Designing for Experienced Simplicity

Why Analytic and Imagined Simplicity Fail in Design of Assistive Technology

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***Abstract*— This paper uses the design of assistive technology for elderly people as a case for exploring why analytic or imagined simplicity often end up as complicated and incomprehensible in use. Our claim is that building on *mastery* and *context* is more important than objective guidelines on simplicity. Rather than relying solely on context-detached principles that cannot guarantee simplicity in use, we introduce the term *experienced simplicity* as a way of shifting focus from how designers shape the design, to how users experience the design. Finally, we present and discuss five design implications for experienced simplicity.**

Keywords — simplicity; elderly; assistive technology.

I. Introduction

As assistive technology is being rolled out in large scale in Norway, designers are aiming at delivering simple interactions specially adapted and tailored for the needs of elderly people. Most designers follow principles of simplicity (e.g., minimalism) in order to create a design simple enough for elderly people with reduced experience and capacities to interact with the technology. However, designing for simplicity does not guarantee simplicity in use, and our prior research has demonstrated how designs claiming to be simple can end up making life difficult [1].

One of the technological devices found in the apartment of an 84-year-old lady residing in a local care home in Oslo is an automated light sensor in her living room. Because of the small size of her apartment she sleeps with the door open, and when she turns in bed at night the sensor in the living room registers her movement and the light is activated throughout the apartment. Her solution to this was to cover the sensor with tinfoil (as illustrated in Figure 1).

Figure 1. Covering a sensor with tinfoil (Photo: S. Finken [2])

This observation exemplified how simple technology may end up making life difficult, and served as a trigger for us to explore the matter of simplicity. In this paper, we (1) investigate why existing assistive technology claiming to be simple end up as difficult in use by looking at simplicity from the perspective of the elderly users rather than the designer, and we (2) introduce *experienced simplicity* as a term that focus on the use rather than the isolated design. We discuss why it is challenging to design technology simple for others, in this particular case making assistive technology simple for the elderly users. The discussion is grounded in data gathered with three different evaluation methods spanning over 13 months. We have engaged 45 participants, including 30 elderly people with an average age of 86 years.

The paper is structured as follows. In Section II, we give an analysis of simplicity in the literature, as well as our perspective on the matter. In Sections III and IV, we outline the research context and research methods of our study before presenting the results in Section V. We end the paper with a discussion in Section VI on why simplicity is challenging through five implications for design pursuing experienced simplicity.

II. Simplicity

A. *Defining simplicity*

In the complex world we live in, taming the complexity is one of our major goals with human-centered design [3]. Simplicity in its most elementary definition describes something with an uncomplicated quality or condition. Researchers have applied the concept of simplicity to various research studies within various disciplines of computer science. Over time, this vague definition of simplicity has made it applicable to different areas of computer science, and in several disciplines the term has evolved into an established term with a more refined and tailored use mainly applicable to that specific discipline or context. As a philosophical principle, simplicity can be differentiated into ontological simplicity, following the principle of parsimony, and syntactical (structural) simplicity, perceived as elegance [4]. Hence, the theoretical perspective of the researchers in the debate of philosophy of science can heavily influence how they perceive and apply such a term. Lee et al. [5] describes simplicity within the area of Human-Computer Interaction (HCI) as "not only simple page layout but also interface organization, functionality, structure, and workflow and framework". Following this definition, simplicity in HCI encompasses various elements and researchers tend to find their own perspectives and definitions to simplicity. One of the most cited authors on simplicity, Maeda [6], defines his ten laws of simplicity (reduce, organize, time, learn, differences, context, emotion, trust, failure and the one). On the other hand, Colborne [7] concentrates on only four strategies (remove, organize, hide and displace) in his discussion on simplifying devices and experiences. Simplicity has also been analyzed through the notion of minimalism by Obendorf [8] who defines four types of minimalism (functional, structural, compositional and architectural) and utilize this perspective on minimalism to discuss simplicity in HCI. However, as Picking et al. [9] points out, design principles are in general often formulated as brief guidelines that aim to cover wide areas of application and apply to multiple domains simultaneously; it is difficult to use these guidelines consistently as they rarely specify which specific design choices to make. Since laws, strategies and principles for simplicity can serve as everything from minor inspirations to governing factors, Obendorf [8] have called for more differentiated and concretized definitions of how simplicity is understood, and exactly how it influences the design outcome.

Several researchers have pointed out the importance of simplicity as a design principle in systems designed for the older population [10]-[12], however, prior studies [4] [1] suggest that perceived simplicity is context-dependent and relies heavily on the users' previous exposure. As a result, we want to expand on the definitions of simplicity currently found in the literature (summarized in Table I).

TABLE I. OVERVIEW OF DEFINITIONS OF SIMPLICITY

Related work	Definition
Lee et al. [5]	*"not only simple page layout but also interface organization, functionality, structure, and workflow and framework"*
Maeda [6]	Ten principles of simplicity: reduce, organize, time, learn, differences, context, emotion, trust, failure and the one.
Colborne [7]	Strategies for simplicity: remove, organize, hide and displace.
Obendorf [8]	Minimalism: functional, structural, compositional and architectural.

B. *Experienced simplicity*

Our understanding of simplicity is anchored in two main elements, namely *mastery* and *context*. Both of these elements revolve around the users' experience and perception of the system in use rather than the isolated and context-detached design itself; simplicity is a characteristic of a system that manifests itself once the intended users take use of the system in its appropriate context. When using simplicity as a design guideline, one should always envision the act of simplification resulting in positive effects on the mastery of the user in the desired context. Blindly following simplicity as a design principle, e.g., reducing or hiding elements because general rulebook on simplicity says so, ignores the true intention behind the design choice, namely disentangling the perceived complexity. We have labeled this perspective on simplicity as *experienced simplicity* as it shifts focus on simplicity from something the designer use as a guideline to something we can only confirm through user experience. A design is not simple unless the user perceives the interaction to be simple in use.

However, analyzing the simplicity laws and principles of Maeda, Colborne and Obendorf one quickly register that these laws mainly consider simplicity as context-independent. All of Colborne's four principles encourage modification to the design detached from the eventual context. Similarly, Obendorf relies on minimalism which itself does not automatically ensure systems free of complexity; it only encourages basic design with deliberate lack of decoration without discussing the perceived simplicity. From Maeda's ten laws we can extract five laws concerning the relational use of the system rather than the system itself, namely time, learn, context, emotions and trust. Only these laws reflect how we understand simplicity, i.e., rather than being a term of size, quantity or volume, it should first and foremost reflect the contextual experience. Thus, simplicity in a system is not something one adds to the design; it is something achieved once mastery is uncomplicated in its appropriate context.

Our view on simplicity aligns with the research of Eytam and Tractinsky [13] who suggest that the ability to design own complexities can be a desire among users. They define this contrast between advocated guidelines for simplicity and the observed behavior as the paradox of simplicity, and argue that simplicity is not defined in objective guidelines, but rather a quality to be understood through how the users perceive simplicity. The explicit focus on the users' side of the interaction in HCI influences how we discuss the concept of simplicity how it is a matter of more than just reducing complexity; simplification is an intricate and dynamic design principle embracing factors such as mastery and context of use as examples of decisive factors of simplicity. This is also in line with [4] who suggest that simplicity as a design principle should be a complex and flexible design paradigm rather than a simple dichotomous variable, incorporating elements such as user interface design, as well as contextual factors (for example integration to other IS). Keay-Bright and Howarth [14] focus on designing intuitive interfaces and describe simplicity not as a compromise in richness or diversity of human experience, but rather a minimal interface that empowers the users to design their own complexities that ensures mastery.

Another early supporter of our perspective is Norman who claimed that designing solely for simplicity would force a compromise on functionality [3]. He pointed out two common implicit assumptions that designers rely on: (1) that features equals capability, and (2) that simplicity equals ease of use. He argued that this one-way logic does not have any guaranteed backwards mechanism. Thus, if we want to achieve capable and usable systems, designing for simplicity alone will not automatically deliver our desired solution: *"Features do not equal capability. Simplicity is not the same as usability. Simplicity is not the answer."* [3].

III. RESEARCH CONTEXT

A. Empirical context

This study is part of a larger long-term research project focusing on newly acquired assistive technology in local care homes in Oslo Municipality. The particular local care home involved in this study consists of 91 individual apartments for the elderly residents (with an average age of 84 years) organized with common reception, cantina and recreation room (depicted in Figure 2). There are no medical services provided, and those in need organize their own arrangements with the district home care services. However, the residents have access to basic services such as hairdressing, foot therapist, gym and cinema. The goal of the local care home is to be a smart house, for instance actively utilizing technology in order to prolong the time elderly people can remain independent in their own homes before being admitted to a nursing home.

Figure 2. The reception and common area of the local care home

Each individual apartment comes pre-installed with a set of new technologies, including automated lighting, heating and ventilation control, stove guard, electrical sockets with timers, motion sensors in all rooms, video calling, door locks with radio-frequency identification (RFID), and a customized tablet. Ever since the building opened in 2012, our research group has been present at this facility, and this local care home is an excellent arena to study existing technology. It also serves a venue where we experiment with new and alternative assistive technology.

B. Technology under evaluation

For the purpose of evaluation in this study, we included the tablet and some of the room control devices found in the apartments of the local care home. The initial main objective was to concentrate solely on the tablet; however, we feared that only studying this touch-based device would restrict the discussion of simplicity to an analysis of touch-screen interfaces rather than being an open discussion of how users experience simplicity in the assistive technological devices that surround them. As a result, we included a set of devices in the room, i.e., light, temperature and ventilation systems, as well as the RFID door locking system.

1) Tablet

The tablet illustrated in Figure 3 comes pre-installed in all apartments and introduces a new way of arranging, planning and keeping an overview of everyday activities, as well as allowing residents to order meals from the downstairs cafeteria straight from the device. The tablet also provides basic opportunities for communication, namely telephoning and text messaging, as well as entertainment services, e.g., radio and an Internet browser. However, the tablet only comes with one mode and offers few options for customization, hence, flexibility and robustness is of great importance as it needs to support the daily activities of all residents and employees.

Figure 3. The tablet

2) Room controls devices

Some of the pre-installed assistive technologies and devices in each apartment is lightning, heating and ventilation control in every room of the apartment. This includes automated motion-activated light sensors, automated thermostat and automated adjustment of ventilation. The photos in Figure 4 depicts a close-up of the heating interface as well as the RFID door locking system used to access each apartment. The door locks automatically, but opens with a RFID-card, and represents an interface few had experienced before. Since all these devices come pre-installed there is no option for the residents to utilize other interfaces or interaction methods, e.g., traditional door locks with keys or two-button light switches, and these pre-installments can all be considered a part of the "welfare package" in each apartment. As a result, they were tested together during the evaluations, and we will refer to these devices as "room control devices" in this paper.

Figure 4. Heating control (left) and RFID door (middle)

IV. RESEARCH METHOD

The data for this study was gathered over a period of 13 months divided into three phases. We were motivated by prior experiences with elderly people and assistive technology [13] [14], where findings suggested that giving enough time could help avoiding or eliminating bias. Three different methods of evaluation were used during these three phases, and Figure 5 illustrates the outline of the research phases.

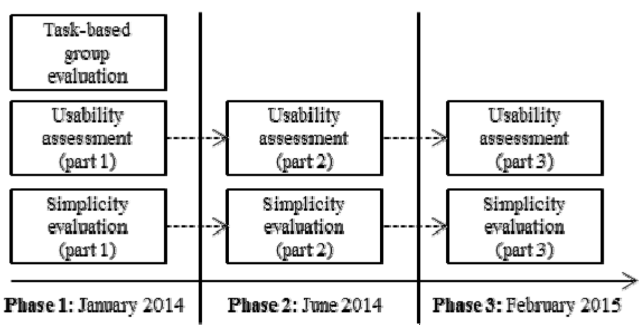

Figure 5. Outline of the research phases

We applied different methods of evaluation. This was partly motivated by methodical triangulation, although the main reason was giving the participant more than just one opportunity to express their perspectives on simplicity. Also, in order to detect any cases of reverse-halo effect, we preferred to have at least one method that was an objective and metric evaluation of performance rather than subjective assessment. The applied methods are listed in Table II.

The task-based group evaluation allowed the participants to freely address simplicity issues during the task walkthrough independent of schemas, heuristics or guidelines. Through the *simplicity evaluation* participants had a chance to evaluate the simplicity by grading pre-selected factors of simplicity, and during the *usability assessment* we did not ask them, but rather observed and measured them in order to discuss simplicity through their performance. The first phase included a task-based group evaluation, a simplicity evaluation and a usability assessment. The initial plan was to conduct these three activities during the first phase and then follow up with an equivalent usability assessment after six months with the same participants and the same usability criteria. However, due to the feedback and results discovered during the second usability assessment, we chose to repeat the simplicity evaluation as well. The results from the second phase suggested that six months was not enough time to capture whether perspectives on simplicity had evolved over time. As a result, the third phase was conducted almost 13 months after the first phase, giving us enough time to reduce the selection bias such as length time bias. It also gave the participants the opportunities to experience the technology through additional stages of its lifecycle, e.g., maintenance, software updates, component replacement, and thereby attributing their assessment of simplicity to actual use over time rather than just first-impression or initial use.

TABLE II. OVERVIEW OF METHODS

#	Method	Participants Phase 1	Participants Phase 2	Participants Phase 3
A	Task-based group evaluation	22	-	-
B	Usability assessment	11	11	11
C	Simplicity evaluation	12	12	12
D	Follow-up interview	-	-	6

A. *Task-based group evaluation*

The task-based group evaluation was a part of a broad study where altogether 22 participants were engaged, namely 11 elderly users, 7 employees and 4 experts. This dataset includes several factors out of which some are not relevant for this study, although data from this evaluation has previously contributed to another study [15]. Nevertheless, the evaluation included a total of 6 sessions, 3 sessions with groups of elderly, 2 sessions with groups of employees, and 1 session with a group of HCI-experts. The employees were recruited from the local care home, and the participants represented both daytime and nighttime employees. The sessions were structured as group walkthroughs of pre-selected representative tasks where the participants were asked to grade the severity of identified issues and then engage in a plenary discussion. Examples of representative tasks were ordering a meal and signing up for activities on the tablet and controlling lighting and ventilation in the room. During this session all participants labeled issues with predefined categories. The data included in this study are those issues labeled by the participants as “simplicity” issues. All participants were free to individually define what issues they considered to be simplicity issues.

B. Usability assessment

The usability assessment involved 11 participants; 7 elderly residents and 4 experts. The participants were given a set of 10 representative tasks to perform while completion time and error rates were measured and the sessions photographed. The tasks are listed in Table III. The given tasks were distributed evenly between the tablet and the room control devices. Errors were counted and also divided into *deliberate errors* and *accidental errors*; the former represents errors where the user performed an action intentionally although performed the wrong action, while the latter represents unintentional actions. An example of a deliberate error is intentionally pressing the channel button on the television remote control when you want to adjust the volume because you in your best judgment consider the channel button to be the correct action for the desired outcome (i.e., adjust the volume), and you intentionally press that button. On the other hand, if you want to change the channel and while reaching for the correct button you unintentionally bump into the power button instead, then it would be a case of an accidental error.

TABLE III. OVERVIEW OF PERFORMED TASKS

Task #	Task description
Task 1	Locking and unlocking the RFID door
Task 2	Playing a game on the tablet
Task 3	Browsing on the tablet
Task 4	Sending and receiving text messages on the tablet
Task 5	Listening to radio on the tablet
Task 6	Ordering food from the cafeteria on the tablet
Task 7	Activating room control devices with movement
Task 8	Setting and adjusting the ventilation
Task 9	Turning on and off wall and ceiling lighting
Task 10	Adjusting the heating level

In the first two phases, these evaluations were carried out in the homes of 5 of the 7 participants, while 2 participants preferred to have the test conducted in an adjacent meeting room along with the experts. In the third phase, we conducted all evaluations in the meeting room. The usability assessment was repeated during the second and third phase in order to study changes in behavior, performance and satisfaction after six and thirteen months. The conditions and environmental factors were similar between the three assessments with the exception of the participants agreeing to have the evaluation along with the experts in the meeting room in the final evaluation.

C. Simplicity evaluation

The goal of the simplicity evaluation was to provide the residents with an opportunity to evaluate the simplicity without being restricted to certain tasks (as in method A) or tied to their performance (as in method B). Hence, the participants were asked only to grade the simplicity of the tablet and the room control systems. The evaluation included 12 elderly users in each of the three phases. All participants were given an individual oral and written explanation of each factor and was then asked to grade the simplicity factor from 1-5.

The evaluation comprised 7 factors redefined from 5 laws of Maeda coinciding with our perspective of experienced simplicity, namely the symbiotic relationship between mastery and context. The 7 elements were *intuitivity*, *organization*, *memorability*, *error rate*, *time*, *learnability* and *trust*. Intiutivity reflects the perceived easiness when first approaching the system in the given context, while learnability and memorability describes the system's ability to foster mastery and maintain it over time. With organization we did not look at organization of the interface, e.g., icon clutter, but studied how the system fitted within its context. We also included time, i.e., their experience on their own performance and error rate, i.e., how many errors they encountered, in order to study their own perspective on mastery.

D. Follow-up interview

The usability assessment and simplicity evaluation during the third phase was accompanied with a few interviews in order to gather perspectives from both experts and elderly participants on their opinions and performance. We chose to include these interviews in the final phase as we could not interpret the rationale behind the fluctuating opinions between phase 1 and phase 2, and wanted to get some insight into this matter. The interviews included three elderly participants and three daytime employees and were conducted immediately after the evaluations.

E. Participants

The three methods involved 45 participants altogether and the participants were divided into four user groups described in Table IV. The elderly people ($n = 30$) participated in all methods during all three phases, while the usability experts ($n = 8$) participated during all phases of the simplicity evaluation and the usability assessment. Finally, the employees ($n = 7$) only participated in the task-based group evaluation. A few daytime employees were invited to the follow-up interviews after the evaluation in phase 3 in order to capture some of their experience since last time.

Figure 6. Elderly residents participating in the task-based group evaluation

The elderly participants were recruited among the residents at the local care home and their age ranged from 79-94 (μ = *86*). Participants from one session are depicted in Figure 6. As a general rule, upon moving into this local care home, all residents are cognitively cleared by medical experts, i.e., possessing at least an acceptable level of cognitive and reasoning abilities. However, they all share in common that they struggle with various medical conditions, e.g., reduced motor abilities or reduced vision, and they represent a broad range of social difficulties. In addition, the cognitive abilities of the residents are not monitored regularly, and several residents, including some of our participants, developed symptoms of beginning cognitive disorder throughout the 13-month period of our study.

TABLE IV. OVERVIEW OF PARTICIPANTS

User group	User role	Use frequency	Expertise	Participated in method #	N
The elderly	End-users	Every day	(none)	A, B, C, D	30
Daytime employees	End-users and trainers	Every day	Health and domain	A, D	4
Shift work employees	End-users and trainers	Once a week	Limited domain-expertise	A	3
Usability experts	None	One-time only	HCI and usability	A, B	8

V. RESULTS

A. *Task-based group evaluation*

Out of a total of 39 identified issues, 17 were considered simplicity issues by at least one of the user groups. Each group that had identified the issue was then asked to grade the severity of the issue as *minor (M)*, *serious (S)* or *critical (C)*. All identified issues are listed in Table V. The *aggregated degree of seriousness* reflects the final level of seriousness assigned to the issue based on the grading of the groups. If there were disagreements between only two groups, the most serious grading took precedence; otherwise the number of occurrences decided this aggregated degree of seriousness. Out of these 17 identified issues 5 were labeled as critical issues, 7 were categorized as serious issues, and 5 were considered minor issues. The group of elderly reported a total of 14 issues, out of which 36 % were graded as minor. The similar percentage was lower for the two other groups, respectively 25 % for the employees and 27 % for the experts. Since both the employees and experts reported fewer issues overall that the other two groups, this implies that the employees and experts regarded identified issues as more severe that the elderly, with a percentage of 75 % (employees) and 73 % (experts) graded as either serious or critical against only 64 % for the elderly participants.

We also wanted to study the balance of simplicity, i.e., identify the level of simplicity where the system was neither too simple nor too complex. As a result, we also asked the participants to differentiate between issues they considered a result of the vendor making the interface or interaction *too simple*, i.e., a matter of oversimplification, and issues they considered *too complex* and wished were further simplified. 13 issues were considered a result of oversimplification and participants expressed usability issues due to interface, language, symbols, etc., being too simple for their liking. 4 of the 5 critical and 6 of the 7 serious issues were labeled oversimplified. It should be noted that similar to the aggregated degree of seriousness, the expressed simplification desire is the aggregated evaluation of the group(s) who brought forward the issues, however, all groups answered unanimously for all issues. As a result, their individual answers are not presented similar to the degree of seriousness where we encountered variations between groups.

Most of the issues had a clear consensus on the grade of severity. Only those 3 cases where two groups addressed an

TABLE V. IDENTIFIED SIMPLICITY ISSUES

Issue #	Issue description	Aggregated degree of seriousness	Group 1 Elderly	Group 2 Employees	Group 3 Experts	Imbalance issue
1	The device screen always stays on (even in standby mode)	**S**	M	S	S	Too simple
5	The phone icon color is misleading	**S**	S	M	S	Too complex
7	There is no indicator of remaining battery	**C**	C	C	C	Too simple
8	There is no indication of the device being charged or already fully charged	**S**	-	S	-	Too simple
10	The system signals two new messages when just one message arrive	**S**	M	S	-	Too simple
11	The system uses separate indicators to indicate the same message	**M**	M	-	-	Too complex
15	There is one phone number for texting (12-digit) and another for calling	**C**	C	S	C	Too complex
20	The default values in text boxes are misleading and unpractical	**S**	S	C	S	Too simple
21	It is impossible to grad the on-screen keyboard in certain views	**C**	S	-	C	Too simple
24	The language is inconsistent	**S**	S	S	-	Too simple
25	It is too easy to delete everything	**M**	-	M	M	Too simple
28	The events in the calendar are not chronologically ordered	**M**	M	S	M	Too complex
29	The duration of phone calls is missing	**S**	M	-	S	Too simple
34	There is no comment feature on activities and events	**M**	-	-	M	Too simple
35	The language is confusing	**M**	S	M	-	Too simple
36	The icons are confusing	**C**	S	-	C	Too simple
38	The notifications are misleading	**C**	C	S	-	Too simple

issue and simultaneously gave it different grades did we encounter any disagreements. Rather than considering the grade of one group as more important than other, we chose instead to always use the highest grade. This was considered an acceptable solution by the participants; for example, the elderly participants labeled the highest number of issues as minor issue, but for 3 of the 5 issues that the elderly labeled as minor issues (#1, #10, #29) the aggregated grading was upgraded to serious since either the employees or the experts regarded the issue as serious. For the two remaining issues one was only reported by the elderly residents (#11) and one group disagreed with the group of elderly on the severity grade of the last issue (#28). Additionally, only in 3 cases were the issue only addressed by one group (out of which two were minor issues), and the overall consistency of the grading of the issues was therefore considered to be good.

B. Usability assessment

The usability assessment included 10 tasks (Table III) tested by 7 elderly people and 4 experts in each of the three phases, and Figures 7-9 present the completion time and error rate for each of the tasks in all three phases. The completion time listed for each task is the average time spent by all 11 participants to complete the task, while the error rate is the average error rate for deliberate and accidental errors.

On average, the experts performed their tasks during the first phase within almost half the time of the elderly participants ($\mu_{experts} = 173.11$ against $\mu_{elderly} = 330.57$), and did so with half as many deliberate ($\mu_{experts} = 1.82$ against $\mu_{elderly} = 3.90$) and accidental ($\mu_{experts} = 1.18$ against $\mu_{elderly} = 3.18$) errors. Their standard deviation also confirms a more consistent performance throughout the 10 tasks both time wise ($\sigma_{experts} = 11.90$ against $\sigma_{elderly} = 36.66$) and error wise ($\sigma_{experts} = 0.52$ against $\sigma_{elderly} = 1.06$ and $\sigma_{experts} = 0.32$ against $\sigma_{elderly} = 0.59$). There is no clear consistency in how the user performs on average in each task. Between the two first phases, the completion time of four tasks decreased with an average of 9.46 seconds, while the completion time of the remaining six tasks increased with an average of 15.98 seconds. The deliberate error rate dropped for six tasks ($\Delta\mu_{1\text{-}2} = -0.36$) and increased for the other four tasks ($\Delta\mu_{1\text{-}2} = 0.46$). On the other hand, the accidental error rate increased for four tasks ($\Delta\mu_{1\text{-}2} = 0.29$), dropped for four tasks ($\Delta\mu_{1\text{-}2} = -0.32$) and remained unchanged for the remaining two tasks (#7 and #9). However, there is no correlation between which tasks that went up in deliberate or accidental error rate. Only for one of the tasks (#4) did the sum of deliberate and accidental errors decrease when the completion time decreased. For the other three tasks, where the completion time dropped (#1, #2 and #10), one increased the sum of errors by 0.14 (#1) while the two other had no change in error rate even though the completion time decreased.

Between the second and third phases, the completion time of seven tasks increased with an average of 16.45 seconds, while the 3 additional tasks demonstrated a 4.38 second drop in completion time. Interestingly, three of the four tasks that decreased in average completion time between the first and second cycle (#1, #2 and #4) flipped between the second and third evaluation and demonstrated an increase between the two final evaluations. Hence, any consistencies were even harder to identify after the third phase. This lack of pattern in performance was further strengthened by the changes in error rates. The deliberate error rate increased for 6 tasks ($\Delta\mu_{2\text{-}3} = 0.29$) and dropped for the other four ($\Delta\mu_{2\text{-}3} = -0.36$). Four of the six tasks that had increased in deliberate error rate since last time had previously demonstrated a negative change between the first two phases, indicating an increased performance (#1, #2, #7, #8). The accidental error rate remained unchanged for two tasks between the second and third phase (#2 and #6), increased for five tasks ($\Delta\mu_{2\text{-}3} = 0.34$), and decreased for three tasks ($\Delta\mu_{2\text{-}3} = 0.33$). Again, the changes were inverted for four of the five tasks comparted to last time. Only for one task (#5) did we register a similar trend between the three cycles.

The average completion time for all ten tasks increased slightly between the first and second phase ($\Delta\mu_{1\text{-}2} = 8.29$, $\Delta\sigma_{1\text{-}2} = 7.36$) for the elderly participants. The difference between the second and third phase almost completely inverted the change between the first two phases by dropping back on both completion time and standard deviation ($\Delta\mu_{1\text{-}2} = -14.63$, $\Delta\sigma_{1\text{-}2} = -4.92$). The standard deviation on average completion time in the second ($\sigma_{experts} = 8.32$ against $\sigma_{elderly} = 29.3$) and third ($\sigma_{experts} = 9.25$ against $\sigma_{elderly} = 25.0$) phase still suggested that the performance of the experts was time wise more consistent throughout all ten tasks. However, the standard deviation kept dropping and between the first and third phase for the elderly participants, the change in standard deviation considering average completion time dropped from 36.6 to 25.0 seconds. This happened despite the average completion time increasing between the first two phases, and then decreasing between the two last.

The standard deviation for deliberate errors hovered around the value from the first phase for both experts and elderly users. For the experts the standard deviation from the first phase ($\sigma_1 = 0.52$) changed both positively and negatively in the two following phases ($\Delta\sigma_{1\text{-}2} = -0.14$ and $\Delta\sigma_{2\text{-}3} = 0.08$). In the case of the standard deviation for the elderly participants, the changes from the first phase ($\sigma_1 = 1.06$) were again both positive and negative in the successive phases ($\Delta\sigma_{1\text{-}2} = -0.16$ and $\Delta\sigma_{2\text{-}3} = 0.08$). The standard deviation for accidental errors also remained very close to its initial value after a year. For the experts, the initial value ($\sigma_1 = 0.32$) decreased before the second phase ($\Delta\sigma_{1\text{-}2} = -0.02$) and increased back before the third phase ($\Delta\sigma_{2\text{-}3} = 0.05$). As this value is marginally higher after the third phase, we see an example of how the accidental error count does not necessarily improve over time even for younger users. For the elderly people, changes followed a similarly fluctuating pattern as the experts. The standard deviation from the first phase $(\sigma_1 = 0.59)$ both decreased before the second phase $(\sigma_{1\text{-}2} = -0.08)$ and then increased before the third phase $(\Delta\sigma_{2\text{-}3} = 0.12)$. This also demonstrates a very low overall deviation from this initial value even after a year.

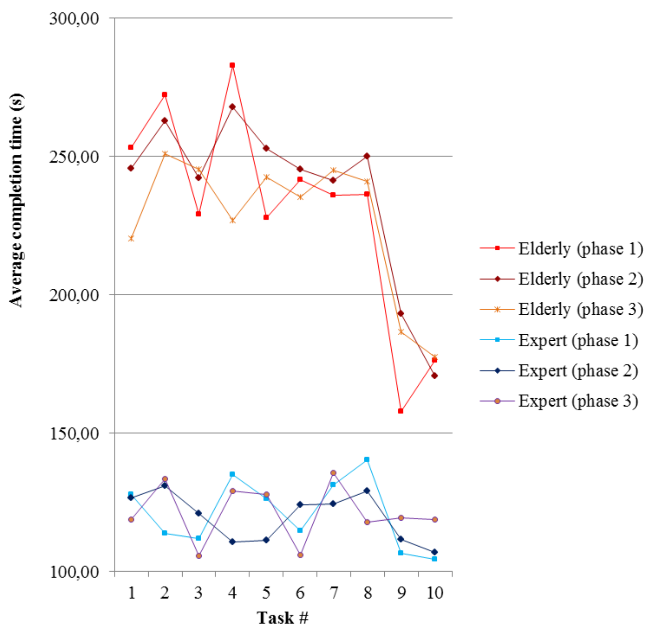

Figure 7. Overview of average completion time (s)

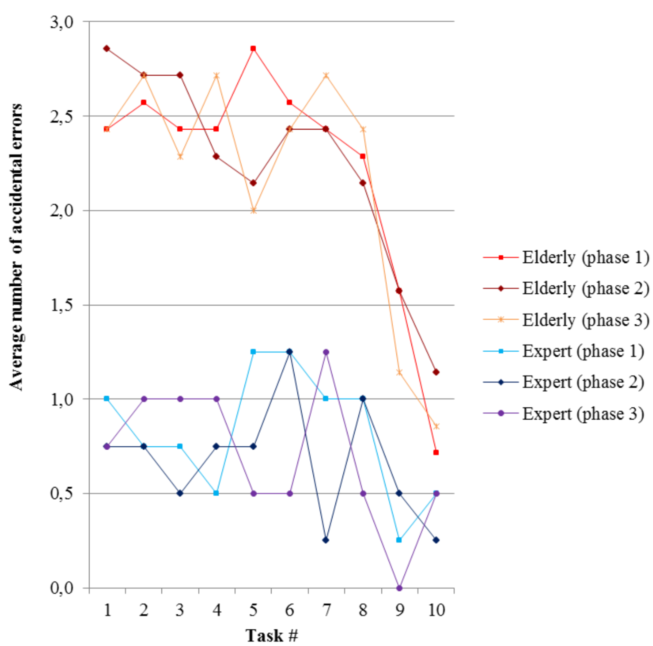

Figure 8. Overview of average number of accidental errors

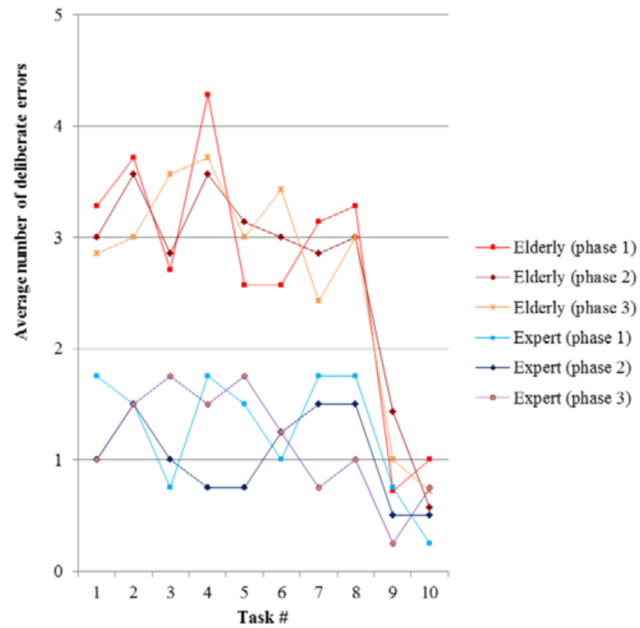

Figure 9. Overview of average number of deliberate errors

Already during the first phase, we registered that the two last tasks had the lowest completion time in both cases for all participants, as well as the lowest error rate (both deliberate and accidental) for both groups. A similar performance pattern was also registered among the experts, a group with less performance fluctuation than the elderly participants, and these were the two tasks with highest mean deviation in all three phases for both groups. These two tasks were also the only tasks where the group of elderly participants matched the performance of the experts. The average difference in completion time between elderly residents and experts in phase 1 was 110.2 seconds $(\sigma_1 = 30.9)$, 117.6 seconds $(\sigma_2 = 26.4)$ in phase 2, and 105.4 seconds $(\sigma_3 = 18.8)$, while the differences for task #9 and #10 were only 61.7 seconds in phase 1, 67.15 in phase 2, and 67.8 in phase 3. Similarly, the difference in deliberate error rate had an average of 1.46 $(\sigma_1 = 0.69)$ in phase 1, 1.68 $(\sigma_2 = 0.73)$ in phase 2, and 1.52 $(\sigma_3 = 0.86)$ in phase 3, while the differences for task #9 and #10 were only 0.48 in phase 1, 0.41 in phase 2, and 0.45 in phase 3. The accidental error rate had an average difference of 1.4 $(\sigma_1 = 0.45)$ for phase 1, 1.57 $(\sigma_2 = 0.48)$ for phase 2, and 1.47 $(\sigma_3 = 0.53)$ for phase 3, compared to 1.2 difference in phase 1, 0.55 in phase 2, and 0.87 for task #9 and task #10. The task order was completely randomized and the participants never saw any task numbers – only tasks. Consequently, this anomaly is not a result of learning effect but rather a sign of tasks that were significantly easier than the rest. This anomaly, alongside the fluctuating opinions on simplicity between phase 1 and 2, was the reason for introducing the follow-up interviews conducted in phase 3. The follow-up interviews helped us confirm the distinction between the eight first and the two final tasks; the participants, regardless of whether they belonged to the elderly group or the employee group, unanimously reported the two final tasks as categorically different from the rest. The participants also unanimously rejected any learning effect as the reason behind the sudden drop in task #9 and task #10. In any case, a pattern of learning effect would have manifested itself through a more constant descending curve from tasks #1 through task #10 rather than the abrupt drop after task #8.

C. *Simplicty evaluation*

Figures 10 and 11 present the results from all three phases of the simplicity evaluation. During the first phase, there were clear differences in opinion between the participants. While the average score of the 12 participants ended up on the upper half of the scale, the deviation within the data was large ($\mu_1 = 3.4$ and $\sigma_1 = 0.79$), and participant #10 gave 4.4 out of 5 on average for the seven factors of simplicity, whereas participant #11 only gave 1.7 out of 5. The average score given to each of the seven factors were much more evenly distributed with only half the deviation ($\sigma_1 = 0.4$) despite some of the factors having a much higher internal deviation (e.g., memorability with $\mu_1 = 3.0$ and $\sigma_1 = 1.2$).

The second phase yielded results very similar to the first phase. There were few changes in how the users perceived and rated the seven factors with the highest factor difference between the two first phases being as low as 0.3 (intuitivity and trust), while the rest averaged at 0.15. However, almost all participants had changed their perception of simplicity since the first phase. Participant #10 and #12 both end up with an average score 0.1 below their previous average, and for some participants, e.g., participant #6 with a 0.9 difference, the change in opinion was much more evident. Five of the participants ended up giving a higher average score during the second phase ($\Delta\mu_{1-2} = 0.53$), while the remaining 7 reduced their average score ($\Delta\mu_{1-2} = -0.37$). Hence, even though the number of participants increasing their score between the two first evaluations is lower than those reducing it, the difference in their average score brings the total average up ($\Delta\mu_{1-2} = 0.1$). While the overall perception of simplicity does not necessarily change much, the reduced deviation between participants carefully suggest that their opinions had harmonized during the six months between the two evaluations ($\sigma_2 = 0.51$ against $\sigma_1 = 0.79$).

During the third phase, we saw very few changes in the simplicity evaluation compared to the previous phase. Two factors represented the biggest changes in opinion (intuitivity and error rate) with a difference of 0.4 in both cases, while the rest had an average difference of <0.01. Yet again, we registered changes both individually and as a group, even though the average remained almost constant. The overall standard deviation between phases 2 and 3 suggested that their opinions continued its convergence ($\sigma_2 = 0.47$), yet the extremities were more apparent. Participant #9 set a new record with a 1.2 positive difference between July and February, increasing the average score from 2.7 out of 5 to 3.9 out of 5. Participant #12 also demonstrated distinct changes in opinion by dropping the average score from 4.0 to 3.1, thereby reducing the score by 0.9. The follow-up interview revealed that the participants had not changed their definition of the seven factors, only their opinion on the matter.

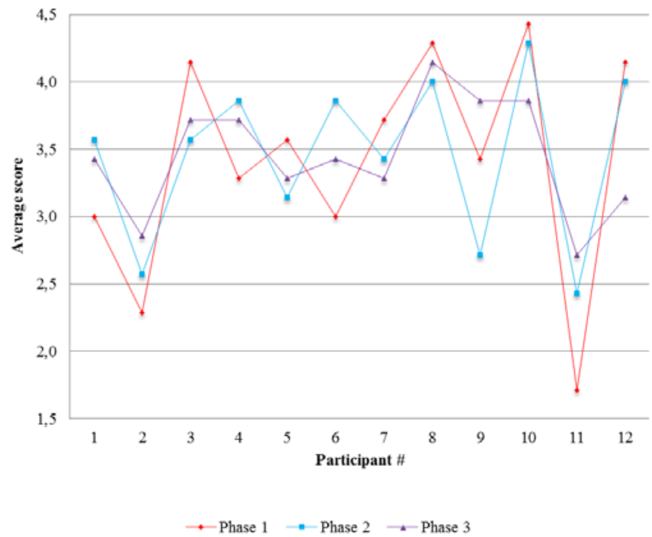

Figure 10. Average score given by each participant

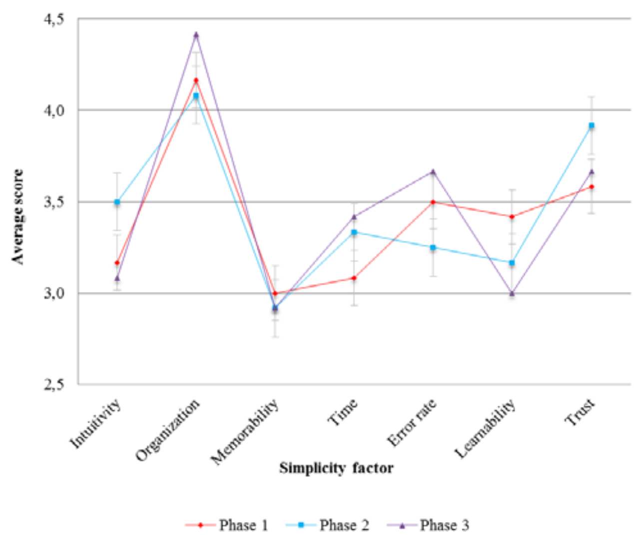

Figure 11. Average score given for each simplicity factor

VI. UNDERSTANDING WILL BRING SIMPLICITY

A. *Designing for understanding rather than simplicitiy*

Our main results from [1] relied on quantitative data to demonstrate how technologies intended to be simple in use were experienced as difficult. We studied the performance and error rate in order to determine the experienced simplicity, and we demonstrated that their aggregated performance over time did not improve. However, we quickly found these usability metrics unable to capture the real essence of the problem, i.e., why the system was not perceived as simple. In general, usability metrics such as aggregated or average speed or error rate does not reflect individual experience, only performance. And there is no guaranteed correlation between an objectively good performance and a satisfactory experience. To expand on our work, we carried out a third research phase with a new cycle of usability assessment and simplicity evaluation where we followed up both activities with a short interview of the participants. Through our interviews, we attempted to capture insight on experienced simplicity of a system where we simultaneously had knowledge about their performance. This allowed us to compare their performance in relation to their perception of the simplicity, and it also provided an opportunity to ask for the reasoning behind the given grades and assessments.

One prominent example within our own empirical context was employees who would consistently outperform the elderly people, despite spending less time on the tablet. They would perform tasks faster and with fewer errors. However, they did not perceive it as simple. As the results in Table V shows, several participants found the system to be oversimplified and preventing them from performing tasks in the preferred manner, and instead drove them into a predefined pattern of use. One participant claimed that she had *“[…] learned to perform this task in a certain way because that is how it wants me to do it"*. This user in particular did not perceive the system as simple. She had written down a step-by-step guide, which she had then memorized over time. It was not a matter of simplicity that led to the fast performance, but rather her learning precise instructions by heart. When asked to perform a similar, albeit slightly different task, she was no longer performing as well. Just by switching to a task with different sequential steps she was unable to use her instructions, and she was unable to transfer the knowledge from the familiar tasks to this new task. This example illustrates how the constructed simplicity imagined by the designers does not manifest itself as a simple experience as long as the user is unable to understand the system, even though they somehow manage to get through the task. As long as the understanding of the system remains at the same level, the experienced simplicity will also remain the same.

From the elderly participants, we learned that we should be realistic on how much effort we can and should expect from elderly end-users. If even basic operations of the system require a lot of new understanding and practice, most elderly would not invest the necessary time. While the employees were able to learn the system during their work hours as a part of their profession, the elderly people would rather choose to abstain from use if the entry level threshold was set too high. This exact phenomenon has also been captured in prior research in the same empirical context; more precisely, lack of familiarity with the features of the system led to fewer people using it [17]. Designers should not spend time on trying to make the design itself simple, but instead focus on designing for understanding and mastery which will give users an opportunity to experience simplicity as their understanding and mastery grows. Designing solely for simplicity will force a compromise on functionality. Norman also argues that by recognizing understandability as the real issue, we are halfway to the solution [3]. In fact, his three suggested principles, i.e. modularization, mapping and conceptual models, all suggest supporting user in their use indirectly by helping them better understand the system.

However, the cognitive capacities of elderly people should not be discarded. Nor should it be the default excuse for interfaces and interactions that fail to deliver simplicity. Several participants demonstrated fully functional cognitive capabilities, and for these participants it was not their mental or physical conditions that prevented them from learning. It was simply the way the tablet had been introduced. During our follow-up interviews, on participant said she still used the tablet regularly after 13 months, and knew exactly what to expect from it. However, she did not understand it. She explained that repetitions help a lot, and she knew exactly what to expect from the tablet. There were issues she could not explain, and *she “[…] knew the errors will show up, because they do every time, but knowing about them was not the same as knowing how to remove them”.* She explained that she would attend a new training course or course for intermediate users, however, no such courses existed, so she had just learned to live with the errors.

B. *Lowering the threshold for understanding*

Designing for experienced simplicity also require attention to the way the technology is introduced and taught to the users. Our initial research was supported by ethnographic studies, and one of the lessons learned from home visits was that only 23.9 % (22/92) of the residents at the care facility were actively using the tablet one year after the introduction. After two years, the number of active users had dropped to 18.5 % (17/92). The number of participants at the introductory training given by the vendor was significantly higher (56.5 %). Through follow-up interviews we could conclude that the reason behind the high dropout rate was that the entry-level threshold was too high for most people. Several elderly people had attempted to learn the basic operations of the system, yet the provided training was not enough to get them familiar and confident enough to continue the learning on their own. The instructions that came along the tablet were also not adapted to individual needs, something that made it difficult to catch up for those who felt comfortable starting after they saw how the early adopters were mastering the system.

The lack of ideal users within the context of assistive technology strongly suggests diversity in both the design of the system and in the way the user is taught to operate the system. It has also been pointed out that heterogeneous qualities can blur out if elderly people are clustered into one or only a few larger groups, and thereby end up ignoring individual needs and understanding [18]. Prior research [19] [20] have pointed out how this homogenous clustering can force user groups over on impractical or difficult alternatives, or even exclude them all together [20]. The generation of elderly people that has grown up without technology also entails diversity in both exposure and prior knowledge [21]. This also suggests a more individually tailored approach in order to help users accommodate and struggle less in order to feel a sense of mastery.

Figure 12. Group training on the left and individual training on the right

Other researchers within our empirical context have addressed this issue by developing an alternative instruction manual of the tablet aiming at a *design for all* approach. The goal was to design an instruction manual understandable for everyone regardless of skills and possible disabilities [17]. Their instruction manual was built around a task-divided design where tasks where grouped into difficulty levels, and thereby only introduced more advanced operations once the users had gained some basic skills. This made the instruction manual more dynamic as it would adapt to the learning curve of the user rather overwhelming the user by introducing all tasks at once. We carried out sessions of individual workshops and training in our prior research [22], and used a similar approach with smaller groups of people. When elderly people with limited abilities to participate in communal activities were unable to join our sessions, we brought in family members or daytime employees who could speak authoritatively on behalf of those who could not voice their own needs. Thereby their challenges and mastery progress were represented through proxy-users who could follow them up individually later. Moving from training in larger groups to smaller groups or even individual training (Figure 12) demonstrated a significant increase in the number of users. One of the quotes reported by our colleges in [17] illustrates the need to adapt the training in order to support mastery: *"I think I could have used this on my own, if someone first just once had showed me how it works"*.

VII. DISCUSSION

A. Ensuring familiarity and transferability

Mastery requires understanding and learning. It also relies heavily on the users' previous exposure, and design following simplicity should evoke a connection to prior experiences. Thus, the elderly users rely heavily on transferring prior skills and knowledge in order to adapt a level of understanding and learning that nurtures mastery. One of the key challenges with both systems evaluated in our study was the lack of consistent metaphors. Several elderly residents with prior experience with devices similar to those used in our evaluation were unable to utilize prior knowledge due to metaphors not being consistent; simplicity also encompasses other design principles, e.g., consistency and affordance. Actions, icons, symbols and other metaphors should mediate experiences rather than direct [13]. And the diverse backgrounds of the elderly participants made us very aware of the difficulty of reducing complex information into simplified metaphors where everyone understands both the metaphors and the symbolic meaning or feeling they encompass. This challenge has been addressed by previous studies [23] who relied on a simplified design to trigger a nostalgic effect in order to help familiarizing metaphors.

In our studies, several elderly users struggled with the tablet responding to their actions with unexpected outcomes. One example included residents trying to use prior knowledge like familiarized gestures on the tablet, e.g., pinching and dragging to zoom or sliding actions to scroll, when visiting websites during task #3 (Table III). The system being of a different operating system than what they had previously used responded differently than expected; the slider scrolled the website in the opposite direction and the pinch and drag gesture were not recognized by the system at all. During the follow-up interviews we confirmed that participants still struggled after 13 months of use as they still had not forgotten the habits of their prior interaction. For many participants, the cognitive and physical load of learning how to independently operate a piece of technology was so straining that the participants were unable to completely unlearned their prior habits, also after 13 months.

Another prominent example was the RFID doors automatically locking if they were closed, i.e., a contrast from the traditional method of locking doors, by turning a key. The doors were heavy and closed automatically, and once closed they would also lock automatically like a spring lock, only without any sound or click. It was especially confusing during the first evaluation as the elderly people still had not memorized that the redundant key hole affording use of traditional keys (Figure 4) served no purpose, and repeatedly expected the door to be locked manually with a key after closing the door, when instead the door would automatically close and lock behind them. In fact, the accidental error rate for the task involving the doors (task #1 in Table III) was one of the tasks with highest combined average error rate and was one out of only four cases where the deliberate error rate increased between the first and second phase. This was a matter of confusion and reported as one of the main issues responsible for the degree of learnability dropping in the simplicity evaluations throughout the three phases (see Figure 11).

A third example included problems during text messaging (task #4 in Table III). When asked to send and receive text messages, several old and familiar metaphors were suddenly replaced by new unfamiliar metaphors, where the residents struggled with applying old knowledge to the new system. For instance, the phone number was not their usual phone number, nor did it resemble a traditional phone number (issue #15), and the icons used to symbolize contacts and messages were not recognized (issue #36). The task of text messaging yielded the highest number of deliberate errors during all three evaluations, and this was clearly a result of their attempt to perform actions associated with prior experience or applying old metaphors to the new system that were no longer compatible or purposeful. The number had too many digits to learn by heart, and it did not make sense for the participants to break with the standard eight-digit phone number system in Norway as their number would not be recognized as a phone number most places. Through the follow-up interview we also learned how this way of using phone numbers eliminated their close identity to their phone number. There was no way of registering the new number on their own name in any of the major phone directories, and no way of people to finding their number by entering their name.

Through these three examples we discovered that the most confusing and frustrating situations arose when the elderly users performed an action where the outcome was unclear or unfamiliar. Familiarity and transferability became strong indicators of the ability to master new systems; when actions became disconnected from their meaning, the purposefulness in the actions disappeared and mastery suddenly became a challenge.

B. Maintaining purposeful actions

In order to further discuss purposeful actions, we gave the participants 6 months and then later another 7 months to familiarize themselves with the systems before asking them to evaluate the simplicity a second and third time. 4 participants (#1, #4, #6 and #11 in Figure 10) reported a higher average score during the second simplicity evaluation, suggesting a more positive attitude towards the 7 elements of simplicity we evaluated. As a result, we used the second and third phase to investigate whether this was a result of increased learning and understanding, or just a matter of increased use frequency. When discussing the mastery of the system, we need to distinguish between increased ease due to more frequent use and increased ease due to actions, metaphors and language suddenly making more sense. It was unanimously agreed upon that the participants reported a higher score as a result of increased frequency rather than actions, metaphors and language making sense. Confusing metaphors were still confusing and over the course of 13 months participants had begun to learn certain use patterns by heart. To them, adopting strategies to avoid problems would result in less complicated interaction and improve the efficiency once memorized.

However, over time, we registered that the average score for some of these participants had normalized. Only participant #2 and #11 in Figure 10 increased their average score between the second and third phase. It was evident that time did not contribute to increased understanding of metaphors, but rather resulted in incorporated strategies and workarounds. Confusing actions, metaphors and language remained confusing even after 13 months of use, also for those reporting a higher average score, and the increased perception bloomed out of the development of personal strategies for memorizing or working around troublesome tasks. This is an important finding as patience is often considered a virtue when elderly people adapt to new technology, including in our own previous work [15] [16]. However, in this study, we observed that actions, metaphors and language confusing the ended up remaining confusing after 6 and 13 months as well; providing more time might heal all wounds, but it does not guarantee disentanglement of perplexities and disorientations.

Another argument for ensuring purposeful actions is to maintain good mapping. Natural mapping is understood as designing the interface in such a manner that the user can readily determine the relationship between the action and the outcome into the world [24]; i.e., a design where the user is able to associate cause with effect, thereby understanding expected output for provided input. For instance, the autonomy and intangibility of the automated light sensor evaluated during the usability assessment (task #9 in Table III) imposed several challenges to mapping. The physical zone in the room where movements were recognized was not clear, and there were no indications in the interface towards the intensity of the light or the duration of the light. One participant claimed that the best mapping for her was a traditional light switch where up meant on and down meant off in the middle in the room where the left switch controlled the lamp to the left and the right switch controlled the lamp to the right. Similarly, replacing traditional door keys with RFID cards to unlock doors had similar effects on the natural mapping; the users were unable to properly answer how long the door remained unlocked once the RFID card was scanned or determine the minimum required distance between the RFID card and the scanner on the door.

C. Adapting to evolving perceptions of simplicity

Trier and Richter [4] argues that the application of simplicity as a design guideline requires flexibility. Between the two first phases we observed two participants undergo changes in their overall health level. There were significant differences in their cognitive and reasoning abilities. Before the third phase, we consulted with the daytime employees and caretakers in order to confirm the appropriateness of their participation. For example, one of these participants could no longer explain the numbers on the display used to adjust heating levels (Figure 4). She had a custom color marker that indicate up and down for temperature as the up- and down-facing arrows no longer served as metaphors for increasing and decreasing the room temperature. While the arrows and display offered sufficient explanation during the first evaluation, she could no longer explain the details of the system during the second evaluation, e.g., the meaning of “1.4^{o}C” on the display (as illustrated in Figure 4). Instead, she found that blue and red colors helped her remembering that if she pressed those buttons long enough it would eventually get colder or warmer. This exemplifies how typical aging symptoms, e.g., reduced cognitive capacities, clearly influenced both their performance and their assessment of simplicity.

Related work [10] discusses how only paying attention to physical and perceptual characteristics of elderly users end up struggling with coping with the cognitive behavioral characteristics and traits of becoming elderly. Consequently, we consider achieving simplicity among elderly people especially difficult as they undergo rapid cognitive, physical and social changes in their lives that alter their attitude and opportunities towards technology. As metaphors lose their abilities to aide us with understanding and interacting with the system, our perception of the simplicity of the system deteriorate over time. Simplicity is not a constant factor that remains the same throughout of life, but rather one of the dynamic and flexible factors that evolves along as we evolve; acquiring new knowledge, entering new contexts and adapting new technologies contribute to reshaping our view on simplicity and what we perceive as simple. Similarly, changes in our lives can contribute to complicating systems we once considered simple; it often becomes a matter not only of preference, but also a matter of limited opportunities. Over a period of 13 months the perspectives of all the elderly participants changed in both the simplicity evaluation and the usability assessment. A design offering simplicity should therefore adapt according to the changing behavior and abilities of the elderly.

Cooper et al. [25] also discuss the phenomenon where visual simplicity leads to cognitive complexity due to an unbalanced reduction. Several participants struggled with adapting to new technology due to cognitive load and preferred to rely on old knowledge and metaphors instead; they preferred familiar technologies, even those comparatively inefficient and impractical, because they could rely on habits. Examples of such desires included installing old landline telephones rather than telephoning from the tablet even though the latter was free, and using old televisions with large physical buttons instead of new flat screen television even though it involved getting out of the couch every time to change channel. A frequent counter-argument is that this behavior is a result of their attitude towards technology in general rather than a matter of cognitive overload, however their attitude during the rest of discussions clearly suggested that they were positive towards technology but struggled with adapting to certain aspects of the system, in this particular case it was the misleading colors (#5), the two separate phone number (#15) and the confusing language (#35) that caused the perceived complexity (Table V). If those aspects of the systems are metaphors intended to bridge the gap between the system and prior experiences, achieving mastery can become difficult, sometimes even impossible. As a result, we argue that design striving for simplicity should be open to seemingly inefficient and impractical features if they evoke positive stimuli for the users, e.g., allowing them to take advantage of old habits rather than adapting new ones.

D. *Avoiding forcing ways of reasoning*

By oversimplifying technology, we limit the users' freedom and make decisions on their behalf by forcing them into predefined patterns of behavior that do not necessarily comply with their needs. The participants in our study disliked the predefined settings and missed working with a system that could adapt or be customized to fit their cognitive and bodily capabilities. Similar to studies of Eytam and Tractinsky [13], several participants desired the ability to design their own complexities. Our principal example was the tablet which did not offer any customization options or the option to install custom application with services that the system did not currently offer. Once one participant discovered a way to override the system and install own application, in this case a video chat application, several others asked for instruction on how to do so as well. This case exemplified how the intention of simplifying the system by removing seemingly undesired features became a restriction of the users’ desires. By directing, limiting or forcing decisions on the elderly, the outcome might end up being stigmatizing rather than inspiring [26]. For the elderly people who feel they are losing control and influence over their own life, this stigma through oversimplification may further assume a role as a reinforcing factor counteracting dignity and integrity by depriving them of their opportunity and right to autonomy [15]. This may again influence the ability to learn how to operate such systems as more general suggestions on simplicity in learning advocates the use of environments where users feel good and able.

From their own results, Keay-Bright and Howarth [14] conclude that environmental factors that stimulate and encourage without prejudgment is a vital requirement for learning. Besides decelerating or even preventing the process of mastering, inhibiting learning has also proven to result in negative experiences for elderly people. The feeling of helplessness that comes with aging makes the elderly people more aware of their own dependability, and previous findings from our studies indicated that several participants felt deprived of their independence due to oversimplified and restrictive systems limited their opportunity to function at their best level [15].

E. *Balancing the simplicity*

The phenomenon of systems involving simplification measurements that end up having the opposite effect is often referred to as fake simplicity. Colborne [7] describes fake simplicity as the idea unable to ever meet its initial promise, instead just making everything unnecessarily complex and less effective. One example was the microwave of one of the participants that instead of using time or watt as input, used pictures of a pizza slice and a cup of tea to signal the duration and strength. Another example mentioned by a participant was his washing machine with only predefined programs where neither duration nor temperature was specified. Oversimplification can prevent mastery by concealing important components of the interaction thereby preventing the user from learning the relationship between action and effect. It also demonstrates how mastery requires balance. On one hand, the system needs to foster mastery through a design that is perceived as free of complexities; on the other hand, the system should encourage mastery by challenging and exciting the user and simultaneously avoiding oversimplified and condescending interfaces. Finding this balance where users are both presented with challenging tasks and at the same time provided with enough help to solve them helps us preventing that the system tips over in either direction.

During the task-based group evaluation, the participants were asked to identify simplicity issues as either too simple or too complex systems. As a result, they were asked to clarify whether it was a case of lack of simplicity or abundance of simplicity, i.e., a complex issue that could benefit from simplification or an issue that was simplified to such an extent that it had become oversimplified and demeaning. Surprisingly, 13 out of 17 issues were classified by the participants as matters of oversimplification, i.e., that the simplification of the interface or interaction resulted in either poor usability or led undesired user experiences. The most important finding from these results was that simplicity is not a principle where “one size fits all”.

One argument presented by an elderly lady for not liking the phone function of the tablet was that with tablets and mobile phones, the action of answering a call required an additional step. With a traditional land line phone, picking up the phone initiated the call, while on newer device she would first have to press an answer button and then pick up the phone, thereby complicating it for her by introducing additional step. Secondly, the internal disagreement between the groups further suggests that the elderly residents might have a different outlook on simplicity relatively compared to the two other groups, thereby demonstrating a variation not only between individuals but also between groups of individuals. What remains a matter of simplicity for the elderly users seems to deviate from what the employees and experts consider simplicity issues further suggesting that simplicity in use is different from analytic simplicity or imagined simplicity. Achieving simplicity without simultaneously weakening the functionality is one of the great struggles of designers, and it is vital to find this point of intersection where constructive simplification suddenly begins to defeat its own end. Simplicity is not only a matter of aesthetics; it is also a matter of balanced functionality.

VIII. Conclusion

In this paper, we have discussed the difference between analytic and *experienced simplicity* in the context of assistive technology. We have examined and evaluated existing assistive technology over the course of 13 months in order to study how perspectives on simplicity evolve over time. We have focused on how the users experience the technology by looking at experienced simplicity as something defined through mastery and context. As a result, central to our studies have been to understand how the sense of mastery changes over time, and whether technology aiming at being simple in use is actually experienced as simple. We have reported from three phases of evaluation involving altogether 45 participants, including 30 elderly people with an average age of 86 years. Our main discussion revolve around the difference between analytic and imagined simplicity, and how analytic simplicity usually do not manifest itself as experienced simplicity within the context of assistive technology. We also discuss how designs aiming at simplicity should focus on understandability and adaptation revolving around *mastery* and *context* through five key implications suggesting that simplicity should (1) build on familiarity and the ability to utilize old knowledge to help mastering the system; (2) ensure purposeful actions where the user can understand and learn to master the system; (3) adapt along with the evolving contextual factors; (4) avoid limiting the users to predefined patterns of behavior and allow them to use and master the system as they find appropriate; and (5) find the balance where the design is simple enough to be understood and learned, yet challenging enough to allow users to progress towards mastery. Only by doing so, we can achieve mastery in the intended context of use, which is what we believe simplicity to be.

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