. A mainstream AD will make the user seem more "normal" prevent stigma and may also make the disability more socially accepted [37]. As many ADs higher up in the pyramid are used by only a small number of people, people around will not be familiar with the ADs unless it is a product that is also available in already existing mainstream markets. This may make it difficult to 'mainstream'. Even though an existing mainstream product is found, the context of use may nevertheless be less than normal. For example, an old person may use walking poles outside and thus seem sporty instead of frail. However, using walking poles inside a house is not 'normal'. It is also interesting to note that though glasses have become a fashion accessory many people do prefer lenses, or no glasses at all. Furthermore, not everyone necessarily considers 'mainstream' positively. Various subcultures, for example hipsters and punkers, dislike mainstream, and want to distinguish themselves from 'normal society' [38].
In the mainstream market the consumer can normally choose whatever product suits his or her lifestyle and needs. This may be a characteristic of mainstream products that could be adopted and emphasized in design of AD. Findings in this article show that AD consumers have many different needs, and finding an AD to suit one's individual needs is important. This may be achieved by user customizable products, or offering a range of different products.

5.2 Widening the term of AD (sensory AT)

As with universal and inclusive design, a goal might be to make an AD valuable also to people without any disability. The more people who use the product, the more "normal" it becomes. To give the product value for users without a disability, it should also hold attributes/characteristics that are valuable to a person without a disability. For example, if a hearing aid improves on normal hearing, or enables you to listen to music and at the same time hear sounds around you, this might make it interesting also for people without impaired hearing.
Hannukainen and Hölttä-Otto also touch this example. They further encourage designers to see users with some sort of disabilities as "lead users", explained as "users that currently experience needs still unknown to the public" [39]. Looking for needs among such "extreme users", this could as well be professional athletes, can help the designer discover latent needs among "normal" users and customers that would not be discovered examining only the "normal" users. This is presented as a way of driving innovation in the mainstream consumer market [40]. It could as well be seen as a way of creating mainstream acceptable products.
A common definition of AT such as the one in "The Technology-Related Assistance Act for Individuals with Disabilities" (section 2.1), is beneficial in a social and public perspective. However, for a designer, embracing a more holistic approach, it is tempting to widen the term AT to account for all devices that in some way aid human beings in performing some kind of task, regardless of whether they are disabled or not.

Table 2: Widening the term "assistive devices" to account for RADs and EADs.

Enhancing assistive devices (EAD)	Restorative assistive devices (RAD)
	

With this somewhat expanded definition, a substantial part of the products we create become assistive devices. However, a difference may be found in the aim of the device and the way it aids us in performing an activity or task. The ADs covered by the official definition can be said to have a restorative (or compensating) function, as they aim to aid the user in coping with disabilities related to physical or mental impairment. This article suggests that these devices be addressed as 'restorative assistive devices' (RAD).
On the other hand, the article will name as 'enhancing assistive devices' (EAD) devices that in some way enhance a human body function and/or the performance of an activity, physical or mental, compared to a "normally functioning" state.
In table 2, this is exemplified by various products affecting the function of sight. Glasses or lenses are used to compensate or restore the function of sight. Glasses and lenses are thus examples of RADs. Microscopes and binoculars on the other hand, are designed to enhance sight, and are examples of EADs. Sunglasses are basically EADs, as they have a protective function that enhances the eyes' tolerance of strong light. However, sunglasses with magnification will have a restorative and an enhancing function, and are EADs and RADs.

Figure 3: Potato peeler from OXO.

We have not seen this distinction addressed in any literature we have found so far. We found the distinction quite helpful in analysing the various aspects of AD design. A simple product like a potato peeler may serve as an example of this distinction. The OXO peeler (figure 3) was given a handle specifically designed with motorically impaired people in mind. However, the peeler also became popular among people without impairments as it turned out that the new handle was an improvement for all users. This potato peeler has restorative as well as enhancing attributes. Its enhancing attribute lies in its value as a tool for peeling vegetables more effectively than with just using the hand. This "enhancement" of the hand's "normal" function makes the peeler a valuable device for all people who need to peel something. However, this particular peeler distinguishes itself from other peelers in its good ergonomics, providing motorically impaired people with an improved grip that makes it easier to handle the peeler. Thus, the peeler's restorative attributes lie in its good ergonomics. The OXO peeler is a good example of inclusive bottom-up design, making a mainstream product available to users higher in the user-disability-pyramid.

A product's transition from being solely an RAD to also having enhancing attributes is very interesting. Prosthetic products show this very well. Prosthetic limbs may aim solely at restoring the basic functions of the limbs, or as seen recently, provide the wearer with new or enhanced functions such as the ability to run faster or jump higher than what is possible on normal human legs due to suspension in the prosthetics. Could one approach to inclusive design be that the product should hold both restoring and enhancing attributes, thus making it valuable also to people who are not disabled? If this leads to more people using the product, it may reduce the stigma associated with it.

5.3 Hidden or not

An important aspect regarding AD and stigma is visibility. As we have seen, "mainstreaming" may be a way of reducing the noticeability of the AD and thus of the disability. Mainstreaming a product can thus be a way of more or less "hiding" a product in plain sight. Other ways of making an AT product less noticeable is making it invisible in use or camouflaging it as or in another product. These approaches are rarely mentioned in the literature studied in this article, maybe because this is more in accordance with the traditional discreet approach towards AT design. However, although similar to the traditional approaches of discretion, they should not be dismissed. Based on the findings earlier in this article, some reasons for this can be:

- A multicultural society might bring other cultures with a more tense relationship towards disability and AT.
- Not everyone is as strong mentally as Aimee Mullins. People acquiring impairments later in life might need time to get used to it.
- Out of sight, out of mind". Invisibility might move the thought away from the disability/impairment.

Table 3: Four levels of visibility

SHOWING		**HIDING**	
1. Signalling A product that is supposed to draw attention, as the user wants to communicate something with people around.	*2. Visible* The product does not try to stand out, but neither tries to hide.	*3. Camouflage* The product is either designed to look like another product, or it is integrated in another product.	*4. Invisible* The product is not noticeable at all by people around.

As the goal often seems to be to reduce the noticeability of the AD, it might prove useful to know how the physical visibility of the product affects this. Considering the physical visibility of a product, this article divides visibility into four different levels, as presented in table 3.

The following examples illustrate how these levels of visibility may apply to ADs:

5.3.1 Signalling: white cane

In some contexts it might be advantageous to make people aware of one's disability. The AD might contribute to this, either through appearance or use, by having signalling characteristics. The white cane does this, both through use and appearance, as people quickly understand that the user is blind, and can take necessary precautions.

5.3.2 Visible: traditional asthma inhaler
If the user does not have any problems with stigma, there is no reason to make it less or more visible. A traditional asthma inhaler is normally only present when used. It is also difficult to hide, due to the nature of its use, and thus the best option might be to neither hide it nor making it signalling.

5.3.3 Camouflage: safety alarm
A person who is starting to develop dementia may need a safety alarm. Because the person does not want other people to know that she/he has dementia, a camouflaged safety alarm, for example designed as a necklace or integrated in a watch, could aid in this issue.

5.3.4 Invisible: hearing aids
Some people with impaired hearing, such as adolescents, might be afraid of being stigmatized. Hearing aids that are truly invisible in use might be a valuable alternative.

These are only examples of the various levels of visibility. Letting the user customize the level of visibility through different "visibility modes" for various contexts may be useful.

6. Conclusions
The brief literature study on AT and AD, shows that users experience as stigmatizing an AD that attracts unwanted and negative attention to his or her impairment or disability. This emotional aspect of AT gives the designer of such products design challenges exceeding those related to more ordinary (/most other product groups) products. Aspects to consider in dealing with the challenge of stigma related to the use of AT are

- Multiculturalism
- Consumers' need of choices
- Different needs and wants
- Contextual aspects
- "Out of sight, out of mind"
- Available resources

One approach currently discussed in AT design is the idea of mainstreaming AT and AD, which entails reducing the noticeability of the AD, or creating positive attention. Mainstreaming an AD is however easier said than done, and few suggestions and guidelines for this have been found in the literature studied. There are several other approaches to reduce noticeability/visibility, which the designer may consider.

This paper divides the visibility of the product into four levels:
1. Signalling
2. Visible
3. Camouflaged
4. Invisible

This paper further suggests an extended interpretation of ADs that will be useful to the designer. Widening the definition of AD to account for 'all devices that in some way aid human beings in various tasks', in combination with the four levels of visibility, will broaden the solution space and hopefully add to the creativity of the designer. One can divide ADs into two categories, "restorative assistive devices (RAD)" and "enhancing assistive devices (EAD)". Most of the devices traditionally defined as ADs can be labelled "restorative

assistive devices" (RAD), as the purpose of these are to compensate for or restore some kind of impairment, physical or mental. "Enhancing assistive devices" (EAD) are devices that improve or enhance some kind of physical or mental body function from a "normal functioning" state.
Incorporating both restorative and enhancing attributes in an AD might give it value to people without impairment The widened interpretation of ADs, including RADs and EADs, and the levels of visibility, are first suggestions from this paper. Ongoing research further explores these aspects and looks at how they can be applied in design practice. A combination of the aspects, such as suggested in table 4, may be good. Just as important as exploring these aspects, is acquiring more knowledge about them and preferably find a method for choosing the appropriate strategy. The list of aspects regarding stigma and cultural aspects of AT may constitute a starting point for this.

Table 4: Combination of RAD/EAD and the visibility levels.

	Showing		Hiding	
	Signalling	Visible	Camouflage	Invisible
RAD				
EAD				

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