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Old Habits as a Resource for Design: On Learning and Un-learning Bodily Knowledge

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***Abstract*—There are many reasons why artifacts and systems are difficult to use in practice. In this paper, we investigate such difficulties as a basis for design for ease of use. Difficulties may stem from the artifact or system itself, or from the artifact or system in use in its real use context. Technology introduces new tasks, and both learning new tasks and unlearning old habits can be challenging. We discuss how users' previous knowledge and habits can be used to understand how and why an artefact is difficult to use. This understanding is useful for designing artefacts that are easy to use. We end the paper with presenting a conceptual framework for design for coherence and simplicity from the users' perspective, where users' habits and bodily knowledge act as resources for design.**

Keywords—usability; habits; automated behaviour; automation; participatory design.

I. INTRODUCTION

Usability is often defined as the ease of use and learnability of an artifact, sometimes narrowed down to specific users in a specified use context having specific achievement goals (e.g., ISO 9241). But what does "ease of use" mean more precisely? We have tried to find out what it is that makes some artifacts difficult to use for some users. This paper builds on an earlier paper [1] and expands the empirical material as well as the depth of discussion of possible reasons why some things turn out to be difficult to use. Our aim is that knowledge about how a piece of technology is difficult to use can be used as a basis for designing solutions that are easy to use.

Much of the research on artefacts that are easy – or difficult – to use is based on Nielsen [2], who lists five aspects of usability: learnability, efficiency, memorability, low error rate, and satisfaction. A more elaborate list is given by [3], who present eight aspects: consistency, universal design, feedback, closure of dialogs, reversal of action, control, error prevention, and memory load. Except for universal design, all the aspects are general and concern the design of the artifact seen as a stand-alone context-independent thing. Our research shows, however, that it is difficult to achieve a total independence of contextual design elements – it is impossible and even unwanted: "All products make some reference to either products extant during previous generations or products from different companies or product families." [4]. Such references are important to build on when trying to understand how to use the product. Even well-designed stand-alone artifacts can be difficult to use for users not sharing the contextual competence pre-supposed in the design. We have seen this in our and our colleagues' research, where we focus on elderly people and the technological support that is supposed to enable them to live independently in their homes longer [5].

The paper is structured as follows: Section II gives a review of literature about problems in using technologies. In Section III, we present two studies of use of technology: the use of public services like tax, and the use of common home artifacts like remote controls or mobile devices that need charging. Section IV summarizes the challenges we have identified in our research. In Section V we discuss the competencies users need to use an artifact, and how such competencies are experienced and embodied. Section VI summarizes what we have found to make things difficult to use. In Section VII, we turn to design for ease of use: we discuss how we can go from knowing about the difficulties people have using an artifact to design of an artifact that is easy for them to use. We divide the discussion in two parts, addressing first how designing with users can end up with design results that are easy to use, and lastly we discuss a more general approach to automation that addresses how the design itself creates user problems and how these can be resolved. Section VIII concludes the paper.

II. PROBLEMS WHEN USING TECHNOLOGY

A close study of people using IT artifacts reveals that they often find technology difficult to use (e.g., [6]). A classic study is Suchman's study of use of a Xerox copy machine [7][8] demonstrating how operating a copy machine was difficult due to the difference between the scripted "plan" in the copy machine and the users' (situated) understanding of copying. Another classic is Gasser's study of how people work around computer systems that do not fit the work they need to do, which shows that people carry out their jobs also with non-supporting artifacts [9]. Even when an IT system works well, it may not work well together with other systems [10][6]. Just using more than one system can create problems as they are often not designed as parts of a larger coherent system or network [11].

A different set of studies shows that an artifact can be used in different ways, e.g., Barley's classic study [12] of the introduction of a CT scanner into the radiology departments at two different hospitals. Although the same technology was introduced, the cooperation and social organisation of the radiology work developed differently. In one department the radiology work became more decentralised with delegated responsibility; in the other, responsibilities became unsettled and the relation between the radiologists and the technicians became less close. This study shows that the same artifact can be part of very different socio-technical practices.

For designers, it is particularly interesting to study the non-users of an artifact. They are, however, very difficult to get hold of (unless they can be located in a particular place, e.g., an organization). Orlikowski [13] and Star and Ruhleder [14] describe how people are not using a computer system with good reasons, indicating that contextual matters (like reward systems) may offer good reasons for not using a system – irrespective of the usability aspects of the system itself. If the system appears to hamper the career of its users by having them share things that are important for their own careers, they will not do that. Even a small uncertainty about how data can be used and by whom may result in not sharing those data [15].

As a way to get access to non-users of the public service web pages of the tax authorities, Verne [16] studied people calling the tax authorities' call centre. She found that even if tax rules are complicated most of the questions concern relatively simple tax issues and that the callers' problems are concerned with interpreting and applying the rules to their own life. Similarly, [17] studied single parents' use of mandatory online services for communicating with the public service and found that some single parents believe that the civil servants do not inform them of the benefits they are eligible to. This causes the single parents to interact with the case handlers through traditional channels such as the telephone or personal meetings. In this example, lack of trust in the relationship with the civil servants led to non-use of a mandatory online service.

Several studies of assistive technology in the homes of elderly people have been carried out, see e.g., [1][18]. Noting that much of the technology is not used, Greenhalgh et al. focus on the subjective opinions and experiences from the elderly's own technology use. They call for a different design approach in order to develop technology that supports the elderly in achieving what matters to them and enhances the quality of their life [19]. Many of the current solutions aimed at elderly users are imported from other application areas and not designed specifically for an elderly user group, e.g., touch screens [20].

We also see that the level of automation of some of the tasks seem to confuse people. Cummings [21] describes automation with reference to human control (decision-making) and information: at the lowest level of automation the computer offers no assistance and the human takes all decisions and actions. At the highest level of automation, the computer decides everything "and acts autonomously, ignoring the human" (p. 2). Fully automated systems may seem like a tempting solution to making systems easy to use but artefacts that act autonomously can pose problems even when they are not used in any active sense – in particular when errors occur [22][23][24].

We know a great deal about systems and artifacts that are not easy to use, but what is less clear is how to get from knowing what is difficult to designing a solution that is easy to use. In this paper, we have set out to do this: we analyse a set of studies of difficult-to-use-technologies in order to arrive at design ideas for easy-to-use solutions.

We report from a set of qualitative interpretive case studies [25] aimed at developing new knowledge on how to design technology [26] that will be experienced as useful and easy to use in practice. As we have been interested in finding out why and how artefacts are difficult to use, hence we have chosen a qualitative rather than quantitative approach to evaluate technologies. Studies of use in situ give a better basis for answering these questions than usability studies where a test person is given a set of pre-defined tasks to solve outside of the real use context.

III. DIFFICULT-TO-USE

Investigating people's reasons for not using an artifact is very instructive for designers: there may be a range of logical and sensible reasons for not using an artifact or using it in "wrong" ways. In this section, we report from our studies of users and non-users of computer technology.

A. *Badly designed Systems and Artifacts*

Some artifacts are difficult to use because of the design. Verne's [22] study of citizens' calls to the tax information call centre showed that many callers had tried to use the online tax self-service without succeeding. Listening in to 474 telephone calls over a period of 22 months gave a basis for understanding the callers' problems. Examples of problems ranged from not finding their PIN-code to more specific questions like a woman receiving welfare benefits and had tax deducted from her pension, but being aware that welfare pension was tax-free she asked for help in correcting the tax deduction. From eight in-depth semi-structured interviews with call advisors and their managers we learned about their work practices and their experiences of the callers' issues. The call centre advisors often walk the callers through the self-service web site and commented to us that the online services were not user-friendly. To callers who do not know which numbers in their tax card they need to change, there is no difference between filling out a paper form and reporting online. But online tax self-services may introduce additional complexity for the citizens [22].

Tax in Norway is almost fully automated. Throughout the year, employers deduct tax from their employees' wage payments and forward to the tax collector. This deduction is specified in the tax card, which is produced by the Tax Administration based on last year's tax return form and information provided by the citizen if needed. The tax return form is produced semi-automatically by the Tax Administration based on input from employers, other public agencies and the citizen [27].

Because tax laws and regulations vary a lot between countries, examples from the tax area are often complicated. We therefore offer a similar but simpler case: online student registration for classes [28]. New students at the University of Oslo are assigned a personal online account when they register. At first this account contains no services or information; the student can only use it for paying the entrance fee to the university. When the fee is paid, the status of the student is changed to “active student” in the system, and services such as signing up for classes become available. Many students do not understand that more services become available after they have paid the fee, and report the non-availability of services and information as an error [28].

A second set of examples can illustrate our point further. The examples are taken from an evaluation study of IT technology for independent living in an apartment building adapted to elderly people [5], involving sensors, alarms and a tablet connected to the Internet. Our investigations started in 2012 and include a number of studies carried out by colleagues and students in our research group. The studies document that many of the technologies do not function well in everyday use. The tablet, for example, has a wall-mounted charger station designed to charge while showing the time (Fig. 1 upper). However, the slot for positioning the charger in the right position is narrow and difficult to see, and many users do not manage to mount it right and do not discover this until the battery is empty [29]. Also the very common stove alarm is difficult to use for people in wheel chairs or people who find it difficult to hold the turn-off-switch while stretching and bending over the stove to turn the alarm off (Fig. 1 lower).

These examples illustrate that artifacts and technology themselves can create problems for their users.

B. *The Artifact in Use*

Some artifacts are difficult to use because of the use context and the use situation. Verne’s [22] study of callers found that many people call because they need help with matching the rules and regulations with events and circumstances in their life, not because tax regulations and rules are complicated. Her data includes several examples of simple tax rules that may represent problems when applied to a person’s life situation.

* When citizens move, they are required to send a notification of address to the Population Register. A citizen called to ask if he needed to send a notification to the tax authorities when he changed his job. (The answer is no.)

*A newly retired citizen needed guidance on how her new status affected her personal economy and on which of her different types of incomes are subject to which taxes.

*A house owner who earned money from renting her house asked if renovating costs could be deducted from her tax. She rented the apartment to her son, and wondered how the rules were applied in this case.

In all three examples, the life situation or circumstances of the citizen triggered the phone call. In the first example, the caller’s life situation was irrelevant to the tax regulation in question, but in the two others the life situation needed to be matched with the rules and regulations by a tax expert.

Again our second set of examples is everyday technologies used by elderly people in their homes. We found that these types of difficulties arise when people use technologies that they do not have previous experience with. One example is an active woman, approximately 85 years old, who uses a hearing aid. She is well organised, educated, and has had an active work life, and she uses everyday technologies like her TV effortlessly. Her occupational therapist has tried to teach her how to use an amplifier for her hearing aid: a wireless microphone that amplifies sounds and submits to her hearing aid.

Figure 1. Welfare technology: Tablet charging (above), stove alarm (below).

The “accessory pen” is easy to use once fitted to the hearing aid: the manufacturer says that it is “zero hassle” because it is “completely simple to use, with one-click connection of receivers and fully automated settings” [30]. Using the pen involves pushing one small button in addition to charging it. However, the old woman finds the pen difficult to use. She does not remember how to use it from one therapist visit to the next. She wants to charge it before she uses it, but forgets. The occupational therapist (whose job it is to adapt support devices to individual users) has suggested that she instead can charge it after she has used it, and that she can keep it in the charger until the next time she needs it. But in the “old days”, keeping devices in the charger could be dangerous, and the old woman therefore does not want to do this – even if the therapist assures her that with this equipment there is no danger. The old woman often finds her hearing aid amplifier not charged when she needs it.

A lady aged 70-something said that she was “not very experienced with technology” when we interviewed her about her use of technology. During the interview, she told us about her use of her TV with several remote controls, her iPad, and a variety of apps, including an app for buying online bus tickets and one for cloud storage of family pictures. She used FaceTime on her iPhone but considered

Skype to be too difficult. Skype was installed on her PC and she considered everything concerned with the PC to be too cumbersome. She avoided using it, but used her iPad and iPhone every day.

C. Other's Doings

Some technology problems are caused by factors outside the user's control, e.g., by actions or errors made by third parties. Some callers to the tax information call centre had a problem having their welfare support reduced because the welfare agency "tidied up their systems" and deducted 50 % of the benefits because of a missing tax card. The tax authorities receive many calls from people who have not received a tax card in the mail, but this is often their own doing (or rather: not doing). However, in one case the street address had been changed by the municipality, and since the caller had not moved she was not aware that she needed to send a notification of change of address.

A more complicated case was a young man who had received a bill for penalty tax for underreporting his income two years ago. His employer had gone bankrupt and his reported income was disputed. There was no employer who could confirm the callers' claims, and he had no documentation of his version of what had happened. In principle, he needed to document the non-event of not underreporting income. The advisor helped him by suggesting steps to take to retrieve documentation and proceed with his claims in his case with the tax authorities.

The smart home technologies in the apartment building for elderly people had automatic electricity saving. However, the first winter everybody experienced that the apartments were very cold, and the elderly people (who normally need higher indoor temperatures because they do not move much) had to get help from the janitor service to correct the temperature. It took a long time to find out that some of the basic calculations for the electricity system were wrong resulting in faulty temperature regulation in the individual apartments [23]. We (the authors) work in a smart building ourselves and have experienced similar difficulties when trying to identify the reasons for bad temperature regulation mechanisms. When using artifacts that are part of a larger complex system, the problems that a user experiences may very well be the result of other people's activities or errors.

IV. DIFFERENT CHALLENGES

Difficulties using artifacts can have several sources: the artifact itself, the artefact-in-context, and shared artifacts that others use and interact with. The users are often unable to distinguish between these sources.

Difficulties that stem from the artifact or system itself pose challenges for users, that are afraid to make errors or reluctant to use cumbersome technology. Such challenges can be met with various practical measures to stimulate and enhance use, such as moving the technology to a place where it is easier to reach, as in the case of the turn-off switch for the stove alarm, which is difficult to reach and the positioning of the tablet charger (see Fig. 1). Users can be trained in using online services, another practical measure towards the challenges posed by difficult technology (see e.g., [31]).

Difficulties that stem from the artifact-in-context or in-interaction pose a different set of challenges. Difficulties stemming from the artifact-in-context originate in challenges with relating the technology to the users' own life situation or circumstances. In order to do their own taxes in a competent way citizens need to learn and to understand the tax rules and regulations and understand how their life situation matches or not matches with concepts from the rules. Active use of an accessory hearing aid requires that the user establishes a new practice that fits into her life and that she can follow up without help from the occupational therapist. To address such challenges, a user may need external help to explain and interpret rule systems or technologies.

Difficulties that stem from others' actions and interactions are the hardest challenges to meet. It seems that errors that stem from other people's actions are particularly difficult to understand as they often surface in unexpected ways and need some kind of "debugging" to be comprehensible. This kind of debugging requires special competence and can be time-consuming. External help is often needed to disentangle difficulties that stem from complex interactions [27]. And often there is not one best solution [14].

We sum up the kinds of difficulties in Table I, and indicate what kinds of challenges they pose.

TABLE I. DIFFERENT KINDS OF DIFFICULTIES WITH ARTIFACTS AND SYSTEMS, AND THE CHALLENGES THEY POSE

What is difficult?	**Kinds of difficulties**		
	Artifact	***Context***	***Activities by others***
Examples:	Holding the turn-off switch. Positioning of the charger. Online tax self services	Personal economy when retiring. Tax deductions for renting out a house to family. Tax card when starting a new job	Bankrupcy by an employer. Welfare agency "tidies up their systems". Errors made by subcontractors.
Challenges:	Practical measures: moving a charger, teaching.	Matching artifact with own life situation or circumstances	Disentangling interactions and complexities

Even though the challenges that meet the users are different, the general feature is that users need experience from previous similar situations in order to be able to differentiate between approaches to resolving the difficulties. The competence for addressing problems can be gained in many ways.

V. COMPETENCE

Competence, as the ability to do something successfully or efficiently, is important for using technology. The examples in Section III show that competence can concern the design that makes the operation of the technology difficult (III.A) as well as the adaptation of the technology to the actual situation (III.B). In both cases, the users have to do fitting work [9] in order to use the technology

A. What we Know

A usability test of a video conferencing system showed that users who did not have the same technological experience as the designers (which in this case was an iPhone) did not understand the interaction mechanisms and had problems operating the system [32]. Langdon et al. [4] discuss this problem on a more general level, showing that "similarity of prior experience to the usage situation was the main determinant of performance, although there was also some evidence for a gradual, age-related capability decline." (p. 179). They conclude that in their test of driving a new car "there was … some clear evidence that experience may be more influential than age" (p. 189). Docampo [33] has identified four technology generations: electro-mechanical period, remote control era, use of displays, and use of layered menus, basically distinguishing between before and after 1960. The generations affect how people learn new technology and are visible as a discontinuity of errors and task timings between the generations.

Previous experience is a salient feature that builds self-efficacy [34]. According to self-efficacy theory for human agency, belief in one's own competence and mastery is important for succeeding. In their study of the effects of training programs in computer use for older adults, Wild et al. [35] found that after one year of consistent computer use the participants reported reduced levels of anxiety and increased self-confidence in their abilities to use computers. Participants with mild cognitive impairments were less likely to demonstrate increased efficacy and competence. This is in line with our own empirical findings. We interviewed an occupational therapist, who had the experience that elderly people with mild cognitive impairments were able to learn new practices, but they would need much training and follow-up from her.

Langdon et al. [4] suggest that "*prior experience with similar products and product features is a strong predictor of the usability of products over the wider range of capabilities. This similarity results from experience with same brand, or functionally and perceptually differing products, provided that key functional features and visual appearances are maintained. . … In particular, in the absence of prior experience of a product interaction interface, or with the appearance of product features, users of all age groups apparently resorted to a means-end or trial and error based approach that was slow, repetitive and error prone.*" (p. 190). Hurtienne and Langdon [36] suggest a continuum of knowledge sources starting with 1) innate knowledge like reflexes and 2) sensorimotor experiences like speed, gravity (early childhood learning), 3) culture (everyday life), and 4) expertise acquired in a profession or hobby. Knowledge about tools crosses these "levels" of knowledge. They suggest that knowledge residing on the sensorimotor level of the continuum is basic to most people and is acquired early in life. Knowledge from culture or professional life differs.

B. How we Know

Langdon et al. found that previous experience provided guidance on how to carry out their tests: "Memories relating to the experience of products will be stored in the long term memory and the ability of the central executive to find the relevant knowledge will depend on the cues provided and the level of previous experience." [4:182]. They conclude that their older test-participants were not able to use the technology, which "is consistent with the idea that they had no previous experience to provide guidance on how to complete the trials, rather than being of lower cognitive capability as a result of ageing." [4:190].

Using technology is also a bodily experience. Höök [37] discusses bodily ways of knowing in her study of the challenges she experienced when learning the English style of horseback riding based on her background in riding Icelandic style. Competence in and experience from horseback riding resides in the body and is expressed by more or less automatic bodily reactions and responses to external events. She uses her experience from learning a new riding style as a basis for reflections on how to design for bodily experiences.

There are subtle differences in how the rider interacts with the horse within these riding schools. Communication with a horse is mainly bodily as the rider gives signals with her legs and hands, but also less explicitly with body posture and movements. The horses are trained to react differently to signals (from the legs, hands, body posture) from the rider. In the English riding style, the rider aims to not disturb the horse with her movements because the horse is trained to move independently based on previously given signals, for example to trot in a circle. The rider aims to sit in a "loose" way on the back of the horse. In the Icelandic style, the rider will need to push forward with her bodily movements and put tension into the horse to enable an unusual gait such as the tölt.

Höök [37] describes how she needed to practice again and again with constant feedback from the instructor to be able to learn the new movements, positioning and interactions. Even though she cognitively knew and understood how she was supposed to move and position her body, it was difficult to *do*/*perform* the new movements at the right time.

C. Learning and Un-learning

Learning new movements and ways of communication implies unlearning the old ways [37]. Unlearning bodily ways of knowing implies consciously and deliberately practicing *not* doing the usual activity and instead practice something new. Having learnt how and when to perform a new movement is different from practicing the old habits. Unlearning bodily knowledge requires conscious cognitive work before it becomes a habitual and automated practice.

Höök's movements for performing Icelandic horse riding were automated while the new riding style was not. The transition required that she spent conscious effort to unlearn the old and learn the new.

Automatic thoughts and behaviour occur without any need for conscious effort as "[m]ost of our thoughts and behaviors tend to be automatic or have automatic components, and for good reason. These processes are fast, allowing us to do things like drive to work without having to think about how to turn the steering wheel each time we get into a car" [38: 991]. Our conscious attention can be directed towards issues that need it more. Such "automaticity" is a result of practicing and repeating an activity over and over again, often coupled with an external event that will later trigger the automatic thought or behaviour. Automaticity occurs on low cognitive levels.

For our purposes in this paper, automaticity and habit plays the same role in describing repeated behaviour that does not require any conscious attention or deliberation. Habitual activities may be triggered by environmental and contextual cues [39]. If a situation requires flexibility and change, strong habits may often emerge as errors. Conscious change away from habitual behaviour is demanding, and people act according to old habits when they are distracted, under time pressure and with limited ability. Older adults were less able to modify habitual behaviour [39].

An example of deep automaticity may happen when using modern hearing aids, where the wearer can train his or her brain to filter out noise from the sound that s/he wants to hear in order to get the most out of the hearing aid. The brain needs some years to re-adjust, and middle-aged people will benefit from starting to use the hearing aids before it is strictly necessary. People who do not start using them until their 70ies may experience that their brains will be very slow in adjusting and they may experience the hearing aid as insufficient and unpleasant. The brain needs time to allow for automation that enables the filtering activity to take place outside of the conscious brain activity [40].

As an example of automation of symbolic interaction we will refer to a woman in her seventies, who told us about her technology use. Our informant is retired, and in periods of her life she has been seriously ill and received treatment. But now she is active in her community with activities and organisations and she is active in her home. She does not have a smartphone and often experience problems when writing sms-es. She asks her husband to finish her sms if she needs help. However, she is the one who masters the remote control for the TV. She says (with a smile) that she has to, because her husband rarely watches TV. Her son gave her a simplified remote control for her birthday, which she never uses – she took it to be a prank and has not taken it as a serious artifact. She has no problems using the usual TV remote control (Fig. 2).

Changes in rules and regulations as well as in the technology for doing taxes introduce new tasks for the citizens. In 2008 submitting the tax return form was made optional in that Norwegian citizens could just accept the figures that was already gathered by the tax authorities and presented in a pre-completed form. Accepting was done by a non-action: by *not* making changes in the pre-completed form. Hence, learning to differentiate and understand when to report changes has become a separate task. Many of the callers were not aware that they did not have to send in a paper form, and that they could report online [16]. In practice it can be difficult to differentiate between learning new tasks and unlearning old tasks, but we argue that analytically they create different kinds of challenges.

Figure 2. A retired woman just laughed about using her large-sized and simplified remote control for her TV set (normal remotes to the left).

Wu et al. [41] present a participatory design project with people with anterograde amnesia, aimed at developing a "memory aid" for and with them. They base their design on the fact that "amnestics rely heavily on external memory aids, such as a calendar or an action item list." (p. 217). Their design provides *a "tool [that] will assist amnestics when they feel lost or disoriented by providing information as to their whereabouts and their* intent *for being where they are. A person having amnesia will typically follow familiar routines in their daily life, such as the same route home, because deviating from this path will often result in disorientation. Our tool enables an amnestic to grow increasingly confident and* independent *in exploring new locations and situations – a feat that is very difficult in current practice."* [41, original emphasis].

The tool was based on the fact that amnestics' procedural memory to a large extent remains intact; therefore, it was possible to train new routines and skills for using the tool. "Interestingly, the overall similarity of products that has been experienced before does not have to be high to allow effective learning" [4].

Occupational therapists working with elderly people have told us that people often install electric water heaters in the homes of their old relatives in order to avoid that they start a fire if they forget the kettle on the stove. However, if the elderly person has a "bad day" and is particularly forgetful, s/he may put the water heater on the stove as a bodily habit, and this may cause fire.

VI. What is Difficult – Seen from the User

Looking closer at what is difficult suggests a distinction between learning and un-learning tasks. We found that the sources for the difficulties were the tasks to learn and the old tasks to unlearn: the two different processes are experienced in different ways both in cases where the artifact is difficult itself and when it is the fitting of the technology to the situation that appears to be difficult. We came across examples of actions and errors made by third parties, such as vendors, employers, other public agencies and other technologies. In these cases, the situation was experienced as unpredictable and confusing and not possible to explain by the user unless s/he had a deep knowledge of the complexity of the technology in its social environment.

We sum up our analysis of what is difficult in Table II, expanding Table I with rows from this more detailed analysis of the nature of the difficulties.

TABLE II. WHAT IS DIFFICULT SEEN FROM THE USER

What is difficult	Kinds of difficulties		
	Artifact	***Context***	***Activities by others***
New tasks to learn	Holding the turn-off switch. Positioning of the charger. Online tax services.	Personal economy after retiring. Charge device after use. Check pre-completed form	Check and act if something unusual
Old tasks to unlearn	Handling paper forms. Putting kettle on stove.	Charge device before use. *Not* pushing the horse. Changed tax rules.	Need trust to stop doing.
Basic knowledge for the task	Understand tax and web pages. Understand a water boiler.	When does the new apply?	Understanding the ecology of humans and technology
Challenges:	Practical measures: moving a charger, teaching.	Matching artifact with own life situation or circumstances. Differentiating between old and new.	Disentangling interactions and complexities.

All the elements in Table II point to existing competence or lack of competence presupposed by the artifact that may make the artifact difficult to use. But how do we go from knowing what is difficult-to-use to designing something that is easy-to-use?

VII. DESIGNING FOR EASE-OF-USE

The three different kinds of difficulties can be a basis for approaching design of easy-to-use technology solutions. In this section, we report from some design experiments with elderly people by colleagues and students [5][18][29][42][43] as well as our own design suggestions based on analysis of identified user problems [22].

Designing from the users' perspective starts with investigating their subjective experiences and competencies. Elderly users need much practice and repetition to establish new habits and unlearning old habits may be the hardest part. Unlearning may require trust to let old habits go to be sure that they are not necessary, e.g., for security. As unlearning old tasks is a challenge in itself, a design that builds on old, habitual tasks will be experienced as less challenging for the user. Enhancing and extending the old tasks instead of making them obsolete in a new design can be experienced as a simple design by the user.

Using everyday technologies like radios, mobile phones, water heaters or remote controls is normally easy and often automated and habituated. Many of our memories and competencies sit in our bodies as automatic movements or perception (e.g., music, smells) and can be carried out without conscious deliberation. A design that incorporates that the user can rely on his/her old habits can make the changing of old practices more likely and the design more robust. Robustness towards unintended and unexpected use is important for the user's ability to manage and carry on with the original task (see e.g., [44]).

Designing for new habits in old age is possible, as the example of the memory aid for the amnestic people above showed [41].

In the large project on evaluation of technologies for independent living, designing for ease-of-use has been explored in two ways: through design of artifacts that resemble familiar technologies [45], and by collaborative design with elderly people on designing or testing different technological solutions in order to identify what works with a minimum of new tasks to learn.

Figure 3. The prototypes for the knob (above) and the digital radio (below). Photo by Johnsen et al. [43].

An example of the first design approach is the design of a digital radio that was co-designed with in total 25 elderly people [43]. Johnsen et al. aimed to design interaction mechanisms that built on old and familiar bodily skills when designing a new way of operating a digital radio [ibid]. Using rotary controls for operating the radio – like in the old days – enabled them to make sense of the interface with their body even if they intellectually could not understand or remember how to turn on the radio. They easily recognized the button as a device for rotary movement. Several buttons were designed and tested for a good grip for old hands and recognizable positioning with different textures and shapes [43], see Fig. 3.

Figure 4. Testing several different induction chargers. Photo: Iversen [42].

The second design approach involved testing a large number of different solutions to the same problem. One example is a test of induction chargers carried out to identify problems and ease-of-use [29]. As a way to provide easy charging of phones, Iversen and Joshi [29] collected seven different off-the-shelf induction chargers and asked a group of elderly men to evaluate them (see Fig. 4). Trying out different technologies and experiencing how they offered different degrees and kinds of difficulties turned out to be instructive to the elderly users as well as to the designers. Furthermore, Joshi [45] built on knowledge about earlier habits, e.g., the fact that in "the old days" (i.e., when they were young adults) telephones had wires and were usually located in a specific place, on a particular table by the entrance door. Maybe it would be easier to charge the mobile phone if, instead, always putting the phone in "its place" was the thing to remember (see e.g., [46]).

Another example is from a participatory design process organized and facilitated by Stark [31]. A group of elderly visitors to an elderly activity centre found their online banking services to be difficult to use: the web site was seen as confusing, with too much irrelevant information and choices on the pages. One of them started a "data club" aimed at helping other elderly visitors with their Internet banking. Stark recruited some of the people frequently visiting the data club to join her in designing a new online banking solution. The design process consisted of seven meetings, and during these meetings the elderly participants suggested a design that was based on a very different logic from the current Internet banking solution. In the new "Easy Bank" banking solution the service mimics the tasks carried out by people going (in person) to the bank: they pay their bills or they want information about their bank account(s). Instead of presenting the bank customer with a virtual place where one can access a range of different bank services, the new "EasyBank" design presents the two most frequent activities: paying bills and getting information about the account, see Fig. 5.

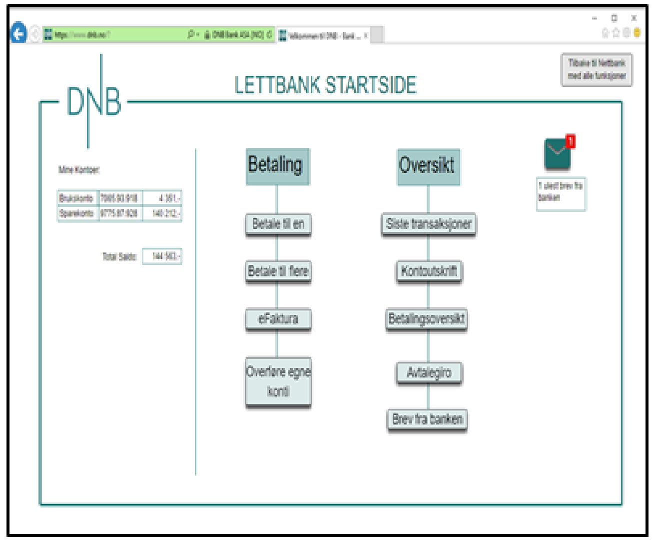

Figure 5. A suggestion for an "easy online banking" made by a group of elderly users [31].

Making online banking easy by referring to well-known and established banking habits may make it easier to adopt the new way of doing banking. It seems that the logic of the current banking solution is grounded in how the bank sees the world rather than what bank customers may be interested in doing in the bank. One can argue that making the Internet bank a virtual "bank place" where lots of services can be activated is a more open solution that may serve all bank customers, however, for most of the less frequent users of bank services paying bills and checking your account are what they do in the bank. Stark's new "Easy Bank" solution is an example of taking the non-expert user's point of view when designing the services, and then designing the service as it is seen from these users. At a more general level technology is often used to automate some tasks and hence enable more self-service or more available services.

Fig. 6 illustrates our view of how technology influences the tasks done by a human user. Fig. 6a illustrates a loosely defined set of tasks for a particular purpose (e.g., doing taxes) as seen from the human's perspective. Fig. 6b illustrates how technology takes over some of the tasks: they become automated. Fig. 6c shows the automated task area as seen from the human user's point of you: s/he encounters some left-over tasks that are not automated and some new tasks.

The tasks left for the human interacting with the technology may appear as fragmented and there may be no or little coherence between different subtasks. New tasks can be of a very different kind than the original set of tasks. Fig. 4d illustrates that in order to make the tasks left for the human user coherent and foreseeable, we should design a coherent set of tasks left for the user instead of letting the technology decide what is automated [22].

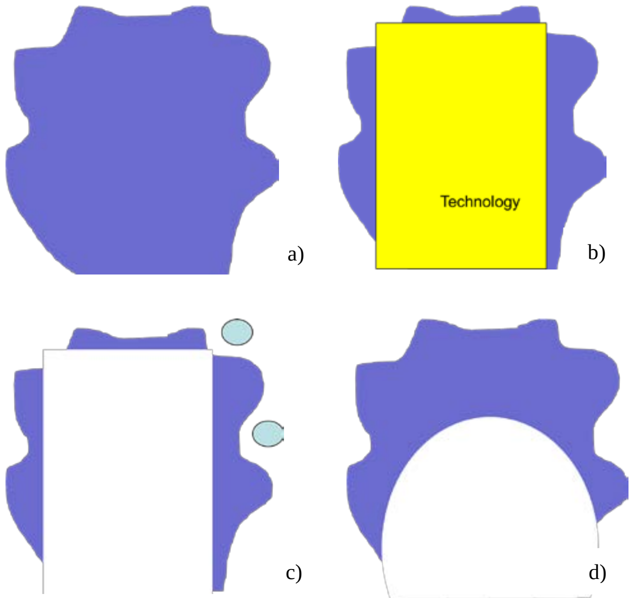

Figure 6. Automation removes some tasks from the user and introduce others. a) A set of tasks for a user - not clearly defined. b) Some of the tasks are made obsolete because of technology. c) Fragmented tasks left for the human user. d) A coherent set of tasks for a user.

Automation and service development usually takes its starting point from the needs and material basis of the service provider. Automation is based on what can be automated. The service provider's logic structures how services and functionality is presented for the users. Users will need to learn and understand the provider's logic to use the services in independent and autonomous ways. Looking for the users' logic will make possible design starting with the user's perspective.

Managing the boundaries between tasks made redundant by technology, tasks left for the user to do and emerging new tasks is a challenge in itself. Design from the user's perspective aims to present the tasks for the human interacting with technology as a coherent whole and with connected subtasks. This will enable the user to disentangle the problems s/he encounters.

Understanding *when* to deviate from old habits and do new tasks requires sorting things out, which should be supported by the design and by training and practicing (with or without helpers). Matching the artifact with the personal use situation and context represents a challenge [22][47], in particular if the artifact is complex (like tax). Showing ways of matching, e.g., by providing several examples, can help the user in the matching of her/his situation with the technology requirements: s/he may be lucky and find an example similar to her situation. FAQs and help texts can provide such examples in the artifact itself, while human helpers like call advisors and occupational therapists will have to assist if the matching is too difficult to be carried out by the user alone. Graphical illustrations and simulations can also help explain complex systems like the tax system.

Often very simple re-designs can contribute to explaining how the automated system works, and reduce the users' anxiety that something is wrong (and at the same time reduce the load on the service provider's call centre/help desk). In the registration service for new students (see Section III A), merely sending an email to new students when they open an account that more services will become available as soon as they pay their fee, will help. The students understand why there are no services/menu choices available and that it is not an error [28]. A citizen who changes her tax card online can receive an email saying that a change is registered, and when she can expect a new tax card to be operative. This will enable a citizen who does *not* receive such an email the next time she makes an online change to understand that her online changes were not registered. Instead of calling the tax authorities, she may be able to check into the matter herself.

A smooth transition between an old and a new system is demonstrated by Denman and Nachman [48], who worked with designing for one user: Professor Stephen Hawking. Hawking uses a specially built interface that enables him to write and speak with an artificial voice based on small muscular movements as input. His use of the interface was developed through many years, and his practices were deeply dependent on and rooted in his old system. Denman et al. found that making changes in the interface was challenging as "Stephen had a rhythm in his use of his system" and he knew some aspects of it by hearth in a way that speeded up his operations even though the operation was based on, e.g., choosing a word from an alphabetic list. Hawkings knew the list by hearth, and was faster using the old list than a new word-prediction engine that suggested appropriate words. Use of the old list involved more typing, which turned out to be faster as Hawking could type without having to read the words in the list as he knew it by heart. The new system was installed as optional and Hawking could switch between the old and new systems, leading him to get practice with the new word-prediction engine. After some time of switching between the old and the new system, Hawking could make better use of the new system and increasingly preferred it over the old one [49].

Starting to use technology that is new to oneself requires mental attention and a cognitive effort. Technology use often involves symbol manipulation and abstract thinking, which may be demanding. People act by force of habit in stressful situations and when they have reduced capabilities because of for example illness or old age [39]. In demanding life situations users need to spend their energies on their primary tasks, and there may not be spare capacity available for the attention needed to learn to use a technology new to them.

Elderly people use technology in many ways. However, our empiric material show that for elderly people, who are not interested in technology as a field of study and for its own sake may only embrace new technologies when they fit into their life. Using technology can contribute to continuity and control, health and well-being when the elderly people can use it their own way and for their own purposes [50].

VIII. CONCLUSION AND FUTURE WORK

Based on examples from our research on design with and for elderly people and on citizens doing taxes, we describe how artifacts and systems become difficult to use. We have reflected on how we can use knowledge about difficulties in a constructive way to suggest better designs. In the paper, we make an analytical distinction between types of difficulties according to where they appear: in the artifact / system itself or when used in its use situation / context. Our analysis also includes a discussion of the differences between learning new tasks and/or competences to benefit from the technology and un-learning old habits and practices. In addition, difficulties stemming from activities and errors made by others may occur, and in order to be able to disentangle the problem and sort out what can be done, the user needs to understand the larger ecology of the service system.

We suggest that habits and bodily knowledge can be used as resources for design to enable users to benefit from familiarity and coherence. Building on and extending old habits instead of making them obsolete in a new design can be experienced as very simple for the user – independent of any usability assessment based on criteria that are external to and irrelevant for the particular user in the particular situation. Our aim has been to present a conceptual framework for design for the user's subjective perspective.

Our conclusion is that "easy-to-use" is difficult to design, and that the notion of "ease-of-use" hides the complexity that comes when artifacts are used in real life contexts. Both the identification of what makes things difficult and what turns out to be easy to use challenge a notion of "usability" that looks at the artifact as a de-contextualized object. Easy to use is a characteristic of the relation between a user, her/his activity and the technology that supports that activity. It is thus both situational and personal. This makes it even more challenging to go from what is difficult to use to designing easy to use artifacts. What is difficult to use is not so easy to detect before the artifact is used hence designers can learn a lot from studying use practices. We therefore argue that usability might be a less useful measure for evaluating a design.

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