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Supporting Interpersonal Awareness Over a Distance

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Many people have supported me in the realization of my doctoral thesis and have played an important role in my life in recent years.
Thank you to all of you great souls!
♥

May we never feel distant

Abstract

Social interaction and togetherness are keys to our quality of life and well-being. Interacting with friends and family members, exchanging information and experiences is important to everyone. Moreover, close social relationships between people lead to higher levels of satisfaction with one's own life and raise an individuals self-esteem. In co-located groups and families communication occurs spontaneously. People communicate explicitly for example by verbally describing situations or instructions; and people communicate implicitly, nonverbally through expression and perception of emotions, activities, presence and appearance. Quite often, nonverbal implicit communication is used for negotiating the availability of people and detecting opportune moments for explicit verbal communication. Both ways of communication are necessary for a meaningful and successful interaction and play an important part in the feeling of belonging.

In our work we explore how human machine interfaces can be designed to support people who live far away from each other and try to keep in touch without feeling obliged to communicate. We use *research through design* methods to develop multimodal affective artifacts and enable people to exchange emotions, experiences and activities with loved ones. We support social interaction and communication by shifting digital interactions into aesthetic everyday objects that can ease usage and improve user experience. Especially older adults, people with disabilities and children can benefit from this approach, as digital software can be challenging to use and often misses the needs of these user groups. One approach to this problem is the use of *tangible interaction* in order to design simple, intuitive and engaging human machine interfaces. At the same time, the use of ambient information systems can unobtrusively provide users with information in the periphery. Drawing from previous works in these fields, the resulting systems and designs enable users to get ambient information about activities of loved ones, exchange memories or ongoing experiences, and express emotions and moods in various ways.

This approach contributes towards enhancing social awareness and social communication between people living over a distance. We present results regarding content types, usage behaviors as well as benefits and costs when using these systems. Results show that users feel a sense of belonging using these technologies, can estimate availability of others and get engaged into storytelling. Furthermore, this thesis contributes design solutions to create social awareness in an affective and unobtrusive way and to ease interaction for users with limited technical experience.

Zusammenfassung

Soziale Interaktion und das Gefühl von Zugehörigkeit sind wichtige Faktoren für eine gesteigerte Lebensqualität und unser Wohlbefinden. Die Interaktion mit Freunden und Familienmitgliedern sowie der Austausch von Informationen und Erfahrungen sind für alle wichtig. Darüber hinaus führen enge soziale Beziehungen zwischen Menschen zu einer höheren Zufriedenheit mit dem eigenen Leben und erhöhen das Selbstwertgefühl des Einzelnen. In Gruppen und Familien, die räumlich nah beieinander leben, findet die Kommunikation spontan statt. Menschen kommunizieren explizit, zum Beispiel durch verbale Beschreibung von Situationen oder Anweisungen. Auf nonverbaler Ebene kommunizieren Menschen implizit durch Ausdruck und Wahrnehmung von Emotionen, Aktivitäten, Präsenz und Aussehen. Nicht selten wird nonverbale implizite Kommunikation verwendet, um Gelegenheiten für explizite verbale Kommunikation zu erkennen. Beide Wege der Kommunikation sind notwendig für eine erfüllende und erfolgreiche Interaktion zwischen Menschen und spielen eine wichtige Rolle im sozialen Miteinander.

Diese Arbeit untersucht inwiefern Mensch-Maschine-Schnittstellen die Kommunikation von Personen über Distanz unterstützen können. Wir verwenden *Research through design*, um multimodale Artefakte zu evaluieren, welche einen Austausch von Emotionen, Erfahrungen und Aktivitäten zwischen Personen die einander nahestehen zu ermöglichen. Die Interaktionskonzepte werden in ästhetische Alltagsgegenstände integriert, welche die Nutzung erleichtern. Besonders ältere Erwachsene, Menschen mit Behinderungen und Kinder können von diesem Ansatz profitieren, da digitale Software häufig schwierig zu bedienen ist und oft die Bedürfnisse dieser Nutzergruppen übersieht. Ein Ansatz zur Lösung dieses Problems ist die Verwendung von begreifbarer Interaktion zur Gestaltung einfacher, intuitiver und ansprechender Mensch-Maschine-Schnittstellen. Gleichzeitig kann der Einsatz von ambienten Informationssystemen den Anwendern unaufdringlich Informationen in der Peripherie zur Verfügung stellen. Ausgehend von früheren Arbeiten in diesen Bereichen ermöglichen es die entstandenen Systeme und Entwürfe den Nutzern, Umgebungsinformationen über die Aktivitäten ihrer Lieben zu erhalten, Erinnerungen oder aktuelle Erfahrungen auszutauschen und Emotionen und Stimmungen auf verschiedenen Wegen auszudrücken.

Wir präsentieren Ergebnisse über den Einfluss und die Wirkung der implementierten Systeme auf das soziale Bewusstsein und die soziale Kommunikation zwischen Menschen über Distanz. Wir stellen Ergebnisse vor, welche Einsichten hinsichtlich Interaktion sowie Nutzen und Kosten bei dem Gebrauch dieser Systeme liefern. Die Ergebnisse zeigen, dass die Nutzer durch diese Technologien ein Zusammengehörigkeitsgefühl empfinden, die Verfügbarkeiten Anderer einschätzen lernen und sich auf das Geschichtenerzählen einlassen können. Darüber hinaus sollen die entwickelten Ansätze dazu beitragen auf eine affektive und unaufdringliche Weise ein soziales Bewusstsein zu schaffen und die Interaktion für Nutzer mit besonderen Bedürfnissen zu erleichtern.

Contents

1 Introduction

Human beings are *social creatures* and therefore naturally seek the companionship of others. Our lives are filled with social interactions with fellow human beings. We have long talks with partners or other family members, we discuss professional and private topics with co-workers, enjoy food with colleagues or friends and spend time with people in the evenings. Overall, the amount of, either superficial or profound social interactions is high on most days of our lives'.

Building strong interpersonal relationships is one of the most important human motivations and crucial for their well-being [LB17]. When failing to create and maintain intimate relationships, people might experience negative impacts on their mental health [Kag09]. Leroy et al. even suggest that the perception of loneliness is more closely linked to self-reported illness symptoms than objectively measured social isolation [LMJ+17]. Many previous works have shown that a feeling of belonging and intimacy is dependent on the quantity of communication one given individual is involved in [MA04]. Furthermore, self-disclosure is an important factor to increase intimacy between human beings who share a bond. The importance of self-disclosure through communication is essential to multiple models and theories on communication: e.g. the uncertainty reduction theory [VP09], the interpersonal process model of intimacy [RP96] as well as Altman and Taylor's social penetration theory [AT73].

The ability of exchanging information and the means to connect with other humans via communication has evolved over a long time – and it's still evolving. Human communication and social interaction was revolutionized with the origin of speech and symbols that allowed mankind to share and exchange experiences and knowledge with peers. The earliest symbols that are known of today are cave paintings dating back to the upper Paleolithic Age. One of the oldest ones found in the *Chauvet Cave* is estimated to date back to around 30,000 B.C. [Les13]. From this pure symbolic and visual representation of information more systematic writing systems have developed. The first systems we know of today have been invented at the beginning of the Bronze Age in the historical region of southern Mesopotamia (modern southern Iraq). Pure alphabets, as we are using them today, have evolved from these early writing systems around 2000 B.C. in ancient Egypt. These alphabets are mapping single symbols to single phonemes.

When societies developed into communities which spread over increasingly bigger territories the need for communication over longer distances became more and more important. For many decades, families lived co-located in extended families with multiple generations together. Resources were often shared, creating more of a community aspect to the family. While this might have included sharing of financial and physical resources, it more included sharing of time. This enabled grandparents to watch over their grandchildren, and allowing parents to continue working. As an outcome, this provided a healthy and supportive environment for children to grow up and the families to naturally interact and take care of each other [LT17]. With time, these structures changed and families more often lived apart from each other, in smaller groups. This smaller circle of

Figure 1.1: Petroglyphs from Häljesta, Sweden.

Figure 1.2: Sumerian cuneiform script

a core family is know as the *nuclear family*, consisting of two parents and their children and provided a very common family structure until mid of the 20th century. The nuclear family is still a common family structure in modern times. However, research in modern sociology shows, that these structures are no longer an adequate cover of the diversity of family arrangements [WSW12]. The postmodern family may include single-parent families, couples without children or families living apart due to work requirements. For example, the number of nuclear families fell from 39.0% of all households in 1968 to 28.0% in 1992 in the UK. The distance within these family structures requires more extensive efforts to keep in touch and create a feeling of family relatedness between distributed members.

Due to this strong need for creating shared experiences and the feeling of being part in social environments, we as humans have always invented new effective and creative ways to stay connected and exchange messages. Based on ancient methods like smoke signals, horns, drums, pigeon post or optical semaphores the first electrical systems were invented in the early 19th century. The use of telegraph communication became popular by the end of the 19th century, it was based on specific codes, designed to work efficiently with telegraph systems. The next logical step was the telephone: invented in late 1870, this device could transfer the voice of an interlocutor over long distance and in real time. Fast technical developments allowed the invention of new and multipurpose means of communication – starting with successful projects like the *ARPANET* in 1969, and leading to a worldwide network to interconnect machines and personal computers. Since the mid-1990s, the Internet has had a revolutionary impact on culture and technology that facilitated the rise of near-instant communication. Electronic mail, instant messaging, interactive calls and social networking communities have changed the way humans communicate and interact with each other. Via this means many have access to larger groups of people, can get in touch with communities in other parts of the planet or participate in discussions taking place thousands of miles away.

Nowadays, inter-connectivity through services and technologies makes it possible for human beings to be connected constantly and at all times. The introduction of smartphones – with the option to install various applications or be provided with mobile data

networks in most regions of the world – enables people to stay connected constantly and everywhere.

Figure 1.3: Instant messaging using smartphones and smartwatches is a very popular and widespread form of communication since the mid-2000's.

Figure 1.4: Grandchildren using video calls to keep in touch with their grandparents.

These developments towards a highly connected society provide many benefits and advantages that foster exchange and the development of relationships over a distance. Usually, people can afford various types of communication means and the majority of them rate the accessibility and usability of most common communication devices as satisfactory. This access to means of telecommunication allows families, friends and loved ones to stay in touch and maintain their relationships even when co-located living is not possible. This becomes more and more relevant: today it is not unusual for individuals to relocate – for example due to job commitments – and, as a consequence, to live further away from family members and friends. Designing and developing technologies to ease social interaction over a distance can support people in these situations and further increase usability and accessibility for inexperienced users. Gooch and Watts showed that technologies which assist in creating emotionally significant experiences in interpersonal communications can support relationships in a meaningful way as it can deepen the feeling of being close to each other [GW14]. Dourish et al. found that social awareness across a distance is meaningful and can pave the way for communications and interactions in a positive way. Additionally, they pointed out that it can contribute to a shared sense of community [DB92b].

However, as communication is ubiquitous and present throughout most days it can become a burden in our day-to-day lives and people might feel overwhelmed by the amount of communication. In her book *Alone together: Why we expect more from technology and less from each other*, Sherry Turkle explains: "We insist that our world is increasingly complex, yet we have created a communication culture that has decreased the time available for us to sit and think uninterrupted. As we communicate in ways that ask for almost instantaneous responses, we don't allow sufficient space to consider complicated problems"[Tur17]. As a counter-movement to a nowadays often typical *"always-on"* behavior of individuals, who feel a virtual pressure to be constantly available, many people take a step back from digital technologies and services. The *joy of missing out* way of

living with technology as an antithesis of a *fear of missing out*, is understood as temporally disconnecting and actively opting out [1]. As a consequence, global technology companies and service providers have understood the customer's desire or need for a responsible and more healthy approach of technologies in day-to-day life. Google has announced their *"digital wellbeing"* initiative [2] and Apple has introduced new features with *Screen Time* [3], that aim at encouraging healthier habits via tools like a dashboard which shows you how much time you spend on each app, suggested breaks and batched notifications to avoid too frequent interruptions.

In the Human-Computer Interaction (HCI) and Computer-Supported Collaborative Work (CSCW) communities long-term research to support belonging over a distance at the workplace or within private circles like families or peer groups can be found. Li et al. have recently presented a review of about 150 research contributions, that investigate the design of unconventional user interfaces for emotional communication over long-distances [LHV18]. This work shows that new means for communication are emerging, that provide a path towards a feeling of togetherness beyond conventional devices and services. Especially the use of tangible interfaces and interesting new form factors define current works on support for communication.

Yarosh and Abowd presented the design of ShareTable that allows divorced parents to interact with their children over distance via audio and video communication. Kori M. Inkpen has demonstrated the use of various prototypes that help to connect children and their friends in play and craft. Judge, Neustaedter and Harrison used video conferencing to mediate between extended family members through Family Window and Family Portals. Hutchinson et al. [HMW+03] report an increasing interest in industry and academia to create communication and awareness technologies for homes and families. Additionally, they state that such designs offer a number of interesting challenges – such as having to accommodate a huge variety of ages, abilities, motivations and interests. In their own living environments, people are much more concerned about aesthetics of technological artifacts and different values influence the use of technologies and services. Further, the use is often aimed to provide playful entertainment rather than efficiency. The body of research, that explored and evaluated long-distance relationships and relatedness over a distance has presented many interesting and exciting technical solutions and has become more and more detailed over the past years. Based on their review of existing solutions, Hassenzahl et al. present six strategies that can be used to create an experience of relatedness. These six strategies include: creating a feeling of awareness and continuity by sharing different types of information (e.g. activities), artifacts to express feelings and emotions in a wide variety of ways, mediating a feeling of physical intimacy by physical proximity (e.g., body heat, heartbeat) or meaningful gestures (e.g., hugs, strokes), demonstrating to care by gift giving, artifacts for carrying out an action together, and support records of past activities and special moments for a relationship [HHE+12].

[1] https://www.nytimes.com/2018/07/12/style/joy-of-missing-out-summer.html; last retrieved: 26.7.2018
[2] https://wellbeing.google/; last retrieved: 26.7.2018
[3] https://www.apple.com/newsroom/2018/06/ios-12-introduces-new-features-to-reduce-interruptions-and-manage-screen-time/; last retrieved: 26.7.2018

We see an increasing body of new technologies that provide ways of keeping in touch over a distance. As these technologies should aim to fulfill user needs and create positive experiences, the user plays an important role within the design process. We further observe a decreasing amount of evaluations with users in real life living contexts over longer periods of time. While a technology-driven approach of supporting relatedness between people living over a distance is important to create more fine-grained experiences, we argue that the evaluation of technologies with users for extended periods of time (great examples are Chien et al. [CH17] or Forghani et al. [FNV+18]) is crucial to understand the impact of design of these technologies in everyday context.

In our work we explore how new human machine interfaces can be designed in order to support feeling close with distant loved ones. Our aim is to design artifacts which enable them to share experiences and be aware of each other without overwhelming them. Throughout our research, we have involved users in the design process and have considered their needs and requirements. We have prototyped concepts, implemented functional prototypes and conducted field studies for extended periods of time. Consequently, these extended evaluations have allowed us to gather fine-grained insights into users needs, their behaviors and potential shortcomings of existing technological solutions.

1.1 Personal Background and Motivation

This thesis researches the use and exploration of new interfaces for creating awareness between loved ones over a distance, using mainly qualitative Methods. This often requires techniques to interpret results based on a given context. As the evaluation of the results highly depends on the knowledge and previous experiences of the researcher, I would like to explain my background. During the past six years I have lived apart from my family and wife and only could see them on weekends or during holidays. We kept in touch using messengers and phones, yet, sometimes it was difficult to create intimacy over a distance and I strongly felt that I missed out on day-to-day activities. After the birth of my niece almost seven years ago, I realized it is even harder to maintain strong family ties with young relatives – after all, there are hardly any technologies which appropriately suit the communication needs of small children. Additionally, I have had many informal conversations with co-workers, acquaintances and new friends, who struggle with similar situations. I noticed recurring patterns regarding the problems, needs and wishes of people who communicate with loved ones over a distance. My research is heavily influenced by these experiences. Some of the artifacts we have developed and evaluated so far both aim at finding solutions to my own needs and those of others close to me. For me personally, the driving force to continue in this field of research has always been to see how designs and devices can help people to maintain meaningful relationships over a distance.

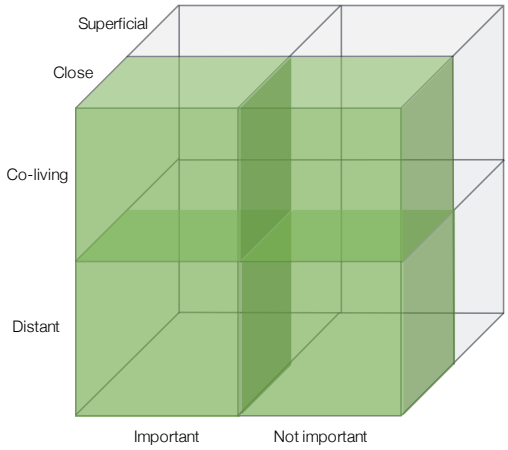

Figure 1.5: Focus application area of this thesis

1.2 Research Outline

This thesis examines the requirements, design rational and implementation of technologies to enable families and friends to feel close and aware of each other while living over a distance. We investigate needs and requirements of family members of different age groups with various levels of technical experience. We seek to understand how families use technologies to share experiences, to express moods and emotions and how they keep in touch by involving each other in daily activities. Based on these insights we explore different designs to support, foster and maintain these acts of connecting. We research the perception of these technologies with regard to user experience, acceptance and the possibility to share things from daily life, moods and activities with others. Additionally, we try to design technologies in a manner that makes them inclusive and simple to use. As this is important for all users of technologies, we aim to support users who are often not able to use these in a self-determined way. Especially children often need support and parental scaffolding to be able to take part in family communications.

Communication and awareness are rather broad topics and may include manifold goals, locations, participants and situations. In this thesis we focus only on parts of these contexts to be able to frame our contributions towards a specific problem space. As depicted in figure 1.5, we have categorized the applications of the presented research along three axes: the relationship between communication partners can be understood as *close* or *superficial*, communication partners may live over a *distance* or can be *co-located*, and communication can be perceived as *important* or *not important*. In this thesis we focus on technologies for people who have and want to maintain a close relationship, who may live close together or over long distances and share important or just casual things.

1.3 Research Questions

One branch of this thesis, focuses on the awareness of activities between users living over a distance. We present two artifacts to enable people to share their day-to-day activities and create a sense of the life of others close to them. Both these artifacts are designed to be embedded into the domestic living environment and try to protect users' privacy while offering insights into daily activities. In a first lab study, we aim to understand users' willingness to share information, the ability to interpret activity-based information and the acceptance to exchange them with others. In a following field study, we investigate effects of such *minimal communication*. We investigate effects on social connectedness, the use of such technologies and the behaviors of users. We research the following questions:

RQ 1: How do users interact with awareness devices conveying activity-based information, and how should this impact future designs of such systems.

RQ 2: Which information can help people to create a sense of a close person's day-to-day life while bearing the privacy of communication partners in mind.

We further research technologies to foster the exchange of life-experiences. We present approaches to enable all members of a family to share and reflect on experiences of others. Our designs aim to ease sharing within a close circle of family and friends and to receive these insights in an unobtrusive way. In a first field study with two families we investigate how the exchange of photographs affects the feeling of closeness within these two families. We furthermore explore different designs to share and involve other people. We research the design of a tangible artifact for sharing experiences and messages between grandparents and grandchildren. In two studies we aim to understand use and behaviors, motivations and inclusiveness as well as user experiences and simplicity of sharing. We investigate the question:

RQ 3: How can technology support family members to share their experiences among each other in an inclusive, engaging and simple way.

Another important branch on interpersonal awareness are designs that enable users to express, exchange and understand feelings and emotional states. On smartphones we explore different models for adults to express and input moods and emotions. In a field study we try to determine how these models fare regarding *intuitiveness*, *inconvenience*, *speed of input*, *everyday use*, *expressiveness* and *overall suitability*. We furthermore explore how we can support the parent-child storytelling practice for teaching emotions through a tangible interactive kit. We present a design of such a tangible toolkit to support emotional storytelling between parents and children and study use, expressiveness and multimodal in- and outputs. We aim to understand the following questions:

RQ 4: What are suitable techniques for in-situ input of emotions and moods and what are advantages and disadvantages of these methods with regard to future designs.

RQ 5: What are needs of parents and children for technologies that could potentially help them explore and understand emotional situations and what are possible designs to support these needs.

1.4 Research Approach

Based on previous works from the field of human-computer interaction (HCI) and computer supported collaborative work (CSCW) [CGGH12, CC17, Dou04], we have decided to use a human-centered qualitative approach to research the relationship between people living over a distance and how technologies influence their social awareness of each other. The focus of this work is to understand awareness technologies within a social context in greater depth by using exploratory studies *in-the-wild*, rather than to trying to explain a behavior in definite.

Human behavior and the use of technology is highly dependent on the situation and a person's current context. To gather insights on needs and requirements, as well as to be able to evaluate concepts and designs, it is crucial to conduct research in the context where individuals live and act. To design and create technologies as close to people's needs as possible, we have utilized different methods like interviews and participatory design sessions, to understand needs and requirements. It further requires a lot of in-depth qualitative insights rather than quantitative measures. To evaluate our artifacts and explore effects on awareness and interpersonal communication, we aimed to create functional prototypes and deploy these in people's living environment. We describe details on the used methods in the following section 1.5. The work presented here utilizes a combination of multiple research approaches to examine the use and effects of our concepts and designs. This mixed-method approach allows for comparison between results found in different contextual situations, with different end-users and their personal requirements. In the following, we briefly describe methods used to conduct the presented research.

1.5 Research Methods

1.5.1 Human-centered design (HCD)

As the base framework for this work, we have chosen the *human-centered design* process. A goal of the HCD approach is to utilize various different experiences and inspirations from users at every stage of the design.
„Human-centered design is an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, usability knowledge, and techniques. This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance. (ISO 9241-210:2010 [DIS09])“

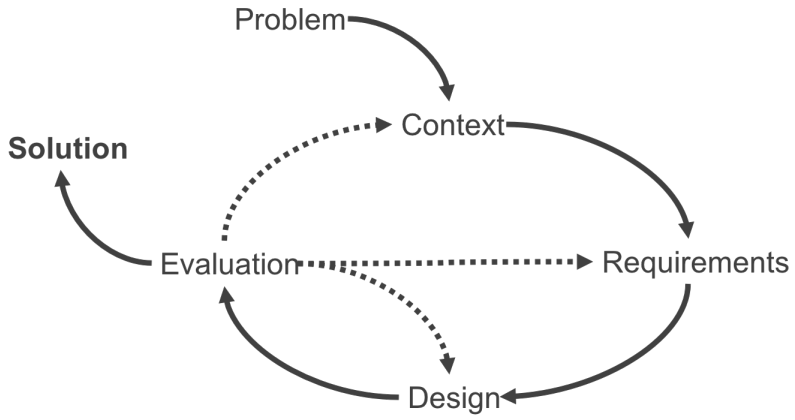

Figure 1.6: Human-centered design process and its steps.

This facilitates high usability of prototypes and encapsulates user experience. In this work, we use the advantages of existing methods to collect rich data with the help of users for future design and implementation [Coo00]. Within the HCD process, we utilize methods and techniques from *human-centered design* to specify contexts of use (e.g. literature reviews, interviews) and requirements (e.g. ethnographic studies, personas), create designs (e.g. brainstorming, rapid-prototyping) and evaluate (e.g. field evaluations, usability tests) these with users in studies (see Figure 1.6).

The human-centered design approach is not without its critics. These include the inability of the process to push the boundaries of available technology by adapting systems to the demands of present-day solutions, rather than focusing on possible future solutions. To overcome parts of this problem, we have extended the methods we use to research future systems by two additional approaches. *Research Through Design* and *Technology Probes* help us to explore concepts and interactions that might be too abstract to pose current solutions.

1.5.2 Research Through Design

For some decades, there has been an increasing interest in design as an essential part in human-computer interaction. Of particular interest is constructive design research [KZB+11], also known as research through design [ZFE07, ZSF10], where design activity in the form of constructing artifacts becomes a central research activity. *Research Through Design*, as a part of *Design Research* methods emerged in the early 1960s and described design activity that operates as research on specific problems. It can be understood as a process of designing and making artifacts to understand and explore research questions:

„The designing act of creating prototypes is in itself a potential generator of knowl-

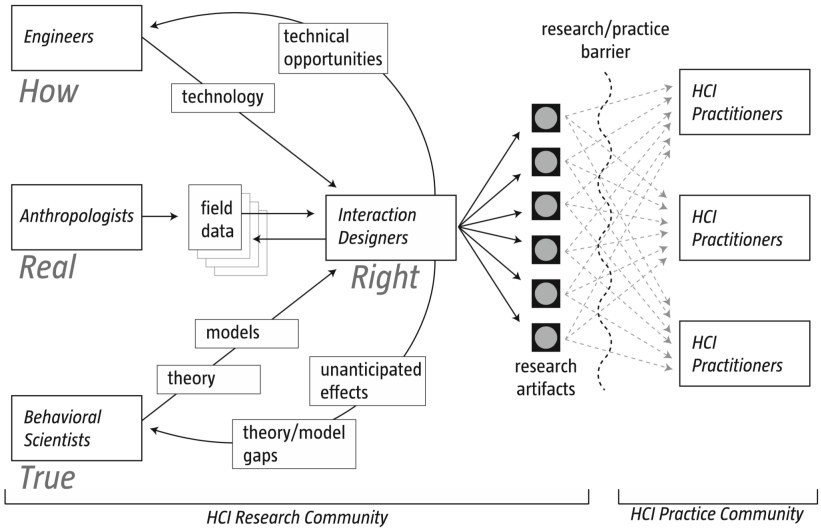

Figure 1.7: Model of research through design among Interaction Design Researchers in HCI as presented by Zimmerman et al. [ZFE07]

edge (if only its insights do not disappear into the prototype, but are fed back into the disciplinary and cross-disciplinary platforms that can fit these insights into the growth of theory) (Stappers[Sta07]) “

As presented by Zimmermann et al., designers of research artifacts, integrate knowledge from various disciplines into the design. These might include theories and models based on results from behavioral sciences, ethnographic field data from anthropologists or cutting edge technologies from fields like engineering and computer sciences (see Figure 1.7). Combining knowledge from these fields into a physical research artifact and studying it in the field can further be used to reflect existing knowledge and provide new insights for other areas of research. Zimmermann et al. argue that the iterative development of artifacts contributes in two ways: it produces more functional artifacts alongside the research process and contributes to knowledge in multiple ways. These ways span from highlighting new unexpected effects to demonstrating existing theories and models. The design itself becomes "a from of socio-aesthetic research towards the integration of aesthetic experiences and everyday life through the development of conceptual products" [SD99].

When evaluating designs and artifacts, we base our approach on research through design in which the design process is used as a form of research to contribute to a design activity. We have incorporated knowledge from other disciplines and disseminated insights back to provide input for other research fields. In this work we aim to improve social well-being for families and friends living over a distance and provide support for meaningful and engaging experiences for three areas, namely: awareness of others, exchange of experiences & memories as well as sharing and understanding emotional

Figure 1.8: Participant is exploring the SocialWall in her living room.

Figure 1.9: Storybox located on a working desk during the field evaluation

situations. However, instead of aiming to develop further ideas about how to connect families or friends, we are more interested to explore existing concepts and practices in more detail. We design our artifacts in a way that is understandable by enthusiastic amateurs and use tools that are publicly available. By this, we follow previous approaches that aim to empower people to change their life-circumstances through *personal design* [CH17] and "helping people to create better environments for their work, learning and leisure activities" [KB12].

1.5.3 Field Evaluations and Technology Probes

Our work aims to design, create and evaluate awareness and communication technologies that follow new paths to share and create a sense of intimacy between people over a distance. We further want to research and explore existing and new interaction concepts and generate new insights into effects of technologies on user behavior and personal relationships. To be able to achieve these goals, we used field evaluations with users as early and often as possible (see examples in Figure 1.8 and 1.9). We saw this approach as a necessary way to gain insights into user behavior - on a level that can generate knowledge tied to real-life environments and circumstances. The design and implementation of functional prototypes is often a missing part in recent research on computer-supported communication and human-machine interaction in more general [Sch17]. We have aimed to contribute to this gab and provide insights from field studies and in-situ interviews with participants using our artifacts.

Our approach was inspired by the method *Technology Probes*, presented by Hutchinson et al. [HMW+03] in 2003, as one step in our process of co-designing technologies with users. This method provide designers and researchers with a source of techniques that enable them to understand social effects and to derive models for design. Cultural and technology probes arose within the design community as a means to conduct broad-based surveys of user experience. These probes do usually include self-reported experiences with artifacts, questionnaires and material which enables the user to reflect

on the experience. Probes are a great way to provide inspiration and gather deep insights into users' behaviors and experiences.

1.6 Main Contributions

The main contributions from this thesis, according to the contribution type, are as following:

1.6.1 Empirical Findings

- **Comparison of techniques for in-situ mood input:** We provide insights about advantages and disadvantages of different input methods to express emotions and moods. We utilize user preferences as a basis for future system designs.
- **Usage behaviors with minimal communication artifacts:** In our field study with artifacts for awareness, we have collected usage data and investigated how users interacted with those devices. We provide information on the effects on intimacy and use of common communication means.
- **Grandparents' and grandchildren's practices and experiences with tangible storytelling:** Based on our work with tangible storytelling, we have collected data on communication behaviors and patterns of both grandparents and their grandchildren. We provide an analysis of this data and reflect how the usage of those systems might impact on the target groups.
- **Findings of needs and practices for exploring emotions between children and parents:** Derived from our research of how children and parents share emotions, we provide insights into contextual factors such as needs and common practices which help to understand affective communication between children and their parents.

1.6.2 Interaction Design

- **Design of a tangible storytelling toolkit for children to express emotions:** Based on user requirements, we provide concepts and design recommendations for designing multi-model toolkits which enable children (aged five to ten years) and their parents to explore and express their emotions. We provide information on the implications of the design as a springboard for discussions.
- **Design recommendations for mood input on mobile devices:** By empirically investigating different techniques for in-situ mood input, we arrived at a set of design recommendations which can be used by interaction designers to design applications for users to track and share emotional states and moods of their day-to-day lives.
- **Design of a tangible storytelling system to support intergenerational communication:** As part of our investigation into tangible storytelling for intergenerational

communication, we provide design considerations for designing and creating engaging and accessible systems. These should be taken into account when conceptualizing and designing future devices.

- **Design of a smart living room table to share activities, moods and presence:** We provide interaction designs for smart furniture to create closeness between separated families or friends. We describe user requirements and user experiences based on one exemplary artifact.
- **Design of an tangible flower to share daily physical activities and greetings:** As part of our investigations into minimal communication for people living over a distance, we provide design considerations for designing and deploying such systems. Along with previous investigations, these serve as guidelines for designers of such interactive technologies.

1.6.3 Sociological Findings

- **Effects of self-determined communication on grandparents/grandchildren interaction:** From our work with communication systems for children and grandparents, we show effects on self-determined and unsupervised communication by children with grandparents.
- **Social awareness through activity information:** We provide insights on effects of social awareness through activity sharing between partners, especially the ability to identify daily activities from minimal light displays.
- **Empirical evaluation of day-to-day experience sharing within families:** We describe effects on social closeness and the use of awareness devices to share picture-based experiences from a field study with three families.

1.7 Overview & Structure

We have conducted research in the three important areas of 1) awareness, 2) sharing and 3) communication that support people to feel close to each other over a distance. We have categorized conducted studies by the way people interact with each other and the content they share: *awareness of activities*, *exchange of experiences and memories* and *expression of affection* and structured this work according to these different areas. This thesis, therefore, consists of three research chapters containing our core contributions in six sections. Additionally, we provide an overarching introduction, a chapter to provide a fundamental background as well as a concluding chapter. Although all of the three research chapters provide independent results and background information, we recommend to read this work chronologically as this provides the best coverage of the topic. For a dense overview of the presented work and the research questions it is sufficient to read the chapters one and six. A short summary of the research chapters is given below:

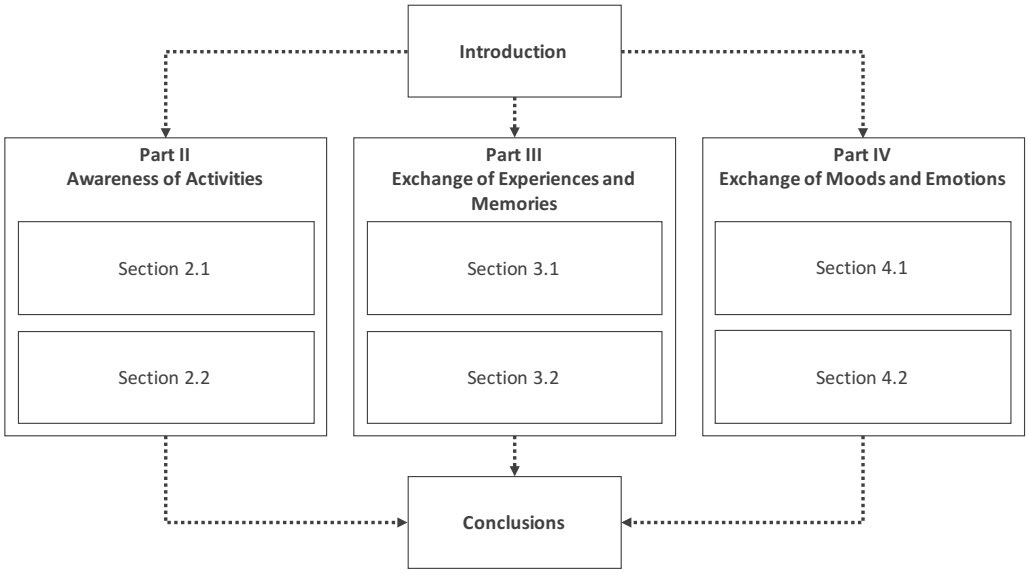

Figure 1.10: Illustration of the thesis structure

1.7.1 Chapter 3: Awareness of Activities

Sharing daily activities and moods using smart furniture
Social interaction and the feeling of emotional relatedness to loved ones is mainly driven by the communication with each other. Co-living facilitates being aware of the other, knowing their activities, getting a sense of their current mood and building long-lasting relationships. Communication over a distance using modern technologies can fail to provide this sort of awareness. This may affect the manner of direct and verbal communication with loved ones over a distance which, in turn, may cause a feeling of isolation or loneliness. To continue the participation in the lives of loved ones, we have developed a concept and prototype of an interactive living room table to share daily activities, current moods and presence information. In a Wizard-of Oz study, conducted in our labs, we found promising results with regard to expressiveness, joy of use, and usability.

Social Activity Awareness Through Ambient Lights
Computer-mediated communication technology is ubiquitous in today's society. However, the design of these technologies often takes a screen-based approach and requires users to adopt new usage conventions. While these methods have been widely successful in helping individuals communicate, we take a step back in this work and explore the design implications of a simpler tangible system for keeping in touch. This system consists of a pair of artificial electronic flowers which transmit information to each other. Our contribution is not the actual implementation, but rather in design implications that follow. In our modest evaluation we found participants using our system in informal, relaxed and sometimes novel ways.

1.7.2 Chapter 4: Exchange of Experiences and Memories

Photo-based Participation in the Life of Loved Ones and Friends
Social interaction, the participation in the life of loved ones and the exchange of experiences and feelings are key needs of human beings. Especially for families living over a distance, it is essential to stay up-to-date and to participate in important moments of loves ones. In this paper, we present requirements, a prototype and results from a first field study to evaluate the design of a photo-wall.

Supporting Communication between Grandparents and Grandchildren through Tangible Storytelling Systems
Grandparents and grandchildren who live apart often rely on communication technologies such as messengers, video conferencing, and phone calls for maintaining relationships. While some of these systems are challenging for grandparents, others are less engaging for children. To facilitate communication, we developed StoryBox, a tangible device that allows sharing photos, tangible artifacts and audio recordings of everyday life. We conducted a preliminary study with two families to identify design issues and further refine the prototype. Subsequently, we conducted a field study with four families for up to four weeks to better understand real-world usage and examine intergenerational connectedness. We found that StoryBox was accessible, simple and helped bridging the technological gap between grandparents and grandchildren. Children communicated asynchronously in a playful and idiosyncratic manner, and grandparents shared past family memories. We provide insights on how to ease communication between different generations, engage them in sharing activities, and strengthen family relationships.

1.7.3 Chapter 5: Exchange of Moods and Emotions

Comparison of in-situ mood input methods on mobile devices
The exchange of daily moods is an important part of interpersonal communication over a distance. Mobile devices offer a platform for sharing on the go and keeping in touch regularly. However, it is still a challenge to design an input for moods, so that the sharing easily integrates into the daily life and is engaging for a longer time. In order to design an input which overcomes these challenges we explore the use of four different methods to express moods on mobile devices and draw from previous works in psychology. We aim to verify the usefulness of these methods and want to investigate this by conducting a comparative study of these four input methods focusing on following factors: intuitiveness, inconvenience, speed of input, everyday use, expressiveness and overall suitability. Results show that use of photographs and emotional terms are suitable to describe the many facets of moods for most participants. Most of the participants prefer personalized input methods as well as combined methods. We discuss the outcomes with regard to the implications on future designs of messenger applications.

Tangible Storytelling Kit for Exploring Emotions with Children
A key aspect of children's development is the ability to manage personal feelings, understand others feelings and needs, and interact positively with others. Storytelling is one approach to help children develop emotional literacy and deal with their own feelings constructively. To facilitate and complement this process, we developed an interactive storytelling prototype to help children and parents explore emotional situations. Specifically, the tangible modular toolkit enables the re-creation of different narratives using a multi-modal user interface. We evaluated the preliminary prototype with parents and children to get feedback on the design and to help us to understand the design space. Our findings revealed how children engaged with tangible storytelling, how they explored emotional states in narratives and what challenges they faced. We also explored the routines and practices parents used and the issues they faced while helping their children to express their emotions.

1.8 Publications

The work presented in this thesis is based on a number of peer-reviewed scientific publications. The core publications are:

- Wallbaum, Torben, Wilko Heuten, and Susanne Boll. "RemoTable: Sharing Daily Activities and Moods Using Smart Furniture." Studies in health technology and informatics 229 (2016): 345-354.
- Wallbaum, Torben, et al. "Forget Me Not: Connecting Palliative Patients and Their Loved Ones." Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems. ACM, 2015.
- Wallbaum, Torben, et al. "Exploring Social Awareness: A Design Case Study in Minimal Communication." Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems. ACM, 2018.
- Wallbaum, Torben, Wilko Heuten, and Susanne Boll. "SocialWall: Photo-based Participation in the Life of Loved Ones." Mensch und Computer 2016-Tagungsband (2016).
- Wallbaum, Torben, et al. "StoryBox: Design of a System to Support Experience Sharing through Visual Stories." Proceedings of the 9th Nordic Conference on Human-Computer Interaction. ACM, 2016.
- Wallbaum, Torben, et al. "Supporting Communication between Grandparents and Grandchildren through Tangible Storytelling Systems." Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems. ACM, 2018.
- Wallbaum, Torben, Wilko Heuten, and Susanne Boll. "Comparison of in-situ mood

input methods on mobile devices." Proceedings of the 15th International Conference on Mobile and Ubiquitous Multimedia. ACM, 2016.

- Wallbaum, Torben, et al. "Towards a Tangible Storytelling Kit for Exploring Emotions with Children." Proceedings of the on Thematic Workshops of ACM Multimedia 2017. ACM, 2017.

2 Fundamentals

This chapter describes fundamentals and key aspects, that form the theoretical basis for the work presented in this thesis. We provide background knowledge on topics that provide the basis for our research on social awareness. These topics include information about human relationships and its different forms of being related. Understanding these concepts is necessary when designing technology to support a feeling of being connected. We provide a glance into the field of communication, which builds the overarching method for our artifacts. To better understand the concepts and ideas behind our designs, we shortly explain research fields, such as: pervasive awareness systems and tangible interaction in this chapter. As our work implies the exchange of personal information, we provide basic information with regard to users privacy. To begin with, we explain the importance and psychological backgrounds of relatedness for human beings. We describe related definitions and its influence on social well-being on the long-term. We present basic concepts of interpersonal communication and provide a short introduction into communication theory and the influence of modern technology on the use and perception of communication in recent times. Additionally, we explain the background of self-revelation and self-disclosure, and how these concepts play an important role in building strong and lasting interpersonal relationships. Moreover, we explain the terms awareness, social presence and connectedness and its importance to create a feeling of closeness for people living over a distance. We provide background information and recent developments in technology, that aim to support a strong feeling of *virtual presence*. Following we describe the concepts of pervasive or ambient systems, with a focus on awareness. We explain concepts as *calm technology* or *connectedness oriented communication*. We investigate what role awareness systems play to create social connectedness and how these systems influence social well-being in day-to-day life. We provide a brief overview of concepts and systems that provide pervasive and ambient information related to social awareness and how these are used in mediated environments.

2.1 Relatedness: The Social Human Being

Feeling related to others and socially integrated in society is a very important goal for the human well-being [CS16, BL95, HDO05, JIW14, Nol02]. Moreover, close social relationships between people lead to higher levels of satisfaction with one's own life and raise self-esteem for individuals [CW85, TTT97]. Throughout the literature a diverse set of terms is used to describe the close and fulfilling relationships between people. Terms like connectedness, belonging, togetherness, closeness or love and intimacy describe similar feelings of human-beings related to each other. Psychology, social sciences and other related sciences research the relationships between people and its effects of well-being for many years. Therefore, relatedness has been described with many psychological theories.

In their work in *Self-Determination Theory*, Deci and Ryan have defined social relatedness as one of the three most important needs for human beings [RD00]. SDT

Need	Description
Autonomy	Feeling that you are the cause of your own actions rather than feeling that external forces or pressure are the cause of your actions.
Competence	Feeling that you are very capable and effective in your actions rather than feeling incompetent or ineffective.
Relatedness	Feeling that you have regular intimate contact with people who care about you rather than feeling lonely and uncared for.
Popularity	Feeling that you are liked, respected, and have influence over others rather than feeling like a person whose advice or opinion nobody is interested in.
Stimulation	Feeling that you get plenty of enjoyment and pleasure rather than feeling bored and understimulated by life.
Security	Feeling safe and in control of your life rather than feeling uncertain and threatened by your circumstances.

Table 2.1: Overview of needs suitable for Experience Design collected by [HED+13] and [SEKK01]

describes three innate psychological needs, that form the basis of self-motivation and personality integration: Competence, relatedness and autonomy are seen as the universal necessities, with relatedness being the need for interaction with others, connectedness and the experience of caring and being cared for. The need to belong to a social group and to maintain these social contacts on a regular basis has been described by multiple researchers. Baumeister and Leary have described an inherit desire for human beings to satisfy these needs through regular interactions with long-term contacts [BL95]. Sheldon et al. have defined a fulfilled social relatedness as a "feeling of regular intimate contact with people who care about you" [SEKK01].

Hassenzahl et al. outline in their work *Experience Design* an approach which aims to design experiences that fulfill users needs and create pleasurable and meaningful moments. They describe opportunities for design that enables people to take control of their experiences and change their own happiness in positive or negative ways. They further explain, that all experiences carry an *"emotional thread"*, which relates these experiences to happiness of a specific person. However, it is in question, where the positivity created through these experiences stem from. Hassenzahl et al. argue, that the fulfillment of psychological needs is what actually makes an experience positive or negative and therefore meaningful to a person. Based on work from Sheldon et al. [SEKK01], who have summarized need theories into ten psychological needs, Hassenzahl et al. have narrowed them down to a set of six relevant needs for interaction design: autonomy, competence, relatedness, popularity, stimulation, and security (see Table 2.1 for a short summary).

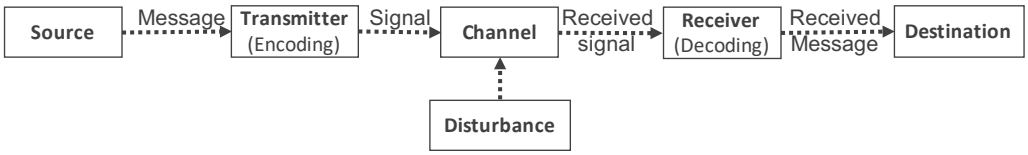

Figure 2.1: Shannon–Weaver model of communication

2.2 Communication

The term communication is used in many different fields and can not be defined by a single statement. From sociology to economics or philosophy, communication is defined with various fundamental backgrounds and intentions. A description of the term communication, as it is used in this thesis, can be found in the field of social psychology: *communication as a way of social interaction*. The word communication, steaming from the Latin expressions *communis, communicare and communicatio*, carries the meaning of *exchange of information*, *do things in common* and *participate* [BBJ12]. Communcation happens between, at least, two involved instances by exchanging messages over time. The exchange is not direct, but happens through signals between source and destination of the messages through a specific medium. After a message is encoded by a transmitter, it is send via a specified channel and decoded by a receiver. A message is fully transmitted, when the destination has receiced it. During transmission, a signal can be distorted through a) noise (not send by the sender) or b) equivocations (send by the sender, but not understood by the receiver) [SW49] (see Figure 2.1).

The model by Shannon and Weaver has been modified and expanded by other researchers in the field. Berlo expanded the model of communication and created the *SMCR* model of communication [Ber60]. This model separates communication in Sender-Message-Channel-Receiver parts (see Figure 2.2). Sender is the source of the message or the person who originates the message. Communication skills are a factor that affects the communication process. If the sender has good communication skills, the message will be communicated. If sender or receiver can not communicate or grasp the message, communication will not be effective. A person's attitude towards self, the receiver and the environment changes the meaning of a message. Existing knowledge on the subject matter increases the message's effectiveness. Values, beliefs, laws, rules, religion and many other social factors affect the way a message is expressed and understood. Similar, cultural differences change interpretations of messages. The message is the substance that is being sent by the sender to the receiver. The whole message from beginning to end can be understood as the content. Elements are the nonverbal expressions e.g. gestures. Treatment is the way in which the message is conveyed to the receiver. Structure and the used code, affects the effectiveness of the message. Channel is the medium used to send the message. In general communication, the five senses of a human being is the channel for the communication flow. Technology supports the exchange of communication in forms like telephones or internet services. Receiver is the person who gets the message

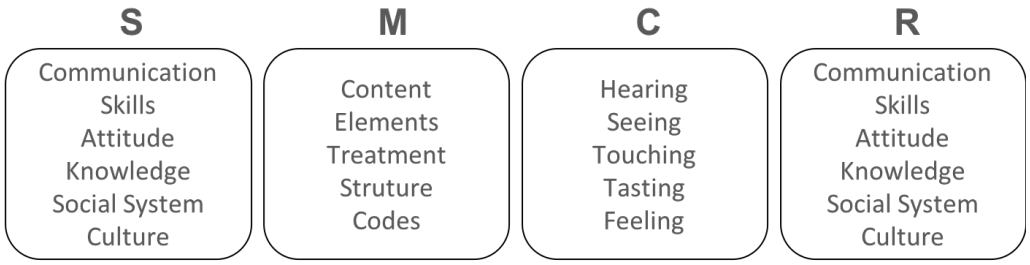

Figure 2.2: Sender-Message-Channel-Receiver Model of Communication

sent. The SMCR-Model states that all factors mentioned above must be in sync to that of the sender for the communication to be effective.

The message send during a communication is defined as the *signal* that is transmitted. A signal, is a sensual perceptible and/or technical transmittable representation of a behavior or attribute. Signals can be differentiated in three types [Pap04]:

1. **Index (Sign or Indicator):** natural correlate of a phenomenon or object. For example the perception of dark clouds that represent a high chance of rain or symptoms that might indicate a upcoming cold. An index requires the existence of an object, but does not look alike. Only by the interpretation of a recipient, the index becomes a natural signal that carries meaning.

2. **Icon (iconic or pictorial sign):** artificially created sign, with a high similarity to what it represents. For example a picture of a specific person. An icon is not depended on the existence of the object it represents, but rather the attributes of the virtual object e.g. a picture of a ghost.

3. **Symbol:** artificial sign without similarity of what is represented e.g. a letter of the alphabet. A symbol is abstract and is based on conventions that need to be learned, before use. It is independent of the existence and the attributes of what it represents e.g. the concept of freedom.

The interpretation of a index does not necessarily include communication, as an index can be created unintentionally e.g. nonverbal reactions like flushing out of shame.

Verbal communication is a human-specific cultural achievement and is based on a reciprocal and reflective exchange of symbols. Verbal communication happens along the model described by Shannon and Weaver and is expected to happen intentionally. This implies that not every verbal expression can be interpreted as communication. Possible exceptions are for example: statements without any communicative intention e.g. expressions of pain, or without the goal to communicate e.g. self-verbalization. Further, we can exclude verbal expressions, that have been unintentionally received by misaddressed individuals (either by accident or eavesdropping).

Nonverbal communication is a vital part in interpersonal interaction and complements verbal expressions by providing additional context and meaning. Within face-to-face communication, nonverbal signals are used to define or specify the meaning of what has been verbally expressed. In a context, where the source of information is visible to the receiver but not audible e.g. within a crowd of people, nonverbal communication can substitute verbal expressions and enable individuals to communicate without verbal language. Generally, most nonverbal behavior is considered part of the communication. However, same behaviors and expressions are excluded from these interpretations such as, behavior of self-regulation e.g. moving into a more comfortable position or activities due to a secondary task e.g. eating. Behaviors of nonverbal communication can be categorized by three main types [BFP13]:

Nonvocal-bodily	***Nonvocal-material***	***Vocal***
mimics, gestures, gaze behavior, posture, body movement, physical contact	possessions, status items, furnishings of the apartment, presents	voice characteristics such as: tone of voice, pitch, loudness
movements within different interpersonal distances (proxemics): intimate, personal, social, public		language characteristics such as: intonation, accentuation

Table 2.2: Behaviors of nonverbal communication, categorized by the three main types: nonvocal-bodily, nonvocal-material and vocal

Nonverbal communication includes gestures we use or the distance we keep while we talk with someone. During conversations, many nonverbal interactions happen beyond gestures. We might smile, frown, grimace, or engage in other facial expressions. This nonverbal signals help our communication partners to know how we feel about what we are saying or what they say. Often, these nonverbal interactions carry the same importance in social interactions, as the words we speak.

The body posture we take, is another form of nonverbal communication. Body posture often combines with facial expressions to convey how a person feels. For example, people may cross their arms or stand with their hands on their hips and glare at someone, when they are angry. Someone sitting slouched in a chair looks might express boredom. Consciously or not, men and women engage in various body postures when flirting with each other: they sit or stand in a way that conveys, that they are romantically interested in a particular person.

2.3 Self-revelation and Self-disclosure

In interpersonal relationships, self-revelation and self-disclosure are important factors that affect how close partners are and how much they are willing to open-up to each other. Self-revelation, is defined as a passive, often unintentionally, exposure of something about yourself in an implicit way [Lev96, Fra97]. As an example, we might reveal parts of our personality, our opinions through our body language or silences in our speech patterns. This happens without a direct intention and continuously. Being able to recognize and interpret these self-revelations by others is described as *exquisite attention* and influences the way we perceive others around us.

When being co-located to individuals, self-revelation happens naturally and can provide a good indication of our thoughts, feelings and moods towards another person. This is an important part of nonverbal communication and can help to build stronger and long lasting relationships. However, when living over a distance, we often miss self-revelations of others. Modern communication can enable us to communicate at all times, but are often not designed to exchange nonverbal signals like activities or daily routines. Therefore, expressing and sharing these signals can be burdensome and often requires our focused attention (when sending as well as when perceiving).

A second important concept happening between individuals that interact socially is know as self-disclosure. Greene describes self-disclosure as "an interaction between at least two individuals where one intends to deliberately divulge something personal to another" [GDM06]. The shared personal information might include specific thoughts, feelings, goals, fears, dreams as well as things the person likes or dislikes. Despite many cultural restrictions of sharing sensitive information or personal views, research indicates benefits of self-disclosure for building relationships with family members and friends. Additionally, nondisclosure, especially in situations of strong emotional stress, can lead to psychological inhibition and suppression of cognitive processing.

While managing disclosure in daily life is considered an intuitive process, that we carry out when a situation is well-suited for it, it can be problematic to find an appropriate situation when using messenger services, phones or video calls. This might discourage individuals from sharing their inner views, although it would be beneficial to them.

The social penetration theory, presented by Altman and Tyler [AT73] states that the development of a relationship is linked to changes in communication. In the beginning, relationships start to exchange superficial information and gradually move on to more meaningful topics in conversations. By increasing the breadth and depth of their conversations, partners are able to develop more intimate relations with each other (see Figure 2.3). Breadth includes the variety of topics two people discuss and depth is the personal significance of these topics. When only increasing the depth of a conversation, the relationship often is held in short intimate times e.g. a summer romance. When increasing the breadth without the depth, the relationship in considered more casual.

Altman and Taylor use a wedge to explain their theory. In the beginning a relationship can be represented by a narrow wedge because only a few topics are discussed. As the

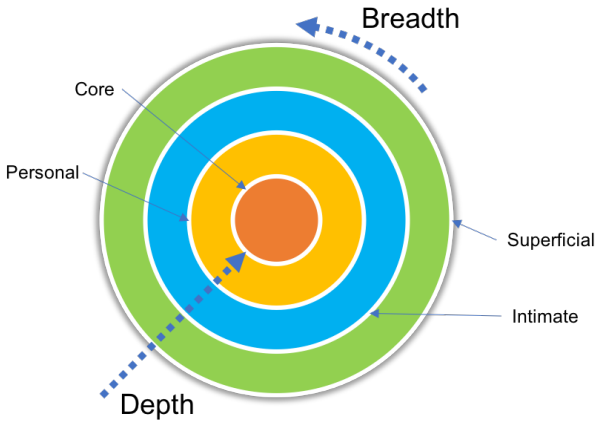

Figure 2.3: Social penetration theory: depth and breadth of social penetration

relationship develops, the wedge becomes broader and deeper, including more topics of personal significance. The wedge must drive into at least three "layers" in order for intimacy to develop. The first "superficial" layer, provides little personal information about the speakers. The next layer is intimate, with increasing breadth and depth and more personal details. The "personal" layer is very intimate, where extremely private information is shared.

Intimacy can only develop if the communication partners are involved in reciprocate disclosures. Intimacy will not develop if only one partner discloses and the other continues to reveal only superficial information. Reciprocity must be gradual, to match the intimacy of the partners disclosures. When sharing too rapidly intimate insights, an imbalance in a relationship is created, that can be discomforting. The speed and details of the process varies from relationship to relationship and is depend on the specific partners.

2.4 Social Presence, Awareness and Connectedness

Following we present the fundamental concepts of social presence, awareness and connectedness. We further explain how these concepts relate to each other. With social presence, awareness and connectedness, we provide information on key concepts in the analysis of communication and the development of communication technologies. The understanding of these concepts is a necessary part of research on social awareness and communication technologies, as there a various important differences ones should keep in mind.

Despite numerous definitions, the concept of social presence is not fully clear and still discussed in different fields of research. Short et al. have defined social presence as *"the degree of salience of the other person in a mediated communication and the consequent salience of their interpersonal interactions"* [SWC76]. Social presence theory

describes the effectiveness of communication for a specific communication medium by its capabilities to provide social presence for interpersonal interaction. For example, while face-to-face communication is considered to provide the most social presence, text-based communication provides the least.

However, although social presence is a property of the communication channel, it still is derived from the effect of the channel on the participants interaction.

Several researchers have further found, that immediacy and intimacy are influencing social presence. Immediacy can be understand as psychological distance conveyed by nonverbal and verbal signals such as nodding or smiling [Wal92], while intimacy describes a measure of communication including eye-contact, distance to others or body language [AD65]. Recent research further directly links the influence of experienced social presence to a feeling of closeness in interpersonal communication [GW14].

Awareness, has been used in various different ways and contexts within research in human computer interaction and its meaning is derived from the object of the awareness [Ret03]. In this work we follow the definition by Dourish and Bellotti [DB92a], who describe awareness as: *"an understanding of the activities of others, which provide a context for your own activity"*. Here, awareness is understood to be the perception of others within a mediated communication as well as one important aspect of the system itself, that facilitates this perception of awareness.

Following the definition by Van Bel et al. [BSI+09], connectedness describes a *"short-term experience of belonging and relatedness, based on quantitative and qualitative social appraisals, and relationship salience"*. In stable relationships, a feeling of connectedness can develop into a long-term experience, as Van Bel et al. found [VBIK08]. A feeling of belongingness can further be perceived as *momentary* or *continous*, depending on the relationship and closeness of the individuals. Participants of a communication can feel a sense of connectedness, which often is more important to strengthen social bonds, then the content of the communication itself. This behavior has been discovered for users of instant messaging services, who monitored the availability status of friends, even when they did not intent to communicate [NWB00]. Nardi et al. stated: *"Even when no direct information exchange is taking place, people want to maintain connection with others, outside the context of specific events of information exchange."*

Connectedness and social presence are related concepts, however they are not equivalent or necessarily depended of each other. While social presence describes the perception of another individual, connectedness can be understood as an emotional experience. For example, the use of messenger systems can convey social presents through the awareness of availability, even when no information is exchanged. At the same time the social presence of a connected partner can be absent in such systems, without affecting the feeling of being connected. Figure 2.4 depicts the relationship of the three concepts. While social presence implies an awareness of another individual, awareness about someones activities can occur without the social presence or a feeling of connectedness. In co-located relationships, social presence and connectedness often occur together, they can be experienced separately e.g. during the use of text messages with a

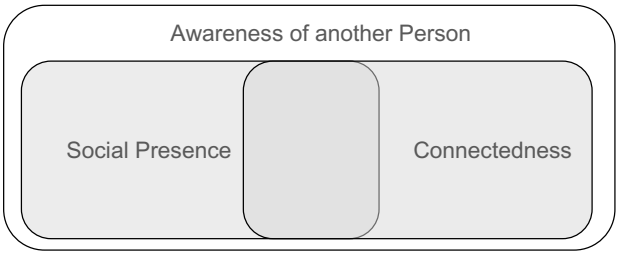

Figure 2.4: Relationship of awareness, presence and connectedness as depicted by Ruth Rettie [Ret03]

loved one or the social interaction with a stranger. Connectedness might arise without being aware of a loved ones activities for example by receiving a present from a loved one living over a distance. However, it is arguable if the awareness is directed towards a meaningful object rather then a person.

2.5 Pervasive Awareness Systems

Pervasive awareness systems have been researched for many years in the areas of human-computer interaction and computer-mediated communication. Since the early works by Ishii and Ulmer [IU97], various systems and concepts have been presented, that convey or visualize information in the environment of human beings. These usually use different modalities, such as light, sound or movement [BHE15, PSM07, WID+98] to provide information, without the need for focused attention by the user [HCML08]. Commonly, research refers to these systems as *peripheral displays* [MDM+04], *ambient displays* [MDH+03], *awareness systems* [MM09] or *notification systems* [MCSN03]. With expanding research in the area, Pousman et al. [PS06] proposed a taxonomy of systems and artifacts:

Symbolic Sculptural Displays: Ambient information displays that display only one or a few information. The representation of information is often abstract e.g. light, movement, water. They are commonly designed to be decorative objects and are highly aesthetic.

Multiple Information Consolidators: Systems that display individual pieces of information in a consolidated way. Typically screen-based, in order to convey more information and make user aware of changes e.g. blinking. Usually follow a trade of between aesthetics and customization of information capacity.

Information Monitor Displays: Displays, that are part of a users computer desktop. They display multiple sources of information in the periphal, usually by using metaphors. User can be notified about changes in ways from subtle to demanding. Might achieve aesthetics, but not as a primary goal.

High Throughput Textual Display: Systems that use text and icons, to present information. These displays are capable to represent voluminous information but usually do not notify. Information conveyance is more important then aesthetic design.

Pousman et al. present these patterns as models for the design of future ambient information systems, but also point out, that developments in the fields of ambient intelligence and ubiquitous computing will advance the four patterns and new archetypes of information systems will emerge.

2.5.1 Calm Technology

The therm *Calm Technology* was first introduced by Weiser and Brown in their article "Designing Calm Technology" [WB96]. Calm technology describes the design of technology, that provides information in the peripheral of a user instead of asking constantly for focused attention. In the case of needed attention, the device smoothly shifts the user's attention towards the information. Otherwise it aims to act unobtrusively in the background. The concept is often used to design and implement technologies in a way that prevents users from feeling overwhelmed by the invasiveness of information systems in day-to-day life.

Calm technology should follow three simple principles described by Weiser and Brown:

1. "... a calming technology may be one that easily moves from center to periphery and back."

2. "... a technology may enhance our peripheral reach by bringing more details into the periphery."

3. "... when the enhanced peripheral reach increases our knowledge and so our ability to act without increasing information overload."

As examples for calm technology design Weiser and Brown describe a "Dangling String". A string connected to a small electric motor in the ceiling. The motor measures information flowing through an Ethernet cable, which causes a twitch of the motor. The more information flows, the faster the motor runs creating a moving effect in the attached string. Another example is the use of a kettle. After filling the device and putting it on top of a stove, the user can relive the attention. By the sounds of boiling water or whistling sounds, the kettle informs the user when she has to refocus her attention.

In our work we use the concept of calm technology, to design interactions and devices that help people to connect, without overwhelming them with information or focused actions to be taken. We use light displays to shift the users attention when necessary, design artifacts to be perceived part of the living environment and keep interactions playful and interesting, so that users enjoy interacting with the device.

2.5.2 Connectedness-oriented Communication

In contrast to many currently used communication technologies, which mainly focus on task-oriented communication e.g. notification or discussion, awareness systems often aim to imitate other types of communication and awareness, that occur naturally when we interact with people in our daily life. Examples are greetings, chatting for enjoyment about experiences or the perception of daily activities of others. Further, we implicitly exchange information of presence, our intentions, moods with social peers in a day-to-day life. This information is used to *cue information* to adapt our social interactions with people surrounding us [KWO+02].

Connectedness oriented communication can be observed in existing means of communication like text instant messages, which tend to be of a short length and their content is usually much less compared to e.g. e-mails. In these cases, the content itself is often less important and the arriving message means more to the receiver. The communication thus can be understood as connectedness-oriented. However, mobile phones were not designed to serve as awareness devices, but rather to be an effective and fast tool for information exchange. In order to facilitate connectedness oriented communication, technology needs to facilitate different behaviors and fulfill rather different requirements on awareness and communication.

The main goal of connectedness oriented communication is the support of awareness about loved ones. Kuwabara et al. present examples of such awareness in their work:

"For example, if the fact that a person is present at a remote location can be conveyed to a person at the other end, it may help maintain the relationship between these two people. Alternatively, if feeling towards a person at the other end can easily be conveyed to the other, it may also help maintain the relationship. For example, a casual greeting sent over the network could be beneficial to keep a social relationship."

In contrast to common verbal communication means, the exchanged awareness information do not necessarily need to be supported by words or written messages. It often is further not needed to use high-fidelity visual or audio to represent these information. Rather, it is assumed, that a symbolic representation is more suitable and less overwhelming to receive.

2.6 Tangible User Interfaces

Tangible user interfaces (TUIs) have been a vital part of research in human-computer interaction for many years. In contrast to software-based interfaces, tangible user interfaces enable the physical interaction with data and information (see Figure 2.5). Early concepts have been presented by Ishii and Ullmer [IU97], who describe tangible interaction as part of ubiquitous computing. The interaction with and direct manipulation of information can support users and their understanding of complex matters:

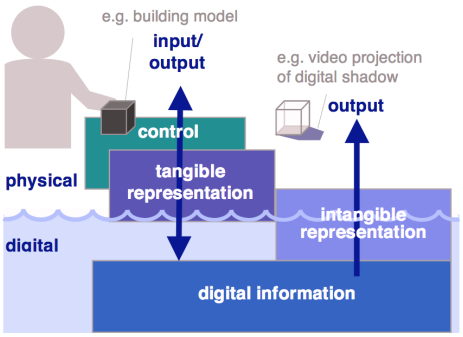

Figure 2.5: By giving tangible (physical) representation to the digital information, TUI make information directly graspable and manipulable with haptic feedback (by Ishii [Ish08])

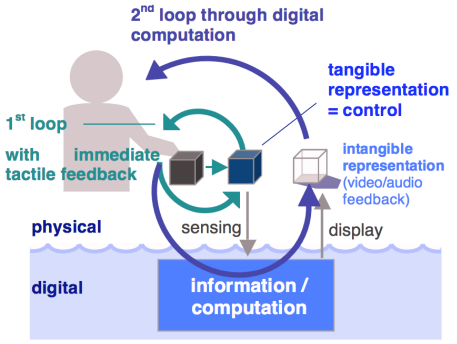

Figure 2.6: TUI provides two feedback loops: 1) 1st immediate tactile feedback, and 2) 2nd feedback through digital processing with possible delay. (by Ishii [Ish08])

> "The key idea of tangible interfaces is giving physical form to digital information. These physical forms serve both as representations and controls for their interwoven digital bindings and associations. TUIs make digital information directly manipulable with our hands, and perceptible through our foreground and peripheral senses."

Hornecker and Buur [HB06], have shown that tangible interaction is engaging and provides a low threshold for accessing interactive systems. Ishii and Ulmer [9] showed that tangible systems are successful in facilitating the smooth transition of attention between foreground and background tasks, what makes them successful for the increase of awareness. Shear and Hornecker [SH+10] provided scenarios and recommendations regarding the future development of tangible interaction.

Tangible user interfaces provide various advantages, that ease interaction for users with tangible artifacts (see Figure 2.6). Such characteristic define the way a user is interacting with the device and therefore with the digital computer. One advantage is the direct manipulation and tactile feedback provided to the user. By manipulating the physical object and the digital representation, the system can provide a double feedback loop to the user. Further, such artifacts still exist and are available in the real environment, although its digital representation might be unavailable. Generally, tangible user interfaces are rather used for special applications, such as learning environments for children.

In addition to existing works on tangible user interfaces, Wallbaum et al. have taken a closer look on the challenges of tangible systems and what we can learn from it [WMHB]. This work is aiming to answer the following questions: (1) What about tangibility makes things work, and what prevent it from being successful, (2) to what extend one can use tangible interaction and (3) where does tangible interaction fail? In this work, the authors discuss the following aspects of tangible systems: (1) scalability, (2) acceptability, (3) novelty and complexity of interaction, (4) form factor and context

of use and (5) maintenance and complexity:

Scalability: Tangible artifacts are often restricted in comparison to most software systems with regards to scalability.

Acceptability: It is a long process of accepting and adapting to a new tangible artifact in the environment, especially when designed to be used in various contexts of use.

Novelty and Complexity of Interaction: Tangible artifact, however, have various form factors. Therefore, a user has to learn an interaction for a specific object and adapt to its affordances.

Form Factor and Context of Use: The form factor of tangible systems might restrict the context of use and can raise acceptability concerns by users, especially when used within a domestic context.

Maintenance and Complexity: Providing users an update for a failing tangible system can be challenging in comparison to over-the-air updates of software applications.

2.7 Ethics and Privacy

Within our research activities, we design systems to share personal information between distributed users using modern telecommunication infrastructure. These systems use various information sources, to create a sense of intimacy and relatedness by sharing information about activities, personal experiences or a partners moods and feelings. While these information are important to enable a feeling of closeness, they also carry sensitive insights into a persons private life with them and therefore need to be handled with care and respect.

To comply with these requirements, we followed a *privacy by design* [STVC+16] approach to protect users privacy and follow modern ethical research guidelines. To ensure correct handling of data within information systems, requirements should be investigated within the first and second phase of the human-centered design process (see chapter 1.5.1). In the first phase the overall context, such as which legal requirements need to be considered at all need to be analyzed. In the second phase, personal and social acceptability of systems sharing specific data might define how services need to be designed.

We identified regulatory frameworks for processing personal data, early in the development stage to base the technical design of the systems. The use and data processing of artifacts designed in the context of this research is based on a user consent and aims to respect the principles of data economy and data avoidance. All systems try to exclusively collect data, that are necessary to research its use and are been anonymized or pseudonymized as soon as possible. Access to user data is limited to a small number of researchers, for maintenance of services and data analysis.

When conducting studies, it is necessary to obtain ethical approval for the overall study design, consent forms, data protection measures as well as safety of participants

and their privacy. This is especially true for sensible user groups e.g. children or patients and when transferring and storing personal data throughout the study's run time. Our work complies with this requirement, by obtaining ethical approval from the internal ethical board of the *OFFIS - Institute for Information Technology* as well as the IRB of the *University of Oldenburg*.

2.8 Chapter Summary

This chapter covers relevant background for this work, that emerge from different fields of research. First, we introduced the concept of relatedness and its effects on social relationships. We explain the basics of how communication happens and which parts are involved for a successful exchange of information. We cover the topics self-revelation and self-disclosure, to explain the ways people build and strengthen relationships. Further, we explain concepts like social presence, awareness and connectedness to understand the perception of others nearby as well as over a distance. We present approaches and previous work on ambient systems to communicate information unobtrusively. We end the chapter by explaining the concepts behind tangible interactions as well as a short reflection on ethics and privacy with regard to our studies.

3 Awareness of Activities

3.1 Introduction

In this chapter, we investigate the design and use of technologies to create awareness of activities between loved ones living apart. We present two example designs for artifacts, that help people to be aware of others day-to-day activities. We further present two evaluations of these artifacts: a lab-based study that investigates visualizations, interaction and acceptance in a domestic context. In a second case study, we present insights into the design and use of social awareness systems for minimal communication in day-to-day life. Findings from both studies lead to a set of design recommendations for awareness systems and their adaption into everyday life.

3.1.1 Activities

We have designed artifacts, that fulfill the role of mediators between people living apart from each other. The casual perception of activities conducted by others near by is an important part of sharing a life and a home and contribute to a feeling of closeness. These activities can be as simple as cleaning, working or relaxing with a cup of tea and a book. In professional environment, other activities become more prominent and create awareness about a colleagues current amount of work e.g. signals of stress or the general mood. We have chosen a subset of activities such as: *physical activity*, *social gatherings*, *relaxation e.g. reading a book*, *working*, *watching TV*, that are conducted in a private environments by persons living co-located or apart from each other. We detect activities and create a mapping into more abstract representations of them. This allows us to design artifacts that can support the perception of such activities over a distance while respecting the privacy of a user.

3.2 Sharing daily activities and moods using smart furniture

3.2.1 Motivation

Awareness of each others activities, moods and life events plays an important role in social relationships between human beings. Feeling the presence of each other and taking part in the life of each other can deepen relationships and create a feeling of belonging and participation. When living together in a household, family members experience activities and moods of each other naturally and almost continuously. This includes the exchange of small conversations about the day in school or at work, cooperative activities like cooking or cleaning the household and emotional expressions like anger, happiness or sadness. Being able to recognize these verbal and nonverbal expressions, co-located persons are able to react to them actively, provide help or be available for a talk.
When living over a distance, these verbal and nonverbal cues are not perceived naturally,

and a person needs to share them actively with others using the phone, video chats or other communication means. These systems provide a great platform to exchange information in detail and talk through a topic or show things visually. However, they are used explicitly with the intention to share or get in touch and miss to convey minor activities from a persons life. To use common communication devices users also have to invest effort to keep in touch with relatives or friends. This effort can be low e.g. when a young digital native user sends a short message via a messenger service or very high e.g. an inexperienced user sends a picture to a group of family members. Another important remark is that many communication technologies are used extensively nowadays and play a major role in the life of people. Being available by messenger, video call or mail continuously is often perceived as being very obtrusive and exhausting. It further can be overwhelming for people who feel they can not escape these technologies any longer.

Since computers have become a ubiquitous part of our everyday life, it is increasingly important to create technology that integrates with our daily environment, to prevent people from feeling overwhelmed. The typical trend of research has often been to create faster and more efficient screen-based tools. This demands users to adopt new and sometimes unnatural conventions. Weiser et al. and Hallnas et al. have presented new views on technology which focuses on the creation of calm and slow technology [WB96, HR01] to encourage the design of products that interweave with users routines and allows for a smooth integration of digital information into the peripheral space [MDH+03]. Shifting digital interactions into aesthetic everyday objects can be used to design simple, intuitive and engaging interactions [IU97], which can ease an interaction and increase the experience for a user. These artifacts can convey information in an unobtrusive way and can, for example, support a user to keep track of her posture [HSCB15] or provide information about a users physiological data [YBVA+16].

In our work we tried to explore new ways of unobtrusive technology for communication, which still is able to create a sense of belonging between people living over a distance. Additionally, the goal was to design artifacts, that integrate into a persons life, are unobtrusive, simple and flexible enough to be used in a different way then originally designed for.

3.2.2 Related Work

Tee et al. have explored the communication patterns among family members, who live spatially apart from each other [TBI09]. Their study shows that most of the participants had a strong need to communicate more often and more regularly with family members than they actually did. The work reveals that people miss out on communicating with each other due to asymmetries in their daily routines. When designing communication technologies, it is important that the user doesn't feel obliged to send messages or to share information. On the contrary, the technology should help the user to feel connected with others in a positive way in case they feel like it.

Kaye et al. & Kjeldskov et al. have researched the needs and requirements for tech-

nologies to support a feeling of closeness and to understand the role of intimate communication in the users lives. [KLN+05, KGV+05]. The results showed a desire for new technologies to support communication by providing presence information and activity awareness for a loved one. Users want to feel a connectedness with each other, provided by e.g. a single light which is displaying physical presence of the other person. The requirements for such communication devices allow the design of simple devices and interactions based on a "minimal communication". Further Kaye et al. presented the concept of intimate objects [KG04]. These objects are meant to support couples living over a distance to create and maintain a feeling of presence and intimacy between each other.

Brereton reports in her work "Habituated objects" [Bre13] results from an interview about objects of greatest significance to an elderly person. Particular attention is paid to how objects are configured to suit needs and interests, and how these objects become habituated into life over time. This provides helpful insights into how design strategies should make use of these habituated objects to support staying in touch. It is further important to understand to which extend objects and technologies have been adopted and habituated in users lifes, and why some technologies fail to do so. This work provides clues to design new IoT-technologies that support elderly people. Further Vaisutis et al. [VBR+14] have presented categories for important objects of daily living, based on interviews with users above 65 years. They could show that objects often inherit a specific connection to memories or events from the past.

Lenz et al. [LHA+16] describe four different concepts to lower the barrier of getting in touch for families living over a distance. The work underlines how important the creation of positive and meaningful experiences is, when designing for such communication technologies. It further describes that it is crucial to use technology sensibly to shape new ways of communication and exchange of information about a beloved one.

3.2.3 Requirements

We wanted to gain insights into the needs and requirements of people living over a distance with regard to their communication behavior, the use of everyday objects, and activities. Further we asked about possible use scenarios to share daily activities and moods. Gaining these insights, helped us to understand the potential use of everyday objects as non-verbal communication means. The requirements show, that people frequently perform daily activities at tables in different contexts of use. This led us to the idea of designing a smart table as a means of non-verbal communication between people living over a distance.

In a first step we conducted semi-structured interviews with eight participants (n=8) within an age range from 17 to 55 (5f; M=33,63 years; SD=15,56). Results showed, that most participants use tables throughout their day depending on their current activity. The most mentioned tables within the homes were living room tables, kitchen tables and desks to work on. For younger participants, the desk within their own room seemed to

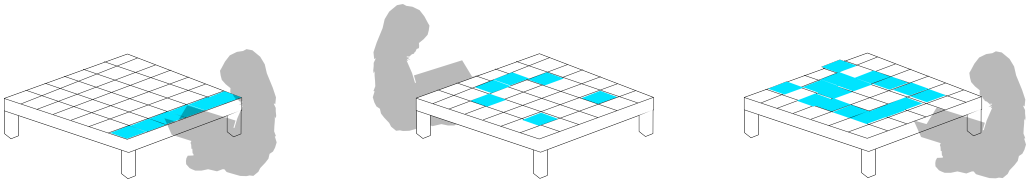

Figure 3.1: Use scenarios implemented for the RemoTable - showing presence of distant people (left), recieving mood visualization (center) and receiving information about activites of a beloved one.

play a more important role. Adults often mentioned the living room table as the most used one. Objects used on or near the tables are often matching the currently executed activity e.g. using a mug to drink coffee together, reading a book or the newspaper or working on the computer. Objects on the tables that did not match a specific use case are mostly decorations and flowers. We asked the participants about their normally conducted activities, when sitting at a table. The most prominent activities were: *eating dinner*, *using the smartphone*, *drinking coffee*, *working on a computer*, *reading* and *watching TV*.

Following, we have asked the participants about the information they would like to get about distant family members or friends using smart furniture. *Mood of the other person (6)* and *activities in the other household (5)* were the most mentioned information. Additionally to that, *health-related information(4)* were especially interesting, when communicating with elderly persons. Further mentioned information are: *general information from the family (2)*, *pictures (1)*, *location (1)* and *visitors are present (1)*. The question how this information should be visualized was answered with: *color for mood (3)*, *pictogram (3)*, *emoji (2)*, *color for activity (2)* and *text (1)*. When interacting with the furniture, users liked the idea to use day-to-day objects and tangibles to represent their current mood (7/8). Additionally to that, some participants mentioned to use touch gestures or buttons to input information or to connect their smartphone with the furniture and use that to interact and input data.

Based on the requirement analysis, we have created an interaction design which enables a nonverbal exchange of presence, activities and moods using smart furniture in the form of a living room table. Following we describe the concepts for three different use cases and the prototype of the RemoTable.

Exchange Presence

By sharing the presence of related persons sitting or standing at a connected table, we aim to create a feeling of closeness between both households. When distant persons are approaching the connected RemoTable, a proximity sensor detects their presence and transfers this information to the local table. This information is visualized by lighting up the pixels on the corresponding side of the local table (see Figure 3.1 - left illustration). Seeing that a beloved one is at home and using the connected table, helps to get a sense about the persons availability.

Exchange Moods

The most mentioned information during the conducted interviews, was the current mood of a connected person. We wanted to enable users to express their current mood easily and without much effort, to simplify the communication. Compared to nowadays normally used messaging services, the RemoTable is only able to present a limited amount of information using a limited space. Therefore the visualization of moods should be clear to perceive and interpret. We decided to build on existing methods to express moods using emojis (see Figure 3.1 - center illustration). This decision is based on a) the wish for Emoji during our interviews, b) existing models to classify mood and c) a high level of awareness for Emoji nowadays. By placing one of five tangible Emoji in the form of a small token on the table, the user can express her/his current mood. This mood is saved in the system, until a new token is placed and transferred to the connected table. To visualize the mood of a related person on the local table, we have created digital versions of the available Emoji, that get shown on the table's surface (see Figure 3.3). Adding new Emoji or ideograms in the future is easily possible and might help to express moods and feelings even better.

Exchange Activities

Besides the exchange of moods throughout the day, the second most wanted information is what activities are currently executed in the distant household. To support this, we want to utilize the detection of objects placed and used on the table. Therefore, objects that relate to a specific activity and are used often during the day are equipped with electronic tags. This enables the RemoTable to detect these objects and transfer this information to a distant connected table (see Figure 3.1 - right illustration). Because the tags are being read automatically, there is no need for explicit communication from the user. This has two main advantages: 1) The user can not forget to share her/his activity and 2) the interaction with the RemoTable is easy and natural. For a later use-scenario, we imagine that users can add tags to objects them-self, which removes possible concerns about privacy protection, e.g. the user decides what object to tag, and therefore what activity to share. Similar to the visualization of moods, we have decided to use symbols to present activity information at the local RemoTable. A subset of these symbols are depicted in Figure 3.2. This subset shows corresponding symbols for the most common activities at the tables. a) using the computer, b) watching TV, c) using the smartphone, d) listen to music, e) drinking coffee/tee and f) reading.

Prototype

The prototyping process was based on the requirements and the defined use scenarios. The design of the prototype was also driven by the ambition, to create a device which does not appear too technical and integrates well into the living environment of younger and older adults. Therefore, we decided to integrate a low-fi light display into a common living room table instead of using a modern display. In the set-up of the first prototype, we have used a Raspberry Pi to enable the communication using WiFi as well as to store

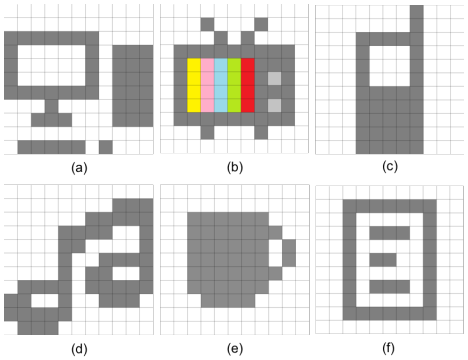

Figure 3.2: Resulting symbols used to represent activities on a low resolution display.

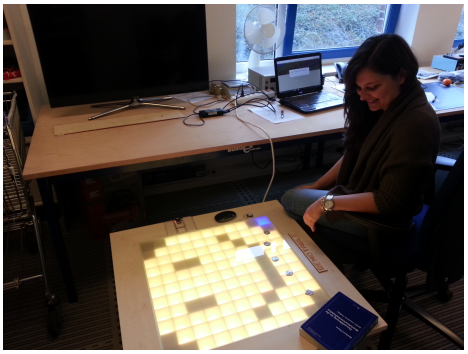

Figure 3.3: Participant during the study, receiving a shared mood from a connected person.

information and to control the visualization on the display. The display consists of 121 individual controllable RGB-LED lights, creating a matrix of 11 x 11 pixels. To control the lights and visualize the content on the matrix, we use a Arduino Mega prototyping board. For reading the RFID-tags applied to different objects, we us a RFID-reader device connected with the Raspberry Pi. On top of a wooden raster, containing a single LED each, a frosted glass is placed to cover up technical parts and to better diffuse the light from the RGB-LEDs underneath. The whole technical setup is depicted in Figure 3.4. Figure 3.5 shows the overall design of the functional prototype, as we have used it for the evaluations.

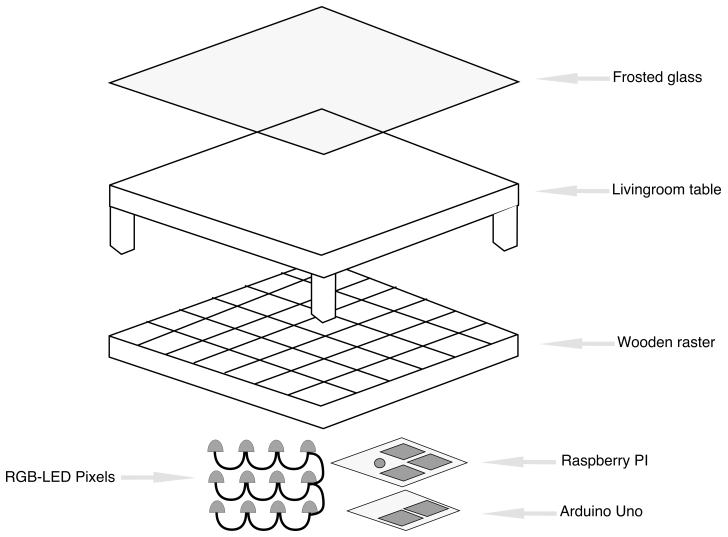

Figure 3.4: Technical design of the RemoTable

All visualization on the table's surface are event-based. Meaning, that if a new event occurs, the receiving table exchanges the last shown information with the new message

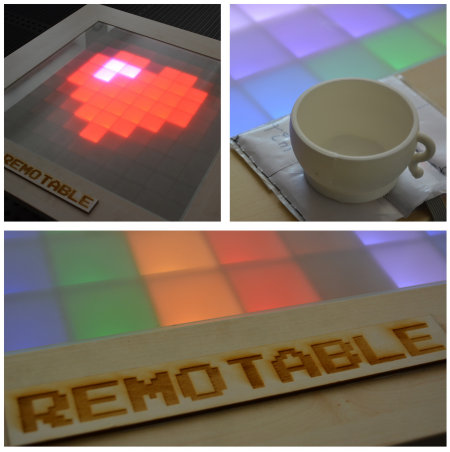

Figure 3.5: Overall appearance of the RemoTable prototype including the light-pixel display and an RFID-reader to detect objects.

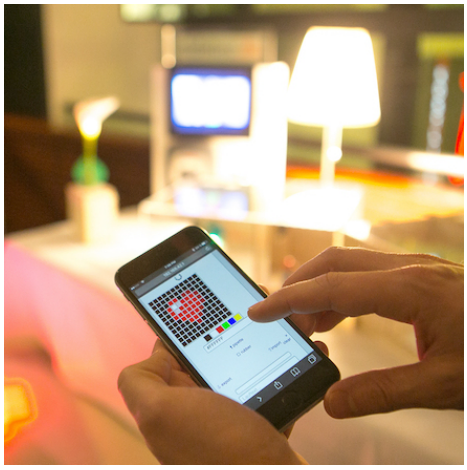

Figure 3.6: Smartphone application for displaying content on the RemoTable's surface. This application has been used within our "Wizard-of-Oz" study.

(either presence, mood or activity of the connected person). To keep the setup simple, which is sufficient for a first lab evaluation, we have designed the system to connect two tables together. However, we also have integrated tags to identify the person who is sharing information, by placing a tag on the table to register. This is especially important, when the table is used in a household with more then one inhabitant. By lighting up one of the corner-squares in a predefined color, the receiving table visualizes that a specific person has registered before sharing a message. To present the information in an unobtrusive way, the table will fade out the light-display after some time and turn of.

3.2.4 Study

The study aimed at assessing three main aspects of our concept which are a) usability and user experiences aspects of the device, b) comprehensibility of the pictograms and emoji and c) support of the communication with distant family members. These aspects were measured using post-study interviews and questionnaires.

Study Design & Procedure

To investigate the above mentioned factors, we have designed a lab study in a controlled environment. Based on the use scenarios, we have developed a wizard-of-oz communication with a virtual communication partner, which is communicating with the user through a software-based system. We achieved this by implementing a simple system, that is able to react to messages from a participant by sharing a mood or an activity respectively. The system could be controlled by a smartphone application, that allowed to depict various contents on the table's surface (see Figure 3.6). This helped us to eval-

Figure 3.7: The RemoTable as used during the lab evaluation study placed in a living lab, which aims to create a natural living environment.

uate the RemoTable with regard to usability and user experience, as well as how such a device might be able to support communication with beloved ones over a distance. After explaining the device to the participant, s/he was able to try out the device and ask questions, without any time restrictions. In a next step, the participant was told, that s/he will communicate with another person, who also using a second table in another room. To communicate with the virtual partner, the participants were asked to execute specific tasks e.g. sharing an activity, sharing a mood. If no questions were left, we started the communication. After completing the tasks, each participant was asked to answer a SUS-questionnaire [B+96] as well as further questions based on the ABCCT- questionnaire by Yarosh et al. [YMA14]. Following we have conducted a semi-structured interview, to get more insights into the user experience as well as possible usability problems. After completing the interview the study ended.

We have recruited 14 participants in the age from 18 to 55 (9 female; M=30.5 years SD=11.99 years) from the local university, personal contacts, and via public announcements. The participants did not receive any incentives for their participation. The results show tendencies of how people perceive activity and presence information and showed promising results with regard to expressiveness, joy of use and usability. We present results and reflections in the following sections.

3.2.5 Results & Discussion

Following we present the results from the study conducted within our lab. The results are categorized in three main parts a) regarding the usability of the RemoTable, b) the ability

for the device to support communication and a feeling of closeness over a distance, and c) further qualitative feedback and possible extension for the system.

Usability

The SUS score for the RemoTable was very high (M=89.46, SD=7.08). Hence, the Usability of the RemoTable was rated as excellent. Additionally to the SUS-questionnaire, we have asked the participant how they perceive the two different input methods (sharing mood and sharing activities) and if they like to use them as a method of interaction. Both interaction methods were rated very good and participants strongly agreed that they like to use them. Both were rated with a median of 5: Input of moods (Figure 3.9 (EE): M=5, IQR=0) and Input of activities (Figure 3.9 (EA): M=5, IQR=1). We further asked them if they would like to have an undo functionality, that enables them to remove a shared mood or activity after sending it for within a specific time frame. Most participants disagreed and therefore, do not see the need for such a feature (Figure 3.9 (LN): M=2, IQR=2.75). Additionally we asked the participants, if they can imagine to use the table to freely draw on it using a smartphone or a touch input and share these drawings with the communication partner. Most participants liked the idea, that they can be creative and express them-self by drawing simple pictograms (see Figure 3.9 (EZ): M=4, IQR=2.75).

Support for Communication

Results from our questionnaire, regarding the support for communication, revealed that the RemoTable has a high potential to support a feeling of closeness between distant family member or friends. Results have been measured using a Likert-scale (1-never to 5-always) and are depicted in Figure 3.8. Participants reported, that they were able to identify how the communication partner feels (Q1: M=4.5; IQR=1) and were able to share their own mood respectively (Q2: M=5, IQR=1). Further participants reported to have enjoyed the use of the RemoTable for the communication with each other (Q3: M=4.5, IQR=1). Participants agreed that the use of the device would support them to feel connected with each other and keep in contact during the day-to-day life (Q4: M=4, IQR=1). The question, if the communication partner might feel obligated to communicate with them using the RemoTable was declined by most of the participants (Q5: M=1.5, IQR=2). Additionally, most participants had no concerns, that they can not fulfill expectations regarding the communication using the device (Q6: M=2, IQR=2.75). We could not find evidence for any possible privacy concerns using the device (Q7: M=1, IQR=1). Further the participants did not report any concerns, that third people could get to know what has been shared using the RemoTable e.g. current moods or activities (Q8: M=2, IQR=1.75).

Qualitative Feedback

During the study multiple participants underlined the simple usage of the device and that illustrations shown on the display can be perceived easily and without misinterpretations.

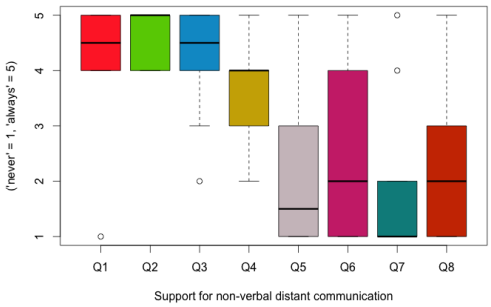

Figure 3.8: Results of the post-study questionnaire regarding the support for non-verbal communication usign the device.

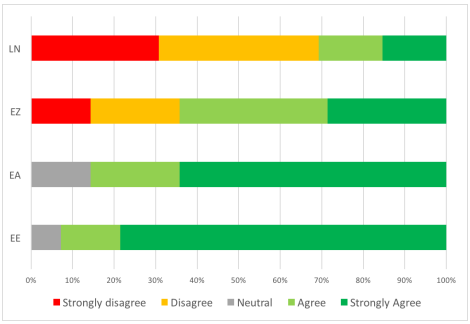

Figure 3.9: Results of the post-study questionnaire rating different input methods to interact with the device.

Some participants described the RemoTable as *innovative* and reported a high *joy of use*. One participant mentioned: *"The table is very innovative and combines everyday objects with communication. Sharing messages that way can replace writing lengthy text messages."*. Another participant summarized: *"The table can give me a very good impression of whats going on at the other place, because my relation to family member is very intimate. This is easy and faster than using WhatsApp or Facebook, which I could use later one to ask more specific questions."*. We also received feedback describing issues, participants had with the device. Some participants mentioned that the display could have a higher resolution to be able to depict more details and more complex symbols. One participant noted, that the display should change direction, depending on what side the person currently sits. This can be easily integrated, due to the fact that we already use distance sensors to detect presence near the table. Further it was mentioned, that the ability to read tags should not be restricted to a specific area, but to the whole table surface. As an addition to the current functionality, participants mentioned the wish to have history of the shared moods (8/14) and activities (6/14) over a longer time e.g. one week. When asked if the participants would exchange their currently used living room table with the RemoTable, eight of them agreed. When asked if they can imagine to extend their current table with a more flexible display e.g. integrated into a tablecloth, eleven of them agreed.

We can not yet conclude if such social awareness systems are able to increase the direct and verbal communication between communication partners that do live over a distance. Although we got interesting and important insights in the usage of such devices, we further need to investigate deeper into how such devices have an effect on peoples communication behavior. Another interesting aspect of this would be, if the additional non verbal communication channel leads to more verbal communication because the awareness of the communication partner is raised or if the verbal communication decreases because a form of communication already happened.

3.2.6 Conclusions

We presented requirements and results from a first study for the design of a smart furniture to convey information about day-to-day activities, presence and moods of a loved one. We proposed the design of an ambient light display integrated into a smart table to exchange activity information between people living over a distance. We based the encoding of information on results from a human-centered design process conducting semi-structured interviews and design sessions. Results show that sharing and receiving information about the activities of relatives and friends is fun and can lead to more engagement in verbal communication. Users reported the use of the device to be a fun experience and a playful way to express moods and day-to-day activities.

3.3 Exploring Social Awareness: A Design Case Study in Minimal Communication

3.3.1 Motivation

In the previous section we have investigated design concepts of how smart furniture can be utilized to create awareness between people over a distance (see chapter 3.2). The previous study was conducted in a controlled lab environment and focused on the exploration of requirements, interaction designs and visual representations of activity information. With this work, we aimed to investigate how people use awareness technologies in a real world setting during their day-to-day life. In our work, we step away from the typical screen-based solutions and explore more simple solutions to the core human issue of social awareness.

Based on previous works covering systems to create social awareness between people living over a distance, we have designed a simple tangible artifact named SocialFlower (see Figure 3.10). A interconnected pair of flowers lets people share their physical activity and send greetings by touching the flower. We designed SocialFlower to blend into people's everyday lives without being too obtrusive or make users feel obliged to get in touch with a connected partner. In this work, we want to research how a very simple artifact can be designed to create a feeling of awareness and what we can learn designing such a simple solution. We further want to explore how the design of simple semantics in artifacts enables users to re-purpose technology and adapt encoded information to their needs.

3.3.2 Related Work

In the following subsections, we address three areas that shaped our work: (1) requirements for communication, (2) activity sharing devices and (3) information encoding for light displays.

Requirements for Communication

Previous work has explored communication needs and patterns of social interaction between close friends, partners or families [TBI09]. Tee et al. showed that people often miss opportunities to communicate with their family members due to the asymmetries in the daily schedules. This creates a strong need for a more frequent communication with family members. Kaye et al. & Kjeldskov et al. have researched the needs and requirements for technologies to support a feeling of closeness to understand the role of intimate communication in the users lifes [KLN+05, KGV+05, KG04]. Their research shows a desire for new technologies to support communication by providing presence information and activity awareness for a loved one. Further, the presented requirements for such communication devices suggest simple designs and interactions based on *minimal communication*.

Devices for Sharing Activities and Experiences

Many different awareness systems that facilitate social connectedness, support interaction with a users social network. These systems use various technologies to create awareness and enable communciation in different ways, such as the representation of presence or availability by an ambient light display [AMF+14, MHF+16], presenting the activity level through light [BLB12] or detecting and conveying activity and emotional states using ambient lighting [DHFO15, WTHB15]. Davis et al. have presented a display to convey activity information between elderlies and caregivers [DOH+16]. However, many of these systems do not consider important design aspects or challanges as presented by Markopoulos [Mar09], e.g., privacy, seamless integration into the environment, effort reduction or have not been evaluated in a realistic environment.

Information Encoding for Light Displays

The use of ambient and wearable light displays to convey encoded information has gained attention in recent years [MRC+15]. Ambient light as an output modality has an advantage of conveying information in a non-distracting way [MRC+03]. Previous work has researched how to encode information using light displays in different contexts of use. Fortmann et al. have presented guidelines for light-displays integrated into wearable technologies [FMHB14]. Various works have researched and presented classifications and guidelines for information enconding on ambient information systems, including ambient light displays [AD02, PS06, TKLG07]. We use encoding for activity information and greeting notifications based on these works.

3.3.3 Interaction Concept

Below, we describe an interaction concept, of how new technological devices can support the needs of users. These particular devices are aiming to encourage social interaction. We use light to present nonverbal information to the user. Our questions regarding the design of the artifact are the following:

- How does the user interact with the device – explicitly (directly) via touch or implicitly (indirectly) through presence in a room?
- Should we design a device, that only connects two relatives, or should we focus on designing a device, that connects two or more relatives?
- Should we use light colors (e.g. red, yellow or green) or light patterns (e.g. pulsing) to encode the information?
- How should messages be transmitted (continuously / discrete or synchronous / asynchronous)?

Based on a discussion with HCI experts from our team, we have designed a concept, that is able to fulfill user needs as well as technical requirements.

3.3.3.1 Use Scenario

Each relative or close friend who is willing to keep in close contact, but feels that s/he is not able to do so due to individual circumstances, can use the device to maintain a continuous feeling of connectedness with each other.

Social flower (see Figure 3.11) will be stationary in the home of each relative. The flower is connected with another flower, that is located at the beloved ones home. Both flowers display an activity score for the corresponding person, defined by various ambient activity sensors, that could measure movements and physical activity, usage of household appliances, quality of sleep, and social interaction with others.

Based on inputs from all connected sensors, the activity score is calculated (e.g. the weighted sum of all activity levels). The activity score is displayed with a corresponding light color. To represent the activity, we use a battery metaphor, that has already been evaluated in previous works [FSB+13]. Green light represents a high activity level, while a red light means sedentary behavior.

If a user wishes to directly and explicitly communicate with the connected partner (for example on the telephone), s/he can use the flower as an input device. If the user touches the leaf of a flower, a message is sent to the corresponding flower. The flower will then start to unobtrusively display this message by showing a pulsing light pattern that slowly fades out over time.

3.3.4 Design and Prototyping

Figure 3.10: The Social Flower presenting a high activity-level with a green light color. A user touches the leaf of the Social Flower to send a greeting to a connected loved one.

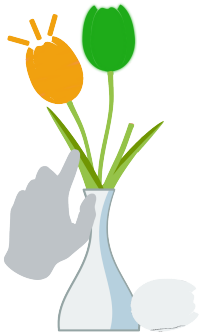

Figure 3.11: Design sketch: Interactive flowers showing an activity level. The right flower has been deactivated by removing the blossom. The left flower shows a pulsing light to symbolize the wish for direct communication. By touching a leaf the user can answer this request, and show her/his consent.

The designing process was based on the requirements as given in the design concepts

we wanted to realize. The decision to use a flower-design is based on the good acceptance of previous works [AMF+14] with similar designs. It was also driven by the ambition, to create a device which does not appear technical and integrates well into the living environment of younger and older adults.

In the set-up of the first prototype, we have used Arduino Uno prototyping boards. Communication between plants is achieved by using a Wi-Fi Internet connection. To show different light colors and light patterns we have used controllable LED lights. We also have created a simple web interface in order to configure the flowers (e.g. setting up the colors for each plant, or defining the light pattern for messages, or assigning flowers to their owners). Apart from the possibility to show different light colors and light patterns, each flower should be able to receive an input, to notify the user of the communication wish of the other user.

The flowers may vary in appearance such as roses, tulips or others. Both flowers visualize the physical activity for the connected partner received from fitness trackers (FitBit Flex [1]). To update the activity information, the system recalculates steps taken every 15 minutes. To adapt the maximum steps within 15 minutes for each participant, we used two days as baseline and calculated the average. For representing the activity, we used a light pattern that linearly fades from red (low activity) though yellow to green (high activity) based on the work of Matviienko et al. [MHC+15] (see Figure 3.13).

A user can touch a leaf to send a greeting to her/his partner. The greetings are represented via pulsing light that slowly fades over time. The color of the pulsing light can be selected by the user. We based our prototype on Arduino Mega and used controllable RGB-LEDs to represent light patterns[2].

To make the application as simple as possible and integrate the functionality into a small and compact design, we decided to use the flower itself as an input and output device at the same time. Therefore, we have designed a leaf, that is able to recognize touch inputs using conductive threads (see Figure 3.12). The leaf itself is made of textile fabric and filled with a soft padding.

3.3.5 Study

We have taken a research through design approach, as presented by Zimmermann et al. [ZFE07], to explore: how well can we support social awareness using an artifact to convey activity information, and how do users utilize the ability to send greetings throughout the day.

We conducted a field study with 10 participants (8 female) aged from 19 to 61 (M=27.0, SD=11.73). None of them had vision problems, color blindness, or any other color recognition limitations. Three couples of the participants were friends, the other two couples were relatives (siblings and mother with son). Each participant received a So-

[1] https://www.fitbit.com/de/flex2; last retrieved: 26.6.2018
[2] https://www.adafruit.com/product/1734; last retrieved: 01-10-2017

Figure 3.12: Leaf made from soft fabric and conductive thread to enable touch-input.

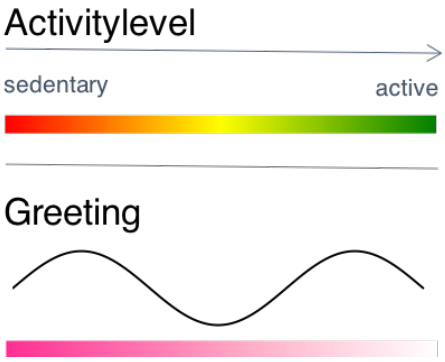

Figure 3.13: light design

cial Flower, a fitness tracker, a smartphone with a cellular data connection and used the system for 16 days. Participants could freely choose a location for the Social Flower. To measure participants' physical activity, we used a FitBit fitness tracker[3].

We conducted semi-structured interviews with each participant before and after the study. We asked about their most common communication channel and their frequency of usage. Additionally, we asked questions regarding the flower's ability to support communication and their perception of the ambient light using a 5-point Likert scale (1 - strongly disagree, 5 - strongly agree). Participants used experience diaries to give in-situ feedback for situations that appeared using the prototype or remarks about the artifact in general. We used server-side logging to receive usage data for each participant.

3.3.6 Results & Discussion

Comparison of Affective Benefits and Costs

To get a sense of the communication abilities of our prototype as well as to see differences with existing and normally used communication means, we asked participants to fill in a *ABCCT* questionnaire for a) their commonly used communication channel and b) the *Social-Light Flower*. To evaluate the results from Likert scales in the *ABCCT* questionnaires, we used 1 for strongly disagree and 5 for strongly agree. We used the Wilcoxon rank sum test to compare the ratings of both questionnaires and were able to find 11 significant differences between the two rated communication channels (detailed results see Table 3.3.6):

The participants rated the statement *S1* significantly better for their commonly used communication channel. They also rated it to better help them-self to know how they feel *S2*. Using the normally used device was also rated to be better to see how much the other person cares about one self *S3*. The item *S4* was rated nearly similar, but still significantly better for the common device. Participants were also more excited to use

[3] https://www.fitbit.com; last revised: 01-10-2017

	Common channel		***Social Flower***		
Questionnaire Item	M	IQR	M	IQR	p
S1 Com. with X using M helps me tell how X is feeling.	4	1	1	1	$p < 0.01$
S2 Com. with X using M helps me let X know how I am feeling.	4	1	1	1	$p < 0.01$
S3 Com. with X using M helps me see how much X cares about me.	3.5	2	1	1.75	$p < 0.05$
S4 I feel that contact with me using M is engaging for X.	4.5	1	4	1.75	$p < 0.05$
S5 I am excited about using M with X.	5	1	4	0.75	$p < 0.05$
S6 After we are done com., I keep thinking back to sth. X shared using M.	4	1.75	2	1	$p < 0.05$
S7 Com. with X using M helps me provide X with social support.	4	1.75	2	2.5	$p < 0.05$
S8 Com. with me using M helps X be there for me when I need them.	4.5	1.75	1	0.75	$p < 0.01$
S9 Com. with X using M when I am having a bad day helps me feel better.	4	1.5	2	1.5	$p < 0.05$
S10 Com. with X using M helps me feel less worried about something.	4	1.75	1	1	$p < 0.05$
S11 I worry that I am not meeting Xs exp. for our contact using M.	2	1.75	1	1	$p < 0.05$

Table 3.1: Significant Results of the ABCCT questionnaire for (a) the most commonly used communication device and (b) for the Social-Light Flower

the commonly used channel *S5*. Sharing something using the common channel made people think more about the shared information than with the *Social-Light Flower S6*. When using e.g. the phone or smart-phone people felt to be able to give better social support *S7*. The commonly used communication mean was also better rated to be more useful when communication was really needed *S8*, to make them feel better on a bad day *S9* and to make them less worried about a problem when communicating through it *S10*. Compared to the common channel, the *Social-Light Flower* made people significantly less worried about not fulfilled expectations regarding their interpersonal communication *S11*.

The following result did not show significant differences between the commonly used communication channel and the *Social-Light Flower*. Nevertheless they show interesting tendencies, that should be investigated closer in further studies. Participants reported that they feel slightly more closer to the communication partner using the *Social-Light Flower* (M: 3.5) than their common used channel (M: 3). The participants did not feel obligated to communicate (M: 1) or that they have to answer a contact request, even if they do not want to communicate (M: 1.5). Compared to the *Social-Light Flower* (M: 1.5), participants reported to feel slightly more often sad, when a response from their partner takes too long with the common used channel (M: 2) eg. a reaction to a contact request.

Social Awareness and Information Encoding

We have included questions (5-point Likert scale with 1 for strongly disagree and 5 for strongly agree) about the ability to create social awareness by the *Social-Light Flower* as well as the perception and encoding of information through the ambient light. We used the Wilcoxon test with an expected value of 3 (mu = 3) to check if the ratings show a significant tendency towards agreement or disagreement. We could not find any significant results for questions regarding the communication aspects: (1) *"I feel sufficiently informed about the activities of the other person"* (M: 2, IQR: 1), (2)*"The information conveyed by the flower is a good complement to our communication"* (M: 3, IQR: 1.75) and (3) *"The Social-Light Flower helps me to start conversations with the other person"* (M: 2, IQR: 1).

Regarding the information encoding and the perception of the light, participants rated the statements as following: (1) *"The conveyed information is displayed suitably"* (M: 2.5, IQR: 2), (2) *"Rate the acceptance by other for the ambient light display"* (M: 3.5, IQR: 1), (3) *"While using the light I felt comfortable"* (M: 4, IQR: 0) and (4) *"I worry about how other perceive me, while using the light"* (M: 2, IQR: 0.75). Only for the last statement we could find a significant tendency towards disagreement with ($p < 0.05$).

Usage Behaviors

To gain insights into the usage behaviors for SocialFlower, we analyzed log files from the server application. Overall, the participants interacted 156 times with a Social Flower

to sent a greeting to the connected person. We found, that, on average, greetings were distributed over each day of the week, with a maximum on Thursdays and often sent between 11am till around 3pm (see figure 3.14 and 3.15). The amount of greetings sent during the weekends was lower, since the peers were spending time together. We found, that for most groups the interaction decreased after the first days, but kept up over the period of the study. This is considered as common with newly introduced artifacts, due to novelty effects (see figure 3.16).

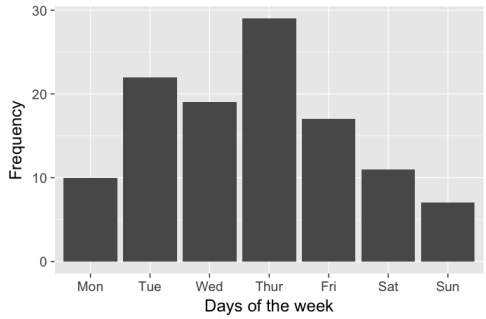

Figure 3.14: Frequenzy of send greetings for Social Flower per days of the week for all participating households

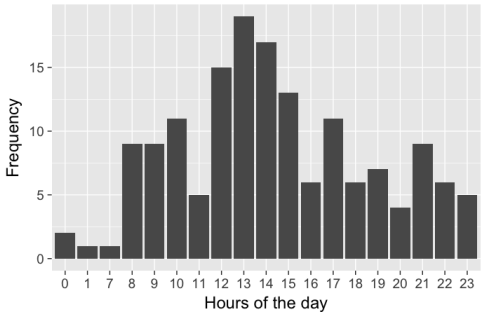

Figure 3.15: Frequenzy of send greetings for Social Flower per hour of the day. Mean out of all days over all participants.

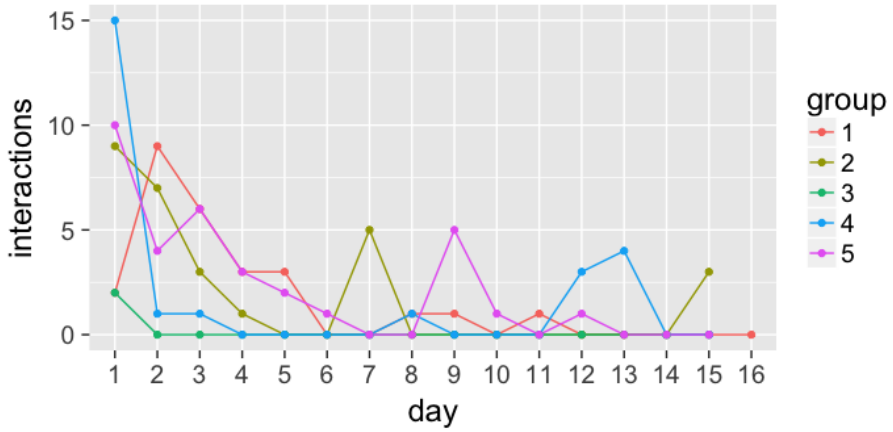

Figure 3.16: Frequencies of using Social Flower per group of participants over sixteen days.

Based on the logging analysis and conducted interviews, we found users to perceive the SocialFlower as an artifact of everyday life early on. This reflects in how the device was used throughout the day and in how users reported to perceive information about connected persons. Often participants mentioned to glance at the flower when they pass by instead of focusing their attention, like they would with a screen-based device. Greetings were sent throughout the day, but did not necessarily ended up in explicit conversations. They were rather used to express a positive feeling with a connected person. We see interesting changes in the way, participants used the device. During our

interviews, we found indications that the simplicity of the artifact and its low barrier to communicate has an impact on how users integrate the interaction in their everyday life compared to screen-based devices.

Send and Receive Greetings

All five couples tended to send most of the greeting in the first half of the day. *P1: "In the morning I send a greeting from time to time. When I get a greeting back, I know that she is already up"*. In the evening hours participants used it to wish the partner a *"good night"*. We could find half the participants mentioning that they like to use this function to *"just say hi"* every once in a while or when they pass by the SocialFlower. It was further used to *"make the other one happy"*, out of curiosity, or to express *"that I would like to hear something from him"*. Greeting someone was especially valued, if the sender got a response: *P2: "I am very happy when I receive a greeting back after sending one"*.

Contrary to results found by Kaye et al. , when researching minimal communication between partners in romantic relationships living over a distance [KLN+05], we did not find participants to feel obliged to send a greeting using the SocialFlower. Participants mentioned the SocialFlower was unobtrusive and something they use whenever their attention shifted to the device. Additionally, users did not feel that they are expected to answer a greeting from their connected partner but rather send something back whenever they felt like. These differences show some interesting insights, while it is unclear what the exact reasons are. It might be that the integration of Kaye's *virtual intimate object* into users computer systems was more prominent during workdays and therefore created stronger expectations by users or the tangibility of our system created a different affordance. To be able to create deeper insights, more research is needed to explore detailed reasons for these differences.

Social and Contextual Awareness

Participants used the SocialFower to estimate contextual information from the activity level of their communication partners and the current time of the day. *P1: "We can continue to watch our TV show soon, because she left her boyfriends house."* Another one checked if her friend was already up in the morning: *P2: "[Name] is up now and maybe on her way to me, cause the light is green."* or estimated what her friend is currently doing at the university: *P2: "She has her lunch break now at the university, because she is moving a lot."*. Participants were also able to recognize where their close ones are and what they were up to: *P7: "The flower is red. She is sitting on the sofa most probably"*, *P8: "Seems that she is on her way home. Because the flower is green"*. The SocialFlower further helped to increase contextual awareness about upcoming events, e.g., a birthday party: *P7: The color is changing - the guests seem to have arrived.*

We showed that users can interpret detailed information about the connected persons day-to-day schedule by seeing their level of physical activity. For this, it is important that both users know each others overall activities and interests, e.g., working hours,

time spent for commute, hobbies. This raises the following questions: how and to what extend do day-to-day rhythms and cycles influence each other? Are two persons aware of the partners activities? What is the influence of different time zones for long distances and how does this affect the perception of schedules? If users rely on known schedules, they may get worried if unexpected changes occur.

Usability and Ambient Light Design

Some usability issues were related to technical problems with the SocialFlower, e.g., *P8: "The flower is showing a different light than normally. I had to unplug it twice. After that it started to work properly again"*. Some also did not like the design of the device. As one participant stated: *P8: "It [the flower] could have a little more beautiful design"*. One issue we found, was that participants reported that they had missed greetings during the day, because they are only shown for about 15 min on the flower. As a consequence, these participants asked for an additional notification: either using audio signals or as notifications on their smartphone.

With regard to the light design of the device, we received mostly positive feedback. One participant mentioned that the pulsing light for a greeting is well done and he can easily differentiate between greeting and activity information. Others asked if it would be possible to add additional light colors to express and invitation for coffee or to ask the other person to come over. Two participants mentioned, that the light color is too bright during the darker hours of the day, e.g., *P2: "At night the light disturbs me when I want to sleep."* and that they would place the SocialFlower in a room where there is no need for a calm light environment like the living room, but rather a neutral room like the kitchen.

The use of an ambient light display to convey information was perceived to be sufficient, although some participants had problems to identify the encoded information. Aesthetics and usability aspects are very important, when designing tangible artifact that are used everyday. Enabling users to personalize objects with regard to their preferences of appearance can raise acceptance and usage of the device. This also extends to technical reliability, especially when designing communication devices.

Form Factor

From the interviews in our study, we can clearly see that participants associate a specific type of information with the form of an artifact. While a lot of participants expressed that they like the flower design as an ambient device, because it fits into a domestic environment, *P3: "I like the flower and its nice that you can use it s decoration in the home"* or *P8: "The flower is beautiful, it reminds me on the logo that ICQ used to have"*, half of the participants mentioned that the design is not well choosen to represent activity information. One participant suggested to use a form representing a physical progress bar: *P7: "A flower does not represent activity, maybe a progress bar placed on my Desktop"*. Other wanted to integrate the activity information into a form factor they

already know: *"..maybe the activity could be shown within a desk lamp."* or *P10: "A glowing round lamp to show activity would be better"*. At the same time, representing the greeting through a flower was perceived to be a very good fit, with regard to the form factor, e.g., P5 stated: *P5: "For showing a greeting its great! I would bring flowers, when visiting someone"*.

When perceiving digital information, users have specific expectations on how these information are supposed to be presented and visualized. This is used in software systems, to design interfaces that are easy to understand and provide a good usability. When designing physical artifacts, the association with real life metaphors can be even stronger due to the physical appearance of a device. Our work showed that, breaking these metaphors or overloading them with multiple information, e.g., activity information and greetings, people might perceive that some of the information is represented in a wrong way. This effect has also been shown in previous works with single or multiple metaphors and how these can help to express a systems functionality [HA+87, HB07, Mar02]. When designing artifacts, it is crucial to keep a clear mapping between the visualized information and possible metaphors. If multiple metaphors are present, it is advisable to keep the aesthetics of an artifact as neutral as possible.

Re-purposing Technology

The greeting function was intended to create a transition between the implicit sharing of activity to an explicit act of communication. This function was based on previous work as well as known functionality from social networks, e.g., poking someone on facebook [4]. However, we could observe some of the participants to re-purpose this feature with new meanings. One pair of participants reported that they used the greeting to inform each other about time when their children are in bed, so they could communicate afterwards. Another participant mentioned *P5: "We have used it to remind each other to answer a question send via messengers. As some kind of notification."*. Some participants used it to check the availability of their peers by sending a greeting and waiting for an answer *P9 "I use it to check, if the other person is at home and available"*.

When using the SocialFlower, we found multiple participants re-purposing the greeting function and adapting the technology to their specific needs. One can observe this behavior often in everyday life. Many people re-purpose objects to use them for different tasks then originally intended. As an example, tools are often used differently from their main purpose. Similar behavior is shown when using technologies. People often re-purpose apps or devices to fulfill a specific task or adapt them to their needs. Related work even takes advantage of this and enables the use of everday objects to serve as input devices [CAMB13]. We see an interesting question evolving from this behavior, which is related to the simplicity or complexity of a system. Due to its simple design and clear understanding, users naturally adapt technology to their needs, e.g., create new meaning of greetings at specific times of the day. It is questionable, if this would be possible for more complex systems, where users are not able to understand the systems

[4] https://www.facebook.com/help/219967728031249; last retrieved: 06-31-2017

whole functionality.

3.3.7 Conclusions

This work reflects on how tangible information systems are designed to convey information. We present results from a case study, where we explore implications of a design in how tangible technologies are used in everyday life. Our study shows that users enjoyed using the artifact to get in touch with a connected person throughout the day. We found that simple activity information helps users to get a sense of a loved one's schedule. We observed the importance of aesthetics and simplicity of information encoding, when designing interactive artifacts that are supposed to visualize data in the peripheral. Our results show further the importance of a clear mapping between the visualized information and possible metaphors. Further results show that users re-purpose objects to use them for different tasks then originally intended. From this, we see interesting research questions for future studies to research the influence of design on how user adapt technology to their needs. It is hard to generalize our results based on a limited sample size, but it allowed us to draw rich qualitative data and interesting insights. In the future, we aim to extend our study into a long-term field study to investigate further design implications and compare these with technologies often used nowadays, e.g., smartphone applications.

3.4 Chapter Summary

This chapter presents two designs and explorations of the exchange of awareness information between loved one's who live apart from each other. We first present a lab study, that aimed to understand the exchange of such information in an ubiquitous and unobtrusive way. We present RemoTable, an interactive artifact, that allows the detection of certain activities and the exchange of symbols or other abstract of these activities with others. We provided insights from our evaluations and reflections on its support for social awareness as well as usability and acceptance by users. Following, we presented a second study that transfers our findings into a field study, were we research the use of SocialFlower. With this second artifact, we aim to understand the effects of abstract information and its representation on social awareness. We describe our approach, design and present results.

4 Exchange of Experiences and Memories

4.1 Introduction

In this chapter, we explore designs and engaging interactions, that foster the exchange of experiences from special or common moments in a persons life. Specifically, we investigate how technology can support users with different technical capabilities and enable all members of a family to share and reflect on experiences of each other. We first present a digital photo-diary application, that intents to provide a simple and continuous way to keep in touch with family members. We describe our system and results from a field evaluation with families. Following, we have investigated a design to facilitate communication for users with less technical experience. The resulting device allows sharing photos, tangible artifacts, and audio recordings of everyday life. We conducted a preliminary study with two families to identify design issues, and further refine the prototype. Subsequently, we run a field study with four families for up to four weeks to better understand real-world use and examine inter-generational connectedness. We found that our design was accessible, simple, and helped bridge the technological gap between grandparents and grandchildren. We provide insights on how to ease communication between different generations, engage them in sharing activities and strengthen family relationships.

4.1.1 Experiences and Memories

Sharing experiences and memories with others is very important in social groups. It helps to connect and strengthens the relationship between persons. It further is an important factor, that helps us to sympathize and feel empathy for each other. People share manifold things from their life's, such as: photographs from holidays, video recordings of a grandchild's first steps, audio messages to say *"I love you"*, text messages that explain why someone is angry or physical objects that include a specific memory. In our work we aim to understand how technology can support users to express what they need to express. As this can vary for different users, we have focused our research on families and specifically users who are often unable or restricted in their use of common communication means, such as smartphones or personal computers. The restriction of topics to be shared, similar to specific activities in Chapter 3, is not a good way to focus work in this area, as people should be able to share and express whatever they feel to. Instead we have focused on the exchange of pictures and voice messages. This selection is based on interviews and experiences from our studies, that showed the importance of speech and pictures for sharing. Text messages, while similar important, can be and have been shared by pictures of letters and short messages throughout our investigations.

4.2 Photo-based Participation in the Life of Loved Ones and Friends

4.2.1 Motivation

Social interaction is an important factor to our quality of life and well being. Interacting with friends and family members, exchanging experiences is important to everyone (Tee et al. 2009). In co-located groups and families, spontaneous communication occurs day-to-day, and therefore allows the continuous exchange of news and experiences within the family. However, for family members that are living remotely from their loved ones, the exchange of experiences and the participation in family events is not as easy as for co-located persons. The use of synchronous verbal communication via the phone or video chats, enables people to participate in the life of loved ones, but requires simultaneous presence. To support an asynchronous exchange of events and experiences within the family we want to investigate the use of a photo-based diary to support an ongoing exchange of experiences as well as an easy and continuous way to reflect on them.

4.2.2 Related Work

Previous work has show promising results for fostering closeness when using photo- and video-sharing applications between co-located and distant people. "The Family window" from Judge et al. [JNK10] creates a permanent connection via video between two family-households without allowing a sound transmission. By using a portable video screen with an integrated camera, the system creates the impression of looking through a window into the other household. Four families evaluated the system, over a period of eight weeks. The participants reported a stronger feeling of connectedness during the evaluation and a better awareness about when members of the other household had time for a verbal conversation. This effect was supported by the visualization of the activities in front of the communication device at the other house-hold. However, the systems value for each family always depends on the relationship the family members had in the first place.

The work “Making Memories: A Cultural Probe Study into the Remembering of Everyday Life.” by Mols et al. [MHE14] about memories of everyday life aimed at discovering if and which everyday experiences are most valued by participants. The research confirmed that everyday experiences are valuable, when they have a social aspect, are occurring on a regular basis or when they have a big impact on the life of a person. Based on these results new systems should be developed, which allow the user to record such everyday events.

Further positive effects regarding the feeling of connectedness between distant partners where shown by a study using the exchange of pictures for patients in a rehabilitation center [BDDH09]. During an evaluation for six to seven weeks, four participants could see pictures of their family members on a digital picture frame. The attendees where positively surprised how sharing pictures helped staying in touch - even without actually talking to each other via phone. Additionally the evaluation showed, that in most

cases the content of the pictures wasn't as important as the simple fact, that somebody cared to send a picture and therefore was thinking about them.

In their work "Supporting social presence through lightweight photo sharing on and off the desktop", Counts et al. [CF04] present a photo-sharing system, which supports a group-centered exchange of photos with family members and friends. The system was designed to be as easy as possible and followed a human-centered approach to present pictures. Results from a field study, lasting one week with 28 participants showed an increase in the number of exchanged photos. Further participants reported an increase regarding their sense of social presence.

Chu et al. have developed the "Tiling-Slideshow" at the National University Taiwan [CCW07]. The system automatically arranges pictures of different size and resolutions in a tile-like pattern. Further, the system automatically changes the visualized pictures, depending on the speed of integrated background music. Experiments with actual photo-collections showed that participants felt much more joy using the slide-show in comparison to classical visualizations with a single picture shown. To foster engagement in photo reviewing, we design our system along the positive experiences created by "Tiling-Slideshow".

We aim at using the positive effects of an ongoing exchange of memories and experiences within a secure and closed environment. Further we are extending the previous works, by designing a system which supports the start of minimal communications. Users are able to express their mood for each picture and share pictures as answers to existing pictures. In addition, users are able to look at the photo-stream, that another family member currently is looking at. This enables users to get a sense of what the other persons might be interested in and therefore serves as a very good starting topic for future communications.

Following the approach of the previous works, we aim to further investigate: a) the usage of such systems and b) how such system could further facilitate more verbal communication between family members by integrating social elements into the design.

4.2.3 Requirements

The SocialWall is a digital photo-wall, which enables the exchange of memories, experiences and events within the family based on photos. To gather requirements, we have conducted interviews with eleven participants from three different families (7f; 11-74 years, M=42.9, SD=20.36) about their photo sharing habits, needs and wishes. Participants reported to take up to 60 (M=15.9) photos per month. Results show that users older then 30 years were taking most pictures during special events, e.g. holidays. Younger participants preferred taking pictures from day-to-day experiences. Five participants mentioned that they were not able to collect photo-based family memories in an easy and well-arranged way. Seven participants mentioned that they often miss to review pictures and to reflect experienced moments at a later point in time. When asked if they could imagine using a photo-based digital diary within the family to share events and

experiences, ten of eleven participants agreed. Eight participants motivated this decision by saying that they would feel more connected with the family and such a system might be able to enhance the participation in the life of the others. We asked, what additional information should be available for a picture. The three main answers were: date and time (11), event description (8) and location (7). Similar parameters were mentioned for the question of how to sort pictures available within the diary: time (11), events (9) and persons shown (9) as well as location (7).

After showing the participants multiple mock-up designs for the visualization of pictures on a tile-based screen, we have asked them about their preferred design as well as reasons for this arrangement of pictures. All participants have chosen a linear layout, with pictures arranged based on the time they were taken, ordered from left to the right of the screen. As reasons most participants mentioned that it is easy to understand the sorting and to identify new pictures.

4.2.4 Design Concept

Based on previous works and requirements collected from our participants, we have designed a photo-based digital diary to enable remote families to share events and experiences with each other. The main goal was to promote a feeling of closeness within the family. We have designed a digital photo-wall that enables the easy exchange of family-pictures within a group of closely related people. We further have designed an application, which visualizes these pictures in an continuous stream of pictures, updating new pictures automatically. To enable sharing of pictures with different specific people, we enabled users to share a picture with only a subset of users.

We have aimed to engage participants in verbal communication by allowing users to show their agreement or disagreement with a picture, using different types of nonverbal communication channels:

1. An image-response is a form of communication that uses pictures as answers to previous shared images. If a user is feeling to share a new picture, which is somehow related to an existing one, s/he has the opportunity to respond to this by sharing a new image and linking it to the original image.

2. The user is able to react to a picture by using emoji. Using these, enables the user to express different emotions from happy to neutral or sad when reviewing one of the shared photographs.

To further facilitate the social communication between members of a family or close friends, we have based our system on streams of pictures. By this, each user is represented by a set of filters that are defining the stream of pictures this specific user is currently viewing. This allows users to switch their own social time machine view to the view of another family member and then see the pictures they are interested in. The

Figure 4.1: Main tile-based photo-stream of SocialWall showing pictures from a family participating in our study

goal of this feature was to lower barrier of getting in touch with each other and to learn something about the interests of others.

4.2.5 Prototype of SocialWall

SocialWall is based on the concepts described previously. We have implemented the system as a web-based application to allow the use on multiple devices like smart-TVs, smartphones, tablets or other consumer devices available. For sharing a new picture with other family members, one is able to upload an image using either the website or an android application.

Pictures are visualized in a tile-based grid and are automatically re-sized depending on the size of the display (see 4.1). The user is able to scroll within this stream of pictures and select specific photos to see them in the original size. When the user is not interacting with the system for a couple of minutes, the application starts scrolling the pictures automatically. This mode serves as an extended digital photo-frame, by presenting the pictures in an endless photo-stream, flowing from top to bottom and automatically loading new pictures in the background.

When viewing a picture in detail, the application displays additional information like the date of creation, tags used to describe the content and if others have shared an emoticon or linked a picture as an answer for this picture. 4.1 also shows the ability to use multiple filter settings to create a personal photo-stream. Because we learned the most important filter and sorting parameters during our requirement analysis, we implemented

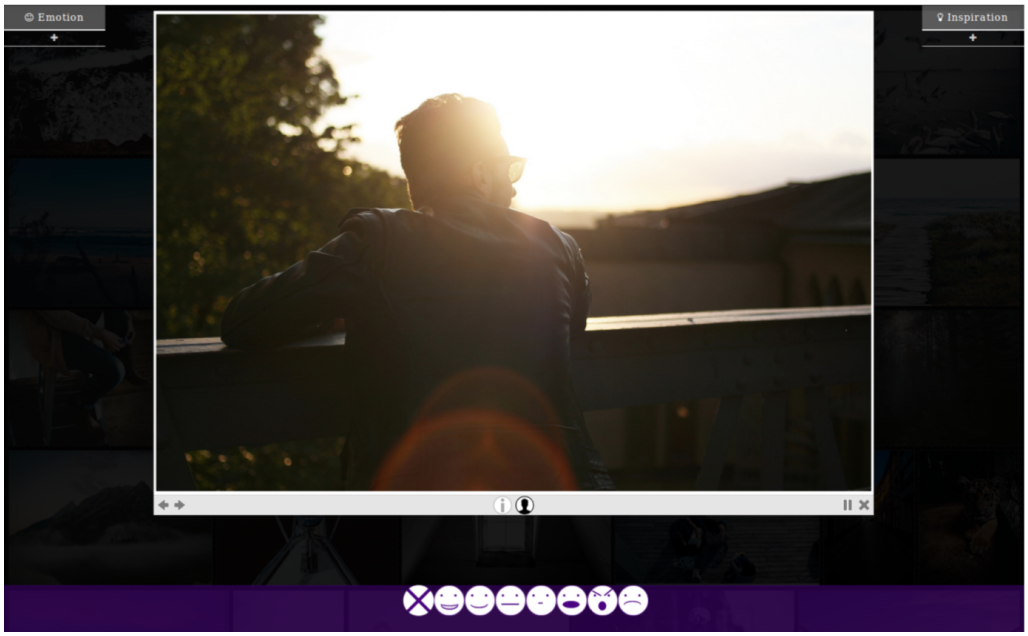

Figure 4.2: Users can attach new pictures or emoticons to a shared memory in their visible photo-stream

these in the prototype application. The user can set a specific timeframe, select one or more creators of pictures and select specific events or topics by including or excluding tags.

By selecting another user from a list, one is able to see this persons photo-stream (4.3, bottom). It is also possible to select multiple persons, to mix their photo-streams together and to see all pictures at once. Pictures that a specific user is not allowed to see are still not visible to her/him, even when viewing the photo-stream of someone else.

4.2.6 Field Study

We conducted a field study for one week. Overall 12 participants have used the system within their daily routine (5f; 12-55 years, M=35.8, SD=15.6). The participants were members of three different families, living in different distances from each other. To investigate how the system is used and to identify possible effects through our system, we have conducted semi-structured interviews, using a predefined questionnaire for the interviews before and after the evaluation. All participants were asked to fill out a predefined diary, each time they were using the system. In addition, we have used the ABCCT - Affective Benefits and Costs of Communication Technologies Questionnaire [YMA14] to measure how the system might create a feeling of closeness.

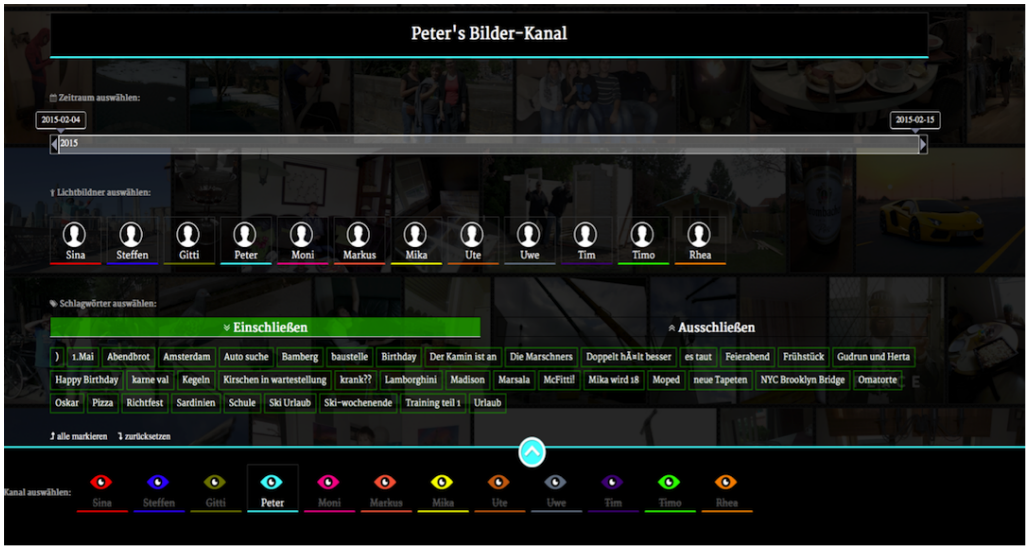

Figure 4.3: Menu to select filters and streams of other persons within the SocialWall application

4.2.7 Results & Discussion

The results from diaries showed that 67% of all shared pictures have not been restricted to specific persons. 29% of uploaded pictures excluded some members of the family from reviewing it and 5% were only shared with one other person (see Figure 4.5). The system was mostly used in the evening hours (49%) and during the lunchtime (36%). The rest of the usage has taken place in the morning hours (see Figure 4.4).

Enjoying the pictures as an automatic stream was the most used function of the system (43%). The second most use-case was the communication with others by sending

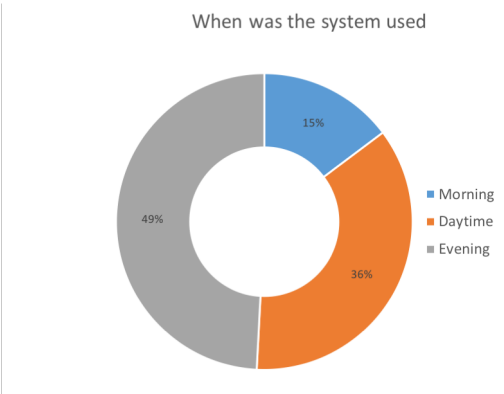

Figure 4.4: Distribution of usage througout the day within the field study.

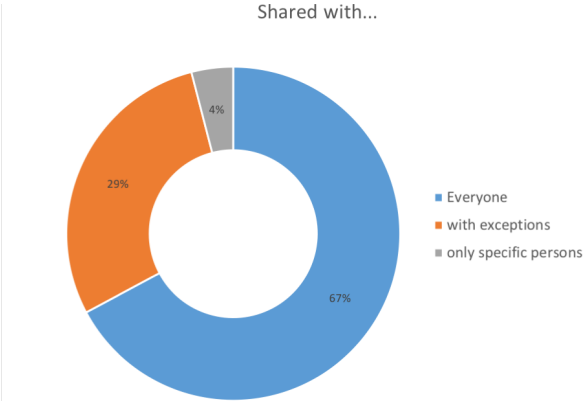

Figure 4.5: Selected receivers of photo-messages using the SocialWall system. Around two-thirds have been shared publicly.

an emoij (23%) and reacting to a photo by linking a new one (7%) (see Figure 4.6). Members of the families mentioned various reasons why they would return and continue to use SocialWall to connect with loved ones. One of the main reasons was that they enjoyed using the system which was perceived to be fun. Another good reason to use SocialWall is to feel connected and to participate in current events. Important reasons to use SocialWall are *out of curiosity*, *to be informed* and *to be up-to-date with current events* (see Figure 4.7). Additionally, we have asked the participants about their usage of classic communication channels (phone, personal contact, messaging) before and after they used our system. Results showed that the usage of direct speech via phone increased by 35% and the personal meetings increased by 85%. Qualitative analysis also showed that the communication within the family has been increased during the evaluation. Further participants mentioned that the exchange of daily experiences was much faster than normally and the pictures were a good reason to start a verbal communication via phone or personally. Participants reported that they feel more informed about news within the family while using the SocialWall.

Results from the ABCCT questionnaire are showing promising results (see 4.8). Questions are answered with a five-point scale from 1 – never to 5 – always. Participants were excited to use the system (Fig.2: X2.1-X2.3) and felt more connected and closer to the communication partners (Fig.2: X3.1-X3.3). Within the category "Opportunity for social support", participants felt special when using the system and it helped them to feel better, when having a bad day (Fig.2: X4.2, X4.4). Users did not feel to have "Unwanted obligations" when using the system (Fig.2: X5.1-X5.4). Some users felt sad when a communication partner wasn't reacting or an answer took too long (Fig.2: X6.1, X6.2). Some users might worry, that others get to know something they shouldn't (e.g. a secret) or that they themselves are violating the privacy of someone else (Fig.2: X7.1, X7.4).

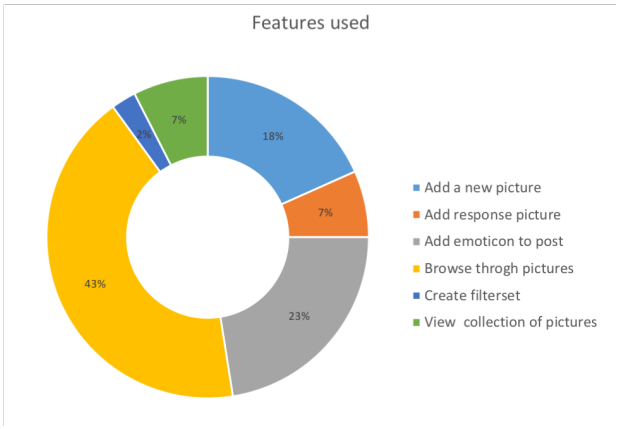

Figure 4.6: Distribution of features used by participants during the study period.

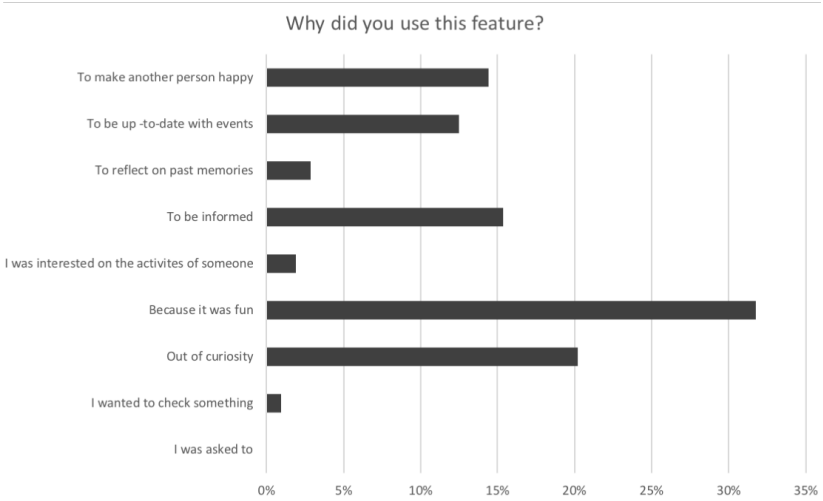

Figure 4.7: Reasons to repeadelty use SocialWall to connect with others from the family group.

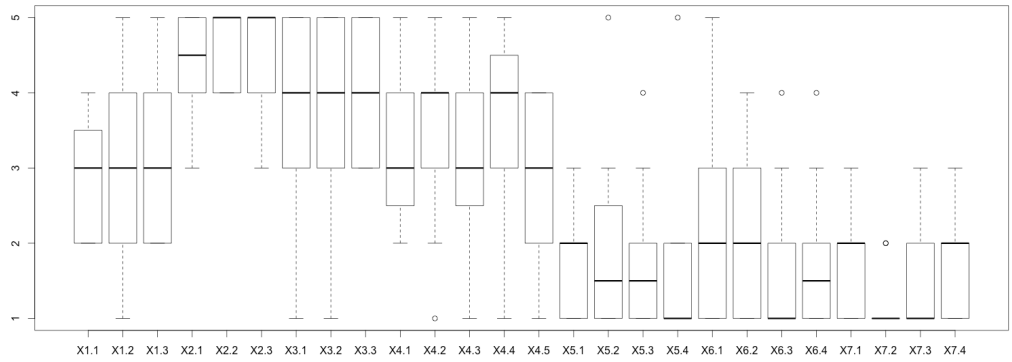

Figure 4.8: Overall results from the ABCCT questionnaire per item

4.2.8 Conclusion

The first results from the field study on SocialWall showed an increased communication within the families. The reasons are the following: 1) a novel system that created an interest in communicating with each other; 2) the availability of topics and reasons to talk to each other; 3) an option of sharing a verbal information related to a picture beforehand. As far as the duration of the study was rather short we aim to conduct another field study with different families for a longer period of time to further investigate the impact of story-sharing on the social closeness within distant families. The results of this study provide a good starting point and provided us with a basis for following investigations. Following, we focus our work on a specific group of users and investigate the support of experience-sharing in more detail for grandparents and grandchildren.

4.3 Supporting Communication between Grandparents and Grandchildren

4.3.1 Motivation

The grandparent-grandchild relationship can offer an important source of mutual support that is unique from other family relationships. For grandparents, participation in their grandchildren's lives is often a source of joy and pride and helps create a sense of purpose and continuity [Kem05]. For grandchildren, grandparents can be nurturers, historians, or positive mentors and role models [KW81]. Moreover, healthy relationships with grandparents have been associated with better mental health for children, especially those from single-parent families [RS07, JIW14].

However, geographical separation or social circumstances, such as divorce, makes it harder for grandparents and grandchildren to develop and maintain close relationships [VKPV10]. Although modern technologies, such as mobile phones, messengers, and video chat, mitigate this issues, they bring with them their own issues. For example, young children below the age of ten have difficulty maintaining phone conversations and older children typically require parental scaffolding [ESRJ04]. Although video calls are more engaging, they are less familiar to grandparents [FN14], require installing programs or web cams, and pre-arranging a suitable time [AGKS10].

To address these multiple issues, researchers have created a variety of systems to facilitate and encourage communication between grandparents and grandchildren, including shared adventure games [MDB13], reading over a distance [RRM$^+$11, RBR$^+$10a], and always-on family portals [JNK10]. Some efforts have even focused on lightweight technologies for helping children keep in touch with their grandparents [Lin12, TBI09]. However as researchers in this space have pointed out, "we do not yet have a solid grasp of how to bridge the conflicting needs and preferences" of intergenerational communication [MDB13]. Older adults typically desire richer contact and want to know "nearly everything" about their grandchildren [FN14], and kids tend to have fluid and asynchronous communication patterns.

Our work aims to strike a balance between the communication needs and technological capabilities of grandchildren and grandparents. We developed *StoryBox* (Figure 4.9), a tangible storytelling system that enables different generations to share the daily stories of their lives. Storytelling in this context is similar to Kennedy's category of "talking together about recent events in each other's lives" [Ken92]. With *StoryBox*, users can share crafted objects, pictures, written messages, and audio samples in an asynchronous manner.

From a children's interaction design perspective, we developed StoryBox to integrate with youth play culture, particularly the practice of crafting, drawing, and sketching. As such, we envisioned our device as existing within a playroom or a common domestic area, enabling children to share any creations immediately with their grandparents. We focus on children aged 3 to 10 years old, since older children (particularly pre-teens) tend

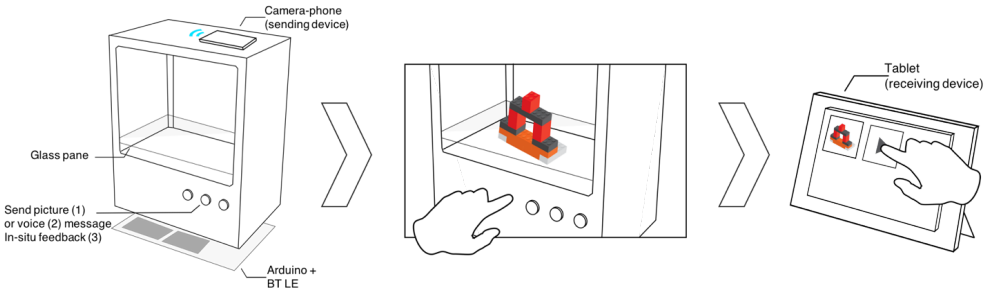

Figure 4.9: StoryBox is a tangible storytelling system that enables grandparents and grandchildren to share daily stories over a distance. They can easily stay in touch by placing objects in the box, writing on the glass pane, or recording voice messages..

to generally talk less with their grandparents [ESRJ04]. From an older adult perspective, *StoryBox* enables handwritten messages, sharing of old photos, and voice messages (akin to writing letters and talking on the phone). Our overarching goal was to create a device that was playful and favored free expression and creativity.

To better understand real-world usage, we conducted two studies with *StoryBox*. In the first study, we evaluated our system with two families for one week to investigate our design and gather initial impressions. Based on the feedback, we refined our prototype and conducted a longer field trial with four families for up to four weeks. We found that *StoryBox* integrated well into children's crafting and play culture and required less parental scaffolding to use. For grandparents, the box provided a personalized view of their grandchildren's lives and offered an opportunity to communicate back using methods they were more comfortable with (through handwritten notes or old family photos).

Our two main contributions are:

1. The design and implementation of a tangible storytelling system for supporting intergenerational communication and social connectedness.

2. A better understanding of grandparents and grandchildren's practices and experiences with tangible storytelling systems.

4.3.2 Related Work

4.3.2.1 Background of Family Communication

Grandparents and grandchildren often have difficulties in developing and maintaining close relationships over a distance. Supporting intergenerational communication is challenging because it requires a thorough understanding of grandparents and grandchildren's communication practices and experiences. A variety of communication technolo-

gies to support family communication over distance have been previously presented in both HCI and industry. Commercial software applications, such as WhatsApp, Telegram or Skype, enable an exchange of text and multimedia messages, including pictures, speech, and video. Such communication applications are multipurpose and focus on users from all age groups. However, young children and older adults often struggle to use these systems, since their communication patterns do not reflect what is enabled by these applications. The design of StoryBox tries to integrate with the communication behavior of grandchildren and grandparents, by letting them easily share what matters in the moment. We see our work as a supplement to existing communication platforms, rather than a replacement.

Communication practices are age-dependent and, therefore, vary within a family. Tee et el. [TBI09] researched communication needs and patterns of social interaction between families and showed that people often miss opportunities to communicate with their family members due to asymmetries in their daily schedules. Older adults, in particular, would like to increase the “quality” of communications to know what is going on in other’s lives. Ballagas et al. [BKA+09] further investigated intergenerational communication and found the phone to be the most important communication medium between grandchildren and grandparents. Grandchildren, however, often faced problems expressing their thoughts verbally over the phone. Evjemo et al. [ESRJ04] also showed that communication over phone is not as rich and is insufficient for sharing information about everyday activities for both grandparents and grandchildren. To better understand this relationship, Olsson et al. [OSVVM08] studied the needs for sharing life memories. They highlight the importance of face-to-face sharing and supporting that with physical mementos and storytelling. This study further reveals that children naturally focus on sharing their day-to-day practical experiences and grandparents tend to share the emotional and nostalgic component. Parents and grandparents try to maintain a constant presence with children, while children tend to engage discretely [YA11]. As a result, grandparents tend to limit their interaction with grandchildren to avoid annoying them or interfering too much in their lives [FN14].

Becker et al. [BS12] showed that grandparents and grandchildren have problems maintaining their relationships independently. Therefore, parents often are the "driving force" for fostering communication and building grandparent-grandchild relationships. When grandparents and grandchildren spend time together, they participate in various types of activities [Ken92], such as storytelling [VKPV10]. In the context of this chapter, we refer to storytelling as *"talking together about recent events in each other’s lives"* [Ken92]. It is this idea of life sharing (e.g., physical mementos and day-to-day experiences) that we aim to support with StoryBox.

4.3.2.2 Systems for Life Sharing

There have been a variety of systems designed to facilitate communication between family members. For example, Judge et al. [JNK10, JNHB11] explored the use of an

always-on video channel to keep families in touch. These systems enabled children to easily show an artifact to a connected family member and take part in other activities such as playing games and birthday celebrations.

Other systems have explored the exchanging of day-to-day photos as a way of connecting remote family members [BDDH09, VMS+12, MRCJ01]. Many of these systems helped users to get better informed about activities of loved ones, take part in special events and experiences, and start conversations. Besides sharing experiences and activities, people also often utilize photo of items from their household to share moods or memories associated with these items [NGN08, MHE14].

Our work aims to combine an easy-to-access share-point for children and older adults, that integrates in their day-to-day life without being obtrusive. We are repurposing the ideas of photo-sharing and voice messaging from previous works. With this, we aim to support children in sharing the results of their daily activities, e.g. play or craft, and encourage older adults to share memories and stories attached to everyday objects and old photographs.

4.3.2.3 Systems for Intergenerational Communication

Specific to children and adults, a variety of communication systems have been developed to support their specific needs. *Family Story Play* and *Story Places* support storytelling over a distance by providing either a video chat application and tangible interfaces or physical books to tell bed time stories [RBR+10a, FRG+10]. Druin [DBQ09] and Bonsignore [BQDB13] presented designs and evaluations of mobile storytelling applications. They found that integrated storytelling interfaces enable children to easily capture their personalized impressions about the world. *People in Books* presented by Follmer et al. [FBR+12] was another such application to support storytelling over a distance, where family members and children are included into the stories as characters. It provided a more immersive activity and was perceived as a catalyst for communication. In our work, we follow a more unstructured approach to communication, similar to open-ended unstructured play.

Another notable application called *Pop Goes the Cell Phone* uses a spring-loaded smartphone to automatically share self-portraits and video messages, and browse family photos [RBR+11]. However, children were sometimes not aware of their communication. For example, children's performances with the device were automatically captured by a front-facing camera on the phone, and shared with distant loved ones on Flickr. With StoryBox, our focus is on helping children explicitly share their own messages, without parental scaffolding. Other researchers, such as Moffatt et al. [MDB13], have focused on identifying the challenging factors in a grandparent-grandchild relationship. They presented different design concepts to ease social interactions between the two groups such as a collaborative reading application, shared photo-books, and shared game-play. StoryBox builds on these design concepts, but focuses on in-the-moment screenless shar-

ing. Perhaps the work closest to our own is *ShareTable*, which uses a camera and projector to enable children and parents to videoconference and collaborate on a shared tabletop [YCMA09]. *ShareTable* was well received by parents and children and was preferred over regular videoconferencing. However, they found that synchronous video communication often lead to scheduling issues and creates a communication-focused environment, similar to a phone. StoryBox builds on asynchronous sharing, which makes it schedule-independent and tries to blend into daily activities, such as crafting, playing, scrapbooking, and knitting. Additionally, from a technical perspective, StoryBox was designed to be a more compact system in comparison to ShareTable, which allows it to be placed close to active areas, e.g., a children playroom or a kitchen counter.

With StoryBox, our focus was on alleviating the barriers of communication between different generations. For young grandchildren, this often means the sharing of crafts, drawings, stickers and short exclamations. For grandparents, the device provides a way to digitize analog memories, and use handwriting for communication. Both these use cases, can certainly be accomplished through traditional messaging platforms, such as Skype or WhatsApp, but as other researchers have pointed out, some grandparents feel trepidation in using these applications [SHE+06]. Moreover, we strongly believe, these applications are not supportive of children's crafting culture.

4.3.3 StoryBox

4.3.3.1 Initial Design

We based the design of StoryBox (Figure 4.10) on previous work by Wallbaum et al. [WEHB16], which was supported by semi-structured interviews and focus groups. Initially, StoryBox was designed as a tangible system for sharing memories, experiences, and feelings. It aided the process of creating visual stories and sharing them with connected family members and friends. These stories consisted of multiple pictures, combined to create an animation, allowing users to alter each frame and tell a story.

Before delving into the details, we provide a simple scenario of how a child might use the system to share an artifact with her grandmother. The child begins by crafting a clay bear and places the bear on the StoryBox glass pane. She takes multiple images of the bear using the camera button while moving the bear slightly each time. StoryBox automatically creates an animation and replays it for review. She sends the animation to her grandmother by pressing the send button. The paired StoryBox on the grandmother's side, automatically replays the received animation.

StoryBox utilizes an Arduino Uno, RGB LEDs and five buttons on the front side of the box. The upper three buttons send to the three most frequently used contacts and the lower two buttons are used to take and delete a picture, respectively. The hardware is enclosed into a wooden box with a glass surface for writing and drawing. The box is big enough to place objects of different sizes inside (L = 30cm, W = 25cm, H = 20cm). Additionally, the StoryBox contains a smartphone on top of the box and a tablet

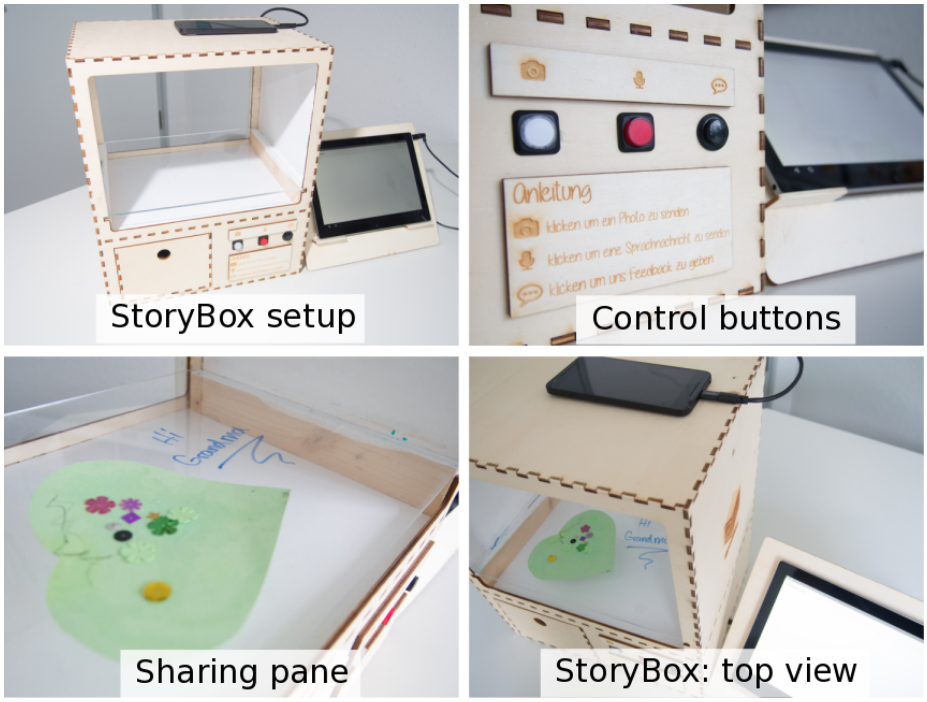

Figure 4.10: StoryBox design.

underneath the glass pane. The smartphone is used for taking pictures of the glass surface inside the box and is activated by a button. It saves and shares the content, which can be reviewed by users in a chat-style view. The tablet is used to enrich the image drawn on the glass pane by adding depth to the drawing or to emphasize the foreground objects. The StoryBox also has a small drawer to store supporting materials, such as sponges and markers. All of the content shared between the boxes are encrypted and saved on servers with limited access.

4.3.3.2 Exploratory Study

To identify early usage patterns, sharing behavior and understand user experience, we investigated the initial design of StoryBox in a exploratory study with two groups of families for a period of one week.

Participants and Apparatus
We recruited two groups of families: the first consisted of two grandchildren (8f, 11m) and their grandparents (67f, 68m). The second group consisted of two grandparents (64f, 65m), their daughter (30f) and her child (1f). Each family was provided with two interconnected StoryBoxes: one at the grandparents' house and another at the children's residences. We also provided different colored markers, plastic emoji tokens and print-outs of pictures used in the Photographic Affect Meter [PAG11] to augment messages

with emotional expressions.

Procedure
Before the evaluation, we conducted a semi-structured interview regarding the participants' experiences with modern communication technologies. Afterwards, we installed a StoryBox and instructed the participants about its functionality. The families were free to choose the location of the system in their household and use StoryBox according to their schedules and preferences. At the end of the study, we conducted another semi-structured interview regarding the shared content, influence on the connectedness among the family members, and their experience with the system.

Results
Overall, StoryBox was perceived positively by both, younger and older participants. They considered the system to be pragmatic while being attractive and engaging to use. Participants found StoryBox engaging and shared messages throughout the whole study period. They reported feeling motivated to exchange messages with their connected partners. Six participants observed an increase in communication with their connected partner and five of them shared creative content they had not done before. P1 remarked, *"We started collecting things from the nature to share it with our grandparents. This is more interesting compared to the usually shared messages"*. Two participants mentioned that the style of communication with StoryBox was *"more intense and focused then normally"*.

After the interviews and analyzing the shared content, we found a strong need for the expression of verbal messages, especially for grandparents. They also mentioned that phone and messaging are the most common communication channels used within their families. In our brief study, grandparents were sending pictures of hand-written letters to their grandchildren. Tangible objects shared among families were also often augmented with written explanations (Figure 4.11). Animation was used infrequently with participants citing it as too complicated to use with less added value. They also mentioned the need for an easier way to review received messages. Some participants suggested the use of an external device like a digital picture frame. Lastly, we found that switching to the review screen was especially complicated to do for the children.

4.3.3.3 Final Design

Based on the results from the exploratory study, we modified StoryBox in the following ways: (1) inclusion of audio messages, because we found a strong need for verbal communication and (2) exclusion of animations, which were rarely used in the exploratory study. Therefore, we changed the functionality of the buttons to send: (1) pictures, (2) audio messages to family members, and (3) feedback to experimenters. Since the animation feature was rarely used, we repurposed the delete button to enable participants to send in-situ feedback to experimenters. We also added a simple wooden stand for interacting with the tablet in an upright position.

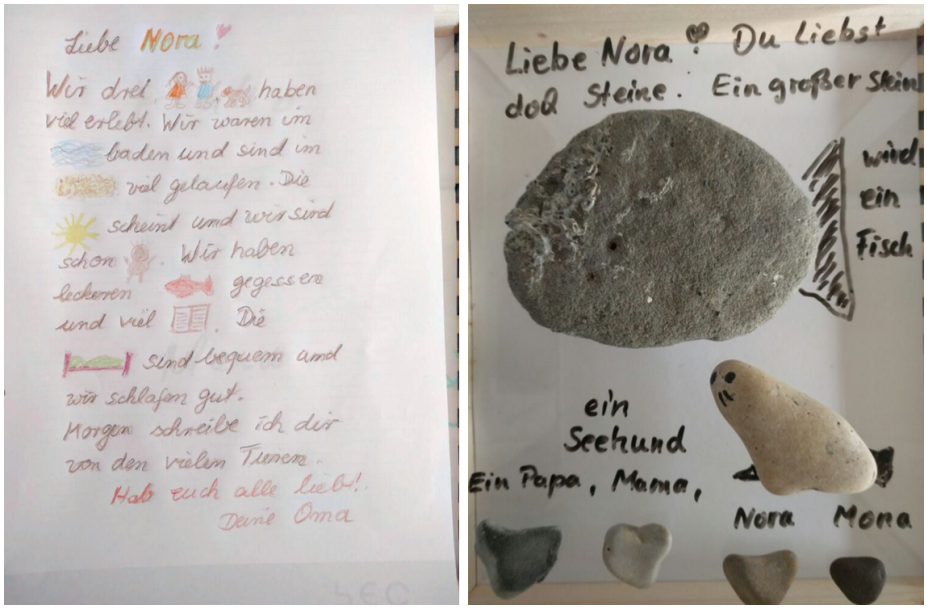

Figure 4.11: Example messages from the exploratory study showing a) a written letter and b) a crafted composition of decorated stones with associated describtions

4.3.4 Field Study

Since our system was designed to be used in a household environment, we conducted a field evaluation to better observe real world use, similar to previous works in this area [YCMA09, VVK10]. Additionally, our methodology drew on several approaches including technology probes [HMW+03] and research through design [ZFE07]. We also periodically interviewed participants and logged system usage and content based on the methods from MILCs [SP06].

4.3.4.1 Participants and Procedure

We recruited four groups of families with grandparents aged from 63 to 76 and grandchildren aged from six to ten years. All the families live in different towns/cities from 5 to 300 kilometers away from each other. A brief summary of all family groups is shown on Table 4.1. In the following paragraphs, we provide a short descriptions of the families in our study.[1]

Family 1. Martin is the 10-year-old son of Lisa and John. Martin and his grandparents, Richard (66) and Marta (66), describe their current communication as fairly frequent. Marta described her relationship with Martin as strong, because both of them use WhatsApp messenger regularly. Richard, Martin's grandfather, calls his grandson every other week and has trumpet lessons with him every month. Since Marta positions

[1] All names anonymized.

	Grandchild age	Grandparents' age	Distance
Family 1	ten (M)	66 (F) and 66 (M)	6 km
Family 2	six (F), eight (F), ten (M)	74 (F) and 74 (M)	20 km
Family 3	six (F)	63 (F) and 67 (M)	5 km
Family 4	six (F), eight (M)	76 (F) and 76 (M)	300 km

Table 4.1: Summary of participants' data. F = female, M = male.

herself as a confident and regular user of WhatsApp messenger to communicate with Martin and Lisa, Richard sometimes asks Marta to send his grandson and daughter a greeting on his behalf. Martin spends 2-3 nights per month with his grandparents, up to one week per month with his father John and the rest with his mom. In Martin's home, the StoryBox was set up in his bedroom on the desk; in Richard and Marta's home, it was in the guest room.

Family 2. Lila (6 years), Anna (8 years) and Thomas (10 years) are children of Michelle and Michael. Their grandparents - Manuela (74) and Wilhelm (74) - live 20-30 minutes away. Grandchildren and grandparents describe their communication as relatively frequent and meet each other almost every weekend for dinner. To stay in touch with their grandchildren, Manuela and Wilhelm prefer phone communication. Even though Manuela and Wilhelm have WhatsApp messenger installed on their smartphones, they have difficulties sending messages to their grandchildren, so they prefer to use it as a receiving device. StoryBox was set up in Thomas' room based on the general agreement of the family. Since Wilhelm described his relationship with the grandchildren as strong, he preferred StoryBox to be set-up in his office, where he spends most of his time.

Family 3. Six year old Tiffany lives with her parents Emilie and Peter in the same city as her grandparents Frank and Angelika. She has two younger sisters who were too young to participate in our study. She joined first grade just as the study started. Tiffany and her sisters visit their grandparents about once a week. Frank and Angelika mentioned that they would like to know more of their granddaughters day-to-day life. The parents and grandparents of Tiffany share pictures via WhatsApp. When Tiffany is allowed to use her mothers phone, she sends emojis that she thinks look cute. Frank and Angelika collect printed images of their grandchildren and compose them into photobooks. Angelika maintains a diary of her granddaughters important life events.

Family 4. Rickarda (6) and Anthony (8) live with their parents Lara and Sebastian in a small city. Their grandparents Lisa and Ernst live about 300km apart from their grandchildren. Due to the long distance, they rarely see each other. Usually, Lisa and Ernst call their grandchildren using the phone. They mentioned that the kids are not very attentive using the phone and do not share many things when talking. When introduced to StoryBox, Ernst was rather skeptical and Lisa was the driving force for communication. The parents of Rickarda and Anthony share pictures using WhatsApp with their grandparents. Although, they like receiving these messages, both grandparents are not

technical savvy.

The evaluation varied anywhere from two to four weeks and consisted of three semi-structured interviews per family. Since the field study was conducted over a three month period, it overlapped with vacation and school holidays. As a result, two families were able to participate for only two weeks. Before the evaluation we interviewed the participants regarding their existing familial relationships, their experiences with communication technology and communication patterns. We used a 7-point Likert scale to estimate current communication technology use. Afterwards, we setup the StoryBoxes and instructed participants about its functionality. Participants were also free to choose where to place the system in their household (Figure 4.12) and use it according to their schedules and preferences. For privacy reasons, all shared data was encrypted and could only be accessed by experimenters. We also supplied the families with additional markers and cleaning materials to ease the usage of the system.

Figure 4.12: Examples of StoryBox setups in different households.

From the pre-questionnaire we found that most of participants (86%) met each other in person almost every month. The most common communication channels between grandparents and grandchildren were the phone, WhatsApp messenger and face-to-face meetings. Grandparents and grandchildren mostly talked about recent events or household routines, such as problems with friends at school, future get-togethers and birthday greetings. When they use WhatsApp, they shared pictures and videos from their day-to-day activities. All of participants perceived new communication technologies as

enjoyable (M = 6, IQR = 1.5), but were only moderately interested in new technologies (M = 4, IQR = 2.25). The participants also considered themselves as average users of these technologies (M = 4, IQR = 2).

We conducted interviews with the families in the middle of the study and at the end. We asked participants questions regarding the content they shared and its purpose, the influence of StoryBox on the connectedness among the family members and their overall experience with the system.

4.3.4.2 Analysis

We analyzed the data using Biemans et al.'s established coding categories [BDDH09], which were used to study social connectedness between friends and family. The categories include: (1) messages, (2) greetings, (3) everyday life, (4) regular events, (5) special events, and (6) something funny or aesthetic. *Messages* refer to content that shows a person something new, *greetings* contain greeting messages, *everyday life* refers to content about normal things in and around the house and environment, *regular events* contain routine-based content, *special events* refer to special moment, such as holidays and birthdays, and *something funny or aesthetic* refers to funny or cheerful content.

These categorizations were used to analyze the threads of messages shared among family members. By “thread" we refer to a sequence of connected messages under the same topic. Audio messages were transcribed and printed together with shared photos. An initial coding was conducted by two members of the research group. To visualize categorization, we used affinity diagrams. Each thread was classified separately and the final category was discussed until both researchers reached an agreement. Furthermore, we compared the affinity diagrams with the qualitative data from all three interviews. This process was used to distill a set of distinct themes.

4.3.5 Findings

4.3.5.1 Quantitative Results

The amount of messages shared over the period of the study varied among families, however, the average number of messages per thread was similar (about 2-3 messages/thread). Among all families, children were sharing almost two (Family 1, 2, 3) or even three times (Family 4) more content than their grandparents.

During the study, grandparents of Family 1 called their grandson once and visited him three times. Grandparents of Family 2 visited their grandchildren twice during the study and called them once. The child of Family 3 visited their grandparents six times. Children of Family 4 were rarely using other communication channels before the study, but they started calling their grandparents more often during the study to discuss the shared content and StoryBox itself.

Pictures were the predominant type of shared content for Family 1 (88%) and 3 (64%).

	Family 1		Family 2		Family 3		Family 4	
Duration	15 days		15 days		23 days		31 days	
Threads	23		50		52		77	
Messages	58		167		97		152	
Pictures	51		82		62		80	
Audio	7		85		35		72	
	GC	GP	GC	GP	GC	GP	GC	GP
Sent	34	24	109	58	59	38	116	36
Received	24	34	58	109	38	59	36	116

Table 4.2: Number and types of threads/messages shared between families. GC = grandchildren, GP = grandparents.

Whereas for Families 2 and 4 pictures and audio messages were equally used (Table 4.2).

Overall we observed a novelty effect during the first three days of the study. A few usage peaks were observed when grandparents came back and shared vacation pictures (Family 4) and when birthdays occured (Family 2 and 3) (Figure 4.13).

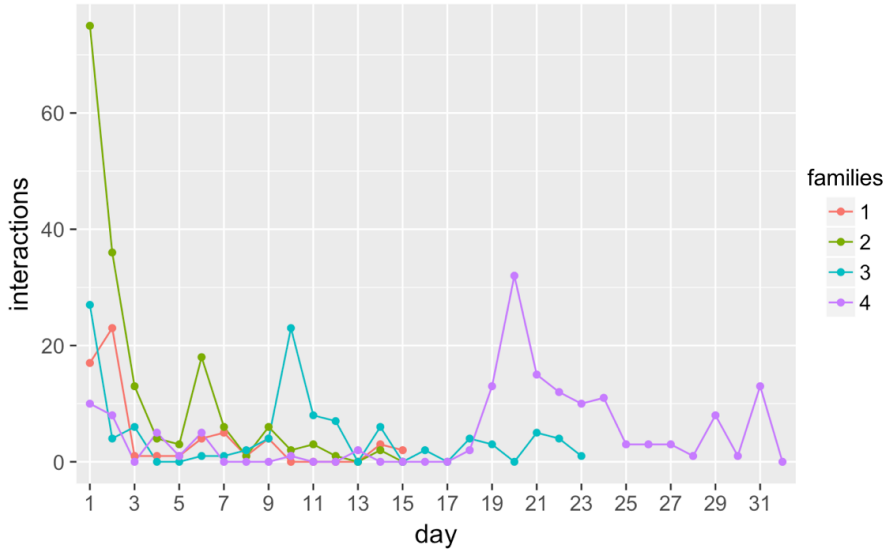

Figure 4.13: Usage of StoryBox throughout the study period for all families.

The Likert scale results regarding the influence of StoryBox on the communication between grandparents and grandchildren showed that it helped to tell how their communication partner felt that day (Q1), see how much they care (Q2), make them feel closer (Q3), make them think about the shared content (Q4) and make them feel better (Q5). Moreover, grandparents and grandchildren did not feel obligated to communicate (Q6) or feel isolated (Q7), did not reveal much of their memories (Q8), were sometimes sad if waited for too long (Q9) and were often surprised to receive unexpected content (Q10) (Figure 4.14). Some participants were not receiving the responses to their messages

immediately, which often made them think that the children were either busy or the system was not working properly. This often led to simple reminder and acknowledgement requests from the grandparents.

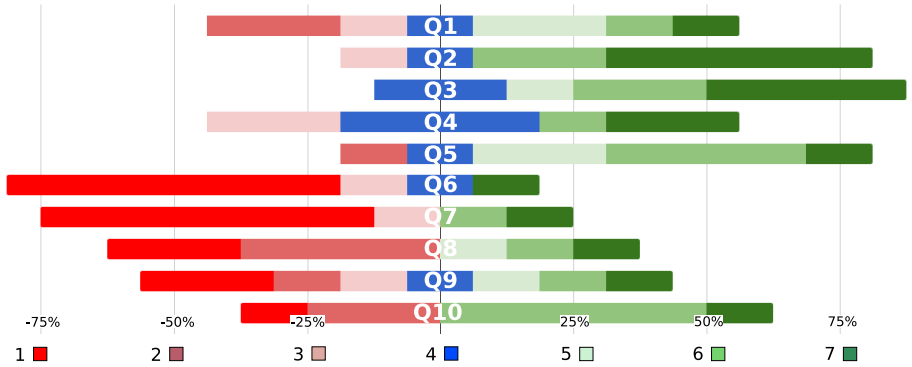

Figure 4.14: Likert scale results regarding communication among grandparents and grandchildren using the StoryBox (1 - strongly disagree, 7 - strongly agree).

During the categorization process we derived three additional categories for information sharing, because our work also included the sharing of tangible artifacts (in comparison to Biemans et al. [BDDH09] picture only sharing work). These three categories are: (1) *artifact* refers to explanations on how to use communication technology, (2) *communication reminder* contains reminder and acknowledgement requests and (3) *feedback* consists of messages to experimenters from users.

Families shared different types of messages throughout the study, which we grouped into threads and categorized into eight types of content (see Analysis). The most frequent type of content category among all families is *funny/aesthetics* (83 threads) and included pictures of handmade objects, musical recordings, pictures of faces, hands and heads and content related to remote games. The second group of shared messages were related to the categories of *everyday life* (30 threads), *messages* (27 threads), *artifact* (22 threads) and *greetings* (19 threads). *Everyday life* included different kinds of day-to-day activities (cooking, writing, drawing, accidents, homework, food), *messages* contained pictures of books or articles recommended by grandparents for their grandchildren to read or pictures and audio of poems, *greetings* mostly included “hi" messages and “kisses" and *artifact* included discussions about the functionality of StoryBox or explanations of children for grandparents, what objects to use for drawing/removing the content from the StoryBox. The fewest messages belong to the categories *special events* (10 threads) and *reminder to communicate* (8 threads). *Special event* included messages regarding birthday wishes, horse riding, vacation impressions or invitations to do something together and *reminder to communicate* contained messages such as “Please let us hear from you when you are back home" or “Please let me know whether you received my drawing". Summary of content shared between all groups of families is shown in Table 4.3.

Artifact (22)	**Everyday Life (30)**
• Explanation of usage to a partner • Usage of different materials for cleaning the glass • Test messages to try functionality • Requests to send confirmations	• Experience sharing • Questions about location and activity • Accident sharing • Appointment request • Goodnight wishes • Reminder to communicate • Food • Weather • Homework and stories from school
Message (27)	**Greetings (19)**
• Pictures of articles/books to read • Audio and picture of a poem	• Messages with names • Greetings to parents over kids • Greeting words and kisses
Special Event (10)	**Funny/Aesthetics (83)**
• Birthday discussion • Visiting friends, vacation • Invitation to do something together • Horse riding	• Playing a remote game • Singing songs • Handmade objects • Playing a song on a trumpet • Hands, heads and faces of kids • Pictures, books, flowers, toys
Reminder to Communicate (8)	**Feedback (3)**
• Messages to remind about communication	• Suggestions to share crafted emojis

Table 4.3: Types of content and number of threads (in brackets) shared among families.

4.3.5.2 Qualitative Results

Tangible Communication: From Drawing to Crafting
StoryBox was designed to support children's crafting behaviors and the exchange of tangible memories from grandparents. Even though Wilhelm and Thomas (Family 2) were using WhatsApp messenger regularly before, they would not normally share old pictures due to the technical difficulties. *"I wouldn't share old pictures usually. The box was the inspiration to share it with my grandchildren. They knew about this one puppet that their mother loved as a child. And now I could share a picture showing them together"* (Figure 4.15) (Wilhelm, F2). Tiffany (grandchild, Family 3) shared a picture of a flower with her grandparents, which she and her friend included into their play of "marriage". This flower initiated a conversation between them, where they explain what and how they played. This would normally not have happened among them, since Tiffany has no smartphone and uses her mom's smartphone to share emojis. The StoryBox was often perceived by children as a toy. They were using it as an alternative for a game after getting bored with playing other games.

Grandchildren got themselves quickly engaged into crafting messages for their grandparents and perceived the StoryBox as a creativity platform. They also started drawing pictures, making something out of clay or searched for other objects that played an important role in their lives. *"Sending pictures was a little bit more fun, because you can get much more creative"* (Anna, F2). Additionally, her parents commented: *"She likes to search for things in her room, which she can share with her grandparents. She liked that the most"*. Some grandchildren also invited their parents to create something together and share it afterwards with their grandparents.

Grandparents liked the fact that their grandchildren used hand-writing for communication instead of typing text using software-based applications. *"I was happy, that my grandson had to write with a pen, because they do not do that very often nowadays. [...] using WhatsApp, they just sent voice messages and they don't learn how to write"* (Marta, F1). Another grandmother (Angelika, F3) used the StoryBox to teach their granddaughter to write: *"I have sent examples of how to write number 3, because my granddaughter had to learn it for school"*.

Inter-generational Communication and Connectedness
We found that some children were thinking about what to say before recording the message, which helped them to better express their thoughts than over phone. *"We were surprised that he communicated so much verbally and told stories in quite some detail. We think, when using the phone he is surprised and does not know what to say. With the box, he could think about what to say before and then record"* (Wilhelm, F2). The same family mentioned that the communication via StoryBox increased social connectedness between them and their grandson Thomas, even though they meet each other almost every week for dinner. *"It has increased the feeling of being connected intensively! Even the physical closeness, when we were visiting, it was much stronger than before"*. Moreover, grandchildren started communicating with their grandparents themselves, without

Figure 4.15: Examples of messages exchanged between grandparents and grandchildren. From left to right: knitting results, crafted items, picture of grandchild with newborn child, hand greeting, homework from school, drawings of toys.

their parents asking them to do so. *“I have decided to send something and then also did it by myself."* (Thomas, F2). *“My parents did not help us at all. I have used the box on my own."* (Tiffany, F3).

Grandparents were often inspired by the messages sent by their grandchildren and therefore were motivated to use StoryBox. One grandmother (Manuela, F2) mentioned: *".. my husband showed me a message sent by our six-year-old granddaughter. It made me so happy that I wanted to answer her. That is why I also started sending her messages"*. As mentioned previously she usually uses WhatsApp messenger to receive messages, but not to send them. In addition to the StoryBox, some children started using other communication channels, such as telephone, more often than before.*"My children wanted to talk to their grandparents about content, that they shared beforehand using the box. So they started to use the phone by themselves"* (Lara and Sebastian, F4).

Almost half the participants used *StoryBox* exclusively for communication during the study. *"I only have used other communications means with my friends and other family members, but not with my grandparents anymore. We just used this box"* (Martin, F1). Other families used StoryBox as a supplement to other communication channels. *"[...] when there was something important, then we would use other things to get an answer directly. When using the box, we exchanged more fun messages"* (Wilhelm, F2). Exchanging messages through StoryBox on a regular basis made both grandparents and grandchildren think about each other more often and be more aware about each others lives. *"After sometime of box usage I realized that my grandchildren really fulfill my life"* (Frank, F3). One of his grandchildren was regularly telling her mother stories shared by the grandparents. Her mother Emilie remarked, *"She liked it, when her grandparents told her what they did and asked questions about her day. Afterwards, she always came to me and told me the news."*

Artifact Design

From the three interviews we found that both grandchildren and grandparents quickly understood the concept and functionality of StoryBox. For example, grandparents mentioned that it was easy for them to share pictures and voice messages using the system. Richard and Marta from Family 1 used messenger applications to receive pictures from their daughter, but had problems responding to them, because they considered themselves *"very bad with technology"*. Martha remarked, *"We use WhatsApp, to receive messages from our daughter. Sometimes even pictures showing our grandchildren. But we don’t know how to send pictures or voice messages back. So we can not react to these messages."*

Most grandparents felt positive about the design of StoryBox. *"It looks like a self-made TV. It kind of looks like the one we had when we were younger"* (Wilhelm, F2). One of the children also mentioned that she would prefer a more colorful and playful design, for example, *"with some colored pictures or patterns printed on it"* (Anna, F2). Both grandparents and grandchildren described StoryBox as a tangible reminder that fosters communication with each other. *"It reminded us to send something, when we saw the box in our living room"* (Frank, F3). At the same time most participants would

have preferred to have some notification on received messages. *"It would be better if the box would inform us, when a new message has arrived. Now we have to check every now and then"* (Manuela, F2).

Grandchildren had no problems sending messages, but sometimes got stuck when receiving them using the tablet. As one mother explained: *"Using the Box was very easy for her, but with the tablet she sometimes pressed a wrong button and did not know how to move on"* (Emilie, F3). Grandparents also faced a few issues; one of the participants unintentionally uninstalled the StoryBox application. Some grandparents mentioned that they would like to see previously shared content. Angelika (F3) remarked: *".. we sometimes don't know what has been sent to our grandchildren"*. In addition, we found that many participants missed the timely information of messages and started mentioning the time and date within voice messages after some time. *"Knowing the time and date when we have received a message is very helpful. My grandson has started to do so and I found it was a great idea"* (Wilhelm, F2).

4.3.6 Discussion

There is a fundamental difference in the communication styles of grandparents and grandchildren. Young children typically have limited attention spans and communicate in an intermittent and asynchronous manner. Older adults on the other hand, are willing to invest time and effort in composing messages and prefer having longer synchronous interactions. Moreover, the relationship between the two groups tends to be asymmetrical with grandparents often giving more than they receive [LHS09]. While StoryBox may not be fully accommodating of both communication styles, there is some modest evidence that suggests it offers a *personalized sense of intimacy* for grandparents and a *playful and creative* communication platform for children. In the subsections below, we take a "step back" and explore the reasons why and reflect on the implications of this work.

4.3.6.1 Designing for Engagement and Creativity

A common message sent by children in our study was a picture of their hands, reminiscent of hand stencils from prehistoric cave art that sought to make a connection with the world [Clo10]. This highlights the need to help children express themselves naturally and creatively. The lightweight and flexible nature of StoryBox helped kids to appropriate and digitize daily artifacts from their lives such as drawings, clay figurines, books, flowers, and toys. This supports the naturally playful and often creative input of the child. The children's artifacts are not exemplars of ideal communication, nor are they intended to be. Instead, they are intended to tap into an impulse for creative atypical conversation that supports a high level of individual decision making. A potential benefit of enabling free expression in this context is that it requires less parental scaffolding, a problem that researchers have cited in the past as being needed for grandparent-grandchild relationships [BKA+09, FN14, RRM+11].

We believe one of the factors that aided engagement and creativity, was simply the tangible nature of StoryBox. As a sizable physical object (relative to a mobile phone) occupying some desk space, it was hard to ignore and reminded participants in our study to initiate communication. While we did not find evidence of children crafting more because of StoryBox, it did offer a lower-barrier for communication through their (already existing) daily crafting practices. For older adults, StoryBox provided a simpler, larger interface (akin to an old television as mentioned by Wilhelm, F2) with the singular purpose of communicating with their grandchildren. As a result, grandparents were more inclined to regularly monitor and share messages via the device. For some groups, it even replaced the usual or traditional forms of communication.

4.3.6.2 Multigenerational Design

As alluded to earlier, there are inherent complexities in designing accessible communication technologies for different generations. Admittedly, StoryBox is geared more towards children's crafting and play culture, even though it is easier to use for grandparents (from a technological perspective). Grandparents in this case, accommodated and tailored the content of their communications to suit their grandchildren. As other researchers have pointed out, this imbalance underpins research in this area [Lin12, MDB13].

However, the asymmetrical nature of familial relationships and its consequent effects on technology design need not be seen as a limitation, if we consider what is important to both user groups. For grandparents, having a personal sense of intimacy with their grandkids is essential, while for children being able to express themselves on their terms is most important. Throughout our analysis, we found many messages from children sharing silly, playful, idiosyncratic voice messages, artifacts, and creations. These range from children telling their grandparents a story with an overly excited voice (that is sometimes difficult to understand), to pictures of crafted objects (that are difficult to identify). This type of informal communication is different from how children are typically asked to communicate with their grandparents through phone or video chat. Perhaps the idea that StoryBox tries to embody is this notion of "making as a form of communication." This idea has been explored in the past in cross-cultural settings to overcome significant differences in language and culture [JZ15]. We feel these differences are sometimes also true of grandparents and grandchildren.

For grandparents, StoryBox offers a view into their grandchild's world and creates potential opportunities for intimacy and personal connectedness. In the case of Wilhelm and Manuela (F2), this view came as a surprise; they never knew their grandson was so articulate, considering that he was often quiet during phone calls. For others (Richard and Marta, F1), StoryBox was a way to relay family history through old photos, allowing the older adult to serve as family historian. This idea of a curator of family stories, culture, and heritage is discussed by Korhaber and Woodward as one of the five central roles played by grandparents [KW81]. Perhaps, more importantly, StoryBox can offer older adults a sense of intimacy with their grandkids. This intimacy might be expressed

through the tone of a voice message, or the unique handwriting of their grandchild. Although these are very simple touches, they allow for a level of expression that is often lost in texting and email.

While older adults would be better served by technologies that allow for a more focused, intense means of communication [FN14], this is often not possible with younger children. The key, as Lindley comments,"lies in making both sides aware of differing expectations and helping them to overcome these" [Lin12]. She further highlights the use of a lightweight message to trigger a richer more satisfying conversation. For some groups this was indeed the case with StoryBox. The children from Family 4 for example, started using the telephone to discuss content they had shared. Similarly, Wilhelm and Manuela (F2) mentioned the increased feeling of physical closeness and connectedness when visiting their grandkids. In this sense, StoryBox was helpful in meeting the communication needs of both groups more fully.

4.3.6.3 Bridging the Non-Digital and Digital

At the forefront of inter-generational communication are the different technological backgrounds of the older adults and children. Children today are raised in the atmosphere of mobile phones, tablets, and smart TVs. Grandparents, however, are typically from a time of land-line phones, hand written letters, and cathode ray TVs. In a sense, these two groups are from different technological "silos" where the cognitive requirements of technology widely vary. The mobile phones of today are hardly just phones compared to the fixed land-lines of yesteryear. These new developments are often overwhelming and confusing to older adults. Even in our modest study, we found grandparents who experienced frustration in sending pictures and voice messages via WhatsApp.

In this landscape, the aim of StoryBox, was to serve as a technological bridge or scaffold between two vastly different generations. From the perspective of grandparents, StoryBox was helpful as a singular communication channel with their grandchildren, much like technologies from their time. Moreover, it provided an interface for sharing non-digital content such as old printed photos (Marta, F1). This is particularly important considering that for many grandparents, memories are not purely "virtual" or cognitive, they often have accompanying physical artifacts that enrich their own sense of narrative history.

Another aspect of the tangible interaction interface that helped bridge the technological gap for grandparents was the glass writing surface. Handwritten messages are closer to their technological "silo" and a burgeoning (and perhaps short-lived) part of the children's. Many of the grandchildren in our study were just learning to write, an activity grandparents were already experts at. We observed older adults helping their grandkids with writing letters and numbers using the StoryBox. We also recognized how it was a source of pride and joy to see themselves as a part of their grandchildren's lives. Perhaps one of the strengths of StoryBox was that it facilitated a level technological "playing field" for both user groups.

4.3.7 Limitations

StoryBox is not without its limitations; during our studies, we found many participants reporting that the StoryBox should notify them about new incoming messages from the connected partner. We designed StoryBox to be an asynchronous communication platform, but we discovered that participants had additional needs. Grandparents and grandchildren requested time-related information particularly, when messages arrived. This was important because messages were sometimes read on a different day than they were received.

A key limitation of our research is, that StoryBox is designed for younger children below the age of ten. With this age group children, crafting and technology use is more prevalent than in comparison to teenagers. It is unclear, how StoryBox will function with older children especially with respect to usage patterns as well as acceptance of the system in general. It may be considered too "childish." Lastly, our results are based on an evaluation of up to four weeks where we noticed a small decay in system use. It is unclear how the usage of the system will fare for longer time periods.

4.3.8 Conclusion

In this section, we presented the design and implementation of a tangible storytelling system – StoryBox – for sharing photos, tangible artifacts, and audio recordings of everyday life. To better understand grandparents and grandchildren's real-world use and examine connectedness, we evaluated StoryBox in a preliminary study with two families and a subsequent study with four families for up to four weeks. We found that StoryBox enabled children to express themselves freely in a playful manner, was simple to use, and helped bridge the inter-generational technological gap. We further provided insights on how to ease communication between different generations, engage them in sharing activities, and strengthen family relationships.

4.4 Chapter Summary

This chapter presented work to explore designs and engaging interactions, that foster the exchange of experiences from special or common moments in a persons life. Specifically, we investigate how technology can support users with different technical capabilities and enable all members of a family to share and reflect on experiences of others. We presented results from three studies with users in their homes. By bringing our designs into the homes of users, we aim to understand how technology can support the exchange of experiences and memories as well as effect their interpersonal relationships. Compared to many previous works, which have not been evaluated in the field, we have provided insights on the impact of such technologies on user's day-to-day life. We presented SocialWall, an interactive pictures-wall, that allows groups to exchange memories from their daily lives through photo-sharing. We provided insights from our evaluations

and reflections on its support for social awareness as well as usability and acceptance by users. Following, we presented StoryBox. An artifact to support messenger-like experiences for non-native users like grandparents and grandchildren. We present our design concepts, implementations in two studies as well as results from these studies. We discussed the impact of StoryBox on the grandparents-grandchildren relationship as well as future explorations.

5 Exchange of Moods and Emotions

5.1 Introduction

In this chapter, we investigate designs to enable users to express, exchange and understand feelings and emotional states. We present a phone-based approach to support adults and adolescents to express moods using different input methods. These methods are based on existing models to express emotions and have been used previously in works from psychology and HCI. We present insights from a field study, and provide guidelines for mood input on phones, to ease ways of emotion expressions. In a second work, we explore emotional expressions with children. Based on a prototype for tangible storytelling, we explore different modalities to express emotional situations. We provide results from multiple evaluation-sessions with children and describe possible applications, based on the presented design. Based on our findings, we try to give directions on designing for complex and intimate topic such as emotions. In comparison to the previous two chapters, this work focuses on ways to input or express emotions with the support of interfaces, instead of the sharing aspect. However, we saw the necessity to explore and improve ways for people to express themselves in more detail, before researching the more complex interpersonal interactions with regard to sharing and understanding emotions and moods.

5.2 Comparison of in-situ mood input methods on mobile devices

5.2.1 Motivation

One of the current ways to facilitate the connectedness between people is the usage of social networks (e.g. Facebook, Twitter) or messenger applications (e.g. WhatsApp, Telegram). But even though we see heavy use of these communication channels [1], they do not yet support comprehensive ways to share emotions and moods in the life of an individual. Even though the continuous sharing of emotions or moods is hard to achieve, it plays an important role for emotional bonds between friends or family members. Thus, it is crucial to provide a mood input method, that is simple to use in different contexts and at the same time allows the user to express mood sufficiently. Moreover, it is important to share moods and emotions at the moment when they occur and not at a later time of the day to create a feeling of empathy with others.

There has been previous work on methods and systems to input and express moods on mobile devices e.g. Church et al. [CHO10], Hemmert et al. [HGL+11], Kaye [Kay06] and Wang et al. [WQ10]. However, we still lack a comparison of different methods on how effectively people can use them while conducting daily activities. In this chapter we explore existing methods of mood input and reveal advantages and disadvantages of them. We seek to collect guidelines that enrich the development of future applications

[1] http://www.businessinsider.com/the-messaging-app-report-2015-11?IR=T; last retrieved: 15.8.2016

and will fit into a users day to day life and allow users to express their current mood easily and sufficiently.

With this study, we provide two main research contributions to improve the utilization of in-situ mood input:

1. We provide an empirical comparison of four current techniques for in-situ input, with regard to *intuitiveness*, *inconvenience*, *speed of input*, *everyday use*, *expressiveness* and *overall suitability*.

2. We show advantages and disadvantages of each input method and describe user preferences as a basis for future systems.

5.2.2 Related Work

Psychology research has shown and validated several methods to describe and measure affect. Russell created the circumplex model of affect to enable user's to capture the different facets of emotions and moods of a subject. This scale is based on the included dimensions of valence (negative to positive), arousal (low to high) and dominance [RM77, Rus80]. However, many following models are only using the reduced set of two dimensions: valence and arousal [RWM89, PAG11].

The Positive and Negative Affect Schedule (PANAS) has been presented by Watson et al. [WCT88, CH04]. The model measures positive and negative affect separately using 20 items to describe a participant's mood. Due to the scale's complexity, it is difficult to use for frequent measurements of mood. Especially in a mobile context and during day-to-day activities. For the comparison, we decided to use input methods that are based on the model developed by Russell. The main reasons for this are: a) ease of use and b) variety of moods.

We based the design for the compared input screens on validated previous work in measuring mood and affect. The methods use (1) photographs, (2) pictorial representations, (3) emotion terms and (4) colors to define the user's current mood. We decided against the use of emoticons, which are widely used nowadays, because they allow the user to express a much broader spectrum of information e.g. activities, objects. Restricting the input to the expression of moods, made the used methods comparable. All used methods are based on a two factor representation of emotions by Russell [Rus80]. Following we present the used methods in detail:

Photographic Affect Meter Input (PAM). Pollak et al. presented Photographic Affect Meter (PAM) in 2011 [PAG11]. Based on the layout of the Affect Grid by Russell et al. [RWM89], the PAM shows 16 photographs arranged in a 4 x 4 grid. Each photograph represents one kind of predefined emotion. Users choose one picture at a time to express their current mood (Fig. 5.1 (b)).

Self-Assessment Manikin Input (SAM). The Self-Assessment Manikin has been introduced by Bradly and Lang [BL94] in 1994. The original model uses a pictorial rating

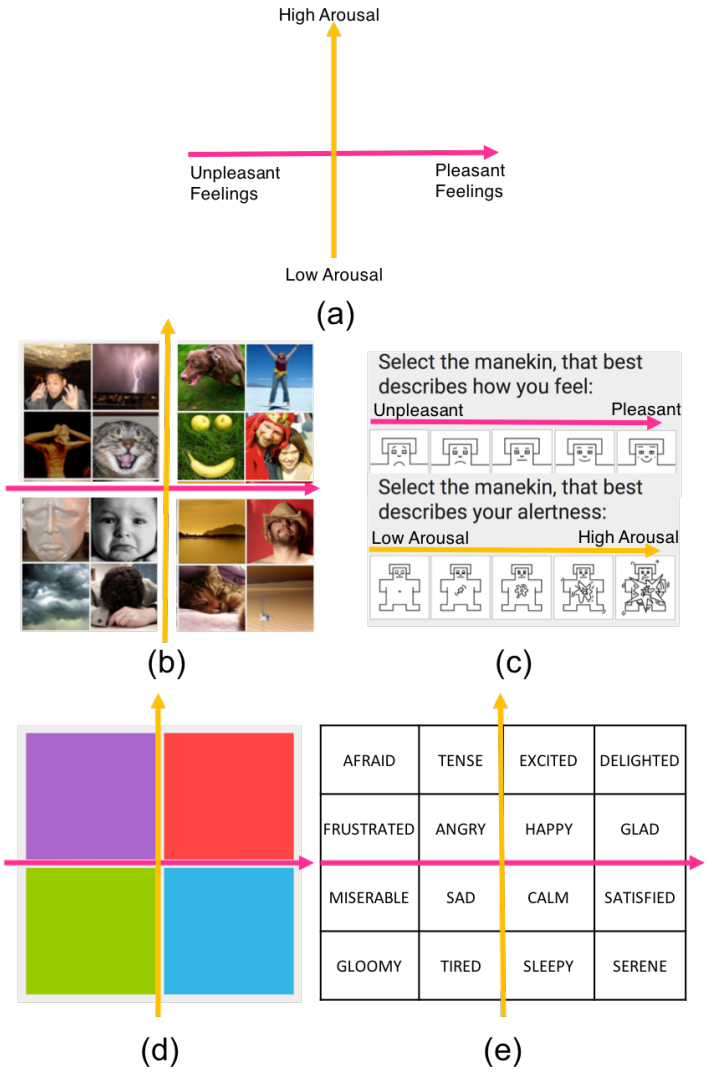

Figure 5.1: The underlying model for the input methods (a) Circumplex model of affect and the compared input methods: (b) Photographic Affect Meter Input, (c) Self-Assessment Manikin, (d) colors and (e) emotion terms

system to let the user describe three attributes of their experienced emotion. The dimensions used to express emotions are 1) affective valence, 2) arousal and 3) dominance. To match the Affect Grid defined by Russell, we used 1) Valence (positive to negative) and 2) arousal (high to low). We choose SAM as one possible method to express mood with iconic representations (Fig. 5.1 (c)).

Color Input. Based on previous works for using color to assess Wexner et al. [Wex54] or to display moods, e.g. Sundström et al., Snyder et al.[SSH07, SMC+15] and as presented in the MoodJam project [Li09], we have designed an input method using colors to track the current mood of a person. The input used four pre-set colors (Fig. 5.1 (d)), but users were able to change them to colors they preferred. We based the underlying model on parameters of the affective space. Each color represents one of four different emotional categories: a) high arousal / unpleasant feelings, b) high arousal / pleasant feelings, c) low arousal / unpleasant feelings, d) low arousal / pleasant feelings.

Emotion Terms. For this method we chose to let the participants describe their current mood with one word. The list of terms we used is based on a subset of emotion words presented by Russell [Rus80] (16 words out of 28 words originally). This set has also been used in the Photographic Affect Meter by Pollak et al. [PAG11]. The words are positioned in a grid style, similar to the grid we used for the PAM Input method (Fig. 5.1 (e)).

Sundström et al. have presented a mobile messaging system, which allows to combine different inputs like gestures, color, shapes and animations helping to express the users current feelings and mood [SSH07]. The eMoto application was designed to enable user to keep track of their own moods and to communicate their feelings with others. After entering a text message, the sender is able to enhance this information with e.g. graphical representations of her/his mood that is connected with this message. The sender is also able to use different combinations of gestures to express a certain mood. By interpreting the combinations of movement done by the user, the application is mapping them into a specific quarter of the Affect Grid by Russell. The receiver of the message is getting the text message as well as an colored and animated background showing the emotional space created by the sender.

Another messaging system called MobiMood has been presented by Church et al. in 2010 [CHO10]. MobiMood is a social mobile application allowing groups of friends to exchange their day to day mood with each other while on-the-go. The users input their current mood by choosing from one of five standard moods or by defining a custom mood for the moment. Each mood is associated with a different color. Colors used in the application have been selected based on previous works from Wexner [Wex54]. Intensity of a specific mood is defined by the size of a colored bubble, growing with higher intensities of that mood. Following, users are asked to add contextual information like their location or who is accompanying them. The users can see all moods entered by the group in a list of multiple entries. Each item of the list can be selected to show detailed information. Communication partners are then able to write a comment, send a private SMS or initiate a phone call. A field study with 15 participants showed that

users liked the enhanced kind of messaging, which also often fostered communications outside of the application.

Gay et al. have developed and evaluated a mobile-phone-based emotion recording and sharing application called Aurora in 2011 [GPAL11]. The main goal of the mobile application is to engage users in reflecting their emotional state, emotion sharing, and social support by others. Aurora is supported by all major mobile platforms as well as with an mobile optimized web application. Users start to express their current mood by selecting a photo from a set of predefined pictures. After the user has decided for a photograph, s/he is able to enter a text note, describing the mood more in detail. The group-mood-view shows all status updates done by the members of a group by showing the corresponding photo of each mood. The user is able to see additional information like the written message or the date for this entry by clicking on one of the pictures in the group mood view. To enable an ongoing communication based on the moods entered by others, users can also send each other a text message. The pilot study showed, that the usage of Aurora increases emotional awareness and encourages emotion sharing as well as socially supportive behavior.

Based on colors and words to express moods, the MoodJam project enables users to keep track of their mood. Users can access their mood trends for a longer period of time and are also able to share moods with others. The main goal of the project, that has been developed at the Carnegie Mellon University by Li et al. [Li09], is to increase awareness of mood among groups.

5.2.3 Design

5.2.3.1 Study

We conducted a study in the field with 18 participants (10 female, age ranged from 25 to 70 with a M=33.6 years, SD=12.29 years). All participants were recruited within our institute. Sixteen participants are of European origin. A mobile application created notifications to remind the participants to enter their current mood at least every 45 - 60 minutes. Every input was used four times within one day of usage. Participants tracked their moods locally on the phone, without sharing them with others. A notification was signaled by a short vibrations pattern and the notification alarm of the device. If a user did not click on a incoming notification, the application did not generate new notifications such that users were able to postpone the input. The method used by the user to report their current mood changed in a randomized order and all methods were used equally often.

We asked participants to fill in a post-study questionnaire starting with demographic questions as well as questions about their prior knowledge with smartphones and touch-screens. Afterwards, participants were asked to rate each input method with regard to the aforementioned factors, using a Likert scale (1 - strongly agree, 5 - strongly disagree). Additionally, we asked participants to answer three additional questions with regard to

the usage of mood sharing systems and their integration within normal communication habits. Participants could also write down additional comments. Finally, participants were asked to rank the input methods from best to worst.

5.2.3.2 Procedure

In case participants wanted to use their own smartphone for the study we send them a link to an application they had to install on their device. Afterwards we explained the smartphone if needed and continued with explaining the four different methods used to input a mood. Participants were allowed to try each method as often as they liked and also could ask additionally questions. For the color input we also helped to set-up the color for each quadrant *"negativ-active"*, *"positiv-active"*, *"negative-passive"* and *"positive-passive"*. Following we have showed the post-questionnaire to them and explained the questions and how each method had to be rated at the end of the study.

If everything was clear to them, we started the study and the participants took the smartphone as well as the post-questionnaire with them. After about 24 hours we met again and the participants were handing back their filled in questionnaire and the smartphone, if provided by us.

5.2.4 Results

All participants were experienced with smartphones (Median (Md)=1, Interquartile range (IQR)=1-1) and touchscreens (Md=1, IQR=1-1). Three participants had previously used methods to track mood (diaries and software).

5.2.4.1 Quantitative Results

The participants rated all input methods with regard to *intuitiveness*, *inconvenience*, *speed of input*, *everyday use*, *expressiveness* and *overall suitability* All median ratings and IQRs are listed in Table 5.1.

	PAM	SAM	Term	Color
intuitive *Md (IQR)*	**1** (1-1.75)	**1** (1-2)	**1** (1-1)	**2** (1.25-3)
inconv. *Md (IQR)*	4.5 (3-5)	5 (5-5)	4.5 (4-5)	4 (3-5)
speed *Md (IQR)*	2.5 (1-3)	**1** (1-2)	**2** (1-2.75)	**2** (1-3)
everyday *Md (IQR)*	**2** (2-3.75)	**2** (1-2)	**2** (1.25-2.75)	**2** (1-2)
expressiv. *Md (IQR)*	**2** (2-3)	3 (2-3.75)	**1.5** (1-2)	3.5 (2-4)
suitablity *Md (IQR)*	2.5 (2-3.75)	2.5 (2-4)	**1.5** (1-2.75)	3 (2-4)

Table 5.1: Experiment: Summary of results: 1 - strongly agree, 5 - strongly disagree; agreements marked in bold

We used the Wilcoxon rank sum test with continuity correction for pairwise comparisons of the input methods. The resulting p values were corrected using the Bonferroni correction. This method applies to all following analyses.We have not found any significant differences for statements regarding the use during daily activities. Intuitiveness was significantly worse between Color and every other method (PAM/Color: $p<.05$; SAM/Color: $p<.05$; Terms/Color: $p<.05$). We also found significant differences for the expressiveness of emotion terms compared to color ($p<.01$). The overall suitability also differed significantly for emotion terms compared to the color input method ($p<.05$).

5.2.4.2 General Acceptance

Participants rated the use of inputs for in-situ logging of daily moods as well as the overall expressiveness of such a system and the capabilities of these methods to enhance interpersonal communication. We used the Wilcoxon test with a expected value of 3 (mu = 3) to check if this rating is significant. The participants rated the statement "I can imagine to track my mood using a scale." with Md=2 (IQR=1-3) significantly better ($p<0.05$). The statement: "I was able to express my mood sufficiently" was rated with Md=3 (IQR=2-3). The statement "The nonverbal exchange of daily moods with a close person is able to enhance the normal verbal communication with them." was rated with Md=2 (IQR=1-2), significantly better than expected ($p<0.01$).

5.2.4.3 Ranking

Participants (n=17) ranked the input methods from 1 - best to 5 - worst, with ties being allowed. One participant did not do the ranking, because s/he could not decide how to rank the methods. The methods *PAM*, *SAM* and *emotion terms* have been all ranked equally with Md=2. Using *color* to input mood data has been ranked with Md=4. We found a significant difference between the ranking of the term input and the color input method ($p<0.01$).

5.2.4.4 Input Speed

To find differences about the average time it takes to input a mood with the different methods, we have logged input speed for each participant. The duration for the input was measured from the time the user clicked on the notification to start the input until the s/he finished the input. Figure 5.2 shows the average input speed for each method. The average times needed for the input from longest to shortest are: 28.19s (PAM), 15.75s (Text), 13.18s (SAM) and 8.92s (Color). We have not found any significant differences for the times between SAM and emotion terms as well as SAM and color. However, compared to all other methods, PAM took significantly more time to enter data: PAM and SAM ($p < .001$), PAM and terms ($p < .01$), PAM and color ($p < .001$). We found, that the color input was significantly faster, than using emotion terms ($p < .01$).

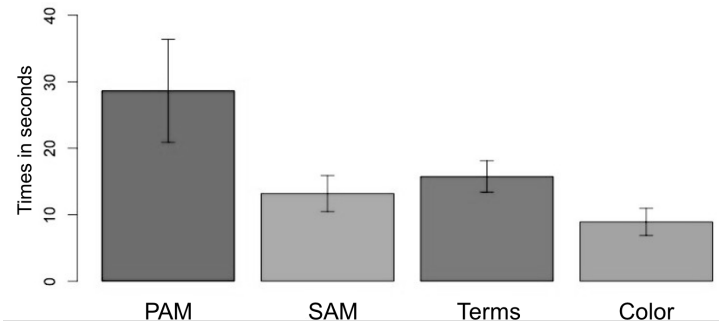

Figure 5.2: Duration of the input for each method. Error bars show the 95% confidence interval.

5.2.4.5 Qualitative Results

Participants were able to provide feedback for each input method.

5.2.4.6 Photographic Affect Meter Input

Participants liked to browse through the pictures and to get inspired by them to identify their mood. One of the participants mentioned: *"i like the pictures very much, because of sharing several aspects of mood; this can also be a good way of tracking your own feelings throughout time. So you can increase the situations when you are feeling better in a way."*. Some participants had problems with choosing a picture. This had multiple reasons: One of them had problems to match a specific mood to a picture in general. It took her/him some time to find a matching picture and therefore s/he had to compare the available images with each other *"Sometimes its hard to assign a mood to a matching picture. I had to look through all existing pictures and compare them."*. Some of the users wanted to have a reduced set of images and stated that some of the pictures could not express a mood clearly. One participant mentioned: *"Less pictures. More expressive pictures!!! Clearly expressed moods"*. Often participants said that it would be nice if they could use personal pictures made by them self *"... I would prefer personal pictures ..."*. Some participants also noted, that this input method seemed to take the most time *"... overall it took the most time to select a matching image."*.

5.2.4.7 Self-Assessment Manikin Input

Using SAM, some participants perceived it as quite precise. One participant mentioned, that s/he would be able to identify a persons mood when receiving the chosen SAM manikins: *"If someone would inform me about her/his mood using this input method, I would be able to understand it."*. Others did not perceived it as precise but rather vague to use the SAM input method: *"... it feels very vague to use this input"* and *"Its too*

complicated to use this and also not clearly enough. How do I express tired?". One participant mentioned that s/he would like to have a more personal set of manikins to choose from. The same participant stated that the mood you can express would not change a lot during a normal day: *"... if nothing exiting happens during a day, you might often choose the same combination of manikins."*.

5.2.4.8 Emotion Terms Input

The emotion word input was perceived by most of the participants as the most precise method: *"Most precise method - best suited if I want to track my moods for a longer time."* or *"You can understand words directly. The meaning is totally clear."* and *"Description is more clearly then with the SAM method."*. On the downside, words were perceived as the most unattractive input method: *"Not attractive but effective."*. One user mentioned that this method would need more time, because a user has to read all available word to decide for one. But because its easier to understand the meaning, you would save some time when receiving the mood of someone else.

Multiple users mentioned, that it would be nice if they could select personal words to choose from. Or if it would be possible to select multiple words at once, to express a more complex mood: *"Adding my own set of word would be nice. So I could use matching words."* and *"I would like to have clusters of words e.g. relaxed and sleepy"*.

5.2.4.9 Color Input

The color input method was perceived as quite vague for most of the users: *"As vague as with SAM but more pleasing to use."* and *"Too little options to express a whole spectrum of moods - to imprecise. If someone would inform me about her/his mood using colors, I would not be able to understand how s/he feels."*. One participant mentioned, that it would be better to have shades of colors (with different saturation) and a neutral element: *"To have shades would be good - a circle with neutral in the center and more intense the further you get to the edge"*.

Some users forgot what color they had chosen in the beginning of the study for the matching mood or wanted to use the color to express something different: *"I had chosen purple to express a negative-passive mood, but later I felt I would like to use this color to express a relaxed and happy mood."* and *"I forgot what I had chosen in the first place. I find it difficult to associate the colors with the correct mood expression."*

5.2.4.10 Overall Usage & General Concept

Most participants liked the idea to input their mood during the day either for themselves, in the sense of a diary, or as an enhancement of their day to day communication with others *"To use for communication without many words I would really like to use this."*. One user compared the input methods with the use of emoticons in modern chat applications: *"Moods are important parts of nonverbal communication, like emoticons.*

Without emoticons, messages are often missing context information and people might misinterpret it." It was mentioned, that the use of a combination of scales, would allow to express a wider spectrum of moods. However, some users did not like to use a scale to express moods: *"Overall I can imagine that this is suitable to use for therapy purposes. I would not use this in my personal day to day life."*. One participant mentioned, she does not keep track of her moods regularly, although it would be nice to see the moods in retrospect.

5.2.5 Discussion

Using an intuitive input method for daily mood sharing – especially in-situ – is an important aspect in the usage of such systems. Our user study showed that the participants had problems using the color input, because the matching of colors and moods were not clear to them during the study. Although we have simplified the input with color to only four possible selections, users still were confused about the mapping of a color to an associated mood. Further, it seems that the interpretation of a single color with regards to a complex information like mood is complicated for the participants. However, it might be more suitable to express one's mood with colors, when being able to select from a larger set of colors or even multiple colors at once.

Most participants rated words and pictures as the best way to express themselves. Based on the study results and the feedback we got from the participants, we assume that the expressiveness even increases when using personal pictures and personalized sets of emotional words for the input. The use of predefined pictures and words can be a way to assist novice users, so they can start right away to input their mood. However, applications should provide a way to personalize the input over time e.g. upload personal content, remove unwanted items. We also assume, that the use of a combined method for the input of mood can increase the expressiveness for users. This can be found in existing messenger application e.g., WhatsApp [2], Snapchat [3]. In these applications, users are able to share pictures, text, or a combination of them to express feelings, moods, and situations.

To foster communication and engage people to share their moods regularly with loved ones, it is important that the use of an input method is based on a positive user experience. Although the use of emotional words was measured to be the fastest and rated the most expressive way to input a user's mood, it also was perceived to be less engaging than other methods. Some users mentioned that words are simple and easy to interpret, but also that they are not that attractive. One interesting question would be, how users would perceive the use of emotion words, when they would be able to use personalized words or combine multiple words to create artificial mood-words that are able to describe their manifold feelings. Compared with the emotion words, the use of pictures was perceived as more engaging and fun. Some participants mentioned that they liked to browse the

[2] https://www.whatsapp.com
[3] https://www.snapchat.com/

pictures for a longer time, especially when they had time and nothing urgent to do.

One limitation of the study is, that the input was used for a rather short period of time. We will investigate deeper into preferences in a follow up study, using the most promising methods to input mood.

5.2.6 Conclusion & Future Work

This chapter presents results from a study to compare four different in-situ input methods on mobile devices. We compare these methods based on: intuitiveness, inconvenience, speed of input, everyday use, expressiveness, and suitability.

An input based on pictures using the PAM model, was rated as enjoyable and interesting but at the same time is the most time consuming method. Using the SAM method to select a mood was mentioned to be relatively vague and restricted to a small set of moods. Participants mentioned for multiple methods, that it would be even more suitable and enjoyable to select a mood, when they could use personalized inputs for the application. Further, qualitative feedback revealed, that it is advantageous to support multiple dimensions to express mood. This is due to the complexity of mood, as well as the different needs for people in different contexts. In some situations, user enjoy to take their time while with others the input has to be as precise and fast as possible. Further interesting questions would be: 1) how users would perceive the use of terms, when they would be able to use personalized terms or combine multiple terms to create artificial mood-terms that are able to describe their manifold feelings and 2) to what extend mood input can support the use of existing messenger system, where text is the mainly used element for communication.

5.3 Tangible Storytelling Kit for Exploring Emotions with Children

5.3.1 Motivation

A child's ability to accurately perceive, express, and regulate emotions is correlated with positive outcomes ranging from better social relationships with family and peers [MSR11, CPBB92] to increased self-control and cooperation skills [IFS+01]. In contrast, the inability to express and perceive emotions in a healthy manner has been associated with hyperactivity, depression, anxiety, and a feeling of loneliness in children [MSR11]. Thus, helping kids better understand emotional states is crucial for their individual development.

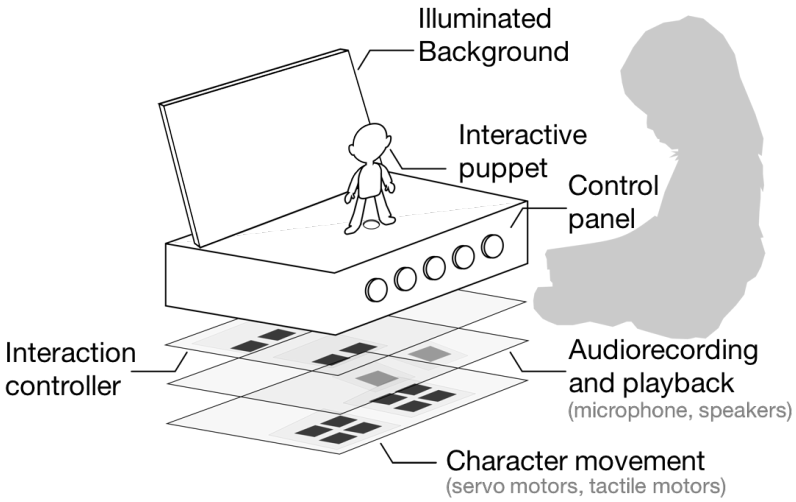

Figure 5.3: A tangible storytelling kit with interactive elements for exploring emotions with children.

Culturally, storytelling has been a powerful method to communicate emotions, values, and social skills [Gol98]. Most parents already know about the benefits of reading bedtime stories to their children. A notable advantage of this practice is that it also helps kids better understand other people's thoughts and emotions in a variety of social contexts [RN07, BSDA09]. To support storytelling, researchers have developed a wide range of interactive technologies, including Family Story Play [RBR+10b], to support storytelling for children and grandparents over a distance; Bear-with-me [FAF13], enabling the exchange of tangible emotional expressions; iTheatre [MCP09], an interactive system to create stories using handpuppets; StoryRooms [ADM+00], allowing a room-size immersive storytelling experience. In our work, we specifically explore how we can support the parent-child storytelling practice for teaching emotions through a tangible interactive kit that can be personalized for different stories. The particular contributions of this study are:

1. A preliminary design of a tangible toolkit to support emotional storytelling between parents and children (Figure 5.3).

2. User study results that identify the needs of parents and children, and how the toolkit could potentially help explore emotional situations.

5.3.2 Related Work

Interactive storytelling can be a powerful tool to engage children as authors and favors free expression, creativity, and fantasy play [Gol98]. Storytelling technologies have had a long rich history both in HCI and in industry, and a variety of interactive approaches for engaging children with stories created by others as well as creating their own personal narratives have been explored. Commercial software applications include interactive books (e.g. TipToi [4]), computer games, and flexible authoring tools (e.g. StoryMaker [5]). Additionally, toy designers have used playful plush characters (e.g. Kimochis [6], Meebie [7]) to help children convey and explore emotions. Despite their popularity, these approaches have typically considered children as "story consumers" offering somewhat predefined experiences.

In contrast, research approaches have favored free expression and creativity by engaging children as story authors. For young pre-literate children, physical spaces with familiar objects have been used in the story telling process [ADM+00, CR01]. Physical envoironments, created to explore stories but also to author and share stories such as KidsRoom [BID+99] and StoryRoom [ADM+00] have been presented. PageCraft by Budd et al. [BMSW+07] was developed to support narrative development for children. It provides a transition from physical objects to digtial media content. Through this multi-sensory environment kids are able to share narratives with caregivers and friends.

Stuffed toys have also been employed to aid in storytelling in various ways. Besides their tangiblity, these objects have the advantage of being able to express emotions or play active parts in a story. The expressive nature of the toy can either be predefined or designed by the child. Examples of previous works include SAGE [BC98] and PETS [DMH+99]. SAGE presents an authoring environment for children to create their own stories. To encourage children's engagement, the storytellers are embodied in an interactive stuffed animal. PETS provides kids with a modular robot set, to build personalized pets and in turn use these to narrate stories.

Previous works show that the process of authoring interactive stories in a colloborative context is associated with substantial benefits [CB00, DBGPS09]. Collaborative storytelling can be supported by authoring tools either within a shared physical space or in a virtual environment. These authoring envoironments aim to involve kids into synchronous collaborative storytelling by providing various functionalities like drawing,

[4] https://www.tiptoi.com/start/index.html; last retrieved: 03-24-2017
[5] http://www.abcya.com/storymaker.htm; last retrieved: 03-24-2017
[6] http://www.kimochis.com/about/what-are-kimochis/; last retrieved: 03-24-2017
[7] http://www.orkidtoys.com/; last retrieved: 03-24-2017

Figure 5.4: Interchangeable emotional faces based on work by Ekman [Ekm92] and complementary characters and objects

typing, and hyperlinking content. KidPad [DSP+97] provides a 2-dimensional space for collaboration, while StoryMat [RC99] and POGO [DR02] foster a more playful partnership using a playground metaphor. Virtual environments to collaborate over a distance have been explored in FaTe2 [GF06] and PUPPET [MRS02]. FaTe2 enables children to collaborate in play and storytelling using a virtual space, while PUPPET is a virtual environment that allows children to play multiple roles in the creation of stories.

5.3.3 Methods

Fundamentally, our goal is to explore the broader design space of tangible interactive storytelling, particularly as a tool that could be used between parents and children. As such we used our implementation as a probe to elicit feedback from both user groups and involve them early in the design process. The prototype served as a focal point for critique that highlighted possibilities and explored interaction mechanisms with children.

5.3.4 Exploratory Prototype

Our interactive prototype (Figure 5.5) consists of a base platform that houses characters, background scenery and accompanying scene elements. The main character of the story is represented by a male or female figure. The figure can move its arms and legs, can shiver, and has interchangeable facial expressions (Figure 5.4). The expressions are based on the basic emotions defined by Paul Ekman [Ekm92]. We acknowledge that some of these expressions might be too subtle for children to identify, but we wanted to

Figure 5.5: Interactive diorama for supporting affective storytelling with children.

have a standardized starting point for our work. Additionally, it is helpful to determine the most troublesome emotions faced by children. To support verbal expressions and ambient sounds, we included the option to record and replay audio.

The scene background can be interchanged to reflect different environments. For example, in our evaluation, we had backgrounds for a kitchen, a playroom, and various forests. The actual background is printed on a transparency (used commonly with overhead projectors) and affixed to an acrylic sheet. Therefore, to create custom backgrounds, all that is needed is a common desktop printer. An RGB LED strip was used to better illuminate the background and to perhaps reflect mood. For example, a light green color in a forest background might be used to reflect a positive mood.

The prototype is approximately 30 cm (length) x 25 cm (width) x 30 cm (height) and contains various buttons and potentiometers on the front panel to control characters, scene audio, and background colors. The electronics used to support these interactions are housed beneath the base platform. Our goal was to make the prototype as flexible and easy to use as possible so parents and children could potentially craft scenes themselves using commonly available equipment.

5.3.5 Study Design

The study consisted of a background questionnaire, a semi-structured interview with the parent(s), and a usability session with the child. In the semi-structured interview, we asked parent(s) to describe their child (e.g., personalities, introverted or extroverted), their joint practices for exploring emotions, and any difficulties or issues they faced in

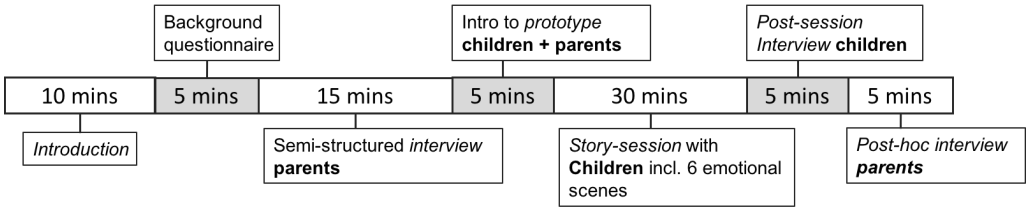

Figure 5.6: The story-session study plan for children and their parents. Each session included interviews with parents, story-reading sessions with children and post-hoc interviews.

nurturing healthy emotions in their children. During the usability session, we introduced both the parents and the child to the prototype, followed by an explanation of how to move the main character, adjust scene colors and record sounds. We used a neutral scene for the introduction and to help children become comfortable with the prototype. We also explained all the complementary characters and objects. A more detailed timeline of the study is shown in Figure 5.6.

To facilitate interaction, we then read a pre-constructed story line with six scenes where each scene was associated with a specific emotion. The six emotions included anger, happiness, sadness, surprise, disgust, and fear. A brief description of the six scenes is given in Table 5.2. After every scene, we asked each child if s/he wanted to change the scene in anyway by using the controls or manipulating the face of the character. To gauge children's responses, we used a form of contextual inquiry as described by Allison Druin [Dru99], where one researcher served as the *interactor* and another took notes. The *iteractor* initiated discussion and asked questions while the child was using the prototype. We used this method to prevent children from feeling like they were "on stage" and to facilitate natural feedback.

5.3.6 Analysis

We analyzed the gathered data from the contextual inquiry with two other HCI researchers from our lab. As a first step we summarized notes taken during the studies. We then used a two-step coding process beginning with basic coding to distinguish overall themes, followed by a more in depth interpretive coding to identify specific patterns within the data. As a last step, we compared the data collected from the parents interviews with the children's actual behavior.

Participants

The understanding of emotional situations and facial expressions improve with age. Between preschool and elementary school, children gain most for their emotionally expressive capabilities [PW91, VHV12, WF82]. Starting around the age of five, children can describe and understand basic emotions [Bor73]. By age seven they are able to describe even more complex emotions such as guilt and shame [GHNJ03]. As a result, we fo-

#	Scene description	Emotion
S1	The main character is playing in her/his room with different toys. She/He would like to get a new wooden horse to play with and approaches her/his mom to ask.	Neutral
S2	The mom explains that the new toy is expensive and that they would have to save money to buy it in a couple of weeks. The main character however is impatient and wants to get the toy now. She/He screams her/his dissatisfaction and leaves home towards the woods.	Anger
S3	The main character arrives to a beautiful, sunny forest. She/He interacts with a friendly squirrel who comforts her/him and offers her some hazelnuts.	Happiness
S4	While walking through the forest, she/he encounters three monkeys who she/he wants to play with. They, however, make fun of her/him and pelt her/his with acorns.	Sadness
S5	She/He escapes the monkeys and wanders the forest hungry. She/He then encounters a small bird and asks the bird for some food. The bird flies away and returns with a big brown worm for her/him to eat.	Disgust
S6	The forest gets darker and colder and the main character is having trouble finding her/his way home. She/He can hear wolves howling in the distance and she/he re-evaluates whether it would have been better to wait a couple of weeks for the new toy.	Fear

Table 5.2: Brief scene descriptions from the story. The story has a happy ending, with the main character getting back home. The day transitioned from afternoon to late evening over the six scenes.

cused on children between the ages of 5 and 10 since they have the most potential for exploring emotional storytelling. We recruited 7 parents and their 6 children aged between 5 to 9 years. The study described in this chapter was approved by our institute's ethical board. Participants received a 10 € Amazon gift card for their time and effort.

5.3.7 Results

Emotional Habits and Behaviors

The majority of children in our study were described as extroverted by their parents; only one girl (C6 [8]) was reported as introverted. Parents found that their child was typically better at expressing clear and simple emotions such as happiness and sadness rather than more complex emotions such as embarrassment. Stressful life events were also described as harder to handle for children. P2 highlighted, *"Strong emotional situations she can't really handle now, such as a relative dying or divorce."*

Parents described a variety of methods their children used to express feelings. These included gestures (hugging, cuddling, shrugging), facial expressions (smiling, frowning, crying), mimicry, body movements (moving closer to a parent, walking away), posture (holding one's knees), verbal communication, and physical actions (hitting, scratching, jumping, throwing). Although this list seems comprehensive, children had varying levels of success in employing these methods; parents still had trouble interpreting their child's emotional state. Perhaps the biggest difficulty parents faced was their child's inability to verbally communicate his/her negative emotions. P1 commented, *"When she (C1) is really sad, she stops herself and doesn't show how sad she really is."*. Another father (P3) added, *"Sometimes he (C3) gets sad, and we really don't know why"*. Some parents also misinterpreted their child's emotional state due to confusing signals from the child. For example, P1 reported, *"Sometimes she says she is hungry when in reality she actually is really tired"*. Another mother (P4) remarked about her child's tendency to exaggerate her emotions, *"Sometimes [C4's] emotions are overly extreme for the situation. She is impatient and has trouble waiting."* With a few children, this inability to express negative emotions in a positive manner resulted in unhealthy behaviors such as pinching (P6, C6) and throwing objects at pets (P5, C5).

Practices and Routines

Parents mentioned a variety of practices to help their children express emotions more easily. These practices included crafting, reading, playing, taking a "time-out" or playing with pets. These routines differed depending on the temperament of the child. One mother (P1) commented how her daughter (C1) used coloring and drawing as an emotional outlet instead of a teddy bear. In contrast, P2 mentioned that her daughter sometimes *"played with a plush toy or puppet"* during difficult times. Similarly, one girl (C4), sought the comfort of the family dog when she was sad.

[8] We employ the prefixes C and P to identify children and parents in this study (e.g., C1, P1)

Another theme that emerged was children's natural tendencies to take a time-out when they were feeling insecure or unhappy. These time-outs sometimes involved staying quiet and "hiding behind mom" (P5, C5), or spending time alone by the swing till the negative emotion(s) passed (P4, C4). P3 remarked on a creative time-out utilized by his son, *"Sometimes he builds himself a cave with chairs and bed sheets to hide in. It needs to be dark and the maximum light allowed is a candle."*

With respect to teaching children about emotions and moods, parents reported that children learned about these issues from day-to-day experiences with other adults and children at school. One parent (P4) noted how her child (C4) often asked her explicitly about *"why a person feels a certain way based on a particular situation."* Half the parents also discussed the use of picture books and storytelling to explore emotions both actively (i.e., books that specifically explore emotional situations) and passively (i.e., books based on a plot with natural emotional arcs).

Figure 5.7: Children re-creating scenes based on the storyline.

Interactive Storytelling

We found children quickly adapted to our electronic prototype and our scene based storytelling approach (Figure 5.7). Although kids were initially shy, they grew more comfortable as the study continued. Overall, the electronic kit was favorably received by

the children, with four out of six children completing all six scenes of the story (Table 5.2). One girl finished only five scenes and another girl utilized our toolkit to create her own story after the third scene. Regardless of the completion rate, and perhaps more importantly, we found children engaged during the storytelling process.

Kids actively identified themselves with the interactive character and often spoke on behalf of the puppet during the scenes. For example, during scene two, C4 audio recorded her angry response to the fictitious mother, *"I will not say anything! I'm really angry because I do not get a wooden horse, and I will not apologize!"* She was also the participant who veered off script on the third scene and remarked, *"I like recording everything and I want to tell my own story."* In the subsequent self-constructed story (which involved all the kit's characters) the main puppet's wish for a wooden horse was satisfied by a magical friend of the bird. Children also stopped us naturally during different scenes to exclaim their insights. For example, during scene four, one girl (C5) interjected, *"It's not raining acorns. It's the apes!"*

With respect to specific prototype interactions, changing the facial expression of the main character was utilized by all children to reflect the emotions portrayed in the story line. Not all emotional faces however, were successfully interpreted. The neutral face was often replaced with the happy face on the first scene. Moreover, we had to clarify the emotional faces for disgust and fear for half the children in the study, even though they understood the concepts.

When expressing negative emotions like sadness, anger, fear or disgust, children often utilized the vibro-tactile motors to make the character shiver. One girl (C1) self-affirmed her decision to turn it on with, *"..because the apes are mean to her and she is alone."*. C2 also mimicked the physical shivering of the main character during negative emotions. For some children, shivering was used to reflect the cold environment of the story. While the vibro-tactile motors were primarily used to express negative emotions, the arm and leg movements of the character often reflected both positive and negative emotions including surprise, anger, and happiness.

Audio recordings were used to augment the story line in a multitude of ways. Some children used it for narration and to repeat the events of the scene. For example, during scene four, C6 exclaimed, *"The monkeys are laughing and the nuts are falling on Emmas head!"* Similarly, C3 recorded his future aspirations for the story, *"Hopefully the monkeys will not return."* In other cases, kids used recording as a way to describe a character or situation in more detail. This included noises such as *"Ewww"* to express disgust or animal sounds (e.g., bird chirping, monkey gibber). One girl (C2) creatively used a candy wrapper to record a rustling noise in the dark woods.

While children successfully used different scene backgrounds as the story progressed, the use of background colors was inconsistent. We had expected children to vary the colors of the RGB LED strip based on mood, but we observed no pattern to what color they chose. Some children used shades of blue for negative emotional situations and green for positive scenes, but they did not have any reasons for their choices. For one participant (C3), the background color was correlated with time. He reflected, *"The*

color does not say anything about [characters name], it just shows the time of the day".

At the end of the usability study, we received positive remarks from the children regarding our prototype. Comments such as *[C3]: "Reading stories like this is fun!"* or *[C2]: "This was a lot of fun"* were common among the participants. Likewise, the parents, who had been observing the process, commented on the usefulness of the tool. One of the parents (P2), who used traditional picture books to explore emotions with her child, mentioned, *"This is a really good idea and it would be an interesting tool."* Another parent observed how the puppet accurately reflected her child's behaviors. P1 remarked, *"My girl showed the same behavior with the puppet as she would in real life."* According to one mother, this ability to identify with characters and mirror emotions through interaction was considered critical for children suffering from adverse life events. She (P5) reflected, *"I know a girl whose parents got divorced and this would be very useful for the child."*

5.3.8 Reflections

Having described both the design of our storytelling prototype and the results from our initial pilot test, we can now take a "step back" and take stock of the implications of this (admittedly still early) work. In this section, we reflect on the boarder technological questions in exploring emotions with children by using our device as a springboard for discussion.

Mediating Children's Emotions

Parents' awareness of their child's inner feelings strongly relies on parental inferences and what the child is willing to share, especially with respect to less observable issues such as sadness and anxiety. Research has consistently demonstrated the difficulty parents have faced in accurately recognizing and the reporting these internal issues [SL93, KK93]. This was also confirmed in our first hand interviews with the parents. The majority of parents in our study faced various issues in understanding the emotional state of their children at some point in time. This problem is particularly salient with negative emotions since children often expressed these emotions in physical ways (e.g., screaming, stomping). In our approach to this problem, we augment the culturally accepted practice of storytelling with a tangible, interactive toolkit. Early results indicate a promising ability of youngsters to effectively engage with our prototype. For example, C1, who was described by her mother as irresponsive when sad, utilized the vibration motion to express sadness in the puppet. Although, this example is not reflective of a real world scenario or how she actually felt at the time, children could potentially use these different feedback modalities to express their internal state. Technology, in this case, can be used by a child to confront what may be too painful or difficult to express otherwise. By telling a story with these interactive props, children can "play out" their feelings just as an adult may "talk out" their difficulties with a therapist [Coc96]. We see our own tangible storytelling kit as an encouraging step in this regard.

Flexible Artifacts

Broadly speaking, we see our tangible interactive kit as an approach toward allowing emotion-based storytelling to blend with personal expressions. Although we created a specific story line with accompanying elements and accessories, we never envisioned this idea to be associated with any one specific device or story. Rather we can think, more productively, in terms of designing multipurpose artifacts in service of an unbounded range of stories. This concept drives against the "one size fits all" tendency and aims to give children more expressive control over their environment. Using a candy wrapper to record a rustling sound in the woods (as C2 did) is exactly the type of engagement and customization we seek. Ultimately, the flexible nature of the story kit would give children control over how they express their emotions. This is important because children have very different ways of dealing with their emotions from building a bed-sheet cave (C3) to spending time on the swing (C5). Moreover, for some children (like C4), this kit could provide a means to explore emotions through their own self-constructed stories. There is however, a trade-off here between leaving children free to create their own stories and guiding them towards emotional expression especially since our goals are to engender healthy emotional outcomes.

Choose Your Own Adventure

One approach to striking this delicate balance between an open-ended story crafting kit and a guided one is to adopt the style used by popular "Choose Your Own Adventure[9]" gamebooks. In these books, the reader (the protagonist) takes on a role relevant to the adventure such as private investigator, doctor or spy and makes choices that determine the main character's actions and the plot's outcome. Many children enjoy these books partially because they feel like they are in control of the stories [Con15]. An interactive and tangible version of this kind of book could explore different emotional situations. The child could chose both positive and negative emotions at various points in the story and see the resulting emotional consequences. For example, choosing to be angry could put the main character in unfavorable conditions. The tangible kit approach is ideally suited to recreating these kinds of stories, especially since various aspects of the characters and scenery (e.g., interchangeable background) can be changed. Ryokai et al. explored a similar concept where children video-recorded facial expressions that became part of an ebook's illustrations [RRK12]. By turning children's facial expressions into manipulable elements, they provided a unique point of entry for engaging children in constructing their own narratives. It gave children an opportunity to collaborate, play, and reflect on their pretend stories. Our own work can be seen as a more tangible and emotional extension of research in this space.

[9] https://www.cyoa.com/; last retrieved: 05-20-2017

5.3.9 Limitations

Our tangible storytelling prototype is still in a relatively nascent stage: it only accounts for a few scenes and is limited to a single main character. Moreover, it only supports a limited subset of interactions for expressing emotions through characters. However, we see our prototype as one possible implementation in the larger, burgeoning ecosystem surrounding tangible storytelling toolkits. Another possible limitation of our approach is the use of Ekman's facial expressions in our design. It could be argued that many of the facial cues and advanced expressions, such as fear and disgust are very hard to recognize even for adults. While this may be true, we did not really observe children mixing these emotions or interpreting them incorrectly; children simply did not use the emotions they did not understand. We used Ekman's expressions as a starting point in our design rather than a definitive solution.

It is hard to generalize our results based on a limited sample size, but for exploratory work, we found it valuable for getting rich qualitative data. Lastly, we acknowledge that instead of parents telling the story to their children as intended in later usage of the device, the story was told by one of our researchers. At this early stage, we wanted to explore the overall concept of tangible storytelling with children and their parents, to further refine the design and implementation.

5.3.10 Future Work And Conclusion

This chapter explores a new tangible storytelling kit for exploring emotions with children. Our findings show that children between the ages of five and nine were able to successfully recreate scenes from a pre-constructed story and even create their own personal narratives using our prototype. The different feedback modalities helped children to express emotional situations tangibly and reflect on their own emotional state. While some of the output modalities could not be associated with emotional expressions, we found others that were used frequently to express the mood of the main character .

We found that our participants had different methods for dealing with their emotions, and families had various routines and practices for supporting these differences. In future work, we aim to generalize the kit to be used for stories created by either children or stories that occur in day to day situations. Therefore, we will build on our results and design a modular kit, which gives the opportunity to craft characters that are part of stories.

Designing technology to support a child's emotional growth is challenging, especially since they are still learning and exploring. Parents often misinterpret their child's internal state and find themselves at a loss on how to help their child. Tangible, interactive storytelling has the potential to act as a mediating artifact to enhance the already existing practice of storytelling between parents and children.

5.4 Chapter Summary

In this chapter we investigate designs to enable users to better express, exchange and understand feelings and emotional states with and from others. This is especially important when using technology to keep in touch over a distance. The ability to express and understand emotions and moods of loved ones has a strong influence on the feeling of closeness and the quality of a relationship (see Fundamentals: Self-disclosure and Self-revelation). In a first study, we research existing methods of mood input when using modern smartphone applications to stay in touch. We reveal advantages and disadvantages of different input-mechanics and describe user preferences. We collect guidelines that will enrich the development of future applications and will fit into a users day to day life and allow users to express their current mood easily and sufficiently. In a second work, we have examined an approach to support young children to build emotional intelligence, understand emotional situations and learn the ability to express emotions to others e.g. their parents. We have presented our design concepts and its implementation as well as results from a field study with young children and their parents. We further have discussed possible impacts and future directions in this work.

6 Conclusion

This thesis is set out to investigate and understand the requirements, design rational and implementation of awareness technologies to enable families and friends to feel close and aware of each other, while living over a distance. We aim to understand how families use technologies to share experiences, to express moods and emotions and how they keep in touch by involving each others in daily activities. We present insights from three main themes of connectedness:

- The design and use of technologies to create awareness of activities between loved ones living apart.
- Designs and engaging interactions that foster the exchange of experiences from life moments with loved ones.
- Technologies to support users to express their emotions and exchange them with people surrounding them.

We explore different designs to support, foster and maintain these acts of connecting, based on these insights. We aim to understand how technologies can be designed to be inclusive and simple to use. Further our goal is to research perception of these technologies with regard to user experience, acceptance and the possibility to share experiences, moods and activities with others. Following, we revisit the research questions, that we have raised and summarize our results.

6.1 Summary

Social awareness solutions, based on research in social interaction and communication technologies, have the goal to connect people over a certain distance and create a sense of being connected and close to the other person or group of persons while physically distant from each other. They aim to support and foster our expressiveness and willingness to share and participate in activities with loved ones. While a feeling of belonging is an important part of our life as well as of our mental and physical health, awareness and communication technologies should prevent us from feeling overwhelmed and obliged to interact. The overarching goal becomes a pervasive and unobtrusive support for awareness and communication that provides a feeling of connectedness while at the same time ensures the users privacy. In this thesis, we show approaches that are suitable for designing and implementing technologies that aim to fulfill these requirements.

6.1.1 Awareness of Activities

In Chapter II of this thesis, we focus on the awareness of activities between users living over a distance. We present two artifacts to enable people to share their day-to-day

activities and create a sense of closeness. We investigate the following questions:

Research Question 1 – How do users interact with awareness devices conveying activity-based information, and how should this impact future designs of such systems.

In a first lab study, we aim to understand users willingness to share these information, the ability to interpret activity-based information and the acceptance to share these with close people. We presented requirements and results for the design of a smart furniture to convey information about day-to-day activities, presence and moods of a beloved one. We proposed the design of an ambient light display integrated into a smart table to exchange activity information between people living over a distance. The encoding of activity information is based on results from a user-centered design process conducting semi-structured interviews and design sessions. We found that sharing and receiving information about the activities of a beloved one is a joyful experience and can lead to more engagement in verbal communication. Our participants reported the use of the device to be a fun experience and a playful way to express moods and day-to-day activities. Participants reported that they were able to identify how the communication partner feels and to express themselves respectively. Our analysis showed furthermore that the interaction does not feel too obtrusive to users, as most of the interaction happens casually through activities on top of the table. While we received predominantly positive feedback with regard to ease of use and support for awareness, the primary limitation was the use of RemoTable within a lab study. To understand the effects of awareness on a relationship, it was necessary to move on to a second step and bring these technologies into the life of people and their loved ones. In following field studies, we investigated the effects of such *minimal communication* on social connectedness, the use of such awareness technologies and the behaviors of users. With this field research, we aim to understand:

Research Question 2 – Which information can help people to create a sense of a close person's day-to-day life while taking privacy of communication partners in mind.

To understand this, we present results from a case study, in which we explored implications of a design in how *minimal communication* technologies are used in everyday life. We conducted a field study with people that used SocialFlower for about two weeks. Using a fitness tracker, participants were able to share their physical activity with a connected partner. We conducted semi-structured interviews with all participants with regards to usage support for social awareness and user experience. From our analysis we found that users enjoyed interacting with the artifact to get in touch with a connected person throughout the day. By sharing a simple information such as physical activities, we found that users were able to get a sense of a loved one's day-to-day schedule. We observed the importance of aesthetics and simplicity of information encoding, when designing interactive artifacts that are supposed to visualize data in the peripheral. Even a simple encoding of only two information can be misunderstood, if not designed correctly. The analysis of our results further suggest the importance of a clear mapping

between the visualized information and possible metaphors. When using a floral design for our prototype, users did understand it as a *gift giving* act e.g. bringing flowers when visiting someone or did not agree with the metaphor of matching flowers with activities. As an important result, we found many users to re-purpose objects to use them for different tasks then originally intended. Our intended interaction to start off conversations by sending a *greeting* was used as a more multipurpose button to encode very different information. The results suggest that minimal information about a persons day-to-day activities can be sufficient to design awareness technologies that, at the same time taking users privacy into account. However, we further state that this is true for relationships that are already close and might not work for superficial relationships.

6.1.2 Exchange of Experiences and Memories

In Chapter III we explored technologies to foster the exchange of experiences from life moments. We presented approaches to enable all members of a family to share and reflect on experiences of others. In this chapter we asked:

Research Question 3 – How can technology support sharing of experiences within families in an inclusive, engaging and simple way.

In a first field study with three families, we investigated how the exchange of pictures form life experiences affects the feeling of closeness within families. We further explored different software-based designs to share and involve others in day-to-day activities. We conducted semi-structured interviews, using predefined questionnaires and collected diaries from each user. In addition, we have used the *Affective Benefits and Costs of Communication Technologies* questionnaire by Yarosh et al.

Our analysis showed that most pictures have been shared with everyone from the family. Participants enjoyed watching the stream of pictures passing by and perceived the SocialWall as an unobtrusive link to their loved ones. We found that the usage of direct speech via phone increased by about a third and personal visits (if possible) nearly doubled. Our participants mentioned that the exchange of daily experiences was much faster than usually and used the photo-stream as a reason to get in touch. The exchange of pictures within the family resulted in a feeling of closeness and being connected. Similar to other prototypes, users did not feel to have *unwanted obligations* when using the system. As our system allowed users to follow the filtered photo-stream of others, some mentioned that this might be privacy intrusive and should be designed with care.

Based on the positive results from our first investigation with families in the field, we designed a follow-up study that aimed to research the design of a tangible artifact for sharing experiences and messages between grandparents and grandchildren. In these two following studies we aim to understand the use behaviors, motivations and inclusiveness as well as user experiences and simplicity of sharing experiences and memories.

We recruited six groups of families with grandparents and grandchildren living over distances between 5 to 300 kilometers. The studies included three semi-structured inter-

views per family. Before the evaluation we interviewed the participants regarding their existing familial relationships, their experiences with communication technology and communication patterns. We conducted interviews with the families in the middle of the study and at the end. We asked participants questions regarding the content they shared and its purpose, the influence of StoryBox on the connectedness among the family members and their overall experience with the system. We further analyzed and categorized shared content for all families.

We found that the lightweight and flexible nature of StoryBox helped children to easily share daily artifacts from their lives. This supports a naturally playful and often creative way of communication with a high level of individuality. Enabling free expression in this context engages interaction within a grandparent-grandchild relationship. For older adults, StoryBox provided a simpler, larger interface with just a single purpose at a time. Therefore grandparents were more inclined to regularly monitor and share messages via the device. Our analysis showed that it is important for grandparents to have a personal sense of intimacy with their grand-kids while children enjoy to express themselves on their terms. We state that technology should foster this notion of *making as a form of communication* to offer a view into a child's or grandparent's world and create intimacy and personal connectedness.

With StoryBox, we have designed a device that tries to bridge the technological gab between generations. We found that StoryBox provides an interface for sharing non-digital content such as old printed photos. This is particularly important considering that for many grandparents, memories are not purely "virtual", they often have accompanying physical artifacts that enrich their own sense of narrative history. With a manual and analog input mechanism, technology could be seen to facilitate a level technological "playing field" for user groups from different generations.

6.1.3 Exchange of Moods and Emotions

In Chapter IV we investigated designs that enable users to express, exchange and understand feelings and emotional states.

Research Question 4 – What are suitable techniques for in-situ input of emotions and moods and what are advantages and disadvantages of these method with regard to future designs.

We explored different models to express and input moods and emotions for adults on smartphones. In a field study, we compared these methods and research differences with regard to *intuitiveness*, *inconvenience*, *speed of input*, *everyday use*, *expressiveness* and *overall suitability*. Participants entered their mood at least every 45 - 60 minutes. Every input method was used four times per day of usage. Participants tracked their daily moods using a smartphone application, which reminded them to do so regularly. We conducted interviews and collected questionnaires from each participant.

From our analysis we found users to struggle with the use of color to express emotional

states as color does not match with emotions consistently. However, it might be more suitable to express one's mood with colors, when being able to select from a larger set of colors or even multiple colors at once, instead of restricting the selection to one specific color. Additionally, color might work in combination with other modalities, to create a more manifold representation of ones emotional state. As we found in our study, pictures and words are an excellent way to express emotions. Based on the participants feedback, we further state that expressiveness even increases when using personal pictures and personalized sets of emotional words. In addition we state that the use of a combined method for the representation of mood can increase the expressiveness for users.

To foster communication and engage people to share their moods regularly with loved ones, it is important that the use of an input method provides a positive user experience. This can be achieved through pictures or combinations of modalities, when designing applications. As we found participants browsing trough the available pictures, this might even increase the time spend by users within a application.

As a second step, we wanted to explore technologies to support children to learn and understand emotions. As children often struggle to understand or express emotional states clear enough, we aimed to provide children a tool, to better learn about emotional states themselves. We presented a design of a tangible toolkit to support emotional storytelling between parents and children and studied its use, expressiveness and multimodal in- and outputs with parents and children. With this work we aimed to explore the following research question:

Research Question 5 – What are needs of parents and children for technologies that could potentially help them explore and understand emotional situations and what are possible designs to support these needs.

The conducted study consisted of a background questionnaire, a semi-structured interview with the parent(s), and a usability session with the child. Our findings show that children between the ages of five and nine were able to successfully recreate scenes from a pre-constructed story and even create their own personal narratives using our prototype. The different feedback modalities helped children to express emotional situations tangibly and reflect on their own emotional state. While some of the output modalities could not be associated with emotional expressions e.g. colors of the environment, we found others that were used frequently to express the mood of the main character.

We found that our participants had different methods for dealing with their emotions, and families had various routines and practices for supporting these differences. We augment the culturally accepted practice of storytelling with a tangible, interactive toolkit. Early results indicate a promising ability of youngsters to effectively engage with our prototype. Children could potentially use different modalities to express their internal state. Technology, in this case, can be used by a child to confront what may be too painful or difficult to express otherwise. By telling a story with these interactive props, children can "play out" their feelings. When creating such technologies, designers need to keep in mind that children behave and learn very differently. Creating multipurpose artifacts can drive against the "one size fits all" tendency and aims to give children more

expressive control over their environment. Our tangible kit approach is ideally to recreate various kinds of stories that might follow different paths dependent on a child's behaviors. Our own work can be seen as a tangible and emotional extension of research in the space of engaging children in constructing their own narratives.

6.2 Reflections and Future Directions

We started this work by looking at the current state of technologies and research to connect loved ones that live apart from each other. Within each main chapter of this thesis that explores relatedness from a different perspective, we review prior works and concepts that support people in various ways with staying in touch. Based on these works, we have designed and implemented technologies that try to explore user behavior and help us to understand the mechanics that help people to feel as an essential part of a social group, even though they can not be physically present at all times. One major part of our investigations is to evaluate concepts and prototypes in real world applications.

We look back on around three months of field evaluations for the designs and prototypes we have developed. In each study, we have closely worked together with our participants to match their needs as good as possible. We gained close insights into practices of families, who maintain their relationship over longer and shorter distances, we were able to listen to older people and their often overwhelmed views on technologies in their day-to-day life and we were able to get a glance on the world through the eyes of children, who can provide the most unbiased feedback. By working together, but even more by informal talks and discussions, we have learned a lot about people's needs and their problems with modern communication means.

We mainly based our investigations on a research through design approach that allowed us to take existing knowledge from various research fields into account and validate this models and methods with users in their private life environments. Our insights contribute information for three different research areas. First, we provide information about requirements and design recommendations for sharing experiences, like new stories and old memories, interaction designs to share and express moods and emotions in new ways and creating awareness about a distant person through common activities. Second, we provide insights into needs and current practices for families when having to keep in touch over a distance, usage and communication behaviors for various users of awareness technology and empirical results with regard to different interface modalities. Finally, we link back detailed insights into the social lives of families and effects of technology for awareness on the relatedness between them over a distance and provide results that explore effects self-determined communication for children and grandparents.

Although we chose a research approach that suits the real world needs of people, we can't give definite answers to all the questions that have initially been raised. When designing technologies for such diverse user groups, it is impossible to cover all aspects that influence the needs and behaviors of our users. Requirements may change

due to different and non-static life situations, preferences depending on persons current interests and technical competencies. Designing technologies for remote relatedness is challenging and considered a delicate matter: "detailed insights into how technology can and will support couples in everyday life to be urgently needed [...]. Consequently, the next wave of couple technologies must become more sensible, more subtle and more realistic." [CH17]. Our investigations allow us to provide valuable insights for practitioners, designers and researchers to be able to understand users needs better and create devices or services that can support people with their communication under changing requirements.

Throughout our investigations, we have utilized various methods and tools to gather insights into user behaviors, user experiences and interface designs. This includes quantitative and qualitative measures for example interviews with participants, ethnographic tools, questionnaires and tools to create insights from data e.g. statistical analysis or coding. Although all of these methods and tool-sets have been used in many studies and therefore have been evaluated and proved to provide valid results, we found some of these tools and methods to work better or worse with our specific user groups. Following we share some of our experiences:

As most of our work has been evaluated in field studies, we have been in close contact with users over the past years of work. We experienced this close contact to be one of the most valuable sources for information that provided us with insights into their needs and thoughts. Sometimes it was helpful to invest extra time and build a relationship with single participants to gain some additional insights. Providing help, being available for questions and in case of technical problems helps to build trust with a experimenter. We have found ourselves to listen to stories of grandparents outside of the "official" part of the visit, which helped to understand their behaviors and how they perceive technology.

During the last years, we have worked with children in almost all of our investigations. Children often provide an additional perspective and therefore an extra layer of valuable Information. Most of the children we have worked with where very enthusiastic about our artifacts and provided great and insightful feedback. However, working with children is also very complex and studies have to be conducted with a lot of care and attention. Many validated and proven ways to gather information from participants might not work when used with a child. Children may feel uncomfortable with a person and therefore hide in their room or feel that they have to answer questions in a correct and pleasing way. At the same time questionnaires or interview questions can be too complex to grasp for a child or their attention-span is just not long enough for a long interview. We found it is important to build trust with a child, take the time to get to know them better, participate in play sessions with them or explore artifacts together with children.

We have used the *ABCCT*-questionnaire by Yarosh et al. [YMA14] in different studies, either in whole or in parts. We found the questionnaire to be effective and data generated by it to be insightful. However, we learned that one has to be careful when comparing two means of communication with each other using it. As an example: We used the questionnaire in our study of awareness devices (see Chapter 3). We compared our

prototypes with commonly used communication means e.g. a phone, video-telephones or messenger services. As these communication means provide different ways to interact and different levels of social communication, we found the result to be analyzed with care, as participants have rated a device not only on its features, but additionally on the missing features that they are used to.

In the following sections, we take a step back, reflect on gained knowledge and look ahead into possible future directions for our research.

6.2.1 Integration Into Routines

While staying in touch with our social environments is important and necessary for our well-being, it is sometimes demanding at the same time. Taking care of ourselves, our families as well as loved ones that live co-located or within a close distance to us, demands attention and time. Due to this it can be challenging to keep a close contact with people we love, but who we are not able to connect with face-to-face on a regular basis. As technology can serve to improve this situation, it still needs active engagement from at least two communication partners to be successful and fulfilling.

In our work about *Awareness of Activities* we found participants enjoying the exchange of subtle information that can hint to social circumstances or current things that happen in a partners life. One remark we found multiple times during our investigations was that the communication happens automatically and therefore does not require focused attention by the person. Rather the execution of action is translated automatically into meaningful information and shared with connected partners. Many participants enjoyed the easiness of sharing and imagined this as a good extension for existing communication means.

We envision the extended use of such information, with respect to a users privacy, as a future development towards social awareness systems that help to connect without adding a higher workload with regard to social communication. By integrating the recognition of activities, easy ways to share in-situ and expressing affection towards others, people can exchange small but meaningful messages of closeness and mutual interest in each others lives.

6.2.2 Analog Components That do Digital Things

The tangible nature of some of our artifacts, along with their non-virtual interaction methods, speak powerfully against the trends we see today. Admittedly, our devices do not all truly follow the footsteps of tangible interaction since there are no tangible manipulatives. However, we would like to highlight the tangible behaviors that some of our artifacts naturally led to. We found the value of tangible in the ease of understanding complex devices. Similar as the use of a physical switch could potentially fulfill very complex tasks that are hidden from the user. By reducing complexity, we found users

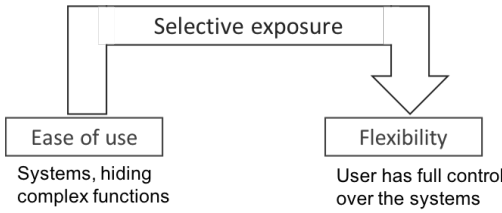

Figure 6.1: Selective exposure enables a transition from novice users towards expert users.

to interact with our artifacts with much higher confidence. Many problems or barriers that occurred during our field evaluations were caused by the use of modern interfaces within our prototypes e.g. tablets or smartphones.

As an example, StoryBox encourages sharing-in-the-moment through a simplified interface for both grandparents and grand-kids. What might have been most impressive during our investigations, is that a simple box with a few buttons, appropriating existing technologies, can yield such interesting usage behaviors. We envision the use of more analog components that *do digital things* to aim for a strong joy of use and more confidence in interaction – especially for non-technical users.

6.2.3 Engagement and Transition Into Digital Technologies

Driving engagement and providing an exciting experience for long-term use of a device or service, can be a challenging goal for designers of technologies. Often the first excitement fades with time and devices fail to keep up with a user expectations. Especially due to changing life situations and/or because a users understanding of technology increases/decreases over time, the requirements and needs may change drastically.

One interesting idea that can be a good starting point for future developments of more adaptable systems has been presented by Blickstein et al. [B+15, CSB17]. Their work describes *selective exposure* as a general approach that builds on the concept of blackboxing. Depended on the exposed features or information of a software system or hardware artifact, the designer of such a system is in control of the usability and learn-ability of the system (see Figure 6.1). The work *Designing a Physical Computing Toolkit to Utilize Miniature Computers: A Case Study of Selective Exposure* provides a simple example of selective exposure:

"Programmable Bricks, on the other hand, hide the microcontroller from the user by creating a higher-level abstraction layer that exposes "port-level" functionalities. Output ports are labeled A, B, C, ... all of which can be dimmed by setting the power level, which is by far more learnable than having to deal with complex technical terms and concepts such as pulse width modulation, which are less relevant for novices [CSB17]."

By reducing complexity and selectively exposing parts of a systems functionality, the barriers to participate in nowadays communication could be lowered or even removed.

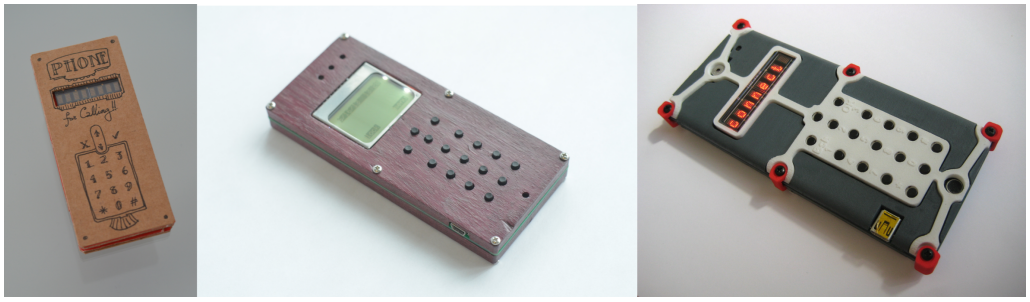

Figure 6.2: Pictures of individualized models of the DIY-cellphone presented by Mellis and Buechely in 2014 [MB14].

Especially young children and adults who have problems learning the use of new communication means would benefit from such an approach. It further allows the flexible addition of new and more complex features by time, so that a novice user who becomes an expert with time can benefit from more sophisticated artifacts that allow finer-grained control and individualization.

In our work we aimed to reduce complexity from the beginning to ease interaction with the artifacts for all user groups. However, users were not able to add more complex features with time. In some technologies, this may not influence the engagement with the device. While StoryBox was not expected to provide more sophisticated features, we found older children to be more engaged with smart devices and the use of messenger systems, rather then StoryBox. In further developments, our artifacts can implement a selective exposure approach and help novice users with their transition from interacting with simplified tools towards more complex ways of sharing, which can even be integrated with other services, such as WhatsApp.

6.2.4 Democratize Technology

Technology is more and more accessible to people who consider themselves as non-technical users. But this does not only include the availability of devices for different applications e.g. smartphones, high-end computers or fitness trackers and home automation appliances, but also methods and devices to get creative and create something useful. The trend of making small scale production methods or prototyping facilities available for users with non-technical background is often referred to as *Maker movement* or *Do-It-Yourself* movement. Providing easy ways to create and personalize devices and objects allows users to adapt them, so they either fulfill their functional requirements or the aesthetics they wish for.

A well-executed and fitting example for the transition from complex technology into an DIY approach are the *Do-It-Yourself Cellphones* presented by Mellis and Buechley in 2014. By providing plans for the production of a fully functional cellphone, they enable interested people to build their own phone from scratch. Dependent on their technical

skill level or the interest and time a person is willing to invest, the making process can vary heavily between fully assembling your own device or using a manufactured platform that can be finalized with an individual casing (see Figure 6.2). As Mellis and Buechley mention in their work:

"A single device, especially one as complex as a cellphone, provides for many different kinds and levels of engagement with DIY practice. For example, some workshop participants were most interested in building a device they could use in their daily life; others wanted to understand how a modern device works. Some wanted to experiment with new interaction design possibilities, like alternative form factors and interfaces, or simply ways to re-engage people with actually talking on the phone. Others were seeking an alternative to buying a phone from a big company. In these different perspectives, we see some of the diversity of activities and interests that can fit within an undertaking like making DIY cellphones" [MB14].

In our study for StoryBox we found children and their grandparents getting engaged in crafting activities. One way to use this engagement in crafting and making can be to democratize technology in a way that supports learning about and understanding of technologies from a young age on. By exploring and producing parts of a device, children as well as other users have the chance to better understand the mechanics and functionality of technology that they use. We imagine the communication means we have developed to be accessible as core modules, encapsulating complicated technical details that can be integrated into objects meaningful, fun or appealing to the users. In a further step, it allows to keep up with changing preferences or different life situations.

6.3 Concluding Remarks

This thesis addresses a variety of aspects and views from different fields of research. While being situated in the area of human-computer interaction, our work is influenced by other disciplines, especially when analyzing and understanding interpersonal behaviors. Our work presented in this thesis is diverse and heterogeneous in its methods and applications, and so are the people who use the technologies we create.

Throughout our research we found our prototypes being used intensively for social interaction. We received many positive remarks and experienced participants asking for the availability of such devices on the market, to continue using such devices with their loved ones after participation in the scientific approach. However, at the same time we found some of our prototypes fail to support all of the initially intended needs. One example concerns the *SocialFlowers* and our work on awareness through physical activities; Participants enjoyed interacting with them, especially sending the occasional greeting message. But in comparison to commonly used communication means, the *SocialFlower* missed to provide enough support for building a strong feeling of being related.
In this sense, technology to support and foster social awareness can only provide parts of the usual social interaction that people conduct. Providing presence of a loved one over

a distance helps to increase interpersonal awareness, however, it lacks the opportunities people have by living co-located. In our studies we found participants to increase their interaction with each other, using the phone over a distance or face-to-face if possible, during our studies. Thus, we see our artifacts as additional ways to stay in touch and be aware of each other, rather than replacements of existing communication technologies.

Designing for the diversity of human needs and behaviors is challenging, especially since technology adapts to user needs and not the other way around. Only by continuously improving our understanding of the variety and complexity of human behaviors, we will be able to design future technology that fulfills expectations without overwhelming users or excluding them from joyful, meaningful and engaging interactions.

Figures

Tables

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