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SUPPORTING NEW INTERACTIONS WITH PAST EXPERIENCES ANCHORED IN MATERIALS

Suhas Govind Joshi and Heidi Bråthen. *Department of Informatics, University of Oslo, Norway*

ABSTRACT

Developers and designers working with assistive technologies for the oldest generation often aim at tailoring the interface and interaction mechanisms after the experiences and competences of their users. We have studied what role materials can have in these design processes by investigating to what degree the material used in the designed artifact itself can help elderly users connect with the technology. More precisely, we report from a study of how the use of different materials influences the perceived familiarity, context-suitability, and intuitiveness of new interfaces and interaction mechanisms. We present our thematically analyzed results from a two-phase study involving 59 participants residing or working in two local care homes in Oslo. Through our findings, we present several examples of how addressing the particular use of materials can trigger different intuitive actions and gestures among the participants, as well as help the participants relate to the technologies and their intended use.

KEYWORDS

Assistive technology, material, older people, tangible interaction

1. INTRODUCTION

The oldest citizens of Norway have been gradually exposed to assistive technologies as part of the municipal welfare programs. The different types of equipment, such as devices, sensors, and wearables, cover a wide array of technologies and the intention and impact vary as well. Common for all these assistive technologies is an overarching goal of extending and supporting the functional and cognitive capacities of the oldest generation. Despite their good intentions, many older citizens struggle with understanding, learning, and adapting to all the different equipment utilizing different types of technologies. For the past four years, our empirical work has explored alternative designs for assistive technologies currently offered by the municipality. More specifically, we have explored, designed, and tested tangible alternatives to current touch-screen based assistive technologies such as tablets and televisions.

The motivation for the research presented in this study, which builds on and extends the work previously reported in (Joshi & Bråthen 2016a, Joshi & Bråthen 2016b), is a further exploration of how we can bring the technologies closer to the technological experience and competence of the oldest generation. We have previously reported from cases of limited use, abstained use, and non-use where people do not end up using technology specifically designed for them as intended by the designers (Joshi 2014, Joshi 2015). Our previous observations and findings confirm the conclusions from other studies such as (Forlizzi et al. 2000) claiming that we have not been able to take into consideration all the dimensions of the aging experience, e.g., social, emotional, and environmental factors. Another relevant issue is the failure to recognize the generational differences between older citizens and the younger generation. This point was also brought up by Blackler et al. (2010) who discovered a generational gap originating from a relatively-compared shorter time-span to gain relevant experience. Another important finding was that this older generation might possess substantial experience with technologies and interaction mechanisms that are no longer present or not replicated in new interfaces to help draw on old experience. One of the aspects of technology that may help this generation re-connect with technology is through a better understanding of what role materials have in the design of assistive technologies.

Our point of departure in this paper is an exploration of whether new and unfamiliar technologies can be made more familiar, contextual, and intuitive in use through the application of specific materials. Our research question is how familiarity and adherence to context may contribute to a willingness to use a new piece of technology. Furthermore, familiarity in terms of recognition and adhering to the context may also help the user understand the intended use of the technology, ensuring better performance, a sense of mastery, as well as continued use. The paper presents findings from two phases. In the first phase, we have explored the relationship between familiarity and context on the one hand, and the users' perceptions, expectations, and choices of materials on the other. During the second phase, we focused on continuing the material exploration by learning more about the relationship between intuitiveness and materials, i.e., to what degree the material itself could suggest any natural actions, moves or gestures.

Data has been gathered from 59 participants (M = 79 years) residing or working at two care homes in Oslo through two phases. These two phases involve a total of six activities: interviews, focus groups, material testing, two types of usability tests of a prototype named GLiMT, and finally a tactile exploration. GLiMT has previously been presented in (Joshi and Bråthen 2016a) and serves as a thinking tool in this study. We have structured the paper around three topics of interest, i.e., familiarity, context, and intuitiveness. We apply a thematic analysis on data collected from the six activities, and discuss the significance and limitations of our findings. This study contributes to the design of assistive technology by exploring the role of materials in the design processes and use of such technology; our findings suggest that there is potential to utilize physical and material characteristics as a means to make technology more intuitive to the oldest generation by building on their experience and competence.

2. RELATED WORK

Hirsch, Forlizzi et al. (2000) have studied design of eldercare technologies focusing on different dimensions of the aging experience. They emphasize that designers of eldercare technologies should consider the users' individual perception of the aging experience as encompassing more than the decline in physical and cognitive function. Rather, it constitutes a complex interweaving of social, emotional and environmental factors. Failure to consider the aging experience as a whole might prohibit adoption and use of assistive technologies, even when the user has a need for the assistance provided by the technological device.

In their investigation into what matters most to elderly users of assistive technology and the materiality of assistive technologies, Greenhalgh, Wherton et al. (2013) argue that the material features of technologies have an important impact on whether and how they will be used. They also point to the sociological aspects of materiality and how materiality can convey cultural meaning such as status and independence, or adversely, dependence and stigma. Hirsch, Forlizzi et al. (2000) found that elderly users' own perceptions of their abilities are often misconceived as below or above their actual capabilities; assistive technologies have a significant influence on the self-perception of elderly users. Users' aesthetic requirements should guide the form of a device and aesthetic considerations like materials, size and «look and feel» are equally important components in assistive technologies as product function (ibid). While good usability ensures that a product can be used, they claim that aesthetic factors determine whether a product will be used.

Materials might be especially useful when designing for usability. An interface that draws on elderly users existing habits and competences have been shown to lower thresholds of use (Joshi 2015, Joshi & Bratteteig 2015). Odom et al. (2009) found that the perceived quality of materials in an object often contributed to the strength of attachment to an object, which in turn led to continued use and perseverance. Krasner (2006) analyses the meaning of materiality to elderly people and states that the habits of elderly people tend to be anchored in the material in the home; the tangibility of the home and immediate surroundings offers the elderly comfort and support their habits, enabling them to mirror their identities and life stories. The familiarity and tangibility of their home and immediate surroundings support elderly people function by providing a "smooth path"; a habitual routine when moving around in the material environment of the home that sometimes enables elderly to function above their level of ability (ibid). However, with declining function, the range of movement tends to contract and the immediate physical environment tends to become more important. It is important that assistive technologies designed for use in the home of elderly are unobtrusive and designed to blend in with the context (Hirsch, Forlizzi et al. 2000). Research on assistive technologies for patients who have dementia has also shown that familiar representations in the immediate physical surroundings of these users' help make sense of sensory input (Fay, Fleming et al. 2010).

Blackler et al. (2010) argue that familiarity is important to achieve in design because it allows users to use a new piece of technology more intuitively and hence improve performance. In some cases, the appearance of features contributed to better the users' intuitive understanding of the interaction. They understand intuitive interaction as a type of non-conscious or implicit knowledge that depend on past experience with similar features. This implicit knowledge allows for faster and more effortless execution of a task. Their findings indicate that past experience is transferable between products, and possibly also between contexts (Blackler et al. 2005). Bakke (2015) understands intuitive use in the context of human activity theory and applies the skill acquisition framework of Dreyfus and Dreyfus (1986). He argues that the novice user depends on the familiarity of the artifact itself for achieving intuitive use, while the skilled user depends more on the familiarity of tasks and processes. Both Blackler et al. and Bakke draw on and support the research of Raskin (1994), who suggests that perceived intuitiveness of an interface depends on the perceived familiarity. Upon recognizing a familiar feature, it is the user's recognition of the feature specifically as *«an opportunity to act»* (Raskin 1994, Bakke 2015) that allows the user to use an interface intuitively.

The topic of materials has become gradually more important within design fields over the last years, yet there is still a need for a better scientific apparatus to describe how materials matter in design processes (Fernaeus and Sundström 2012, Wiberg 2014). Döring, Sylvester et al. (2012) present material-centered design concepts for tangible interaction through theories from material iconography. Their work explores how material aspects influence the users, e.g., by discussing how materials can strongly influence body movement and manipulation and stimulate engagement. Furthermore, Vallgårda and Redström's (2007) understanding of materials in interaction design and Wiberg's (2014) suggested a framework for a methodology of materials in HCI design offers some guidelines regarding a methodological application of materials in the design process.

3. RESEARCH METHODS

3.1 Empirical Context

Our study is part of a larger research project focusing on assistive technology in cooperation with Oslo Municipality. Two local care homes for residents with cognitive and physical impairments served as the primary locations for our empirical research. Visitors at a local daytime activity center for citizens above the age of 60 served as our control group during the usability tests. Many of these participants lived in their private homes and came to the care home in the daytime to participate in scheduled activities and sharing meals. The study presented in this paper was organized in two phases, one major phase spanning over a period of three months in the autumn of 2015, and a secondary follow-up phase in the summer of 2016. We structured the study around six complementing activities with 59 participants; 37 participants comprised the experiment group and 22 participants contributed in control groups for four of the six activities. The participants in the experiment group were all between the age of 67 and 92 years old (M = 79) and had resided in the care homes between nine months and three years. The control group participants were recruited and organized into two separate groups for the first and second phase respectively. We also consulted three domain experts through interviews in the various phases of the research, aged 23 to 54 years old. We recruited our participants through the method of convenience sampling by visiting the care facilities and joining activities in the common rooms. We aimed at achieving a balanced and representative distribution of age and gender within the target population, but the gender balance was skewed towards women (68%).

3.2 Data Gathering

To explore open-ended perspectives as well as the performance of concrete technical prototypes, we applied a mixed-method approach. During the first phase, we started by conducting semi-structured interviews with a combined total of 16 participants. This included six individual interviews and two sessions of group interviews with five participants from each group. We also conducted an experimental blindfold testing with material samples and performed two usability tests, namely one formative test and one summative evaluation, on the GLiMT prototype.

During the follow-up session in the summer of 2016, we introduced a new test involving 12 participants. Table 1 gives a summary of involved methods and participant distribution from the experiment group and control group respectively.

Table 1. Overview of methods involved in the study showing participant distribution

#	Activity	N *Experiment group*	N *Control group*	Collected data	Inquiry method
A	Interviews	6	-	Photographs, field notes, probes	Semi-structured interview
B	Focus group	5	5	Photographs	Semi-structured group interview
C	Material test	5	-	Field notes	Blindfolded material testing
D	Formative test	11	8	Photographs, field notes	Observation, think out loud, interview, task performance testing
E	Summative test	3	4	Video, photographs, field notes	Task performance testing
F	Tactile exploration	7	5	Photographs, transcribed recordings, field notes	Blindfolded tactile testing

3.2.1 Interviews and Focus Group

The *semi-structured interviews* and *focus group* were conducted in the common rooms of the care homes and activity center. The interviews were held over the course of three weeks where we visited the care home on five separate occasions to take part in daily activities like dinner in the cafeteria, afternoon coffee, and reading group in the library of the care home. The aim of this research was to learn about the challenges with the use of current assistive technologies. We asked open-ended questions about what technological devices they used regularly, as well as related questions regarding social aspects, daily activities, routines, and communication with relatives. We also observed the daily life in the common rooms of the care home and discussed their current assistive technological devices. In addition to photographs and fields notes, other probes such as activity leaflets, food menus, facility brochures, etc. were also collected.

3.2.2 Material Test with Blindfolds

The blindfold test of material samples was conducted in the same facilities and during the same period as the interviews. Vallgårda and Redström (2007) argue that materials in design are chosen to a large degree because of their properties and that these choices are made with respect to the focal points of interest to reflect the concerns at hand. We explored potentially suitable materials by gathering objects placed in ordinary homes. We utilized a bricolage approach (Louridas 1999) to explore combinations of our chosen digital "material", e.g., sensors, Arduino, and different traditional materials. To generate and communicate ideas regarding surface, size and shape we used wood, play dough, polymer clay, paint, stickers, yarn, fabric, canvas, and cut paper to make quick and expendable prototypes. Some of these material ideas are illustrated in Figure 1.

We conducted blindfold testing of samples of contrasting materials with five residents. The aim was to explore what the elderly users associated with different materials and what the perceived as desirable concerning the experience of manipulating a physical object with their hands; the focus was on the experience of the surface of the materials, the natural first contact with the material (Vallgårda and Redström 2007). As both the texture and color are related to the experience of materials, the participants were blindfolded to avoid that the visual appearance of the material sample affected the immediate experience of the material. The test was performed with one participant at the time. The material samples were covered with a cloth; the participant was blindfolded, and one researcher handed pieces of materials to the user's one at the time. The user was then asked about their immediate impression of the sample and asked to associate freely for a short while. Then they were asked what they thought of the material in their hands in regards to an assistive technology product that they would enjoy using. They got to see the material samples afterward and comment further if they wished to do so.

Recruiting participants for the blindfold tests was challenging due to potential participants being uncomfortable with the concept of using a blindfold. However, the goal of this experimental study was to explore whether the materials could influence perceived familiarity or context at all rather than drawing a strong conclusion in any direction from these data. While its main function was to contribute to our overall results with empirical observations, this small experiment also resulted in interesting preliminary data regarding the method of blindfold testing materials themselves. Experiences from this activity later served as the initial and main inspiration for the final test during phase two. It also yielded some interesting findings concerning the perception of the material samples, although the sample size was too small to be conclusive.

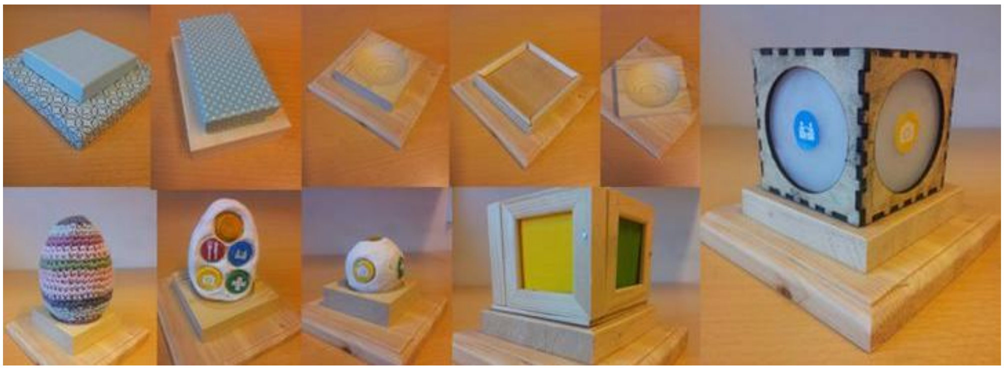

Figure 1. Using a bricolage approach, we explored combinations of digital and traditional materials by generating quick and expendable prototypes from cardboard, wood, yarn, polymer clay and silicone

3.2.3 Usability Testing

We conducted formative usability tests and a summative evaluation of tangible prototype named GLiMT (see Figure 2). GLiMT is a prototype designed as a tangible alternative to services currently offered through touch-screen interfaces such as tablets. Designed as a small wooden cube, it receives online information through a wireless configuration, and the cube has four sides with corresponding symbols to represent the four categories of information; the information is identical to the information offered through an existing touchscreen-based tablet currently in use in one of the care facilities. Incoming messages are indicated as the corresponding side of the cube lights up. The four chosen categories of information included social messages, organizational information, and home care services (Joshi and Bråthen 2016a). The message can be displayed on a bigger screen that the residents are comfortable with, like the TV, the tablet, and cell phone by placing the lighted side of the cube next to the screen. The small screen embedded on the top of the device displays the sender of the message. The base station contains inductive charger and a separate control unit for TV. GLiMT has been previously described in

(Joshi and Bråthen 2016a). We do not claim this prototype to be a definite piece of technology; instead, it serves as a demonstrative prototype in exploring the role of materials in the design of assistive technologies for elderly users.

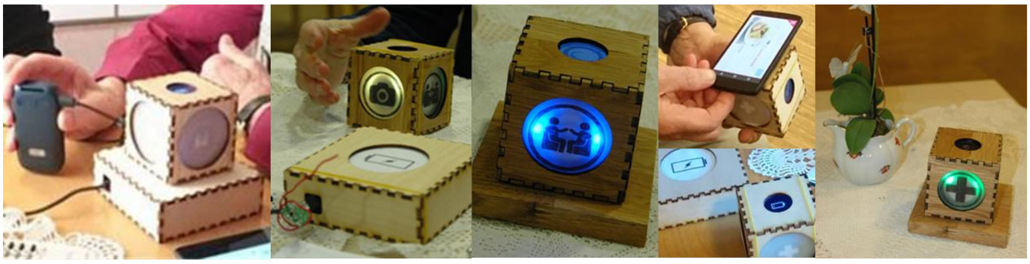

Figure 2. The prototype GLiMT was used during both formative and summative usability testing

The aim of the usability test was twofold. The aim of the usability test was twofold. Firstly, we wanted to compare a representation of a current touchscreen-based interface, i.e., the tablet with our tangible alternative GLiMT. Secondly, we wished to explore further how the materials chosen for our tangible interface and its resulting appearance were perceived by the elderly users. To measure performance, we asked the participants who struggled to use the touchscreen-based interface to carry out two sets of daily tasks. Open-ended questions about the users' perception of the appearance of the GLiMT prototype complemented the set of tasks. They were also encouraged to think out loud while performing tasks to uncover expectations and opinions about the prototype.

3.2.4 Tactile Exploration

This activity was the only one conducted in the second phase of our study. The blindfolded testing in the first phase left us with a desire to perform more accurate explorations of materials without any "disturbance" from visual stimuli and cues. The aim of this experiment was to explore the intuitiveness of the interaction mechanisms found in the material properties of the GLiMT prototype. The goal of this activity was to study whether particular interaction mechanisms came intuitively to mind as the participants came in touch with the material; our sole focus was on capturing all tactile movements and responses from the participants. The participants were asked to think-aloud and explain their actions and questions as they move along in their exploration. To further focus our attention on the intuitiveness, we recorded time for all task performances. Intuitive use is believed to be efficient and faster than other, conscious, forms of cognitive processing, and as a result, completion time becomes a significant indicator in this context (Blackler et al. 2010).

The participants were asked to perform two tasks: (1) placing the cube next to a tablet, and (2) placing the cube on top of the base box. Their task was to locate the interaction mechanism and figure out how to use it as quickly as possible. The participants were only told that there were two separate objects in front of them, i.e., the base and the cube/tablet, and that the intention was to couple these two objects. The time was started when the participant first touched the device, and we recorded the time as the first intended interaction was acted out. The think-aloud protocol invoked encouraging feedback from the test leader and participants were specifically asked how they felt about carrying out the discovered and intuitive interaction. They were also encouraged to explore whether they could find any additional actions, movements or gestures that felt natural in contact with the material. We stopped the time when the participant felt that all options were explored and stopped looking for additional solutions; this was indicated by the participant either returning the cube to the table, by removing their hands from it, or by stating that they felt content and had tried everything they wished to try. After the completing the task, the blindfold was removed, and the participant got a demonstration of the intended GLiMT interaction while being able to see the entirety of the interaction including actual functionality and feedback. Figure 3 portrays two of the blindfolded participants that contributed to this activity.

Figure 3. Blindfolded users participating in the tactile exploration

4. RESULTS AND FINDINGS

4.1 Familiarity

When blindfolded during the material test, the participants experienced the material with their tactile sense exclusively. While the blindfold test did not reveal any materials as unanimously favored, the participants expressed enthusiasm towards different material properties. We registered a strong relationship between the material properties, e.g., the finishing of the object's surface, and the perceived familiarity. For instance, when asked to feel a brushed steel cup, a material usually associated with coldness, several participants described it as warm and comfortable. This was surprisingly similar to the feedback for other materials, i.e., wood, silicone and crochet fabric. At the same time, two samples of wood with different finishes, one varnished bowl and one rough block of wood rendered very different associations from the participants although being the same material. These two cases demonstrated to us how the finishing of the surface would influence the texture of the material to such a degree that the materials were no longer perceived as similar. During interviews, the participants explained that trying to identify the purpose or application of the material further affected their ability to identify the material; expectations of intended application could potentially yield confusions about the material itself. Similar objects were identified as ranging from a lid (woman, 81) to a ball (man, 79), and their perception of the material was very different due to this conflicting interpretation of purpose. Besides the surface, the form of the object also played into the experience of the material. One participant explained how the smoothness of materials was a key factor as it influenced resistance and ability to grip (man, 84) while another participant related their perception and preference to the physical shape of the material (man, 80). However, most results suggested that participants favored materials that were perceived as warm and smooth such as wood and silicone.

The GLiMT-prototype used in the usability tests further allowed us to explore material properties such as weight and size. Through testing various shapes and sizes, we ended up with a form that all participants were able to handle, i.e., lift and hold (Joshi and Bråthen 2016a). However, certain participants with psychomotor challenges expressed concerns with the weight of the material: “I have arthrosis, so it is a bit heavy for me, but I can do it.” (woman, 79). Another participant struggled with the size due to challenges with dexterity: “My fingers are a little stiff, but I can manage this.” (man, 86). The participants’ perception of the material properties was not a static and definitive relation; it evolved along with changes to bodily capacities.

4.2 Context

Interviews and usability tests revealed how the aesthetics properties of the material were of importance to the participants. This was the motivation for also facilitating blindfold testing where preferences towards aesthetics properties would not bias their tactile experience of the material. A material particularly favored by several participants was wood. One of the main comments during the usability testing of the GLiMT-prototype was that they enjoyed that the prototype was neat and simple, frugal, and Nordic in its design. The simple and Nordic design were explicitly associated with the wooden material: “It is very nice and neat. This is what you associate with the Norwegian; it is wood.” (woman, 87). Interviews revealed that the aesthetics were a part of how they experienced the object in relation to its surroundings, a factor that for most participants heavily influenced the perception of the material. Most comments on appearance revolved around envisioning how the material properties of the exterior of the prototype would fit in their homes. For certain participants, the material would decide whether it needed to be stowed away during visits: “It is not ugly, either, it could very well be left out on the table.” (woman, 89). The participants associated technology with certain materials and colors and materials that would remind less of assistive technology would be easier to have laying around. This was to them an advantage of the design that the younger participants did not perceive as equally necessary or important.

The difference in preferences between generations was further strengthened by the statements from the domain experts who were very much satisfied with the cold, shiny, and sharp look of existing technology: “It should be black and look more like the other technological devices I have so that it would fit in my home” (domain expert, 45). We also registered a difference in expectations between the younger and older participants within the user group (67-92 years). While the oldest participants preferred simple and traditional aesthetics, the preferences of the younger participants aligned more with the views of the domain expert: “It should be black or light so it could go with anything. Then it would be more appropriate in my home” (woman, 67).

Finally, the intrinsic value of using certain materials in assistive technologies played an important role to the participants. In contrast to most screen-based interfaces, GLiMT was described during the usability tests as “something real, not just a screen” and favored due to its material properties. Interacting with physical components in a physical environment yielded a different experienced compared to performing similar tasks on a screen-only device, and the material properties of the physical components stimulated particular emotions. In our case, the participants described the wooden material as fun and playful, thereby inviting to interaction. Participants explained that the physical and material properties triggered a curiosity and that the shape and material invited to play: “I feel like a child playing with blocks! It is fun!” (woman, 83).

4.3 Intuitiveness

When interacting with the two different components of the GLiMT prototype, we noticed a consistent difference between the behavior of the user group and the control group. To figure out how the two devices could be used together, six out of seven participants in the user group found it natural to explore the GLiMT cube itself before exploring the base box or tablet. Three of the participants in the user group commented that they intuitively searched for something on the base box to complement the cut-outs on the cube. One of the participants also got the impression that something removable from the base box could be placed inside of the cut-outs on the GLiMT cube. Some participants struggled with finding any elevations or bricks; they all proceeded to place the smaller cube on top of the other. In the control group, all the participants chose to start exploring the base box or tablet first, and then move on to the smaller GLiMT cube. Two of the participants in this group explained that they were looking for cables to connect, input/output ports, as well as complementary input mechanisms.

As this data came from a tactile exploration, we paid particular attention to all the interactions attempted by the participants. Rather than examining whether they understood what particular interaction mechanism we had implemented through the materials, we were instead interested in studying what interactions they found most natural when they came in contact with the material. There were vast variations in how the different participants perceived the intended interactions, both between the experiment and control group and within the experiment group. Two participants attempted to push down the insides of the cut-outs like a pushbutton (woman, 68; woman, 86), and one participant stroked inside cut-outs in a circular movement like a touch-based scrolling wheel (man, 54). Other participants used the physical sides to feel for cues, for instance, one participant who looked for some way to differentiate between the sides and expected there to be some detectable difference between them (woman 68). We did not control the order in which they explored the different components, and in the control group, all the participants chose to start exploring the base box or tablet first, and then move on to the smaller GLiMT cube. Two of the participants in this group explained that they were looking for cables to connect, input/output ports and (man, 35) and complementary input mechanisms (man, 54).

While only two out of nine involved participants managed to figure out the interaction involving the tablet and GLiMT cube, 7 out of 10 participants managed to place the smaller GLiMT cube on top of the larger base box. The other two participants chose to place the box and the cube next to each other on the table instead of on top of each other. The observed difference between the two forms of interaction – tablet and base box – seemed to be related to the material similarities between the box and the cube. They were both made of wood and raised a similar experience. Similar circular cut-outs that were easily recognizable to the hands of the participants provided a tactile resemblance. The cubical shapes also reminded some users of building blocks that were easily recognizable to the hands of the participants. This observation was similar to what we observed in the analysis of context issues during the first phase.

One consistent feedback from participants during the blindfolded tactile testing was that they would have liked the cube to be smaller to fit better inside the hand. However, when allowed to visually assess the GLiMT cube after the initially blindfolded exploration, they suddenly expressed concerns that it was too small; this was due to the legibility of the visual symbols. Suggestions were made by participants in both the experiment group (woman, 92; woman 86) and the control group (man, 35; man, 26), e.g., to let the symbols fill the whole side of the cube to ensure better legibility: *"The icons should have been larger, maybe filled the whole side"* (man, 35). Participants had other opinions on how to solve this such as filling the whole side with necessary graphics or even removing the wooden frames to allow more space for the image without having to compromise on the size. In both the blindfolded exploration and the visual assessment, there was a unanimous agreement across the participants that the cube should not be any heavier.

4.4 Findings

The qualitative data from both phases were thematically analyzed to look for emerging patterns. The analysis during the first phase included data from the individual and the group interviews, as well as from the usability tests. We analyzed the data in both phases using the thematic analysis procedure described by Braun and Clarke (Braun and Clarke, 2006). Using open coding, the data sets were initially read carefully to identify and code for patterns in the data. The resulting 28 codes were reduced to three main themes by ordering and clustering them. During the first phase, we chose to focus our analysis on a priori coding using themes of familiarity and context within the data to answer our initial questions about assistive technology and materiality. The categories and themes were selected based not on quantitative measures of prevalence, but of salience to our research question. We chose to subject all our different types of data to an analysis that had its point of departure from our research question and chose the theme based on what Braun and Clarke terms "keyness". In the second phase, we based our analysis on data from post-experiment interviews during the tactile exploration. The transcribed data was paired with observation, photos and field notes to triangulate the data material. The analysis revolved around our third research interest, intuitiveness. A summary of the three thematic areas from both phases along with main findings for each thematic area is presented in Table 2.

Table 2. Overview of main findings

Thematic area	*Main findings*	*Source method*	*Key observations*
Familiarity	▪ Familiarity with materials is tied to experience and expectations ▪ Material properties such as texture influence the perception of material type ▪ Perception of material changes along with the bodily changes	[C], [D], [E]	▪ Expectations of the purpose or application affected the tactile experience of the material ▪ Different textures conveyed different meanings when using the same material ▪ Participants with psychomotor challenges expressed concern with long-term use due to bodily capacities
Context	▪ There were strong preferences and objections towards the aesthetics ▪ Expectations regarding appearance seemed to be different between age groups ▪ The opinions of material were largely dependent on the intended use context	[B], [C], [D], [E]	▪ Wood as a material was appreciated for its simple, frugal, and clean aesthetic properties ▪ Domain experts preferred ergonomic values while elderly participants focused on simplicity ▪ Shaping an opinion on a material was difficult without understanding the context as the material had to "blend in" with the environment
Intuitiveness	▪ Expectations regarding the functionality seemed to be different between age groups ▪ Tactile evaluation yielded different preferences for size ▪ Similar materials created an association to similar tasks	[F]	▪ The older participants looked for other tactile cues than the young participants ▪ During the blindfolded testing, the participants expressed preferences that did not depend on visual cues ▪ Participants completed tasks faster when all components were of similar material

5. DISCUSSION

5.1 Designing for Familiarity

Our goal was to explore how materials could support habits and capacities. Incorporating materials in the design of assistive technologies for elderly people has contributed something more than the mere pleasure of inviting aesthetics. Our application of materials in the design process also aligns with the notion of the texture as central to the communication of a material's properties to the user through its surface and appearance (Vallgårda and Redström 2007, Wiberg 2014).

We found a clear tendency between the tactile experience of the material and what the participants believed the intended purpose of use to be. Furthermore, it is the characteristics of materials as well as the material itself that anchor habits and bodily capacities, something that is particularly true in cases where the users are experiencing declining function (Krasner 2006). We also found that exploring materials helped to invoke not only a familiar association but also appropriate associations. Familiarity may help the user relate to the technology and perhaps even provide usability. However, usability alone does not guarantee that the technology will be used (Hirsch, Forlizzi et al. 2000) as the material features of technologies has an important impact on whether and how they will be used (Greenhalgh, Wherton et al. 2013). We saw how certain aesthetics properties of materials carried stigmatizing and undesired signals discouraging use, e.g., technologies built with material that reminded the participants of their own helplessness. This low use rate due to stigmatizing has been previously observed in our empirical context (Joshi 2014). A material explanation for low use rates is that certain designs look like they belong in a hospital and that their presence and use bring the users "one step closer to institutional care or death" (Greenhalgh, Wherton et al. 2013). Similarly, we registered how certain materials such as wood yielded encouraging designs, something Hirsch, Forlizzi et al. (2000) argue can add dimensions to the design that contributes to a positive self-image of mastery and a more positive perception of own abilities by empowering the user.

Furthermore, certain materials afford certain actions or behaviors through expectations of the material properties. This phenomenon is for instance mentioned by Döring, Sylvester et al. (2012) who observed in their studies that users interacting with soap bubbles as the material would act cautious and calm in response to the fragility of the material.

Besides discovering the appropriate material itself, the use of the material may highly influence the experienced familiarity. Physical objects naturally link visual appearance with other characteristics such as weight, material, texture, and sound (Djajadiningrat, Wensveen et al. 2004), and directly engaging with materials alters our relationship to and experience of materials (Wiberg 2014). Removing visual stimuli from material exploration allowed us to explore isolated characteristics of materials (e.g., the surface) by exploring the surface as the material's interface to its surroundings (Vallgårda and Redström 2007). The blindfold testing in our study revealed different associations for similar materials based on the texture of the material. Based on our findings, we argue that all material dimensions such as aesthetics and functionality need proper exploration in order to communicate appropriately with old habits and familiar gestures.

5.2 Designing for Context

Even though new technological designs cannot directly represent the past and the lived life of an elderly user, the design may support the elderly by building on a metaphor that reminds the user of familiar things and blends into a cherished tangible environment to avoid disruption. The aesthetics of the material were important to the participants and all participants who expressed a preference or objections on the aesthetic properties of the GLiMT-prototype evaluated it explicitly in the context of their homes. It became challenging to disentangle the material from the context, and it was hard to discern whether it was the material or the finished product in their homes that were being evaluated by the users, even during the blindfolded test. Their main concerns were linked to how well the design would blend in or not, and whether it could be "left in plain sight" without disrupting their home aesthetics. Krasner (2006) argues that the immediate tangible surroundings provide comfort and support their habits by “enabling them to mirror their lived lives and their identities”. By their very nature, older adults’ memories and stories can highlight their identity in terms of their home. Often, the home is where people age and ‘‘what has happened in life is increasingly likely to have happened in this place’’ (Rubinstein, Kilbride et al. 1992). Thus, the disruption of the aesthetic harmony in the homes of the users should be avoided when designing assistive technologies. This importance of the home to elders is also emphasized in the in the EAT guidelines for designing for Alzheimer patients (Fay, Fleming et al. 2010), and Greenhalgh, Wherton et al. (2013) describe how assistive technology left in homes can disrupt the equilibrium by making the room untidy or cluttered.

Another reason that the home becomes gradually more important to elderly people in need of assistive technology is that many elderly people find their surrounding space narrowing down. The accessible world often shrinks with declining functioning abilities, including their immediate surroundings, their homes, and often also parts of the home, e.g., the kitchen or the living room (Krasner 2006). Accordingly, the presence and influence of the assistive technology become stronger as the space shrinks.

5.3 Designing for Intuitiveness

The understanding gained during the first phase helped us develop our understanding of intuitive characteristics of materials; the theme of intuitiveness grew out of the conclusions from the first phase, as presented in (Joshi & Bråthen 2016b), and gave us a new theme to explore during the second phase. Blackler et al. (2003) developed three design principles for increasing intuitiveness by promoting familiarity in the design of interfaces. The first principle recommends using existing designs to introduce familiar features in new products. By choosing familiar shapes and materials in the design, we attempted to build on the users’ past experience interacting with technology. Several users told stories about the radios their families used to have and vividly described the wooden cases, including the feel and even the smell of the materials that constituting the radio. The shapes and material properties aimed at suggesting intended use by reinforcing past experiences with building blocks, wooden material, and the assemblage of multi-component devices. This also corresponds to the second principle: using metaphors to illustrate the intended use of entirely new functions in a design. The similarities between the base box and the GliMT prototype in appearance, shape, and materials seemed to aid the participants in executing the given tasks. There also seemed to be an advantage in the relative sizes; one box was smaller, and the participants reported that the size itself suggested that its place was on the top of the other.

However, people struggled with combining the wooden block with the tablet. We may attribute this failed attempt amongst the participants to a lack of material consistency within the design. The third principle of Blackler et al. (2003) is to ensure a strong consistency between all the design components. Even though the action of placing the lit side next to the different types of receivers (e.g. base box, tablet, and phone) was the same across the devices, the tactile exploration indicated that this was perceived as very different types of interactions. The technology, the users, and the actions were the same, yet still, the material differences changed the intuitiveness of interactions. We might also have failed to reproduce sufficient interaction metaphors with our design to properly replicate an interface that truly exploits past habits and competences (Blackler et al. 2010). A failure to properly simulate or reproduce past interaction experiences may explain why the participants in the experiment group demonstrated less intuitive interaction relatively compared to the younger control group.

We also registered a strong link between the material and the natural actions. In the same way that people would handle a glass vase more carefully than a plastic vase, the participants gave feedback on the relationship between the material properties such as durability and the intuitive actions to which they led. Odom et al. (2009) found that the perceived quality of materials in an object plays an important role in perceived durability; the perceived quality of materials in an object usually contributed to the strength of attachment, which they claim contributes to continued use and preservation. We registered responses, both through intuitive gestures and verbal loud-thinking, suggesting that the wooden quality of the box triggered a sensation of dealing with “something real”. They implied that its solid and durable nature also enforced a strong attachment to the object. Our findings mirror the findings of Odom et al. (2009) who experienced a similar attachment due to the durability signaled by materials such as wood and metal.

6. CONCLUSION

We have seen how the use of materials affected the users' perception of all the three themes of this paper, i.e., familiarity, context-suitability, and intuitiveness. We have studied expectations, preferences, and responses to various materials in the context of assistive technology, and we have summarized the analyses as nine main findings accompanied by key observations. The results presented in this paper are still too limited to draw any definite conclusions. However, our claim is that there is a noticeable and traceable relationship between the materials used and to what degree the participants experience the interface or the interaction as familiar, contextual, or intuitive in use. The blindfolded tactile exploration provided interesting findings on how users react when they first come in contact with materials. We believe that a better understanding of users' past experience with various technologies and materials can support interfaces and interaction mechanisms by building on past competence.

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