Morning Routines Between Calm and Engaging: Designing a Smart Mirror

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Abstract: Frequently the main purpose of domestic artifacts equipped with smart sensors is to hide technology, like previous examples of a Smart Mirror show. However, current Smart Homes often fail to provide meaningful IoT applications for all residents' needs. To design beyond efficiency and productivity, we propose to realize the potential of the traditional artifact for calm and engaging experiences. Therefore, we followed a design case study approach with 22 participants in total. After an initial focus group, we conducted a diary study to examine home routines and developed a conceptual design. The evaluation of our mid-fidelity prototype shows, that we need to study carefully the practices of the residents to leverage the physical material of the artifact to fit the routines. Our Smart Mirror, enhanced by digital qualities, supports meaningful activities and makes the bathroom more appealing. Thereby, we discuss domestic technology design beyond automation.

1 INTRODUCTION

In recent years smart home systems to save energy, increase security, and enable (self-)monitoring were researched and developed (Hargreaves and Wilson, 2017; Jakobi et al., 2018). For most parts, the current Internet of Things (IoT) is built to collect data and automate routines (Tuomela et al., 2019; Castelli et al., 2017; Wilson et al., 2015). By making the gathered information accessible to households, typical IoT consumer technology design shall facilitate behavior change or real-time reactions to unusual events. Additionally, Intelligent Personal Assistants (IPA) are increasingly integrated into speakers or ambient displays to allow for 'natural' interaction with all IoT appliances (Ammari et al., 2019). That falls in line with Weiser's vision of calm technology (Weiser and Brown, 1997) with technology 'disappearing' and little to no digital interruption.

However, such design credo ignores user expectations of engaging and exciting interactions, for example, when talking with IPAs (Cho et al., 2019; Clark et al., 2019). Mostly, building close relationships with technology fails as users desire true conversational interactions going beyond short and single commands (Cho et al., 2019). Besides IPA control interfaces, other work even indicates that people fear becoming passive and lazy in fully automated home settings (Mennicken and Huang, 2012; Ambe et al., 2019). This lack of practice engagement and missing meaningfulness throughout IoT interaction leads to limited long-term use of home IPAs and even non-use (Cho et al., 2019; Luger and Sellen, 2016). Still, the concept work of smart home artifacts is often technology-driven with the main purpose to conceal ambient displays by neglecting the variety of domestic needs and values (Ardito et al., 2015; Athira et al., 2016; Cho and Saakes, 2017). Instead, meaningful qualities that traditional artifacts inherit, should be further digitally extended (Hallnäs and Redström, 2006).

To explore the potential of making traditional artifacts interactive, we investigate the design space of a Smart Mirror. Thereby, we followed a design case study approach as proposed by Wulf et al. (2011). First, we studied entangled morning and evening routines in and outside the bathroom by a focus group of seven and a diary study of ten participants. Based on the material, we developed a modular concept as a mid-fidelity prototype. Lastly, we evaluated the mir-

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ror design with five participants in their bathrooms.

Our findings indicate that the design trend for "optimization" of domestic routines limits the perspective on valuable smart artifacts. Our prototype offers an alternative design for pleasant interactions that fit personal and steady as well as rapidly changing routines and needs. However, many of them create space for self-care or conscious moments of reflection or creativity. Engaging applications like embedded in our Smart Mirror may support those pleasant activities.

2 RELATED WORK

2.1 Smart Artifacts Between Automation and Control

From a traditional perspective, smart home technology has been mostly associated with optimized, efficient routines and autonomous decision-making of the system (Tuomela et al., 2019; Cedillo et al., 2018; Hargreaves and Wilson, 2017). This includes installations of automation infrastructure to save energy, to increase safety, or to enable (self-)monitoring (Castelli et al., 2017; Cedillo et al., 2018; Jakobi et al., 2018; Colantonio et al., 2015; Wang et al., 2019). According to Mennicken and Huang (2012) the perceived benefits are 'small conveniences rather than substantial support for routines'. Previous work (Mennicken and Huang, 2012; Ambe et al., 2019) shows that people fear such technologies to deprive them of the activities they enjoy and, hence, make them passive and lazy. Furthermore, frequent notifications contribute to a constant distraction and reduce well-being (Woodward and Kanjo, 2018).

Smart Speakers, Displays, and Mirrors are frequently introduced as smart home control interfaces (Clark et al., 2019; Athira et al., 2016; Ardito et al., 2015). Following the predominant design paradigm, their main purpose remains to control lights and music, inform about weather conditions, or set reminders (Ammari et al., 2019). However, Cho et al. (2019) shows that users expect those devices to interact intelligently. This mismatch disillusions long-term users, subsequently adapting their language and expectations (Cho et al., 2019; Ammari et al., 2019). One reason devices are not becoming substantial is the lack of engaging interaction and greater support for daily routines. Pleasure is limited to colorful mood-setting, light controls, or connected entertainment devices (Strengers et al., 2019; Jensen et al., 2018).

Similarly, most studies investigating the design and use of smart mirrors focus on ambient information access (Ardito et al., 2015; Athira et al., 2016; Cho and Saakes, 2017; Wang et al., 2019; Fujinami et al., 2005). They often lack the enhancement and extension of their physical properties such as the mirror surface, but merely serve to mask built-in technology. Persuasive mirrors (Nakajima et al., 2008) tend to overemphasize behavioral change for long-term interactions and objectives, while meaningful applications can also arise from sporadic interactions.

2.2 Towards Engaging Artifacts

By recognizing the current downsides of the predominant design paradigm, various researchers proposed directions for a future beyond automation and control (Eggen et al., 2014; Rogers et al., 2007; Desjardins et al., 2019; Strengers et al., 2019). There is a chance to understand the home as a design space inspired and shaped by various interactions and activities between residents and artifacts (Kranz et al., 2010; Cila et al., 2017; Paay et al., 2018). Here, Gaver (2001) argues, 'unless we start to respect the full range of values that make us human, the technologies we build are likely to be dull and uninteresting at best, and dehumanizing at worst'. In particular, when we treat domestic practices with the same optimization approaches as the workplace (Crabtree and Rodden, 2004; Hargreaves and Wilson, 2017). Similarly, Desjardins et al. (2019) propose placing a stronger effort into conceptualizing and exploring the look and feel of alternative visions of co-living with smart IoT. Therefore, design approaches should leverage the range of activities performed in the home rather than decrease their relevance through automation. In this light, Hassenzahl et al. (2013) argues to focus on positive activities. Therefore, the level of interactivity does not necessarily have to be reduced in favor of efficiency (Eggen et al., 2014; Desjardins et al., 2019; Hassenzahl et al., 2013), but enhanced towards more enjoyable interactions.

Verbeek's (2005) notion of things that 'act' allows following this perspective by recognizing the values and inherent attributes of the artifacts as actors. These properties 'enable and constrain certain ways of interaction simultaneously.'(Fuchsberger et al., 2013) and thus, allow the building of close relationships between objects and residents through greater engagement and personal interactions (Jung et al., 2008). A mirror surface, for example, is appropriate to display content but simultaneously confronts people with self-reflection as they observe themselves (Mols et al., 2016). Onward, it may also support workouts (Hämäläinen, 2004) or even art (Jacobs et al., 2019).

Hence, we need to explore how to create interac-

tive resources for engaging experiences that support currently performed activities (Rogers et al., 2007) by understanding the context and already established material of the domestic practices. We thus aim at better understanding what it means to shift between calm and engaging experience and how to design for more well-being in Smart Homes.

3 DESIGN APPROACH

Following a user-centered design approach, we conducted a Design Case Study by Wulf et al. (2011) to align the design of an interactive mirror with the needs of potential users. At first, we conducted a focus group to discuss the actual use, meaning, and entangled practices around the mirror to determine potentially engaging design opportunities. Due to the primary use of mirrors in the morning and evening, we continued with a diary study of according routines and follow-up interviews. The results of our formative study led to a conceptual design of four separate digital applications later embedded in the artifact. Finally, we evaluated the prototype in a Wizard-of-Oz study (Yu et al., 2016).

3.1 Focus Group

The focus group aimed to explore the meaning, actual use, and activities surrounding mirrors in everyday life. Therefore, four female and three male participants, aged between 26 and 29 years, were recruited by snowball sampling. We decided to foster discussion by inviting three early adopters who can weigh in their experience and curiosity towards consumer electronics and four technology critical and hesitant adopters. The discussion was led by the host asking guiding questions but otherwise remaining silent. After a brief personal introduction, participants shared their estimated time per day in front of the mirror and situations when and where actively using the mirror. Thereby, the most commonly reported practices involved the bathroom. Afterward, mirrors as home materials and goods were discussed. We intended to encourage reflection of personal experience and interaction with the traditional mirror to explore new design possibilities for computational properties. Finally, each participant sketched on paper their personal vision of an ideal mirror with potential applications and desired interaction. The discussion was audio-recorded, transcribed, and thematically coded by two researchers. Afterward, we discussed the themes within our research group, likewise all participants' drawings (Braun and Clarke, 2006).

3.2 Diary Study

To gain a thorough understanding of the qualities of a traditional mirror and associated routines, ten participants shared information about their everyday life for seven days within our diary study (Bolger et al., 2003). The sample was heterogeneous considering prior technical knowledge, marital status, occupation, living situation, and experience with digital assistants. It was recruited by snowball sampling and aged between 21 and 33 years. Six participants had a significant other, with three of them living in the same household. The others lived alone or shared an apartment. The type of education or occupation partially structured their everyday life: Six employees, with one working frequently from home, one student, one pupil, one freelancer, and one mother occasionally working as a freelancer.

We used EthOS[1] to record everyday events that participants logged via their mobile phones, and supervisors were allowed to view, sort, and code entries simultaneously. The first question required a photo response, and the other questions alternated between descriptive free-choice media and forced/multiple-choice options. A total of five questions had to be answered descriptively in the morning and evening, and three multiple-choice items in the morning and two in the evening. Besides automatic notification of any changes, the supervisor sent emails twice a day as reminders to the participant.

Afterward, in-depth interviews (70 minutes on average) addressed possible ambiguities and specific questions on occurring events. As the recordings were limited to a one-week diary study and represented just a fraction of daily life, we aimed to reflect with the participants on their perception of their behavior, such as the general handling of digital devices, the corresponding applications, and its meaning to them. The mirror was discussed as an interactive artifact in domestic spaces between relaxation and activity within evening and morning routines. Thereby, reported photos and further media enabled us to ask more detailed questions about context-related activities such as daily planning, bathroom activities, relaxing routines, morning motivation and priorities. Finally, the participants were asked to express their ideas and criticism on the applications, interaction, and the use of a smart mirror. Particularly, we aimed to discover differences between people as well as deviations in the same person (Bolger et al., 2003). Therefore, daily reported enumerations, descriptions, experiences, and final interviews were coded and analyzed for similarities, differences, ambiguity, and needs.

[1] www.ethosapp.com

4 CONTEXTUAL ANALYSIS

4.1 Expectations of a (Smart) Mirror

The participants estimated their mirror use between five and 30 minutes, on average 18 minutes a day. All participants owned a bathroom mirror which they referred to as the principal mirror of use. The actions performed in front of the mirror range from the last glance before leaving the door to engaging interactions like conscious personal care. The bathroom itself represents for most of the participants the most private and intimate space in the home. Within this context, the mentioned media applications are strongly entangled with personal morning and evening routines, as the most frequent hours spent at home. Most of the participants desire functions related to infotainment and organizational tools. The analysis of the drawings implies that all of them request effortless syncing of their favorite smartphone applications with the mirror, besides monitoring home appliances. Some participants see great benefit to watch make-up tutorials on a Smart Mirror. Presenting the drawings of their 'Dream Mirror' revealed new ideas and thus mutually influenced the desires and inspirations of all. Hence, alternative scenarios encouraged the evolution of further needs that had not previously been thought of by all (Rogers et al., 2007). Although many of the described functionalities would require cameras and microphones for implementation, every participant had privacy concerns regarding smart home systems.

4.2 Morning and Evening Routines

The documentation of daily digital activities, the interaction with physical objects, and the associated significance for the participants provide information about the interrelated factors that influence well-being at the corresponding time of the day. Both individual moments and long-term use can provide context-based personal goals and values.

Spending time in the bathroom ranged daytime-specific from five to 15 minutes for a short stay and 20 to 45 minutes for more time-consuming practices. The average time for each participant per day turned out to be quite similar. All participants expressed that their bathroom design has a considerable effect on their well-being and thus on their stay. Therefore, they had hung up personal pictures or photos and set up decorative elements such as plants. Lighting design, music system, bathtub, and photos contributed significantly to a pleasant bathroom atmosphere. The weekend resulted in several short visits to the bathroom as there was no time pressure compared to workdays. The sequence of activities differed between participants, but brushing teeth or drinking coffee in the morning were usually among the first after getting up. Longer stays usually involved showering with body and face care. Dental care usually was done twice a day and took a planned minimum of two minutes. Meantime, the activities performed consisted of looking in the mirror, doing nothing, seeking engagement or entertainment in or outside the bathroom. Some noticed their tired face or checked it for health in general. In the evening, all female participants followed their facial skincare routine.

Participants considered a morning atypical as soon as something unforeseen had to be done, thus increasing the time pressure. The same applies to difficulties getting out of bed or being sick. One participant structured his morning with a mobile app that was designed to encourage good habits and included a checklist to do so. Another participant started to wake up by interacting with his mobile phone, while another one often laid down for a few more minutes to think about the day ahead. Many of the participants depended on public transport and therefore always kept track of time. Daily planning was sometimes omitted by those who had structured days and hardly required any additional preparation for work. Otherwise, participants intended to do the planning of work tasks in the office before leaving. Depending on the evening before, 'morning activities' could last the whole day or until leaving home. The use of reminders involved only cases of unusual events or for irregular notes like bringing musical instruments or sports equipment to work for after-work events. The morning routine at the weekend could no longer be recognized as such, as most of the participants started the day without any time pressure. Shortly before falling asleep, many of the participants reached for various media such as videos, books, music, or devices to browse the Internet. Media activities can generally be categorized as follows: Social media, news and communication, entertainment, online learning and tutorials, health and well-being, shopping and renting, dating, and smart home appliances. For more complex tasks, participants preferred a bigger screen size and the appropriate interaction style.

5 CONCEPTUAL DESIGN

Previous results show that even if established routines exist, participants carve out time for (self-)reflection, conscious personal care, or enjoy moments of doing nothing in specific. Daily planning was either done

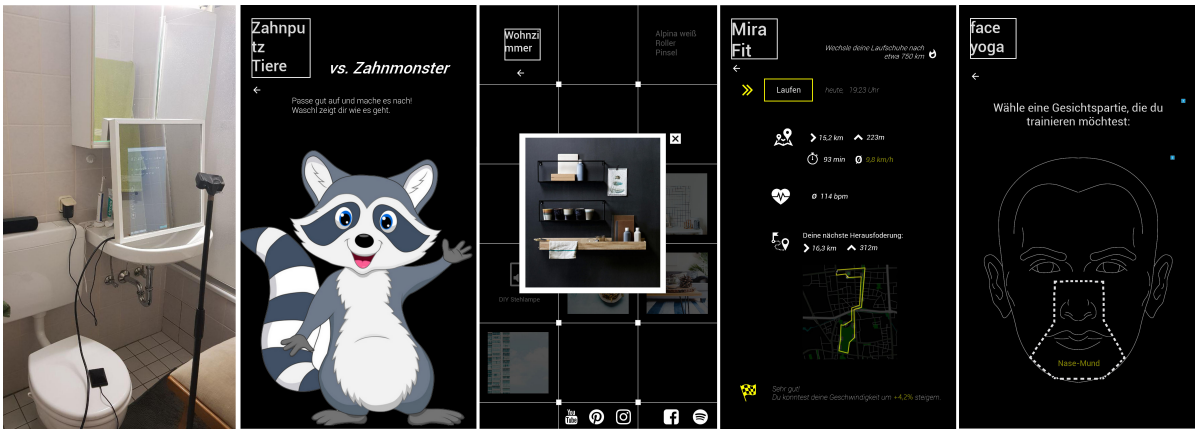

Figure 1: Evaluation set-up and exemplary prototype screens: Tooth Brush Animal, Instant Idea, MiraFit and FaceYoga.

during the working time or only in case of unusual events. In contrast to previous research, we wanted to go beyond the design for optimization and efficiency and focus on conscious and active moments of interaction and experience. Thereby, aesthetics, personalized design, and well-being strongly influenced the stay in the bathroom. We consolidated the gathered data, needs and actions, and used a scenario-based design approach to develop our mid-fidelity prototype. As follows, we will outline our general concept and the prototype in detail.

The concept entails four main applications and a home screen with basic functionalities for communication, connected devices, and reminders (1). A personal agent enables navigation through several applications and functions to facilitate seamless interaction in the whole room. Depending on the application, the agent changes roles supporting the media style, e.g., the character of an animated animal. Our heterogeneous samples showed clearly that future designs have to be customizable. Meanwhile, our concept focuses on engaging support for the activities at hand, situated well-being, and (self-)reflection. The four proposed applications build a modular foundation for various engaging features and interactive media elements adapted to the needs of the residents and the specifications of a mirror.

6 MID-FIDELITY PROTOTYPE

As follows, we built a mid-fidelity prototype to illustrate the possible look and feel of a Smart Mirror in reality (1). Therefore, we examined the application ideas to determine their feasibility with respect to the technical limitations of the hardware elements and the test environment for evaluation. The central part of the smart mirror is a light monitor display concealed by a spying mirror glass as an interaction surface. This surface is partly translucent, hence, hiding everything dark. We tried to provide an experience as realistic as possible regarding the interactive digital elements and current hardware options. The interaction comprises voice in- and output as well as visual support. Icons and text prompts provide an overview of the application and support menu navigation. The size and distance of the visual elements are proportional to the size of the display, taking up about half of the mirror surface. The arrangement of the elements attempts not to interfere with the person's mirror reflection. By triggering an application, the content extends across the entire display as needed while enough mirror surface remains usable as such.

Home Screen. Organization and communication tools have clear value for domestic life. Hence, for completeness, we decided to incorporate visual signifiers that illustrate further tools. As with conventional end devices, the screen functions as an overview of the installed applications that are represented by icons. Those are accessible by saying the voice command 'Mira, please start application xyz'.

Face Yoga. This interactive video tutorial is based on yoga practices to train and relax facial areas and support mindful recreation. Short audio and video instructions provide exercises for different face parts. They offer personal care for personalized time budgets of two to seven minutes, creating opportunities to incorporate more active time with and for oneself. Calm music and wording contribute to a reflective atmosphere by building on the context of Yoga. The agent acts as a guide and describes further steps as well as the flow of the exercise. The user can check the correctness of movements simultaneously in the mirror. For demonstration purposes, we have currently provided offers such as anti-aging and relax-

ation exercises only. Finally, these should be easy to integrate into personal care routines and create moments of conscious interaction and reflection.

Tooth Brush Animals. In this application, the agent acts as one of three animated animals to motivate and teach children to brush their teeth properly. Therefore, the agent transforms from a calm background assistant to an active coach and has distinct characteristics to build a trustful and engaging relationship with the child. Further, the animal tells a story about 'little tooth monsters' that try to attack the teeth and can be defeated only with the help of proper tooth brushing techniques. An animated dental model shows the correct brush movements in the oral cavity. The embedded gamification approach aims at additional motivation by offering further animals to unlock. This approach can be applied and modified for different topics relevant to children and to support parents in child care. However, this is a way to create more well-being in bathrooms which often seem sterile and not fun espacially to children.

Instant Idea. Many of the best ideas and creative moments arise during a moment of relaxation and non-activity of the brain (Krampen, 2019). Additionally, people take active time to think of the day ahead. Instant Idea shall support users to capture and pursue spontaneous ideas right in the bathroom, e.g., by doing a voice memo or an image search. Moreover, every media format and platform, e.g., videos, screenshots, or tweets, can be saved for a future purpose and processed on other devices. It is possible to insert and compile the content into a personal grid of inspirational ideas and quotes, allowing users a versatile combination of the collected material to develop new ideas and concepts. In general, this application supports thought activities and creative moments by enabling users to capture and structure their thoughts.

MiraFit. MiraFit imports and visualizes data like current activity results and goals collected by the users' preferred mobile fitness application or tracker. The aim is to support personal care and self-reflection on physical goals as well as sports habits. The mirror proactively visualizes information and acts as a coach with further data-based advice. For example, motivational quotes from successful athletes will appear or new challenges are proposed. This application is timed to suit the users' post-exercise needs while they are following their care routines. In particular, the main results should be visible at first glance and engaging to users for future habits, exercises, and well-being.

7 EVALUATION

We conducted a heuristic evaluation to explore the potential value of the concept and discuss future design implications for smart artifacts. At least two of the four applications matched the participants' needs and goals for personal care and well-being in the bathroom. We recruited our participants by snowball sampling with an average age of 28.4 years, ranging between 23 and 32. Two of them lived alone in a one and two-room flat, and one shared a two-room flat with a co-inhabitant. The other two participants are married and live together with two little children, three and six years old, in a three-room flat. All participants had some experience using mobile voice assistants.

For an authentic atmosphere and personal experience, we conducted the evaluation in the bathroom of the participants. The mirror prototype 'Mira' was placed on the washbasin in front of the actual mirror (1). The test leader and assistant observed the interaction next door on a live video stream. The test leader acted as 'voice assistant' within the Wizard-of-Oz (Yu et al., 2016) scenario set-up. Therefore, we equipped the bathroom with a microphone and a small speaker. The participants used their voices to command actions. The test leader executed them by clicking on the according elements in the digital prototype transmitted from the laptop to the Smart Mirror display. Each participant received two scenarios and a corresponding task. Meanwhile, the actions were recorded on video, and observations were noted. Afterward, participants had additional time to explore the rest of the content freely. The participants were asked to think aloud during the whole session but needed to say 'Mira' as an activation word to use voice commands. Otherwise, the test leader would not respond. General questions that emerged during the test were not answered until the end unless the participants had specifically asked Mira for such information. In total, one session lasted between 45 and 60 minutes. The videos were transcribed, coded, and deductively classified in MAXQDA (Braun and Clarke, 2006).

7.1 Findings

All participants had a positive first impression, like P1 noted: 'I actually thought it would look more "Do It Yourself" and not so professional'. They described the handling as intuitive and well-structured. All of them agreed that the applications added value, but the better they corresponded to personal practice, the greater the enthusiasm: 'Fitness or relaxation helps me to relax in everyday life, it could increase my quality of life' (P3). As P5 elaborated: 'The idea with the

toothbrush animals is great, Instant Idea is very good, FaceYoga I don't know'. Most of the participants successfully completed every task and handled the fictive voice control well. In particular, three participants completely blanked out the test leader, fully engaged in the interaction, and explored all applications via voice command. Both during the test and in follow-up interviews, the adjectives mentioned, such as 'presentable', 'innovative', 'likable', 'pleasant', and 'motivating' indicate a positive experience.

7.1.1 Home screen

Participants particularly embraced the displayed clock and reminders on the home screen, e.g., taking their sports equipment with them, since they had no time indicators or note board in their bathrooms. Offering clothing suggestions in the case of rainy weather was perceived twofold: 'I will make my own decisions for myself, just take a jacket or umbrella is fine' (P5). He was deliberately refusing to be patronized by technology. Further, some participants would have liked more visual indicators for possible voice interaction because of the unfamiliarity with it.

7.1.2 FaceYoga

The opinions on this application differed. Regarding design and interaction, the participants described it as entirely positive, supportive, and pleasant: 'It was clear which parts of the face could be selected. I also found it good that the voice guided me. I also liked the fact that it asked me if I wanted to do another exercise.' (P3). In terms of content, however, only two of the participants would repeat the exercise and one would try out different exercises first because this particular session was not effective. Several participants emphasized the benefits of demonstration, an easy way to simultaneously join the actions and correct oneself by using the mirror: 'It's super intuitive because you can't go wrong with it.' (P2). In the beginning, P4 was irritated by the simultaneous dubbing and texting of the instructions because of a mismatched timing: 'I would not have needed the written instructions because Mira explained it to me"(P4). P1 would prefer effortless switching between speech and text, as he sees an advantage in both. Besides, he experienced difficulty in his hand-eye coordination between watching the video and checking his movements in the mirror all at once. Therefore, he suggested that the video should overlap with his face in the mirror. Overall, while there is a value for personal well-being, more individualization is desired. Text, sound, and image should be more balanced to ensure smooth interaction.

7.1.3 Tooth Brush Animals

All participants watched the animation, and two of them got engaged. The general impression was positive, and everyone could imagine children enjoying the application. P5, a father himself, indicated the mirror 'anchors learning where learning takes place'. Gamification purposes like unlocking further animals were well received and created immediate engagement: 'Mira, which animal suits me"(P1) or 'Can I create a new character there?' (P5). The video is well suited to develop a sense of time, and the raccoon is, in any case, a positive factor to increase motivation. However, most of the participants criticized the fast movements in the cartoon. P5 mentioned limits to check his teeth simultaneously in the mirror at this speed. Besides, he added that the final check of the child's teeth and responsibility still lies with the parents. Thereby, it would not save time. However, even if he did not buy the mirror just because of one application, he would install it if he already had one. Yet, some of the participants had parental concerns about exposing children to further screens. One parent (P5) was excited 'to see how they do it with the mirror and imitate. How much they stick to it'. The other parent (P4) added that 'If they are more grown-up and are allowed to brush their teeth themselves at lunchtime and without supervision, that would be something'.

7.1.4 Instant Idea

Despite initial insecurities about the concept and application, all participants agreed that the concept was valuable and fit their routines: 'I really believe that I would use it because I always use notes to write something down. Just like that, if I think of something, I would write it down briefly. And you can hold on to it without searching for my mobile phone with my wet hands, and I can do other things on the side'(P5). P4 recognized its practicality, e.g., while brushing teeth or doing make-up. The visualizations of the sequences were very authentic in their functionality, whereby the prototyped interaction caused confusion. However, one reason was the simulation, where certain options had to be prepared in advance and some restricted in use. Therefore, one participant suggested having animated hints, for instance, to record his voice. Besides, he wished for references to the sources of the filed media in the future. The social media links were only noticed on a second look but tended to be positive. One of the participants wanted to sort his stored content by link categories like 'living room' (P4). Despite the initial difficulties in interaction, this concept has the potential to support reflective moments and creative thinking.

7.1.5 MiraFit

All participants liked the well-structured fitness results and suggestions by Mira. They emphasized the automated synchronization of data and the mirror application to reduce additional effort. Equally, after exploring the training advice on the mirror, they would like Mira to send the information to their phones or fitness tracker. Besides, one participant asked for an automatic calendar entry for the next run. P1 noted that he is not familiar with the displayed times on the mirror, and he is expecting classification and interpretation by the agent. All participants emphasized the importance of context and timely suggestions, for instance, depending on different times for workouts, as P2 remarked. Besides, recommendations to buy new running shoes after a specific number of miles were well received, with P4 expecting to get this information timely and simultaneously some links for direct purchasing. All participants asked for valuable advice and information and emphasized the importance of timing to engage with the data and the agent.

7.1.6 Impact on the Atmosphere and Well-being

Four participants described their bathroom as a very intimate retreat, where they particularly want to feel calm and cozy: 'It's a very private room, you're usually alone there' (P2). Further, they repeatedly emphasized the positive impact of the mirror on the atmosphere in the bathroom: 'I find it very user-friendly and a bit like a girlfriend in the bathroom (...) With the mirror, the bathroom would no longer be so sterile and cold, but cozier.' (P3). P4 added the positive effects of speech: 'So that makes it more human, of course, because of the voice.' However, P5 encountered: 'I don't know if you need a name for the mirror and if it has to speak, perhaps it would be enough if only I would speak and then I get the feedback on the screen" (P5). He did enjoy the interaction, but sometimes visual feedback would be sufficient to engage with the content and activities. Without considering additional effort to clean fingerprints off the surface, he also would like to shorten some interaction paths by touch. In contrast, P3 explained that speech particularly fosters engagement and motivation.

Although the participants enjoyed engaging with the mirror, they all had privacy concerns. Even without an integrated camera in this prototype, they mentioned, it would make them feel uncomfortable. Likewise, they were concerned that the sounds of the toilet might be recorded and distributed. Therefore, some participants suggested mechanical features like a flap to blind the camera and preferred a self-determined control. The same goes for switching the microphone on and off, as a digital marker, e.g., light still leaves them suspicious. Besides those reservations, the participants valued most of the applications and made design suggestions as taking selfies in the bathroom without considering prior stated privacy concerns.

Some participants speculated on more design ideas to enhance their well-being. Aesthetics contributes equally to a sense of well-being as the applications themselves. P2, for instance, imagined an effective weather display by letting rain run over the mirror or a sunrise. Similarly, P1 suggested the mirror simulates a real window or a mood light to feel more comfortable in his small and window-less bathroom. That may also lead to spending more time in this particular room, in general. All participants already listened to music frequently, and some mentioned watching music videos as an additional benefit. Although spending most of their time alone in the bathroom or helping their children, P5 emphasized that this artifact might also impress and entertain friends and acquaintances at their visit: 'It is a luxury item that is not only beautiful but also has a benefit. (...) It is also a wow factor for guests.' (P5). However, P2 wished for a 'calmer' design, which reminds her less of technology like the mobile phone. The clock was a little too big, and she associated the functions of reading emails or getting messages on the mirror with her working day ahead. She would prefer to hide these functions and displaying the watch in an 'analog' design on the mirror.

7.1.7 Fitting the routines

The results show that participants expect a personal fit to their habits and time-critical events. For the latter, one participant (P5) particularly described a stressful situation storming into the bathroom and handing over several tasks to the mirror. In this scenario, the agent has to react quickly and send, for instance, a voice notification to a friend for his 15-minute late arrival. Besides, participants reflected on their daily routines and possible fit of the applications: 'In the morning, the applications that I tested, like FaceYoga. And in the evening perhaps rather as a little toy and for entertainment. And something like the news I would watch at noon. However, actively I would use the mirror in the morning and evening' (P4). Likewise, P2 added that this mirror might support a relaxed and organized start to the day: 'You feel more organized, you do things that you would do anyway, and you get information. I would feel more comfortable with it.' (P2). She also stressed that she would use beauty advice for skincare and make-up and preferred motivational content for the day. For building healthy habits, P3 emphasized the benefits of embed-

ding the mirror in the bathroom and the immediate use: 'I always miss to do the relaxation exercises, but if it's right in front of the mirror and you're right there, then you do it.' Usually, the first thing she does after coming home from work is going to the bathroom, so she imagines starting an application immediately while drying her hands.

8 DISCUSSION

We want to discuss the main findings of our design process in light of the design space for engaging interactions (Rogers et al., 2007) and leveraging properties of traditional domestic artifacts (Verbeek, 2005).

8.1 Traditional Artifacts Extended

So far, research treated mirrors and ambient displays as very multi-purpose, public furnishings and artifacts for all household residents. Hence, they have been usually assigned the task of communication and coordination work. Ambient displays have traditionally been developed for public spaces to disseminate information widely and make it accessible to all. For the most part, enhancement or intelligence of IoT artifacts has been understood as the need to hide technology or visible aspects of domestic technology in everyday objects. As a result, the original meaning of the object and its inherent qualities, such as the mirror surface, and the primary moments of situated interaction are insufficiently considered. Moreover, when interacting with technology, the technology's need to communicate organizational information, for example, takes a salient role, forcing the residents to immediate reactions rather than supporting their environmental needs associated with the mirror and space. The spatial design of the bathroom impacts personal well-being substantially. Strengers et al. (2019) show that aesthetic and ambient features in the home are as important as the technology itself and lead to more pleasure. Therefore, the object and its properties carry well-being, either as a traditional material or digitally enhanced by applications. The qualities of the artifact enable and constrain the inherent interaction and expressiveness (Hallnäs and Redström, 2006; Fuchsberger et al., 2013). Traditional mirror reflections shift the focus to more self-reflection, and with digital qualities, it is now possible to engage in active and reflective ways. Thereby, a digitally enhanced mirror might actively offer space and time for calmness and more engaging experiences in the 'currently doings' (Rogers et al., 2007). The same surface might constrain the usefulness of some applications like the calendar in the bathroom and simultaneously be a valuable feature on a decorative mirror in the living room. With an iterative design approach, we were able to uncover actual use and entangled practices of the traditional mirror at home and show how to center those in the further design development considering the constraints and opportunities of the material. The examination of the social practice in which the material encounters meaning and the potential for use helps to re-contextualize the purpose of digitization and visualize the vital qualities of the artifact.

Our approach is not limited to mirrors but emphasizes exploring artifacts in their original embedded use to integrate technology purposefully and open up new design perspectives. Therefore, the main quality of everyday artifacts should go beyond concealing technology and find the natural fit by leveraging inherent properties and affordances. There is a potential to carefully extend properties digitally that build on prior structure, use, and desires and see IoT as active and embedded contributors to more well-being in the home.

8.2 Adaptive Resources for Action

We withdrew to condense the needs of our participants to an average user to avoid the 'One-size-fits-all' design paradigm. Leveraging the design space of the bathroom and traditional mirror, we present four applications that promote and inspire mindfulness and well-being in the home, aligned with the call of Desjardins et al. (2019) for alternative IoT concepts. We based our concept on the engaging interaction between inhabitants and their artifacts, offering resources for action to find substantial and joyful support for their routines (Mennicken et al., 2014).

Concise moments and activities define the potential value and support of the technology for everyday life (SplendidResearch, 2016). Our diary study shows the frequent media use in the mornings and evenings. Yet, we can observe participants attempt to integrate time for (sub)conscious reflection, self-care, and to establish enjoyable or healthy habits in general. In contrast, prior studies often neglect the variety of needs that can be projected on one artifact or the entanglement of different practices associated with one room or artifact. Those systems tried to enhance well-being by more automation of tedious tasks or processes like regulating heating (Jakobi et al., 2018) that not primary focus to promote joyful interaction but instead passive and peripheral information consumption (Ammari et al., 2019). With our empirical studies, we could reveal the entanglement of media use with the variety of morning and evening practices, pointing

to different phases of calmness and engagement that personalized technology has to consider. This also extends to the investigation of the personal relationship between inhabitants and their objects in use. Regular encounters that involve memories, engagement, and experience create personal value and strengthen the relationship with the object, leading to appreciation and acceptance of the technology-enhanced artifact as well. However, our prototype shall enable humans without strongly intervening or patronizing, yet offer resources for engagement (Taylor et al., 2007). Users value a variety of unique applications to choose for their individual purpose and might build close relationships with the agent if their needs are taken seriously by design (Paay et al., 2018). This will need long-term investigation of said relationships to understand how more IoT can, for example, live up to the expectation of being personal.

A thorough investigation of domestic practices with a central view on the material and respecting the former object relationship contributes to the creation of personal value within the adoption of the interactive artifact as a whole. Therefore, we need to find a balance between automation and engagement by offering adaptive resources to a variety of needs and connecting existing activities and objects.

8.3 Rethinking Productivity

At the beginning of the broad implementation of technology in homes, practices were investigated by means introduced to study workplaces, and success was determined by increased values of efficiency and productivity (Crabtree and Rodden, 2004; Hargreaves and Wilson, 2017). Yet, we have to rethink the value of efficiency and productivity in smart domestic environments (Desjardins et al., 2015; Crabtree and Rodden, 2004) and their meaning to the inhabitants.

Time-economic advantages exist and can reduce stress by proposing an efficient structure or overtaking tedious, previously manual tasks. Yet, inhabitants might not experience this as a value because they do not mind, e.g., opening windows by themselves or they want to make own decisions. Consequently, they still might not perceive a technology dictating the daily structure and which is concealed by daily objects as calm. Calmness emerges from the absence of distraction and fitting interactions between inhabitants and artifacts. Ambient access to information does not increase efficiency necessarily when further activities like self-care or creativity are interrupted. For example, information retrieval in the morning might even produce stress by displaying work messages. Therefore, an alternative approach might be the active support of moments that often remain invisible to technology and unconscious to inhabitants.

Additionally, users fear becoming passive and lazy in the opposite of being productive, when too much automation is implemented in their homes. Understanding that being active equals not always being productive, we can move towards the design of artifacts and interfaces that promote engagement which is welcomed and desired. Productivity is often linked to specific goals and tangible results, whereas being active can also be associated with mindful experiences in the moment, e.g. self-reflection or self-care. Moreover, being productive can be understood as being active and engaged in favorite activities. Accordingly, technology should instead foster the reallocation of resources like time and space to more meaningful engagements. Tools for more self-reflection and mindfulness help to increase the productivity of the inhabitants throughout the day. Finally, our work enables users to implement more positive activities in their daily routines and establish desired self-care habits.

Finally, the properties of artifacts are appropriate to resolve the contradiction of calm and engaging by rethinking the values of efficiency and productivity. Therefore, we need to design beyond the automation of routines and control of smart appliances (Desjardins et al., 2019; Strengers et al., 2019) and consider which spaces in the home are appropriate for coordination and communication work and which are used for calm and mindful interactions.

9 CONCLUSION

Inspired by the idea of IoT artifacts going beyond efficiency by digitally extending the qualities they already inherit, this paper presents a design case study for a Smart Mirror that supports activities and is easy to integrate in everyday life. Our findings indicate that the design trend for 'optimization' of domestic routines limits the perspective on valuable smart artifacts. Moreover, our 'Mira' prototype offers an alternative design for pleasant interactions that fit personal and steady as well as rapidly changing routines.

Our research is limited by the small number of participants in the evaluation and selection of the sample, which should be broadened in future work. Moreover, we can only speculate about the design of other artifacts because they are determined by their inherent properties, still our results clearly show the need to investigate a variety of IoT artifacts. Further research should focus on digital enhancement of traditional artifacts and purposes for well-being beyond automation.

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