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The CuDe Framework: Designing Digital Souvenirs for Meaningful Remembering Experiences

DISSERTATION

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by

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Erklärung zur Verfassung der Arbeit

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Abstract

Snapping a photo now is quick and convenient, but how many of these photos are ever revisited again and how many photos can later serve as valuable digital souvenirs?

The aim of this research is to explore opportunities for employing digitally captured media content (e.g., photos, text, *GPS* locations, etc.) as resources for meaningful remembering. This notion of 'meaningful remembering' is defined here as enabling 'subtle' experiences such as moments of reminiscence and reflection. Using a mixture of *design-led research* and (mostly) qualitative user studies, the work explored novel approaches to capturing digital information, often involving photographs and often featuring playful or unconventional aspects. The primary facilitator of such experiences is the modern mobile phone with its affordances for capturing (multi)media data.

We developed a series of prototypes and 'augmented memory systems', which we deployed in field studies. Each prototype varied the application of media data capture or replay and hence the handling of *memory retrieval cues*. Thus, these artifacts can be seen as part of an iterative process of *exploring opportunities* for engaging the user with past events by offering different ways in which digital content can be captured, reviewed and related to each other.

The three most advanced prototype systems created in the course of the thesis were named *Hearsay*, *2sidez* and *Media Object (MEO)*. *Hearsay* explored the 'out-of-context' presentation of digital content, that is, the user was presented with memory retrieval cues, which invited them to reflect about the (contextual) origin of this information. While the *2sidez* prototype or application was for capturing 'two-sided photos' (by means of mobile devices that feature two opposite-facing cameras), *MEO* provided the user with the opportunity to capture rich multimedia data and aggregate it into a single file structure. A mixture of in-depth (longer-term) and larger-scale studies suggested that these applications indeed were appreciated by the participants for the original way in which they made use of the digitally captured information and for their potential in providing valuable memory retrieval cues.

The findings of the user studies are synthesized into the *CuDe Framework (Memory Cue Design Framework)* for supporting the designers of augmented memory systems in analysing, understanding and exploiting digital memory retrieval cues. More precisely, this conceptual framework provides guidance in making choices about the kind of user experience to be addressed, about what to capture and about how to present this captured information.

In summary, the outcome of this research is a set of prototype systems or applications (*Hearsay*, *2sidez*, *Media Object* and a set of technology probes) and derived design principles (synthesized into *CuDe*) that can be employed to design for evocative memory triggers and meaningful remembering experiences.

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Kurzzusammenfassung

Ein digitales Foto ‚zu schießen' ist nicht schwer, aber wie viele dieser Aufnahmen sehen wir uns jemals wieder an und welche dieser Fotos werden für uns zu wichtigen Erinnerungsträgern?

Ziel dieser Dissertation ist es, digital aufgezeichnete Informationen wie zum Beispiel Fotographien, Texte, *GPS* Koordinaten, usw., als Mediatoren *wertvoller Erinnerungen* zu eruieren. Unter *wertvollen Erinnerungen* verstehen wir in dieser Arbeit subtile kognitive Vorgänge wie das *Schwelgen in der Vergangenheit* oder auch (selbst) reflexive Prozesse bezüglich des eignen Lebens. Die *Eruierung* bezeichnet einen *explorativen* Forschungsansatz unter dem Einbezug einer vor allem Design-basierter und qualitativen Forschungsmethodik. Letztendlich erkundet diese Dissertation neue Ansätze, Erinnerungen digital aufzuzeichnen und schlägt hierfür neue Konzepte vor, vornehmlich mit dem Einsatz digitaler Fotographie und unter der Verwendung von *Smartphones*.

Im Rahmen der Arbeit wurde eine Reihe von *Erinnerungs-Prototypen* entwickelt und diese in Feldstudien evaluiert. Hierbei stand die Qualität des subtilen Erinnerns und der emotionale Mehrwert im Vordergrund und nicht etwa die quantitative Bestimmung mediierter Gedächtnisleistung. Der Einsatz digitaler Medien (Fotographien, Video, Texte, etc.) wurde variiert und somit explorierte jeder Prototyp den Einsatz verschiedener Erinnerungsträger. Insgesamt können diese Prototypen oder Design-Artefakte als Teil eines iterativen Prozesses gesehen werden, in welchem den Versuchspersonen und Anwender/-innen verschiedene Möglichkeiten angeboten wurden, Erinnerungsinhalte digital aufzuzeichnen, anzuordnen und zu konsumieren.

Die Namen der am weitesten elaborierten Prototypen dieser Dissertation sind *Hearsay*, *2sidez* und *Media Object*. *Hearsay* ‚spielte' mit dem Präsentationskontext von Erinnerungsträgern, *2sidez* ermöglichte es, doppelseitige Fotographien aufzunehmen (sog. *Duographien*) und *Media Object* stellte eine Containerstruktur bereit, um multimediale Daten in einem ‚Erinnerungsaggregat' zu bündeln. Eine Mischung von Langzeitstudien und detaillierten Fallstudien ergab, dass die Versuchsteilnehmer/-innen die Anwendungen schätzten, um originelle digitale Erinnerungsobjekte aufzuzeichnen und damit wertvolle Erinnerungsanstöße (*memory retrieval cues*) zu erstellen.

Schließlich wurden die Erkenntnisse der Studien in einem theoretischen Rahmen zusammengeführt (im *Memory Cue Design Framework* – kurz: *CuDe*), um Designer/-innen digitaler Systeme, welche sich mit dem Thema *Erinnerungen aufzeichnen* befassen, zu unterstützen. *CuDe* bietet Orientierung bezüglich einer Reihe von Design-Entscheidungen, zum Beispiel, was aufgezeichnet werden und wie diese Information dargestellt werden soll, beziehungsweise welches Nutzungserlebnis realisiert werden soll.

Das Ergebnis der Dissertation läßt sich also wie folgt zusammenfassen: Eine Reihe von ‚Erinnerungs-Prototypen' (*Hearsay*, *2sidez*, *Media Object*) wurde entwickelt und in Feldstudien evaluiert, sowie davon abgeleitete Design Ratschläge (zusammengeführt duch *CuDe*) erarbeitet, welche darauf abzielen, möglichst wertvolle Erinnerungsanstöße (*memory retrieval cues*) zu schaffen.

Acknowledgements

Over the last couple years, I had the pleasure to meet many great people while having the privilege to work at the Institute for Design & Assessment of Technology. I would like to use this opportunity to express my gratitude to those who made an impact on the work in this thesis.

First of all, I want to thank Geraldine Fitzpatrick for being such a great supervisor. I consider myself as very lucky to have had the opportunity to work with this remarkable mentor. The impact of her rich knowledge, dedication and reliability on this thesis cannot be overestimated.

Additional warm thanks goes to my dear 'roommates' Eva Ganglbauer and Francisco Nunes, who are some fine and fun people. After having spent so many hours together in the office, I am sure, they will never ever get boring or into a bad mood, or out of good advice.

Although I am a bit worried that I might miss some significant names, I would like to list a number people (in alphabetical order) who dedicated their time to me by offering advice, providing important ideas or pointers to literature, or testing my prototypes and giving feedback. I appreciate the help of Florian Bauer, Michael Emhofer, Roman Ganhör, Friedrich Fritz Glock, Sebastian Haas, Michaela Hinterleitner, Oliver Hödl, Tobias Köstlin, Anna-Lena Krebs, Genadi Marinchev, Juri Pawlakowitsch, Daniela Pfabigan, Pippo, Margit Pohl, Peter Purgathofer, Wolfgang Reitberger, Petr Slovak, Wolfgang Spreicer, and Armin Wagner.

Special thanks goes to Özge Subasi and Martin Sertscho Sereinig. Özge was always supportive and shared her knowledge and one or two 'postdoctoral secrets' with me (*aka mentoring*). Sertscho spent many unpaid hours on implementing software, which will be presented in the course of this thesis. Without his great expertise I would probably not have finished *2sidez.com*.

The best product ideas in this thesis, perhaps, were inspired by my dear girlfriend Dorothee. Her imaginativeness and sensible point of view can only be beneficial to a research endeavor like the one on hand. She discussed every prototype with me, every user study, every insight, and she was always there for me.

Finally, I would like to thank my father who kindly (and recklessly) agreed to give this thesis a final and last-minute proofread.

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Associated Publications

This thesis was created in the period from 2010 to 2014 in the course of fulfilling a research and teaching position at Vienna University of Technology. The following list comprises associated peer-reviewed research papers of studies that were published in conference proceedings or as journal articles. All of this research was primarily conducted, and likewise the corresponding papers were principally written-up by the author of this dissertation thesis (and first author of the individual papers).

1. Güldenpfennig, F. and Fitzpatrick, G. Getting more out of your images: Augmenting photos for recollection and reminiscence. In Proceedings of the 25th BCS Conference on Human-Computer Interaction, British Computer Society (2011), 467-472.

2. Güldenpfennig, F., Reitberger, W. and Fitzpatrick, G. Capturing rich media through Media Objects on smartphones. In Proceedings of the 24th Australian Computer-Human Interaction Conference, ACM (2012), 180-183.

3. Güldenpfennig, F., Reitberger, W. and Fitzpatrick, G. Of unkempt hair, dirty shirts and smiling faces: Capturing behind the mobile camera. In Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design, ACM (2012), 298-307.

4. Güldenpfennig, F., Reitberger, W. and Fitzpatrick, G. Through two different lenses: A tool for new perspectives into context. In Proceedings of the 24th Australian Computer-Human Interaction Conference, ACM (2012), 170-179. *Best Paper Award*

5. Güldenpfennig, F., Reitberger, W., Ganglbauer, E. and Fitzpatrick, G. Duography in The Classroom: Creative Engagement with Two-sided Mobile Phone Photography. ***To appear in International Journal of Mobile Human Computer Interaction (IJMHCI)***

6. Güldenpfennig, F. and Fitzpatrick, G. Personal Digital Archives on Mobile Phones with MEO. *J Personal and Ubiquitous Computing*, doi: 10.1007/s00779-014-0802-3.

7. Güldenpfennig, F., Fitzpatrick, G., and Reitberger, W. Making Sense of Rich Data Collections on Mobiles. In Proceedings of the 2014 European Conference on Cognitive Ergonomics, ACM (2014).

8. Güldenpfennig, F. and Fitzpatrick, G. De- and Re-contextualization as a Design Concept for Provocative Interactive Experiences. ***Full paper submitted to CHI'14.***

Parts of the papers listed above were reworked into chapters from this thesis:

- **Introduction**: A fragment of the introduction of *paper 6* was employed for the introduction of the thesis.
- **Contextual Review**: Parts of *paper 1, 3*, *6* and *7* were employed for the literature review of the thesis.
- **Initial Probes and Pre-studies**: Parts of *paper 1* and *8* were integrated into this chapter.
- **Hearsay**: Parts of *paper 8* were integrated into this chapter.
- **Duography**: Parts of *paper 3*, *4* and *5* were integrated into this chapter.
- **MEO**: Parts of *paper 2* and *6* were integrated into this chapter.
- **Discussion**: Parts of *paper 7* were included into the discussion.
- **Glossary**: Parts of *paper 6* and *7* were included into the glossary for describing some of the items.

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In the corridors of his brain he had constructed a chamber to be visited whenever his hopes had been dashed yet again, when his fear was at its greatest and his despair overpowering. This was the *Chamber of Memories*.
Major and minor incidents in his life hung on its walls like oil paintings, frozen in time and waiting for him to reactivate them. These mental images would have meant nothing to anyone else. They could be a view across a gloomy bay or a little hillside inn at dusk, a battlefield in turmoil, a chessboard bearing an exceptionally complicated arrangement of pieces, or a leg of roast pork with a knife about to carve it.
When Smyke stood in front of one of these pictures and devoted his attention to it, it seemed to come to life, expand and literally suck him in. He then experienced some pleasurable memory as if for the first time.

Walter Moers*, Rumo: And His Miraculous Adventures*

What matters in life is not what happens to you, but what you remember and how you remember it.

Gabriel García Márquez, *Living to Tell the Tale*

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1 Introduction

1.1 Augmenting Human Memory with Technology

This thesis aims to contribute to the design challenge of augmenting personal memories with interactive technologies. As powerful computing devices grow smaller and become more and more ubiquitous, it is a timely question to ask, whether these technologies offer opportunities to support us in one of our core human capabilities and concerns: *to remember*. Memory or remembering is a most complex concept and, therefore, needs further defining. Before we move on to do so in the subsequent chapter, we state up front that this thesis primarily focuses on personal memories that are kept for mostly sentimental reasons. In the analogous world of technology this kind of memory is often materialized into photo prints, souvenirs or other kinds of physical mementos that carry a sentimental meaning for its owner. Now, in these 'digital days' an increasing number of ways for capturing memories and electronically storing them can be observed. For instance, people raising their hands and holding small electronic gadgets to trigger camera shutters is a common sight (see Figure 1.1 for a convincing example of how extensively the people's behaviour changed in only a few years). This observation is not restricted to particular countries, say, to such located in the western hemisphere. It has grown into a global phenomenon. Digital cameras have become affordable for many people now and by 2015 two billion camera phones alone are forecasted to be in use worldwide (InfoTrends, 2011). Right back in the 1980s, Chalfen, who did seminal anthropologic research into photography, realized an exploding number of photographs were being taken and wondered about the cause of such action:

Throughout the thesis this margin column is used to provide complementary information such as illustrations or definitions. We also present interesting and additional quotes in this column, which are not linked by reference to the main body of the text.

"There are no biological or physical pressures that require these kinds of photographic activities or accumulation of pictures. In contrast to physical survival, it appears that we are exploring a massive, but optional form of symbolic support for our existence and our lives" (Chalfen, 1987, p.15).

One human matter that certainly can be supported by photography is remembering and it is likely that its popularity to a large extent stems from this capability. Further, it can be claimed that memory is of fundamental importance to us, because this is not just about recalling 'where did I put my glasses?'; rather, the things we remember shape the actions we take, and the sum of our memory fragments constitutes our identity as an individual as well as a group (Van Dijck, 2007).

Advancing technology such as cameras built into mobile phones (denoted as 'camera phones' in this thesis) is one of the key motivators of Human-Computer Interaction (HCI) for increasingly dealing with the topic of (digital) remembering. In this context, this thesis in HCI investigates how technology, first and foremost in the form of mobile phones, can be employed to create meaningful remembering experiences of mostly personal events. Mobile phones have a number of features and affordances that make them ideal devices for capturing experiences, namely video cameras, *GPS* sensors, large storage capacities, Internet connectivity, big screens, etc. It is no surprise then that they are regarded as the future main facilitator in capturing digital life memories (Olsson, Soronen, & Väänänen-Vainio-Mattila, 2008). In addition to smartphone-generated content, we will also investigate additional sources of digital data in the context of remembering, for instance, publicly available information downloaded from the Internet.

Besides these advances in technology, a number of challenges around systems for supporting digital remembering have been reported in the HCI literature that relate to *information overload* and the *effort to create order, the invisibility of digital resources,* and supporting the *(re)constructive nature of memory* and *creativity* (see for example, Sellen and Whittaker (2010) and Whittaker et al. (2012)).

In this thesis we take a *research through design* related approach to illuminate these challenges and propose design concepts to offer, if not solutions, at least insights and inspirations for designing remembering systems that tackle some of the current systems' and products' shortcomings. To this end, a number of prototypes are created and studied 'in the wild' or in everyday contexts. The findings of these individual studies are presented in dedicated chapters together with the corresponding prototyped systems. Towards the end of the research processes, all findings are "pulled together" and integrated within a conceptual framework (the CuDe Framework) for making the insights of this thesis applicable and accessible to designers. This proposed framework also constitutes the summarized outcome of this overall design-led research endeavour and draws on Höök and Löwgren's theory of *Strong Concepts* (Höök & Löwgren, 2012).

Figure 1.1. Contrasting the inauguration of Pope Benedict (top; 2005) and Pope Francis (bottom; 2013) at St. Peter's Square (Siemaszko, 2013). These photos bear testimony to an almost 'epidemic' spread of camera phones in only seven years.

1.2 Research Agenda

The work in this thesis can be regarded as part of HCI's latest interest in exploring broader facets of life, reaching far beyond the workspace or *usability*. As HCI moved out of the offices where productivity and *human factors* were at the centre of investigations, the field began to open up for explorations in all different kind of application contexts (Rogers, 2012). Suddenly, researchers' interest shifted from the workplace to the private and thereby to the leisure time. Within this *third wave* of HCI all human matters are subject to studies or technological augmentations, for example, culture, experience and emotion (Bødker, 2006). This expansion is also made possible through newly available technologies. The computer and its interfaces is no longer bound to the Desktop but emerges *onto and under* every arbitrary surface including the surface of our skin, even. As a consequence, now there is more at stake than merely bad software design for word or spread sheet processors. Creating these new technologies has delicate implications for your life and we are better advised to carefully consider what 'human values' we intend to design for (Sellen, Rogers, Harper, & Rodden, 2009). The actual process of creation is speeded up by simplified and yet powerful developer tools. Characteristic to the evaluation of HCI research in this new area is the deployment of prototypes in the field (in contrast to studies conducted in the lab) to study how participants use, make sense of and value the proposed technologies (Rogers, 2011).

In this thesis we too explore one aspect of the private life domain that is particularly intimate: *personal memories and remembering*. This topic prototypically fits into the *third wave* of HCI, to stick to the terminology from above. Likewise, we are concerned with studying how the proposed systems for augmenting human memory are adopted by the users in everyday situations. As stated in the introduction, our method of choice is related to *research through design* or it can be described as being *design-based* (methodology to be detailed in Chapter 3). This approach certainly resonates both with contemporary developments in HCI and with the research challenges in supporting memory. Broadly speaking in this dissertation project, a number of prototypes are created and deployed in the field with subsequent iterations. Participants using and adopting these systems to their needs are observed and findings are synthesized into a framework (*Memory Cue Design Framework* – the CuDe Framework) to support designers in creating *augmented memory systems*, that is, interactive applications for supporting remembering. (The term *augmented memory system* and additional important notions to this thesis are also described in the Glossary.)

1.2.1 Objective and Scope

In this section we explain *by which means* the proposed research is intended to support human remembering and *which gap* in the literature is supposed to be targeted at.

The endeavour of augmenting memory is not new to HCI and its related fields. Given that memory is a complex and essential concept, there are a vast number of different research strands that have to be put in order to understand the design space of 'digital memories'. For instance, there have been many research projects, subsumed under the name of *lifelogging*, that aim to automatically capture as much information as possible to overcome the 'curse' of forgetting. This is, for example, attempted by head-mounted cameras or 'smart' glasses that continually record the user's field of vision. This 'capture everything' mode, is of course only one possible approach to sup-

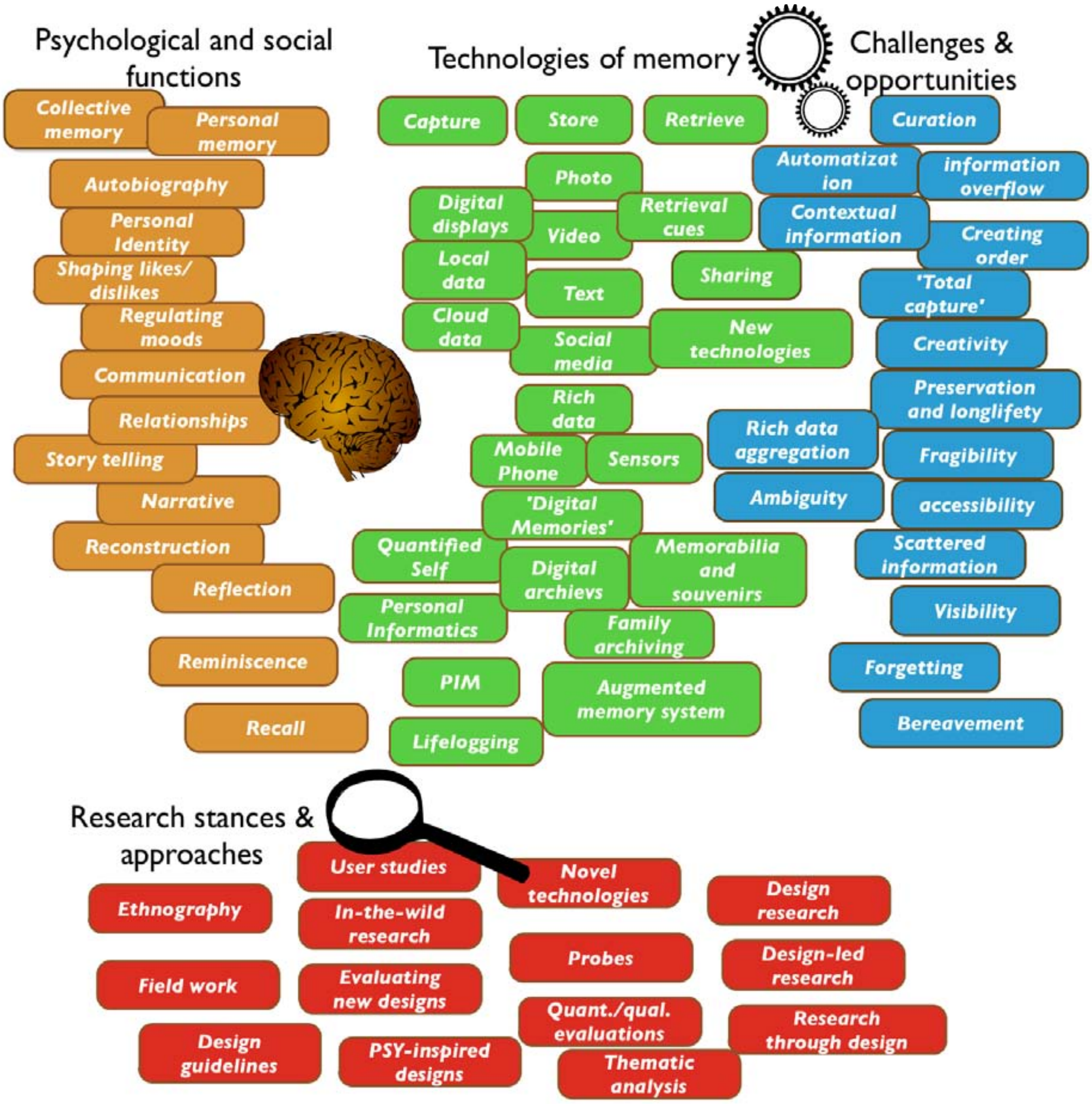

Figure 1.2. 'Digital memories' design research space. Key terms from the literature review (see Chapter 2) arranged in a loose affinity map.

porting memory with technology. Figure 1.2 gives a brief overview of the design space of 'digital memories' or the augmentation of memory with technology. In Chapter 2 (contextual review) and Chapter 3 (methodology) we will consult these illustrated concepts, research strands and methods in great detail. An up-front reference to the concept of *memory retrieval cues* is given in the next paragraphs, as they belong to the key concepts in the thesis.

These memory cues or stimuli are assumed to enable us to *reconstruct* memories by triggering information retrieval from the long-term storage systems of our brains. Memory (including considerations into retrieval cues) is typically subject to studies in psychology. However, researchers in HCI lately drew attention to the biological or psychological working principles of the human remembering process in order to improve the design of *interactive* memory systems:

"[…T]he memory itself cannot be stored in an augmented memory system, because a person is needed to recreate this memory for every recollection. In order to help people reconstruct a memory one can cue memories and these cues could be stored in an augmented memory system" (Hoven & Eggen, 2008, p.435).

Memory retrieval cues are part of the key concepts in this thesis. These cues or stimuli are assumed to help us reconstruct memories by triggering information retrieval from the long-term storage systems of our brains. Technically, they are digitally recorded by media files, which we call *entities*. In this thesis, we investigate different ways of capturing and replaying retrieval cues to the end of creating *meaningful remembering experiences*.

This quote illustrates that researchers in HCI have turned away from the 'brute force' *capture everything* approach of some *lifelogging* projects and started carefully thinking about *what* data to capture best for passing information from our long-term memory into consciousness. A number of HCI researchers argued that it is *not* memories that can be digitally recorded to our hard drives for later retrieval and revival (Hoven & Eggen, 2008; Sellen & Whittaker, 2010). Instead, they propose that memories actually are *reconstructed*[1] from bits of information and memory traces, which constitute the building blocks of our recollections. Consequently, in their research they emphasize that augmented memory systems store *retrieval cues* instead of memories and that these cues have the potential to bring back to life memories by evoking meaningful responses. This perspective is shared within this thesis.

Hence, there is an increasing number of systems that carefully record specific information as later retrieval cues, for example, *who* was part of a specific event, *when* did it happen and *who* else was there (Eagle & Pentland, 2006), et cetera. There is currently much thinking about data capture in specific projects, and also across different research prototypes common strategies for recording digital memories emerge. For instance, the augmentation of photos with additional meta-data such as *GPS* location and camera settings within the *EXIF* file format. Or, on a less technical but more conceptual level, transferring properties of physical memorabilia to 'digital memories' (Kirk & Sellen, 2010). However, what is still missing are systematic explorations into *how to present and replay* those retrieval cues. How can we take advantage of the affordances of 'the digital'? How can we develop interactive systems for unfolding the interplay between different pieces of multimedia data and for engaging the user in

While we have seen noteworthy considerations in *what* to capture, there is a need for systematic investigations in *how* to replay this material.

The base assumption of this thesis is that we can design and steer the presentation of memory retrieval cues in such ways that they will enable meaningful and thought-provoking remembering experiences.

[1] Note that by *reconstruction* we denote a process of *making sense* of available cues or entities. This can also involve 'subtle' processes such as reflection or reminiscing, and *reconstructing* doesn't necessarily involve *exact* and 'mechanical' recreation.

meaningful remembering experiences? Again, while we have seen noteworthy considerations in *what* to capture, there is a need for systematic investigations in *how* to replay this material. The base assumption of this thesis is that we can design and steer the *presentation of memory retrieval cues* in such ways that they will enable meaningful and thought-provoking remembering experiences by trusting the mind's capacities for sparking imagination.

To put this idea across, it is important to state that we might want to design augmented memory systems for different types of remembering, starting from 'simple' factual recall and ending with more complex and engaging remembering processes such as *reminiscing* or *reflection* on personal behaviour. Consider, for instance, a software program to support people in reminiscing about their past holidays and travel. To this end, software designers might choose to present all available cues at the same time *or* revealing one cue after the other to facilitate recall (e.g., showing pictures and corresponding picture annotations synchronously, or providing additional annotated information to photos on request only). Moreover, they might decide to start with the newest data, for example, beginning with the last photo taken and then moving on to older material, or vice versa. Indeed, there is, empirical evidence that in certain contexts the names of people can be recalled better if the inquiry starts with the near past and then moves back in time (compared to inquiries that start way back in time to proceed towards the present) (Whitten & Leonard, 1981).

Nevertheless, the variety of possibilities for presenting retrieval cues depends on the data capture beforehand. *How* to replay is inseparably linked to *what* was recorded. One particular device with huge potential for recording digital memories is the mobile (smart)phone. This 'all-purpose tool' has gained increasing popularity and availability during the four years period of the thesis studies and shaped – due to its affordances – the research process significantly as it became more and more prominent in peoples' digital life.

The proceeding considerations, assumptions and technological developments lead to the formulation of the research questions presented in the following.

1.2.2 Research Questions

Even though there is much research in augmented memory systems *and lifelogging*, the uptake of these technologies to date is relatively low (Whittaker et al., 2012). Above, we already mentioned a set of research challenges around systems for supporting digital remembering that relate to *information overload* and the *effort to create order, the invisibility of digital resources,* and supporting the *(re)constructive nature of memory* and *creativity.* In this thesis, we give special attention to these issues; however, we do not take a reductionist approach, that is, illuminating only one challenge at a time while eliminating the others. Instead, we argue that taking a *holistic perspective* in this endeavour can generate valuable insights as stripping technology mediated remembering from its context does not account for the interplay of the many factors involved in supporting memory in everyday situations. Information overload, the effort to create order and relocating data, the invisibility of digital material – these issues all go hand in hand and mutually affect each other. For this reason we take a route that can be labelled as *research through design* or *design-based research* and that features explorative components. This is also why at the beginning of the thesis there is one relatively broad research question (RQ1) including one sub-question (RQ.1) for opening the investigations.

> **RQ1:** How can people be engaged in meaningful remembering experiences when dealing with digital files and souvenirs? ('Meaningful remembering' is defined here in providing the user with opportunities for reflection, reminiscing or other forms of 'sentimental' recall that go beyond plain *factual* recall.)
>
> **RQ1.1:** How can properties of emerging digital technologies be exploited to meet some of the challenges identified in the literature?

This research question was initially explored by a set of five functional prototypes or initial technology probes. They investigated different ideas about employing digital media as memory retrieval cues including personal files (primarily digital photos) as well as publicly available data such as downloaded headlines and quotes from online news stories. The probes evolved as a response to the four research challenges from the literature (see also above and Section 2.4.1) and covered a number of ideas for addressing these current issues. As they partially dealt with novel kinds of digital material or file formats, these applications necessarily involved both information presentation and capture (the novel files needed to be recorded). This is particularly true for our applications where we *combined* digitally recorded data in a particular fashion (more details below). Thus, studying how data can be represented by means of these applications necessarily involved data capture. Other probes, again, operated with only single media files or *single entities*. For this, it was possible to use already existing media files, be it personal data or public information downloaded from the Internet.

1.2.3 Overall Research Strategy and Research Strands

Overall, the beginning of this design-based research endeavour is marked by one research question including one sub-question and four related challenges in 'digital memory' systems (see above). These four issues inspired a set of five technology probes for exploring different ideas that were addressed to the initial challenges. These probes, again, fall into and motivate three design or *research strands* (RS1-3; see below). While RS1 deals with memory retrieval cues contained within *single entities*, RS2 and RS3 investigate the interplay between *multiple entities*. Each strand explores a very specific concept, which was invented and refined throughout the process of researching the literature, creating technology probes and gaining iterative user feedback.

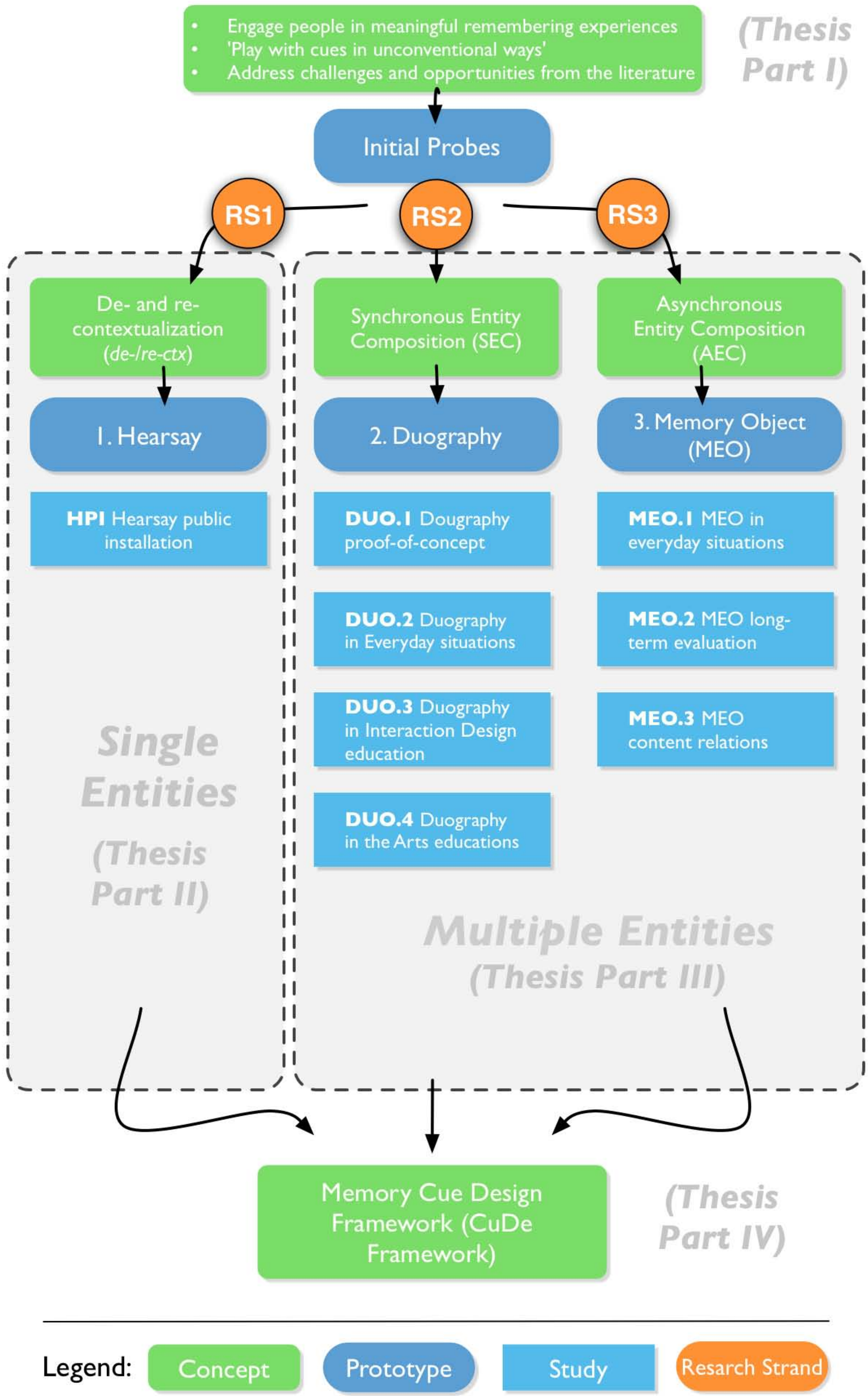

Figure 1.3. Schematic illustration of the overall research strategy and the studies conducted (blue boxes) in the course of the thesis resulting in a theoretical framework (CuDe Framework; green box).

We go on to outline the research strands RS1-3 and also discuss Figure 1.3[2], which is illustrating the research strategy of this thesis including its different components:

RS1: This strand concentrates on *single entities*. It comprises the Hearsay prototype, which was deployed in a field study. Overall, RS1 investigates how single media files or entities can be exploited in novel ways to enable meaningful remembering experiences, for example, by slowing the user down and focussing attention when revisiting their digital souvenirs. In particular, RS1 asks questions regarding the context and style of presentation for the to be revisited entities or memory cue(s). How can we increase the evocativeness of digital memory retrieval cues that are contained within a digital file or single entity? Is there a value in removing digital media (as potential memory triggers) from its original context, so that the users have to make sense of this material without having access to all of its contextual data, and hence fill in this missing information by their mental efforts? Can the presentation of 'out-of-context' data provoke deep engagements and lead to complex and demanding, however potent memory retrieval cues? We address these questions by synthesizing the findings of the Hearsay study into a theoretical interaction design concept that we named *de-/re-ctx* (de- and re-contextualization).

RS2: This strand explores the combination of *multiple entities* (media files) by extending conventional digital photography by one additional picture. More precisely, we invented and theorized about Duography (implemented by an application for *Android* we named 2sidez), which triggers two opposite-facing cameras at the same time, leading to a *synchronous* composition of two entities. This research strand addresses questions such as the following. What are the implications for digital photography, if conventional photos were extended by 'an additional dimension' and each photograph would feature the picture of its photographer on its backside as an additional memory retrieval cue? Hence, what do the users make out of these two *combined entities* when composing and remembering 'digital memories'? These questions are addressed by a concept for interaction design we named *synchronous entity composition* (*SEC*).

RS3: This strand is to some regard an extension of RS2 and Duography. In RS3, we propose the *Media Object* (*MEO*), which allows the *asynchronous composition* of a variety of media entities into a novel file format. That is, the user can join an arbitrary number of media files, for instance, combining a photo with an audio recording or text file. In a way, MEO is the extension of conventional photos by 'arbitrary dimensions'. The asynchronous composition of these entities also

[2] While the focus of Figure 1.3 is on the *user studies* conducted, a simliar illustration can be found in the methodology chapter (see Section 3.3.2) that focuses on the *process* of research.

gives more 'degrees of freedom' to the user when combining the MEO cue aggregates (unlike Duography, where two photos are captured synchronously). What will the user make out of an application for bundling arbitrary media content (contextual data) leading to a novel kind of aggregated file format and hence to a potentially rich reservoir of *combined* memory retrieval cues? The underlying interaction design concept we propose for addressing these questions we named *asynchronous entity composition* (*AEC*).

Figure 1.3 provides a structured diagram of the thesis research, which is divided into the three research strands RS1-RS3. Each strand is headlined by conceptual considerations or research objectives (green boxes). Names of the prototypes ('Initial probes', Hearsay, Duography, Media Object (MEO)) are depicted by dark blue boxes (rounded corners). All conducted user studies to address the research questions are displayed with light blue boxes (squared boxes; HPI; DUO.1-DUO.4; MEO.1-MEO.3).

As outlined above and in retrospect, the Hearsay prototype (RS1) explored an alternative approach to context and presenting memory retrieval cues by employing *de- and re-contextualization* (de-/re-ctx) as a design concept. Duography (RS2) dealt with the extension of conventional digital photography by one additional photo, resulting in two *synchronously* combined entities (SEC) or carriers of memory retrieval cues. RS3 with its prototype system Media Object (MEO) explored the combination of entities, as well. MEO, however, considered the aggregation of an arbitrary number of media files into a novel file format (AEC).

The Memory Cue Design Framework (CuDe) integrates the findings of the design-based research and all three strands (RS1-RS3) into one theoretical frame. Hence, CuDe emerged out of the studies during the course of the thesis. The interplay between multiple entities, either in a synchronous or in an asynchronous fashion, plays a leading role in the synthesized learning of CuDe, and hence, in this thesis. Research on revisiting single entity data complements this work and also informs the framework. With regard to theoretical considerations, the framework draws on Höök and Löwgren's idea of *Strong Concepts* (Höök & Löwgren, 2012), which will be introduced in the methodology chapter (see Section 3.2).

We go on now to account in more detail for the contributions of these explorations and investigations.

1.2.4 Contributions and Audiences

This thesis entails several contributions. Firstly, it presents a number of novel interaction concepts for the digital augmentation of memory. In contrast to 'pure' factual recall, these concepts particularly foster deeper engagement and thinking about and with digital materials, for example, recollecting memories and reminiscing or reflecting on experiences. Also, the latter two memory processes (reminiscing and reflecting) are under-researched in comparison to other augmented memory systems that focus, for example, on information retrieval (Sellen & Whittaker, 2010). Secondly, these concepts were instantiated into functioning prototypes (see the Glossary for an overview of all prototypes) and, thirdly, studied in the field. As this thesis follows a design-led or design-based research approach, we also consider these prototypes an important contribution, since they embody conceived ideas and serve as design examples. Fourthly, the findings from the field studies are synthesized into a framework (the CuDe Framework) to make available the insights to designers of augmented memory systems in a structured and applicable way.

The main concepts for interaction design and the advanced prototypes introduced in this thesis are the following:

- *De- and re-contextualization* (*de-/re-ctx*) is the underlying design concept of Hearsay. This application works with single entities (media files) and intentionally removes contextual information when replaying memory retrieval cues. Hearsay is a research vehicle for exploring the *out-of-context* presentation of information in order to create engaging retrieval cues and hence meaningful remembering experiences. While Duography and MEO explored the combination of multiple entities (compare items below), Hearsay and the concept of *de-/re-ctx* considers how single entities can be employed to attract the users' attention, to make them engage with the presented digital content, and to maybe 'slow them down' a bit when revisiting their digital souvenirs.
- Duography extends conventional photography by adding an additional side to it. That is, metaphorically spoken, these novel photos can be flipped around to reveal their photographers' or creators' portrait on the backside. This additional back picture is enabled by the newly available mobile phones, which feature two opposite facing cameras. One camera for conventional photography and the other one primarily for video telephony. Our software prototype, the 2sidez application, triggers both cameras synchronously to capture what we call *Duographs* (short: *Duos*) – photos that can be turned around, because they show two opposing perspectives. The Duography concept of *synchronously combining* visual memory cues (see Figure 1.3, Synchronous Entity Composition, SEC), and its potential as a memory retrieval cue has been studied extensively through the 2sidez app. We report the results of three qualitative studies (DUO.2-4). In addition, it was launched on the *Android Play Store* (reported as DUO.1), where it was downloaded over 115.000 times.
- The Media Object (MEO) is a specification of a novel file format and serves as a research prototype or research vehicle in this thesis. The pur-

pose of the MEO file specification is to create a container structure that can enclose arbitrary media content such as photos, photo annotations, videos, text, text messages (*SMS*), *GPS* coordinates, and so forth. Thereby, the underlying concept of MEO is to provide the users with a tool for capturing experiences in 'multidimensional' ways and hence, to *asynchronously* create a rich reservoir of *combined* memory cues (see Figure 1.3, Asynchronous Entity Composition, AEC). As MEO bundles the captured data into containers, the user is further offered an opportunity to remember past events by means of aggregated resources providing a multitude of fragments for the *reconstruction* of memories. The Media Object concept and its corresponding applications (e.g., MobRecMobile2) were given to participants for up 28 weeks and extensive data could be collected.

In summary, this thesis examines different ways of presenting and capturing digital data to support remembering. The process of remembering, as interpreted in this thesis, goes beyond 'plain' factual recall of information. In particular, we focus on more subtle memory processes such as reflection and reminiscing. To this end, the potential of *single* and *combined entities* in triggering memories is investigated within three different strands of research (RS1-RS2). RS1, single entities, explores concepts (*de-/re-ctx*) for presenting digital files in perhaps unconventional ways and, thus, for 'getting the most out' of this material when revisiting it.

RS2 and RS3, multiple entities, combine digital files either *synchronously* (SEC) or *asynchronously* (AEC) and thereby create 'multidimensional' rich data aggregates. Hence, in contrast to RS1, where conventional files are displayed in unconventional ways, RS2 and RS3 established unconventional or novel file formats.

The findings of the user studies on the applications from RS1-RS3 are collated into the CuDe Framework. This framework is primarily addressed to interaction designers that aim to develop augmented memory systems. It is sought to provide orientation, inspiration and design strategies for such purpose. The proposed framework depicts a systematization and collection of different practices of employing digital files or *entities* as memory retrieval cues. Thereby, it demonstrates how digital media data or memory retrieval cues can be incorporated to accomplish certain effects for the user. To the best of your knowledge, such systematization is yet missing in the literature and CuDe therefore offers a unique frame or lens for looking at the usage of digital files/entities or cues in the design of augmented memory systems.

For this reason, this thesis might also be of interest for researchers in HCI that work on a more theoretical level. The collected data with regard to digital remembering in this thesis is quite extensive and the framework is able to explain or at least to describe certain phenomena in people recalling, reflecting or reminiscing about past events by means of digitally recorded information.

1.2.5 Limitations

The work presented in this thesis deals with the recording of digital resources for remembering. Thereby, in terms of targeted user groups, the individual in the western hemisphere is at the centre of our research interest. There are many facets to memory and these will be detailed in the subsequent related work section. This thesis does not seek to support 'plain' factual recall, that is, we are not attempting to prove that the introduced concepts can increase memory capacity by a certain amount of percentage. Instead, this thesis deals with more subtle qualities and processes in memory, such as how to collect data to later evoke engaging thinking and reminiscing. Moreover, this thesis is not concerned with the long-term performance of memory. The phenomena studied in the following refer to effects that may occur shortly after data capture, but also in the distant future. Maybe a bit paradoxical, time does not play a leading role in the described memory studies of this thesis.

From a technological perspective, this research primarily deals with interactions that are facilitated by modern mobile phones (smartphones). Also, in some instances, physical computing prototypes are developed. The interactions are locally restricted to the corresponding devices ('they are offline'), that is, the research on hand does not investigate augmented memory in conjunction with concepts of the Internet such as cloud computing, social networks, instant sharing of data, and so on.

The scientific approach in this thesis can be labelled as related to *research through design* or as a *design-based* methodological stance. Most significant findings in this thesis are based on qualitative data such as interviews, collected digital recordings (e.g., photos) or observations. From this is evident, that the conclusions drawn in this work are not understood as generalizable knowledge. Instead, we provide a rich and descriptive account of individual design cases that are theoretically structured by means of the CuDe Framework and that might provide inspirations to fellow researchers.

1.3 Thesis Structure

The thesis is structured as follows (please also note Figure 1.3 when studying this section). Starting with the literature and contextual review, we then move on to the methodology section. After the general research philosophy of this thesis and the employed methods have been laid out, an overview of the CuDe Framework is provided. While this framework emerged out of iterative and reflective design explorations, we present it here up front to support the further reading of the thesis and the comprehensibility of the presented ideas. (Later on, in the discussion, the CuDe Framework will be revisited.) These first three sections together comprise Part I of the thesis (see Figure 1.3) and specify the theoretical foundations to all further efforts.

Part II deals with all interventions, prototypes and user studies that are based on single entities. Thereby, Part II comprises one research strand (RS1), which again includes three initial technology probes and one more advanced prototype called Hearsay. The findings of this strand (RS1), in particular, of the Hearsay user study (HPI) contribute to the understanding of the usage of single entities for creating engaging remembering experiences. More precisely, drawing on these findings, we propose a *Strong Concept* candidate that we named *de-/re-ctx* and which proposes how to de- and re-contextualize cue data for the sake of catching the users' attention and letting them reflect on the presented information.

Part III then continues to elaborate multiple *and* combined entities. It comprises two research strands (RS2, RS3) featuring a total of two initial probes and two advanced prototype applications. RS2 deals with the *synchronous composition* of visual entities by means of Duography. R3, on the other hand, provides the opportunity for the user to *asynchronously combine* arbitrary entities by means of the Media Object. User studies of both applications (DUO.1-4; MEO.1-3) revealed various ways in which the participants made sense of these cue compositions, and also how they employed AEC/SEC to create precious digital resources for remembering. We explain how the study results informed our understanding of the interplay between multiple available media entities and hence memory cues.

Part IV synthesizes the findings of the three research strands (RS1-RS2) into the Media and Memory Cue Design Framework (CuDe) as a theoretical device for structuring the outcomes and making the insights accessible to both practical interaction designers and design theorists. This pulling together of the framework marks the general discussion of the study outcomes. It is followed by the conclusion.

Part I: Theoretical Foundations of the Thesis

2 Contextual Review

Figure 2.1. Wax tablet with 'stylus' (Sippel2707, 2005).

Figure 2.2. Drawer cabinet (Gossler, 2005).

In this chapter[3], we review relevant literature relating to 'organic' memory and to digital technologies, both in the context of designing interactive systems for supporting remembering. We first turn to the psychological and sociological aspects of memory, and then examine literature primarily from HCI regarding *technologies of memory*.

2.1 What is Memory?

As this thesis aims to augment human memory, a definition of what exactly is to be supported here is needed. When talking about memory, we often use metaphors. One of the oldest was created by the ancient philosopher Platon (although he later revised his idea of memory), when he compared memory to a wax tablet (Figure 2.1), which can be engraved and thereby stores information. Similarly, our brain was shaped by impressions and experiences. Figuratively, the same plasticity can also be seen in our organ, as memories are not stable but dynamic and change over time. A more static, however also common metaphor, is given by a drawer cabinet (Figure 2.2), where things can be stored, locked away and later be retrieved again.

In an attempt to find a systematization of the term 'memory', Kregel (2009) employed a set of dualisms and interprets memory as being settled between a number of 'different poles'. Accordingly, memory describes things that are gone or *absent*, but still in a way *present* at the same time. We carry it *inside* ourselves and yet employ *external* aids for remembering. Thus, memory has to do with *mental* processes as well as *material* belongings. Every person develops his or her *individual* memory that again is interwoven with society's *collective* memory. Memory depicts a *static* room for storage, still it is also *flexible* and to remember is a *dynamic* activity (Kregel, 2009).

The preceding list of dualisms illustrates that describing or categorizing memory is a complex task due to its multidimensionality. Depending on the perspective, different aspects of memory move to the foreground. The philosopher sees memory in a different light than the psychologist and the social scientist, again, is interested in yet distinctive features. As we deal with the design of interactive systems in this thesis, we are interested in all positions and perspectives that can support us in *building meaningful remembering tools*. Thus, we cannot restrict ourselves to one particular interpretation of memory but employ multiple and interdisciplinary viewpoints to inform our designs. For this reason, the remainder of this chapter brings together different

[3] Parts of this chapter are based the prior publications (Güldenpfennig & Fitzpatrick, 2011, 2014; Güldenpfennig, Fitzpatrick, & Reitberger, 2014; Güldenpfennig, Reitberger, & Fitzpatrick, 2012b).

memory research stances to provide a broad overview of the design space of digital memory systems in HCI (illustrated in Figure 1.2 of Chapter 1).

We start with describing the contributions of psychology in understanding individual and autobiographical memory. We go on to briefly reflect on the notion of 'collective memory' as studied primarily in sociology, history and cultural theory. From then on, we turn to core HCI research. Beginning with an outline of different HCI research approaches for supporting remembering by means of computerized tools, we continue by introducing different *technologies of memory*. Here, also concrete implementations and case studies of digital remembering tools are presented. We conclude the literature review by summing up lessons learnt and identified challenges in the design of future digital memory systems.

2.2 Psychological and Social Functions of Memory

Memory cannot exist on its own right; it demands some sort of carrier medium. As such, Kregel (2009) contrasted internal, natural carriers (our brain) with external, artificial storage media (e.g., the written word). Besides this rather obvious distinction, she also differentiated individuals as memory carriers from groups that establish collective memories between their members. For the question, whether memory is primarily a biological function or a learnt technique of culture, there is no easy answer (Pethes, 2008). Both biologically motivated approaches to memory research and cultural perspectives on remembering are relevant for the design of interactive systems, since different tools can target at supporting different types of remembering. For this reason, we outline theories of memory as interpreted by the social science as well as psychological research with a more biological lens on the individual. We start at the individual level and with the psychological perspective.

2.2.1 Memory Theories in Psychology

Experiences made, learnt skills and even unconscious impressions leave their traces in our mind. Sensory input is rendered into persistent structures to create a model of our surroundings and to steer and regulate everyday life. Neuroscientists long say these structures are basically made of connections between neural cells (*synapses*), allowing information to be passed on between *neurons* (cells of the nervous system or neural cells). As something new is *learnt*, new connections are established; the more training or repetition, the stronger and more persistent the impression, and the stronger is the connection (Hebb, 1949). Traditionally, in the literature these traces were named *engrams* (Semon, 1921). However, there is no agreement among psychologists about the concrete nature of memory, not even about the number of its subsystems or about the different components that constitute memory (Eysenck & Keane, 2005, Part II Memory and Concepts). Nonetheless, the *multi-store model* as proposed by Atkinson and Shiffrin (1968) gained much interest and is still an influential director of contemporary research. In this model memory is divided into three components according to different storage periods of held content and current data usage: *sensory stores*, *short-term store* and *long-term store*. Of most relevance with regard to this thesis is the long-term store or *long-term memory* (LTM). Thus, in the following the sensory store and short-term store are outlined only briefly, followed by a more detailed explanation of the current understandings of LTM systems.

2.2.1.1 Sensory Stores, Short-term Stores, and Long-term Stores

According to the multi-store model perceptions enter through the senses into the sensory store and are able to persists there for nearly a second. This is a first step toward the reduction of vast amounts of perceived information, because only key features that have been paid attention to are extracted and transferred to the short-term store. Miller's 'magical number seven' (Miller, 1956), that is, the estimation that the short-term store is able to synchronously hold 7$\pm$2 elements or *chunks* of information for a short duration of time, is well-known and early research into measuring the capacity of this memory component. (However, today it is questioned whether Miller's estimation is still practicable to describe human memory capacity.)

More recent research refined the term short-term store and now speaks of the *working memory* (WM). Within this conceptualization theorists still assume a short storage duration (approximately half a minute); however they put emphasis on the WM's being comprised of three subcomponents: a *central executive* and two auxiliary short-term stores (Baddeley, 2003). The central executive plays, as suggested by its name, the most important role in the WM. Its functions are, among others, to distribute attention and to 'reload' content from the LTM into the WM (to make this content accessible again), which is needed for fulfilling the current task.

Figure 2.3. Long-term memory (LTM) and its proposed components.

The multi-store model proposes that information from the short-term store is transferred to the LTM by means of *rehearsal*. In this memory component, information can be preserved for long(er) periods of time (ranging from minutes to decades). The LTM can comprise any conceivable content: general knowledge, algorithms and rules, biographic events, motor capabilities, implicit and explicit knowledge, and so on. Due to this immense variety of content, current research hypothesises that the LTM consists of a set of long-term memory subsystems, each serving a particular purpose (Eysenck & Keane, 2005, Chapter 7). This is illustrated by Figure 2.3 (adapted from (Maderthaner, 2008)), which depicts proposed LTM components. The *Perceptual Representation System* aids in the fast identification of familiar shapes and items. *Procedural* *memory* denotes skills and capabilities such as walking, speaking, motor skills, etc. Most of the time, we make implicit use of it, that is, we employ this knowledge unconsciously and without paying attention to it. The more explicit *declarative memory* system embraces knowledge that concerns facts about our lives and the world we live in. Thus, the content of the declarative memory can also be verbalised more easily compared to the information of the procedural memory (e.g., learnt motor skills). There are two further differentiations in declarative memory: *semantic* and *episodic memory*. While semantic memory denotes factual knowledge (e.g., the algorithm to calculate the area of a circle or the name of the capital of Austria), episodic memory constitutes recollections of concrete events. This latter concept is of particular relevance to this thesis, as we primarily aim at designing for supporting this sort of (personal) remembering. The notion of episodic memory was first proposed by Tulving. In the words of this influential psychologist

"[e]pisodic memory is a [...] past-oriented memory system, more vulnerable than other memory systems to neuronal dysfunction, and probably unique to humans. It makes possible mental time travel through subjective time, from the present to the past, thus allowing one to re-experience, through autonoetic awareness, one's own previous experiences" (Tulving, 2002, p.5).

2.2.1.2 Autobiographical Memory

Event-related episodic memory, as described above, is connected closely to *autobiographical memory (*AM)*,* which refers to significant events that are directly related to one's own life (*life memories*). AM can be broadly structured into a three-stage hierarchy of knowledge based on different levels of specificity: *lifetime periods* ('when I was at kindergarten'), *general events* ('my vacation in Sweden' or 'our secret parties at the school roof'), and *event-specific knowledge* ('the first time I went to a particular restaurant) (Conway & Pleydell-Pearce, 2000). Time spans vary among these three different levels from minutes/hours to days/weeks to years/decades (with an decreasing level of specificity, the time span of the period increases).

According to Cohen (as cited in an article by Hoven and Eggen (2008)) AM fulfils a set of important functions. Among these are the construction of the self-concept and self-history, the regulation of moods, the fostering of social activities and its positive effects by sharing stories (maintaining relationships), problem solving based on life-knowledge, making predictions about future events, and establishing likes/dislikes or attitudes (Hoven & Eggen, 2008). Similarly, Schacter (1996) highlighted the importance of AM, when he claimed that it is the autobiographic narratives that persist in memory and thus constitute the core of our personal identity. AM bridges the past and future self and thereby provides the narrative continuity which is needed in creating our identity (Schacter, 1996, Chapter 2 Building Memories and Chapter 3 Of Time and Autobiography). A special form of AM is reminiscing ('dwelling in the past', revisiting past moments) (Bluck & Levine, 1998). By "thinking and talking about [...their personal] past", which happens on a daily basis, people strengthen social bonds, plan prospect behaviour and establish a sense of self-continuity (Bluck & Alea, 2009). The thesis on hand is partially motivated by these important functions of the AM and explores novel ways in which technology might be able to support them.

Schacter (1996, Chapter 2 Building Memories) further emphasized the very subjective nature of the AM remembering process. In his opinion (and in the opinion of many of his colleagues) engrams can be buried deep in our brains and remain inactive for years. Only on coincidence, a recollection might be woken (or *cued*) after years. The way in which this long 'forgotten' ("dormant") thought is experienced depends, again, on our current mood and (random) environmental factors that influence our state of mind. Consequently, the same event can be relived in very different manners (a 'bright' moment suddenly can 'turn grey', and vice-versa) and consequently its recollection does not constitute a precise replica of the original event (Schacter, 1999); "[t]his means that an important part of your recollective experience [...] is, to a large extent, constructed or invented at the time of attempted recall" (Schacter, 1996, p.21-22). " Schacter elaborated further:

"Instead, such experiences are always constructed by combining bits of information from each of the three levels of autobiographical knowledge. Just as memories for individual events resemble jigsaw puzzles that are assembled from many pieces, so do the stories of our lives" (Schacter, 1996, p. 91).

2.2.1.3 Encoding and Retrieving Memories

Retrieving memories is inseparably combined with the *encoding* of memories, which has to precede any retrieval (Schacter, 1996, Chapter 2 Building Memories). The quality and hence endurance of encoding is a function of various factors and memorizing strategies. For example, if a person analyses a stimulus (fact, event, experience, etc.) semantically, it will more likely be remembered than a stimulus that has only been paid shallow attention to (Eysenck & Keane, 2005; Schacter, 1999). By thorough analysis this stimulus is connected to existing knowledge, which increases the chance of later recollection. Furthermore, the modality of a stimulus (e.g., perceived as spoken words, a melody or a set of provocative photos) influences the performance of the LTM. Of importance is also the condition under which encoding is conducted, as already indicated. Conditions can differ with regard to the amount attention/distraction, available context information, the structure of the stimulus or the order of the to be encoded information (Maderthaner, 2008).

The engram that results from the encoding process can be 'activated' by means of a *memory retrieval cue*. Van Hoven & Eggen (2008) define *cue* (or trigger) as *"a stimulus that can help someone to retrieve information from the long-term memory, but only if this cue is related to the to-be-remembered memory. […A]nything could be a cue (a spoken word, a colour, an action or a person) […] A combination of cues increases the chance of retrieving a memory […]" (Hoven & Eggen, 2008, p. 435).*

Research on memory retrieval cues dates inter alia back to Tulving's well-known *encoding-specificity principle* (see e.g., *(Tulving & Thomson, 1973)*), which basically argues that the probability of recall is increased, if the same information (cues or context) is available at recall that was perceived during the encoding process. Thus, successful recall is dependent on *context*. This was most impressively demonstrated by Godden and Baddeley (as cited in (Maderthaner, 2008)), who let participants learn lists of words on land and under water. The participants showed a 10-12% increase in recall-performance if the learning environment matched the learning environment (e.g., better recall under water, when the list was learnt under water).

Due to the paradigm of controlled experiments, current knowledge on memory is based on 'artificial' lab settings in large parts (e.g., memorization of word lists or random nonsense syllables) and focused on "mechanistic issues of performance and accuracy" (Bluck & Alea, 2009, p. 1090). The number of experiments on cue effects on AM under more naturalistic conditions is limited (Hoven & Eggen, 2009). Wagenaar (1986) marks an exception with a case study on his own memory over the course of five years. In this period of time, the memory researcher documented more than 2000 events in his own life accompanied by basic information (memory cues) for each event, among other things: *what* had happened, *where* it had happened, *when* it had happened, and *who* had been involved. By attempting to recollect random events of his documentation, Wagenaar (1986) found that after five years he was able to remember more than the half of the events by means of these retrieval cues. The 'what cue' had the strongest effect in bringing memories back to life, whereas the information 'when' something had happened, generated the weakest recall performance. In line with this finding, Brewer (1988) (as cited in (Sellen & Whittaker, 2010)) found that place, event and people are better memory cues than time.

It can, however, also be the case that our brain generates 'false memories' (Loftus & Loftus, 1980), that is, we absolutely believe in the correctness of our recalled information, which is nevertheless wrong as a matter of fact. This may be caused, for instance, by the misattribution of correct facts to faulty ones, by 'two-edged' clues that suggest wrong ideas, or by other cognitive/emotional biases such as one's current mood (Schacter, 1999).

In this section, we have learnt that remembering is thought to be dependent on the availability of appropriate memory retrieval cues. A memory is not a copy of some experience that is stored as a precise replica of the corresponding event to be later retrieved again (comparable to the drawer cabinet metaphor). Instead, remembering is more similar to imprints on a wax tablet (Figure 2.1): only salient pieces of an incident or experience leave their traces. By means of these traces, however, the original incident can later be reconstructed and hence re-experienced. If this common hypothesis holds true, it has far reaching consequences for our ability to remember past events. Indeed, Schacter (1996, p.63) recognizes that the "[…] understanding of ourselves is so dependent on what we can remember of the past, it is troubling to realize that successful recall depends heavily on the availability of appropriate retrieval cues".

2.2.1.4 Consolidation and Forgetting

While encoding and retrieving depict a 'dipole' of memory processes, consolidation and forgetting can also be seen as closely related complements. Consolidation or keeping information in the LTM is accomplished to a large extent by repetition, whereas appropriate time spacing between repetitions (or elaborations) and certain brain activities during nightly sleep play a crucial role (Maderthaner, 2008). Repetition and hence the consolidation of memories are among other things accomplished by means of *story telling*: "autobiographical memories are created and re-created in daily interactions in which we share our stories with others […] in everyday family reminiscing" (Fivush, 2008, p.49). This reemphasizes the afore-mentioned importance of social activities in remembering.

Forgetting, as the complement to consolidation, is most often perceived as an unwanted shortcoming of our brain and its consequences are regretted, even feared. Nevertheless, forgetting brings also beneficial functions, such as the protection from a flood of information or the releasing of baleful experiences. There are a number of hypothesised causes for forgetting. On the one hand, engrams can simply fade away over time and get lost. On the other hand, engrams might still exist, however, cannot be accessed due to the lack of appropriate memory cues or they might temporarily be blocked from retrieval (Schacter, 1999). Still another reason for forgetting might be that newly learnt information interferes with older content and consequently recall gets disturbed by the close similarity of this information (Eysenck & Keane, 2005).

As van Dijck (2007, Chapter 1 Mediated Memories as a Conceptual Tool) noted, (cognitive) psychology investigates memory without taking social contexts into much consideration. It is researchers from sociology, cultural theory and history, who extended the notion of personal to *collective* memory by shifting the focus from individuals to groups as the carriers of memory. This extension seems only logical, given that the social product of language is a main facilitator in memory. We employ language to verbalize memories, to share stories (and thus memories), to preserve past events by means of written words, or even to conduct basic research in cognitive psychology to study memory by means of word lists. Hence, memory as well as research on memory appears to be inevitably shaped by culture.

2.2.2 Collective, Communicative and Cultural Memory

Often we neglect that our actions and thoughts are deeply shaped by the culture we live in. It was Maurice Halbwachs (1985) who coined the term *collective memory* to emphasize that the reconstruction of memories is not only influenced by cultural conventions, but also dependent on them even. In contrast to preceding research in psychology, he described memory not as an individual psychological function, but as a social phenomenon. Halbwachs interpreted memory as a social process, embedded in social context and fulfilling cultural functions such as constructing group identity. Starting with sensory and subjective perceptions, all subsequent interpretations of the perceived information make use of cultural tools for making meaning and of communication (language). Meaning is assigned to individual memories by relating them to the overall societal context. As such, memories have two intertwined and complementary components. On the one hand, memories are perceived and experienced individually. On the other hand, they have a social function and meaning (Halbwachs, 1985).

The cultural scientist Assmann connected to Halbwachs' work by introducing an additional differentiation of collective memory: *communicative* and *cultural memory* (Pethes, 2008). The first differentiation denotes knowledge, facts and content that is exchanged verbally by the members of society. It grows organically and is shaped by the sharing of stories, that is, it is communicated in everyday situations. Due to this verbal mode of communication, this subtype of collective memory is fragile and often subject to modulation. While it is established and shared by a social group without intentional maintenance, cultural memory is established by deliberate acts and builds on artificial means for storage (e.g., text, documents, museums, and so forth). Both preservation and erasure are employed to build the identity of a social group and to make statements about the ideals of this society. Whereas the more short-term communicative memory reconnects the individual's present to the recent past, the cultural long-term memory reminds the group members of their far distant roots (Kregel (2009) citing Assmann (1997)).

2.2.3 The Dependence of Memory on Technology

Apparent from above, tools for capturing information (e.g., information on important events) play a crucial role in establishing cultural memory. In the course of this thesis, these tools will be denoted as "technologies of memory" (Sturken, 2008). Let us borrow the words of van House and Churchill (2008), two researchers concerned with the impact of technology on society, to once more stress the importance of artificial tools in the process of remembering: "Our basic argument is that what is remembered individually and collectively depends in part on technologies of memory and the associated socio-technical practices, which are changing radically" (Van House & Churchill, 2008, p.296).

In this passage the authors depict collective as well as individual memory as dependent on significant shifts in technology. Another researcher, who shares their interest in the in interplay between memory and technology is van Dijck, inter alia author of the book *Mediated Memories in the Digital Age* (Van Dijck, 2007), where similarly emphasis is put on the significance of current technological developments: "Scientists and philosophers agree material environments influence the structure and contents of the mind; objects and technology *inform* memory instead of transmitting it. Memory is not exclusively located inside the brain, and hence limited to the interior body [...]" (Van Dijck, 2007, pp.41-42). Van Dijck created the model of *mediated memory* as a tool to analyse how the construction of memory changes, as we move towards the digital age. In this author's interpretation instances of "memory objects" (photos, albums, letters, audio, video, etc.) mediate between individual and collective memory, private and public, past and presence ("constructing a sense of individual identity and collectivity at the same time" (Van Dijck, 2007, p. 9)). This view is shared by Kuhn, according to whom "memory is a process, an activity, a construct [... and] memory has social and cultural as well as personal, resonance" (Kuhn, 2010, p. 298).

"As we keep saying, the technologies of memory will strongly influence what can and will be remembered. Although we are not technology determinists, decisions are being made now from which it may be hard to recover" (Van House & Churchill, 2008, p.302).

We live in a time of massive technological progress. For instance, one relatively small device with huge potential to change our personal as well as collective memory is the modern mobile phone. Equipped with its precise digital camera, large storage capacity and Internet connectivity, we now can record and share what we see immediately, everywhere and more easily than ever before. The quotes by van House, Churchill and van Dijck already hint that this will come at its price, and consequences might be vast and unpredictable. Naturally, researchers from various disciplines have picked up this topic and we will continue to elaborate on identified challenges and opportunities at the end of this section. Before this, however, we have a detailed look on what these "technologies of memories" (Sturken, 2008) actually are.

2.3 Technology and Memory

Sturken (2008), taking a perspective from memory studies and related fields such as cultural studies or visual culture, assumed a broad range of artefacts as *technologies of memories*. Among these are memorials, souvenirs, objects and visual technologies such as photography or videography. In everyday life, these artefacts or objects can serve us for re-enacting our past and hence for establishing life narratives and continuity, according to Kuhn (2010). We dedicate the remainder of this chapter to these technologies of memory while applying a perspective from a human-computer interaction. That is, the overall goal of the following work is to support the design of interactive systems. To do so, a variety of research was conducted in HCI, ranging from ethnographic fieldwork (e.g., on souvenirs and beloved objects) to the implementation of complex systems for archiving digital material.

One key player in technologies of memories is (digital) photography, as it represents a nearly ubiquitous medium in our everyday life today. Certainly, other media such as written text and video (or film) are also omnipresent. However, with regard to personal remembering, the role of (digital) photography is more significant, or at least, more work in HCI was done on the digital still image. Sellen and Whittaker (2010) referring to Conway (1990) suggested that the design of digital systems supporting *recollection* should make pictures "the backbone" of their interfaces, as autobiographical memories are strongly connected to (internal) visual images. For these reasons and also because photo is the key medium in the practical design part of this thesis, we start the following section on *technology and memory* with a rather detailed review on photography. While photography can be considered as an instance or as one particular medium for capturing information, there is also much work on the general organization of digital media data, on the problem of storage and retrieval. In this context, after photography we turn to research, which aims to optimize personal information for keeping track of one's own created content and '(digital) life' in the broadest sense. *Personal information management (PIM)*, and *lifelogging* are some of the terms, which describe this kind of research. In particular, *lifelogging* applications sharpened the field's vision for incorporating findings from psychology into improved designs to address user needs from a psychological standpoint, that is, considering carefully how the mind remembers to provide the best memory retrieval cues possible. In parallel, researchers in HCI increasingly drew on field studies to inform their applications for archiving meaningful personal data collections. Both of these 'movements' generated important insights and guides for future directions. Thus, next we carefully report on these efforts in the literature review. Finally, we conclude the contextual review with a set of grand challenges, which were identified within the corpus of HCI literature, and which are of particular relevance for the proposed designs in this thesis.

2.3.1 Photography

One influential technology of memory, if not the most influential one, is photography (O'Hara et al., 2012; Van den Hoven, Sas, & Whittaker, 2012; Whittaker, Bergman, & Clough, 2010). Sarvas and Frohlich (2011) identified three "disruptions" in the history of *domestic* photography (i.e., the photography of 'ordinary' people) and accordingly outlined its development in three periods or *paths*: the *portrait path* (ca. 1830s-1888), the *Kodak path* (ca. 1888-1990s) and the *digital path* (1990s - *today*). By describing the transitions between these paths as "disruptions", as opposed to linear change, the authors stressed the 'game-changing' influence of some technological innovations that fundamentally rearranged the practices around photography. We go on to draw on the book by Sarvas and Frohlich (2011) for outlining a short history of photography based on the three paths suggested by these authors.

Figure 2.4. *Carte-de-visite* of Queen Victoria I (Mayall, c. 1860).

The *portrait path* was shaped by the desire of the middle class for having one's portrait taken, a representative practice, which has been reserved until then for the upper class as a sign of status. This desire was met gradually by a number of technological improvements. Starting with the *daguerreotype* (invented by Louis Jacques Mandé Daguerre) and the *talbotype* (named after its inventor William Henry Fox Talbot), technological innovation made it possible to permanently store and reproduce copies of images captured by the *camera obscura* (an optical device for projecting the images of objects/people on a surface and hence allowing to study or draw these images from that plane), and providing an affordable alternative to existing portrait techniques such as painting or creating *silhouettes*. Eventually, the *carte-de-visite* was enabled by these developments around the 1850s. This was a relatively cheap method for producing (portrait) pictures. The *carte-de-visite* 'went viral' in the following years and formed the basis for picture collecting as well as the family photo album (Sarvas & Frohlich, 2011). Besides personal portraits, famous people or landmarks were also popular subjects to *carte-de-visites* (see e.g., Figure 2.4).

The second path in the history of photography, as proposed by Sarvas and Frohlich (2011) is the *Kodak path*. Its name originates from the global corporation *Kodak* (originally *The Eastman Dry Plate and Film Company*), which established the roll film and corresponding photo finishing services in photography. Before the inception of the Kodak business model (the customer purchases a roll of film, takes pictures, gives the film to a finishing service and receives photo prints in return), photography was quite complicated, and as a result, photos (e.g., portraits made in a photo studio) were taken and developed by specialists. However, the separation of the photo taking and developing process opened up photography to yet broader audiences and to the mass market. Specifically, unskilled amateurs from the middle class now began to take their own photos, in contrast to only purchasing pictures from professional photographers. Kodak advertised this ease in operation as one of the company's most important selling points with its motto: "You press the button, we do the rest" (see Figure 2.5). Via its ads, Kodak was also eager to make suggestions on what to photograph, since photo-taking practices had not established at that point of time. In the beginning, the most popular (and advertised) motifs were such of outdoor leisure activities (e.g., going to the seaside, doing sports, etc.) and a few years later, as the light sensitivity of photo film was improved, the family in the setting of its home too became one of the most prevalent motifs. Besides few alternatives (e.g., *Polaroid* photos that did not require a finishing service), the Kodak business model (send in film and receive prints) remained dominant and static for approximately one century, which marks a surprisingly long period of time with no significant shifts in photo technology (Sarvas & Frohlich, 2011).

Figure 2.5. Advertisement for the Kodak camera and its ease in use: "You press the button, we do the rest." (Kodak, 1889).

In the 1990s, the Kodak path came to an end when digital cameras and hence the *digital path* took over. Sarvas and Frohlich (2011) considered the advent of the digital image sensor and corresponding digital storage media as the biggest disruption in the history of photography. Where exactly the journey will go is hard to anticipate from our current position, since the establishment of the digital path is still in progress and it gets deepened or reshaped by the introduction of every new photo related product and practice. However, what is striking about digital photography is its close relationship to the personal computer (PC), a digital multipurpose tool. As a consequence, the originally 'locked in' photography (into the camera, on film and on prints) was set free and the photo infrastructure was extended significantly. Photo editing software, different kinds of cameras (e.g., *DSLR* camera, camera phones), online photo sharing services, and so forth, are all part of the new digital photo hemisphere. Interestingly, many practices of digital photography are still very similar to those of the Kodak path, probably because developments have been very fast and people are still working out how to take on this new configuration of photography (Sarvas & Frohlich, 2011). Nevertheless, certain aspects of the way people deal with photography, of course, have changed, moving along the digital path. To highlight practices that have been stable for decades and to contrast them with those that have been transformed by digitisation, we will visit Chalfen's (1987) classic ethnographic and theoretical work on photography in the subsequent section. This report will be followed by the description of HCI research endeavours into *digital* photography, which serves to represent works in contemporary (*digital*) photography as opposed to Chalfen's classic study on practices regarding analogue techniques. The reader should note, that the presented observations primarily refer to photography as practiced in the western hemisphere.

2.3.1.1 Photographic Practices: From Analogue to Digital

Analogue. In the cultural sciences, there is a significant body of work looking at the social and cultural practices around domestic photography, both analogue and digital. One of the classic works is by the visual anthropologist Chalfen who conducted some large-scale ethnographic studies to examine "how ordinary people do ordinary photography" (Chalfen, 1987, p.12). In his noteworthy book *Snapshot Versions of Life* (Chalfen, 1987), which depicts one of the most detailed investigations of photographic practices (Frohlich, Kuchinsky, Pering, Don, & Ariss, 2002), he drew on round 200 examined photo collections of mostly white Americans from the middle-class. Hence, this study can at least provide us with an informative inventory of photographic practices of that specific social class up to the 1980s. His analysis led to the conclusion that most people engaged with photography as a means of interpersonal communication and self-expression and Chalfen coined the term *Kodak Culture* to emphasize that people abide by social rules when capturing or looking at pictures. For instance, most people intuitionally know what occasions are appropriate for taking a photo and which are not. Chalfen argued that this kind of shared knowledge is fundamental to the "home mode of pictorial communication", his label for the form of communication enabled by photography that allows "[a]ny ordinary person [...to] make personal audio-visual statements about private aspects of life" (Chalfen, 1987, p.7). As these statements follow the social code of the *Kodak Culture*, Chalfen studied photography as a tool for people to construct their own reality in symbolic pictures. For instance, he found that people in their 20s or 30s were often portrayed next to material acquisitions (e.g., a new car) to celebrate the new possession and, moreover, to state that their life is good and successful. The most common snapshot in Chalfen' ethnographic studies, however, was not related to material belongings but contained a statement about personal relationships, for example, a parent holding a baby and thus marking an important milestone in one's life career.

Generally speaking, these "snapshot versions of life" were all drawn in a very positive light. In contrast to written diaries, the analysed albums contained almost no photos of negative or sad occasions ("off moments"). Moreover, there was an absence of mundane activities being photographed. Taking snapshots, at least to the date of the study (which included photos from the 1940s up to the 1980s), was about the (biased) documentation and communication of socially approved life events. Looking at someone's photos, as already mentioned, also abided to social rules: "We see what we have been trained to see" (Chalfen, 1987, p.128), the same kind of pictures are repeatedly shown and "the same stories are heard time and time again" (Chalfen, 1987, p.130).

Perhaps unsurprisingly, Chalfen also articulated questions about photography and its relationship to memory:

"How do snapshot appearances of particular people influence our memories of people we have actually met in the past, or structure an impression of people we will never meet? For instance, how do we come to 'know' a grandmother or grandfather no longer alive, or a relative living in another country, from their pictures in the family album? In turn, what does 'being in the album' mean, and, conversely, what does not being there mean?" (Chalfen, 1987, p.11)

Surely, *Snapshot Versions of Life* cannot provide definite answers, but in Chalfen's interviews he found at least support and information that allows for some speculations about the functions of personal imagery in memory. With regard to sole documentation purposes, the interviewees often experienced taking a photo as creating a testimonial that a certain event had happened. They attributed this fact to the camera's capability to create 'photorealistic' images of reality (in contrast to, e.g., diary keeping where one can more easily write in fiction). Moreover, this is a quite surprising observation, given people's tendency to draw very biased and incomplete excerpts of life by means of the camera. Unloved family members or people can be, and are, banned from the photo collections and, thus, are banned from memory. In addition to this incompleteness, photos are not definite, but allow multiple interpretations, which are often steered by accompanying oral background information and story telling activities. Still, photos are regularly perceived as strong memory aids and interviewees often associated photography with the desperate desire of preserving a slice of time or encapsulating a precious moment within a photo print. Hence, as time passes by and personal memory fades away, many photos become even more valued, "[…since] the photographs offer evidence of the fact that a meeting did occur, that interaction took place, and that these people touched and held each other at one time. Secondly, informants frequently mention that these photographs tend to structure and maintain the memory of forgotten events" (Chalfen, 1987, p.78).

For his analysis, Chalfen developed a descriptive, heuristical framework of different photo-related activities. Among these activities are *shooting events* (i.e., what the photographer does in order to frame a picture, when and why, etc., and what is happening in front of the camera as a product of Kodak Culture), *editing events* (image processing, (re-) arrangements and manipulations before public showing) and *exhibition events* (public showing). More than 25 years later, Petrelli, Bowen and Whittaker (2014) introduced their related works section in an HCI journal article on digital photo mementos with the following words:

"Digital photography has excited the interest of researchers since its inception. We review aspects of the huge literature most directly related to this paper: techniques for photo management; the social dimension of digital photos; and photo displays at home" (Petrelli et al., 2014, p.321).

We propose a certain similarity between these three subdivisions and Chalfen's framework items (see above) for domestic photography. The aspects captured by Chalfen's categories appear to have remained relevant for decades. (In fact, Petrelli et al. (2014) draw on Chalfen (1987) in their paper.) Thus, we employ them as guidance for structuring the next section on digital photography in HCI. More precisely, after a general reflection about the increase of photos taken, we start with looking into research on photo management (including organization, retrieval and enhanced capture of photos; in the broader sense related to *editing events*), followed by works on photo displays and picture sharing technologies (*exhibition events*), and concluding with social aspects and practices around digital photography (in the broadest sense related to *shooting events*, which consider *Kodak Culture* 'in front of and behind the camera'). The decision to use these three categories in the following is also intended as an anchor for connecting the photographic practices of the 1980s to contemporary photography.

Digital. Although we mentioned earlier, that surprisingly many practices of photography remained stable for decades, some aspects did certainly alter (Miller & Edwards, 2007) and new photo technologies were "incorporated into a range of the social practices associated with photographs" (Lindley, Durrant, Kirk, & Taylor, 2008, p. 3921). Among the most prominent new features of digital photography are the ease of capturing photos and the simplified procedure of editing the pictures (e.g., removing 'red eyes', printing manipulated photos) (Kirk, Sellen, Rother, & Wood, 2006). Along with the possibility to have immediate photo previews on the camera device (Van House, 2009) and to be able to share digital photos easily, these features helped photography in gaining even more popularity compared to its analogue predecessor.

With regard to pure quantities, digital photography changed significantly compared to its analogue implementation. The number of images taken has exploded since the inception of the first analogue cameras and the costs for photo capture decreased significantly (Durrant, Taylor, Frohlich, Sellen, & Uzzell, 2009; Petersen, Ljungblad, & Håkansson, 2009). An extended range of the population engaged in the capturing of pictures (Durrant et al., 2009; Sarvas & Frohlich, 2011). While in 1973 6.23 billion images were taken in the US, this number approximately doubled ten years later. By 1983, round 93% of all U.S. families owned some kind of camera (Chalfen (1987) citing the *Wolfman Report*, an annual marketing report of the photographic industry). Few decades later, in 2007, with people using mostly digital cameras, the annual number of photos taken in the U.S. was estimated at between 420 and 670 billion (Sarvas and Frohlich (2011) citing Shankland). Still, the number of pictures taken continues growing at an exponential rate. 10% of all of humanity's photos were captured within the past 12 months, according to estimations reported by Good (2011). It is also this massive popularity that reemphasizes photography's significance as a technology of memory.

Photo management research and enhanced photo capture. Digital photography as an object of research clearly falls into the interest of HCI (and the related field of computer-supported cooperative work (CSCW)). There have been vibrant HCI research efforts in this subject now for more than a decade. Some of the classic studies aim at gathering insights in order to inform the design of improved systems. Hence, these earlier works deal to a larger extent with organizational challenges around this increasingly important technology of digital photography (Petersen et al., 2009). Rodden and Wood (2003), for example, investigated whether their digital photo management tool called *Shoebox* could support users in organizing their digital photos. At the time of this study digital cameras were still not widely adopted, however, most people were very familiar with analogue photography and physical prints (Rodden & Wood, 2003). Thus, these authors presented one of the first investigations of computationally supported browsing and sorting of (digital) photos. To this end, their *Shoebox* system offered advanced multimedia features such as speech-to-text annotating or content-based image retrieval. They found that participants did not significantly alter their photo organization habits as they moved from the analogue to the digital. While most people tended to keep a label on the envelopes of their physical printouts (e.g., labelling the specific event that is captured by the photos within that envelope), the participants also created folders on their computers with specific names hinting at its content. However, this is where most participants' effort to create order over their photos came to an end. Their virtual *Shoebox*, in a way, became a physical one, considering the carefree way in which people stored away (or 'dropped') their photos. Participants made only little use of the system's advanced annotation capabilities, however, they highly appreciated the affordance of the digital system to automatically sort images by chronological order and to generate large sets of synchronously presented preview thumbnail images (Rodden & Wood, 2003). Both, the participants' disinterest in adding meta-data annotations to photos and the lack in creating order over the photo collections is in line with the work of other researchers, for instance, as reported by van House (2009). Van House found that participants were often apologetic about the condition of their photo albums and promised to improve them *someday*. These issues around the (dis)organization of collections are elaborated later in this chapter.

Kirk et al. (2006) introduced the term "photowork" to describe activities in digital photography after picture capture but prior to revisiting the photos with their intended use as visual souvenirs. These activities relate to Chalfen's *editing events* of analogue photography and comprise reviewing, downloading, organizing, editing, sorting and filing (Kirk et al., 2006). The authors found these investigations timely and necessary, since by the middle of the first decade of the 21st century, HCI could still not give sufficient answers to questions such as "[d]o users search through their [digital photo] collections? How often? Why? Using what criteria?" (Kirk et al., 2006, p. 762). They were particularly interested in their participants' searching habits as they aim at designing


Figure 2.6. *SenseCam*. Image taken from (Hodges et al., 2006, p.181).

for supporting users in searching their collections. However, they observed that users do surprisingly few searches and instead engage most of the time with current photos. Thereby, the sorting of new photos is one of the most common and time-consuming tasks. As a consequence, they suggested supporting these sorting activities rather than facilitating searches for particular images. It must nevertheless be said that their participants reported not using any photo management software for the sake of sorting. For the majority, moving all photos of a certain event from the camera onto the computer into a folder labelled with the name and possibly the date of that event was the preferred practice.

While the above-described efforts aimed at assisting the user in finding, relocating, browsing and editing already-captured photos, other researchers augmented the process of photo capturing per se and thereby (indirectly) assisted the users in relocating and making the best use of their pictures. That way, augmenting photos with additional context or meta information was "[…] a rich source for selecting a specific image from a larger archive" (Holleis, Kranz, Gall, & Schmidt, 2005, p.536). To this end, Holleis et al. (2005) considered a set of context information as important, namely: camera device meta-data (e.g., camera orientation), environmental information (e.g., the weather situation during photo capture), physiological data (e.g., galvanic skin response as an indicator of the level of excitement of the photographer) and social context (who was around when the photo was captured?).

There are also a couple of noteworthy experimental approaches and devices for capturing contextual data in digital photography. Maybe most prominent of these devices is *SenseCam* (Hodges et al., 2006), a passive photo camera that is worn on a string around the neck (see Figure 2.6). *SenseCam* captures images automatically at a certain time rate and/or as triggered by various on-board sensors, from a first person point of view. Researchers looked into many aspects of this device, including issues such as its capabilities for supporting memories (Sellen et al., 2007), considerations regarding the aesthetics and originality of *SenseCam* photos (Ljungblad, 2009), its potential in everyday life for digital narratives and creating stories (Harper et al., 2008; Harper et al., 2007; Lindley et al., 2009), and for assisting reflective learning in an educational setting (Fleck & Fitzpatrick, 2009). We will elaborate more on *SenseCam* with regard to memory and *lifelogging* in Section 2.3.5.

The capabilities of 'the digital' to capture contextual data beyond plain visual information led to the creation of further new and unconventional forms of photography. For example, Frohlich and Fennell (2007) looked into ways in which digital photography can be supported by simple means by recording a snippet of audio input synchronously to image capture. They created so-called audiophotographs (Frohlich & Tallyn, 1999). Others approached the bringing of context into photography in a more playful fashion and with a focus on creative engagement or play: they used a camera in conjunction with other sensors (e.g., a microphone) to influence the resulting picture by the environment. For instance, loud noises would blur the image and hence the noise would be 'engraved' into the visual output of the camera (Håkansson & Gaye, 2008; Håkansson, Gaye, Ljungblad, & Holmquist, 2006; Ljungblad, Håkansson, Gaye, & Holmquist, 2004).

Making visible digital files: photo display technologies and digital photo sharing. Digital imaging technology also allows previously unconceivable new ways for displaying photos. While revisiting photos at the time of Chalfen's *exhibition events* mainly involved 'old-fashioned' photo albums and photo projectors, digital imaging technology offers a number of new alternatives for viewing and sharing photos (O'Hara et al., 2012). These alternative modes of display and photo handling comprise: "private home printing, self-service or web-service printing, […] transmission and publishing of photographs, […] and photo viewing on every possible kind of screen" (Frohlich & Fennell, 2007, p.107). As mentioned before, HCI and computer-supported cooperative work (CSCW) focused on organizational challenges such as photo retrieval in an early stage of research. Photo display related challenges are part of these organizational problems ever since. To improve photo browsing on regular Desktop computer screens, novel algorithms were proposed to better and more lucidly display pictures. *PhotoMesa* (Bederson, 2001) can serve as an early example of such systems. As computer technology advanced and partly 'moved away from the Desktop', some devices for displaying photos too became more complex. Hilliges, Baur and Butz (2007), for instance, explored (co-located) photo browsing and display on an interactive tabletop device. The latter two works can be considered as endeavours that seek to improve photo-display by advancing algorithms or hardware and are thus driven (at least partially) by the ambition and passion of the engineer. There is, however, also research that deliberately employs a *less-is-more* principle. With an eye on developments in the photographic mass market, Frohlich and Fennell discovered "a general *more-is-more philosophy* to provide the largest number of features at the lowest possible price" (Frohlich & Fennell, 2007,p. 109). As opposed to this, for photo display they proposed a system comprised of conventional photo prints and a table. Whenever a user puts a photo on that table, this specific picture is identified and associated meta-information (voiceover, music, ambient sounds, conversations at the time of photo-capture) is provided by means of audio speakers. The design rationale of this setup was influenced by the observed discontent of camcorder owners and by repeated participant feedback that supported the role of still photography as memorabilia and story trigger, because of its reduced visual information. Video recordings, on the other hand, were perceived as very detailed and explicit and thus as taking away room for speculation as well as the need for the user to fill in missing frames (as with photography) by means of imagination (Frohlich & Fennell, 2007).

O'Hara et al. (2012) emphasized that different photo presentation modalities along with its specific materiality (e.g., photo frames fixed to a wall, photo albums, photo slideshows on a computer) can lead to different 'social responses' when dealing with the photos. These different modalities bring different ways in which people can, for example, arrange themselves around the displays, leading to different patterns of interaction (e.g., one person might be in the centre of the screen and in control of the presentation, whereas persons in the periphery might become more of a passive audience) (O'Hara et al., 2012). Lindley and Monk (2008), for instance, showed that providing each person participating in a reminiscing session facilitated by photos on a central display, with their own remote control, can lead to a more informal, more enjoyable and increasingly sociable reminiscing conversation (as opposed to having only one remote control assigned to one person being in charge of leading the photo show) (Lindley & Monk, 2008). Van House (2009) and Frohlich et al. (2002) found that revisiting photos by means of a conventional computer display was not always perceived as "a comfortable viewing site" (Van House, 2009, p. 1080) due to matters of location, screen size and space restrictions with regard to multiple people attempting to group around the screen.

Other exemplary projects, which probe for 'social responses' on different photo displays are *PhotoSwitch* (Durrant et al., 2009) and *4Photos* (Bhömer, Helmes, O'Hara, & Hoven, 2010; O'Hara et al., 2012). While *PhotoSwitch* explored how photo collections and memorabilia made by family members from different generations might be integrated and put on display in a shared household, *4Photos* studied collocated photo sharing in social settings facilitated by novel displays. One key consideration of the latter project was that photo "mementos are not passive signifiers of memories simply to be preserved but rather that they are more actively consumed in the context of everyday behaviour and social practices" (O'Hara et al., 2012, p.126). O'Hara et al. (2012) showed how their prototype *4Photos* integrated into the setting of a shared meal and furthermore how it was able to promote conversations. They picked this specific context as eating together has been identified as an important event that helps organize social life and establish autobiographical memory by means of sharing stories and conversation. In their study they identify, among other things, conversations around topics that are related to the creation and functions of autobiographical memory (e.g., remarks on pictures that are referring to notions of self identity). Crabtree, Rodden, and Mariani (2004) run an ethnographic study about how people interact with photo-printouts and investigated different styles of collaborations to support distributed photo-based conversations and to inform the design of photo-sharing technologies that do not operate on a face-to-face basis, but over a distance.

These conversations around photographs have been denoted as *photo-talk* in Frohlich et al.'s (2002) landmark article "Requirements for photoware". More precisely, photo-talk is further distinguished in *storytelling* and *reminiscing talk*. The first subcategory denotes a form of photo-mediated contemplation about an event in which only the presenting person participated. The second kind of photo-talk brings memories back to life that were experienced together by everyone attending the session. The authors' primary interest in this paper was on evaluating requirements of photo-sharing technology or *photoware*, another important use of digital photos to be discussed in this review. The strength of this article is that many of these identified requirements can now, approximately one decade after the publication, be found in many commercially successful products. For example, Frohlich et al. (2002) observed a need in "instant photo sharing", a feature that nowadays contributes to the success of mobile phone photography and social networking, enabled by the Internet connectivity of modern mobile phones. Another proposed concept, targeting at the aggregation or 'bundling' of related data to be later shared, today is a fundamental part of products such as *Evernote* or *Google's Keep*:

"Active selection of small photo sets for special projects such as homework assignments or anniversary gifts was a relative frequent activity, and already linked with digital photography. Future technology should capitalize on this link and target such behaviour. […] For example, photos might be arranged in a montage which indexes accompanying audio or video clips, and can be printed economically by the recipient as a permanent token and reminder of the project. Alternatively, a small photo collection might be set to music and animated in a self-playing slide show" (Frohlich et al., 2002, p.174).

Only a few years later, HCI began to examine photo-sharing technologies and interaction concepts that were still sketched by Frohlich et al.'s (2002) work as these services have not yet been widely available or have only been envisioned at that point, even. For instance, *Flickr* as a prominent online photo-sharing platform became the target of a number of investigations (Ames & Naaman, 2007; Miller & Edwards, 2007; Van House, 2007). Ames and Naaman (2007) explored the reasons for photo tagging on web services such as *Flickr*. They came up with a taxonomy of reasons, arranged along two dimensions: *sociality* (*social* or *self*) and *function* (*communication* or *organization*). The first dimension, *sociality*, indicates for whom an image has been tagged. The second dimension, *function*, describes the reason for doing so. For instance, a tag for the sake of communication to oneself, was described to fulfil the function of preserving the memories about the incident in the photo by verbalizing it with a tag (Ames & Naaman, 2007). Miller and Edwards (2007) identified two subsets of *Flickr* users. While one group was comparable to 'traditional Kodak people' (i.e. people, dedicated to old, 'analogous' practices), who employed the platform to share photos with people they know, a second group of users appeared untypical in terms of their use behaviour as they shared photos with strangers and did not bother at all about privacy issues (Miller & Edwards, 2007). These *Flickr* and related studies increasingly point at new patterns and practices around digital photography, which are hypothesised to be the product of improved stand-alone digital cameras and, above all, ubiquitous camera phones with increasingly brilliant image sensors, better photo storage possibilities and instant picture sharing over the Internet (Ames, Eckles, Naaman, Spasojevic, & House, 2010; Gye, 2007).

Social aspects and practices around digital photography. By the middle of the first decade of the 21st century, sharing digital images via websites such as *Flickr* (see paragraph above) became popular (Miller & Edwards, 2007) and caused the establishment of new photo practices. These new practices have to do with the new ease of photo capture (e.g., by camera phones at very low cost) and the rise of the Internet resulting in shifts in the use of photography. While taking images has been reserved for special moments and motifs since its inception, now the mundane and non-durable (Ames et al., 2010) too became target of the camera and photos are being taken for plain functional or (everyday) communicative purposes (Van House & Churchill, 2008; Winston, 2013). These new forms of photography are still to be understood:

"While no baseline data exist on personal photographic practices, and existing research like Chalfen's (1987) is dated by changes in technology, we conclude […] that cameraphones change the definition of what's photoworthy from what's special and enduring to what's often transitory and ordinary" (Van House, Davis, Ames, Finn, & Viswanathan, 2005, p. 1854).

To shed light on this and to complement Chalfen's work from 'the analogue times', researchers have investigated the processes around picture taking on mobile phones and developed various taxonomies of use. Okabe (2004) pointed out some differences between regular cameras and camera phones. In contrast to traditional photography, pictures made by smartphones can be exchanged very easily. They described pictures that have been captured by a mobile phone as being more personal, oftentimes showing a mundane viewpoint of the world to be shared with close friends. They identified three prevalent camera phone usage patterns for their Japanese participants by an ethnographic study: *personal archiving*, *intimate sharing* and *peer-to-peer news and reporting*.

Kindberg, Spasojevic, Fleck, and Sellen (2005) investigated camera phones, which were used for personal purposes and differentiated between the reasons why images have been captured. They came up with a taxonomy classifying images along social, individual (personal), affective and functional (e.g., an image as a memo for oneself) purposes.

Van House (2011) and Van House and Davis (2005) analysed the use of camera phones as well as regular cameras and presented a list of functions of photography that holds intersections with Kindberg's et. al.'s taxonomy. Van House (2011, p.125) described "personal photography as, in effect, multiple, overlapping technologies: of memory; relationships; self-representation; and self expression". For such purposes, the characteristics and limitations of camera phones afford a couple of advantages. The particular aesthetics of photos made by mobiles have been reported as appealing, the easy-at-hand devices were encouraging to experiment and introduced spontaneity to picture taking (Van House et al., 2005).

Others (Van Dijck, 2008; Winston, 2013) too put emphasis on photography's increased use for identity formation and communication. Van Dijck (2008) observed a shift in photography from being a remembering aid to a tool for communication and identity sculpturing. This was attributed to the easy dissemination of pictures over the Internet. However, van Dijck (2008) argued that the function of memory cannot be separated from photography and persisted as a networked product across all distributed images. The function of memory was also identified in photography by van House, as mentioned above. Here, she reported on participant feedback from a photo study revealing their relationship to photography and memory:

"Personal photos are valued for both personal and collective memory and identity, and autobiographical narratives. Although contemporary thought stresses the constructedness and contingency of both memory and photos, the popular view is that photos 'capture the moment.' Many participants described off-loading memory to images, to ensure that something was remembered later. Photographs may also reveal things we did not see at time" (Van House, 2009, p. 1082).

Van House's observation that photos are widely used to 'capture the moment' seems important and valid. Throughout the user interviews that were conducted as part of this thesis (for more information see study chapters), participants time and again used the words *photo* and *memory* almost in a synonymous fashion – to many people, to capture a photo is to capture a memory. Not surprisingly, this concept is also reflected by recent advertisements for mobile phones as apparent from Figure 2.7.

Besides digital photos, there are a number of additional media types such as video, audio recordings or text, which are considered and used as *technologies of memory* within HCI research projects (see for instance, Mann (2004), Petrelli, Villar,

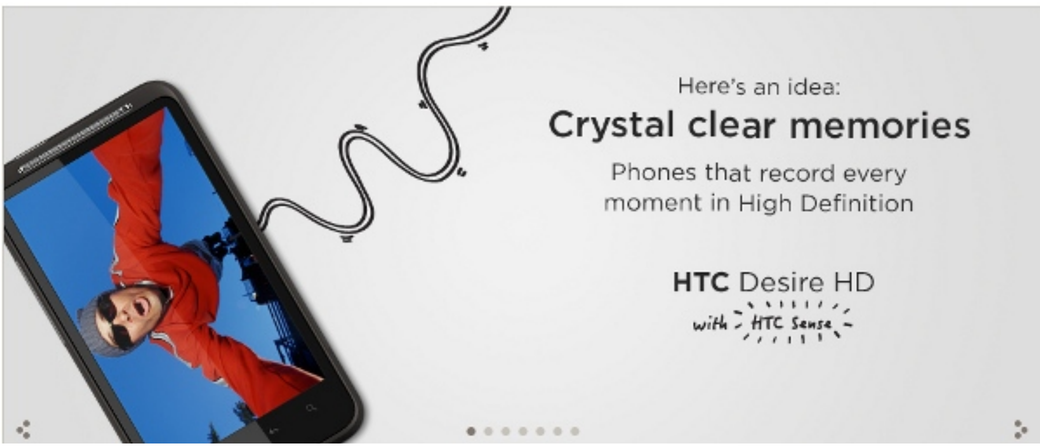

Figure 2.7. "Crystal clear memories" – Advertisement for a smartphone found on the webpage of *HTC*. (Retrieved 11 June 2012 from https://www.htc.com).

Kalnikaite, Dib, and Whittaker (2010), or Hangal et al. (2011)). Still, as stated above, photography will play the leading role in the practical work of this thesis, in particular for the Duography and also for the Media Object application. For this reason, we provided this in-depth description of photography.

The Hearsay installation, in contrast, made use of audio and text. The outlining of additional media types as employed by Hearsay ('the secondary' *technologies of memory*, for example, video, text or email, etc.) will be given as part of a review on HCI work about *supporting memory*. This objective and its challenges will be detailed in the remainder of this chapter. This also marks the introduction of digital mementos and souvenirs, which employ more general and recent digital technologies (not restricted to photo).

2.3.2 From Managing (Personal) Documents to Personal Information Management

"A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory" (Bush, 1945).

A common starting point of HCI articles on digital remembering systems is Vannevar Bush's *memex* ("Memory Extender") (Bush, 1945). This hypothetical mechanical device (illustrated in Figure 2.8) is suitable for compressing, storing and retrieving all sorts of an individual's data such as records, conversations, books and so forth. Bush conceptualized the *memex* as some kind of desktop for documents to be put on to, annotated and edited. He also suggested creating links between documents for later retrieval and thus his ideas became the predecessor of *hypertext*. By connecting these documents, *trails* of information get created. In his inspirational article, Bush (1945) described an example in which one *memex* user passes a copy of a trail to a friend:

"Tapping a few keys projects the head of the trail. A lever runs through it at will, stopping at interesting items, going off on side excursions. [… He] sets a reproducer in action, photographs the whole trail out, and passes it to his friend for insertion in his own memex, there to be linked into the more general trail" (Bush, 1945).

Clearly, these are some visionary thoughts (and not implemented technologies) dating back more than half of a century. Nevertheless, many efforts have been made to "fulfill the memex vision" (Gemmell, Bell, & Lueder, 2006, p.88) in recent years. In HCI, a general umbrella term that was established for describing computer-supported activities as outlined by Bush is *personal information management (PIM)*. The term PIM is also used in a broader contexts (outside HCI) for non-computer meditated organization of personal information, however, in HCI it describes "the collection, storage, organization and retrieval of digital objects (e.g. files, addresses, and bookmarks) by an individual in their personal computing environment" (Boardman & Sasse, 2004, p.583). Thus, targets of PIM studies are, among other things, the use of email (Whittaker, Bellotti, & Gwizdka, 2006; Whittaker & Sidner, 1996), web bookmarks (Abrams, Baecker, & Chignell, 1998), or the organization of files on the personal computer (Barreau & Nardi, 1995), to name just some exemplary works from this relatively large body of lit-

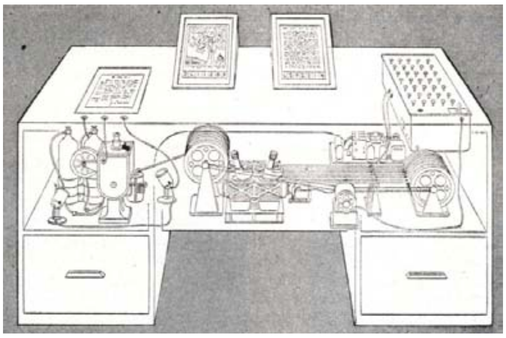

Figure 2.8. Original Illustration of Vannevar Bush's *memex* (1945).

erature. In recent years, ever since services such as cloud computing allow users to upload their personal digital content to the web, the Internet has also attracted interest as a subject to PIM studies, for example (Lindley, Marshall, Banks, Sellen, & Regan, 2013).

A lot of PIM work suggested special-purpose tools, often with an emphasis on document retrieval. For instance, *Stuff I've Seen* supports the organization of personal digital files, by making use of *retrieval cues*. The system provides a "unified search interface to existing data sources" (Dumais et al., 2003, p.72). More precisely, *Stuff I've Seen* builds on top of an existing file system and complements information retrieval by indexing the documents with contextual cues (date last opened, authors, thumbnails, etc.).

"Personal Information Management (PIM) refers to both the practice and the study of the activities a person performs in order to acquire or create, store, organize, maintain, retrieve, use, and distribute the information needed to complete tasks (work-related or not) and fulfil various roles and responsibilities (for example, as parent, employee, friend, or community member). PIM places special emphasis on the organization and maintenance of personal information collections (PICs) in which information items, such as paper documents, electronic documents, e-mail messages, Web references, and handwritten notes, are stored for later use and repeated reuse" (Jones, 2007, p.453).

At the 'lower' technical level, researchers are experimenting with different ways to structure the digital files on the hard disk drive. One possible approach to document management, which most people are familiar with, is to hierarchically store the files in a system of folders and directories. This is the most conventional solution that can be found on almost every personal computer. However, there are also alternative proposals to this standard. For instance, *Presto* (Dourish, Edwards, LaMarca, & Salisbury, 1999) is a document management system based on a 'flat' file structure and on document *tagging*. In contrast to conventional, hierarchical filling structures, here documents can be dynamically organized by their labels as opposed to the position within a hierarchical system of directories.

Hierarchical and flat file systems are generally targeted at the organization of all kinds of documents that can occur in the context of computer use. However, there are also a large number of projects that aim to aggregate and organize particular subgroups of files or content. In the context of mobile phones, for instance, *UbiLog* (Rawassizadeh, Tomitsch, Wac, & Tjoa, 2013) was created as a generic framework for (automatically) capturing sensor data in the service of memory augmentation.

Ubilog is an application, which can be can be attributed to the class of *lifelogging* systems. The idea of *lifelogging* is to digitally capture one's complete lifetime experiences into a record, into a *lifelog*. Hence, conceptually *lifelogging* can be interpreted as the consequential implementation of the *memex* vision (Gemmell, Bell, Lueder, Drucker, & Wong, 2002), and particularly in recent years this idea has gained significant popularity in academia (Sellen & Whittaker, 2010).

2.3.3 Lifelogging, Quantified-Self, Personal Informatics

The backbone of *lifelogging* applications is technology. This might be the case for many, if not the very most HCI projects. However, 'capturing one's complete life' is an ambiguous endeavour, which in particular depends strongly on technical possibilities. It comprises the recording of all different kinds of digital objects, starting from information that was already relevant to PIM research: emails, various other digital files, interaction logs of these files, and so on. Moreover, *lifelogging* goes further as it is not only interested in data that we use on our computers in our daily routine. While many PIM tools were geared towards a particular task, for example, keeping track of emails, the objective of *lifelogging* now is to keep track of one's 'entire' life (or at least create dense records of particular aspects of life). To this end, additional information is captured, indexed and stored (not only the emails, etc., which get created in the course of using the computer anyway). This additional information can be about anything in our life, as long as it is technical feasible to record it: the locations we have been to, first-person perspective video recordings, encounters with other people, environmental conditions (e.g., the temperature and noise level) captured by sensors, and so forth. As evident from this description, the primary motivation of *lifelogging* is to overcome the fallibility of human memory. Often, projects in this area are driven by enthusiasm for technical feasibilities (Sellen & Whittaker, 2010).

Sellen and Whittaker (2010) described two main classes of *lifelogging* applications. The first class of systems ("total capture") aims at "capturing as many kinds of data as possible, as continuously as possible", whereas systems of the second class ("situation-specific capture") are more restricted regarding the application domain and "can be viewed as a specialized form of *lifelogging*, aiming to record multiple kinds of data as completely and automatically as possible for specific activities or in particular places where the activity occurs" (Sellen & Whittaker, 2010, pp. 72-73). Two years later, Whittaker et al. (2012) suggest a classification of three main categories: (a) "personal digital repositories", (b) "mobile activity capture" and (c) "domain specific capture".

MyLifeBits (Gemmell et al., 2006; Gemmell et al., 2002), which is one of the most prominent lifelogging projects, falls into category (a). At its core, it is comprised of an enormous personal database that is designed to hold

"[…] articles, books, music, photos, and video as well as everything born digital e.g. office documents, email, digital photos. It evolved to have a goal of storing everything that could be captured. The later included web pages, phone calls, meetings, room conversa-

tions, keystrokes and mouse clicks for every active screen or document, and all the 1-2 thousand photos that SenseCam captures every day" (Gemmell et al., 2006, p.88).

SenseCam (Hodges et al., 2006), which was already introduced in the context of the review on digital photograph leads to category (b) "mobile activity capture". *Lifelogging* as described so far, which is restricted to the boundaries of the visual Desktop, must 'hopefully' miss essential parts of an individual's life. To capture broader aspects of the human experience, miniature computers are employed to record data 'on-the-go'. As such, *SenseCam*, which is worn by a string around the neck, captures a photo every other minute triggered by time or by a certain event (e.g., changes in the surrounding light condition). These 'passive' photos then get indexed and stored, for example by the *MyLifeBits* database to establish a record of visual testimonials for the life one has lived (Gemmell et al., 2006; Gemmell et al., 2002). While *SenseCam* today is a relatively unobtrusive device, initial experiments featured rather cumbersome setups, which eventually advanced into the miniature technology we now have. This progress seems rather impressive, if we compare Figure 2.9 showing one early prototype of Steve Mann, pioneer to wearable computing (Mann, 1997), to Figure 2.10, which shows an image of the commercial (prototype) product *Google Glass*.

Figure 2.9. Steve Mann wearing an early prototype of digital glasses (EyeTap) (Stewart, 2013).

The third category as proposed by Whittaker et al. (2012), "domain specific capture", subsumes *lifelogging* systems, which are engineered to augment specific tasks by capturing data and providing structured access. For instance, the recording of group meetings (see e.g., (Renals, Hain, & Bourlard, 2007)) as they occur in day-to-day working life, is a popular application domain for such augmentation. In combination with wearable sensors, perhaps synchronized with a mobile phone for the recording of the readings, this domain can be extended to a broad range of sectors. Doherty, Tolle, and Smeaton (2009), for instance, proposed to log physiological data in conjunction with additional contextual memory retrieval cues to provide a system, which allows the user to identify critical situations with regard to their health life and wellbeing.

Figure 2.10. *Google Glass.* Wearable user interface with display and camera. (Zugaldia, 2012).

In recent years, the recording of personal information has gained popularity in commercial products as well as in particular communities of amateurs and hobbyists. The kind of information that is logged in this context relates to measurable qualities of the individual. The objective is to learn about the own life and habits by logging behaviour patterns. For this reason, the community or 'movement' is named *quantified-self*. While some users might not even be aware this community exists, but still track, for examples, their footsteps in order to loose weight, other people engage in it with no particular goal but to be part of the community and out of curiosity. To address the 'quantification of the self' in scientific HCI studies, Li, Dey, and Forlizzi (2010) formulated a "stage-based model" to improve the design of systems "that help people collect and reflect on personal information" (Li et al., 2010, p.557). They named this kind of application area "personal informatics".

2.3.4 Designing Digital Mementos

2.3.4.1 Informing the Design of Digital Mementos

As we have seen, Personal Information Management (PIM) and *lifelogging* are two influential and closely related concepts with the aim of establishing a sustainable archive of significant personal electronic records. We can yet distinguish another approach in HCI that has to do with the preservation of personal memories and also features intersections with the afore-described concepts. A number of researchers explore what they call *digital mementos*, *digital souvenirs* or *home archiving*. Some of these authors have already been cited in the preceding paragraphs, another hint for the correlations between all three subjects (PIM, *lifelogging* and digital mementos). However, while PIM often focuses on the management of digital data that is created in day-to-day life (e.g., work-related content, email, photos), and *lifelogging* has the ambition to record particular aspects of our reality, digital mementos are keepsakes similar to physical souvenirs (e.g., photo prints, favourite stuffed toys) but exploiting technical affordances for providing an enhanced remembering experience. To inform the design of digital mementos, some researchers are oriented towards analogous or physical mementos and evaluated ethnographic field studies to learn how people handle their keepsakes.

Petrelli, Whittaker, and Brockmeier (2008) conducted 'home tours' at their participants' houses to learn why a small selection of objects become significant mementos unlike the vast majority of things that we encounter in our daily life only to discard them. They defined a memento as an object that is deliberately "kept as a reminder of a person, place or event" (Petrelli et al., 2008, p. 53). For the 'home tour', they asked their participants to choose a certain number of sentimental objects without any restrictions. To their surprise only one out of 159 selected mementos was digital. (The exception was computer-created maps of journeys). Upon inquiry, the participants reported more digital mementos, for example, videos, photos, or emails. However, these mementos did not come to their mind spontaneously. 13% of all mementos represented a certain event, 59% cherished social relationships and 28% of all mementos were kept for personal reminiscing. Some of the objects were put on prominent display, while others were concealed. As a whole, they constituted a carefully crafted "memory landscape of autobiographical objects" (Petrelli et al., 2008, p.62). Participants kept all kinds of different pieces as souvenirs. For instance, photos were kept, however, they did not play a very prominent role. Other mementos spawned professional artwork, mundane objects such as cups, clocks, and books. Petrelli et al. (2008) also found, that their participants dedicated time and creativity in creating (amateur) artwork as mementos. They concluded that 'home archiving' is much different to the kind of archiving as it is interpreted and practiced by *lifelogging*. Thus they suggested the usage of a different set of tools, which can rarely be found in the lifeloggers' toolbox:

"It may therefore be that the processes involved in the creation of highly meaningful memory objects are very different from the rhetoric of total capture of one's entire life. Meaning construction rather than easy search should therefore be the goal of memory technology and time spent managing digital mementos should be perceived as creative and enjoyable, a substantially different experience from standard PC use. In practical terms, we need to build tools that facilitate sifting and selecting, rather than tools to retrieve any event from one's past" (Petrelli et al., 2008, p.61).

Petrelli and Whittaker (2010) extended their earlier study on mostly physical mementos by also examining digital ones and contrasting them to their tangible complements. They found that while physical mementos are "expressive", easy to access and put on public display, digital objects are hidden inside the computer and not very convenient to access and hence less revisited or forgotten even. As a consequence, the 'real' objects are part of everyday remembering, employed to create continuity in the history (bridging past and present) and identity of family, even. Collections of physical objects of particular emotional significance are kept by some participants in hiding-places, for example, in old shoe boxes or 'memory boxes' ("treasure boxes"). Curating physical mementos demands some effort, but is manageable compared to digital collections, which tend to grow at a fast rate (in particular digital photos) and are scattered across multiple devices. Moreover, the latter kind of memory objects is perceived as more fragile, given their virtuality and their lack in tangibility. Nevertheless, the great pleasure in revisiting physical mementos reported by the authors constitutes a good motivation for the attempt to transfer some of this felt joy to significant digital keepsakes. To this end, Petrelli and Whittaker (2010) came up with three design guidelines. First, they recommend reducing the work and effort for the user that is associated with managing and organizing digital objects. This challenge has primarily to do with smart algorithms for data aggregation, automatic clustering and meta-data annotations, and intelligent backup mechanisms. Second, they observed little variety in the appearance of digital mementos and thus propose to find ways for broadening the look and feel of virtual sentimental possessions. This could be accomplished either by scanning physical objects and creating a digital version, or by integrating bits and atoms, that is, linking physical and digital objects. This would lead to "mixed reality mementos". The authors saw additional mental benefits in the act of creating these augmented objects:

"Physical archiving practices such as making albums or scrapbooks or revisiting collections engender positive emotions; whereas digital archiving does not. One challenge for new digital archiving tools is to try and support new practices similar to making albums or scrapbooking that will lead participants to enjoy the process of sifting through their digital archives, selecting and composing" (Petrelli & Whittaker, 2010, p. 165).

Third, they recommended making digital souvenirs more accessible as they are too often forgotten and overseen. This is related closely to the second recommendation and again, they proposed an augmented reality approach to accomplish this. Meaningful sentimental objects could be linked to digitally stored accompanying information, which is accessed by digital devices such as ambient displays.

To further broaden the understanding of home archiving, and in particular, with regard to what sorts of objects people want to endure for remembering, Petrelli, van den Hoven, and Whittaker (2009) ran another study in which they asked participants to assemble "time capsules". These were containers for holding arbitrary objects and to be opened in 25 years of time. Thus, the general idea of the study was to learn, which objects are cherished enough to be included in the time capsules and thus be part of "long-term mnemonic representations of their lives" (Petrelli et al., 2009, p.1723). One key insight from their work was that the participants showed little support for the *passive lifelogging paradigm*. That is, they were not interested in vast auto-created archives of a captured life, but preferred a highly customized and personal selection of mnemonic representations. Thus, the authors proposed "active meaning building" as an alternative to "passive capture". They were struck by the efforts participants made in assembling content for the time capsules. 37% of the objects were newly created, another 26% were deliberately collected to be included in the collection. Existing belongings accounted only for 37% of all content. Most items were photos, followed by physical things such as old commodities or won trophies. Craftwork, ephemera, essays and public documents were also included, but to a lesser extent. In line with the expectations of the researchers, the participants wanted to capture information about people, places and events. To their surprise, however, participants also aimed to create a 'snapshot' of today's society to be reflected on 25 years later. Petrelli et al. (2009) classified 46% of the content as attempts to *record* certain information about life not to be lost in the future, 30% as objects to foster *reminiscing*, 12% as testimonials to *compare* today versus 'tomorrow', 8% as objects passed on to later generations for solely preservation reasons, and 4% as items added in for the pure fun of it (i.e., to make the person laugh, who opens the capsule in the future; a joke addressed to the future self). However, the participants still valued physical objects a lot more than digital ones and chose almost solely (93%) physical artifacts for their time capsules.

"To our surprise, participants put a lot of effort in assembling new content: 37% of objects were created for the sole purpose of being included in the time capsule, a further 26% were deliberately collected for this reason. This is an important result not only because it challenges the *lifelogging* notion of passive event capture, but also because it shows the level of commitment and interest that the overall project engendered in our participants" (Petrelli et al., 2009, p.1725).

Kirk and Sellen (2010) took a similar approach to designing for home archiving and conducted a study "of people's practices around their own collections of important artifacts (both physical and digital) […]" (p.3). From this investigation of sentimental things that were kept by the people, and from interviews they derived a set of requirements and implications for future "domestic archiving technology". Thereby, they were both interested in physical and digital keepsakes. Key insights included, that artifacts were not only kept for remembering purposes, but on the contrary, also to be able to 'safely' forget. Moreover, personal belongings were archived to connect to others, to construct (family) identity and because of binding obligations. Hence, they showed in great detail that the role of the keepsakes or artifact is more complex than 'just' to embody memories. Rather, these mementos were carefully integrated into the fabric of the home to fulfil multiple ends. Kirk and Sellen (2010) also saw advantages of digital objects, for example, the possibility of indexing, convenient retrieving, sharing, editing, annotating with meta-information, and minimizing space needed (as compared to keeping the original objects). However, they also acknowledged that physical objects feature certain qualities and affordances, which digital copies perhaps never will be able to accomplish. For example, the quality of a physical object that is treasured for its uniqueness should be hard to be emulated by a digital facsimile. Other physical belongings want to be hold and used with the hand in order to evoke sentimental reactions, an affordance which might also be difficult to compete with for 'the digital'. Finally, 'real' objects can be put on display somewhere in the house to express personality or as an invitation for conversations. Kirk and Sellen (2010) envisioned a home that constitutes a 'large' integrated digital archive as a whole and consisting of a heterogeneous collection of different digital objects and hybrid artifacts (CDs with audio recordings). If copies of physical belongings were to be integrated into this archive, the challenge was to still transfer some of the original values to the digital version.

Recent research in HCI, which is settled in the broader context of home archiving and digital mementos, has started dealing with question about what will happen to our digital belongings after we have passed away, for example (Banks, Kirk, & Sellen, 2012; Gulotta, Odom, Forlizzi, & Faste, 2013; Odom, Harper, Sellen, Kirk, & Banks, 2010). This question is rather pressing, given that many of our most precious possessions now turned digital and that not much research has been done yet to make sure that they will persist on the long-term and be meaningful to our heirs (Odom et al., 2010).

2.3.4.2 Exemplary Prototype Systems for Digital Mementos

As pointed out by Kirk and Sellen (2010), much of the work on personal digital files in the home was conducted to improve the interaction design and offered file manipulations. For example, the work on *photoware* (Frohlich et al., 2002) was carried out to provide better digital photo managing tools. However, there's also research that goes beyond providing digital support for more efficient archives, and which aims to uncover completely new and interesting ways of interacting with our sentimental (digital) belongings. In contrast to the above-described field studies, these are novel designs, technologies probes (Hutchinson et al., 2003) so to speak, that are exposed to users and evaluated for their usefulness in archiving digital mementos.

Many of these prototype systems combine 'the physical' and 'digital' (as already suggested by Kirk and Sellen (2010)), and thus feature elements of tangible user interfaces. *Memory Box* (Frohlich & Murphy, 2000) is an early example of such an application. Its inventors used the *Memory Box* to enhance physical objects by means of attached *RFID* tags. Placing the tagged objects upon a corresponding *RFID* reader replayed associated recordings of narratives. Thereby, *Memory Box* constituted one pos-

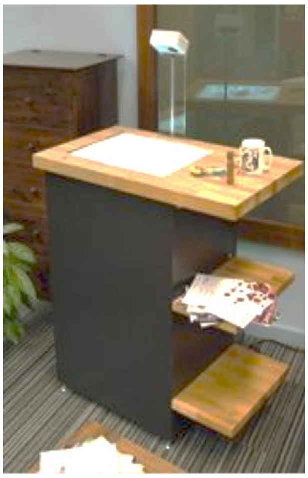

Figure 2.11. *The Family Archive* (Kirk et al., 2010, p.261).

sibility to create hybrid objects to be integrated into the digital archive of the home, as outlined by Kirk and Sellen (2010). The prototype can be seen as another variant of *audiophotography* (Frohlich & Tallyn, 1999), however, this time with tangible objects and souvenirs as the carriers of information instead of photos.

Another often-cited research effort into personal archives is the so-called *Living Memory Box* (Stevens, Abowd, Truong, & Vollmer, 2003). "At its very core the Living Memory Box project is about people, their experiences, hopes, dreams, pains and pleasures – and how we seek to capture these experiences" (Stevens et al., 2003, p.210). By doing ethnographic work Stevens et al. (2003) elaborated a set of design guidelines that the authors suggest to be considered when designing systems for remembering. A paper that refers to the *Living Memory Box* looks into the so-called *Family Archive* (Kirk et al., 2010). This is a technology probe for studying (digital) archiving practices of families regarding sentimental memorabilia (see Figure 2.11). *Memory Lane* (Kalnikaité & Whittaker, 2011) is to some extent similar to the *Family Archive*, but provides a more predefined frame for organizing digital memorabilia based on psychological research. In contrast to *Memory Lane* where images are among other options arranged along the map of a digital house, the *Memento system* (West, Quigley, & Kay, 2007) employed the classic photo album or scrapbook as the reference model for the storage of digital mementos. Here, the motivation was to combine the advantages of the physical world with those of digital tools, namely to have a tangible scrapbook with all the affordances of a real object and the possibility to share, copy, delete etc. digital content very easily. *Memento* focused on elderly users and employed its semi-digital scrapbook primarily for reminiscence. The latter four projects share a similar strategy for supporting digital remembering: they provided or conceptualized systems for the digitalization of multiple souvenirs and subsequent storage in some sort of container or aggregate as a personal archive.

Petrelli et al. (2010) took, to some extent, an unconventional way to design for personal archiving or digital mementos. To make digital memorabilia more visible and accessible, these researchers employed an old ('retro') radio to create the *Family Memory Radio* (*FM Radio*). This is a device for recording and playing audio mementos. In a field study, Petrelli et al. (2010) found that the prototype was perceived as easy to use and fun. Moreover, the audio recordings made very interesting mementos. In a comparative study between photos and audio recordings ("sonic souvenirs"), Dib, Petrelli, and Whittaker (2010) described reminiscing with audios as highly social and engaging, just as photo reminiscing. However, "sonic souvenirs" showed a greater variety of content in contrast to photography, which also captured the mundane and even negative aspects of life. The audio content, though, was harder to interpret than visual mementos. Still, participants showed a high level of engagement and creativity in particular when creating the audio recordings.

Other recent and related work introduced design concepts or prototypes for photo mementos (Petrelli et al., 2014), digital mementos in more general (Bowen & Petrelli, 2011) and "technology heirlooms" (Banks et al., 2012). Some of the prototypes of the latter publication are outlined by Banks (2011) in detail in his book *The Future of Looking Back*.

In the following we will denote systems for managing digital keepsakes, mementos or souvenirs (as outlined above) as *augmented memory systems* (see also the Glossary on *Augmented Memory Systems* for a differentiation of different notions in digital remembering research).

2.3.5 Challenges and new Directions in Designing Augmented Memory Systems

In this section we assemble critical challenges and new directions in the design of augmented memory systems. In the following, a lot of the posed issues stem from the context of *lifelogging*. It might be true perhaps that *lifelogging* has been central to many concerns lately, and for this thesis we also prefer a different approach. Nevertheless, it is by no means our intention to portray *lifelogging* as an intellectually weak or half-baked idea. Rather, *lifelogging's* prominence in this section is caused by the outstanding influence and inspiring effect of this concept. Furthermore, as apparent from the historic descriptions above, *lifelogging* marks the beginning of efforts to digitally support remembering and of using diverse media objects. As a consequence, new approaches such as *home* or *personal archiving* or *digital mementos* draw on *lifelogging* and can be seen as a reaction to some of its shortcomings.

A number of researchers currently question the motivation of the actual implementation of *lifelogging* technologies (see below). They argue that careful considerations in how the human mind remembers in conjunction with an in-depth understanding of the actual problem a particular system is supposed to solve, can improve the usefulness and acceptance of *lifelogging* applications.

"The design of contemporary information storage and management technologies is often driven by unarticulated models of memory processes, both human and computer. From a technical perspective, many applications derive from design choices narrowed by what can be stored (digital file storage with data and many forms of metadata) and what can be indexed (some things are very hard to index, for example elements in a video) and searched (string match in text is easy, image match is improving but far from perfect, and so on)" (Van House & Churchill, 2008, p.300).

2.3.5.1 Re-thinking the Objective of Lifelogging

Leaving aside the popularity of domain specific *lifelogging* applications such as *quantified-self* or *personal informatics systems*, *lifelogging* in general could not meet the ambiguous expectations of its visionaries. The practical uptake remains somewhat disappointing (in contrast to the academic uptake) and most *lifelogging* (besides *quantified-self*) takes place in the scientific laboratory (Sellen & Whittaker, 2010). Rigorous long-term evaluations for the efficacy of such systems are yet to be conducted with few exceptions looking at the well-known *SenseCam* (Kalnikaite, Sellen, Whittaker, & Kirk, 2010; Sellen et al., 2007). However, these particular studies delivered disappointing results for the potential of passive image lifelogs to support everyday recall on the long term. For these reasons, researchers started questioning the original 'capture everything philosophy' of the early *lifeloggers* (Sellen & Whittaker, 2010; Whittaker et al., 2012).

Sellen and Whittaker (2010) identified a lack of specifications with regard to the actual objectives of *lifelogging* applications

"Surprisingly, many lifelogging systems lack an explicit description of potential value for users, focusing instead on technical challenges (such as data capture and retrieval mechanisms). When claims are made about potential benefits, they tend to be ill-defined. Nevertheless, it is important to clarify what these claims might be." (Sellen & Whittaker, 2010, p.73)

The researchers went on to specify five processes or activities (the five "Rs") in human remembering, which they suggest as a promising target to design for: *retrieving*, *remembering intentions*, *recollecting*, *reminiscing* and *reflecting*.

"Despite the memory terminology used in *lifelogging* work, little attention seems to focus on human memory and how it operates. Psychological studies of memory are largely ignored, even though they provide relevant concepts and results that lead directly to new design principles: *Strategically targeting the weaknesses of human memory*" (Sellen & Whittaker, 2010, p.75).

In this thesis the latter three processes (*recollecting*, *reminiscing* and *reflecting*) are of great importance, while the former two activities are of secondary relevance. *Retrieving* is to some extent related to *recollecting* (see below) and denotes the relocating of a digital document, for instance, an interesting article on a webpage. *Remembering* intentions, on the other hand, regards prospective memory, that is, remembering actions or events in the (close) future. Not forgetting to congratulate a friend on her birthday, might serve as an example for this memory process. In line with the arguments of Sellen and Whittaker (2010) it seems rather obvious that *lifelogging* systems might be useful in supporting these processes.

By *recollecting* Sellen and Whittaker (2010) described the process of 'bringing past moment back to live', that is, remembering details such as 'where did I park my car' or 'where have I seen this face before?'. Thus, *recollecting*, is connected closely to episodic memory (see contextual review on 2.2.1 Memory Theories in Psychology) and thus necessarily precedes reminiscence as well as reflection (Fleck & Fitzpatrick, 2009, 2010).

Reminiscing, as also already outlined earlier in this chapter, is a process of allowing oneself to drift away in memories ('dwelling in the past') for sentimental reasons. Often, this is a pleasurable activity, done alone or within groups.

Reflecting about past events, on the other hand, is a process of taking different perspectives on one's life. *Lifelogging* technologies can be useful here by making visible behaviour patterns. For example, the food-log might reveal a tendency towards eating too much sugar in time periods with stressful deadlines, etc. Thus, Sellen and Whittaker (2010) also saw a potential for technology to both support *reminiscing* and *reflecting*.

2.3.5.2 *Cuing Memories, not Capturing Them*

Along with other researchers in HCI (Alallah & Hinze, 2011; Petrelli et al., 2009; Sellen et al., 2007), Sellen and Whittaker (2010) strongly recommended considering knowledge from psychology about memory when designing new *lifelogging* applications, in contrast to concentrating on technical challenges. "[…P]sychology research provides a deeper understanding of the most frequent and critical kinds of memory problems people have, allowing system designers to focus on areas of true value to users" (Sellen & Whittaker, 2010, p.75).

They went on to promote the role of memory cues in augmented memory system design and clarified, that it is not *memories* per se that can get put on digital storage. "Collections of digital data (such as sets of digital photos and sounds) can serve as cues to trigger autobiographical memory about past events but are not memories in themselves or in any way facsimiles of personal experience." (Sellen & Whittaker, 2010, p.75). Prior to this well-cited paper, Hoven and Eggen (2008) reflected on autobiographical memory theory in order to inform the design of augmented memory systems (see also contextual review Section 2.2.1.3). They recommended to explicitly design for a particular function of autobiographical memory (e.g., "the construction of the self-concept") and to deliberately make a decision about what technical process to design for (recording and/or retrieving information). They too suggested using retrieval cues in the service of augmented memory systems. Thereby, Hoven and Eggen (2008) drew on constructivist theories to make the argument that past experiences don't simply get retrieved "as complete events", but are actively reconstructed from cues and influenced by various additional factors such as our current emotional state (Schacter, 1999) (cf. Section 2.2.1 Memory Theories in Psychology). They summarized that "[a]ll media types, from digital photos to physical artifacts, can be used as memory cues in an augmented memory system, although none of the [in 2005 reviewed] papers explicitly mentions cueing as such" (Hoven & Eggen, 2008, p.439). Having retrieval cues available can also lead to 'indirect' benefits for the user. Sellen et al. (2007) found that their participants at times could not truly recall a particular event, however, from having the cues at hand (photos) they nevertheless inferred that a certain event must have happened. This is in line with results of a study by Kalnikaite et al. (2010), who investigated the effects of visual and locational cues on memory. They found that while photos where able to evoke rich and more genuine recollection, spatial information (i.e., *GPS* data) allowed inference on behaviour. They conclude that

> "[R]ecollecting the past is highly dependent on the kind of cues presented to people […]" (Sellen & Whittaker, 2010, p. 76).

> "[…T]here are multiple *types* of data that we might collect about our past, as well as different ways that we might present logged data. These might have different implications for how and what we remember" (Kalnikaite et al., 2010, p. 2045).

"there are multiple types of data that we might collect about our pasts, as well as multiple ways of presenting this data. Different data types and views promote different acts of remembering, including ones which might be more properly called inference rather than memory" (Kalnikaite et al., 2010, p. 2052).

Work done by Gouveia and Karapanos (2013) extended the findings of Kalnikaite et al. (2010). They were interested in identifying the best kind of memory trigger for bringing *episodic memories* back to life. To this end, they created software (the *Footprint Tracker*) that made use of four different types of retrieval cues, namely *visual*, *locational*, *temporal* and *contextual* (*social*) triggers. They motivated their design decision by citing (Tulving, 1984), who suggested that episodic memories primarily comprise information on *who*, *what*, *where* and *when*. In their study, they reported a participant preference for the visual and confirmed the conclusions of Kalnikaite et al. (2010) that visual cues evoke genuine recollection, while locational information allows inference about things that must have happened. Temporal cues proved also to be effective in the recall of episodic memories. Regarding social memory retrieval triggers the authors had to admit that their study design needs improvement to also include more relevant social triggers such as social networking messages (as opposed to rarely used *SMS* messaging). Nevertheless, their setup revealed one interesting insight, namely that participants used social and locational information to confirm inferences made from their *SenseCam* photos.

2.3.5.3 Design Principles for Lifelogging Systems

In summary, Sellen and Whittaker (2010) presented four key insights or recommendations from their explorations into *lifelogging*: (1) As described in the above section, designers should focus on capturing valuable memory retrieval cues by establishing an in-depth understanding of how the mind remembers; (2) Also, there are different types of memory to address (the five "Rs") and designers should be aware of that fact when building systems; (3) The 'total capture' strategy is called into question. Instead, *lifelogs* should preferably address feature information that is likely to be needed one day. Hence, data should be recorded *selectively*; (4) Designers should not aim for replacing human memory with technology, rather, digital aids should assist memory's weaknesses and enhance its strengths.

While the work of Sellen and Whittaker (2010) is based on psychological considerations, Whittaker et al. (2012) investigated the challenges of *lifelogging* from a more socio-technological perspective. They too derived a set of design principles. This was accomplished by analysing empirical observations on prior augmented memory systems, deploying technology probes and conducting user studies. The resulting set of design principles – (1) *selection*, (2) *embodiment*, (3) *synergy not substitution*, (4) *reminiscence and reflection* – is similar to the recommendations by Sellen and Whittaker (2010). This is little surprise. Differences might result from the slightly different perspectives (psychological versus socio-technical) and points in time when the studies were conducted.

Their first principle, (1) *selection*, aims to highlight salient spots in the *lifelog* stream. This can be accomplished by selecting particular events or data, for instance, by applying machine learning algorithms or by using additional indicators (e.g., changes in noise levels, frequently accessed passages of a logged meeting). Alallah and Hinze (2011) proposed the concept of "marking a moment". That is, a small device with a button, maybe connected to the house key ring, is used for indicating special events within the *lifelog* for later review.

(2) *Embodiment* seeks to increase the visibility of digital information, a disadvantage featured by *lifelog* data in contrast to physical souvenirs. Personal digital data is to be better integrated within our surroundings and life. To this end, Erve, Vos, Hoven, and Frohlich (2011), for instance, drew on *embodied interaction* (Dourish, 2001) theory and introduce a series of design proposals. These concepts aim to establish "meaning between digital media and the physical artifacts through the interaction" (Erve et al., 2011, p.343). One of their designs featured tangible objects used as 'stamps' to annotate collections of 'digital memories'. The authors hypothesised that this can lead to fewer but more meaningful memory artifacts, as the preparation of annotations or cues takes more effort, while at the same time resulting in high-quality collections.

(3) By making *synergy not substitution* a design principle, Whittaker et al. (2012) highlighted in line with Sellen and Whittaker (2010) that technology should not replace memory, but complement it. Their empirical findings showed that people avoid using external *lifelogging* tools whenever they find their unaided memory sufficient for the task.

(4) Finally, opportunities for *reminiscing and reflecting* are recommended to be included into *lifelogging* tools. As the authors noted, most existing *lifelogs* focus on recalling facts, however, most of the time when we look at, for example, old photographs we reminisce and reflect about our past. As these are two primary processes in memory that we want to support in this thesis' designs, we go on to review some work on reminiscing and reflection in more detail.

2.3.5.4 Reminiscing, Reflection, Alternative Perspectives

The number of systems that have been developed to support reminiscence and reflection or similar purposes is limited (Sellen & Whittaker, 2010). Nevertheless, particularly within the last years, some noteworthy applications have been created. As a response to the increasing interest, in 2011 a workshop was held during the influential *CHI Conference* (Human Factors in Computing Systems) with the topic of "Bridging practices, theories and technologies to support reminiscence" (Cosley, Mulvenna, Schwanda, Peesapati, & Wright, 2011). In the following, we report some indicative work to show how technology is currently used to facilitate this kind of memory process. For clarity, we might want to say up front that the boundary between reflection and reminiscence is a blurred one.

To start with, we point again to the work by Li et al. (2010), who introduced the term *personal informatics*. More precisely, they did not propose one specific system but a "staged-based model" for systems that support people collecting and reflecting on personal information. The model was conceptualized to address issues in 'quantified-self' applications, distinguishing between the *preparation*, *collection*, *integration*, *reflection* and *action stage*. Reflection, as defined in (Li et al., 2010, p.562), "may involve looking at lists of collected personal information or exploring or interacting with information visualizations. Users may reflect on their information immediately after recording the information (*short-term*) or after several days or weeks involving extensive self-reflection (*long-term*)." While short-term reflection makes people aware of current behaviour, reflection on long-term data allows the user to discover trends and patterns over a period of time.

Footprint Tracker (Gouveia & Karapanos, 2013) let users explore *lifelogs* with the primary goal to allow them to reflect on their daily activities. To this end the interface provides simple mechanisms for navigating through a stream of captured data. To technically get a record of the *lifelog's* retrieval cues, Gouveia and Karapanos (2013) gave a *SenseCam* (passive image capture) and a mobile phone (social context, i.e., phone call log and *SMS* messages) to each participant.

Another concept for reflection that employed *SenseCam* was proposed by Fleck and Fitzpatrick (2009). Here, teachers wore the device during class, resulting in a pool of photos, which featured a perspective in the direction of the students. In follow-up sessions these images were employed to provide the teachers with the opportunity to engage in reflective learning, supported by this novel perspective on their lectures. One key feature of the *SenseCam* images for being a useful tool for reflection, was the multiple interpretations of the photos that were enabled by the 'incompleteness' of the time-lapse series of in-class *SenseCam* images.

Lindley, Glancy, Harper, Randall, and Smyth (2011) studied the potential of *SenseCam* for reflecting on one's own life by giving these devices to a number of family members, which took photos for one week. After 18 months, the first author revisited four families and the *SenseCam* images were revisited again. The participants attributed a broad range of feelings to these one and a half year old images. While streams of routine were perceived as boring and mundane, others were surprising, funny, strange or ambiguous. Hence, the photos demanded the participants to make sense of them, which eventually led to the reflective power of the device.

"Participants frequently had to work out what was happening in the image streams, drawing contextual information from bookmarks, folder names, knowledge of who was wearing the camera, and time of image capture. This ambiguity was noted by some as having the potential to increase engagement with the images" (Lindley et al., 2011, p.317).

Not always were the recollections of the participants reconfirmed by the *SenseCam* images. On the contrary, in some cases an 'alternative past' to that which was remembered had to be considered (i.e., at times our organic memory is biased (Schacter, 1999), cf. also Section 2.2.1.3 Encoding and Retrieving Memories).

In yet another *SenseCam* study, Harper et al. (2008) also reported how their participants derived benefit from the somehow unfamiliar perspective and distortion of the camera. They further explained how the device fostered reflection by turning attention to mundane things, which are usually neglected. In addition, *SenseCam* motivated the participants to capture photos with artistic qualities (i.e., trying to take unconventional, aesthetical photos). This shift in attention and perspective, however, at times made the past also appear in different lights compared to the participants' organic (unaided) recollections. The authors summarized and suggested for the development of novel technology the following:

"[Devices like *SenseCam*…], in their design, *makes the past in particular ways*. Hence, they should be designed with sensitivity as to how they allow 'users' to render the past. What we have seen is that these renderings can offer delight, surprise, foreignness and strangeness in equal measure" (Harper et al., 2008, p.279).

"A fish eye lens creates one way of exploring the past, for example, just as a passive capture technique creates another. Each design choice creates a particular vision on what the past was, can be seen as, and ventured into. [...] Further designs that capture and construe visual, auditory, tactile, or indeed other „human-like" data traces ought to be developed so as to create opportunities to explore and discover how users can find new delights" (Harper et al., 2008, pp. 278-279).

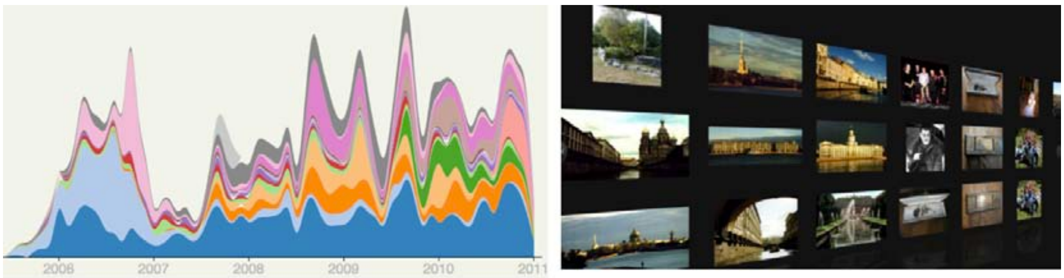

Figure 2.12. Two snapshots of the *MUSE* user interface (Hangal, Lam, & Heer, 2011, p.79 and p.81). Graph with accumulated numbers of emails grouped by different dialogue partners and across time (left). "Attachment wall" showing all images that were sent as email (right).

MUSE (Hangal et al., 2011) provided the opportunity to reminiscence and reflect about one's life by making use of digital information that amasses as a side-product of our daily communication: email messages. Thus, the application allowed the users to explore their "passively acquired life-log" data in an uncommon fashion. By a set of algorithms, visualization techniques and entry points via a user interface, the software was supposed to spark memories. Figure 2.12 illustrates two ways in which email data could be examined. Besides exploring clustered *images attachments* and *communications with inferred social groups*, *MUSE* also supported browsing emails by *sentimental words* and by *recurring named entities*. The researchers were struck by the many different ways in which their participants made use of the *MUSE* application, since their initial intention was to create a dedicated tool to primarily foster reminiscence. However, participants adapted it to their own needs and used it for all kinds of different actions, for example, gaining insights in work life, serendipitous browsing, or renewing friendships.

Isaacs et al. (2013) coined the term *technology-mediated reflection* to describe applications that employ personal digital media data, which was originally created to be shared via social networking sites, to facilitate moments of reflection. One could argue, that *MUSE* also falls into this category of systems. Isaacs et al. (2013), however, introduced their own application named *ECHOES* to explain the concept. Their hypothesis was that *ECHOES* could improve wellbeing by the promotion of reflection. They backed up their claim by literature from psychology which showed that reflection on (negative) experiences could lead to improved well-being, health benefits and personal growth, see for example (Lyubomirsky, Sheldon, & Schkade, 2005). Their mobile application featured an interface for capturing and annotating photos, and thus it allowed recording *events* on a phone. In addition, these photos, that is, the corresponding events could be rated regarding their emotional valence (positive to negative). From time to time, the system prompted the users to revisit some of the events and to rate again the happiness that the user associates with it. On this occasion, users were also enabled to add additional annotations. This second activity, the revisiting and re-rating of happiness with an optional annotating, was crucial to systematic reflection. The researchers were able to show in a study that the concept of *ECHOES* improved the perceived well-being of the participants by supporting reflection on both positive and negative experiences.

Pensieve (Cosley et al., 2009; Cosley, Sosik, Schultz, Peesapati, & Lee, 2012; Peesapati, Schwanda, Schultz, Lepage, et al., 2010) is a system, which also facilitated *technology-mediated reflection*, although its authors indicated that it was made primarily for reminiscing. The application also re-used "memory-laden" personal content from social networking sites. Registered *Pensive* users were occasionally sent random content from their social networking sites via email. For instance, a photo, which the user posted a long time ago on *Flickr*, suddenly appeared in their mailbox and thus demanded a moment of reflection. The application was generally well-perceived and positive consequences such as improvements in mood or impulses for getting in touch with old friends were reported by study participants. Other memory triggers than email, private photos or social networking site content that were employed by prototypes for reminiscing are *locations* in online maps (Peesapati, Schwanda, Schultz, & Cosley, 2010) and *publicly available media* (André, Sellen, schraefel , & Wood, 2011).

The above-mentioned systems all originated from a *lifelogging* context, or at least, are closely related to this application area. Nevertheless, there are also a number of systems that don't feature typical *lifelogging* characteristics, but do still mediate reminiscing or reflection. These applications don't share the desire for conserving vast amounts of significant and mundane information. Rather, they are designed for the deliberate archiving of a selection of personal digital(ized) objects. As such, the Living *Memory Box* (Stevens et al., 2003), *Memento* (West et al., 2007) or *FM Radio* (Petrelli et al., 2010) are mentioned in the literature (Cosley et al., 2011; Isaacs et al., 2013). Certainly, *Memory Lane* (Kalnikaité & Whittaker, 2011) was designed for reflection, as well.

> "A visible shift in memory in recent years has been the increasing availability, sophistication, capacity and portability of consumer-, professional- and enterprise-level capture/record technologies – they are smaller, lighter, wireless-internet enabled, have a longer battery life and are cheaper. We need never be not recording. The result is an explosion in type, format and sheer amount of data being gathered. Developments in the technologies of data storage are creating a world in which ever-larger data repositories are possible. These factors are in a seemingly endlessly reinforcing arrangement. In fact, one could say that memory has been central to the digital information revolution: improvements in digital memory (processing memory and storage memory) dovetail nicely with a seemingly voracious human appetite for creating, capturing, circulating and keeping more information, faster" (Van den Hoven et al., 2012, p.2).

2.3.5.5 Information-overflow

There are some obvious issues in *lifelogging* that stem from capturing vast amounts of data related to individual people and partially recorded in public spaces. Hence, the discussion of privacy or legal matters and considerations about the fragility of this immense data storage is not new to the HCI community (Czerwinski et al., 2006). Also, the danger of 'drowning' in all this accumulated information was addressed widely, for example, by Mayer-Schönberger (2009). As privacy and security matters are not so much a topic for this thesis, we will disregard these two (no-doubt important) challenges and leave them to other research, and now focus on information-overflow.

This wide-spread problem of way too many personal digital files (Marshall, 2008), not only applies to *lifelogging* endeavours or sophisticated personal information management systems, but also to conventional personal archives of digital data (e.g., digital photos, saved emails) on a PC. Deleting these files appears to be overly 'hard' for the users and, thus, content accumulates at a fast rate (Whittaker et al., 2012). It seems, in these days of immense storage capacities "forgetting has become the exception, and remembering the default" (Mayer-Schönberger, 2009, p. 2).

One big contributor to the general problem of information overload regarding personal digital data is the sheer number of digital images taken, often scattered across multiple storage systems as noted, for example, by Churchill and Ubois (2008), Sellen and Whittaker (2010), or Van House and Churchill (2008). The downside of easy photo capture and having that many pictures taken is that it is becoming increasingly difficult to relocate significant personal photos, and to ensure that private digital data collections are also backed-up on the longer-term. A large number of users take vast numbers of digital images, but don't get to sort or label them properly and don't revisit them. To examine this phenomenon, Whittaker et al. (2010) asked participants to locate personal digital photos of salient family events older than one year. They found that participants failed to find approximately 40% of the photos, even though they were from important events. The authors conclude that the newly gained abilities to take and collect large numbers of images is not matched by the ability to create order over them. They identified a couple of factors accounting for their participants' poor performance in retrieving important photos. These comprised: taking too many images, poor organization (on multiple file systems), the inability to maintain collections and an overoptimistic belief in being able to relocate them (Whittaker et al., 2010). On the general handling of personal digital files (not just photos), Marshall (2008) remarked that users do not consider their collections' needed curatorship. To make

> "Since the beginning of time, for us humans, forgetting has been the norm and remembering the exception. Because of digital technology and global networks, however, this balance has shifted. Today, with the help of widespread technology, forgetting has become the exception, and remembering the default" (Mayer-Schönberger, 2009, p. 2).

things even worse, she also observes that the users are not willing to invest much time or effort into curatorship, even of their most precious digital archives.

2.4 Summary and Implications for Design

We began this chapter with reviewing important concepts of memory from psychology and sociology. This served to establish a common understanding of what *remembering* actually means on an individual as well as societal level. Thereafter, we discussed memory retrieval triggers or *memory cues* as the key facilitators in the process of reconstructing memories. Relatively new now enabled by technology, is that we can build systems to support the process of remembering (*augmented memory systems*). The most prominent class of such systems is the domain of *lifelogging* applications. Much consideration on how to improve digital mementos has been initiated by this influential class of applications.

Recently, the usage of *appropriate memory retrieval cues* was addressed by *lifelogging* researchers, too. As stated by some researchers, for example by Kalnikaite et al. (2010) and Gouveia and Karapanos (2013), there are different ways for recording and presenting cues to the user. However, while different types of cues were proposed and evaluated, there is no *systematic exploration* in the literature of *how* memory retrieval cues can be displayed. For example, designers of augmented memory systems might consider displaying all available memory retrieval cues at once, or 'giving them away' gradually for creating an enhanced reminiscing experience.

In the remainder of the thesis we will address exactly this challenge: in which *different ways* can memory retrieval cues be presented to the user to facilitate meaningful remembering experiences? Thereby, we distinguish between different kinds of remembering and focus in particular on more sentimental recollection or contemplation (not the recall of 'plain' facts) such as reminiscence and reflection. As a consequence, this is not a project to 'maximize' memory performance including metric benchmarks. Rather, it is our aim to support designers in creating applications for remembering, which employ memory retrieval cues captured by digital files in useful ways. For this endeavour, we chose a design approach, which is related to *research through design*, to be detailed in the next chapter. In summary, it is our intention to explore different ideas and modalities for presenting digitally recorded information to the user to support encounters with their past. This exploration is led by a design research approach and systematically maps out different ways for displaying memory retrieval cues to support the users in making sense of this information and in inscribing their personal meaning. From a theoretical interaction design perspective, it is our goal to uncover and propose design concepts or mechanisms that give guidance to fellow researchers and practitioners in making use of digitally captured memory retrieval cues.

We conclude this chapter by highlighting a summary of key findings of the literature review on augmented memory systems (see above), which will be particularly addressed during the practical development of our prototypes in the course of the design-based research process.

2.4.1 Implications for Design

Specifically, our strategy in creating meaningful resources for memory is to address four current design challenges that were identified in the literature review. These challenges relate to *information overload and the effort to create order,* the *invisibility* of digital resources, and supporting *creativity* and the *(re)constructive nature of memory.*

2.4.1.1 Information Overload and Effort to Order

A common problem noted in literature on digital archives is information overload and information being scattered across multiple locations, for example (Churchill & Ubois, 2008; Sellen & Whittaker, 2010; Van House & Churchill, 2008). In connection with archives for personal remembering this means that a large number of users take vast numbers of digital images, but don't get to sort or label them properly and don't revisit them. The researchers conclude that the newly gained abilities to take and collect large numbers of images is not matched by the ability to create order over them. This leads to a predominant problem of unsorted, lost, scattered and too many personal digital files. It seems timely to search for technical solutions that assist us in creating order over our digital mementos.

2.4.1.2 The Invisibility of Digital Resources

A drawback of digital souvenirs compared to their physical counterparts is that they are perceived more and often as *invisible* (Whittaker et al., 2012), despite efforts on, for instance, digital displays that we have reported in Section 2.3.1.1. Recent work has highlighted the importance of *providing the virtual a physical home* to know where these materials are and to have quick access (Odom, Sellen, Harper, & Thereska, 2012). Novel physical prototyping tools open up a feasible possibility to comply with a specific recommendation for designers of digital memory systems: to move away from the PC (Stevens et al., 2003). These tools enable us to explore more integrated devices that bring digital mementos into everyday spaces in engaging and highly visible ways.

2.4.1.3 Enable and Encourage Creativity

A recurring theme in the augmented memory systems literature is *creativity* or the power of creative engagement and activities that are related to creativity. We use the term *creativity* to describe two distinct things here. Firstly, a creative act can denote *constructive* activities such as setting up folders, organizing photos (as investigated by PIM research, see Section 2.3.2) or even bringing old memories back to mind - things are (re-)created, moments are captured and memories are reconstructed. Secondly, the term *creativity* can also be used in a more artistic sense. For instance, there might be a lot of originality and engagement in the way people are using their camera to capture a moment.

As an example of the first, we already referred to the '*lifelogging* workshops' conducted by Petrelli et al. (2009), where they let participants create *time capsules* (see Section 2.3.4.1). One key insight from their work was that the participants showed little support for the *passive lifelogging paradigm*. That is, they were not interested in vast auto-created archives of a captured life, but preferred a highly customized and personal selection of mnemonic representations. Relating to this, within our work here we also understand *creative engagement* as taking the time and making an effort in fulfilling an action.

Creativity is also important in our second sense. A principal resource for digital souvenirs is the photo camera and there is a history of people using their cameras for self-expression. In fact, in recent years more and more non-professionals are observed engaging in art photography (Van House, 2011). Camera phones often catch more mundane motifs and often with humour being involved. In a *SenseCam* study centring on capturing digital memories for later narrative (as already reported in Section 2.3.5.4) Harper et al. (2008) found that the participants appreciated uncommon and *arty* pictures and enjoyed using *SenseCam* in a creative fashion (Harper et al., 2008).

Inspired by the observations listed above, we hypothesise that tools, for example, for mimicking the creation of the physical time capsules and for supporting other sorts of creative self-expression and digital crafting might be powerful in designing digital mementos and, hence, repositories of digital memory retrieval cues.

2.4.1.4 The (Re-)creation of Memory and Retrieval Cues

This leads to the next point relating creativity and memory cues. The predominant understanding in psychology is that memories have to be re-created by means of retrieval cues (Hoven & Eggen, 2008; Schacter, 1996) and that successful recall depends heavily on our access to appropriate memory cues (Schacter, 1996). From a media studies perspective van Dijck characterizes "products of memory [to be] first and foremost creative products, the provisional outcomes of confrontations between individual lives and culture at large" (Van Dijck, 2007, p.7). She highlighted that a prerequisite of a memory is that resources for later recall have to be created in the present moment. Furthermore, she reminds us that photography has always been a tool for the *construction* of identity, that is, we capture photos that represent us in the way that we would like to be remembered. In HCI literature van Hoven was among the first authors to emphasize that it is not memories that can be stored to disk, it is retrieval cues for recreating that experience (see also Section 2.2.1.3):

"A cue (or trigger) is a stimulus that can help someone to retrieve information from long-term memory, but only if this cue is related to the to-be-retrieved memory. The stimuli most often used in studies are photos, smells or text labels. But anything could be a cue […], as long as there is a link between the cue and the to-be-remembered event. A combination of cues increases the chance of retrieving a memory […]." (Hoven & Eggen, 2008, p.435)

Reflecting similar perspectives, others also critiqued that the archive metaphor is used too often as a model for the design of digital remembering or *lifelogging* systems (Petrelli et al., 2009; Sellen & Whittaker, 2010). Hence, it is our ambition in this thesis to make use of reasonable digital memory cues to create engaging remembering experiences.

2.4.1.5 Practical Mission Statement for our Design Proposals

As stated above, the theoretical mission statement of this thesis is to investigate different ways for presenting memory retrieval cues to the user.

Form a practical interaction design perspective we aim to create technology for capturing rich digital memory cues and also for supporting the users in their self-expressiveness. Supporting creative engagement, we believe, can lead to more meaningful memory triggers. With respect to the challenge of *information overload*, it is not the goal of our prototypes to (automatically) capture excessive repositories with cue data. Rather, we seek to slow the users down a bit and invite them to carefully plan and design their digital mementos that may then become useful resources for memories. Finally, these resources might *be used by the human brain* one day to reassemble and reconstruct memories. Today is the time to ensure the quality of this digital material including the memory cues.

We go on to describe our design-based research methodology. In doing so, we will make a case for this interaction design method, as *research through design* or similar approaches haven't found much recognition in augmented memory system research yet.

3 Methodology

In this chapter, the methodology of the thesis is introduced. To this end, we initially take a brief look at the field of theoretical human-computer interaction and its boundary conditions. Subsequently, we detail the approach of *design-based research (DBR)* as the overall method of inquiry in this thesis. These theoretical excursions seem necessary, as DBR or design-led research is not a well-established method yet, but is currently being actively negotiated.

In addition to the presentation of the methods, an overview of the conducted studies of this thesis is provided. Finally, we explain how the insights of the individual studies are integrated within a design framework (the CuDe Framework) to systematically show how the individual findings relate to each other and to provide a theoretical device as the basis for future work.

3.1 Research in HCI

One peculiarity of the field of HCI is that this relatively young discipline is exposed continually to rapid technological innovations, which are leading to constant shifts in its theoretical foundations. As a consequence, the field at times suffers from a lack of agreed-upon standards for conducting 'proper' research in comparison to more established scientific disciplines with gold standards for inquiry. In such disciplines, there is generally no need to fundamentally argue for a certain method, for example, to conduct a *laboratory experiment* in psychology, as the corresponding research community has a shared set of assumptions including widely approved methods for 'seeking truth'. Certainly, HCI also has basic belief systems and finds itself united by a shared history. However, due to technological developments and due to the multidisciplinarity of the field, there are uncertainties within the community about which methods are appropriate means to contribute knowledge and to advance the field. A widely considered textbook on the human-computer interaction discipline describes this problem as follows:

"[HCI] achieved an effective integration of software engineering and the human factors of computing systems through the concepts and methods of cognitive science. […] An ironic downside of the inclusive multidisciplinary of HCI is fragmentation. This is in part due merely to expansion of the field and its scientific foundations. In the 1980s, it was reasonable to expect HCI professionals, particular researchers, to have a fairly comprehensive understanding of the concepts and methods in use. Today, it is far more challenging for individuals to attain that breadth of working knowledge. There are too many theories, too many methods, too many application domains, too many systems " (Carroll, 2003, p.6).

In this thesis we employ a *design-oriented* research methodology, enabled by the novel availability of rapid prototyping tools such as convenient programming environments for mobile phones or the *Arduino* microcontroller board (see Figure 3.1), which facilitates the creation of physical devices. These practical tools for developing and deploying applications within short periods of time and quick iterations enable us to situate fully functional systems in daily contexts with relatively little effort. While earlier HCI research dealt with the improvement of the interfaces of existing products, that is, examining the *usability* of certain applications under lab conditions, these new opportunities of rapid prototyping allow us to extend the analysis of existing applications to purpose-built systems. Thus, we now have appropriate tools at hand to study how *possible futures* might look like and how users adapt prototype systems to their ends and integrate them into their life:

Figure 3.1. Arduino microcontroller board for fast prototyping of physical computing devices. (Stoneburner, 2010).

"Armies of computer scientists and engineers are no longer needed. Interaction designers with less technical expertise and modest resources, can conjure, create, and deploy a diversity of prototypes in all manner of places in the everyday world" (Rogers, 2011, p.58).

Still, the question remains about what methods to employ for the evaluation of these prototype systems and how to generate theoretical knowledge that can be used for advancing the field. This question is additionally complicated by the fact that the newly created systems and designs are no longer restricted to working environments but also focus on leisure time activities in a multitude of different use contexts (Rogers, 2012). From this follows as well, that research has to move from the controlled environment of the laboratory into real world settings, facing people or research subjects that are adapting technology in unanticipated ways to their own needs. How can we find appropriate measures for assessing the success of a technology? In fact, how do we define *success* within interaction design, now that it considers such broad areas? And how can research insights be generalized and transferred to the development of further systems?

The research approach we take in this thesis is *oriented towards design* to help tackle the above questions. Nevertheless, the approach of basing research endeavours primarily on design (practice) is also relatively new to HCI and by no means established. Naturally, design has always played a role in such an applied science like HCI (Wolf, Rode, Sussman, & Kellogg, 2006); still particularly within the last decade the arrival of a new design-oriented approach to research can be observed within the HCI literature. In fact, there are a number of concepts proposed under different names, but they are heading in a similar direction. The research of this thesis can be considered part of this movement, which is also fuelled by the fact that conventional HCI theory is rarely considered in HCI practice in contrast to more 'designerly' methods (Stolterman, 2008). We go on to describe major contributions to design-oriented HCI research and relate them to the approach taken in this thesis.

3.2 Design-based Research in HCI

A salient label that is currently attached to *design research* projects in HCI is *Research through Design (RtD)*. However, besides shared understanding and philosophies there are active negotiations about how to define RtD and "what to expect" from it with regard to knowledge production (Gaver, 2012). In addition, there are different proposals for design-oriented HCI research that are related to RtD, however distance themself from it, for example, *Concept-driven Interaction Design Research (CDDR)* (Stolterman & Wiberg, 2010), *Strong Concepts (SC)* (Höök & Löwgren, 2012) or *Constructive Design Research (CDR)* (Koskinen, Zimmerman, Binder, Redström, & Wensveen, 2011). Nevertheless, these approaches are united by the researchers' shared interpretation of HCI interaction design as a design discipline and by their theoretical foundations in design research (Höök & Löwgren, 2012).

3.2.1 Design Research

Design research is the umbrella term that is commonly used for theoretical investigations into design and for the development of design knowledge regardless of the applied research subject (human-computer interaction, architecture, product design, etc.). The notion is employed since approximately half a century and it deals with the "systematic inquiry whose goal is knowledge of, or in, the embodiment of configuration, composition, structure, purpose, value, and meaning in man-made things and systems", to use the words of pioneer design researcher L. Bruce Archer (as cited in Bayazit, 2004, p.16). It is important to note, that design research does not denote the practical activities in which designers engage in order to create a certain product (e.g., identifying the most appropriate kind of plastic); however, such action can become subject to design research in a more abstract fashion as it "is concerned with construction as a human activity, how designers work, how they think, and how they carry out design activity" (Bayazit, 2004, p.16).

Koskinen et al. (2011, Chapter 1) distinguished design *practice* from design *research* by the study objective. One the one hand, insights from prototype deployments could be used to improve the product (design practice), on the other hand, additional theoretical work could be carried out in conjunction with empirical studies and finally resulting in more general knowledge that can be applied to problems that go beyond the implementation of one specific product (design research). They emphasized the coincident presence of "planning and doing, reason and action [...]" (Koskinen et al., 2011, p.2) and strong theoretical underpinnings in this kind of applied design work.

3.2.2 Research through Design (RtD)

Frayling (1993/94) suggested a widely embraced differentiation within design research. He distinguishes between three different research schemes, namely *research into design*, *research for design* and the above mentioned *research through design*.

While the first kind of research denotes activities such as studying the history of design and design as a human activity, the second kind comprises actions that are undertaken to improve the production or the outcome of design. RtD, in turn, seeks to attain new knowledge that goes beyond examining relevant factors for a particular design implementation and wants to contribute to the design discipline more generally and also to disciplines other than design. RtD is conducted to "[…] help designers and design researchers develop critical understandings of design problem spaces; in other words, instead of doing research in support of design, design becomes a research methodology" (Bardzell, Gross, Wain, Toombs, & Bardzell, 2011, p.372).

Research through Design (RtD) is defined by some authors as "a research approach that employs methods and processes from design practice as a legitimate method of inquiry" (Zimmerman, Stolterman, & Forlizzi, 2010).

Zimmerman, Forlizzi and Evenson (2007) directly referred to Frayling's classification as they proposed RtD as "a method for interaction design research in HCI". Their method is shaped by deep respect for the practical skills and *design thinking* designers can contribute to research endeavours. These competencies are employed to "focus on the *right* thing; artifacts intended to transform the world from the current state to the preferred state" (Zimmerman et al., 2007, p.497). In their model interaction designers are at the interface between engineering and the social sciences. Through an iterative process of ideation, prototyping, testing out, hands-on activities and the critique of proposed design solutions or ideas, the design problem is repetitively reframed and looked at from different angles in an attempt to accomplish the "right thing". In doing so, the design researcher integrates social science knowledge (e.g., behavioural theories or empirical data from field work) with technical capabilities, finally resulting in a "concrete problem framing and articulation of the preferred state" and a number of prototypes, artifacts, products, etc., including a proper design process documentation (Zimmerman et al., 2007, p.497). This model places particular importance on the designed artifacts, as they embody the things that have been learnt throughout the process and are seen as (implicit) carriers of theoretical design knowledge to be passed on to the design practice community.

"The artifact reflects a specific framing of the problem, and situates itself in a constellation of other research artifacts that take on similar framings or use radically different framings to address the same problem. These research artifacts provide the catalyst and subject matter for discourse in the community, with each new artifact continuing the conversation" (Zimmerman, Forlizzi, & Evenson, 2007, p.498).

Besides these artifacts, Zimmerman et al. (2007) also claim two further contributions resulting from their approach. First, RtD can help identify gaps and opportunities in the stock of knowledge of the involved disciplines. For instance, design research artifacts might inspire engineers to create new types of technologies, or social scientists might gain insights from the reactions of study participants exposed to design research prototypes. Second, the authors attribute integrative accomplishments to RtD, as it has the capability to take a holistic perspective on conflicting positions and find a balance in its products.

Besides these contributions and advantages, there are on-going discussions about how to better integrate RtD findings into HCI and design theory. Zimmerman et al. (2010) criticized that RtD is not a formalized process and lacks negotiated criteria for assessing the outcome of RtD projects. Hence, they called for more standardization in the shape of guidelines for research processes, design activities and documentation,

> "Seeking conformance to agreed-upon standards and processes may be a route towards disciplinary legitimacy within HCI, helping clarify expectations for research through design both within and outside the design community. There is a risk, however, that such standards might lead to a form of self-policing that would be overly restrictive of a form of research that I value for its ability to continually and creatively challenge status quo thinking." (Gaver, 2012)

with the overall goal to better distil single RtD projects into design theory. Gaver (2012), on the contrary, highlighted the creative opportunities which are offered by an approach that is not bound to the fixed methodology of rigor sciences. Instead, he pointed to RtD's ability to engage with explorations, speculations, and detailed studies as well as broader views. Gaver further contrasted RtD in a thought experiment to 'conventional' science (research that is widely being recognized as being 'scientific'), which conducts experiments and falsifies hypotheses (*post-positivist* research paradigm). He pointed out that RtD theory could never be falsified (or verified), as there are an unpredictable number of contextual factors that come into play during design practice. Hence, it is almost impossible to setup conditioned experiments for the sake of falsification. Such experiments would miss important aspects and cannot account for the richness of design. In addition, RtD was never intended to generate precise, unambiguous and confirmable statements. On the contrary, the approach was brought into being for its potential to make generative statements, that is, the capability to point to possible new worlds and "what might be" (Gaver, 2012).

Part of the generative nature of RtD is that design practitioners seek inspiration in design examples. Most of the time they even prefer these exemplars to theoretical knowledge when creating new products. Gaver (2012) attributed this preference to the liability and definiteness of the artifacts compared to more tentative theory. He suggested *annotated portfolios* as a means to capture RtD outcome and knowledge, which are collections of design explorations on certain matters, compiled and explicitly annotated to illustrate the investigated design space.

3.2.3 Concept-driven Interaction Design Research

However, RtD in general was criticized by others for being too narrowly focussed on artifact creation and for its lack of "strong theory" to give reliable guidance to those who want to conduct practical work (Koskinen et al., 2011).

As a response to this shortcoming, Stolterman & Wiberg (2010) proposed their own research model named *Concept-driven Interaction Design Research (CDDR)*, focussing specifically on advancing theoretical knowledge. They suggested that their model is different from Zimmerman et al.'s *Research through Design* approach (2007) and highlighted that RtD

"[…] can lead to artifacts that in themselves open up a design space and people's understanding of what is possible and also desired. It is possible to see the process they proposed as a pretheoretical activity, that is, it presents a design space that later can be theoretically examined. […] The proposed model by Zimmerman et al., however, is not intended to address specifically theorizing around the concept of interaction, at least not as a primary goal. […The model's…] primary focus is the improvement of the use situation, while contributing to theory in supporting disciplines but with a couple of differences. […] The overarching purpose is that the design will lead to a more desired situation than the

present. This means that, although their approach also produces knowledge, it is a combined approach where the outcome, as an artifact, and its success also is part of the evaluation" (Stolterman & Wiberg, 2010, p.100-101).

In contrast to Zimmerman et al.'s model, the emphasis in Stolterman's & Wiberg's (2010) approach is on the production of theory particularly geared towards interaction design and with *no primary* attention to the quality of the prototypes or products (i.e., there is no priority in improving a specific situation), which are employed to gather these insights. In other words, they have a strong focus on *theory* as opposed to other research, which particularly tries to satisfy the *use situation* of a designed product. The latter prioritization is the orientation chosen by the majority of practical interaction design work as well as HCI research projects in the argumentation of these authors: a particular use context is analysed in order to find an innovative design, which solves a particular problem of this use situation and often is based on former implementations as a source of inspiration. This is accompanied by mandatory user studies to provide empirical evaluation. Often, this kind of research draws on established theories from outside of HCI, for example theories on human memory or behaviour change. Stolterman & Wiberg (2010) now argued that the majority of design proposals, however, soon get forgotten without having a sustainable impact on the theory of interaction design. In their paper they investigated why a few design concepts such as, *ActiveBadges* (Want & Hopper, 1992) or Bricks (Fitzmaurice, Ishii, & Buxton, 1995), on the other hand, have a substantial influence on succeeding designs. They concluded, that few outstanding designs manage to embody a set of particular features, and that this carefully crafted composition accounts for the theoretical success of this concept design.

"We argue that exploiting concept-driven design research allows us to develop knowledge that cannot be fully expressed in text or other typical research outcome formats. A theoretical concept manifested as a designed artifact can be seen as externalized knowledge; the concept itself carries most of the experience and results from the design process. The concept design becomes a carrier of knowledge but also establishes a conceptual framework and challenge for future design work" (Stolterman & Wiberg, 2010, p.104).

This set of particular features balances traditional and futuristic interaction mechanisms, established theory and potential starting points of new research agendas, and is giving guidance for other researchers and inspires "creative theoretical exploration in a certain direction" (Stolterman & Wiberg, 2010, p.105). When engaging in CDDR, designers face the challenge to integrate all knowledge that has influenced the interaction design in the product, while at the same time aspects, which distract from the actual idea, have to be eliminated. The authors name *Bricks* (Fitzmaurice et al., 1995) as an exemplary concept design, as this proof-of-concept prototype embodies the idea of tangible user interfaces and led to many related graspable user interfaces as well as to a body of theoretical work on tangible interaction (e.g., "embodied interaction" by Dourish (2001)). Bricks, as any good concept design, "is optimized in relation to a specific idea, concept, or theory rather than to a specific problem, user, or a particular use context" (Stolterman & Wiberg, 2010, p.98).

Höök & Löwgren (2012) use Stolterman's & Wiberg's (2010) CDDR as a starting point for developing the model of *Strong Concepts* (SC). While the latter approach (SC) primarily constitutes an alternative to the predominant use-situation oriented research, it considers to a lesser extent how the research outcome of a CDDR process, for example, a set of design artifacts, can be abstracted into *higher-level knowledge*. This is where the work of Höök & Löwgren (2012) actually begins.

They drew on design theory and proposed that interaction design features *intermediate-level knowledge*, which is settled somewhere between theories and particular instances (or design artifacts to use the language of, for example, Zimmerman et al. (2007)). *Strong Concepts* are located within this space and, thus, describe a contribution that is more than 'just' a specific product, but not yet a 'fully-grown' theory. An important difference to theories is that intermediate-level knowledge can often be viewed from different angles, that is, it can be looked at through the lenses of different theories. In addition to *Strong Concepts*, Höök & Löwgren (2012) identified several other approaches in the territory of intermediate-level knowledge, for example, *design patterns* (Alexander, Ishikawa, & Silverstein, 1977) or *annotated portfolios* (Gaver, 2012). One of the driving forces of their motivation for developing *Strong Concepts* was that they identified an opportunity for constructing knowledge through design-oriented practice, which is settled at a higher abstraction level than particular design artifacts (as mentioned above). They hoped that designers would engage in the collaborative production of this kind of knowledge and employed indicative artifacts to communicate their ideas. Ideally, these ideas mature into fully-grown *Strong Concepts*, which are used by other researcher as a source of inspiration and incorporated into their designs. It is important to note, that *Strong Concepts* can be applied across a variety of different use situations or applications. Höök & Löwgren (2012) highlighted the generative nature of *Strong Concepts*, as "designers ideate by exploring the solution space" as opposed to engineers, who "work in a space of problems to be solved" (Höök & Löwgren, 2012, p.3).

"Strong concepts are design elements abstracted beyond particular instances which have the potential to be appropriated by designers and researchers to extend their repertoires and enable new particulars instantiations. We connect the notion of abstraction to scope of applicability. A specific artifact is fully concrete, that is, not abstracted at all, and as such, it is (primarily) applicable only in the situation for which it was designed. Elements of that particular artifact, or instance, can be isolated and abstracted to the level that they are applicable in a whole class of applications, a whole range of use situations, or a whole genre of designs" (Höök & Löwgren, 2012, p.5).

They related Zimmerman et al.'s RtD (2007) approach to both *Strong Concepts* and to the study of canonical examples, as it is practised in design education to teach the (tacit) knowledge, which is embodied in these objects and point out that

"[t]he knowledge contributions [they] are interested in here reside on an abstraction level above particular instances. Beyond bringing out novel design instances and mapping out new territories or novel experiences, a designer-researcher can also engage in the reflection, articulation, and abstraction necessary to tease out strong concepts, rather than stopping at performing the design work and presenting the resulting instance." (Höök & Löwgren, 2012, p.11).

Social navigation (i.e., decision making/support based on other users' ratings or experiences; see Figure 3.2 as an example) was described as an exemplary *Strong Concept* in their article. The authors praised its wide spread success as well as its multitude of different implementation forms. Further, they linked it to the grounded theories of embodiment and constructivism and thereby indicated explanations for the success of the social navigation concept.

Figure 3.2. Example of a social navigation system: user reviews in *Google's Play Store.* (Retrieved 10 July 2014 from https://play.google.com)

3.3 Design-based Research (DBR) in this Thesis

In this section, we first explain the main commitments of the research method as it is employed in this thesis (DBR). Second, we detail which studies were conducted as part of the research. On this occasion, we shortly refer to two qualitative research methods, which were incorporated into the design-based research to systematically probe peoples' reactions to designed prototypes. Third, we explain how the individual design and prototypes are conceptualized into a theoretical framework.

3.3.1 The Four Commitments of DBR

So far, we have outlined different variants of design- and practice-oriented HCI research. We have revisited these approaches in some detail, as they constitute the foundation of the methodology of this thesis. However, the theoretical stance in this work does not follow one of these models step-by-step, using it as a blueprint. Instead, a blend of these different but related methods is employed. This seems feasible, as none of the above introduced methods claims to be the only valid approach to interaction design research. On the contrary, they are all characterized by their openness and desire for experimentation. Additionally, the summary in the section above suggests that the approaches are closely related to each other, and that they can be read to some extent as being built upon one another (a hint for this is also given by the dates of publication).

We give our method the simple name of *design-based research (DBR)* to indicate that it differs from each of the introduced approaches, if interpreted in their 'purest' form. However, this should not be understood as the proposal of a complete new design research method, but rather as a shared label for bundling the philosophies and our interpretations of the reviewed research methods. More precisely, the common commitments upon which DBR is built are listed below. Thereby, the first item describes *why* we chose to conduct design-based research, and the subsequent three items entail *what* we did throughout this process.

1. *Designing for wicked problems.* In line with the authors on RtD (Gaver, 2012; Zimmerman et al., 2007; Zimmerman et al., 2010) we believe that design-oriented research (or DBR) is particularly strong at addressing *wicked problems* (Rittel & Webber, 1973), that is, challenges which are hard or impossible to tackle with conventional (reductionist) engineering or research strategies.

Supporting remembering (i.e., processes such as reminiscing and reflecting) is a wicked problem. Definitions or goals such as *support for reminiscing*, for instance, can be framed in many different ways. Further, the proposed solutions to these challenges cannot be classified as "true-or-false" (rather: "good-or-bad") and there is no "ultimate test" for them (Rittel & Webber, 1973). Countless factors and independent variables involved in many design endeavours extend the solution space way too far to be modelled in an engineering-like approach. Such an attempt would "underspecify design" (Gaver, 2012). Also design is both evaluative and generative, that is, design is oriented towards the future and "is concerned with creating *what might be*" rather "than making statements about *what is* […]" (Gaver, 2012, p.940). Therefore, design research can be an appropriate means to address augmented memory systems.

2. *Constructive hands-on practice*. The act of creating and making takes centre stage within this thesis and design serves "as exploration of the solution space" (Höök & Löwgren, 2012, p.3). Designing is interpreted as *reflection-in-action* (Schön, 1983), that is, design practice creates the opportunity to learn through the practical engagement with different situations, requirements, materials, etc. The process of designing is seen as some kind of 'designer-artifact dialogue' (the designer reflects on their actions and products), which results in a gain in theoretical and practical knowledge. Or, to use Löwgren's & Stolterman's (2007) explanation:

   "[T]he problem and the solution have to evolve in parallel. While trying to solve a problem the way we currently understand it, we create situations that will surprise us […]. These surprises, this learning, form the basis for the questioning and development of new creative solutions. This kind of learning cannot be achieved without working with solutions, since we need them to find out if we are moving in the desired direction" (Löwgren & Stolterman, 2007, p.23).

   Naturally, this problem solving process is iterative and includes the consideration of new insights and the reframing of the design problem.

   Fallman (2003, p.231) also attaches value to the act of making, creating and designing in HCI research as "[f]ieldwork, theory, and evaluation data provide systematically acquired input to this process, but do not by themselves provide the necessary whole. For the latter, there is only design."

3. *The role of the artifact*. This third commitment of DBR is closely tied to the second one. The appreciation for the 'making of things' necessarily leads to great interest in the designed artifacts per se, as they embody implicit knowledge that has been gained throughout the design process and that at times cannot be expressed verbally or by any other means than the actual object (Stolterman & Wiberg, 2010). Thus, we see the design outcomes as carriers of

ideas to be studied by colleague interaction designers, similarly to the *canonical examples* as used in design education (Höök & Löwgren, 2012). From this follows, that the prototypes in this thesis are regarded more than solely *proof-of-concepts*, as commonly applied in HCI research (Fallman, 2003). Further, the prototyped systems are geared towards specific concepts or ideas and not towards meeting the requirements of a specific situation (Stolterman & Wiberg, 2010) or aesthetical optimization. At times we also like to think of them as "*probes* or *measuring instruments* used to get a sense of how people (or a market) will 'read', react, and respond to the character and composition of a design" (Stolterman & Wiberg, 2010, p.104). Finally, as we highlight the importance of the concept as the basis of design artifacts, we attach less importance to the fact that the objects have literally been constructed and made out of atoms ('hardware' artifacts) compared to other authors (Koskinen et al., 2011). Instead, we fully acknowledge the potential of software prototypes for the exploration of interaction-design concepts and design software prototypes to a larger extent in this thesis.

4. *Theorizing about interactions*. We seek novel theoretical understandings of interaction-design in the context of digitally augmented remembering. That is, we aim to theorize about the nature of interactions in that realm. The primary goal is neither to gain core psychological findings, nor is it to proof that computers can be used for supporting memory in certain ways. Rather, the objective is to elaborate and describe interaction mechanisms or elements that can be employed across different applications and lead to situations in which rich remembering is likely to be fostered. To this end, the designed artifacts and prototypes should have a clear focus on one particular interaction concept. No additional, unnecessary elements that constitute other interaction concepts should be included in the design proposals (Stolterman & Wiberg, 2010) in order not to dilute the concepts and the users' reactions to them (i.e., multiple concepts should *not* be explored by one *single* prototype. Rather, the goals and functions of the prototype should be outlined clearly).

   In line with Stolterman and Wiberg (2010) we propose to initiate the design activities with the grounding of a concept on prior work, considerations, and theory. Similarly, Höök & Löwgren (2012) suggested to engage in an initial process of concept identification and exploration:

   "[A] typical approach may be to identify a tentative strong concept from one or several design experiments (in effect abstracting from the instances, pointing out what connects them) and then try the strong concept in new design experiments to assess its generativity, scope, and validity. If the aim is to reach a strong concept that has a relatively wide scope, the experiments can be made to intentionally address different genres or application domains" (Höök & Löwgren, 2012, p.13).

We agree with both Stolterman & Wiberg (2010) and Höök & Löwgren (2012), and begin the DBR endeavour with a literature review, shortly followed by design experimentations with initial prototypes or 'probes' (first pre-studies). Later in the process, Höök & Löwgren (2012) suggest to perform "vertical grounding", that is, identifying other instances, which incorporate the concept, and linking it back to theories, which might account for its working principles.

Eventually, a successful design process concludes with, as already mentioned, an artifact, which reflects all choices that were made and which "manifests desired theoretical ideas […]" (Stolterman & Wiberg, 2010, p.109). This artifact enriches theory by connecting things that we already know with novel design or interaction elements. It also adds to theoretical advancements by guiding future research (or even setting a research *agenda* based on the introduced concept) and inspiring others. As mentioned earlier, Höök & Löwgren (2012) elaborated on CDDR (Stolterman & Wiberg, 2010) and denoted this kind of theoretical development as *intermediate-level knowledge*, which is more abstract than particular instances, however, without claiming the generalizability of a grown theory. In the course of this thesis, in particular during the discussion of the Memory Cue Design Framework (CuDe), we aim to propose candidates for what they call *Strong Concepts* (i.e., one category of *intermediate-level knowledge*) for supporting digital remembering.

3.3.2 Research Process and Study Overview

To begin with the outlining of the overall research process and study overview, let us recall the main research question (RQ1) and sub-question (RQ1.1) of this thesis as presented in the introduction (see Chapter 1):

RQ1: How can people be engaged in meaningful remembering experiences when dealing with digital files and souvenirs? ('Meaningful remembering' is defined here as providing the user with opportunities for reflection, reminiscing or other forms of 'sentimental' recall that go beyond plain *factual* recall.)

RQ1.1: How can properties of the emerging digital technologies be exploited to meet some of the challenges identified in the literature?

We started with this rather open question, as we saw opportunities as well as the need to improve the 'status quo' by taking a holistic and design-led path to explore these research challenges. In particular, modern mobile phones promise unprecedented opportunities to support remembering. Consequently, initial background research relatively quickly resulted in a set of five initial technology probes or prototypes (Pro.1-5; see Figure 3.3) that we used to play with different ideas for triggering memories, and were explored in the short-term pre-studies P-S.1-3 and P-C.1-2.

Figure 3.3 (note Figure 1.3 of Chapter 1, which is similar, but puts emphasis on the user studies conducted) provides a structured diagram of the thesis process and research, which was divided into the three research strands RS1-RS3 (to be explained below). Each strand is headlined by its conceptual considerations or research objectives (*de-/re-ctx*, SEC, AEC). The names of the prototypes or design explorations (Initial probes Pro.1-5, Hearsay, Duography, Media Object (MEO)) are depicted as well. All conducted user studies for addressing the research questions are displayed with their identification abbreviations (P-S.1-3, P-C.1-2, HPI, DUO.1-4, MEO.1-3).

The probes evolved as a response to the four research challenges from the literature (cf. Chapter 2.4.1) and covered a number of ideas for addressing these current design issues. As they partially dealt with novel kinds of digital material or file formats (in this thesis, we call individual digital files *entities*), these applications necessarily involved both information presentation and capture (the novel files needed to be recorded). This is particularly true for our applications where we *combined* digitally recorded data in a particular fashion (multiple entities; described in Part II of the thesis; see below). Thus, studying how data can be represented by means of these applications necessarily involved data capture. Other probes, again, operated with only single entities. For this, it was possible to use already existing personal media files. Besides private files (e.g., photos), we also employed *public* data downloaded from the Internet for evoking notions of *personal* reflection and reminiscence. Others in HCI, for instance André et al. (2011), have successfully used *public* data for *personal* reminiscence before this thesis work. The reason for this success might be the strong link between collective and personal memory (Van Dijck, 2006).

These pre-studies or initial prototypes and the on-going literature review (the literature was an on-going process throughout the whole thesis as indicated in Figure 3.3) then led to three different strands of research (RS1-RS3; see also Figure 1.3 of Chapter 1). Each strand elaborated a very specific concept (*de- and re-contextualization*, *synchronous entity composition (SEC)*, *asynchronous entity composition (AEC)*), which was invented, shaped and redefined throughout the process of researching the literature, creating technology probes, and gaining user feedback.

Thereby, strand one (RS1) dealt with memory retrieval cues contained within single entities (media files), while the other two research strands (RS2, RS3) involved multiple combined entities. We go on to outline RS1-RS3 and the design concepts, which steered the strands' directions (see page after next):

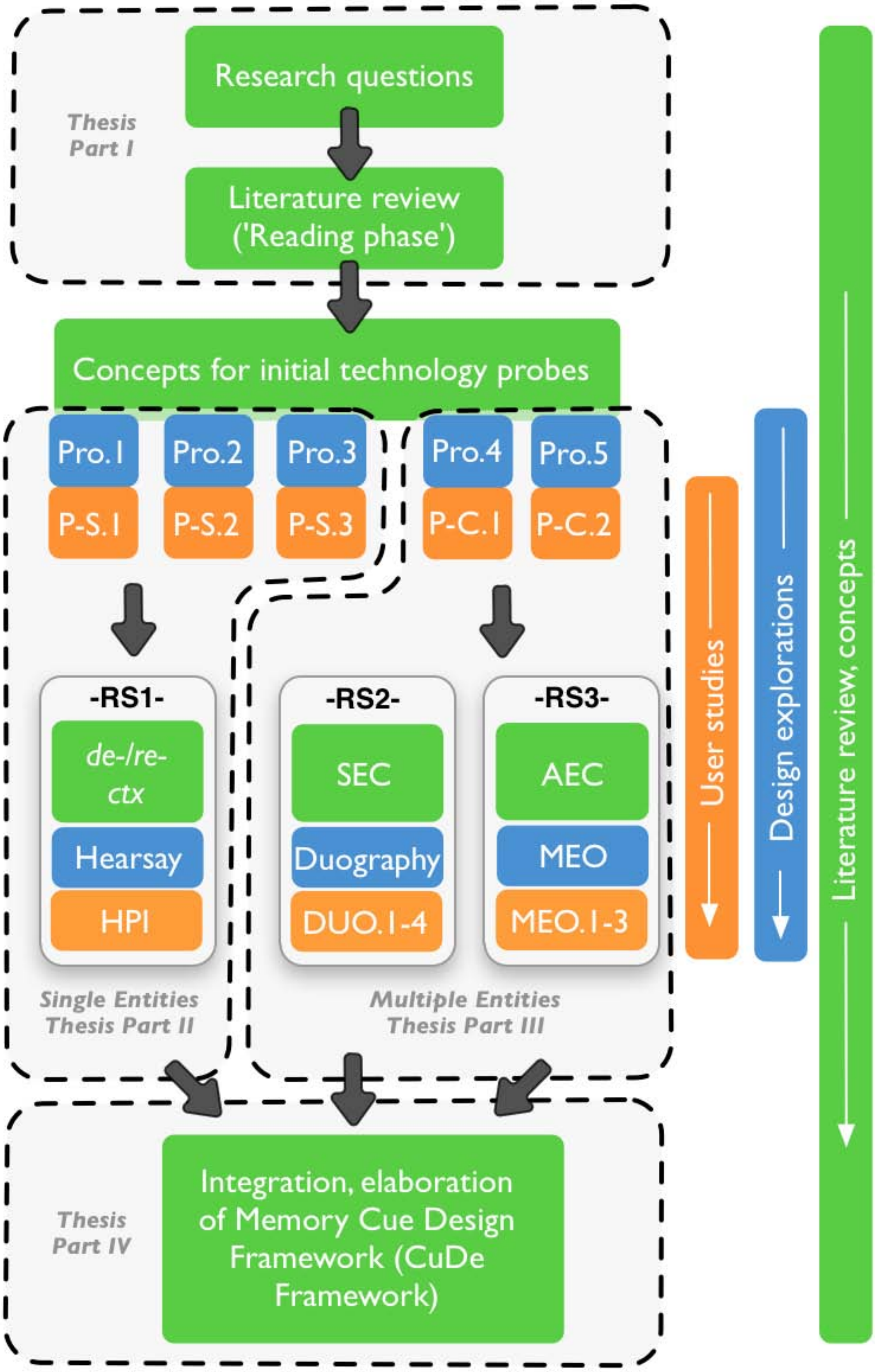

Figure 3.3. Diagram of this thesis' research strategy and process. Blue boxes represent prototypes or designs (Pro.1-5, Hearsay, Duography, MEO), green boxes refer to conceptual considerations (e.g., *de-/re-ctx*, SEC, and AEC are concepts for interaction design), and orange boxes mark user studies (P-S.1-3, P-C.1-2, HPI, DUO.1-4, MEO.1-3).

RS1 (de-/re-ctx): This strand concentrated on *single media entities*. It comprised the Hearsay prototype, which was deployed in a field study (HPI). Overall, RS1 investigated how single media files and their contained memory cues can be exploited in novel ways to enable meaningful remembering experiences, for example, by slowing the user down and focussing attention when revisiting their digital souvenirs. In particular, RS1 asked questions regarding the context and style of presentation for the to be revisited memory cues: how can we increase the evocativeness of digital memory retrieval cues that are contained within one *single media entity*? Is there a value in removing digital media (as potential memory triggers) from its original context, so that the users have to make sense of this material without having access to all of its contextual data, and hence fill in this missing information by their mental efforts? Can the presentation of 'out-of-context' data provoke deep engagements and lead to complex and demanding, however potent memory retrieval cues? We addressed these answers by synthesizing the findings of the Hearsay study into a theoretical interaction design concept that we named *de-/re-ctx* (de- and re-contextualization).

RS2 (SEC): This strand explored *multiple entities* (media files) and *combined* memory cues by extending conventional digital photography by one additional picture. More precisely, we invented and theorized about Duography (implemented by an Android application we named 2sidez), which triggers two opposite-facing cameras at the same time, leading to the *synchronous* composition of two entities (SEC). This research strand asked and addressed questions such as the following: what are the implications for digital photography, if conventional photos were 'extended by one dimension' and each photograph would feature the picture of its photographer on its backside as an additional memory retrieval cue? Hence, what do the users make out of these two *combined* entities when composing and remembering 'digital memories'?

RS3 (AEC): This strand is to some regard an extension to RS2 and Duography. In RS3, we proposed the *Media Object* (*MEO*), which allowed the asynchronous composition of a variety of entities into a novel file format. That is, the user could join an arbitrary number of media files, for instance, combining a photo with an audio recording or text file. In a way, MEO is the extension of conventional photos by arbitrary 'dimensions'. The asynchronous composition (AEC) of these cues also gave more 'degrees of freedom' to the user when combining the MEO entity or memory cue aggregates (unlike Duography, where two photos are captured synchronously). Our question here were: what will the user make out of an application for bundling arbitrary media content (contextual data) leading to a novel kind of aggregated file format and hence to a potentially rich reservoir of *combined* memory retrieval cues?

The general purpose of the user studies was to gather some 'real life' feedback on the design concepts, and to unveil possible usage patterns or working mechanisms, which underlie the proposed interaction designs. To this end, we examined the participants' reactions and feedback by in-situ deployments. We employed qualitative research methods and, on fewer occasions, descriptive quantitative statistics (e.g., analysing log data). These evaluations were used to inform design iterations of the prototypes (the Duography application 2sidez and MEO were comprised of two iterations) and to finally narrow ideas down to the elaboration of *Strong Concept* candidates (see CuDe Framework in Chapter 4).

Given the importance of qualitative methods, we now detail the most important of such techniques as employed in this thesis.

3.3.2.1 Qualitative Research Methods

It was argued in prominent form (Guba & Lincoln, 1989) that both qualitative (e.g., interviews, focus group, ethnography, etc.) and quantitative techniques (e.g., experimental setups, statistical inference, descriptive statistics, etc.) could be employed in assistance of any research approach or research paradigm (as relevant to answering the research questions). In design research, qualitative methods play an important role, see for example Laurel (2003) for an overview. Not surprisingly, the methodology of this thesis is also supported by qualitative methods (and, to some extent, by quantitative methods).

For *data collection*, we conducted semi-structured interviews and collected documents that were created by the participants (primarily photos). In addition, we logged their interactions with devices in files whenever appropriate and feasible, and we video-recorded them while interacting with the computer in test conditions.

When conducting the interviews, we attached importance to allow the participants to speak without interruptions on whatever they thought relevant. We used interview guidelines to put them back on track when they strayed from relevant research topics. However, we formulated these guidelines, in accordance to the research questions, to be rather loose and open.

For *data interpretation*, we primarily drew on *thematic analysis (TA)* as proposed by Braun and Clarke (2006). While these authors outline this method primarily for text, we employed TA both for interview transcripts and adapted it to analyse media files such as digital photos. According to Braun and Clarke (2006), TA is a widely used qualitative research method, which is often mistakenly confused with similar methods such as content analysis, discourse analysis or grounded theory. In contrast to these methods, TA is not "wed to any pre-existing theoretical framework" and thus can be employed in a broadly explorative fashion, without upfront detailed theoretical foundations, research questions or readings into the literature. They describe it as follows:

"Thematic analysis is a method for identifying, analysing, and reporting patterns (themes) within data. It minimally organises and describes your data set in (rich) detail" Braun & Clarke (2006, p.79).

A theme or pattern captures an important aspect about the data, and there are no strict guidelines for elaborating themes. It can be comprised of any number of observations within the data set. Even if evidence occurs in only a few instances, this occurrence can still be the foundation of a theme, as long as it "captures something important about the data in relation to the research question" Braun & Clarke (2006, p.82).

In this thesis, we employed TA primarily to create a rich description of the collected data. Our analysis was primarily inductive, that means, driven by the data, and did not aim to fit the content into an existing scheme or theoretical framework. While the main research question considered how digital materials can be used to support remembering, we did not restrict ourselves to patterns and themes that directly relate to memory. That is, while we were particularly sensitized to matters touching upon memory, we were also open to additional salient patterns that might *indirectly* support processes of remembering. As the thesis progressed, however, and specifically when synthesizing the framework or *Strong Concept* candidates (see Section 3.3.3), we increasingly started to narrow investigations down to memory issues.

To conclude the outlining of the qualitative methods, we present the TA guideline as proposed by Braun & Clarke (2006, p.87), before reporting details on research ethics and on the individual prototypes/study setups in the next sections:

1. Getting familiar with the data. Going through the material in multiple iterations, taking notes.
2. Generating initial codes. More systematic collating of salient aspects.
3. Searching for themes. Grouping initial codes into themes.
4. Reviewing themes. Is the grouping sound?
5. Finalizing themes and finding good names.
6. Reporting themes, referring to the research questions, providing appropriate examples from the data set.

3.3.2.2 Research Ethics

While the Vienna University of Technology has no formal research ethics approval process, we attached value to conducting research to high ethical standards. We carried out a number of different user studies as outlined in the following:

- P-S.1, P-S.3, P-C.1-2 (light weight technology probe explorations): These explorations were conducted with colleagues, familiar university students and friends. They were informed about their rights (i.e., they could drop out of the feedback session or withdraw their data at any time, and allowed us to publish their feedback) and verbally agreed to participate in these short-term explorations. We explicitly asked for permission to record user interviews.

- P-S.2, HPI, DUO.2, MEO.1.2 (user studies with formal interviews): We provided consent forms before the studies to our participants, informed them about their rights, and let them sign these forms (see Appendix E.1 for an exemplary consent form from DUO.4). When the participants were legally under-age, we asked the students for their verbal consent and their parents to sign the forms. We explicitly asked for permission to record user interviews, to analyse multimedia content created by the participants, and to publish study material in an anonymous form. Participants could withdraw from the studies at any time or withdraw their data from publication.
- DUO.3, MEO.3 (analysis of user created content): Both studies were conducted as part of a university interaction design course, and we informed the students during the lecture that we planned to scientifically analyse their created content. We asked the participants of DUO.3 for permission in written form to publish their Duographs as these contained pictures of the participants. We verbally asked the participants of MEO.3 for permission to publish their Duographs as these contained mundane objects only and no persons. We did not record interviews in the course of these studies (as we concentrated on the analysis of the created data/digital artifacts).
- DUO.1 (large-scale user study on the *Google Play Store*[4]): Users were provided with *terms of use* and *privacy policy* on *Google Play* and 2sidez.com[5]. They were informed that uploaded user data is subject to a scientific study and that we reserved the right to scientifically publish this data in an anonymous form. They had to agree to these terms in order to be able to use the 2sidez application.

3.3.2.3 Prototype and Study Details

Table 3.1, as shown below, provides specific overview of all technology probes and more advanced prototypes, which have been studied in the course of this thesis. The same table also contains information about the underlying concepts and motivations of these applications. As outlined above, the Hearsay prototype of RS1 explored

[4] https://play.google.com/store (last accessed 4 September 2014)
[5] https://2sidez.com/termsofuse/ (last accessed 13 September 2014)

an alternative approach to context and presenting memory retrieval cues, leading to the articulation of *de- and re-contextualization* (*de-/re-ctx*) as a design concept. Duography (RS2) dealt with the extension of conventional digital photography by one additional photo, resulting in two *synchronously* combined cues (SEC). RS3 with its prototype system Media Object (MEO) explored the combination of multiple entities as well. MEO, however, considered the *asynchronous* aggregation of an arbitrary number of media files into a novel file format (AEC).

Table 3.2 relates to the diagram of Figure 3.3 and provides further details about the illustrated user studies and their underlying concepts. A more detailed description and overview of all created prototypes and artifacts involved in these studies can also be found in Appendix D.

The Memory Cue Design Framework (CuDe) integrates the findings of the design-led research, the conducted user studies, and all three strands (RS1-RS3) into one theoretical frame. The interplay between multiple entities and their contained memory cues, either in a synchronous or in an asynchronous fashion (Part III of the thesis), plays a leading role in the synthesis of CuDe (Part IV), and hence, in this thesis. Research on revisiting single entity data complements this work (Part II) and also informs the framework. With regard to theoretical considerations, the framework draws on Höök and Löwgren's idea of *Strong Concepts* (Höök & Löwgren, 2012).

The synthesis of the studies into the descriptive CuDe framework is further described in the subsequent section.

Table 3.1. Overview of all prototypes and probes, which were studied in the course of the thesis. Early systems created for initial and quick feedback are labelled as *technology probes* (Pro.1-5). More advanced systems, building on this feedback are denoted as *prototypes* (Hearsay, Duography version 2, MEO).

Prototypes and Technology Probes	Short Description	Concept/Motivation
Pro.1 ForgetMeNot (first technology probe named ForgetMeNot and exploring the use of single entities) *THESIS PART II* *(Single Entity)*	ForgetMeNot is a screen saver, which displays random and blurred photos. The older the images are, the clearer the photos are presented to the user (rendered with less distortion). The intention is to provide the user with more retrieval cues, as the photos get older.	• Revisiting conventional photos in unconventional ways • Revealing information gradually • Creating a 'puzzle', that is, requesting the users to make sense of the blurred memory cues and mentally fill in missing details

Prototypes and Technology Probes	Short Description	Concept/Motivation
Pro.2 EyeOfDetail (second technology probe named EyeOfDetail and exploring the use of single entities) *THESIS PART II* *(Single Entity)*	EyeOfDetail is an image viewer, which displays blurred photos with the exception of a small, movable pane. The content of this pane is not distorted. The intention is to make the user pay attention to a photo's details by moving the pane.	• Revisiting conventional photos in unconventional ways • Focusing the users' attention on details • Slowing the users down • Gradually exploring the photo 'step-by-step'
Pro.3 Audio Peephole (third technology probe named Audio Peephole and exploring the use of single entities) *THESIS PART II* *(Single Entity)*	Audio Peephole is an interactive installation, which downloads trending text messages from *Twitter*, that is, *Tweets* and messages that currently attract wide attention. These *Twitter* trends are downloaded (by means of the web service *whatthetrend.com*) as text messages and then converted into a voice message by a commercially available text-to-speech engine. The installation was available in a (semi-public) space and users could listen to the trends by plugging in (their) own headphones.	• Revisiting conventional public postings to social networks in unconventional ways • Focusing on details • Slowing the users down • Creating a 'puzzle', that is, requesting the users to make sense of the *de-contextualized* memory cue and mentally fill in missing details
Hearsay (prototype system exploring the use of single entities) *THESIS PART II* *(Single Entity)*	Hearsay extracts Information from its original context (fragments from online news sites) and presents it in a different situation. We were interested to see, how the participants give meaning to this *decontextualized* information. More precisely, we investigated the de- and re-contextualization (*de-/re-ctx*) of cues as a design concept by means of Hearsay as a research vehicle.	• Revisiting conventional public postings to online news sites in unconventional ways • Focusing on details • Slowing the users down • Creating a 'puzzle', that is, requesting the users to make sense of the *de-contextualized* memory cue and mentally fill in missing details
Pro.4 Duography (fourth technology probe introducing Duography version 1 and exploring multiple combined entities) *THESIS PART III* *(Multiple Entities)*	The Duography application (2sidez for *Android*, version 1) triggers both front- and back-facing camera of mobile phones synchronously, resulting in a combined photo with two different perspectives captured into one picture.	• Revisiting and capturing *combined memory cues* • Exploring memory cues, which consist of multiple aggregated cues or files and which were composed *synchronously* (synchronous entity composition; SEC) • Exploring how these combined cues mutually alter meaning

Prototypes and Technology Probes	Short Description	Concept/Motivation
Pro.5 ContextShaker (fifth technology probe named ContextShaker and exploring multiple combined entities) *THESIS PART III* *(Multiple Entities)*	ContextShaker presents random Internet photos (from *Flickr*) altogether with random online newspaper quotes and headlines. Here, we were curious how the user reads and makes sense out of this coinciding information, which actually is not related.	• Revisiting *combined memory cues* • Exploring memory cues, which consist of multiple aggregated cues or entities and which were composed *synchronously* (synchronous entity composition; SEC) • Exploring how these combined cues mutually alter meaning
Duography version 2 (prototype system, also named as *2sidez for Android*, exploring multiple combined entities) *THESIS PART III* *(Multiple Entities)*	Due to positive feedback about **Pro.4**, we implemented an advanced version ('version 2') of the Duography application (2sidez for *Android*), and used it for subsequent and extensive studies.	See **Pro.4** Duography
Media Object (MEO) (prototype system exploring multiple combined entities) *THESIS PART III* *(Multiple Entities)*	MEO is a mobile phone application, which supports the asynchronous aggregation of an arbitrary number of different multimedia files into a container structure (MEO file)	• Revisiting and capturing *combined memory cues* • Exploring memory cues, which consist of multiple aggregated cues or entities and which were *composed asynchronously* (asynchronous entity composition; AEC) • Exploring how these combined cues mutually alter meaning

The technology probes (Pro.1-5) and more advanced prototypes (Hearsay, Duography, Media Object) were explored in use in studies as summarized in Table 3.2.

Table 3.2. Overview of the studies in this thesis. More detailed descriptions can be found in the corresponding study chapters.

Study and Study Target	Evaluation
P-S.1: Pro.1 ForgetMeNot	• *Informal evaluation*: demonstration of Pro.1 to interested people. Usage for a longer period of time (10 days) by one participant with a subsequent interview • Data collected: log of photos displayed, interviews • Analysis: review of the interviews and log data for interesting observations

Study and Study Target	Evaluation
P-S.2: Pro.2 EyeOfDetail	• Setting: lab • Participants: 8 • Duration: 30-75 minutes • Data collected: interaction log, interviews • Analysis: descriptive statistical analysis of log data, qualitative content analysis of interviews
P-S.3: Pro.3 Audio Peephole	• *Informal evaluation*: demonstration of P-S.3 to interested people • Data collected: log of memory cues presented, interviews • Analysis: review of the interviews and log data for interesting observations
HPI: Hearsay *Public Installation*	• Setting: field study of the application as a publicly available interactive 'art' piece • Participants: 8 • Duration: 4 weeks • Data collected: interaction log data, interviews • Analysis: descriptive statistical analysis of the log data, thematic analysis of the interviews
P-C.1: Pro.4 Duography (2sidez *for Android*, version 1*)*	• *Informal evaluation*: demonstration of the 2sidez application (version 1) to interested people. Usage during the visit at the zoo by one person with subsequent interview • Data collected: interview and photos captured by the participant • Analysis: review of the interviews and log data for interesting observations
P-C.2: Pro.5 ContextShaker	• *Informal evaluation*: demonstration of P-C.2 to interested people. • Data collected: interviews • Analysis: review of the interviews interesting observations
DUO.1: Duography proof-of-concept study *(*2sidez *for Android*, version 2*)*	• Setting: 2sidez app (version 2) offered as free download on *Google Play* • Participants: > 115.000 user installations • Duration: 433 days • Data collected: interaction log data • Analysis: descriptive statistical analysis
DUO.2: Duography in everyday situations *(*2sidez *for Android*, version 2*)*	• Setting: field study • Participants: 8 • Duration: 10 months • Data collected: participant-created Duographs Analysis: thematic analysis of Duographs

Study and Study Target	Evaluation
DUO.3: Duography in interaction design education *(2sidez for Android*, version 2*)*	• Setting: field study • Participants: 30 • Duration: 2 weeks • Data collected: participant-created Duographs • Analysis: thematic analysis of Duographs
DUO.4: Duography in art education *(2sidez for Android*, version 2*)*	• Setting: field study • Participants: 18 • Duration: 12 weeks • Data collected: participant-created Duographs and interviews • Analysis: thematic analysis of Duographs and interviews
MEO.1: Media Object (MEO) in everyday life situations	• Setting: field study • Participants: 7 • Duration: 2-5 weeks • Data collected: participant-created Media Objects, semi-structured interviews • Analysis: thematic analysis of Media Objects and interviews
MEO.2: Media Object long-term evaluation	• Setting: field study • Participants: 10 • Duration: 24-28 weeks • Data collected: participant-created Media Objects, semi-structured interviews • Analysis: thematic analysis of Media Objects and interviews
MEO.3: Media Object content relation	• Setting: field study • Participants: 18 • Duration: 2 weeks • Data collected: participant created Media Objects, informal interviews • Analysis: thematic analysis of the Media Objects

3.3.3 Synthesis of the CuDe Framework

As outlined above, research was conducted within three different strands in this thesis (RS1-RS3). Each strand had its specific characteristics in terms of application idea and study outcomes. Nevertheless, as the work progressed, we developed the clear impression of the existence of common themes, which traversed the research endeavours in this thesis and which connected the individual explorations. As the topic is digitally augmented memory and there was – to the best of our knowledge – no conceptual framework for the structured exploitation of digitally recorded memory retrieval cues as contained within media files/entities, we decided to 'carve out' a conceptual or theoretical frame to this end.

We reflected across the outcome of all user studies to draw out the understandings and synthesized them into a conceptual device to be employed in future projects, to be made accessible and to be given to fellow researchers. Analysis and synthesis were conducted within two primary steps.

As a first step, we individually analysed the different research strands and unveiled their 'driving' and underlying interaction design concepts. For this we drew on Höök and Löwgren's idea of *Strong Concepts* (Höök & Löwgren, 2012) and identified a candidate of such a concept for each strand (cf. Section 3.2.3). Using these authors' explanations we investigated our collected data and finally proposed *de- and recontextualization* (*de-/re-ctx*; RS1), synchronous entity composition (SEC; RS2) and asynchronous entity composition (AEC; RS3) as *Strong Concept* candidates.

In a second step, we further aimed to integrate the three different research strands and, hence, *Strong Concept* candidates within the framework. To this end, we iteratively gave labels to all phenomena that we observed in the data in addition to the already proposed *Strong Concept* candidates. For instance, the interventions involved *reductive* and *additive* strategies, *single* and *multiple entities*, or *data capturing* and *revisiting*. This activity of labelling, rearranging labels and looking for common or distinct patterns was a process, which gradually evolved over the course of one year, but which also had many interruptions. Finally, for practical reasons (from an interaction design perspective) we decided to use the distinction between *single* and multiple entities and the corresponding interventions as a central entry point into the framework. (For more details see next chapter.)

In hindsight, one could almost describe this process as the 'thematic analysis (TA) of all the thematic analyses' that were conducted so far. However, this latter TA was more strongly driven by theoretical considerations in contrast to the initial TAs. To cite Braun and Clarke on this kind of TA:

"[A] 'theoretical' thematic analysis would tend to be driven by the researcher's theoretical or analytic interest in the area, and is thus more explicitly analyst-driven. This form of thematic analysis tends to provide less a rich description of the data overall, and more a detailed analysis of some aspect of the data" (Braun & Clarke, 2006, p.84).

We employed a constructivist lens for conducting a "theoretical" TA on latent concepts to examine how people *make sense* of (multiple) digital files as memory triggers and how they (re-)construct their memories. This also means, that the data work is more interpretative to this end. While the proceeding analysis aimed to only capture what was objectively to be observed, the 'meta-TA' attempts to unveil *latent* themes about why the participants might have used the applications in a certain way and what the consequences for them were. Braun and Clarke further explained:

"Thus, for latent thematic analysis, the development of the themes themselves involves interpretative work, and the analysis that is produced is not just description, but is already theorized. Analysis within this latter tradition tends to come from a constructionist paradigm […]" (Braun & Clarke, 2006, p.84).

Here, we have come full circle as memory research, sensemaking, and qualitative research methods all have links to constructivism. Moreover, we propose, that the underlying philosophy of DBR also relates to constructivist ideas quite well, when we attempt to design in a way that supports people in shaping their life as they wish.

3.4 Summary

In this chapter we presented the methodology of this thesis. We named it *design-based research (DBR)* as it draws on recent design research movements within HCI (e.g., *Research through Design* (Zimmerman et al., 2007)), while at the same time it features its own commitments for conducting inquiry. At its very core, DBR is about gaining insights by both the process of creating prototypes and exposing these prototypes to the field. Study outcomes and learning from design practice are included into prototype iterations. During the studies, we collect a vast set of user created content and interview recordings. For analysis, we primarily draw on the method of thematic analysis (Braun & Clarke, 2006). At the end of the overall process, the singular design concepts are proposed as *Strong Concept* candidates (Höök & Löwgren, 2012) and synthesized into the CuDe Framework to offer conceptual guidance to future designers of augmented memory systems.

4 The Memory Cue Design (CuDe) Framework

In this section, we briefly outline the conceptual and descriptive framework, which synthesizes or structures the abstracted learning from the individual studies (the *Memory Cue Design Framework*; short: *CuDe Framework*). The presentation of the framework (before the individual studies) shall enable the reader to understand the arrangement of the subsequent study chapters, and what the most important aspects of the proposed designs are. Throughout the presentation, we will emphasize salient findings with regard to the framework, which constitute the 'take-away-messages' of this thesis. In the course of the discussion we will revisit the theoretical ideas of the framework and also draw on Höök and Löwgren's *Strong Concepts* (Höök & Löwgren, 2012) to suggest how CuDe or its components carries "intermediate-level design knowledge".

4.1 Making Sense of Digitally Captured Data

We live in a world that amasses amounts of digital data that are becoming increasingly difficult to comprehend. Most recently, a new protagonist has entered the stage, which is responsible for the creation of vast amounts of personal data such as photos or videos: the modern mobile phone or smartphone. In particular, this phone-created and highly personal data offers great potential to serve as valuable memory retrieval cues, if we manage to make use of it in the right way. Still, there are numerous additional sources of (digital) information that can aid in remembering. This spans different material from photos captured by conventional digital cameras (e.g., *DSLR cameras*) to publicly available online data such as the local weather conditions or even the news.

The Cue Design Framework (CuDe Framework) primarily addresses designers of augmented memory systems, who wish to make use of this wealth of potential memory triggers to create engaging user experiences. It might also be of interest to people, who work in different interaction-design areas and are concerned with digitally captured content.

At its core, CuDe describes different design strategies for providing users with digital content in order to assist them in reliving relevant and meaningful memories. As outlined in the contextual review (Chapter 2), we believe that we cannot capture *memories* directly and save them to disk. Rather, in line with constructivist approaches, our assumption is that memories have to be *(re-)created* within the mind of the contemplator. It is not possible to capture memories on digital storage systems, however, what can be captured are triggers of memories.

The objective of CuDe is to outline different possibilities for the considered use of digital media as memory triggers for creating meaningful remembering experiences. Finally, It is up to the users to *make sense* of their digital materials, and the CuDe Framework is a *tool to think with* to inspire designers in 'laying out' retrieval cues to assist the user in sensemaking and in the reconstruction of past events. CuDe is neither a 'rule tool', nor is it 'complete'. Rather, it provides systematic structure to the endeavours in this thesis and to other interventions in the realm of augmented memory system design; however, CuDe is less of an evaluative tool. We suggest that it can provide valuable conceptual guidance to designers in thinking about alternative ways for capturing and replaying media content, in particular in the context of augmented memory systems.

4.2 (Multi)media Files ('Entities') as the Building Blocks of CuDe

To proceed, it is necessary to define a couple of terms or assumptions with regard to CuDe. So far, we clarified that the framework describes relations between digitally captured content. The elementary 'content unit' or 'building block' of the CuDe Framework is the media file, as it is commonly stored by digital devices. A media file can be anything from digital photos, videos, text files, audio recordings, *GPS* coordinates, emails, *SMS* text messages, and so on. The key characteristic of such a media file is that it results from recording content by means of a digital device, for example, a mobile phone camera, and that it carries information (potential memory retrieval cues). In the following, we will denote these basic units (the individual files) as *entities*. Naturally, these entities could further be split into fragments, which again carry distinct information and meaning. For instance, a video could be broken into single frames, or parts of a photo could be extracted and analysed in isolation. However, the objective of the CuDe Framework is not to analyse individual media instances for their unique content and qualities as a memory trigger (e.g., we don't aim at determining how many separate memory cues are contained within one particular photo). Instead, we operate on a more abstract level and raise the question, what is, for instance, happening in the eye of the beholder, if they are presented with multiple related entities (multimedia files) at the same time.

While the first type of examination, detailed analysis of the content of a particular media instance (for example, in-depth analysis of different parts in a photo and their meaning; how do the different people in the photo relate to each other?), is subject to fields such as visual sociology[6], the latter considerations (how can we relate *entities* to

[6] Refer to Appendix C for an example of the content analysis of one individual and particular photo. This supplementary material illustrates what the CuDe Framework is <u>not</u> trying to accomplish, although we regard the work described in Appendix C as highly interesting to related but different ends.

be meaningful for the users?) is much more generic and practical, and is a target of interaction design research.

To illustrate these theoretical considerations and make them easier to understand, let us refer to an example. Figure 4.1 (left) depicts an old private photo with an associated photo caption in German, saying "Vater, Mutter + Sohn" (translated: "Father, mother + son"). Surely, it would be possible to speculate about the content of the photo without this caption. Also, this particular annotation does not offer great detail anyway. Nevertheless, we can tell with some confidence, that at least three people in this photo should be family.

We can most likely make the case that most people, if not everyone, would relate the caption to the photo to interpret the content. This is simply due to the mutual proximity and the learnt convention that photos can feature captions, which provide explanations.

Figure 4.1. Old photo with caption: "Father, mother + son" (Breckner, 2012, p.152) (left). Recently uploaded digital photo to a social networking site with caption: "Just smile and wave […]" (right). (Retrieved 10 July 2014 from https://www.facebook.com)

Annotations are an integral part to CuDe. In this framework these captions are labelled as references, as they point to a photo (or video, etc.) and provide complementary information. Today, photo albums certainly look different from the example in Figure 4.1 (left side). On the right side of the same figure a recent digital photo is displayed, located on a social networking site. It was captured by a mobile phone, which was not only used for taking the photo and uploading the picture. It was also used for assigning an annotation or reference: "Just smile and wave, boys." In addition, it is annotated with the location where the picture obviously was created (Punta Tombo). Technically, photo, caption and location are captured separately by the mobile device and saved in three different files (parts of the information can also be saved in a database instead of a file, but this distinction is not relevant to our considerations here). These three distinct carriers of information constitute three separate entities, to keep with the terminology of the CuDe Framework. Most likely, the average observer will conclude from this information, that these two people (a couple?) have been to a place called Punta Tombo (Argentina) and that they show a good sense of humour ("Just smile and wave, boys […]") while enjoying the penguins.

The case of the CuDe Framework now is that users of augmented memory systems (e.g., a *lifelogging* application) will mentally relate the entities to each other, given that the interaction designers of such systems *indicate* that they belong together or they share some kind of *link*. We propose that the user cannot help but try to create meaning out of this information. If we manage to capture and display entities or memory retrieval cues (as contained within entities) cleverly, this may result in more valuable remembering experiences and spur the user's imagination while (re-)constructing the story depicted in these entities. (Note that by *reconstruction* we denote a process of *making sense* of available information. This can also involve 'subtle' processes such as reflection or reminiscing, and reconstructing doesn't necessarily involve *exact* and 'mechanical' recreation.) The CuDe Framework was conceptualized to provide the designers of augmented memory systems with a *tool to think with*, which maps out several possible entity relations (or *links*) and the effects these relations might have on the observer's remembering (Part III of the thesis). In addition, it also suggests methods for processing single entities to increase their potential as memories triggers or carriers of memory retrieval cues (Part II of the thesis). This will be detailed in the following section.

4.3 The Structure of the CuDe Framework

The CuDe Framework suggests two different levels of analysis and intervention when designing digital memory retrieval cues (see Figure 4.2) for achieving the same and final goal, namely, to support the user in recreating meaningful memories. While one level of intervention is targeted at individual files (single entity), the other level looks at multiple entities and how they mutually contribute to the remembering experience.

For both target levels, we each propose *one particular intervention*, which aims at the design of elaborate memory cues. These interventions are detailed in the subsequent two sections (each including one descriptive diagram). At the level of single entities, we suggest *(pre-)processing* the corresponding media file, that is, to manipulate its content to increase its potential in triggering memories. In particular, we describe how we employed filtering techniques to photos and how we extracted textual information from webpages to this end.

At the level of multiple entities, we introduce the application ideas of SEC/AEC (synchronous entity composition/asynchronous entity composition). In short, the concept of SEC/AEC for enhancing remembering is to offer a set of entities to the observer along with the information of the *link* between these entities, that is, the information about what they have in common (e.g., "all photos have been captured at the same day").

In summary, the CuDe Framework investigates interventions for building augmented memory systems on two different levels: *single entity* and *multiple entity level*. On each level, the media files (i.e., the entities) are processed or exploited in specific ways. In this thesis, we propose entity *processing* (i.e., filtering techniques, etc.) as an intervention for modelling digital memory cues in advantageous fashions on a *single entity level* (as implemented, for example, by the Hearsay installation). On the other level, for multiple entities, we provide the user with the information about the connection or *link* (*entity linking*) between these entities (and with tools for creating such aggregates of multiple entities, e.g., MEO, Duography).

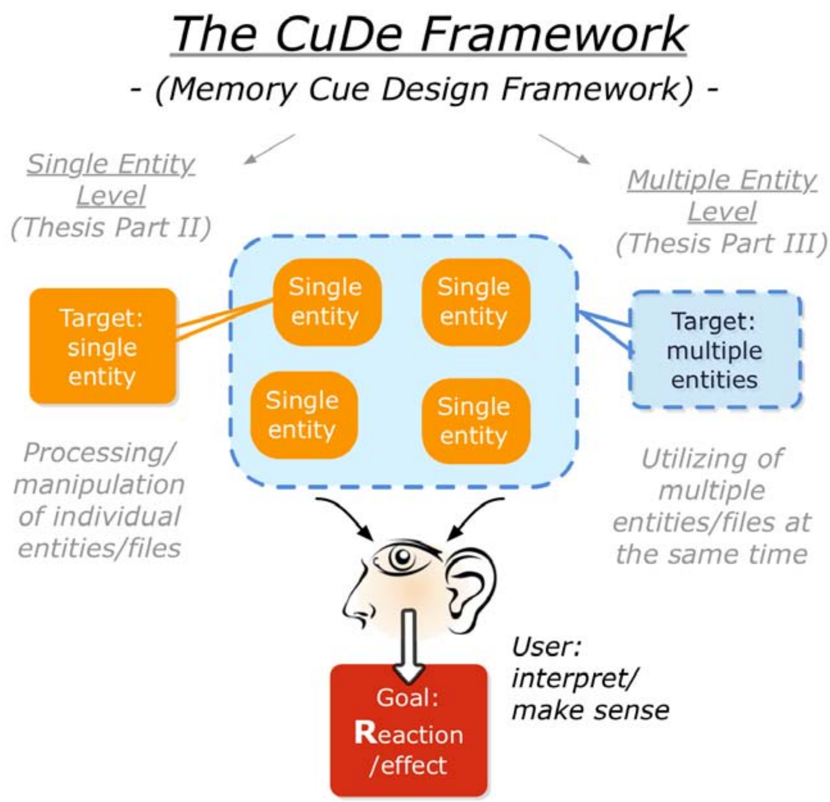

Figure 4.2. The CuDe Framework suggests two different levels of analysis and intervention when designing digital memory retrieval cues: either single entities or multiple entities can be the target of design concepts with the final goal to create meaningful remembering experiences for the user.

We hypothesise, that other entity interventions or operations exist besides *processing* (on the *single entity level*) and entity composition including *link* specification (on the *multiple entity level*); however, in this thesis, we restrict ourselves to these two entity operations. Nevertheless, as CuDe is not a 'closed' system, the framework may be extended by designers or researchers by additional operations on either *single* or *multiple entity level*.

4.3.1 Single Entity Level

The *single entity level* of analysis and intervention is comprised of three different dimensions or layers (see Figure 4.3): (1) entity processing (P), concept for single entities (CS) and reaction/effect (R).

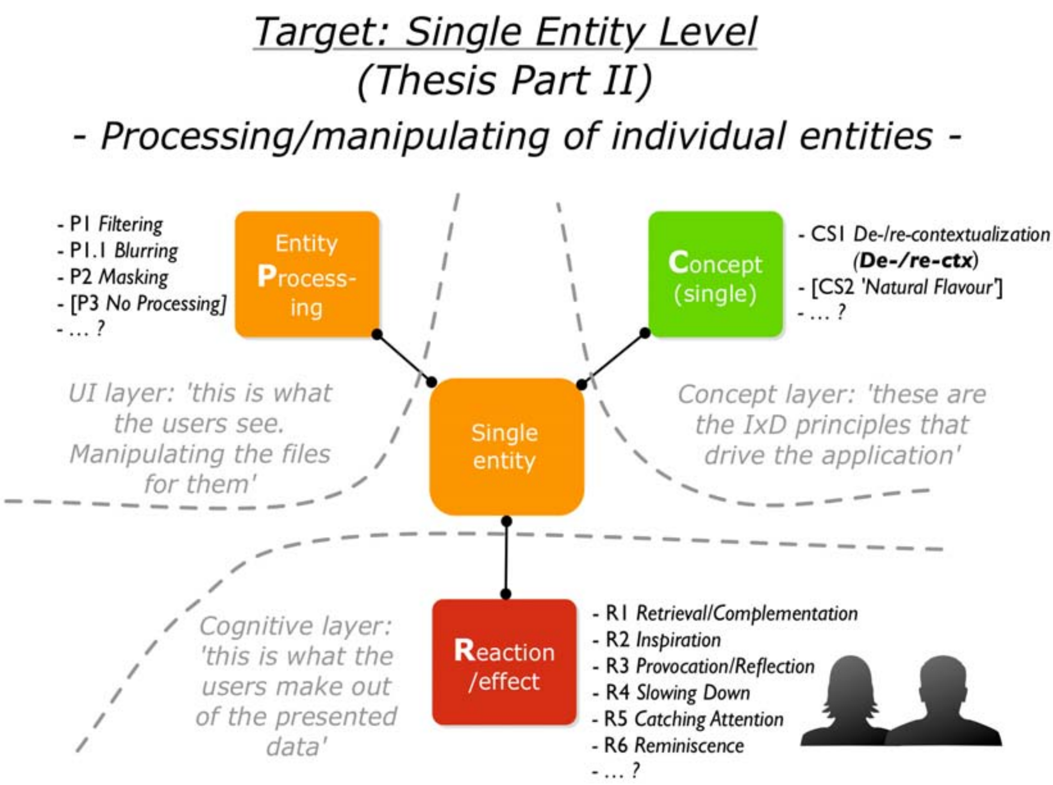

Figure 4.3. *Single entity level* of analysis and intervention.

- **(P)** The processing dimension describes different file operations that can be applied to an entity. In this thesis we focus on filtering and masking operations. However, many additional file operations might be possible, for instance, performing *no processing* (P3) at all and, hence, simply presenting the original file to the user. In this thesis, we focus particularly on image filtering (P1) and on the masking (P2) of some extracted information. These operations are involved in the EyeOfDetail, ForgetMeNot and Hearsay prototypes and will be described later in detail.

  The processing dimension is directly reflected by the user interface (UI) of the digital memory application. Entity processing and operations manipulate the digital file before presenting it to the user. For instance, a photo might be filtered in a specific way to highlight salient parts of the picture and, thus, increases this entity's value as a useful memory retrieval cue.

- **(CS)** The concept dimension represents the underlying working mechanism or principle of a particular entity operation. In the course of the thesis, we will suggest the concept of *de- and recontextualization* (*de-/re-ctx*) as a candidate for a *Strong Concept* (Höök & Löwgren, 2012). *De-/re-ctx* (CS1) accounts for the potential of filtering (P1) and masking (P2) as implemented by our prototypes. The concept dimension points to a deeper theoretical understanding of the applications and their entity processing/operations. The aim of this profound conceptual knowledge is to enable designers to more deeply grasp what kind of mechanisms 'drive' their applications and not to 'blindly' employ some interventions. Ideally, each entity processing can be explained by a corresponding concept. Likewise, concepts can be implemented and reused by many different applications or types of *processing*. In this thesis, we suggest no additional concepts on the *single entity level* next to *de-/re-ctx*. The easiest thinkable concept, however not investigated, relates to (P3) *no processing* and correspondingly would present non-manipulated ('natural flavour' CS) entities.
- **(R)** The reaction dimension comprises different effects, which entity processing and, therefore, the entire application can have on the users. These reactions are caused by the confrontation of the users with the presented data, that is, digital entity. From an information processing perspective, this information is perceived by the senses (e.g., seeing or hearing), and the user then cognitively makes sense of and interprets this data. In our user studies we observed a number of different but related effects, which together led to meaningful remembering experiences. Different applications created different effects and reactions differed between participants. Hence, it is unlikely to precisely predict the effect of a particular application. Nevertheless, CuDe outlines a set of (related) reactions, which developers might consider to design for: *retrieval/complementation* (R1; i.e., the entity is processed to support the retrieval of a fact), *inspiration* (R2; i.e., the entity is processed to inspire the users' imagination in reconstructing memories and making sense), *provocation/reflection* (R3; i.e., the intervention might provoke some deeper reflections about past events), *slowing down* (R4), *catching attention* (R5), *reminiscing* (R6; i.e., 'dwelling in the past'). This reaction dimension is shared with the *multiple entity level* and three of the proceeding examples on reactions (R) are elaborated in following the section.

4.3.2 Multiple Entity Level

At the *multiple entity level*, the CuDe Frameworks also features a set of three dimensions or layers: entity linking (L), concept for multiple entities (CM) and reaction/effect (R).

- **(L)** The *multiple entity level* differs from the *single entity level* with regard to the concept dimension and, hence, also from the entity processing dimension. This has direct consequences for the user interface. While we introduced entity processing (e.g., filtering) to single entities, we now suggest the method of *linking* (L) multiple instances for creating meaningful remembering experiences. Here, it is crucial to let the user know now by means of the application's interface that the presented entities are *somehow* connected. This connection has to be further specified to allow the users making sense of the presented entities and reconstructing the 'story' behind the presented media files or memory cues. These further specifications of links are outlined in the following. (We provide some more detail as compared to entity processing (P) of the *single entity level* for the sake of comprehensibility.)

  The *reference* (e.g., a photo annotation) is one of four primary links (L) between entities that are currently part of the CuDe Framework. As Figure 4.4 indicates (by the empty spot and the question mark in the linking dimension), we do suggest the extension of CuDe by additional links in the future. Besides by *references* (L1), entities can also be linked by a *common factor* (L2) and they can be linked in *time* (L3) or by *perspective* (L4):

  - (Link L1 *Reference*) An entity complements another entity with additional information. For example, a text annotation to an image or video, or the location to a temperature sensor's reading.
  - (Link L1.1 *Static Reference*) A static reference depicts a special case of L1 and is of less importance for the remainder of this thesis. In fact, a static reference is not information captured by a user into a file and thus slightly differs from our definition of entities. Static references spring from information, provided by the system designer and does not change over time. For instance, a static reference can be a text label that is linked to a photo and says "all photos that appear in this frame have been triggered by your pulse sensor when it measured a heart rate above 180 beats/minute".
  - (Link L2 *Common Factor*) Two or more entities are linked by a common factor. For example, photos that are part of the same album or that have been captured by the same person, on the same date, or in the same place.

- (Link L3 *Linked in Time*) Two or more entities are captured synchronously (this is also a special case of L2) or within fixed time periods (for instance, a time lapse photo series).
- (Link L4 *Linked in Perspective*) Entities are linked by their perspectives, that is, the viewpoints of the camera sensors are known to the user and how they relate to each other. For example, two cameras that are triggered synchronously (also special cases of L2 and L3) and facing in opposite directions are linked in perspective.

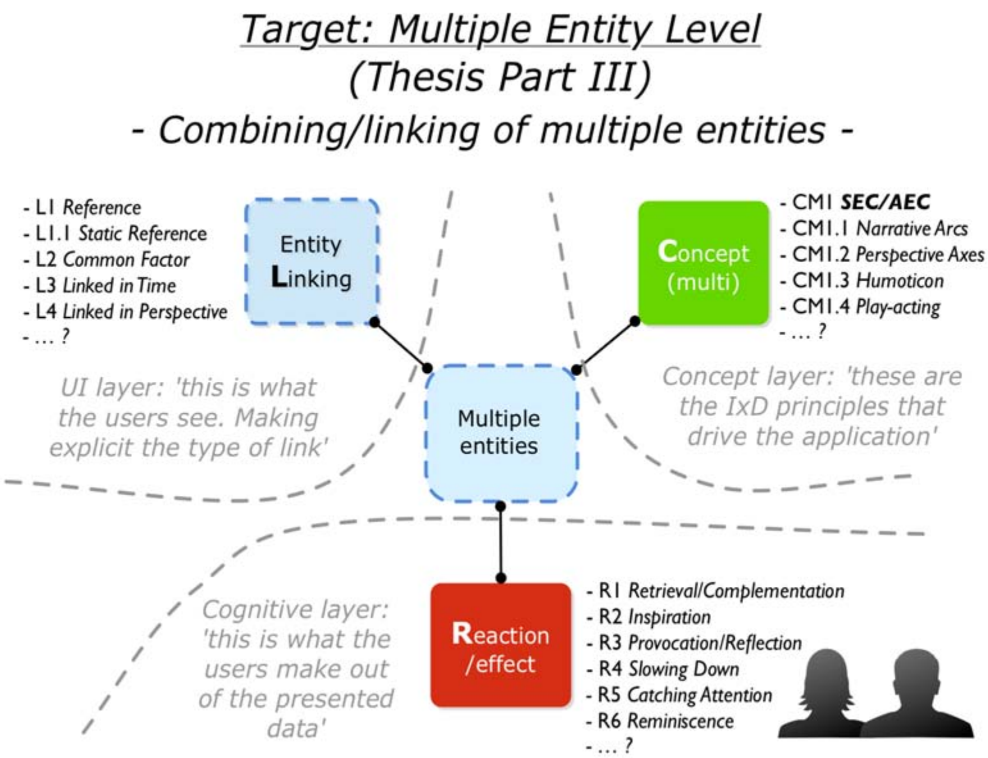

Figure 4.4. *Multiple entity level* of analysis and intervention.

In summary, L1-L4 describe different ways for relating media files to each other in augmented memory system design (and other digital interactive systems). We suggest clearly indicating the *link* between entities in the application's interface, because our study findings show (see next chapters) that the users draw heavily on these relations when interpreting digital material.

- **(CM)** On a conceptual level, entity linking (L) and the corresponding user reactions (R) can be supported by a number of theoretical considerations. Again, similar to the *single entity level* concepts, these explanations should aid designers in establishing a deeper understanding of the underlying working principles of their multiple entity applications. As a consequence of such understanding, different variants of the interaction mechanisms can be implemented into a design.

(CM1) SEC/AEC: The application idea of SEC/AEC (synchronous /asynchronous entity composition) is the foundation of entity linking (L) as an interaction design concept and as presented in this thesis (without entity composition there are no links). SEC and AEC, again, enable a set of mechanisms, which account for the potential of *linked* entities as powerful memory retrieval cues.

- CM1.1 *Narrative Arcs*: This is the figurative description for a link between two (or multiple) entities, which is characterized by a 'shared story' between these files. The connection between the entities has to be established by the imagination of the observer. For this, it is necessary, as already outlined, to let the user know via the interface that the corresponding entities belong together. Multiple photos, for instance, which are displayed as being part of the same event (i.e., they share one *common factor*, which is given by the shared event), are likely to be related by the observer and 'missing images' will 'mentally be added' to create a coherent story between these photos. In both MEO and Duography applications, we have seen this mechanism as a powerful device for creating powerful digital souvenirs that allow the contemplators to relive the depicted events.
- CM1.2 *Perspective Axes*: This can also be regarded as a sub-concept of CM1.1 *narrative arcs*. *Perspective axes* are given if different entities capture a location in different perspectives. It is then up to the users' imagination to locally arrange the entities and relate them to each other. *Perspective axes* were afforded by the Duography application as introduced and described in this thesis.
- CM1.3 *Humoticon*: The concept of *humoticon* is closely tied to the Duography application and denotes the linking of media entities where one entity contains an expression of human emotion that comments on the other entities. More precisely, in the case of Duography, the picture of a human face hinted at this person's appraisal for the motif captured in another photo. (This somewhat abstract description will become much clearer in the Duography Chapter 8.)
- CM1.4 *Play-Acting*: This concept describes the affordance of Duography of inviting the users to capture Duographs in a certain way, namely, to pose certain situations and to act out social interactions.

- **(R)** The reaction dimension is the same as already described for *the single entity level*. It contains the effects in the thinking of the user, which might be caused by the application. As outlined above, this effect might be the inspiration of thoughts, a provocation to the user's thinking, or simply the provision of complementing information for memory retrieval. We briefly discuss how the users can draw on the proposed entity relations by outlining three possible and exemplary user reactions.
    - (Reaction R1 *Retrieval/Complementation*) One entity provides additional information to another one. Thus, the effect, simply stated, is that the user possesses more information to make sense of the data (e.g., L1 - photo and corresponding photo caption).
    - (Reaction R2 *Inspiration*) The users' imagination is spurred by the presence of several linked entities. For example, when looking at a number of photos that belong to a time lapse series (L3 – linked in time), the user might mentally connect the images and fill the gaps to (re-)create the story behind this sequence of information.
    - (Reaction R3 *Provocation/Reflection*) Entities that are indicated to be linked, but don't quite seem to belong together can lead to surprise or reflection. It might also be the case that an entity is intentionally removed or that something has been omitted to provoke the users to deeply engage with the present information and make up this gap. In other words, entities can be presented in a somehow 'surprising' or 'obfuscating' fashion, which can initially even lead to confusion. For instance, a link can be simulated, which actually does not exist. Two entities might be presented together, which absolutely have nothing in common.

4.4 Summary

In this chapter we introduced the CuDe Framework, *a tool to think with* for designers of augmented memory systems and other similar interactive applications. It distinguishes between two conceptual levels of analysis and intervention: 'working' with single or with multiple entities.

On the *single entity level*, the framework compromises the dimensions entity processing (P), concept single (CS) and reaction/effect (R). On the *multiple entity level*, the dimensions are entity linking (L), concept multi (CM) and reaction/effect (R). Hence, concept and reaction dimension are contained within both levels of examination. While (R) describes the effects, which can potentially be accomplished for the user when being exposed to the interactive experience, the concept dimension discusses in-depth mechanisms, which account for these user reactions as the underlying working principles.

Entity processing (P) and entity linking (L) are each specific dimensions of the single or *multiple entity level*, respectively. (P) denotes the manipulation or processing of an individual file, for instance, filtering an image. (L), on the other hand, describes different relations or links (L1-L4) between captured media data entities, which contribute to an entity-compound's potential in carrying rich memory triggers.

In summary, the CuDe Framework lines out how designers of interactive systems can make use of user-captured or other publicly available digital content to support meaningful remembering, and to spur the user's imagination when revisiting their content. The framework is neither complete, nor is it a step-by-step recipe. Rather, it is a set of descriptions and observations, which emerged from the study findings of this thesis, and which can serve as an aid for designers in finding ideas for new remembering systems, for describing applications, or for analysing their underlying working mechanisms.

We now move on to the study chapters, upon which the CuDe Framework is built.

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Part II: Single Entities

5 Initial Probes and Pre-studies (Single Entity)

The starting point of this thesis, besides the initial literature search, is marked by practical hands-on explorations into technological possibilities for supporting remembering. More precisely, a set of five applications (two for the Desktop computer, one for the mobile phone, one as a mobile device, and one interactive installation) were designed and given to participants. They were intended as technology probes to get our *design-based* research process started and to decide on further directions.

This chapter 5[7] marks the starting point of Part II of the thesis and presents three of the initial technology probes (Pro.1 ForgetMeNot, Pro.2 EyeOfDetail, Pro.3 Audio Peephole). In the subsequent Part III, we will describe the remaining two initial prototype systems (Pro.4 Duography and Pro.5 ContextShaker). The reason for the separation is the introduction of the applications based on the 'dimensionality' of the incorporated digital data: *single entities* and *multiple combined entities*. In technical terms, this denotes the number of media files, which are (synchronously) provided to the user to make sense of and to enable meaningful remembering experiences. More figuratively speaking, it is the number of 'content carriers' that is given to the observer for creating meaning.

Each entity can contain a potentially arbitrary number of memory retrieval cues. The exact analysis and identification of these contained cues is not in the scope of this thesis, as we remain at the more abstract level of files and entities, which again favours the practical applicability of this research in interaction design.

The Hearsay public installation also incorporates single entities and, hence, can be found in Part II of the theses. In contrast to the three initial probes (Pro.1-3), this application features a more elaborate user study and is conceptually based on Pro.1-3.

In Part III, we introduce advanced prototypes (Duography and MEO application) as follow-up designs of the initial multiple entity probe explorations Pro.4 and Pro.5.

5.1 Single Entity Prototype Motivation and Design Strategy

The rationale for the single entity design proposals was motivated by the study of related work, technical feasibilities and spontaneous ideas. The overall aim was to explore alternative approaches to presenting digital content, that is, possible memory retrieval cues, to enhance the experience of technological supported reflecting and reminiscing. To this end, the single entity applications employed *one media file only* (as

[7] Parts of this chapter are based on a prior publication (Güldenpfennig & Fitzpatrick, 2011).

indicated by the name), and attempted to work with this file in specific ways to grant the user new perspectives into (familiar) digital material.

As reported in the related work chapter (see Section 2.4 for a summary of relevant issues), we identified a set of four primary design challenges during the literature review to be targeted within this thesis. The single entity design proposals particularly address the issues of *invisibility of digital data* and the *re-constructive nature of memory*.

In the remainder of this chapter, the three initial probes (Pro.1-3) will be detailed and the subsequent chapter describes the Hearsay public installation. Therefore, we now explicitly explain the design motivations or strategies of the probes Pro.1-3 by referring to two out of the four challenges from the literature (note also the summary in Table 5.1 in this context).

5.1.1 Invisibility of Digital Data

Digital souvenirs are perceived as invisible compared to their physical counterparts (i.e., 'real' mementos consisting of physical objects). As a consequence, research is being conducted to support the revisiting of digital files, for instance, by building digital photo frames or other devices for displaying digital content (see Section 2.3.1.1 and 2.4.1.2). Similarly, the single entity design proposals were created to bring digital files to the fore. P-S.1 (ForgetMeNot) is a screensaver, which displays photos from the personal collection and, thus, draws attention to these pictures. P-S.2 (EyeOfDetail) is a photo-viewing application, which provides a physical interface and invites the users to deal with their photos in unconventional ways. P-S.3 (Audio Peephole) and HPI (Hearsay, see Chapter 6) are both public installations and physical artifacts that embody and make available textual digital messages.

5.1.2 Reconstructive Nature of Memory

By highlighting the *reconstructive nature of memory* we draw attention to the fact that *memories* cannot be captured to disk; rather it is memory cues that get recorded and aid the observer in reconstructing the corresponding memory by interpreting it (see also Section 2.2.1 and 2.3.5.2).

The objective of our designs is to support the users in recreating past moments by exploiting digital entities and the contained memory retrieval cues in purposeful ways. Thus, we aim to facilitate the process of making meaning of the digitally recorded files.

To this end, we developed a number of different application ideas to support the reconstructive nature of memory. Both Pro.1 (ForgetMeNot) and Pro.2 (EyeOfDetail) make use of *conventional* photos in *unconventional* ways. While ForgetMeNot's main principle is to reveal information (and thus memory cues) gradually, EyeOfDetail seeks to focus the users' attention on particular aspects of a photo and to slow them down when revisiting their digital mementos (see also Table 5.1). Overall, these applications were made to engage the users in a *mindful* and novel perspective on their personal digital photo collection.

Pro.3 (Audio Peephole) and Hearsay, on the other hand, employ textual information in unconventional ways to trigger memory and associations. Again, it is our intention to slow the users down and to focus their attention to solve some sort of 'jigsaw puzzle' (see Table 5.1).

We go on to detail these application ideas and corresponding user studies after a short note on the evaluation of these prototypes.

Table 5.1. Overview of the *single entity* applications in this thesis (application idea/concept and evaluation).

Study and Study Target	Application Idea/Concept (Single Entities)	Evaluation
P-S.1: (Pro.1) ForgetMeNot	• Revisiting conventional photos in unconventional ways • Revealing information gradually • Creating a 'puzzle', i.e., requesting the users to make sense of the blurred memory cue and mentally fill in missing details	• *Informal evaluation*: demonstration of Pro.1 to interested people. Usage for a longer period of time (10 days) by one participant with subsequent interview • Data collected: log of photos displayed, interviews • Analysis: review of the interviews and log data for interesting observations
P-S.2: (Pro.2) EyeOfDetail	• Revisiting conventional photos in unconventional ways • Focusing the users' attention on details by masking • Slowing the users down • Gradually exploring the photo 'step-by-step'	• Setting: lab • Participants: 8 • Duration: 30-75 minutes • Data collected: interaction log, interviews • Analysis: descriptive statistical analysis of log data, qualitative content analysis of interviews
P-S.3: (Pro.3) Audio Peephole	• Revisiting conventional public postings to social networks in unconventional ways • Focusing on details • Slowing the users down • Creating a 'puzzle', that is, requesting the users to make sense of the *de-contextualized* memory cue and mentally fill in missing details	• *Informal evaluation*: demonstration of Pro.3 to interested people. • Data collected: log of postings presented, interviews • Analysis: review of the interviews and log data for interesting observations

Study and Study Target	Application Idea/Concept (Single Entities)	Evaluation
HPI: Hearsay (public Installation)	• Revisiting conventional public postings to online news sites in unconventional ways • Focusing on details • Slowing the users down • Creating a 'puzzle', that is, requesting the users to make sense of the *de-contextualized* memory cue and mentally fill in missing details	• Setting: field study of the application as a publicly available interactive 'art' piece • Participants: 8 • Duration: 4 weeks • Data collected: interaction log data, interviews • Analysis: descriptive statistical analysis of the log data, thematic analysis of the interviews

5.2 A Note on the Evaluation of the Probes

As the methodological approach to this *thesis is design-based research* (*DBR*; see Chapter 3.3), the focus is not on evaluating these applications by rigorous 'scientific' studies. Rather, we used them as an entry point for gaining research guidance through participant responses. Therefore, we demonstrated the applications (Pro.1 ForGet-MeNot, Pro.2 EyeOfDetail, Pro.3 Audio Peephole) to a number of people and asked them to use the applications as they wished. (The corresponding user studies have the identifiers P-S.1, P-S.2 and P-S.3.) Both their reactions and the experiences we gained by elaborating our own thoughts and ideas during the act of making informed the design of expanded prototypes to be studied in greater detail (see also Table 5.1 for further details on this kind of evaluation).

5.3 System Descriptions Pro.1-3

5.3.1 Pro.1 ForGetMeNot

ForgetMeNot is a Desktop screensaver for *Ubuntu Linux* (see Figure 5.1). This application randomly chooses pictures from a selected folder and displays them with various degrees of blurring on the user's screen during idle time. The images are replaced after a couple of seconds. The aim of the application is to provide the observer with cues to encourage them to proactively remember an event. Cues are given by the degree of de-blurring of the image and the degree of blurring is *inversely related* to time passed.

The main mechanism behind ForgetMeNot is that the degree of distortion is modelled as a function of time in the same fashion as Ebbinghaus' (1885; reprint 1964) model for human memory retention. Figure 5.2 displays a typical forgetting curve as first described by Ebbinghaus (1885; reprint 1964). It visualizes how the content of human memory fades away over time.

Figure 5.1. ForgetMeNot Desktop screensaver at three different points of time.

In ForgetMeNot, the curve also indicates the degree of distortion of the images, the rationale being that when images are fresh in memory fewer cues are needed. Hence, a freshly shot picture will be shown in a very blurry fashion. The more time passes by the clearer the images get (note that the images of Figure 5.1 are de-blurred from top to bottom as indicated by the arrow). Hence, as images in our mind fade away and become cloudy, ForgetMeNot will reveal more and more details as retrieval cues in the randomly displayed images (noticeable over weeks). The application will therefore help compensate for loss of memory by off-loading to the clearer photos. It also provides an element of serendipity and surprise in its random selection.

Newer pictures, however, are not 'served on a silver platter', leaving it to the user to fill in strongly blurred (and thus missing) information by their imagination. Thus, ForgetMeNot was primarily designed for stimulating the observer's memory. Due to the strong distortion of new pictures there is enough space for the mind to make up the story behind the photo. The application requires the observer to "participate in making meaning", because of its ambiguous display (Gaver, Beaver, & Benford, 2003, p.235).

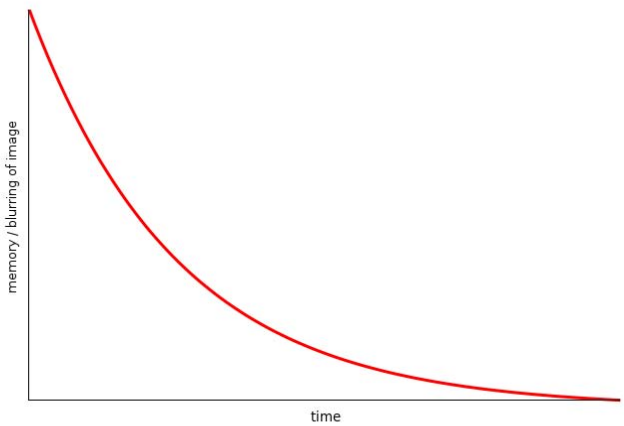


Figure 5.2. Forgetting and de-blurring curve: The images of ForgetMeNot get less blurry as our memory fades away.

This strategy is also supported by a study incorporating images taken by the Microsoft *SenseCam* device. Here test participants reported that the distortion of the *SenseCam* images eventually turned out to be a benefit; because they were incomplete, participants had to do more work to fill in the details and this promoted reflection on the pictures (Fleck & Fitzpatrick, 2009, 2010).

5.3.2 Pro.2 EyeOfDetail

As with ForgetMeNot, EyeOfDetail also draws on notions of *blurriness* or *fuzziness*. This Desktop application is the attempt to create software that in a way maps and supports the concept of mindfulness. In philosophy and psychology, mindfulness is most commonly defined as a state of being attentive and aware of the present moment and of what is taking place around us (Brown & Ryan, 2003, p.822). Higher levels of this distinct form of awareness and attention can have strong positive effects on wellbeing (Langer, 1989) and are associated with less emotional and cognitive disturbance (Brown & Ryan, 2003).

The overall intention then of EyeOfDetail is to slow the observer down for a while, to focus attention and to encourage them to spend time, and deal in-depth, with the moment that is captured in the image. The application loads an image from data memory, blurs the pixels by Gaussian filtering and displays the modified content

Figure 5.3. EyeOfDetail image viewer. Left: screen as presented to the user. Right: magnified detail view (note the small spot, which is not blurred).

Figure 5.4. Navigating the clear spot of EyeOfDetail by moving an accelerometer input device.

on a common LCD screen. While at first sight there is a loss of image quality and data, we hypothesise that the observer will actually be able to get more out of the image. To accomplish this, one small spot of the image is left un-blurred. This clearly visible spotting window is designed to focus the observer's attention to one area at a time (see Figure 5.3).

Figure 5.3 displays a snapshot of the EyeOfDetail image viewer. The image shows a marriage scene of rich colour and detail. Due to the limited capacity of visual attention (Verghese & Pelli, 1992) the viewer is likely to miss some interesting content of the image, for example, the flowers in the girl's hand. This is where EyeOfDetail comes into play, inviting the user to pay mindful attention to even unobtrusive elements by masking more salient details.

The setup of EyeOfDetail allows the user to coarsely navigate the position of the spot by 'wobbling' an accelerometer device (see Figure 5.4). Thus, the observer is capable of controlling what part of the image can be clearly examined. In doing so details can be discovered that would have been dwarfed by more prominent content of the original image. We choose to give the user control of the spot by an accelerometer in order to provide a different experience from the common screen-mouse interaction.

5.3.3 Pro.3 Audio Peephole

Audio Peephole (see Figure 5.5) features differences compared to the aforementioned applications, both in the kind of media modality presented (usage of text and speech) and targeted memory type. The motivation of this device is to foster reminiscing and reflection by means of publicly available memory triggers. While recent research by André et al. (2011) employed the display of nostalgic advertisements to this end, we use social media (downloaded from *Twitter*) as source material to engage people in provocative thinking.

Audio Peephole doesn't primarily deal with autobiographical remembering (as the other prototypes in this chapter). Rather, it plays with notions of *collective memory* (cf. Section 2.2.2), as Audio Peephole incorporates *Tweets* on recent news stories and social media that reflect current concerns of the society.

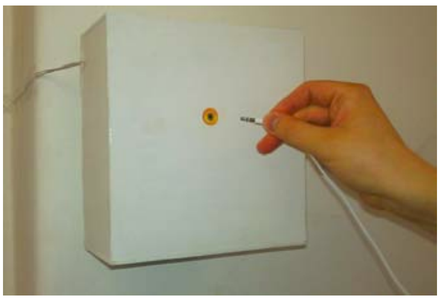


Figure 5.5. User plugging headphones into the Audio Peephole installation.

Hence, the interactive installation makes use of trending text messages from *Twitter*, that is, *Tweets* and social media messages that currently attract wide attention (see Figure). These *Twitter* trends are downloaded as text messages and then converted into a voice message by a commercially available text-to-speech engine. The Audio Peephole installation was available in a (semi-public) space and users could listen to the trends by plugging in (their) own headphones. There were no signs or instructions given at all. By removing one stimulus from its context, that is, playing random statements without any further explanations, we aimed to spark the observer's imagination when attempting to make sense of the isolated bit of information.

Two exemplary *Tweets* that trended at the time of this pre-study are the following:

"Wimbledon 2011 starts today, and the Centre Court is the main court at Wimbledon."

"Lady Gaga won best International Video ('Judas') and Favourite International Artist at the MuchMusic Awards."

5.4 Participant Feedback P-S.1-3

As these three initial prototypes constitute the starting point of our research into multimedia data as triggers for meaningful memories, we were keen to probe some participants for their reactions. Following a design-led research methodology, our primary aim for these first evaluations was to gain guiding user input and inspirations for iterated, similar or perhaps different prototypes.

A summary of the evaluation setups can be found in Table 5.1

5.4.1 P-S.1 ForgetMeNot

In a first pilot study, ForgetMeNot was installed on the PC of one test participant for the duration of ten days (female, 27 years old). The number of images randomly displayed was restricted to five photographs, which were older than three years. Each one of the photos involved the participant and they were provided by one of her friends. We adjusted the curve for de-blurring to reveal the content of the images within the ten days time-period. The modifications towards the original version were applied in order to get initial user feedback within a shorter range of time.

Here we highlight one interesting finding. ForgetMeNot appeared to reveal incidents of false memory for the participant as she found that surprising details were disclosed when the image became less blurry. What is particularly interesting about this is that the test participant "could have sworn when looking at the blurred image" that she remembered clearly and was "one hundred per cent accurate" in recounting that it was her favourite restaurant and recognizing roughly the date of the image. She was later very surprised, as the image became less blurry within the ten days time-period, to realize that the photo was actually taken in her garden and not in the restaurant. It can be argued that the image opened up a rich space for remembering two events. It might also demonstrate an occurrence of a false memory, and a propensity to believe that the link between a (memory) cue and a target memory is accurate. A large amount of literature from psychology deals with people's disposition to blindly believe in false memories (e.g. Loftus and Loftus, 1980) and accounts for the observation of this pilot usage.

5.4.2 P-S.2 EyeOfDetail

Figure 5.6. Test image for pilot study (top). Test image as displayed by EyeOfDetail (middle; circle added in this figure to highlight the 'clear spot'). Scan path of a test participant.

EyeOfDetail, was evaluated in a shorter time period than ForgetMeNot, however with more participants. We conducted a qualitative study using an image of our HCI group on a trip and recruiting eight test participants (P1-P8), aged between 25 and 37, who were all present in the photo. Hence all of the participants attended the trip, knew the image and thus had a personal relation to the picture.

The participants were divided into two groups (2 females and 2 males each). Group A was asked to simply view the image displayed in Figure 5.6 (top). Group B had to use the EyeOfDetail application to explore the same image (Figure 5.6, middle). Each test participant received the same instructions, regardless to which group the person belonged to:

Talk me through the image and any thoughts you have around it. You can take as much time as you like. We have up to 10 minutes. If you can think out loud for me that would be great.

The interviews were audio recorded. Additionally, the path along which the user moved his viewing window or clear spot with the EyeOfDetail version was tracked (see Figure 5.6, bottom), that is, all positions of the 'clear spot' were recorded. After the participants finished viewing the picture the image viewers were switched. Hence, in the end every participant was exposed to both treatments (EyeOfDetail image viewer and a regular non-blurred image viewer).

In terms of results, most of the participants took delight in the EyeOfDetail application and thought it was fun to use it. However, one participant (P8) thought it was dull and preferred the complete non-blurred image. Both groups spent considerably more time using the EyeOfDetail application as shown in Table 5.2.

These times are reassuring, because we actually wanted to slow the observer down. Moreover, we observed a tendency in group B (use of EyeOfDetail viewer first, details revealed gradually) to describe details whereas participants of group A (use of regular viewer software first, all details displayed immediately) more often talked about the image and trip in general. Exemplary statements of group A were "The image is not even" (P5) and "Taking the trip was a good idea" (P8). On the other hand, test participants using EyeOfDetail stated: "What is the name again of the guy from PhD school and where is Peter?" (P1) and "I moved from person to person and thought about what is connecting me with each person" (P6). Furthermore, P7 reported on the way people held their hands. P6 found herself talking about clothes, which according to her usually doesn't bother her at all. Also, two participants were attracted by the play between bright lights and shadow within the leaves and enjoyed exploring the treetops (see scan path of Figure 5.6, bottom) and experienced EyeOfDetail as "more intense" (P1). This kind of openness (paying attention to the clothes, examining the treetops) nicely mirrors the "welcoming new information" criteria for mindfulness by Langer (1989, p. 62).

Table 5.2. Mean time spent viewing the images.

Group	STD viewer (mins)	EyeOfDetail (mins)	Increase (mins)
Group A	3:23	5:12	+1:49
Group B	2:05	4:24	+2:19
A&B (mean)	2:44	4:48	+2:04

5.4.3 P-S.3 Audio Peephole

Audio Peephole was demonstrated to members of the HCI Group and informatics students of Vienna University of Technology to ask them for their feedback. We chose this rather informal evaluation strategy, as this device was conceptualized from the very beginning as an initial probe to gather inspirations for further developments. Participants were interviewed right after they experienced the Audio Peephole installation and notes were taken.

Audio Peephole (Pro.3) delivered a user experience different from Pro.1 and Pro.2, as it presented isolated cues (popular *Tweets* spoken by a synthetic voice). The perception of these cues as being isolated and focussed, was increased by the fact that they were presented in audio. In order not to miss parts of the message, participants had to concentrate and carefully listen to it. As a consequence, Audio Peephole was reported to “support focusing on one issue and thinking it through”. Also, participants reported that the installation pointed them to specific facts, which they would never have encountered in their daily routine without Audio Peephole:

“To me it’s a welcome change to shortly fade away from daily life and, so to speak, listen to things, which I would not be actively looking for. Because, actually, one always visits the same web site and news site … one is not so much attentive to new things. With this audio thing one thinks a little bit out of the box … It provides the opportunity to be confronted with things, which are something completely different. Well, I, for example, didn’t know that Lady Gaga won a prize last night.”

Participants considered the selection of random *trending Tweets* as very useful, compared to just playing any arbitrary and probably irrelevant message.

In summary, in Audio Peephole we observed the participants enjoying having to make sense of the presented information. Audio Peephole demanded them to interpret the cues (*Tweets*) that were presented to them without any additional contextual information and focussed their attention to this ‘isolated’ bit of information. The application to some extent was like ‘solving a puzzle’.

5.5 Single Entity Probes Summary and Discussion

In this chapter we have seen three different prototypes that all played in different ways with digital media as memory retrieval cues. They covered different ideas for revisiting previously captured data. The applications made use of different types of files, but each of them incorporated only one single entity at a time. (1) ForgetMeNot is a photo-based screensaver that revealed more (visual) cues as the displayed images grew older. ‘Fresh’ images, on the other hand, were accompanied by only few cues. (2) EyeOfDetail attempted to slow the user down and focus them on details while inspecting photos. (3) Audio Peephole aimed at directing the user’s attention towards publicly available (= not private media data) cues to engage them in reflection about them. As Audio Peephole involved public cues, both applications also concern notions of collective memory.

The proposed ideas were evaluated by different methods. However, every application was tested with about the same effort and appropriate to their purpose as initial probes. While, for instance, EyeOfDetail could be presented relatively quickly to a larger number of participants, the time-dependent concept of ForgetMeNot demanded significantly more time. Thus, the latter application was evaluated with one participant only, however within a test period of ten days.

Most strikingly, all participants were open to review digital content in perhaps uncommon ways to support an enhanced experience of recollecting, reflecting and reminiscing. Alternative approaches to revisiting conventional materials, for example, digital photos, were well appreciated. As a consequence, we decided to further develop the underlying principles of these applications.

5.5.1 Lessons Learnt and Taking Forward

We took forward a number of insights and inspirations gained through the technology probe studies P-S.1-3. These insights resulted either directly in a more advanced prototype (Hearsay), or influenced the design of subsequent new applications (Duography, MEO) on a conceptual level.

5.5.1.1 Slow and Mindful Engagement

The observations on ForgetMeNot (P-S.1) and EyeOfDetail (P-S.2) indicated the participants' interest in taking a more mindful approach to remembering, to slow down and 'lean back', and to carefully investigate their photos in detail. We think this mind set is very beneficial for the sake of meaningful remembering supported by technology. Thus, we consider this attitude of the participants for the continued efforts in this thesis. Mindful engagement and slower processes of information revisiting/capturing will, among other things, play an important role in the development and use of the MEO multiple entity prototypes (see Chapter 9).

5.5.1.2 Alternative and Playful Approaches to Data Representation

As stated before, the participants were open to unconventional ways to data representation, for example, using novel kinds of photo viewers or listening to social media comments. We see this interest of the participants as a chance to enhance the visibility of digital data and decided, due to the positive feedback on Audio Peephole to iterate on this application idea (resulting in the Hearsay installation of Chapter 6). In the context of the MEO application (see Chapter 9), additional physical devices for 'materializing' digital mementos are introduced.

Elements of playfulness will later in this thesis also contribute to the success of Duography (see Chapter 8).

5.5.1.3 De- and re-contextualization

While Audio Peephole was iterated in the form of the Hearsay installation (Chapter 6), ForgetMeNot and EyeOfDetail are not 'translated' into direct prototype successors. Nevertheless, the application's underlying design principle of masking parts of the contained memory retrieval cues (the 'clear sport' of EyeOfDetail) or to reveal information gradually (the (de-)blurring of the photos in ForgetMeNot), is also picked up by the Hearsay installation and conceptually informs it. Thus, the overall objective of the Hearsay follow-up is to elaborate further this underlying interaction design concept of 'playing with contextual information'. Basically, Hearsay elaborates the idea to extract meaningful information from its original context and present it to the user in an 'out-of-context' situation. In a way, it is up to the users to *re-contextualize* data, which has been *de-contextualized* beforehand. We are curious to see whether this design principle can engage the user in reflective thinking and provocative user experiences. Moreover, we see interesting parallels between the concept of *de-* and *re-contextualization* of data and the *re-constructive* nature of organic memory.

5.5.1.4 Personal Data vs. Public Data

Audio Peephole (and also Pro.4 ContextShaker of Chapter 7) dealt with the consumption of publicly available data. We were interested to see whether these applications could foster reflections on the presented media. As these concepts received positive feedback in general, we decided to further explore some of the opportunities offered by public data downloaded from the Internet. In particular, participants appreciated being confronted with random, but at the same time important, relevant or 'trending' issues. Also, they engaged in making sense of the presented information, that is, interpreting what the presented cues mean without any additional contextual information. Even though, Audio Peephole does not directly address *autobiographical* memory, we believe that this application can teach us different lessons for presenting memory cues in general (see e.g., the description of *de-* and *recontextualization* above). One advantage of publicly available data for studying presentation concepts of media data is that it is gathered easily compared to private data or data, which is yet to be captured before/in the course of the user study. Also, research highlighted the close relationship between personal and collective memory (Van Dijck, 2006), and others in HCI successfully used public data from the Internet for creating personal reminiscence experiences (André et al., 2011).

6 Hearsay

6.1 Introduction

The Audio Peephole (see Chapter 5) technology probe directly inspired the design of the Hearsay installation. In addition, EyeOfDetail and ForgetMeNot influenced Audio Peephole, although in a more implicit fashion. As outlined in Section 5.5.1.3, the masking and blurring of information played a significant role in these three probes. In this chapter[8], we pick up this concept in an attempt to 'formalize' or to develop it further as a concept for interaction design. To this end, we introduce Hearsay as our 'research vehicle', an interactive application operating with single entities.

On a more abstract level, the underlying design principle of Audio Peephole, EyeOfDetail and ForgetMeNot was to remove a number of memory triggers from a larger set of memory retrieval cues. This strategy is illustrated in Figure 6.1 (left), where the EyeOfDetail application removed certain memory cues (that is, the image was

Figure 6.1. Left: masked (blurred) image with the exception of one 'clear spot' (the dog; photographer: Elliott Erwitt). Right: schematic drawing of an online news page with all content masked (the news story is not readable visually) with the exception of one user comment, which hence is extracted from its original content.

blurred, thus information was removed), while saving the 'clear spot' showing a dog). As a consequence, the observer or user has to make sense of these filtered photos without all available cues and mentally 'fill in' missing information. ForgetMeNot and Audio Peephole were different applications, however, they employed a similar con-

[8] This chapter is based on " De- and Re-contextualization as a Design Concept for Provocative Interactive Experiences", a full paper by Güldenpfennig and Fitzpatrick submitted to CHI'14.

cept. While ForgetMeNot also worked with the blurring and de-blurring of images, Audio Peephole displayed text messages (*Tweets*), which were removed from their original context. In other words, these messages were presented in 'isolation'. Consequently, its users had available some sort of textual cue for sparking their imagination, however, they were lacking full contextual information and had to 'fill in this gap' mentally, as well.

Hearsay employs the same strategy in yet a different implementation. This application extracts user comments on online news stories and presents them to the user without any more contextual information or hints of origin (to be explained in the following sections in more detail). It is up to the observer to interpret this single entity cue. The *de-contextualized* information has to be *re-contextualized* within the mind of the users. Figure 6.1 (right) illustrates the concept of Hearsay and juxtaposes it to the idea of EyeOfDetail.

More precisely, Hearsay is a (semi)public installation that deals with the consumption of online newspapers and social commenting. By means of the de-contextualization of these comments, that is, separating them from the corresponding news articles, the installation provides a novel experience for reading the news including the potential to open new perspectives and processes of mental engagement. We describe how Hearsay invites the users to reflect on their online newspaper consumption and on the role of the often-embedded social commenting functions in influencing the perception of the reported events.

By conducting this study, we elaborated on the interaction design concept of *de-* and *re-contextualization* (*de-/re-ctx*). At its core, *de/re-ctx* aims to capture the attention of the user by deliberately omitting or displacing contextual information and hence cause deep system engagement of the user when making sense of this data, or "putting the puzzle back into place" (to quote one of our participants). Note that "context" is an important notion in HCI research and some further information on this concept is presented in the Glossary.

Like the ContextShaker probe (see Chapter 7), Hearsay also employed publicly available (thus not personal) media data as memory triggers. However, we hypothesise that public data is also relevant in autobiographical memory, as others already used such data for personal reminiscing (André et al., 2011) and because of the close interplay between collective and personal memory (Van Dijck, 2006).

6.1.1 De-/re-contextualization (de-/re-ctx)

As outlined above, Hearsay embodies a design concept we named *de- and re-contextualization* (*de-/re-ctx*). This concept denotes the deliberate removal of contextual cues to create thought-provoking interactive experiences. We investigate this potential of *de/re-ctx* at a more general level, that is, as a design principle for different kinds of applications. After the presentation of the findings we narrow it down and suggest that it is particularly useful for creating augmented memory systems.

The user data we collected with Hearsay show how this interactive installation let the users reconstruct context or hypothesise about missing contextual information and thus engage in meaningful interactive experiences. As our dataset suggests, this kind of de-contextualized presentation of data can lead to intellectual effort and mental processes such as self-reflection, curiosity, speculation and reconstruction of context. We argue that capabilities like these constitute the power or potential of *de/re-ctx* for augmenting the design of digital memory systems. We apply Höök's and Löwgren's theoretical lens of *Strong Concepts* (Höök & Löwgren, 2012) to the idea of 'experimenting with context' to design meaningful interactions, and propose *de/re-ctx* as a candidate for such a *Strong Concept*.

To illuminate the qualities of *de-/re-ctx* as a concept for the design of augmented memory systems, we structure this chapter as follows. First, we describe background information regarding the origin of the Hearsay application idea and related work. Second, we give further details on the Hearsay installation from a more practical perspective (design, user experience, implementation). Third, we report a user study that was conducted in order to investigate Hearsay's underlying design concept (*de-/re-ctx*). Fourth and finally, we conclude by a brief discussion of the study findings and consider these results in relation to the overall thesis contribution and to the CuDe Framework.

6.2 Theoretical Background of Hearsay

6.2.1 On the Application Idea of the Hearsay Installation

The specific idea of *de/re-ctx* as a "resource for design" springs from a known creativity or ideation method as outlined, for example, by Mangold (2007) (see also ContextShaker in Chapter 7). Here the author describes how the juxtaposing and associating of two originally unrelated stimuli, for example, an image and written words, generates new meaning and ideas, which does not arise from reading the isolated stimuli. This method inspired the application ideas of ContextShaker and Hearsay. However, instead of creating new meaning by combining two stimuli, we apply a 'reverse strategy'. By removing one stimulus from its context, while at the same time indicating its removal, we aim to spark the observer's imagination when attempting to reconstruct the origin of the isolated bit of information. In the following, we also refer to the isolated stimulus as *cue*, because of its function to hint at the original context and to trigger mental processes. This leads to the question *but what is it all good for*?

It is our assumption, which is to be supported in the subsequent user study, that there is a space for the proposed concept in interaction design as it can foster deep user engagement and thought-provoking experiences, which are otherwise hard to generate. To make this easier to understand, we briefly introduce the Hearsay idea up front (with a more detailed description later in the chapter).

Hearsay is an interactive installation that downloads user content from social web platforms and presents this information in a *de-contextualized* fashion on the touch of a button. More precisely, user comments about news articles are presented via audio without access to the corresponding news items. By employing a specific algorithm, Hearsay only selects user comments, which contain rather polarizing or extreme statements (i.e., comments, which were either strongly approved or disapproved by the community). In the subsequent case study, we report how participants *re-contextualized* these comments (i.e., deducing the original news item), and how this process of 'puzzling' lead to deep engagement and reconsiderations of the actual statement that was presented out of its original context.

One important design feature of Hearsay is the application of *randomness* as part of the user experience. This is because the user has no control in the choice of the presented cue apart from choosing between a red and green button, representing a positive or negative polarization respectively (i.e., the comments are selected randomly). This idea is not new to interaction design and purposeful randomness and unpredictability was applied to enrich different application domains such as photography, web blogs, music playback and web search (Leong, Vetere, & Howard, 2006). To explain the creative power of randomness, Leong et al. drew on examples from the arts, as "it encouraged the use of free association, fragmentary trains of thought, and unexpected juxtapositions" (Leong, Howard, & Vetere, 2008, p.17). As supported by these observations and considerations, there is perhaps a linkage between the concept of *randomness* and *de/re-ctx*. While *randomness* can lead to interesting juxtapositions and "out-of-context experiences", *de/re-ctx* describes situations in which *de-contextualization* has specifically taken place. Our aim now is, by means of Hearsay, to investigate how to design for this particular situation and take advantage of it for creating engaging user experiences. Finally, we reflect on *de/re-ctx* from the theoretical perspective of *Strong Concepts* (Höök & Löwgren, 2012).

6.2.2 Related Interactive Systems

There are also various other systems that draw strongly on the notion of context, a concept of great significance in interaction design and in particular in ubiquitous computing applications. It is the functioning of the human brain that demands designers to consider contextual factors when creating purposeful systems, because we as the user need to make sense of the available information and integrate it with our assumptions and perceptions of reality.

In the following, we review work that served as a source of inspiration for Hearsay. However, we also quote this research in support for developing *de/re-ctx* as a *Strong Concept* candidate that draws on Hearsay and these related systems; According to Höök and Löwgren, a *Strong Concept* (see also Section 3.2) is a theoretical construct that constitutes "intermediate-level design knowledge" (Höök & Löwgren, 2012). Thus, it encloses design knowledge, which is more abstract than design-lessons embodied in particular instances or exemplary artifacts, however without being a 'fully grown' theory yet. For a design concept to qualify as a *Strong Concept*, it requires successful examples, which embody the design knowledge or principle across different application domains. We suggest that the following related work points at the usefulness of *de/re-ctx* in interaction design as it shares similar features with *de/re-ctx*. This will become more evident when the findings on Hearsay are presented in the subsequent section. (We will also return to considerations about *de/re-ctx* as a *Strong Concept* in the discussion section).

Gaver et al. proposed "ambiguity as a resource for design" (Gaver et al., 2003) and thereby dealt with contextual information in a formerly uncommon way. While ambiguity of information is quite naturally avoided by any means in interactive design, these authors play with the idea of deliberately 'causing confusion' for the sake of creating "intriguing, mysterious and delightful" (Gaver et al., 2003, p.233) user experiences. Still, they did not intend to encourage fuzzy and hence bad design (of course). Instead, they proposed blocking easy system interpretations and letting the user participate in "making meaning" (Gaver et al., 2003) for the sake of deeper system engagements and novel perspectives into socio-digital systems. As a consequence, it is the user who defines the end purpose of the system by interpreting proposed interactions and adapting the system according to their current interest (Sengers & Gaver, 2006).

Some years later, Gaver et al. again explored contextual issues when describing the design of their "threshold devices" (Gaver et al., 2008) (digital systems for connecting the inside home to the outside world). They proposed two devices, which each captured data from the outer world and imported it into the house in the form of abstract information displays. Their first threshold device displayed the flight routes of planes passing over the house and allowed to look up their destination and thus to daydream about this particular place: "recontextualising found data to a particular location is a powerful method for developing engaging systems, and key to the strengths (and some of the weakness) of those we report here." (Gaver et al., 2008, p.1430). The second threshold device displayed fragments of local (communal) online advertisements on small screens in different locations of the home. These fragmented ads were ripped from their context without further explanations.

Interestingly, the authors did not link this newer research project to the 'ambiguity paper' to elaborate further on the 're-contextualization theme'. Nevertheless, these design concepts are clearly related to Hearsay, where user comments on newspaper articles are removed from their conventional context to be read out by a 'text-to-speech' software (see next section for a detailed system description). In a way this concept is also similar to Gaver et al.'s prayer companion (Gaver et al., 2010), which crawled news headlines (RSS feeds) from the internet and displayed them as inspirations for the spiritual activities of nuns. In addition, Hearsay has been inspired by Hansen's and Rubin's *Listening Post* (Hansen & Rubin, 2002) which showed random online communication on displays. Furthermore, it relates to the *Photostroller* device (Gaver et al., 2011), which depicted random photos from the Internet on a screen located in a care home. Again others have employed de-contextualization of information ("out-of-context" use of sounds) for evoking curiosity (Tieben, Bekker, & Schouten, 2011).

We go on now to describe Hearsay, the background and detailed motivation for this installation, as well as the study setup.

6.3 The Hearsay Installation

The Hearsay installation consisted of a wooden 'nostalgic' speaker (see Figure 6.2), with two illuminated push buttons, one green, the other red, located in a semi-public location. Pushing either one of the buttons triggered a female voice reading out random comments on news items that have been posted by the (mostly anonymous) readers of an online newspaper (*DER STANDARD*[9]). The green button played comments that have been highly positively rated by the readers, whereas, the red button triggered comments that were highly negatively rated. Following every comment, the voice also read out the corresponding number of positive and negative votes. (The votes are named "notches" and evolved as a kind of 'trademark' for this popular newspaper).

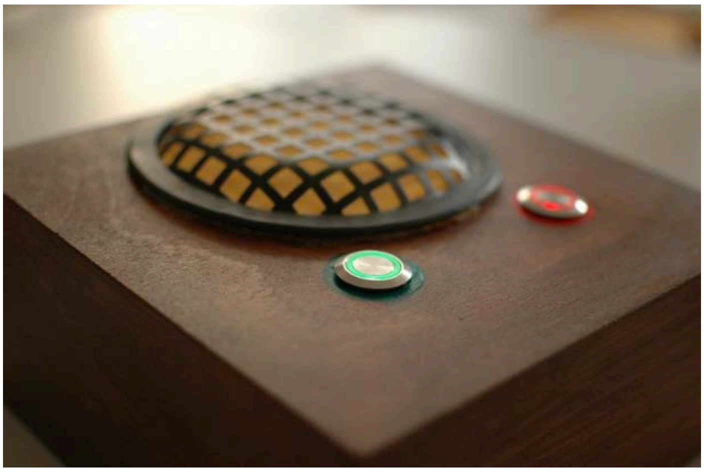


Figure 6.2. Hearsay speaker box with two illuminated buttons for playing random comments on news items.

As there were no information provided about the origin of the comments, the data was de-contextualized in multiple ways: (a) the comments were separated from the corresponding news article; (b) besides calling the votes 'notches' there was no hint for the origin or purpose of the comments/device so listeners had no other specif-

[9] http://www.derstandard.at (last accessed 15 September 2014)

ic cues to these even being newspaper comments; (c) in a broader sense, the actual print medium to be consumed on a computer screen was transformed into audio and thus removed from its conventional interactional media context.

6.3.1 User Comments as Cues

We decided to create a provocative installation called Hearsay around the topic of social commenting, as we repeatedly caught ourselves spending considerable amounts of time reading comments on news items, at times even favouring them over the actual articles. Often, these comments are emotionally charged and laden with content that many users can relate to. As many people follow the news, this kind of content gives ideal (recognizable and meaningful to many people) cues and so provides a good argument for employing online news articles and comments for exploring the concept of *de/re-ctx*. With Hearsay we had a precious reservoir of relevant items. In a way, comments on news articles reflect (certain parts of) society, or at least constitute decontextualized snapshots of issues, which a society is currently dealing with. The idea now was to investigate how these comments could provoke thoughts and engagement by presenting them with only limited contextual cues (no information about the original newspaper article).

The involved news comments were taken from the online version of the nationwide newspaper *DER STANDARD* (www.derstandard.at)[10]. Besides posting own comments on news items, the readers of this newspaper can also rate the other users' comments by assigning positive or negative votes (green or red 'notches'), as previously noted.

Below is an exemplary user comment with a high number of positive ratings (53 green, 1 red). It was posted in the context of an article about a former minister of finance, who got into legal issues and aggravated almost the whole country:

"Waterboarding... – will not be necessary. For a complete confession threatening with a shower but no hair dryer should suffice."

This comment ironically refers to the minister's vanity and sumptuous haircut. Its irony seems to be understood and appreciated by many readers, as indicated by the many positive ratings. At this time, 'waterboarding' was a discussed cruelty that had attracted the broad attention of the public and that thus also made its way into this user comment as a side blow. Another highly rated posting is displayed below. As the preceding and the subsequent comment show, a lot of recommended comments involve a decent amount of humour and often irony (the original article that is com-

[10] As an 'historic' side note, it is interesting to mention, that a couple of years ago, *DER STANDARD* ran a campaign to draw more attention to its actual news articles rather than to just the comments and thus deactivated its popular commenting function once every week.

mented on in the following refers to a computer game that was finally released 14 years after its announcement):

"Since the first announcement of Duke [Nukem Forever] I started saving up my pocket money. Since than I have finished school, became a father, finished my university degree, started my PhD, my son finished preschool and now the game is going to be published. I hope they will still accept old coins and notes of our former currency."

With 74 positive and 0 negative votes, this is the comment with the highest rating that has been posted within the study period. (Note, that even if the comment might appear a bit 'geeky', the general audience of the online newspaper does not have a particular affinity to technology.) At the negative end of the ratings, comments are found such as the following two examples:

"Good luck – It can't get any worse than with the current president!"

"I hope they have to pay for the rescue team. I don't want to waste my taxes on such jerks."

While the first comment was posted with regard to the US presidential election in 2012 and Michele Bachmann (8 positive votes, 49 negative votes), the second posting (6 positive votes, 61 negative votes) relates to a tragedy where two students died in a trial of courage. Negative comments typically reflect offending opinions (e.g., extreme political positions, racism or a lack of empathy) or statements that convey totally wrong facts. Evenly balanced negative and positive ratings point to controversies among the readers.

6.3.2 Implementation

The Hearsay installation was built as a wooden speaker with two illuminated push buttons (see Figure 6.2 and Figure 6.3) and a small personal computer (PC) for running the software. The PC was not visible to the users as it was connected to the speaker with hidden wires and located in a different room. The buttons of the speaker were operated by an additional *Arduino* microprocessor that was also connected to the PC. A custom-developed *Java* software 'crawled' the website of *DER STANDARD* once a day and stored all new comments including ratings into a database. 165.854 comments were downloaded over the study period of one month. A commercially available text-to-speech software was used to read out the randomly chosen positive/negative comment. The quality of this female voice was described as very good and rather charming by the study participants.

6.4 User Study Hearsay

The installation was available in a semi-public space (a corridor within a university institute) for 4 weeks or 20 workdays. This corridor connects the rooms of a small working group in computer science (approximately 15 employees) and it is neither overly crowded nor is it deserted. Besides the members of the working group, students are passing by to visit faculty (approximately an average of 15 persons a day). The Hearsay speaker was deployed without any announcements or explanations. Figure 6.3 shows the speaker box as it was installed on a wall and used by people passing by. All interactions were saved to a log file on the Hearsay computer.

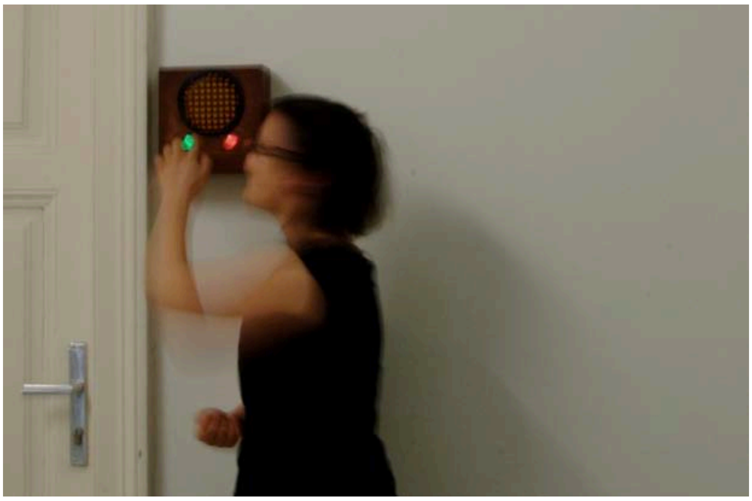


Figure 6.3. User pressing a button on the speaker to listen to a random newspaper reader comment.

After the installation had been available to the public for 4 weeks, 9 participants were recruited for interviews (3 females, 6 males, aged between 20 and 49). In order to be eligible as interview participants, they must have used Hearsay at least 8 times (according to their self report) out of their own interest during the 4 weeks study period. (We asked people whom we observed listening to the installation until we identified 'heavy Hearsay users' who were also willing to participate in an interview.) 5 participants were part of the faculty, 4 participants were interested students who requested information on the installation. They were not financially remunerated.

The interviews were semi-structured and the questions were formulated openly, because we were interested in the participants' reactions to Hearsay and its decontextualized triggers without steering the participants' answers to a particular direction. The interviews lasted 15 to 43 minutes and were structured by the following four primary questions, which were able to stimulate engaged feedback:

(1) Can you describe your first encounter with the box?

(2) What do you use the box for?

(3) What do you think is the purpose of the box?

(4) Do you read online newspapers?

Each one of the 9 user-feedback sessions was initiated in the corridor in front of the Hearsay speaker to provide the participant with the opportunity to listen to a couple more comments and refresh their Hearsay user experience before the interview. After this short introduction, the participant was invited into a quiet room across the floor and an audio recording device was switched on. All of these interview recordings have later been transcribed for the analysis.

6.4.1 Data Analysis

The analysis of the transcripts followed an adapted thematic analysis approach (Braun & Clarke, 2006). The author of this thesis read through the text assigning codes to label interesting passages. These passages or codes were revisited and then summarized to higher-level themes, which are used to structure the presentation of the findings in the following findings section.

6.5 Findings Hearsay

We start with reporting findings regarding the general use and appeal of the Hearsay installation. Hence, these observations deal with the aesthetics and design of this specific device. Then, we go on to summarize user feedback and reactions that point to issues around online newspapers and user comments. These are primarily findings from the interviews, which illustrate how Hearsay facilitated a critical reflection on the participants' own reading habits and self-reflection. Subsequently, we consider phenomena in the data set that deal with *de/re-ctx* as a means to provoke engaging thoughts, in particular with regard to remembering, solving puzzles, curiosity or similar related mental activities.

6.5.1 Hearsay from a Design and User Experience Perspective

Within the study period, both buttons were pressed a total of 292 times according to the log files (147x green, 145x red, i.e., a rounded 15 times per day). Overall, the participants complimented the design and described it as "elegant and simple" (P2), "looking retro" (P3) and stated that the "buttons were clearly an invitation for use" (P3). Furthermore, Hearsay was understood as an art piece by P1 and P4: "It looks like an exhibit" (P4). P3, on the other hand, was reminded of some sort of intercom, however, the buttons were remarkable to him:

"But why red and green? – This does not match an intercom. This was my first thought".

Nevertheless, as all participants except one person (P2) read this particular online newspaper at least a couple of times per week, everybody except P2 figured out surprisingly quickly where the messages (comments) originated from. This was due to the characteristic red and green 'notches' of the rating system, which have been translated to the red and green buttons and are also called 'notches' by the text-to-speech computer voice. The quality of this voice (pronunciation, etc.) was perceived as "surprisingly pleasant" (P8) by all participants. P6, for example, associated "official announcements" with Hearsay because of the flawless voice quality:

"Because it is read out by such a professional computer voice, it has a formal appeal … like an official announcement."

From a general user experience perspective common descriptions for interacting with Hearsay were very different, for example, "suspenseful", "amusing" and "provocative", and the system was said "to put the users into a curious frame of mind" (P4).

6.5.2 Hearsay as a Critical Design Piece, Food for Thought

This 'provocation' among other things had to do with Hearsay*'s* pre-sorting and selection of reader comments that were "polarizing" (P3) or extreme in their ratings. P3, for instance, put it like this:

"Yes, I read [online] newspaper comments. In particular those of DER STANDARD, because they are easily accessible. And above all I think the rating system is pretty enthralling. Somehow it's really fun to have a directed look at the green or red ones, because it's them, who polarize […]."

These 'extreme' comments or opinions often left the participants in amusement, agreement or disagreement. In any case, Hearsay engaged the participants in a kind of 'meta' or reflective thinking about their own newspaper reading behaviours and the role of user comments in news sites. We therefore propose that the Hearsay installation functioned well as a piece from *Critical Design* (Bardzell, Bardzell, Forlizzi, Zimmerman, & Antanitis, 2012). Some of the participants, for instance, admitted that they regularly spent more time reading the article comments than they actually intended to. Likewise, P3 cited in the paragraph above, continued:

"I also think it is a pity that other news sites don't feature this commenting and rating system … On the other hand, now that I think about it … the system actually is a bit bothersome, because often time you find yourself drifting away, even though you intended to read one article for 3 minutes only […] and then you get lost in the comments and spend much more time on the article than you wanted to, because you read them all … and they weren't even that enlightening in the end."

Similar, P6 asked himself:

"I question myself why I read the comments at all, because actually I think they are foolish or cruel in the first line. […] It's addictive to read the comments, however, their quality seems to become worse and this might finally cure me."

There was also evidence from the interviews that the reader comments can have an influence on the own opinion about a certain topic. P7 saw this in a relatively positive light:

"[The comments] give you a new angle on the topic."

In contrast, P9 realized that he does not appreciate the way his opinion shifts easily:

"Sometimes it is a bit bothering me, how easily I float with the tide. One comment with a lot of greens can immediately change my opinion by 180 degrees."

P3 and P2 were more critical as well:

"If you get a, for instance, very populist comment on a certain topic, then you may certainly think 'yes, he is right'. However, if someone argues against this populist thinking in a reasonable fashion, then you might think 'well, maybe it's not that simple'. Sometimes you become too opportunistic when reading the comments. You should be careful when reading these populist comments" (P3).

"It makes you question whether you share an opinion or not. You relate yourself to the comments and ask 'where is my position?'" (P2).

"The device was thought-provoking at times … I remember clearly about that one comment. It was a bit longer. It made me think. And then I went back down the corridor and kept thinking about it … It wasn't a foolish comment, it was appropriate. And then I went slowly back to business" (P3).

6.5.3 Specific Reflections on Society

Other quotes revealed that reading user comments resulted both in thinking about societal issues and about society itself. Participants dealt with the content of the messages, however, they also asked about the senders of these messages:

"The comments are influencing my opinion … not on the article, but on the society I live in. It gives me a sense of what's going on. The users would not post the comments if they weren't an issue to them. […] Sometimes I even ask myself how could one possibly post such an comment" (P4).

P1 and P2 expressed related considerations with the following words:

"I think by myself 'cool' this is what the people are currently struggling with… this is online democracy … they either applaud or yell 'boo' […]" (P1).

"[…] You are requested to listen to a variety of different opinions … and all of this in a playful manner and randomized … so you cannot restrict yourself to the most convenient topics, but you are listening to a multitude of different opinions on different topics, which you never would have heard of and you get to know what the people are currently thinking about and what is moving them" (P2).

Like magnified detail shots, these individual newspaper comments give a glance on certain aspects of what is currently being discussed among the people, and Hearsay directed the attention of the participants to these voices.

6.5.4 Remembering

Besides these examples of how the participants dealt with societal issues, there is also evidence for Hearsay*'s* potential to trigger individual or personal memory processes by means of its de-contextualized comments. Some of the participants (P1, P2, P5, P6, P9) directly related some of the news comments to their own life, for example:

"I remember this one comment quite vividly. I am a pretty sure that I have even read the corresponding article on the newspaper. That's one reason why I remember well. […] It was about the poor conditions of the subway […] all the dirt on this one particular line and so on … It made me remember this one particular hot day and it was so crowded [in the subway], it was exhausting and rather nasty" (P9).

"Well, they were talking about waste and shopping. Something about planned obsolescence. This made me a bit annoyed, because it reminded me that I have recently bought a phone that broke after a couple of weeks. Damn planned obsolescence. I think I also read the news article to this comment" (P8).

6.5.5 Putting the Pieces together, 'Puzzling'

As mentioned before, Hearsay aroused the participants' curiosity. P5 explains his own theory about this:

"[…] It's because the comment is a puzzle … it's the puzzle that makes me listen to it. Actually it's two puzzles. First, 'what kind of device actually is this'? ... With its illuminated buttons and so inviting … Then you press one of the buttons and try to figure out, what's coming out of the box. And that's the second puzzle … which news article belongs to that comment?" (P5)

"There are two sides to each puzzle. The first side is, 'do you really want to figure it out'? And the second one is, 'are you actually able to figure it out'? The first one is a prerequisite and the second one is a question about skills or knowledge" (P5).

This 'puzzling activity' was enjoyed by all of the participants. Some of them reported that they tried to "deduce the bigger picture starting from the details" and finally aimed to put "the puzzle back into place" (P8).

6.5.6 "Out of Context"

We were very cautious in the interview not to mention phrases like 'out of context' or 'removed from its original setting' or similar expressions, because we were interested to see whether the participants would refer to Hearsay*'s* underlying design concept without being prompted. Nevertheless, all but one participant (P7) directly referred to the *de-contextualization* principle within the interviews. P1, for example, made the following related observation:

"I think it is a transformation regarding the medium. It is transformed from comments to text-to-speech. That is the first transformation. The second one is, that it is re-

moved from the context … from the website as well as from the article and the other comments."

P4, P5 and P6 had similar considerations, for example:

"I think it is original. The comments fall out of line, because I only know them from the Internet and news sites. You usually don't have it like this. It is removed from its everyday context, so to speak. That's why it caught my attention" (P4).

"I think the idea of de-contextualization heavily depends on the fact that it is being read out" (P5).

"The speaker appeals to me most, because it sets up a whole new context" (P6).

P5 elaborated further (on request of the researcher):

"Creating context is one of our very strengths … to give things a meaning. This is such a strong instinct … We make meaning all the time. […] The funny radio is the trigger, if you ask me. […] It's an invitation to make sense."

In summary, the participants surprisingly often used wordings such as "out-of-context" during the interviews. They admitted that at times interpreting the comments was hard, however, they enjoyed trying to reconstruct the missing information and found "[...] it fascinating that some arguments perfectly make sense without context" (P1) and to most of them it "was enthralling to try figure out the original context" (P8).

6.6 Chapter Summary, Design Implications and Thesis Contribution

In this chapter we have considered the concept of *de/re-ctx* of information and how it can be employed for creating thought-provoking interactive systems. We (as designers) introduced three instances of *de-contextualization*: (a) the removal of the comments from its original news story, (b) the separation of the online newspaper as a whole with only 'notches' as hints to the original context, (c) the transformation of text into speech.

On the user or participant side, this initiated a process of *re-contextualization* and sensemaking of the presented information. We go on to discuss what the findings in the study meant to the participants as well as what should be taken into consideration by designers when incorporating this instrument or method into their systems. In particular, we suggest how *de-/re-ctx* might be employed in augmented memory design and theorize about the principle referring to Höök and Löwgren's idea of *Strong Concepts* (Höök & Löwgren, 2012).

6.6.1 Specific Reflections on the Hearsay Installation

Although the primary contribution of the study is the elaboration of the *de/re-ctx* concept, for completeness we briefly recapitulate specific insights on Hearsay in relation to online news. Admittedly, some useful functions of the installation might spring from its overall design and topic domain, and not solely from the principle of *de/re-ctx*. Nevertheless, *de/re-ctx* might well have functioned as a powerful catalyst for unveiling *specific* aspects of our online news consumption and *made* the Hearsay installation.

On a variety of occasions Hearsay stimulated its users to reflect on things people said or posted, as the installation confronted them with random and different opinions. In many cases, their reaction was being amused or entertained, however, some comments also made the participants angry or let them revisit their own opinion on certain topic aspects. Also, the intervention led to considerations on societal issues. After all, Hearsay can be said to have functioned as a multipurpose tool that at times was uncomfortable and thus was able to open up new perspectives. This was particularly true regarding the participants' consumption behaviour of news articles.

This finding interestingly points to a well-cited evaluation of news consumption. Iyengar and Hahn (2009) showed that consumers selected their favoured news source on anticipated agreement. As a consequence, Republicans ended up with 'Republican TV' (e.g., *Fox News* is widely considered *conservative*) and Democrats consumed 'Democrat TV' (e.g., *CNN*) (Iyengar & Hahn, 2009). This kind of selective exposure and polarization, however, minimizes the encounter of different, maybe inconvenient opinions. Admittedly, Hearsay obtained its comments from only one particular news source. Still, we hypothesise that one specific strength of the application was to break *selective exposure* against *attitude homophily* and to promote greater reflection about what opinions we usually pay more attention to.

In addition to the occasions where participants encountered unfamiliar news items and different opinions, there were also some situations in which a participant remembered reading one particular article, at times relating it to their own life even. Hence, the comments served as a memory trigger, both supporting remembering the article and autobiographical remembering. The process of *re-contextualization* was in this instance a re-matching between comment and article, and also recalling information from a broad context.

Admittedly, it can be argued that the participants' reflections were caused by the interview and not by the installation. However, for this reason we kept the interviews as open as possible and let the participants talk with very few interruptions. Moreover, on many occasions the participants described reflections they already had before the interview session.

6.6.2 Reflections on de/re-ctx as a Strong Concept

As P5 stated, we seem to have a strong desire to make meaning of our surrounds. It can be hypothesised that this is the most important underlying principle of *de/re-ctx* as a concept for the design of thought-provoking interactive systems. Similar considerations were brought forward by Leong et al. (2008), who investigated the use of *randomness* as a resource for design:

"Encounters with randomness exploit our natural urge to interpret and our tendency to try to make sense of things when engaging with content in unpredictable and unexpected ways" (Leong et al., 2008, p.13).

Similarly, the Hearsay and *de/re-ctx* concept challenged the curiosity of the users and a desire to make sense of the presented information. Besides this intellectual effort in sensemaking, people also engaged in the already mentioned processes of self-reflection.

We have seen a number of illustrative examples for the usefulness of the proposed concept. But how to theoretically proceed with *de- and re-contextualization* as a resource for design and to establish it as a provocative design strategy? As indicated throughout the chapter, a promising chance for developing the design principle might be offered by Höök and Löwgren's *Strong Concepts* (Höök & Löwgren, 2012). The authors describe this theoretical construct as "intermediate-level design knowledge", because it involves insights that are more abstract than particular design pieces, and yet does not constitute a 'full-fat' theory (cf. Section 3.2). They summarize that a *Strong Concept*

"… is generative and carries a core design idea, cutting across particular use situations and even application domains; concerned with interactive behaviour, not static appearance; is a design element and a part of an artifact and, at the same time, speaks of a use practice and behaviour over time; and finally, resides on an abstraction level above particular instances" (Höök & Löwgren, 2012, p.1).

While in this chapter we have provided one particular instance – the Hearsay installation – we propose that there are many more use situations and application domains, which can benefit from *de/re-ctx* as a resource for interaction design, in particular with regard to augmented memory system design (see Section 6.6.4). This is also evident from this chapter's related work overview (Section 6.2.2), where in particular Gaver et al. (2003) already employed notions of contextual ambiguity in interaction design. Leong et al.'s considerations into randomness (Leong et al., 2008; Leong, Harper, & Regan, 2009; Leong et al., 2006) also involve context, as arbitrary encounters generate unusual combinations and hence de- and re-contextualize meaning. All this research, including Hearsay, plays in various ways with notions of de- and re-contextualization. Thus, on a more abstract level these experiences can support the drawing out of *de/re-ctx* as a *Strong Concept*. If we succeed in strengthening *de/re-ctx* by creating additional useful instances in different domains and reflecting on them, the concept can become intermediate-level design knowledge, that is, be part of the interaction design repertoire and improve or inspire interactive applications.

6.6.3 How to employ de/re-ctx in Design?

We consider the following three factors important for employing *de/re-ctx* in a successful design and use the Hearsay example for illustration.

First, the design of the interactive system should set up the right frame of mind for its intended use. Hearsay, for example, was perceived as "retro", "homey" and "inviting". Also, the synthetic voice was perceived as pleasant or realistic and thus supported a positive user experience. At the same time, the installation was a bit mysterious. This combination appeared to be just right and the participants knew how to encounter it. In addition, the medium was transferred from text to audio, which hinted at the 'out-of-context' theme according to the participants, and also contributed to creating the appropriate aesthetic for the particular ends of the installation. So far, we have referred to the users when reporting processes of re-contextualization (e.g., matching comment and news story). However, it is interesting to note that re-contextualization was also applied by us as designers. For instance, textual reader comments were re-contextualized in a voice and also found a new 'housing' in the wooden Box of Hearsay.

Second, the application should give clear hints on its purpose or function. All participants except P2 realized very quickly what Hearsay was about and soon began to engage with the system. P2, on the other hand, who did not read the corresponding newspaper with its well-known social commenting system, initially lost interest in the installation. When a friend explained to her what the purpose of the device was, she picked up interest in the installation and even started to read the related online news. The lesson learnt from a designer's perspective is to try not to be too mysterious and provide clear indicators for the system's intentions and functions.

Third, the trigger or cue per se must be appropriate. In the case of Hearsay, many of the successful cues were amusing and the participants could relate to them, or interpret them in their own manner (Sengers & Gaver, 2006). Thus, this entertaining element was motivating and the process of re-contextualization did not end in frustration. Other successful triggers were the provocative ones, because of their extreme positions (viewpoints) that challenged the participants. Also, with Hearsay's huge database, there were enough cues for browsing and finding interesting ones. In summary, there is clear evidence in the data set that the participants enjoyed the activity of making sense and 'putting the puzzle together'. Interestingly, it was not necessary for the participants to figure out the *correct* context of each reader comment to have a meaningful user experience. Wrong deductions or no ideas about the origin at all could also lead to insights.

6.6.4 De-/re-ctx in Augmented Memory System Design

We suggest that there are many additional system domains, which pose promising ground to 'play with context' (see also the related interactive system Section 6.2.2 of this chapter). Other system domains that build on *de/re-ctx* comprise, for example, the above-mentioned applications, which remove context in order to make information more *interesting*, *suspenseful* and *inspiring*. To this end, Gaver et al. stripped contextual information from commercial advertisements and flight routes (Gaver et al., 2008), public images (Gaver et al., 2011), and news headlines (Gaver et al., 2010). Tieben et al. presented 'out-of-context' noise, to create and study curiosity (Tieben et al., 2011).

One application area that promises to particularly benefit from the *de-/re-ctx* concept is augmented memory systems or *lifelogging* (see Sections 2.3.3 and 2.3.4). In fact, one of the primary reasons for this thesis's explorations is that researchers began to postulate about *deliberately capturing memory retrieval cues* instead of attempting to record as much data as possible ("total capture"). These cues then can be revisited and employed by the user to engage in activities such as recollection, reminiscing, or reflection (Sellen & Whittaker, 2010), and to reconstruct and relive memories in their mind (Hoven & Eggen, 2008; Sellen & Whittaker, 2010). André et al. (2011), for instance, used random public images such as old advertisements to trigger reminiscence and nostalgic feelings. As we have observed processes of (autobiographical) remembering within the Hearsay study, we propose that 'out-of-context' display of such cues can be employed to support reflection on one's past. Thus, *de/re-ctx* as a strategy might be particularly useful in the service of augmented memory systems. To facilitate such recall and reflection, *de/re-ctx* presentation might be a powerful alternative to revealing all available cue data at once and immediately. We have already seen this in the single entity technology probes of Chapter 5 (EyeOfDetail, ForgetMeNot and Audio Peephole). ForgetMeNot, as a quick and exemplary reminder, 'extracted' parts of a photo as a *de/re-ctx* cue and presented them to the user. This focused the observer's attention and highlighted specific details in the photos. The user now had to make sense of this isolated excerpt and to connect it back to the broader picture.

6.6.5 De-/re-ctx and the CuDe Framework

The Memory Cue Design Framework (CuDe Framework) proposes the distinction between a *single* and *multiply entity level* of analysis and intervention. On the *single entity level*, we introduced the processing of media files (e.g., the filtering or masking of an image) as a strategy for designing meaningful memory retrieval cues. Based on the evidence of this chapter and the Hearsay study we suggest that the design concept of *de-/re-ctx* can be used as an interpretive device to explain the potential of such processing strategies: if data or memory cues are removed from a larger set of cues, and the users have to make sense of this information, this can lead, as our Hearsay data set

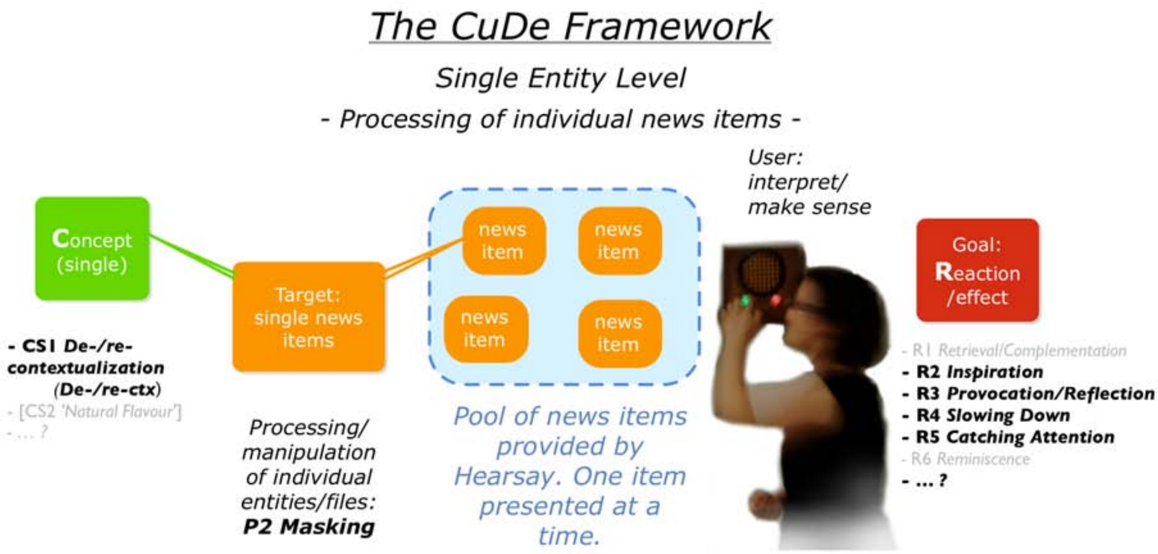


Figure 6.4. The Hearsay installation explained by CuDe as an analytical device. Items of particular relevance are printed blacked, others are greyed out.

suggests, to a deep engagement with the presented media entity. For this reason, we assign *de-/re-ctx* to the conceptual dimension of the *single entity level* of the CuDe Framework.

We explain Hearsay in Figure 6.4, using the terminology of CuDe. This illustration shows how the interactive installation (conceptually) operated, in particular, how single news items (entities) were processed (parts of the context were *masked*), and this let to specific user reactions such as reflection.

De-/re-ctx can contribute to a broader understanding of the 'appeal' of applications such as Hearsay or, for example, EyeOfDetail and thereby also inspire further related designs.

Having proposed interactive systems on the *single entity level*, and having conceptually illuminated one possible underlying working mechanisms, we now turn to augmented memory systems, which make use of multiple entities.

Part III: Multiple Entities

7 Initial Probes and Pre-studies (Multiple Entities)

This chapter introduces Part III of this thesis and focuses on digital designs for supporting remembering, which feature multiple entities (i.e., media files). While Part II employed one entity at a time, the following proposals made use of multiple entities to facilitate meaningful remembering experiences such as reminiscence and reflection. This also involved the invention of novel file formats (featuring multiple entities; see MEO, Chapter 9). As a consequence, Part III deals with both data representation and capturing in contrast to Part II, which involved only data displaying. This is a necessity caused by the novelty of the concepts of our multiple entity applications. As these ideas and file formats are new, corresponding files had to be created or captured by the participants in the course of the user study.

The initial probes Pro.4 (the Duography application[11], also named 2sidez for *Android*) and Pro.5 (ContextShaker) operated with multiple files and are thus described in this third part of the thesis. These applications were developed and tested in parallel to the single entity probes Pro.1-3 (Part II). As with Part II of this thesis, the initial probes were succeeded by the development of more advanced prototype systems (Duography version 2, Chapter 8; and MEO, Chapter 9), which picked up feedback from these initial explorations.

With regard to information capture, these applications of Part III of the thesis dealt with the synchronous and asynchronous recoding or composition of media entities (SEC/AEC). For revisiting this information this meant that all recorded and related entities were exposed to the user at the same time or are available immediately, as opposed to being revealed one after the other or over a period of time. This will be detailed when the functions of the corresponding applications are described. We now briefly discuss the motivation of the multiple entity probes.

7.1 Multiple Entity Prototype Motivation and Design Strategy (Pro.4-5)

The four challenges identified in the literature review (see Section 2.3.5) informed the design of the multiple entity prototypes. While in this chapter we only pre-

[11] The Duography application is a mobile phone software implemented for *Android*. In *Google Play* it can be found by the name of *2sidez*. In this thesis we call the app both *Duography application* and *2sidez*. In fact, 2sidez was created for capturing *Duographs*. In earlier publications (Güldenpfennig & Fitzpatrick, 2011; Güldenpfennig et al., 2012b; Güldenpfennig, Reitberger, & Fitzpatrick, 2012c; Güldenpfennig, Reitberger, Ganglbauer, & Fitzpatrick, 2014) 2sidez or the Duography application was labeled as *BehindTheCamera* (*BTC*), but we don't use this latter name in this thesis for simplicity.

sent the initial probes Pro.4-5 in detail, we nevertheless refer to the more advanced implementation Duography version 2 (Chapter 8) and MEO (Chapter 9) up front. These follow-up prototype applications resulted from the literature research and from our experiences with Pro.4 and Pro.5. For this reason and for completeness, Table 7.1 presents information on the ideas behind the probes and on their evaluation, as well as on Duography and on MEO.

7.1.1 Supporting Creativity

With both of our probes Pro.4 (Duography version 1) and Pro.5 (ContextShaker) we aimed at supporting creativity, as we observed the occurrence of creativity in the context of digital memory systems in the literature review (see Section 2.4.1.3). We hypothesised that Duography (see below) would enable the capturing of original and unconventional photos. The concept of ContextShaker was based on a creativity technique (to be detailed in this chapter).

7.1.2 Reconstruction of Memories

It was our goal in the implementation of the multiple entity probes and also the more advanced implementations of Duography and MEO, that the availability of multiple files, that is, memory retrieval cues, can support the recreation of past moments. Our hypothesis is that each entity contains a certain number of retrieval cues and that the (a)synchronous 'consumption' of these cues can be used by the human mind to put the 'memory jigsaw' back into place.

7.1.3 Information Overflow and Efforts to Create Order

Although not in the focus of this chapter, we state up-front that the concept of MEO was inspired by the problem of too much created personal information (see also Section 2.4.1.1), as this application introduced structure to the captured data (see Chapter 9).

7.1.4 The Invisibility of Digital Data

The challenge to make digital information more visible also contributes to the design of MEO. This will be explained further in Chapter 9.

Table 7.1. Overview of the studies in this thesis, which involve *multiple entities*.

Study and Study Target	Application Idea/Concept (Multiple Entities)	Evaluation
P-C.1: **(Pro.4)** Duography *(2sidez for Android*, version 1*)*	• Revisiting and capturing *combined memory cues* • Exploring memory cues, which consist of multiple aggregated cues or entities and which were composed *synchronously (*synchronous entity composition; SEC*)* • Exploring how these combined cues mutually alter meaning	• *Informal evaluation*: demonstration of 2sidez for *Android* (version 1) to interested people. Usage during the visit to the zoo by one person with subsequent interview • Data collected: interview and photos captured by the participant • Analysis: review of the interviews and log data for interesting observations
P-C.2: **(Pro.5)** ContextShaker	• Revisiting *combined memory cues* • Exploring memory cues, which consist of multiple aggregated cues or entities and which were composed *synchronously (*synchronous entity composition; SEC*)* • Exploring how these combined cues mutually alter meaning	• *Informal evaluation*: demonstration of ContextShaker to interested people. • Data collected: interviews • Analysis: review of the interviews interesting observations
DUO.1: Duography proof-of-concept study *(2sidez for Android*, version 2*)*	• See **P-C.1** (the same application idea as previous, however, studied in a different context and with an advanced implementation of the software)	• Setting: 2sidez app offered as free download on *Google Play* • Participants: > 115.000 user installations • Duration: 433 days • Data collected: interaction log data • Analysis: descriptive statistical analysis
DUO.2: Duography in everyday situations *(2sidez for Android*, version 2*)*	• See **P-C.1** (the same application idea as previous, however, studied in a different context and with an advanced implementation of the software)	• Setting: field study • Participants: 8 • Duration: 10 months • Data collected: participant-created Duographs Analysis: thematic analysis of Duographs
DUO.3: Duography in interaction design education *(2sidez for* Android, version 2*)*	• See **P-C.1** (the same application idea as previous, however, studied in a different context and with an advanced implementation of the software)	• Setting: field study • Participants: 30 • Duration: 2 weeks • Data collected: participant-created Duographs • Analysis: thematic analysis of Duographs

Study and Study Target	Application Idea/Concept (Multiple Entities)	Evaluation
DUO.4: Duography in the art education (2sidez *for Android*, version 2*)*	• See **P-C.1** (the same application idea as previous, however, studied in a different context and with an advanced implementation of the software)	• Setting: field study • Participants: 18 • Duration: 12 weeks • Data collected: participant-created Duographs and interviews • Analysis: thematic analysis of Duographs and interviews
MEO.1: Media Object (MEO) in everyday life situations	• Revisiting and capturing *combined memory cues* • Exploring memory cues, which consist of multiple aggregated cues or files and which were composed *asynchronously (*asynchronous entity composition; AEC*)* • Exploring how these combined cues mutually alter meaning	• Setting: field study • Participants: 7 • Duration: 2-5 weeks • Data collected: participant-created Media Objects, semi-structured interviews • Analysis: thematic analysis of Media Objects and interviews
MEO.2: Media Object long-term evaluation	• See **MEO.1** (the same application idea as previous, however, studied in a different context)	• Setting: field study • Participants: 10 • Duration: 24-28 weeks • Data collected: participant-created Media Objects, semi-structured interviews • Analysis: thematic analysis of Media Objects and interviews
MEO.3: Media Object content relation	• See **MEO.1** (the same application idea as previous, however, studied in a different context)	• Setting: field study • Participants: 18 • Duration: 2 weeks • Data collected: participant created Media Objects, informal interviews • Analysis: thematic analysis of the Media Objects

7.2 A Note on the Evaluation of the Probes

As already outlined in Section 5.2, the methodological approach to this *thesis is design-based research* (*DBR*; see also Section 3.3), and so the focus is not on evaluating these applications by rigorous 'scientific' studies. Rather, we used them as an entry point for gaining research guidance through participant responses. Therefore, we gave the applications (Pro.4 Duography, Pro.5 ContextShaker) to a number of people and asked them to use the applications as they wished. (The corresponding user studies have the identifiers P-C.1, and P-C.2). Both their reactions and the experiences we gained by elaborating our own thoughts and ideas during the act of making informed the design of expanded prototypes to be studied in greater detail in the subsequent chapters. Table 7.1 contains further details on the evaluation of the probes (P-C.1 and P-C.2). Moreover, it provides 'preview-information' on the studies of the more elaborate systems (DUO.1-4, MEO.1-3), which are to be reported in the further course of Part III of the thesis.

We go on to describe the initial multiple entity probes Pro.4 and Pro.5.

7.3 System Descriptions and Motivations Pro.4 and Pro.5

7.3.1 Pro.4 Duography

Both single entity probes ForgetMeNot and EyeOfDetail of Part II aimed to provide a novel perspective on existing photos. Duography (Pro.4) takes a different approach to augmenting reminiscing with media files by adding *additional* information during the process of capturing new photos. Duography adds novel perspectives to digital photography, as this mobile phone application (registered by the name of 2sidez on *Google Play*[12]) triggers both front and rear camera of the device synchronously and hence adds a second 'dimension' to conventional photos (i.e., two photos with opposing perspectives are created). This kind of photo app is enabled by the design of modern smartphones, which integrates two cameras into good quality phones. One camera on the back of the phone and one additional front camera, principally designed for video-phone calling. If the user is now taking a picture, the application triggers front and rear camera at the same time when the user is taking a picture. As a consequence, the photo does not only contain the target image, but the photographer as well (or whatever what was positioned in front of that additional camera when it was triggered).

This process is shown in Figure 7.1 where we can see a person taking a photo of a flower. Here the application captures the photographer with the front facing camera (f) and the plant with the rear camera (r). The result is what we call a Duograph (short: Duo): a photograph, which features two sides.

[12] https://play.google.com/store/apps/details?id=com.behind.the.camera (last accessed 9 September 2014)

We hypothesise that this simple application will deliver interesting meta-information and insights, especially as time passes by. Duography draws a more complete picture of the whole scene. This is illustrated by the images of Figure 7.2, for example, which captured the interplay between animal and person.

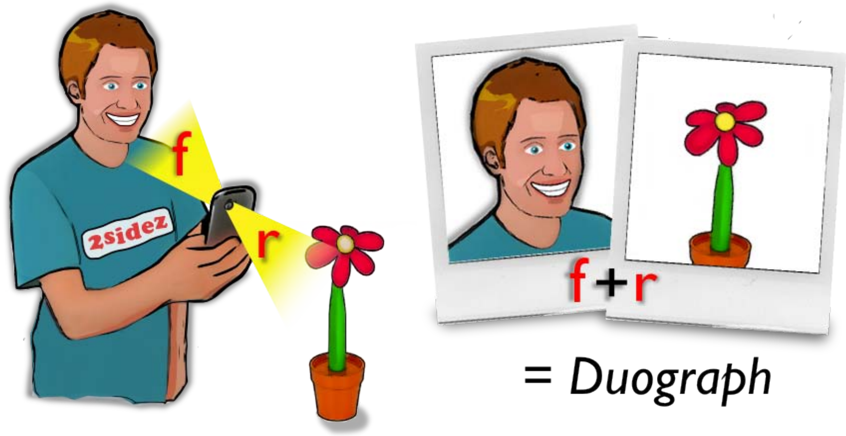


Figure 7.1. Capturing a 'two-sided' photograph (= Duograph) with a mobile phone. Left: front (f) and rear (r) cameras are triggered synchronously. Right: this results in a Duograph, that is, a 'two-sided' photo showing both photogtapher (f) and motif (r).

Figuratively, the Duography application conforms to Langer's definition of a mindful state of being, because it allows for more than one perspective and it is welcoming new information (1989, p.62). Hence, the application eventually will be able to promote a deeper experience for the observer in contrast to just viewing a regular image. Fleck and Fitzpatrick (2010) also talk about the value of seeing from different perspectives to support reflection. Moreover, we hypothesise that a Duograph will provide valuable retrieval cues, which are of great importance for recollection and remembering (Tulving & Pearlstone, 1966). The photographer not only possesses the image, but also a self-portrait of him/her taking the image. This additional portrait can potentially trigger memories, because it provides the observer with additional retrieval

Figure 7.2. Duograph taken at the zoo. Left: motif. Right: photographer.

cues (see also Section 2.2.1). Recalling the way the photographer felt at that instant, for example, can support recalling the whole context. Emotional states not only have an effect on memory encoding, they are also able to facilitate memory retrieval (Buchanan, 2007).

7.3.2 Pro.5 ContextShaker

ContextShaker (see Figure 7.3) aims at fostering reminiscence and reflection by means of publicly available memory triggers (similar to Pro.3 Audio Peephole). While recent research by André et al. (2011) employed the display of nostalgic advertisements to this end, ContextShaker uses online news stories and social media as source material to engage people in provocative thinking. We don't restrict our concepts to the 'static' display of digital content, but seek to 'experiment' with memory retrieval

Figure 7.3. ContextShaker device.

cues by combining or showing them in unusual contexts (see description below). Due to this kind of interaction design, ContextShaker doesn't primarily deal with autobiographical remembering (as the other prototypes in this chapter). Rather, it also plays with notions of *collective memory*, as it incorporates recent news stories and social media that reflect current concerns of the society (cf. Sections 5.3.3 and 5.4.3).

The specific idea of ContextShaker springs from a known creativity or ideation method as outlined, for example, by Mangold (2007). Here the author describes how the juxtaposing and associating of two originally unrelated stimuli, for example, an image and written words, generates new meaning and ideas, which does not arise from reading the isolated stimuli. This concept is now translated into software and hardware by the ContextShaker. The shaking of the device starts both the download of a random photo from the Internet and a random headline or quote from an online newspaper. Both stimuli are then combined by juxtaposition as illustrated in Figure 7.1. Here, we can see ContextShaker as it displays a random photo featuring a bride and groom in front of a building and a random quote next to the image, which reads:

"We have been waiting for this moment for years and now we are at peace because he is gone". Again shaking the devices shows another combination of photo and message entities.

7.4 Participant Feedback P-C.1 and P-C.2

Analogous to the single entity probes (Pro.1-3), the two initial prototypes (Pro.4 and Pro.5) presented in this chapter constituted the starting point of our research into multimedia data as triggers for meaningful memories, and we were keen to probe some participants for their reactions. Following a design-led research methodology, our primary aim for these first evaluations was to gain guiding user input and inspirations for iterated, similar or perhaps different prototypes.

A summary of the evaluation setups can be found in Table 7.1

7.4.1 P-C.1 Duography

The Duography or 2sidez application (Pro.4) was given an initial testing by one participant (female, 28 years old). The application was used during a visit to the zoo. One snapshot (Duograph) of this occasion is displayed in Figure 7.2. The participant commented on this Duograph that the animal picture will surely lose of interest as time passes by. On the other hand, the image of the photographer might gain interest in the future. Overall, the feedback on Duography from the participant and from many more people that heard about the concept for this application was so encouraging that we decided to implement an advanced version (Duography/2sidez version 2, with bug-fixes, and more comfortable to use) for *Android* mobile phones and continue studying it. In the discussion of this chapter, we highlight what particular aspects of Duography served as a recommendation to further investigate this concept and to iterate on the application. For comprehensive findings on Duography (resulting from extensive user studies) we point to the dedicated chapter (see Chapter 8), where this application will be described in great detail.

7.4.2 P-C.2 ContextShaker

ContextShaker (Pro.5) was demonstrated to members of the HCI Group and informatics students of Vienna University of Technology in order to ask them for their feedback. We chose this rather informal evaluation strategy, as these devices were conceptualized from the very beginning as initial probes to gather inspirations for further developments.

ContextShaker produced similar reactions as have been reported on the creativity technique, which served as its 'blueprint' (Mangold, 2007). Figure 7.3 showing bride and broom and the accompanying quote ("We have been waiting for this moment for years and now we are at peace because he is gone"), for instance, evoked very different interpretations. One participant put it like this: "The bride had to get divorced from her former husband to be able to marry the new guy". This was also the interpretation of most other participants. However, originally the quote came from a completely different context, as it was a statement on the overthrow of Muammar Gaddafi reported on the news. It was fascinating to see, how the combination of cues or triggers (different image and text entities) completely altered their perception, interpretation and thus meaning. In conclusion, ContextShaker sharpened our awareness that memory triggers can have different propositions when presented in different contexts. Hence, when applied in augmented memory system design, we must consider that the choice for synchronous (or isolated) display of cues might alter the reconstruction of the memories.

In summary, we observed that the participants enjoyed using ContextShaker, and making sense of the presented information, that is, interpreting the cues. Both sides had to be 'brought together' (the photo side on the left, and the text side on the right) to make meaning of the two different data entities. We go on to explain how the observations on ContextShaker and Duography informed succeeding research.

7.5 Multiple-Entity Probes Summary and Discussion

In this chapter we have seen two different initial prototypes that played in different ways with digital media as memory retrieval cues. They covered processes of media capture as well as revisiting previously captured data. Moreover, they both involved multiple digital files, that is, they incorporated multiple entities.

Duography (Pro.4) added an additional 'dimension' to conventional photos, and thus increases the amount of possible memory triggers. ContextShaker (Pro.5) combined multiple and unrelated cues by juxtaposition to explore if and how media that is present at the same time mutually alters its meaning.

The observations on these initial probes (user studies: P-C.1 and P-C.2) led to the design of more elaborated prototype applications (Duography version 2 and MEO), which will be presented in the subsequent chapters. Before we move on, we explain which findings or lessons learnt from the probe studies had a particular influence on their concepts. We relate this to the challenges in augmented memory system design identified in the literature review (compare Section 2.3.5).

7.5.1 Lessons Learnt and Taken Forward

7.5.1.1 Alternative and Playful Approaches to Capturing and Representing Data

As with Pro.1-3, we again observed the participants' openness for playful approaches to revisiting digital souvenirs. Both Duography (Pro.4) and ContextShaker (Pro.5) received positive feedback for their rather uncommon presentation of information. This time, however, the concepts were not restricted to data representation; through the Duography application the participants were also enabled to capture information in a novel way. Due to a very positive response, we decided to study Duography in greater detail. We continue the research on Duography in the following chapter with a re-implementation of the 2sidez software to improve usability and general user experience. In particular, we are interested in the interplay between front and back photo, and how the photographer makes use of these two related pictures to frame digital memories.

This leads to the notion of *creativity* in the context of recording digital souvenirs.

7.5.1.2 Creative Engagement

The Duography application (Pro.4) afforded different ways to express creativity. In the pre-study (P-C.1), for instance, we saw how our participant captured the interplay between sun and shadows by using the two sides offered by the application (see Figure 8.12A of Chapter 8 for a similar example). Figure 7.2 embodies creativity in a broader sense. Here, Duography enabled the capturing of the 'social dialog' between animal and photographer. Thus, Duographs made it possible to express situations in a rather unique fashion.

This is also one of our reasons for running follow-up studies of Duography. The interplay between front and back photo was such interesting in our as well as in the participant's eyes, that we wanted to learn more about the underlying working principles of this multiple entity application.

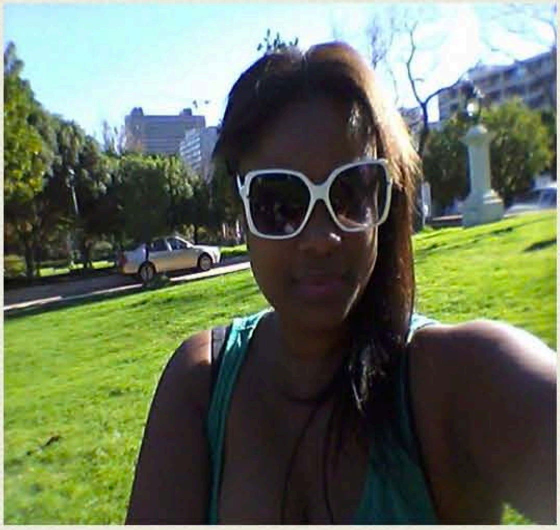
7.5.1.3 Reconstruction of Memories

We hypothesise that both Duography and ContextShaker were interesting vehicles for studying novel interventions for supporting memory with technology, because they provided the human imagination with bits of information to be 'assembled to some bigger picture'. In Duography, for instance, the observer could reconstruct the captured event based on these two synchronous sources of information. ContextShaker spurred the participants' imagination by the juxtaposition of two different information entities (photo and text).

We seek to further study Duography as a tool for supporting the reconstruction of past moments by providing two closely related building blocks/data entities (i.e., front and back photo). In addition, MEO picks up this concept by extending the idea of Duography and offering an interface for capturing arbitrary media files and combining them in an asynchronous fashion (see Chapter 9).

7.5.1.4 Personal Data vs. Public Data

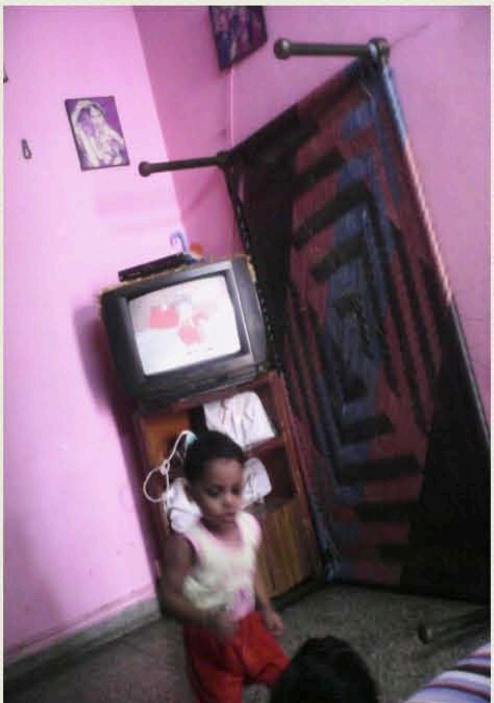
ContextShaker (Pro.5) and Audio Peephole (Pro.3, Part II of the thesis) both dealt with the consumptions of publicly available data. While the Hearsay installation is the direct successor of Audio Peephole, we do not introduce a multiple entity application as a response to ContextShaker in Part III of the thesis. However, as the technology probes haven been developed in parallel, our positive experiences with ContextShaker also encouraged the design of Hearsay, besides of being part of a different research strand.



July 22, 2013, 9:57 p.m.
by coco0306 at this location

lovely winters day

comments & details



8 Duography

Figure 8.1. (see opposite page). Recent posts on 2sidez.com. Clicking the Duographs will flip them around and reveal the back side.

In this chapter[13] we further investigate Duography, which was already introduced in Chapter 7 (initial probes). Figure 7.1 of Chapter 7 illustrates the process of taking a Duograph. This novel kind of photography (we call it *Duography*) is enabled by modern mobile phones, which ship with two built-in and opposite-facing cameras. These cameras can be triggered (almost) synchronously, and thus, Duographs are photos, which have, figuratively speaking, two sides. While one side is showing the motif, the other side captures the photographer (or whatever is located behind the mobile phone when the cameras are triggered). In the terminology of the CuDe Framework this kind of recording is labelled as *synchronous entity composition* (*SEC*; this will be discussed in detail in the summary of this chapter).

We created an application for *Android* called 2sidez (Güldenpfennig, 2013) for capturing these Duographs. To the best of our knowledge this software was the first one[14] designed for taking two-sided photos, and hence we were also first to introduce the concept of Duography.

The most distinctive difference of Duography in comparison with conventional photography is that 'Duos' most obviously posses one additional picture. This additional stimulus potentially opens a range of new possibilities both when capturing these novel (multi-dimensional) photos and when looking at them or interpreting them. In a way, one Duograph consists of two combined cues (front and back image). Naturally, each picture can again contain, strictly speaking, a number or a subset of cues that are contained within the corresponding photo. However, in this thesis our aim is not to analyse the content of individual photos or to break them down into their subcomponents. As our objective is to support the design of interactive systems, to us a cue is equated with a digital file (e.g., a photo) or the set of information, which can be captured into one digital file. Thus, we define a Duograph as a two-sided photo, which combines two cues (two entities) or which connects two pictures (= two formerly single files), and hence possibly opens up whole new perspectives.

To explore Duography and its affordance for combining cues, both in terms of capturing and also revisiting these two-sided photos, we conducted four studies (DUO.1-4), which are presented in the remainder of this chapter.

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[13] This chapter is based on one previous journal publication (Güldenpfennig, Reitberger, et al., 2014) and two conference contributions (Güldenpfennig et al., 2012b, 2012c). In these publications 2sidez was also named *BehindTheCamera* (*BTC*) or *BTC application*.

[14] The initial idea and an early version of 2sidez was published at the British HCI Conference 2011 (Güldenpfennig & Fitzpatrick, 2011). 2 years later, similar applications for taking two-sided photos were introduced to the market, for example, as a key feature of Samsung's flagship mobile phone *Galaxy S4* (Dolcourt, 2013). Approximately at the same time, *Frontback* (Dillet, 2014) was pushed into *Apple's* and *Google's* app stores at considerable expense.

As our work regarding Duography pioneered in HCI (and also in the commercial sector), the first exploration (DUO.1) constitutes a large-scale proof-of-concept evaluation for this kind of application. To this end, we deployed 2sidez in *Google's Play Store* (Güldenpfennig, 2013) and logged the users' interactions with it. To gain in-depth insights into how people capture Duographs and how they read them, we further analysed the Duographs of 8 people and also interviewed them in detail about their experiences with Duography in everyday life situations (DUO.2). As it became apparent that 2sidez was particularly capable of creating original and creative digital content, we then explored its potential for capturing situations in the creative settings of interaction design education (DUO.3) and the arts education (DUO.4).

While the first study resulted in descriptive statistics that bear testimony to the app's success in the market, the other three studies revealed a set of underlying working concepts of Duography. That is, the in-depth qualitative analysis of the Duographs and participant interviews suggested a number of mechanisms that made Duography interesting both for the photographer and the beholder.

To report these findings in a structured and compact fashion, we divide the reporting of the key outcomes into two sections. First, we present the descriptive statistics of study DUO.1 as a metric for the users' 'readiness' for Duography. Second, we combine the results of studies DUO.2-4 by presenting a set of categories that emerged from thematic analysis of the participant created content. These categories eventually provided the foundation for elaborating the aforementioned working principles.

Before we go on to describe the four studies of Duography, we briefly introduce the 2sidez application for *Android* and its corresponding web application 2sidez.com.

8.1 2sidez application

8.1.1 2sidez for Android

2sidez is available for free for *Android* mobile phones and tablets on *Google's Play Store* (Güldenpfennig, 2013). Its main function is to create Duographs, that is, to trigger both cameras of the *Android* device (almost) synchronously and hence to capture the photographer (or whatever is in front of that second camera) as well as the motif.

From a user perspective, the application is similar to the standard camera functionality of a smartphone. After framing her picture, the user presses a soft button and the app takes a picture of the motif, and with a slight latency, a picture of the user. This latency time is demanded by the system for switching cameras and emptying the image buffer, which takes up approximately 500ms. (However, in the system settings of 2sidez, it can be extended up to 5.000ms to give the user even more time to frame the image of the front-facing camera.) Depending on the specific *Android* device, this latency time is also necessary to allow the camera adjusting to the ambient light (suboptimal light conditions demand more time for the camera to adjust its visual sensor). As soon as the cameras are switched, the user is provided a 'live-preview' of the front-facing camera, while the image buffer is processed. This view allows the user to frame the second side of the Duograph, and it allows the system to concurrently adjust the camera (thus, latency time is, in fact, 'felt shorter' by the user, because 'something -the 'live-preview'- is being presented). To create a somehow more suspenseful user experience and to 'brand' this second picture taking as the special feature of 2sidez (and of Duography in general), this live-preview is covered by a veil of transparent orange colour (see Figure 8.2).

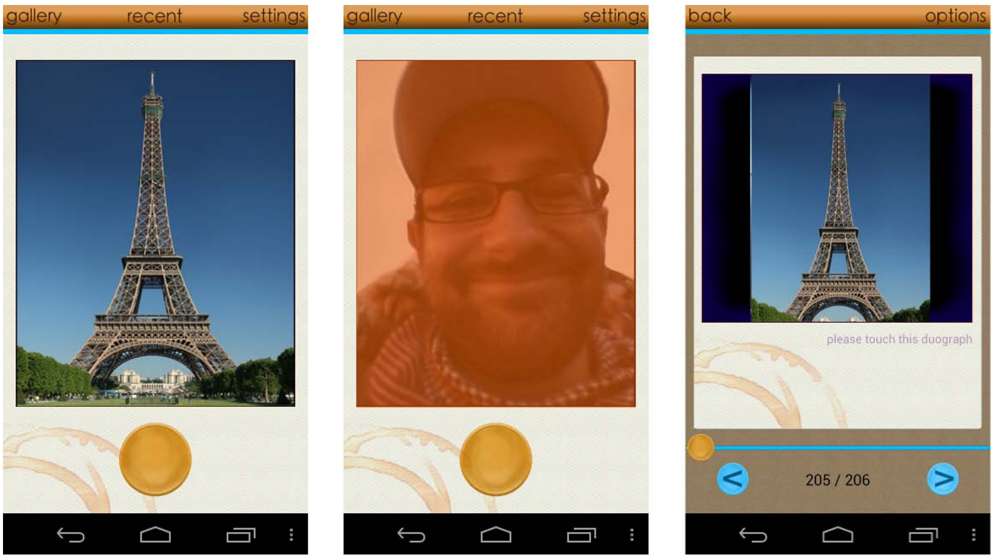

Figure 8.2. Three screenshots of 2sidez for *Android*. 'Live-view' of the back camera for capturing a Duograph (left). 'Live-view' of the front camera including an orange filter overlay (middle). Duography gallery (right).

After capture Duographs can be revisited in the gallery. The software sticks to the metaphor of a two-sided photo and hence implements a flip animation that turns over the Duograph on the touch of the user. For sharing and viewing Duographs online, they can also be uploaded to the corresponding web application 2sidez.com (Güldenpfennig & Sereinig, 2013) (after the user has created a free account on 2sidez.com). Moreover, Duographs can be shared via the user's *Facebook*, *Twitter* or *Tumblr* account as a flip animation (roughly speaking, the 2sidez.com code/link, which implements the animation gets injected into the *Facebook/Twitter/Tumblr* posting when a certain option is 'ticked' on the 2sidez posting). 2sidez also allows the creation of combined photos, that is, overlays of front and back photo within only one picture. These combined photos (i.e., no additional code for the flip animation required) can then be shared via email or any other social networking site, which offers an *Android* client that can process images (a great number of such clients is available).

Besides revisiting one's own Duographs, the user can also take a look at recent postings of other 2sidez users, which have been flagged by their owners as being publicly available to the 2sidez community.

In summary, the main functions of 2sidez are:

- taking (saving or deleting) Duographs
- revisiting Duographs in the gallery (a flip animation is provided for literally flipping around the two-sided photos)
- tagging Duographs with geographical coordinates (*GPS*)
- annotating Duographs with text
- sharing Duographs via 2sidez.com, email or external social networks such as *Facebook*, *Twitter* or *Tumblr*
- browsing recent public Duographs, that have been submitted by other 2sidez users

The structure of 2sidez is illustrated in Figure 8.3 (see next page). Additional documentation or designs of 2sidez for *Android* can be found in Appendix A.1.

8.1.2 2sidez.com Web Application

2sidez.com (Güldenpfennig & Sereinig, 2013) is a web application that was implemented complementary to 2sidez for *Android*. It is the server where the 2sidez user accounts are administrated and where the uploaded Duographs are stored. Users, which have signed up for 2sidez for *Android*, can log on 2sidez.com using the same credentials. However, logging on 2sidez.com is not necessary, since 2sidez for *Android* provides the same functions (and more; see section above) as the web application 2sidez.com.

A screenshot of 2sidez.com is displayed in Figure 8.1, additional documentation can be found in Appendix A.2.

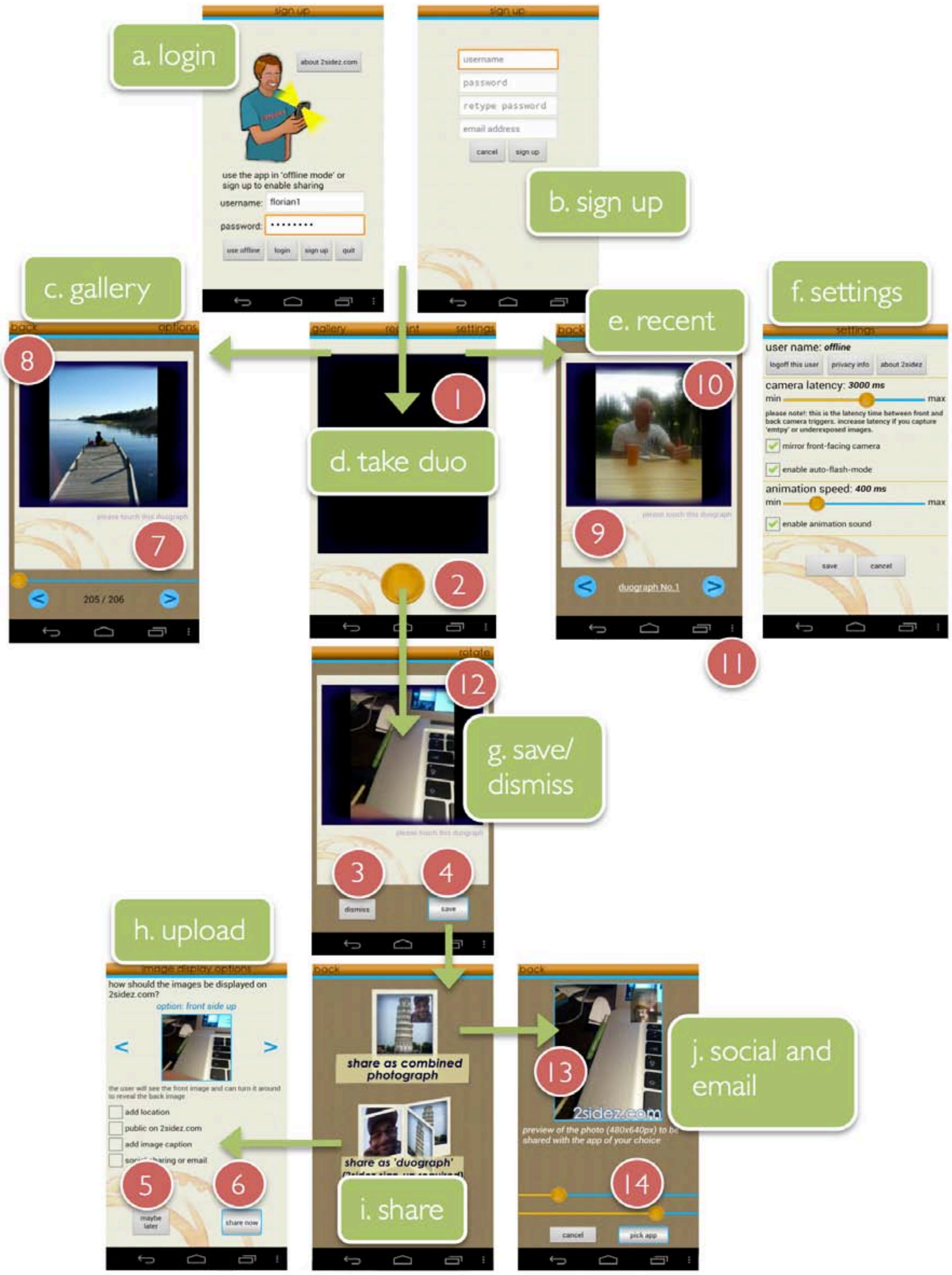

Figure 8.3. Structure of the 2sidez application for *Android*. Green boxes label different screens. Red and numbered circles annotate user interface elements or entry points that are monitored online via logging messages sent to a server (2sidezLogger; see also **Table 8.1**).

Table 8.1. Description of the screens of 2sidez for *Android*. One or multiple log codes are assigned to most of the screens (see 'log codes included' column). That is, particular user interface elements of these screens trigger the sending of notification messages to the logging server (2sidezLogger).

Screen	Description	Log Codes included
a. login	Log into the application with an existing user name or go to sign-up screen for creating a new account. User name and password are the same for both the 2sidez for *Android* and web application. The app may also be used in offline mode without the need to register. However, in offline mode Duographs cannot be uploaded to 2sidez.com and/or shared via the 2sidez server. Sharing by email or another external third party app (e.g., the *Facebook* app) is still supported in offline mode.	-
b. sign up	Create a new 2sidez user account both for the *Android* and the web application.	-
c. gallery	Look at the collection of own Duographs. Turning these two-sided photos around is implemented by a flip animation. Delete or share existing Duographs (the latter option will bring up screen *h. upload*).	7, 8
d. take Duo	Take a new Duography.	1,2
e. recent	View recent Duographs uploaded by the community and set as available to the public.	9, 10, 11
f. settings	Adjust settings of the 2sidez app such as delay between front and back image trigger (camera latency), auto-flashlight, photo mirroring, sound setting, speed of flip animation. The user can also switch user names and read about the privacy policy in this screen view.	-
g. save/dismiss	Save/dismiss the Duograph that has just been captured. A flip animation is provided to inspect the Duo. Touching the save button will bring up the sharing options screen (*i. share*).	3, 4, 12
h. upload	Upload Duo to the 2sidez server. Optionally, add caption, *GPS* location and share the link to the Duograph via email, *Facebook*, *Twitter*, and/or *Tumblr*. Set the Duo private /public. Public Duos can be browsed on 2sidez.com	5, 6
i. share	Sharing options: share Duograph via 2sidez.com server (see *h. upload*) or as a combined photo/photo collage of front and back image (no flip animation) via email or any other external *Android* app that can process images (*see j. social and email*).	-

Screen	Description	Log Codes included
j. social and email	Create a combined photo (to integrate the Duograph within one image file; no flip animation needed to see both sides) and share it via the email client or any other external *Android* application that can process images (e.g., *Facebook client*, *Twitter client*, etc.). The back image can be included into the front image as an overly. Size and opacity can be defined by the user.	13, 14

8.2 Setup of the Studies DUO.1-4

The four studies on Duography were conducted in different contexts and to explore different aspects of two-sided photography. Table 8.2 outlines key information (participants, duration, analysis) to these studies DUO.1-4, which will be detailed in the subsequent subsections.

8.2.1 DUO.1 Duography Proof-of-Concept

Mobile phones or tablets with two built-in cameras are still relatively new. First devices were introduced to the market approximately 3-4 years ago at the beginning of the 2010s. Not surprisingly, Duography was not researched within HCI by that time when we implemented our *Android* application. First commercial 'competitors' of 2sidez (2sidez was deployed as a research probe and not to win market shares) launched their products in 2013 (cf. introduction of this Chapter 8). For this reason, we decided to run an initial large-scale proof-of-concept study to evaluate whether there was a demand for two-sided photography from the users' perspective. To this end, we deployed 2sidez to *Google's Play Store* (Güldenpfennig, 2013), and also put online a corresponding web application named 2sidez.com (Güldenpfennig & Sereinig, 2013). 2sidez for *Android* was available for free and supported a relatively wide range of different *Android* devices. We logged the number of installations and user interactions. After a period of 433 days we downloaded all of the logged use information to quantitatively analyse it, and eventually to assess whether Duography as instantiated by 2sidez was successful.

The application was not advertised in any way. It was released on *Google Play*[15] (see Figure A7 of Appendix A.1), which is the most common way for publishing *Android* apps and which doesn't cost any fees (except for a one-off registration fee as an *Android* developer of $25). We added a demonstration video[16] to the description of 2sidez, which walks potential users through the application's functions (see Figure A10 of Appendix A.2).

[15]https://play.google.com/store/apps/details?id=com.behind.the.camera (last accessed 9 September 2014)
[16]Available on *Youtube* (last accessed 16 August 2014) https://www.youtube.com/watch?v=voSQI0_XGnA

Table 8.2. Overview of the four Duography studies DUO.1-4.

Study	Participants	Duration	Analysis
DUO.1 Proof-of-concept	More than 115.000 user installations	433 days	Statistical analysis of log data
DUO.2 Everyday life context	8 participants	10 months	Thematic analysis of Duographs and interviews
DUO.3 Educational context (interaction design)	30 participants	14 days	Thematic analysis of Duographs and interviews
DUO.4 Educational context (fine arts)	18 participants	12 weeks	Thematic analysis of Duographs and interviews

8.2.1.1 Methods and Analysis

We employed four different sources or techniques in order to monitor the users' behaviour (2sidezLogger, *Google Analytics*, *Flurry Analytics*, *Google Play Store Console*).

Most importantly, we implemented our own interaction logging mechanism called 2sidezLogger. This logging software sent notifications to one of our servers, each time the user touches one of the monitored user interface elements of 2sidez. Figure 8.3 and Table 8.1 show the sections of the user interface where these monitoring elements were embedded. Table A1 of Appendix A.3 summarizes the numbers of user interactions that were registered by 2sidezLogger.

In addition, we employed *Google Analytics*[17] and *Flurry Analytics*[18] for monitoring 2sidez. These free web analytics tools are similar to 2sidezLogger. Likewise, they require the injection of some code snippets, which are responsible for sending messages to the *Google/Flurry* server when certain actions are triggered by the user interacting with the *Android* app. We incorporated these tools to complement 2sidezLogger, as they are employed widely for evaluation and due to their easy accessibility. The additional implementation of 2sidezLogger, however, grants us full control and transparency of the logged data. Users were informed about data logging, and also about our plans of analysing their data in the course of a scientific study in the *terms of use*[19] of

[17] http://www.google.com/analytics/ (last accessed 4 September 2014)
[18] https://www.flurry.com (last accessed 4 September 2014)
[19] 2sidez terms of use (last accessed 16 August 2014)

2sidez. In addition, users had to accept or decline these conditions during the installation of the app (see also Section 3.3.2.2).

Google Play Store Console[20] is the backend for managing applications that are published via Google's app store. As it tracks information regarding the distribution of the apps, we were also able to use it as an additional source of user statistics.

8.2.2 DUO.2 Duography in Everyday Life Situations

We also recruited 8 participants for a qualitative in-depth study of Duography in everyday life situations. To learn how ordinary people capture and revisit two-sided photos, we equipped them with mobile phones (*Galaxy Nexus S*). We installed 2sidez for *Android*, however, with the option to share Duographs (and some other features) deactivated, as we wanted to reduce complexity and to focus on Duo capturing as well as revisiting.

The study took place in two phases: 2sidez trial combined with image-pair analysis and final interview including an image review activity. In the first phase, we carried out a series of 3-week field trials. These trials were conducted serially over the course of 10 months. While the reason for doing this was practical - we only had a limited number of phones - it also gave us the opportunity to have a pool of participants with images taken more or less recently, reflecting that people commonly review their images at varying times after the images were taken (see Table 8.3).

We targeted young users (in their 20s and 30s; 3 females and 5 males) who were already familiar with smartphones and shared an interest in digital photography and recruited such participants from our social networks. They signed consent forms and were not remunerated. Each participant was provided with a *Samsung Nexus S* mobile phone with the 2sidez software installed. The participants were told that they could use the app as they wished, but they were given one 'rule': once a Duograph was saved to the phone's storage participants were asked not to review the image before a concluding interview (also, the gallery feature was not available to them). They were also given the option of deleting any images they did not want included in the study, though none took this up. At the end of the study, the phone with the Duographs was returned to the researchers.

8.2.2.1 DUO.2 Methods and Analysis (Duography in Everyday Life Contexts)

To explore how the participants made apparent use of front and back camera, we collated and analysed the data pool of Duographs from all 8 trials (see Table 8.4), looking for recurrent patterns or themes. To do this, we (two researchers of the institute) iteratively coded the images using an inductive thematic analysis procedure (Braun & Clarke, 2006). The outcome was a set of seven categories (to be described in

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https://2sidez.com/termsofuse/

[20] https://play.google.com/apps/publish/ (last accessed 4 September 2014)

the findings section). The categories or themes were then independently crosschecked by a third researcher, who had not seen any of the Duographs and, as instruction, received a description of the themes and examples.

In the second phase, we focused on the participants' perspectives of 2sidez and the resulting images and conducted in-depth interviews with each of the participants, in a setting of their choice. In the interview, we asked them to reflect on their experiences using the camera phone and then gave them a series of their own and others' Duographs to explore their responses to having front and back image pairs for later review. All the interviews were scheduled within the same two weeks after all the trials were concluded. This provided us with the chance to also observe whether there would be any differences regarding their reactions because of varying time lapses (ranging from several weeks to multiple months) since they had last seen their Duos (see Table 8.3).

Table 8.3. Trail duration and time-passed since last 2sidez-use for the participants of DUO.2.

ID	Duration of 2sidez use	Time since last use of 2sidez
P1	3 weeks	9 months
P2	3 weeks	8 months
P3	3 weeks	8 months
P4	3 weeks	7 months
P5	3 weeks	7 months
P6	3 weeks	4 months
P7	3 weeks	2 months
P8	3 weeks	2 months

The interviews lasted between 70 and 150 minutes and were audio recorded, video taped and transcribed. Once all of this qualitative material was present the researchers employed the transcripts in conjunction with the videos to analyse the participants' view of 2sidez and Duography. Again, attention was paid to re-occurring patterns and themes, this time within the participants' direct account.

More details about the interview procedure can be found in Appendix A.4.

8.2.3 DUO.3 Duography in Interaction Design Education

Our qualitative and explorative study on 2sidez in everyday life situations pointed at the high potential of Duography for creating creative or original two-sided photos, and at its capability for capturing broad contextual aspects of a situation. We assumed that this was afforded by the combination of cues (photos/entities) and wanted to further investigate the underlying mechanisms of this powerful device. We identified the educational setting of an interaction design course as an appropriate condition for studying Duography and its potential for capturing context, as understanding and analysing contextual factors for interactive systems was one of the key challenges of that class. (Note that we employ a relatively open-ended definition of *context* in this thesis and don't aim at contributing to the theoretical discussions about context in the HCI literature. Nevertheless, different uses of this notion in HCI are elaborated in the Glossary.)

As an example, Figure 8.4 illustrates how 2sidez can be employed to capture important situational factors. In this instance, a 'context researcher' visually joins a ticket machine and ticket validation machine (see (C) green arrow) to visualize the practice of using the public transportation system (note, Figure 8.4 is a re-enactment of a Duograph as it was captured and submitted during study DUO.3).

Figure 8.4. 'Context researcher' using 2sidez to investigate a public transport system. Ticket validation machine (A) and ticket machine (B) are of primarily interest in this illustration. As indicated by arrow (C), the machines (A) and (B) are arranged contrarily along an axis.

Hence, to explore the novel ways Duography can be used to capture context, we ran an explorative field study with 2sidez featuring 15 groups of Master-level students. Each group was comprised of two persons. The participants were asked to employ 2sidez to document either an existing ubiquitous computing system or to explore a possible design context for a new ubicomp technology. This was part of a user centred design process, beyond the scope of this thesis to fully discuss, eventually resulting in fully implemented ubicomp systems that were informed by the results of this context analysis. They were given the written instruction (excerpt):

Context Analysis: Pick a specific context (for a future) "beyond the Desktop" application. Describe the context, including users, relevant context factors and how they might influence the users and the interaction with potential "Beyond the Desktop" applications. Understanding context can include an analysis of people, their behaviours, their situations and environments, their perceptual, cognitive, and behavioural capabilities, and/or their interaction with their artefacts. Such an understanding should serve to inspire and ground new design directions and/or form the core of a requirements analysis. [...] Photos are an important form of documentation for context research, thus the documentation should *involve a textual description of the context as well as at least four photos taken in the context including their description. [...] Students [...] will receive a Nexus S phone with a preinstalled photo app (2sidez) [...].*

Each group had 2 weeks to fulfil the exercise after they received the *Nexus S Android* smartphones. It is important to note that the participants were only provided with a technical briefing for 2sidez and did not get any further explanation of the app's purpose or usage suggestion, since we were interested in unbiased observations of 2sidez use cases. In other words, we were interested in what our participants would make out of this new kind of 'two-sided' photography (Duography) without being pushed into a specific direction. The Duo sharing function of the app was deactivated, as it was not needed for fulfilling the assignment.

8.2.3.1 DUO.3 Methods and Analysis (Duography in Interaction Design Education)

After two weeks, the participants came back and gave a 20 minutes presentation of their Duos. They submitted their images and a written discussion of the investigated context. This resulted in pool of 193 Duographs as noted in Table 8.5 with accompanying text descriptions that were the focus of the analysis. Subsequently, we collated and analysed the data pool of all Duographs for recurrent patterns or themes. We identified salient usage patterns by iteratively coding the images following a thematic analysis procedure (Braun & Clarke, 2006).

8.2.4 DUO.4 Duography in the Art Education

As mentioned before, Duography afforded the creation of original digital content. This characteristic of Duographs created by the participants was striking, and we were hence looking for an opportunity to dig deeper into this aspect of Duography.

This opportunity came in the shape of an art teacher (10 years teaching experience; abbreviated with T from now on), who wanted to bring innovative digital media to his lessons. T aimed at augmenting his teaching with novel but widely available technologies (in particular digital photography) and therefore contacted us. He was in charge of an art class consisting of 17 students aged from 16 to18 years (7 females, 10 males; 11th Danish grade) in a secondary school in Denmark. Hence, we decided to conduct a study, which took place over 12 weeks. The head of school as well as the students' parents (if the students were under the age of consent) granted permission for the study to take place in the class.

8.2.4.1 DUO.4 Methods and Analysis (Duography in the Classroom)

Research was conducted in three phases. (1) In the beginning, we had multiple meetings and discussions (informal meetings as well as semi-structured interviews) with T to understand what learning targets he had to meet and what kind of technology intervention he envisioned. We also attended and observed a lecture unit in the classroom (2x45 minutes). This first phase resulted in the decision to use 2sidez as a creative tool (sharing of Duographs was disabled) and a set of exercises to be carried out by the students in the second phase of the study. (2) This second phase was initialized by a workshop where the students were introduced to a first set of exercises. Also, they were briefed about the mobile phones and their functions with special regard to their potential for creative engagement. The students formed 5 groups with 3-4 persons each and were provided with one *Galaxy Nexus* or one *Nexus S* phone per group. The phones remained with the students for the remainder of the study. (3) The third and final phase consisted of two presentations per group (10-15 minutes for each) held by the students on two different days. Each group had to present their results. After each presentation there was time for group discussions and collaborative reflections, facilitated by the teacher. The created digital material and the phones were returned to the researchers. A final semi-structured interview was held with T.

Interviews and classroom sessions were audiotaped and later transcribed. Notes were made during the in-class observations and written up immediately after the session. The students' images (their artwork) were also collected for analysis. Both interviews and the images were qualitatively analysed by the authors, using the categories of study DUO.2 (Duography in everyday life) and DUO.3 (Duography in interaction design education) as a starting point, and identifying new categories as relevant to explain both the collaborative interactions and the images created.

8.3 Findings of the Studies DUO.1-4

In this section we collate the combined findings of Duography study DUO.1-4. We first report statistics on the dissemination and use of 2sidez resulting from the large-scale study (DUO.1). We then turn to the qualitative results of study DUO.2-4. Here, the primary interest is to explore the different ways in which the participants made use of 2sidez and the possibility to join two cues within one Duograph. To optimize readability, we combine the presentation of study DUO.2-4. Each of these studies contributes related qualitative results and altogether they capture well-balanced insights into the Duography user experience.

Finally, we summarize the findings by discussing possible underlying working mechanisms or concepts of Duography by drawing on the data provided by the participants. These underlying mechanisms are closely tied to the CuDe Framework and we conclude this chapter by relating them to the framework.

8.3.1 DUO.1 Duography Proof-of-Concept

8.3.1.1 User and Download Count

During the 433 days study period 2sidez for *Android* was downloaded and installed more than 115,000 times. While the 2sidezLogger recorded 151,173 installations,

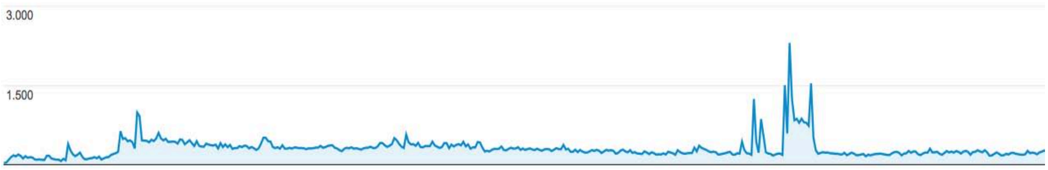


Figure 8.5. Graph of new daily 2sidez users across the 433 days study period. (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

Google Analytics and *Google Play Store Console* counted 132,878 and 115,123 users, respectively. *Flurry Analytics*, again, registered 142,012 installations.

The growth rate of daily new 2sidez users is displayed in Figure 8.5. As evident by the 2sidezLogger data and, as well as *Google Analytics* and *Flurry Analytics*, these users were distributed all over the world (see Figure 8.6).

8.3.1.2 Interactions logged by 2sidezLogger

A Total of 1,914,877 user interactions were recorded by 2sidezLogger. This makes a daily average of 4,419.3 interactions during the 433 days period. The daily average of installations was 348.62. Table A1 of Appendix A.3 displays the distribution of all recorded interactions across the monitored user interface elements of 2sidez.

As 2sidezLogger monitors the application's use in real-time and online, it is most likely that the total number of interactions well exceeded 2 million interactions. 2sidez use on mobile devices, which have no access to the Internet at the moment of interac-

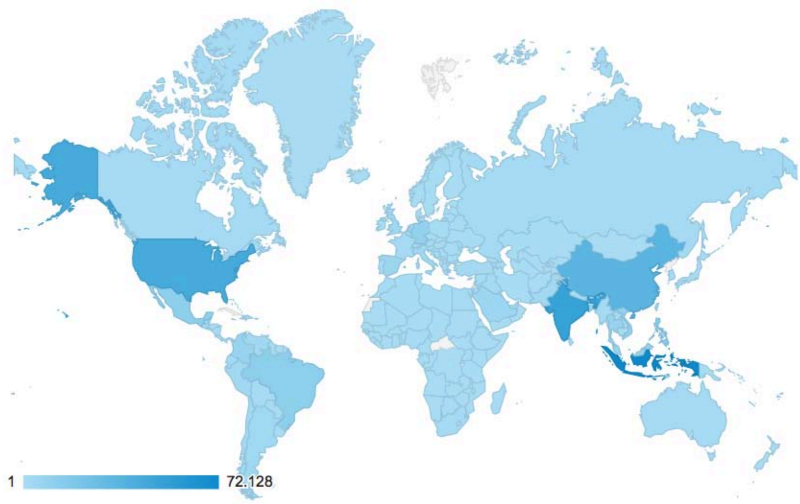


Figure 8.6. Distribution of 2sidez users. United States(18,143; 13.27%), China(18,089; 13.23%), India(16,111; 11.78%), Indonesia(5,648; 4.13%), Philippines(5,342; 3.91%), Mexico(5,296; 3.87%), Brazil(5,042; 3.69%), Germany(4,079; 2.98%), Vietnam(3,456; 2.53%), Malaysia(3,249; 2.38%). (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

tion, did not get registered. The only exception[21] is marked by the total count of *Duographs taken*. These are monitored in real-time (count = 395.373) as well as by means of an offline database (count = 2,379,312) for delayed reports. That is, as soon as a disconnected device regains access to the Internet, the number of *Duographs taken* during the offline time is transmitted to 2sidezLogger. According to the real-time monitoring, the user with the maximum number of *Duographs taken* has captured 656 Duos (average per user *avg* = 2.62). The data from the offline logging, on the other hand, accounts for 975 Duographs (average per user *avg* = 15.74) as the highest number of Duos captured during the test period.

The remaining numbers on 2sidez for *Android* presented in this section refer to the data that has been logged in *real time*.

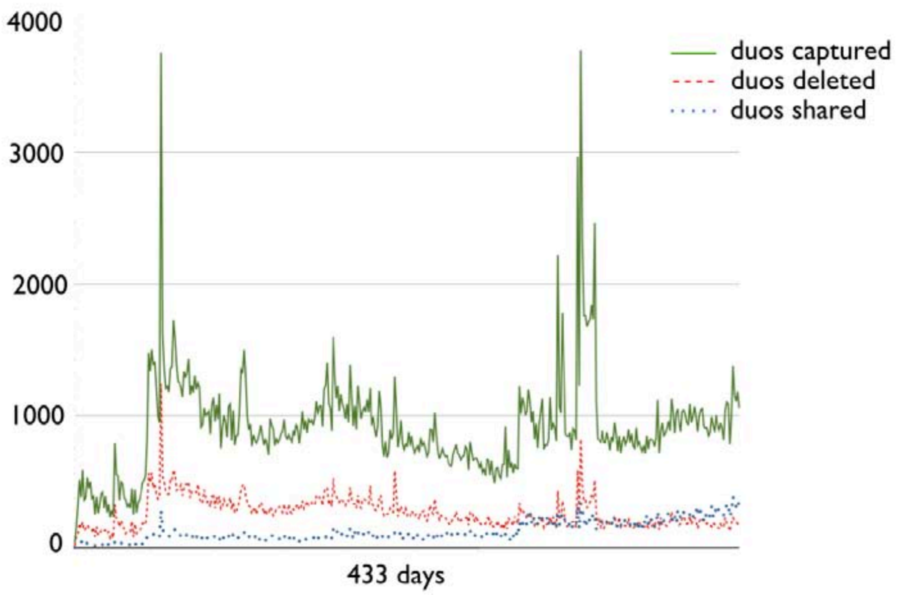


Figure 8.7. Daily capturing, deleting and sharing of Duographs across the 433 days study period as logged by 2sidezLogger.

Figure 8.7 shows three graphs of daily *Duographs taken*, *deleted* and *shared* as registered by 2sidezLogger. As evident from the figure, 2sidez use peaked at two particular points of time. It is interesting to note, that a relatively high number of Duos was deleted (count = 114,298). The lowest graph in Figure 8.7 (blue dots with largest spaces between dots) visualizes the number Duographs, which was *shared* via email, *Facebook*, *Twitter* or any other external social networking site or sharing client (count = 54,208). This number differs significantly from the number of Duographs that were shared by means of our own service and social network 2sidez.com (count = 3,933). Further details about user numbers of 2sidez can be found in Appendix A.1.

[21] We decided to log *Duographs taken* as the most important metric into an offline database. We did not log additional events/interactions to minimize database requests, and hence to ensure a good app performance. Moreover, we intended to minimize the amount of data stored to the user's device, which is of no direct benefit for its owner.

The quantitative analysis revealed some interesting details about the *top-100 2sidez user group* (i.e., the 100 users, who took the most Duographs).

As this group of 'heavy' 2sidez users shared a total of 40,777 Duographs, they accounted for 75.22% of all Duographs that were ever shared via an external client (e.g., email or *Facebook* app). While this is a relatively large number, only 6 Duos were uploaded to 2sidez.com by these *top-100* users. (A figure illustrating further these numbers can be found in the Figure A.14 of Appendix A.3.)

In general, we found that a relatively large number of Duographs were deleted again. On average, the rate of Duo deletion across all users was 28.91%. The *top-100* 2sidez *users*, however, deleted relatively few Duographs (3.26% of all Duos that were ever deleted; count = 3,722), in contrast to a large amount of Duographs taken (8.38% of all Duos taken; count = 33,125) by this particular user group. (This data is illustrated further by a Figure A.15 of Appendix A.3.)

8.3.2 DUO.2-4 Duography Qualitative Studies

We complement the above-presented proof-of-concept data by insights from three qualitative studies on Duography:

- DUO.2 Duography in everyday life situations
- DUO.3 Duography in interaction design education
- DUO.4 Duography in art education

The participants of all studies created a large number of Duographs. In DUO.2, overall 445 pairs of images were taken with 2sidez in everyday situations and with no predefined topic. 7 of the participants took between 41-55 pairs of images (*avg* = 49.1), and one person (P2.2) took many more images (101), explained by being on holidays for most of his 2sidez use (see Table 8.4 for the detailed distribution of the Duos across the participants).

Table 8.4. DUO.2: Numbers of Duographs taken by each participant (P).

P	Number of Duos	P	Number of Duos
P2.1	55	P2.5	47
P2.2	101	P2.6	41
P2.3	51	P2.7	51
P2.4	54	P2.8	45

In DUO.3, the Master level interaction design students created 193 Duographs. They chose to capture the following settings or contexts by means of 2sidez: smart home environments, restaurants, pubs, Internet cafes, intercom systems, hiking tracks, shopping streets, public transportation systems, supermarkets and social gaming events.

The distribution of the Duos across the different student groups is depicted in Table 8.5.

Table 8.5. DUO.3: Number of Duographs taken by each group.

Group	Number of Duos	Group	Number of Duos
3.1	9	3.9	24
3.2	12	3.10	19
3.3	11	3.11	7
3.4	10	3.12	28
3.5	10	3.13	5
3.6	11	3.14	11
3.7	7	3.15	19
3.8	10		

The students/participants of DUO.4 were asked to create Duographs as well as conventional digital photos on three different topics (*space*, *professions*, *sculpture*) by their art teacher. In response to this assignment, they captured a total of 84 Duos and 55 photos (see Table 8.6).

Table 8.6. DUO.4: Distribution of group-submitted Duographs and photographs; ordered by topic. Numbers of instances are separated by a slash.

Group	Topic 1-3 (n Duographs / n Photographs)		
	Space	Profession	Sculpture
4.1	1 / 4	4 / 4	17 / 8
4.2	6 / 5	6 / 3	6 / 4
4.3	5 / 4	2 / 4	5 / 1
4.4	5 / 4	2 / 1	3 / 2
4.5	1 / 4	8 / 6	13 / 1
Σ	**18 / 21**	**22 / 18**	**44 / 16**

In particular in DUO.2 and DUO.3, we wanted to learn how the participants made use of Duography *without being instructed*. In other words, the purpose of these two studies was to explore participants' natural reaction to 2sidez without being briefed about the app in detail. To structure the created Duographs we conducted a thematic analysis (Braun & Clarke, 2006).

In DUO.2 this procedure resulted in a set of salient themes or patterns of Duos, which we have labelled as follows: *Conventional Use*, *Story Telling*, *Exploration*, *Being There!*, *Sense of Location, Engagement* and *Shared Experience*. Drawing on these categories, we also conducted a thematic analysis of the dataset of DUO.3. As this study was conducted in a completely different context, it is not surprising that the resulting categories differed from DUO.2 to some extent. Here, in addition to *Conventional Use* and *Sense of Location*, we also identified the following four themes: *Facial Tagging*, *Social Interaction*, *User Perspective*, *Technical Perspective*. The frequency of these categories is depicted in Figure 8.8 (DUO.2) and Figure 8.9 (DUO.3). Each Duograph was assigned exclusively to one category (the one closest related), although many instances fit into more than just one category. Hence, it is important to note, that we consider our categories to be quite fluid and without strict boundaries. They serve as an analytical instrument for illustrating the ways in which 2sidez was employed by the participants. Nevertheless, we used two independent coders to capture two potentially different opinions. As could be expected and due the fluency of the categories, we did not accomplish perfect concordance rates for the categorization of the Duographs by the coders. Similar to other visual materials such as photos or drawings, Duographs are open to interpretation. Nonetheless we still see the same general pattern in how the overall collection has been categorized, if we follow the shape of each person's graph.

We go on to report how the participants used and experienced the 2sidez application both from the researchers' and the users' perspective. In the course of this report we look at the participants' accounts from the interviews through the lens of our categories (both of DUO.2 and DUO.3) to substantiate, enrich and complement our findings. Subsequently, we will summarize the findings of DUO.4. In this study, we did not conduct a thematic analysis of the patterns of use, because we gave the arts stu-

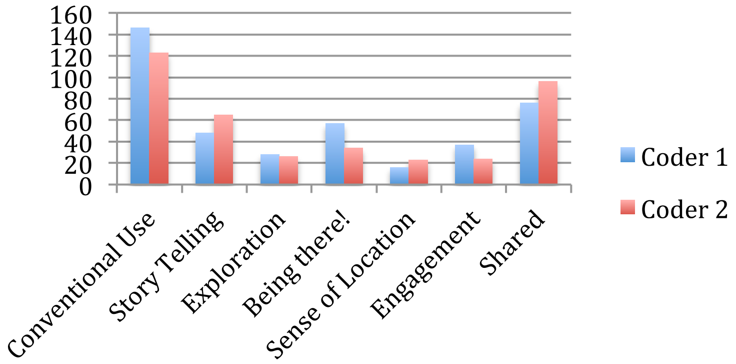


Figure 8.8. DUO.2: Distribution of Duographs across the use categories for both raters/coders.

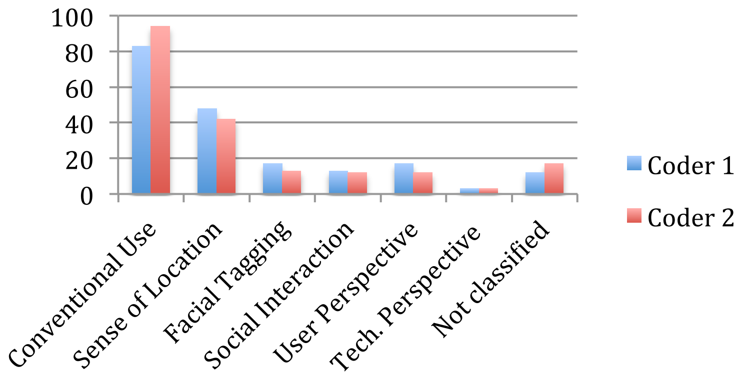


Figure 8.9. DUO.3: Distribution of Duographs across the use categories for both raters/coders.

dents rather restricted instructions for how to employ 2sidez. Rather, this last study served to investigate one further characteristic of Duography that became particularly apparent in the previous studies: the affordance of two-sided photography for creating creative or original content.

8.3.2.1 Categories of Use in DUO.2 and DUO.3

In this section, we explain the use categories in detail and depict original statements of the participants that underpin the themes from the thematic analysis, together with typical instances of Duographs for each category. We will display the picture pairs side-by-side, with the left side showing the motif and the right side the photographer/back scene.

Conventional Usage

We assigned Duographs to the *Conventional Usage* category whenever it seemed that the participant used the application as if it was a regular mobile phone camera, that is, where it appeared that there was no particular attention paid to the front facing camera and there is no further evidence or indicator within the picture, that would qualify the image as being part of another category. Figure 8.10 depicts a typical example image from this category.

Figure 8.10. Conventional Usage. P2.3 took a picture of his parking disk as a reminder (left side; motif). He confirmed in the interview that he did not pay any attention to the other camera, which depicts an image of the sky (right side).

Story Telling

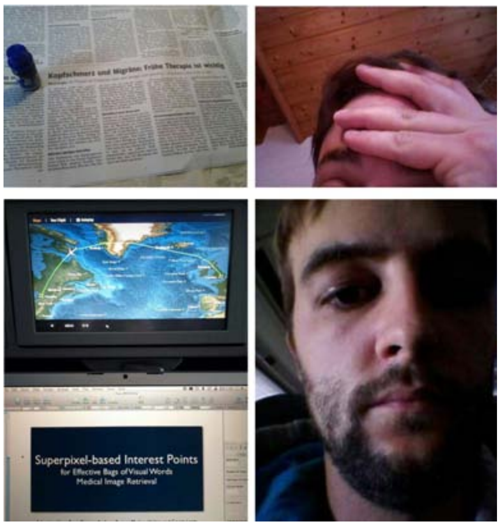
More than any other Duographs, instances featuring the *Story Telling* theme appeared to be telling a story to the spectator. While almost every Duo contained at least some bit of narrative, the images assigned to this category seemed to employ 2sidez to unfold a story between the front and back picture. The narrative context lives between both images, so to speak. Figure 8.11 shows 2 instances of Duographs that feature the theme of *Story Telling*. In Figure 8.11 (A), P2.3 is holding his head while taking a photo of a newspaper article about headache with a pill bottle siting next to it. Other participants also identified these as stories. For example, P2.5 spontaneously commented on P2.3's Duograph: "Oh, that's a story! – Right? The photographer wants to leave us a message." Concluding from our observations and confirmed at interview, most of the images from this category had been staged by the participant photographer.

However, Figure 8.11 (B) depicts a story without the photographer deliberately staging or posing for the photo:

"Here, I am working on my presentation. We are heading towards Toronto […]. I took the image, because it tells that we are on the plane, you can tell our approximate position and you can see that I am not nearly finished with my presentation […]. My facial expression is just tired" (P2.4).

P2.7 explicitly stated that the aspect of narrative was the most appealing feature of 2sidez to him:

"What I like best about the application is its story-telling aspect […] when both images together form a story" (P2.7).



A

B

Figure 8.11. (A) P2.3 in right side and newspaper article with the headline "Headache and migraine demand early therapy" and pill bottle left side. (B) P2.4 on an airplane, looking at two screens.

Exploration

According to our participants there was something about the 2sidez application that spurred their playfulness and fuelled creative exploration (Hence, the later study DUO.4). All users but P2.8 created multiple instances that featured experimental or playful usages of the two cameras provided by 2sidez. In this context P2.2 mentioned:

"It is a new kind of photography. You can play with it […]. You can try there to bring both images together" (P2.2).

Similarly P2.6 stated on his experimentations with 2sidez:

"It gives you new possibilities for fooling around […]. It is another type of photographic tool. It is a very simple extension and very easy to use. It provides you with more opportunities to express yourself with images" (P2.6).

Figure 8.12 shows two examples of exploration images. At interview, P2.6 commented on P2.1's picture pair in Figure 8.12 (A):

"[This is] a 'cause and effect thingy' – sun and shadow. This generates a nice arc of suspense between the two images. In addition, they made good use of the app, because the sun looks very luminous" (P2.6).

P2.5 stated that at some point she began to frame the back image as well as the front image to capture more interesting Duographs:

"That's were I have started playing with the camera. I've tried to catch other people on the back image. It tried to be creative there [. . .]. At some point of time, it occurred to me that it would be cool to collect people with the back camera" (P2.5).

Figure 8.12. (A) P2.1 playing with the image of her shadow. (B) P2.6 bringing together speaker (left side) and his ear (right side).

Being There!

Traditionally, tourist photography has been a big issue in research on picture taking in social and cultural science disciplines (e.g. (Chalfen, 1987)). This is partly due to the fact that a lot of the images available to researchers back in the 'analogue photography age' had been made by people on their holidays. Our sample also included pictures that had been shot by some of the participants during travel, for example, as displayed in Figure 8.13. Participants reported that 2sidez had been like a valued "companion" then. P2.5, who had to travel a lot alone lately, remarked that she liked that fact that she had pictures of trips that also included her *being there*:

"I am quite happy with the way I look in the images. Thanks to the back side I get to images that would never have been created travelling alone […]. I think these images are great, because I have been there alone and so I can relate the things in the images to myself" (P2.5).

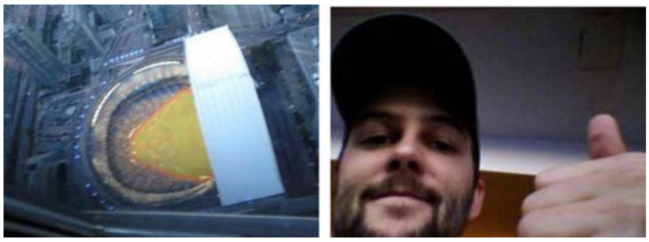


Figure 8.13. P2.4 proudly commenting on a tourist feature (sports stadium), stating: "I was there! [At the top of the tower.]"

A couple of participants said that 2sidez was in their opinion good for capturing monuments or landmarks:

*"I could imagine that something like this [(*2sidez*)] would be great for tourist sites […]. This could replace the classical tourist photo of a site. You take a nice image of the site and you are integrated in the back image" (P2.2).*

Figure 8.13 displays such a picture, with P2.4 proudly together with a tourist feature:

"I am doing this gesture for whoever will be looking at the image. Not for me. It is just a little bit of showing off" (P2.4).

Not all Duographs that fit into *Being There!* necessarily have to be taken during vacation or demand the photographer to pose. We defined instances that placed the photographer into a scene as part of this category, whenever his or her *being there* in the context of the location appears to be the main motif when front and back image are viewed in a bigger picture.

Sense of Location

Some of the Duographs appeared to do well in capturing the sense of the photographed location. For instance, P2.2 commented in the context of Figure 8.14:

"I intended to capture more of the location and not me. That's why I am not in the picture. I've just raised the camera to capture the whole scene or to see it from a broader perspective […]" (P2.2).

Thus, Duographs were assigned to this category when they helped capture the location, to get a more complete feel for the place shown in the picture by capturing in front and behind scenes. P2.6 thought out aloud during the interview:

"Both perspectives [of the two different cameras] adhere. This is really interesting […] it is exactly the other way round. There we have ⅓ of ground and over here we have ⅔ of horizon. It is kind of reversed […]. This perspective coupling creates tension. If one image faces the sky the other one faces the ground. This is reciprocal feedback, this is interesting" (P2.6).

Figure 8.14. P2.2 employed both cameras to capture the sense of a location (each row represents one Duograph).

Engagement with Motif

Duographs of the category *Engagement with Motif* depict a visible, genuine reaction or response of the photographer to the part of reality represented in the front image. Figure 8.15 illustrates a typical instance of this theme. P2.2's cheerful facial expression adds to the richness of the depicted moment. The back image sets the tone for the perception of the scene by conveying the spontaneous, emotional reaction of the participant. P2.8 remarked on one of her Duographs, with which she was trying to capture an impressive sunset:

"The atmosphere of the sky was reflected in the expression of my face" (P2.8).

Figure 8.15. P2.2 showing a genuine and spontaneous response to a children's bouncing castle.

This category of *Engagement with Motif* is about the photographer engaging with objects that do not explicitly react to the photographer, whereas the next category is about social interaction and shared experience.

Shared Experience

Instances featuring the theme of *Shared Experience* do especially well in capturing the social interaction between the photographer and their motif. We assigned Duos to this category whenever a clear response of the portrayed person(s) to the photographer (and vice versa) was visible. 2sidez was employed to document the encounter of friends, families and couples. Our participants explicitly stated that 2sidez was good for "documenting encounters" (P2.7), its capability for taking "multi-portraits" (P2.3) was appreciated and Duographs that capture people (photographer and portrayed persons) laughing at each other were considered to be a "classic use" case for 2sidez (P2.5).

P2.7 commented on Figure 8.16 (A):

"The situation, the dialog between the two persons in the coffee bar can be caught by means of the app" (P2.7).

P2.1 also commented on the same images from Figure 8.16:

"I like that as well. If you take a picture of a group of people and you get the chance to integrate yourself into that group. That means you won't be missing in the image later on" (P2.1).

Figure 8.16. P2.5 took two Duos of friends (each row represents one Duograph).

Facial Tagging

We assigned images to the category *Facial Tagging* whenever the backside conveyed an affective commentary regarding the motif on the front side. In other words, the facial expression of the photographer reveals their emotional reaction towards the captured situation. This kind of facial tagging was used as an easy way to add an additional layer of information. Hence, the user employs the back camera to direct a message to a future observer of the picture, for example, “look, this is funny” (Figure 8.17) or “I don’t like that” (Figure 8.18).

Group 3.1 (of DUO.3) chose public transport as their design space and aimed to understand the motivation for why people decide to use the public subway system and which context factors influence this behaviour. Among other things, this group captured Figure 8.17 that displays an architectural model of the planned rearrangement of a metro station in order to make it more attractive to the passengers. Figure 8.18 shows public phones in a metro station. On the back side of these Duographs they show their approval and dislike, respectively.

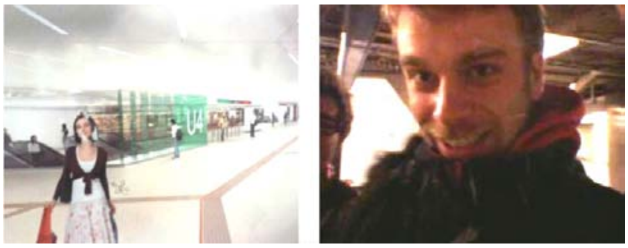


Figure 8.17. Participant (right) smiling at advertising billboard (left; detail).

Figure 8.18. Participant looking sceptically at the decrepit state of the public phones in a metro station.

In contrast to some instances of the categories *Story Telling*, *Being There!* or *Social Interaction*, which also contained faces showing certain emotions, Duographs assigned to *Facial Tagging* employed the face of the photographer to annotate the opposite photo with supplementary information (e.g., approval). In Duographs featuring faces from *Story Telling*, *Being There!* or *Social Interaction*, both front and back side were equally important (and not supplementary).

Social Interaction

In line with the proceeding category, in many instances of *Social Interaction* the back sides depicted the face of the photographer. However, in the category of *Social Interaction*, front side images also contained one or multiple persons. Moreover, the images revealed the interplay or relationship between the involved subjects in this particular moment. In contrast to *Facial Tagging*, the affective response of the photographer is not primarily addressed at a future audience as a comment but rather to demonstrate aspects of social interaction as part of a particular context.

Group 3.7 aimed to design novel technology augmented services for bars and restaurants (e.g., ordering, entertainment, etc.) and used 2sidez to understand social interaction in this context (see Figure 8.19). The images show different types of social interaction, amongst peers, with the wait staff (Figure 8.19 (A)) and situated around games (Figure 8.19 (B)). In their description of the images, group 3.7 stated that in the context of a bar the main aims of the guests are “fun, relaxation and social interaction”, that “nobody wants to be bothered by complicated systems” and that the systems have to be robust regarding dirt and heavy (physical) use (see also Figure 8.23).

A

B

Figure 8.19. Documenting social interaction in a bar (A) at a soccer table (B).

2sidez was also used in a different way to capture social interaction without placing the face of the photographer centre stage. An example is from group 3.2 who captured social interaction, or rather its absence, in a subway station (Figure 8.20), stating that: “[T]he passengers keep a certain distance at most times. The fewer people are in a station, the bigger the personal distance”. Figure 8.20 also captures the *sense of the location*, however even more so it describes the social interaction of the passengers as emphasised by group 3.2.

Figure 8.20. Passengers keeping social distance in the subway station.

User Perspective

In the category *User Perspective* the context can be seen through the eyes of a potential user. The user is connected to the interactive system, which potentially includes the effect of specific context factors on the interaction.

Figure 8.21. Passenger buying ticket (left); ticket validation machine (right).

For instance, in Figure 8.21 the observer can see how a subway ticket is bought as well as the machine where the ticket had to be then validated. Hence, this is showing a potential progression of the user interaction.

Figure 8.22. Interaction with the intercom at day and night.

Figure 8.22 shows the influence of the time of day on the visibility of the intercom interface to a building. Combining both front and back side, the experience of the user being blinded by the reflections of the sun during the day becomes rather vivid and thus comprehensible for the observer (see Figure 8.22 (A)). On the other hand Figure 8.22 (B) depicts the same device under different lighting conditions at night.

Group 3.7 positions the context researcher right into the middle of a crucial moment of the interaction with a dart machine. Not only does the observer see the interface from the user's perspective but also the position and gesture taken by the dart player in this interaction (see Figure 8.23).

Figure 8.23. Capturing the essence of the interaction with a dart machine.

Technical Perspective

In contrast to the aforementioned *User Perspective*, the category *Technical Perspective* is about the relationship of a specific technology with its surrounding context. On the one hand, 2sidez shows how a technology impacts its surroundings and on the other hand the context can be seen through from the perspective of a certain technology located within it. Thus, on one side of the Duograph one can see a section of the environment and on the other side a technology intertwined with this environment by design.

Figure 8.24 illustrates such a relationship between technology and context, namely lights with the purpose to illuminate the fruit on display below.

Figure 8.24. Fruit on display in a supermarket lit favorably.

Literally through the lens of a technology, in this case a security camera, Figure 8.25 shows the stairway in a subway station as if it were taken by the security camera. As group 3.1 puts it: "There are cameras at every stairway for the surveillance of the passengers. [2sidez shows] the scene from the perspective of the surveillance camera".

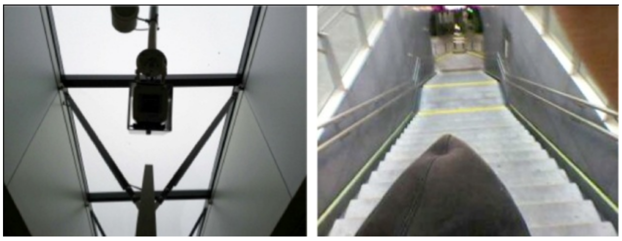


Figure 8.25. Stairway (right) seen through the security camera (left).

8.3.2.2 Uses of Duography in DUO.4

In studies DUO.2 and DUO.3 we observed a number of Duographs, which reflected a high amount of originality in the way they were created (see e.g., section *Exploration*). We suspected this immanent characteristic of Duography as being key to understand its underlying working mechanisms or core concepts. For this reason, we also explored Duography in a particularly creative context, namely as a digital tool for art education and designed some corresponding study instructions for the participants.

In contrast to DUO.2 and DUO.3 (with only limited instructions given to the participants), the use instructions for 2sidez were quite detailed in DUO.4. Therefore, DUO.4 drew attention to some characteristics of Duography, which consequently were reflected in the participant-created Duographs and which made 2sidez an interesting tool for art education. For this last study DUO.4 we omitted conducting a thematic analysis of 2sidez use patterns due to the detailed instructions.

In the next sections, we go on to describe these characteristics using participant created Duographs, which relate to *spontaneity, dynamics, action, reaction* and *multiple interpretations*. This will then lead to the chapter summary (Section 8.4) where we further elaborate the underlying working principles or core concepts of Duography (in particular in Section 8.4.2), and also link these core concepts back to the CuDe framework (Section 8.4.3).

Participants of DOU.4, that is, the students are labelled as P4.1 to P4.17 in the following report of study DUO.4.

Spontaneity, Dynamics, Action and Reaction

According to the student's teacher (T), Duography featured some typical characteristics, which made it an especially appropriate technology for art education. For T this potential has to do with Duography's immanent "spontaneity" ("a tool with low entry barriers delivering quick and nice results" (T)) and capability to catch the "dynamics of a scene". Moreover, Duography would create more intriguing artefacts for later group discussions and interpretations compared to conventional photography (see next Section *Multiple Interpretations*).

Figure 8.26 (left) is an example of how Duography demanded spontaneity and introduced dynamics. In this 'living sculpture' two students are "planking" (P4.3) on some sort of pedestal. It indicates how taking a Duograph differs from capturing two conventional pictures one after the other (which the students in DUO.4 never chose to do anyway with their conventional camera). As noted by T regarding the close trigger points of front and back camera, "taking a Duograph has to be spontaneous; you cannot work on one side and then turn to the other one […]".

Figure 8.26. Each column depicts one Duograph. Left: "Planking sculpture". Right: "Offender and target".

The occurrence of 'action and reaction' became apparent in the students' work as another theme or creative tool. This is to some extent related to dynamics or spontaneity and can be observed in Figure 8.26 (right). The subsequent excerpt of a discussion refers to this Duograph:

T: "What two positions can we see [in the Duograph]?"

P4.12: "The position of the offender and the position of the victim."

P4.14: "Well, I see two different roles, whereas you could empathize with both of them. […] Maybe because they are captured at such a close distance. And both roles are definitely related."

T: "And what is your reaction as an observer?"

P4.14: "I empathize with them."

P4.2: "I think this is a new perspective. Normally you could only see it from one perspective. Either from the perspective of the offender or of the victim […] if you would take a conventional photo. And yes, you can empathize with them. You can feel the aggression of the offender and you can feel the fear of the offended. You can see things from both perspectives."

P4.13: "One side is the action side, the other one is the reaction side – you can't separate them."

T: "Great appraisal!"

Multiple Interpretations

The Duographs made interesting pieces of art in their own right. However, in addition, T's experience was that they served as excellent facilitators of discussions and he was able to expertly incorporate them into the art lessons in order to provoke the students' thinking. T used the two images to encourage the students to see and reflect together in 'artistic' ways. T facilitated the following discussion on Figure 8.27, a 'sculpture' depicting two 'homeless' people and one observer:

P4.2: "Well, […] we are lying on and under a bench. We are homeless […] and C is a passing by thinking to himself: "I don't want to end like this."

T: "[…] I think [the Duograph] leaves much room that allows for speculations. And that is great for art, in my opinion. What do you think?"

P4.5: "But I in my opinion we do not know what he thinks […]. It would be no difference if they had made a conventional photo [and not a Duograph*]."*

T: "I think there is a difference. Can you tell why?"

P4.3: "Well, you wouldn't know who is watching the scene […]."

T: "We figuratively see through his eyes. I think it is artistically suspenseful, because we can't see a facial expression […] In this way the photo does not contain any judgements. [Due to the additional photo] a whole new dimension for interpretation opens up. Normally, you would have only one photo, which is more straightforward to interpret […]. However, the backside of the camera displays an additional suggested observer who is somehow related to the other people."

Figure 8.27. "Spectator looking at homeless people".

As apparent from the excerpt, the additional photo of a Duograph added a second dimension or "room for speculation" to use T's words. According to his opinion the combination of the two photos "can lead to unexpected moments" (T) and consequently Duographs were very suitable for engaging the students in group-discussions.

8.4 Chapter Summary and Thesis Contribution

We proposed 2sidez for *Android* (including the web application 2sidez.com), which is a mobile phone (or tablet) app for creating photos that, figuratively speaking, have two sides. While one side captures the motif, the other side usually shows the photographer of the scene. We called this kind of novel photography *Duography* and conducted four studies (DUO.1-4) to explore this kind of photo application.

8.4.1 DUO.1 Duography Proof-of-concept

The first study (DUO.1) served as a proof-of-concept test of Duography. With more than 115 thousand installations within 433 days and hundreds of thousands Duographs taken, we regard Duography as a success, especially when considering that the 2sidez developer team consisted of only two people (the author of this thesis and Martin Sereinig) and we did not spend any money (besides the $25 developer fee and the costs for the 2sidez.com server plus *SSL certificate*).

It is interesting to note, that the *top-100 2sidez users* (with regard to the number of Duos taken) had a Duo deletion rate of 3.26%, while the collective of all users had an average rate of 28.91%. These many deletions (28.91%) of the 2sidez community are uncommon, as in the age of digital photography users gladly make use of ever-increasing storage capacities and omit deleting a lot of photos (Sarvas & Frohlich, 2011, Chapter 5). Hence, there is a feature in Duography (vanity, maybe?), which motivated the majority of users to delete lots of Duos. However, those users, who particularly enjoyed 2sidez (the *top-100*), deleted far fewer Duos.

What was also striking is the fact that the *top-100* users accounted for a total of 40,777 (75.22%) of all Duographs that were shared over the Internet. This points to the fact that one of the main motivations of 'heavy' 2sidez users was sharing Duos. It was quite surprising that these users chose to share their images over the established social networks such as *Facebook*, *Twitter* or email and did upload almost no Duos at all to 2sidez.com for sharing (only 6 Duographs over 2sidez.com compared to 40,777 over the social networks).

In contrast to 2sidez for *Android*, the webpage 2sidez.com did not attract a large number of visitors. This is due to the fact, that 2sidez.com was designed as the supporting infrastructure for 2sidez for *Android* from the beginning. It was never our intention to have the visitors primarily use the web application. Instead, we wanted them to apply the mobile phone app 2sidez, which finally attracted a lot attention as evident from the approximately 2 million logging entries as recorded by 2sidezLogger (see Table A1 of Appendix A.3).

8.4.2 DUO.2-4 Duography Working Principles and Core Concepts

We have seen a number of interesting Duographs, and in our analysis we observed a set of use categories, which we employed to structure the rather large pool of two-sided photos: *Conventional Use*, *Story Telling*, *Exploration*, *Being There!*, *Sense of Location, Engagement, Shared Experience*, *Facial Tagging*, *Social Interaction*, *User Perspective*, and *Technical Perspective*.

Moreover, DUO.4 highlighted Duography's ability to capture the *Dynamics* of a scene*, Action and Reaction*, and to support *Spontaneity*. These immanent characteristics led to an appealing set of participant created digital content, which supported art education by allowing *Multiple Interpretations*.

From a broader perspective, we suggest that Duography was valuable both in capturing Duos and in revisiting them, because of its core concept of taking two photos at a time and hence to *synchronously combine two digital entities*. In the terminology of the CuDe Framework, we labelled this primary interaction concept as SEC (synchronous entity composition) and hypothesise that this mechanism is the reason for Duography being interesting.

Taking the analysis beyond the borders of the use categories described above, we have identified four common phenomena within the picture set that we will discuss in the remainder of this section. We believe that these four phenomena are consequences of SEC, and therefore included them into CuDe as secondary concepts on the *multiple entity level* of analysis and intervention: First, we will further elaborate the themes of *narrative arcs* (CuDe concept *CM 1.1*) and *perspective axes* (CuDe concept *CM 1.2*), which might offer an explanation for the working principles of Duography and why Duographs might be useful for the viewer. We discuss each in turn, drawing attention to how they can contribute to a relational understanding of context, where the connections between the images convey additional information beyond the individual constitutive images. Second, we will describe an observation that we have labelled as *humoticon* (*CuDe* concept *CM 1.3*), that is, the human face as an emotional cue (see Section *Facial Tagging*). Third and finally, we briefly reflect on the occurrence of *play-acting* (*CuDe* concept *CM 1.4*) as observed in study DUO.4 where the students employed 2sidez for staging scenes and acting out.

8.4.2.1 Perspective Axes and Narrative Arcs (CuDe Concepts CM 1.1 and CM 1.2)

Duographs allow us to explore relationships, not just between the photographer and target image, but also *temporal*, *spatial* and *narrative* relationships. This is caused by the technical implementation of 2sidez that enables us to trigger both cameras at a time, and results in two images that are by definition temporally and spatially intertwined.

From a geometric viewpoint, the spatial configuration of front and back image is arranged along a *perspective axis* (see Figure 8.4, indicated by the green arrow C, which connects front image A and back image B). In addition, Duographs can also feature sequential attributes by building a *narrative arc* between front and back image to convey an elementary story. That is, by creative construction these two entities are also possibly narratively connected.

These observations may seem trivial, however they are worth further elaborations, as they can imply certain advantages for both the observer and for the photographer.

The observer can rely on the 'fidelity' of the spatial relationship captured by the Duo, that is, front and back images are arranges along this *perspective axis*. This is essential for the viewer to make sense of the images, putting front and back together to reconstruct the space in which the Duograph instance is situated. The reconstruction of a scene can be more detailed or richer when the observer has a Duo with its two sides rather than a traditional photograph as we have seen from the instances of *Sense of Location*. In these Duographs, the surroundings were captured particularly well, because the photographer intentionally pointed the camera away from their body to draw an axis between opposing points of interest (see e.g., Figure 8.14). This kind of geometric relationship is also quite prevalent in Duographs from the category of *Technical Perspective* (see Figure 8.24 and Figure 8.25).

Therefore, the photographer, might be encouraged by 2sidez to explore uncommon perspectives or positions. This became evident when we tried to reconstruct certain Duos of the participants. In Figure 8.21, for instance, the camera was positioned in such a way that the subway ticket validation machine was captured synchronously with a passenger buying a ticket at the ticket counter. In Figure 8.4, we re-enacted this situation to understand and to explain this particular Duograph.

While Figure 8.4 and 8.21 can be employed to understand what we mean by *perspective axes,* what is even more prevalent in these instances is a sequential and/or temporal relationship between the two images that constitutes a *narrative arc*. The observer learns not only that the validation machine and the ticket counter are connected spatially, but can also infer that there is a sequential relationship in the story of this use context, namely that the passenger is likely to walk from the counter to the machine to validate their ticket. Technology, its users and the potential interactions as part of a task flow are connected together in front and back image.

In a similar fashion, Figure 8.22 contains the story about the user pressing a button of an intercom and captures interactional aspects within the images, as well as temporal aspects between the sets of images conveying the differences between day and night. A different sequential-temporal narrative is told in Figure 8.23, which tells us about a person who will be throwing a dart at a board. As observers of both figures, we are put in a moment of suspense before an interaction that is about to happen. The user is just about to press a button (Figure 8.22) or to start a game (Figure 8.23).

Thus, we suggest that creating visual connections promote occasions for photographers to more deeply engage in, and analytically reflect on, the situation they are observing and capturing. As such it can encourage a conceptual shift of focus from an object as a potential target (as in conventional photography) to exploring relationships in the scene. Figure 8.24 and Figure 8.25 is a case in point. We therefore envision that 2sidez when used as a tool (e.g., for interaction design and context analysis) can lead to similar provocative new insights or provide new lenses on everyday life as Gaver, Dunne, and Pacenti (1999) intended with their *cultural probes*.

With regard to the four design challenges from the literature (see Section 2.4.1), we argue that Duography with its ability to create *narrative arcs* and *perspective axes* is useful in supporting in particular creativity and the reconstructive nature of memory. We will elaborate this further in the section *User Perspective* of the discussion of this thesis (see Section 10.2).

Reflecting on the information gathered in DUO.4, we also see that the students submitted several Duographs (e.g., Figure 8.26 (left)) that depict clearly what has been described above as *perspective axes*. Also, there is a prevalence of *narrative arcs* in several Duographs (Figure 8.27). The students' discussions, for example, on Figure 8.27, are indicators for this kind of narrative that is facilitated by a story that lies in between front and back image.

8.4.2.2 Humoticon (CuDe Concept CM 1.3)

Many Duographs revealed a human face on the back side image and often this face hinted at the emotional valence of the displayed person. In most cases that person is the photographer of the Duo. We termed this effect *humoticons* (human + *emoticon*), as a form of *emoticons* enacted in-situ. Hence, this did not apply for images from the categories *Sense of Location* and *Technical Perspective*, because here one key attribute was that the backside did not display the creator of the picture. However, for Duograph instances containing a human face in the back image, these so-called *humoticons* can potentially allow for the inference of the emotional response of the photographer or user to the situation at hand. This is most prevalent in images of the *Facial Tagging* category, where the participants appear to deliberately send an emotional signal (see e.g., Figure 8.17). More examples of this phenomenon can be found in images from *Social Interaction*. Here, we see participants deliberately staging social interaction. As part of this, we learn about their social as well as emotional involvement in a situation. Moreover, images from this category can also contain a spontaneous response to an actual social situation. We can also see this in *Engagement with Motif*, *Story Telling*, *Shared Experience* or *Being there!*.

In contrast to traditional photos, the observer's understanding of the scene or photo-context can be extended by images that are not only focused unidirectional on an external object, but also explicitly relate the user's engagement with the scene. Another possibility is the portrayal of persons who can be (emotionally) connected by a 2sidez image pair. Examples of this use can be found in Figure 8.16.

8.4.2.3 Play-Acting (CuDe Concept CM 1.4)

We observed another phenomenon or concept facilitated by *synchronous entity composition* (SEC) in the forth study of Duography (DUO.4), which is related to *humoticon* and *narrative arcs*: *Play-acting* describes the fact that Duography worked out well for capturing the social interplay between two individuals. That is, participants enjoyed staging interactions with one protagonist on the front image and one on the back picture. In DUO.4 there were numerous examples of *play-acting* and an instance from this category is shown in Figure 8.26 (right side). Instances of *play-acting* are most likely to be found in *Social Interaction* or *Shared Experiences* Duographs.

8.4.3 Duography and the CuDe Framework

With respect to the CuDe Framework, Duography contributes on a *multiple entity level* and enables the *linking* of two memory cue carriers (two files/entities). We described such linking as *linked in time and linked in perspective*. That means, if designers present two entities along with the information, that these entities share either a temporal or perspective common ground, the users can exploit this information to make sense of the entities; that is, they can relate the photos (or other media files) to each other. Figure 28.8 describes Duography by employing the CuDe Framework as an analytical device.

On a conceptual level, we named the underlying interaction design mechanism *narrative arcs* and *perspective axes* to assign labels to the processes that might be triggered mentally by the observers. *Narrative arcs* (CM 1.1) denote the 'bridging' of both entities (e.g., front and back photo) by a shared story, which unfolds between these entities or which connects (*links*) them. *Perspective axes* (CM 1.2), on the other hand, describes the spatial relationship that can exist between multiple entities.

In the case of Duography, both photos were captured in opposite directions. However this is only one possible and particular arrangement of the cameras. Other entities might show a shared situation or location from different perspectives. Different audio recordings, might tell a story from different angles.

Along with *narrative arcs* (CM 1.1) and *perspective axes* (CM 1.2), we proposed *humoticons* (CM 1.3). This concept is more specific as the latter two as it demands the existence of an emotional face that is referring to another entity. Nevertheless, we hypothesise that *humoticons* are useful in the design of digital memory cues and thus deserve the inclusion into the CuDe Framework.

Closely tied to *narrative arcs* (CM 1.1) and *humoticons* (CM 1.3) is *play-acting* (CM 1.4), which exploits the combination of two photo entities as well, and is therefore also integrated into CuDe as sub-concept of SEC (CM 1).

Narrative Arcs, *perspective axes*, *humoticons*, and *play-acting* are all secondary interaction design concepts of CuDe and are hypothesised to be a consequence of the primary concept SEC.

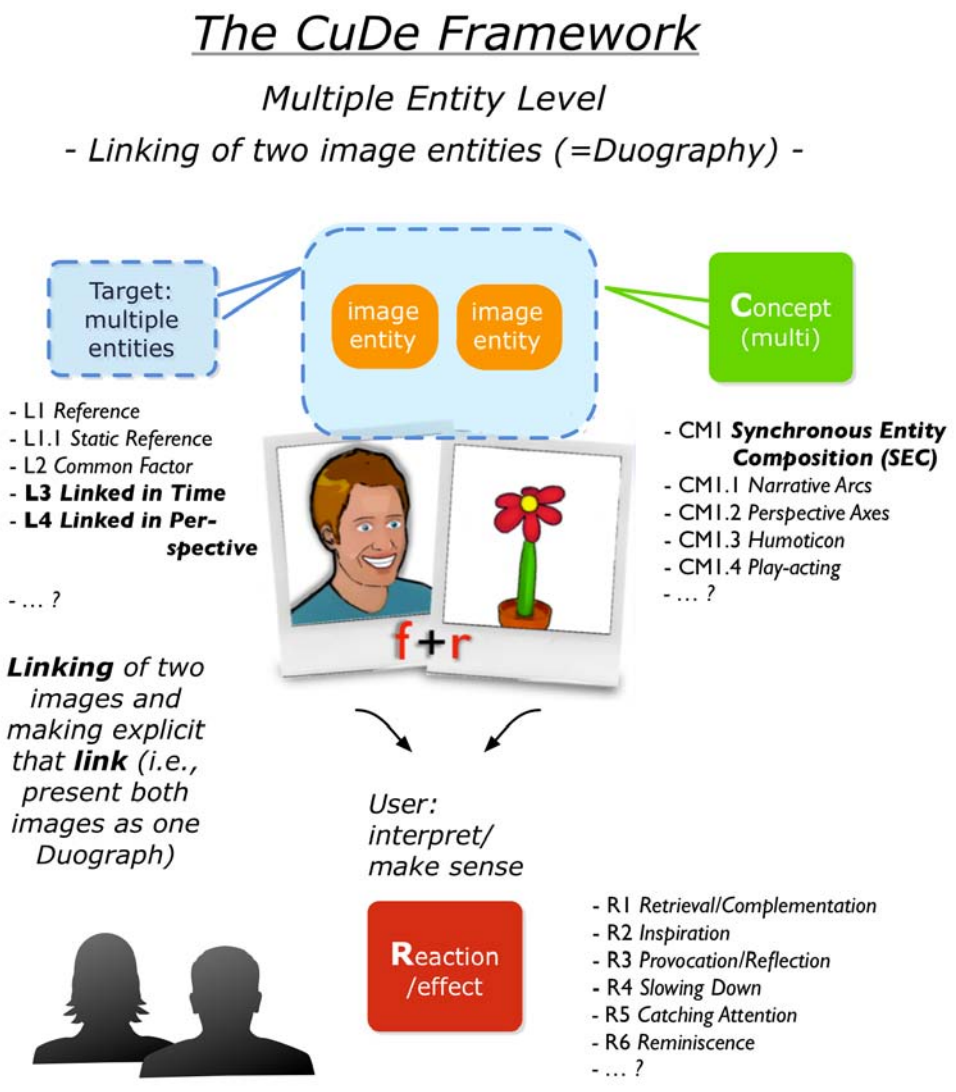


Figure 8.28. Duography described by means of the CuDe Framework as an analytical device.


SPIND

9 Media Object (MEO)

Figure 9.1 (see opposite page). Mobbox put on display on a table.

In the previous chapter on Duography we have seen how the *synchronous composition* of two visual cues or entities (SEC) provided an opportunity for both capturing and reconstructing past experiences. Media Object (MEO) takes this concept a stage further by extending the number of entities that can be combined. While Duography (and 2sidez) made use of two photos to be joined in one single Duograph, MEO allows a theoretical aggregating of an infinite number of arbitrary media files into one container structure. In a way, this depicts a radical extension of the concept of Duography and leads to an *asynchronous composition of entities* (AEC, to stick to the terminology of the CuDe Framework). In other words, MEO provides tools for recording and linking multiple media files and this can be done over a period of time (i.e., composing does not happen simultaneously as with Duography).

We researched this idea in three successive studies:

- MEO.1 Everyday life context
- MEO.2 Long-term evaluation
- MEO.3 Content relations

We started off with MEO.1 and explored the application in everyday life situations. Encouraged by positive participant feedback, we iterated on the MEO software and deployed an improved version during a long-term evaluation in MEO.2. As stated above, the concept of MEO is to support the combination of multiple (memory retrieval) cues. To better understand how people combined their digital cues by using the MEO software, we run a third study (MEO.3) looking at the concept through the prism of sensemaking.

In this chapter[22], we first introduce the MEO concept and detail how it was instantiated into software and hardware applications. Second, we describe the studies MEO.1-.3 including their setups and results. We then discuss the findings and relate them to the CuDe Framework.

9.1 The Media Object (MEO)

We use the term Media Object (MEO) for two different but closely related things. On the one hand, we speak of MEO by referring to its underlying concept – the idea of aggregating rich media (arbitrary file types) into a file or container that is defined a priori, and having various applications and devices that can capture and replay such

[22] This chapter is based on three prior publicatios (Güldenpfennig & Fitzpatrick, 2014; Güldenpfennig, Fitzpatrick, et al., 2014; Güldenpfennig, Reitberger, & Fitzpatrick, 2012a). Parts of these papers are incorporated into the chaper's text.

files. On the other hand, we also name actual files, that is, the instances produced by the applications, as Media Objects. When referring to these files, we abbreviate them as mob files (plural: mobs), because the extension of such files is ".mob".

9.1.1 Description of MEO's File Concept

MEO can be seen as a novel file format that allows the bundling of a theoretically unlimited number of arbitrary files using *XML* for organizing the content. A rich variety of media files (e.g., images, video, audio, text or additional Media Objects, that is, mob files) and metadata (ID, date, location, access statistics, etc.) can be stored into one Media Object (mob file). The underlying concept of this new file format is to extend traditional media files, for example, images, beyond common metadata information such as *EXIF* while keeping everything in one aggregate. Technically speaking the Media Object is a container that can wrap any kind of information.

A commercially successful product that is to some degree related to our concept is a commercial platform for 'remembering everything' called *Evernote*[23]. Similarly, in 2013 *Google* introduced a service named *Google Keep*[24] that can be used for taking (audio/text) notes, photos or creating checklists and keeping them in one central place. Yet another product that relates to the Media Object concept is the commercially successful micro-blogging platform *Tumblr*[25]. Again, this service allows taking photos, video, text notes, etc., and representing them as associated data or blog entries. Moreover, there are standards such as *MPEG-7* that share common aspects with MEO as they also employ *XML* to describe multimedia material. However, the focus of this research report here is not the technical implementation of MEO per se, but the way people make use of MEO and capture such mob files. The special feature of MEO is that it provides a container that exists *a priori* for data capture unlike, for example, conventional folders that are created mostly *after* data capture. Consequently, the users have to decide what (multimedia) data to fill into that mob container and are invited to populate it with their digital memory cues. Thus, MEO so-to-speak reverses the conventional way of archiving and provides a frame for rethinking the procedure of creating digital memorabilia. The users become the deliberate 'engineers' of their future digital memories, which one-day will hopefully become precious to them. This relates to the design challenge (see Section 2.4.1) of *information overflow* and *the effort to create order*. With MEO we explore a novel approach for avoiding huge unsorted archives of personal files. At the same time we aim at *encouraging creativity* in making use of the apps' repertoire of different functions.

[23] https://www.evernote.com (last accessed 8 June 2014)
[24] https://keep.google.com (last accessed 8 June 2014)
[25] https://www.tumblr.com/ (last accessed 8 June 2014)

9.1.2 Description of MEO Software and MEO Hardware

We go on here to briefly describe the features of the MEO software and hardware that was created as prototypes in the course of this thesis. In the subsequent section the design rationale of these prototypes is further detailed.

We instantiated this MEO concept via two iterations into software and hardware components for *Android* phones enabling capture and reply: mobRecMobile (capture; 1st iteration; studied in MEO.1), SimpleMobView (replay; 1st iteration, studied in MEO.1), Media Object Recorder Mobile 2.0 (MRM2; capture; 2nd iteration; studied in MEO.2) and Mobbox (replay; 2nd iteration; studied in MEO.2). The MEO capturing software (mobRecMobile and MRM2) enables the user to collect data and to store it into Media Object files.

These mob files are saved to SD card or to internal phone memory and can be transferred to a Desktop computer in the same way as other conventional file types (via *USB* cable), for example, *JPEG* images. Besides creating and storing Media Objects the user can edit and view existing mob files. Figure 9.2 shows the interface for MRM2 (a screenshot of the first iteration of this software, mobRecMobile, can be found in Figure B1 of Appendix B.2). The concept of using tiles for displaying options is motivated by findings of MEO.1 and also reflects current trends in the software industry (e.g., *Windows 8 tiles*). In MEO.1 participants appreciated the fact of having all options visible at the same time as being inspiring. In addition, for the MRM2 study we did not want

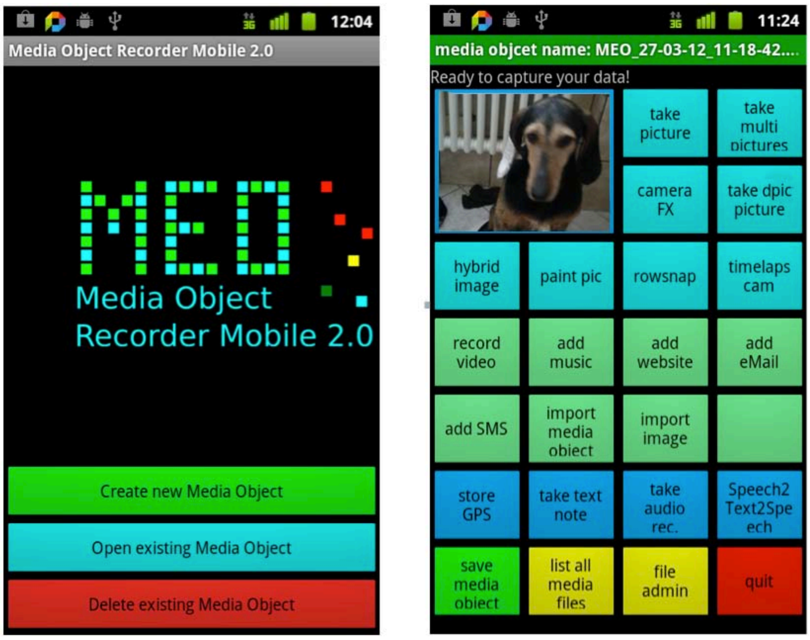


Figure 9.2. Interface of the Media Object Recorder Mobile 2.0 (MRM2): (left) new, delete or load a mob file; (right, rows a-c) main screen with all options for data capture. All tiles are visible at once, because we try to avoid a hierarchy between different functions and aim to inspire the user to capture a moment with different modalities.

to prioritize some functions over others by assigning better/worse visibility enforced by some hierarchy. The MRM2 interface is used to:

- Capture a new image / video / audio note / text note / location (*GPS*) etc. and add it to the current mob file
- Optionally annotate media (associate media data), for example, add a text note to an image and/or add the *GPS* position
- List all files contained in the current mob file
- Open and display a specific file contained in the current mob. Play associated content synchronously (e.g., fade in a text note to a photo or play back an audio note)
- Start a slideshow (big button top left with last image captured on display, in this instance a dog)

The three options/buttons on the left side of Figure 9.2 are for managing mob files. The buttons on the right side of Figure 9.2 are explained below:

- The top three rows (a) are all related to picture taking: take picture (regular camera), take multi picture (convenient mode for taking series of pictures), camera FX (retro camera with image filters), dpic (combine two photos), and hybrid image (another variant of dpic), paint pic (draw on a photo), row snap (four-parts photo mosaic). The latter five apps are more playful in nature and are summarized as *playful photo apps* in Table 9.3
- The subsequent two rows (b) trigger actions that are not directly related to photography: record video, add music (*MP3* from the phone's memory), add website (browse the Internet and add a screenshot of a webpage), add email, add *SMS*, import Media Object (add another mob file to the current mob file), import image (any image from the phone's memory)
- The buttons of row (c) trigger content capture that can be associated with other content (i.e., function as an annotation): store *GPS*, take text note, take audio recording, Speech2Text2Speech (dictate a text to be synthesized as an artificial voice)
- The last row (d) is for administrative functions

9.1.2.1 Replaying Mob Files

As MRM2 is primarily intended for the recording of mob files, Mobbox (see e.g., Figure 9.1 and 9.3) was created for playing back those files. Mobboxes are stand-alone devices with a homely design to be placed somewhere on a table, shelf or wall, and thus they aim at making mob files more visible (cf. the design challenge of the invisibility of digital data in Section 2.4.1). These devices are basically comprised of touch screens (10 inch displays) embedded into wooden frames and can either play a random mob file or the user can select one. Playing back a file means that all images, videos and other content are displayed sequentially (chronologically) for a couple of seconds. Associated content is displayed at the same time, for instance music is playing in the background, text notes pop up as image annotations or audio comments are played back. The user can open a browser and choose a specific mob or initiate the playing back of a random mob file by a long touch on the display. A short touch on the screen will show an options menu where specific files can be deleted, annotations and sound can be switched on/off and the speed (time each photo is displayed until the next photo or video is presented) of the file presentation can be set. Now three different Mobboxes have been made (see Figure 9.3). The interaction with these boxes was designed to be simple, since the devices are intended for a more passive consumption of mob files that were created beforehand with, for example, MRM2.

While the Mobboxes were created in the course of the study MEO.2, in MEO.1 we employed a software for the Desktop computer (SimpleMobView) for replaying mob files. This (rather simple) software enabled loading mob files, browsing and displaying their content. However, it was intended more as a tool for inspecting the participant created mobs before and during the interviews and we did not study SimpleMobView*'s* value as a product per se.

Figure 9.3. Three different instances of Mobbox put on display in a home setting.

9.2 MEO Design Rationale

As outlined in Chapter 3 (methodology), the approach we took in this thesis is characterised by design-led technology explorations. The development of MEO, in particular, was an iteration between literature-grounded research and user feedback on the implemented technology. We chose this approach to tackle the wicked problem (that is, a challenge that is ill-defined and fuzzy in nature) of designing technology for supporting human memory (compare Section 3.3.1). While earlier research indicated value in systems designed for supporting remembering, (e.g. (Sellen et al., 2007)), ever-updated technologies such as mobile phones provide us with new possibilities and opportunities we seek to investigate. However, being such an open design space, there is a lack of well-defined measurable end-goals and so we designed MEO as an exploration tool for this vast design space. Taken together, the desired output is not only a working prototype but also wanting to generate new insights about the wicked problem itself (as, e.g., articulated later within the CuDe Framework) by exposing the created artifacts to participants.

As already mentioned in this chapter, we paid particular attention to the design challenges identified in the literature when designing MEO (compare also Section 2.4.1). These challenges relate to *information overload and the effort to create order*, the *invisibility of digital resources*, and *supporting creativity* and the *(re)constructive nature of memory*. (For a detailed description of how MEO considered these challenges in its design we refer to Appendix B.1)

9.3 Setup of the Studies MEO.1-3

The MEO applications were evaluated within 3 user studies:

- [MEO.1] A short-term exploration of MEO in everyday situations for testing the first prototype (mobRecMobile).
- [MEO.2] A long-term study for an in-depth evaluation of the MEO concept using MRM2 (the iterated version of mobReMobile).
- [MEO.3] An exploration of the inner entity (media files) relations of Media Objects to reveal how MEO can be used to give structure to collections of memory cues.

The encouraging participant feedback of MEO.1 motivated MEO.2 and we further developed the software based on this feedback. Thus, while MEO.1 can be considered as a pre-study to MEO.2 and we present some exemplary MEO.1 user data, the main focus of the report is on MEO.2.

9.3.1 MEO.1 Everyday Life Situations (Short-term)

As a first exploration of what people make of the mob concept, we recruited 7 participants in their 20s and 30s from a variety of backgrounds. Participants signed consent forms and were not remunerated.

Every person either owned or was provided with an up-to-date smartphone. The mobRecMobile app was installed on each device and the participants were asked to use it for 2 weeks. However, three participants (P1, P2, P3) with own smartphones kept using our app for 3 more weeks (see Table 9.1 for an overview of all participants of both MEO.1 and MEO.2). Since the study was exploratory and no comparisons between participants were made, we also included this additional material into our data pool. They were given no further instructions besides the invitation to capture anything with the app they liked to record. After the test period each participant reported their experiences in a semi-structured interview (lasting between 50 and 80 minutes), while also viewing mob files on the SimpleMobView app. The interviews were audio taped, transcribed and then analysed qualitatively looking for common themes. We also did a thematic analysis (Braun & Clarke, 2006) of the content of their mobs.

9.3.2 MEO.2 Long-term Evaluation

The user feedback from MEO.1 encouraged us to create new software (MRM2) and devices (the Mobboxes). For MRM2, we added 14 new integrated apps or functions to the existing 5 integrated apps of mobRecMobile for capturing data. This was given to 10 participants who were recruited for a long-term evaluation (t = 24-28 weeks). As depicted in Table 9.1, a subset of users participated in both MEO.1 and MEO.2 (P1-5 participated in both studies).

In line with MEO.1, in MEO.2 we also targeted young users (in their 20s and 30s) who were already familiar with mobile phones and shared an interest in digital photography and recruited such participants from our social networks. Participants signed consent forms and were not remunerated.

For the long-term study (MEO.2), every participant was provided with an *Android Galaxy Nexus* or a *Nexus S* phone, if they did not own a comparable device (P1-3, P9, P10 had their own high-end *Android* phones). They were asked to use the phones as their primary mobile phone devices. Participants were provided with our mobile phone application MRM2. They received explanations and demonstrations for how to operate the app. In addition, they were shown pictures of the Mobboxes to familiarize them with one particular aspect of the MEO concept, namely that mob files were designed to be replayed on a variety of different devices that could potentially be located or built into the house at any place. In this study we primarily focus on data captured by means of MRM2.

We gave no instructions to the participants except an explanation of the software and allowed them to use it as they wished. We also avoided speaking of memories or souvenirs and named our concept Media Object (and not *Memory Object*) in order to not provoke biased usage behaviours.

After the duration of 24 weeks the mob files were collected and analysed. For this purpose MRM2 also incorporated an interaction logging mechanism with timestamps. The mob files were iteratively inspected by the author of this thesis and categorized across salient reoccurring topics (displayed in Table 9.2) following a thematic analysis approach (Braun & Clarke, 2006). Participants were also interviewed about how they experienced our software; the talks were audiotaped, transcribed and analysed by the researcher. For this analysis, the transcripts were repeatedly read looking for common themes (also using the thematic analysis approach (Braun & Clarke, 2006) as a guideline) or salient statements/observations. Each mob file was later assigned to one category only (the most evident one, see Table 9.2); however multiple assignments to (secondary) categories would have been possible in a number of instances.

Table 9.1. Participants (P) involved in the evaluation of MEO: weeks participating in MEO.1 and/or long-term study MEO.2; number of mob files created (also divided between studies) and the number of media files contained in these mobs. Key: *…participant dropped out, **…participant provided with a Mobbox after 24 weeks. P1-5 and P11-12 participated in MEO.1 and P1-10 participated in long-term study MEO.2.

P	Sex	Duration study 1 / 2 (weeks)	Study MEO.1		Study MEO.2	
			n mobs	Σ files	n mobs	Σ files
1	f	5 / 28**	15	226	21	621
2	f	5 / 28**	8	71	12	186
3	f	5 / 3*	22	77	3	10
4	m	2 / 28**	7	26	30	118
5	m	2 / 5*	6	36	4	20
6	m	- / 24	-	-	28	112
7	m	- / 24	-	-	3	27
8	m	- / 24	-	-	30	449
9	m	- / 24	-	-	7	210
10	f	- / 24	-	-	11	175
11	m	2 / -	3	10	-	-
12	m	2 / -	5	36	-	-

During the semi-structured interviews participants were shown their own mob files on a Mobbox and they talked aloud about the content that they have created. They were allowed to interact freely with the Mobbox. Of particular interest during the interview analysis were questions such as whether they saw value in the MEO concept or not, on what occasions they used the software, whether they had suggestions for improvements and so forth. After this first 24 weeks, we also provided 3 voluntary and engaged participants (P1, P2, P4) with the available Mobboxes and let them live with them for an additional 4 weeks. Despite focusing on MRM2 and mob capture in this study, we wanted to probe the reactions of a small number of interested participants to the Mobbox user experience in order to incorporate this feedback in future work. After these 4 additional weeks another interview was conducted with each of the 3 voluntary participants about their experience with their Mobboxes.

9.3.3 Study Objective Summary MEO.1-2

In summary, MEO.1 and MEO.1 were explorative studies on a novel concept attempting to identify opportunities and inspirations for the design of future digital memory systems. In a way, MEO extends the dimensionality of Duography (Chapter 8) by supporting the aggregation and *asynchronous composition* of an arbitrary number of media *entities* (AEC).

While we have designed MRM2 with a view to its potential value for later remembering, our focus here was on capturing digital resources as a first step in this process. Future work will build on this to evaluate the created mob files with regard to their precise quality as memory retrieval cues in the long term.

In the design of MEO, we considered the four challenges identified in the literature (see Section 2.4.1 and 9.2). As a consequence, in investigating these multiple entity prototypes and interventions, we are particularly interested in a set of sub-research questions, which are directly related to the addressing of the four design challenges:

Will the participants embrace the Media Object concept, namely to reverse the conventional process of capturing and sorting data? How will they make use of the different possibilities of recording experiences (different modalities such as photo, video, text, etc.) offered by MRM2? Will the participants enjoy crafting their own mob files? Can MEO spur their creative engagement and increase their readiness to invest effort in creating digital resources for memories? Will the Media Object be helpful for them in creating order over their digital material and do they consider mobs in combination with devices such as Mobboxes to improve the visibility of digital memorabilia? Will the participants see a potential in the mob files as memory retrieval cues?

9.3.4 MEO.3 Content Relations

In MEO.1 and MEO.2 it became apparent that the participants employed our software in a number of different ways to combine media data. That is, the recorded cues were not simply ‘dumped’ into the container mob file. Rather, the participants made plentiful use of the different options to relate entities or files to each other (e.g., annotating image entities with text entities). We suspected this capability of MEO - to define a number of different *relations* between the content files - as one of the concept’s basic strengths or underlying working principles to support the users in creating order over their cues and making meaning of their digital material. Therefore, we ran a third study (MEO.3) to explore the inner structure of Media Objects, as collated by participants, and what the consequences of this structuring were from a sensemaking perspective. (Note that sensemaking is a research area on its own right. We do not intent to contribute to sensemaking research per se in this thesis, but make use of this notion for hypothesising how the participants might have ‘read’ their mob files. Further information on sensemaking is provided in the Glossary.)

Overall, MEO.3 was conducted to learn how users inferred information from the internal structure of MEO containers and how they used the application to put their media entities into order.

The study took place in the course of an interaction design class at Vienna University of Technology, as we identified this particular setting as an appropriate frame for the intended MEO.3 study. It featured 18 participants, who had two weeks to fulfil a Media Object homework exercise. The objective of this exercise for the students was to understand contextual factors of an everyday environment. We aimed at supporting this goal by providing MRM2 as a lightweight and mobile tool for capturing and documenting relevant contextual aspects by means of rich multimedia data. Moreover, the application allowed (as already described) aggregating related information into digital Media Object collections. It was our assumption that this particular study setting would generate a set of MEO files, which were more comparable due to their shared background than the mobs from MEO.1 and MEO.2, where the participants employed MEO without instructions in everyday situations. We hypothesised that the MEO container structure could provide a *mental frame* and reference for structuring and making sense of this recorded data. More precisely, MRM2 was intended to help the students to sharpen their view and focus on relevant aspects of an environment (not part of the evaluation of MEO.3).

To investigate how the students would make use of MRM2 and, most importantly, how they would structure their Media Objects, we chose *coordination of household tasks* as the problem space of the interaction design exercise (see below). We assumed that every student had easy access to this context, and moreover, that this setting would facilitate the capturing of interesting media data. We were interested, again, in how they would use MRM2 to give structure to their data, which they captured ‘in the wild’.

The exact exercise description as given to the students was the following:

This exercise is about different responsibilities in housekeeping. In particular, it is about the coordination of household tasks in shared apartments such as doing the cleaning, tidying up, doing the laundry, etc. Typical workflows and possible problems or challenges are to be documented and later analysed. What kind of tasks is to be carried out? How is the work distributed among the household members? Who is in charge of which tasks? [...] The purpose of this exercise is to gain deeper understandings of this particular context (housekeeping) and should aid to inspire new design ideas that are based on empirical observations. It is an important part of your design requirement analysis. For this exercise you have to create 'Media Objects' by means of the corresponding smartphone application (the 'Media Object Recorder') in order to capture the use context of the to be developed system. 'Media Objects' are container files and the 'Media Object Recorder' allows capturing a variety of multimedia files to be aggregated in these containers. Create 'Media Objects' to capture a specific use context (approximately 2-4 'Media Objects')! Capture specific aspects of the household user context that seem relevant to you (e.g., specific details, locations, persons, situations) and that you later whish to design for!

After the two-week 'homework' period, the students handed in the assignment and they were informally interviewed about the exercise. These interviews centred on general user acceptance of the software and its usefulness in relation to fulfilling the task.

However, as noted above, the main focus of the study was on the analysis of the *entity relations* and not on the content per se. That is, we were not so much interested in *what exactly* was depicted by the participants' MEO files or how it influenced later design work. Instead, more abstract patterns were of primary interest in this research.

To this end, we conducted a descriptive statistical analysis of the data set by looking into every Media Object and counting the actual media files within the container structures. (The resulting cumulative statistic is depicted in Table 9.4.) During this first round of analysis, we observed certain relations between the files, for instance, specific files serving as annotations to other groups of files. It occurred to us, that we were unconsciously exploiting these relations while interpreting the Media Objects. We decided to further investigate this occurrence as we suspected a powerful working mechanism of the MEO concept. To this end, we started a second round of analysis and looked closer at the actual relations between the files (e.g., what aspect is depicted in a series of photos and which photos are part of that certain group), adapting a thematic analysis approach (Braun & Clarke, 2006), to iteratively and repeatedly review the data to identify patterns of relations (depicted in Table 9.5).

9.4 Findings MEO.1-3

9.4.1 MEO.1 Everyday Life Context (Short-term)

The participants of the exploratory study MEO.1 created Media Objects on many different occasions. In total, 482 media files (images, video, audio, text, *GPS*) were captured and were distributed over 64 Media Objects (see Table 9.1). These mobs differed strongly in content and in their properties. Also, the mob creation time-span varied from short (minutes) to longer periods of time (where mobs grew successively over multiple days). Here we provide a list with example events or occasions that have been captured into Media Objects:

P1: impressions of a short trip (see Figure 9.4)

P1: documentation of childhood memories (various cherished physical mementos)

P2: long winter walks

P2: Christmas Day and a New Year's party

P3: sound installation at a museum

P3: night at the opera

P4: indoor climbing wall visit (see Figure 9.6)

P5: preparation of a special tea ceremony

P5: beverage bottles and the sounds they make when opening them

P6: snowfall in the city

P11: breakfast with parents-in-law

P12: documentation of an electronics tinkering project

The vast majority of media files contained within the Media Objects were images. However, all except 17 mobs were comprised of different file types (e.g., images combined with audio, etc.). The most common Media Object consisted of a set of im-

Figure 9.4. "It starts! I am on my way. The train was 5 min late, but I have a good seat. Brrrrr it is freezing outside." – Text note by P1 referring to the left image. The right image is extracted from the same Media Object. In an audio note P1 explains, that it was the first night at the hotel shown in the picture.

ages accompanied by a video clip or text note. Figure 9.4 illustrates such a typical mob file. It displays two pictures that have been enriched by P1 with text and audio notes, because this was "a most appropriate way to capture atmospheres" (P1). Two more exemplar Media Objects are shown in Figure 9.5 and Figure 9.6. Both contain images as well as movies. P3 states that images are "for capturing moods and colours", whereas movie clips are made for "things that happen". Accordingly, she tried to capture her first impression of a fun fair with an image and made a video clip later on for showing and commenting on the children's play in the straw (Figure 9.5). P4 provided orientation of an indoor climbing wall by means of a video pan shot. Further still images went into the same mob, for instance a detail picture of a climbing grip (see Figure 9.6).

Through the analysis of the collected Media Objects and interview data we could identify prevalent usage patterns and observations regarding mob that occurred in the course of the study. These include:

- Most participants reported having mild to severe problems managing their conventionally recorded digital media (mostly photos) in terms of ordering or relocating data. They also saw a potential for Media Objects to bring more order to their data collections due to the fact that the mob container is created a-priori and found the concept useful for retrieval. 5 participants stated that they wanted to continue using Media Objects. 2 participants appreciated the mob concept, but stated that mob needs some extra features before they could imagine using it in a real life setting.
- A great number of Media Objects were created by the participants for personal reminiscence and reflection. P3, for example, talked about mobs as "virtual memory albums". Some mobs had been captured for sharing experiences with others and story telling. A couple of mobs represented strange or funny things and had been made for pure amusement.
- Participants reported capturing Media Objects in addition to, rather than replacing, regular photography. It was considered as a creative act and mobRecMobile was reported to inspire creativity, because "the line-up of tools is always visible" (P12).

The participants appreciated the fact, that Media Objects could be *unzipped* by common file archiving software in order to ensure future data access.

9.4.2 MEO.2 Long-Term Evaluation

In contrast to the initial exploration of MEO.1, MEO.2 was a long-term study with a great number of user data gathered. To report the findings of MEO.2 in a structured way, we further divide this section into the following subsections: *overall uptake of MEO*, *MEO usage practice*, *opportunities for improvements* and *opportunities afforded by MEO*.

Figure 9.5. Picture of a fun fair (left). Still from a movie displaying children's play in the straw (right).

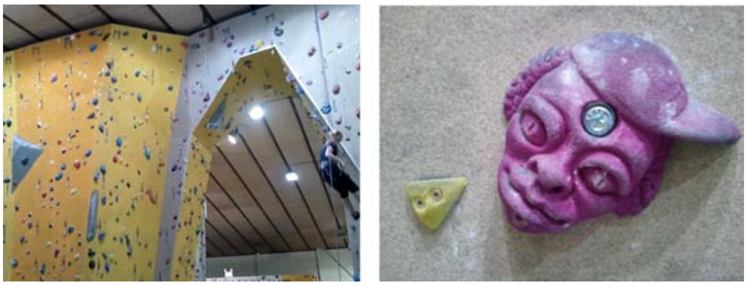


Figure 9.6. Still from a movie showing and commenting on a climbing wall (left). Detail picture of a climbing grip (right).

9.4.2.1 Overall uptake of MEO

Overall 149 mob files comprised of 1928 media files were captured during the long-term study (see Table 9.1 and 9.3). According to the participants, most mob files were created as a digital resource for remembering. On many occasions they used the words 'photo' and 'memory' almost synonymously throughout the interviews. P2, for example, commented on one of her photos as follows: "I think this is charming. I think this makes a very nice memory for the whole thing." Thus, we identified two broad types of uses. Firstly, in most instances (n = 114 / 77%) mob files were about remembering (precious) things/persons/pets/events – mostly in a sense of reminiscing. Secondly, a smaller number (in sum n = 35 / 23%) of functional (e.g., for recalling mundane facts) or experimental mobs (playing with the app, creative engagement, etc.) were created. While most mob files (n = 104 / 70%) were centred on particular events (these were primarily for reminiscing and sentimental reasons), a number of mobs (n = 20 / 14%) were organized around a certain topic or theme. We denote these as collections, that is, mobs that combine media files on a common topic or matter (not necessarily event-related). The following list illustrates exemplary mobs for both event-related mobs and mobs that serve as collections: “a nice walk on a sunny day” (event-related, P6), “my trip to Paris” (event-related, P2), “all about my dog” (collection, P10), “my stone collection” (collection, P1), “graffiti.mob” (collection, P9, see Figure 9.7), “all job advertisements from a black board” (collection, P8), and “documentation of a dinner with friends” (combination of event-related mob and collection, P6, see Figure 9.8). As can be seen in the last example, these categories are not mutually exclusive. For instance, collections can be used for reminiscing as well.

Figure 9.7. “graffiti.mob” (excerpt) – a collection of “interesting graffiti” in town (P9).

Figure 9.8. Making a mob about a dinner with friends (P6). Left column top to bottom: dish with beans, still image from a video on preparing the sauce, pan at the cooker. Right side: putting the ready meal on the table. This mob was created for both remembering as well as collection since it contains a rigorous documentation of how the meal was prepared.

Table 9.2 provides a detailed view of all (sub)categories that were derived from the inspection of the mob files and from the participants’ interviews. The most prevalent subcategories comprised mob files of (day) trips (n = 79 / 53%), that is, files recorded during a holiday or journey, and mobs of social or special events such as parties (n = 25 / 17%). In addition, the following subcategories emerged from the data set: practical collection of things such as notes about a book (n = 10 / 7%), sentimental collections such as images of cherished physical objects or videos/photos of pets (n = 10 / 7%), playful mobs (n = 25 / 17%) that have been created for the sake of playing with the app and creative exploration in first line and not for capturing specific content.

The acceptance of the Media Object concept was high among all participants. However, the actual frequency and quality of usage of the technology varied. To reflect this, we characterize the participants into three broad groups: the *mob enthusiasts*, the *undecideds* and the *mob rejecters*. Before discussing these in more detail, it is useful to note one feature around frequency: as mentioned above, in our study Media Object turned out to be most appropriate for capturing special events such as weekend trips or, for example, the documentation of a dinner event (see Figure 9.8). Consequently, small numbers of captured mobs did not necessarily indicate missing engagement of the participants. In fact, except for rare exceptions, every mob in our sample was comprised of a number of often deliberately captured media files. Due to the tendency to capture events and trips it was hard to assess a potential novelty effect of MEO, since usage frequency was dependent on the points of time of these events. However, it seemed to be clear from the log data that at least the *mob enthusiasts* and parts of the *undecideds* were using the app on a regular basis until the very end of the study.

Table 9.2. Different (sub)categories of mob files (n = 149). While a number of mobs fit into more than one category, we did single-assignments only (to the most evident category).

Category	(Sub)category	n mobs	Percentage
Remembering (reminiscing); n = 114 mob files total (~77%)	*(Day) trips*	79	~ 53%
	Social/special events	25	~ 17%
	Sentimental collections	10	~ 7%
Recalling (functional, mundane);	*Practical collections*	10	~ 7%
Experimentation (artistic, playful);	*Playful mob files*	25	~ 17%

9.4.2.2 MEO Usage Practice

As apparent from Table 9.1 and Table 9.3 a huge amount of digital content was collected during the study. There is not enough space in this article to accommodate the richness of this data, however, we would like to present the content of one exemplary mob file that represents a typical and very common class of mobs. Figure 9.9 shows an excerpt of a Media Object that was made for documenting one specific event, namely a day spent at a lake by P1. This MEO file consists of 10 photos (of which four of them are depicted in the figure) and various other media files. For example, it contains a text message reading "brilliant weather, found mushrooms and a jumping deer – nice!" The creator of this file especially appreciated the possibility to capture different media modalities and found great appeal in the heterogeneity of mob data.

From the statistics of the previous section (different mob categories) it follows that mob creation was primarily centred around specific events or (day) trips. The mob of Figure 9.9, for example, is dedicated to the boat trip. From the interviews and log files it was apparent that the participants also adjusted their mob recording usage according to these events. That is, normally they started a new Media Object file, populated it with data and finalized it whenever the event was finished. Most events did not last longer than one or two days. When an event took place within another event, for example, the visit of museum during a trip, the minor event (visit to the museum) would be integrated into the more significant or longer event (e.g., the trip). Most of the time, participants did not reopen and edit mob files on an event that was already over. An exception was Media Objects that were dedicated to collections (e.g., a collection of stones and minerals). These mobs were opened, edited and closed again and hence grew over the time. However, participants regularly returned to their mob files in order to review them. This was done on various occasions, for example, before going to sleep at night, while waiting for the bus or when showing impressions caught by MRM2 to friends. The participants reported that they usually made use of the automatic slideshow function to replay mobs. In addition, participants stated that they think that the mob files will eventually become even more interesting and valuable as time passes by.

We go on now to highlight suggestions by the participants for further improving MEO. After this we report which features were particularly appreciated. In the course of this, we describe the three different user groups. Naturally, for every participant there were things regarding MEO that they liked and other features that they did not appreciate. Still, we use the groups (*mob rejecters*, *undecideds*, *mob enthusiasts*) as a reference for moving from more critiqued to more valued features of our software. The group names were chosen in a slightly exaggerated fashion to indicate a certain polar-

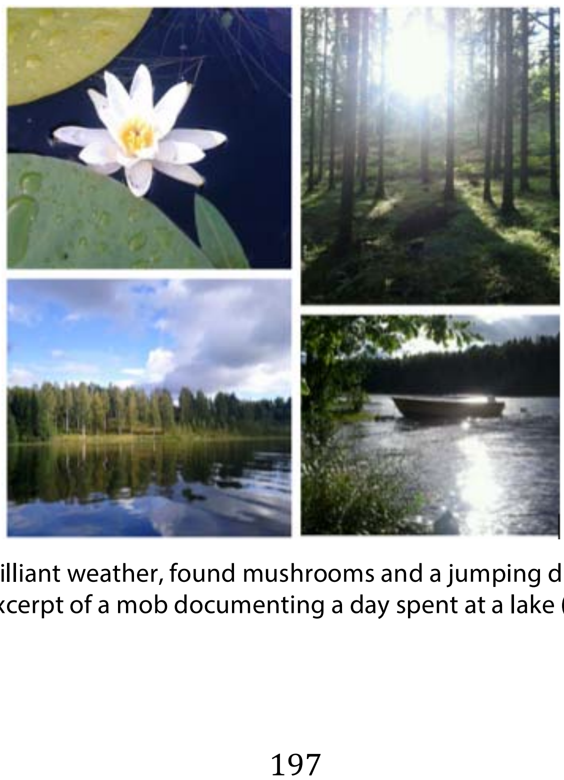


Figure 9.9. "[B]rilliant weather, found mushrooms and a jumping deer – nice!" (Text annotation by P1) - Excerpt of a mob documenting a day spent at a lake (P1).

ity regarding MRM2 that became apparent during the study.

9.4.2.3 Opportunities for Improvements

The *mob rejecters* (P3, P5, P7) did not use the software continually until the end of the test period. P3 and P5 even dropped out early in the study (in week 3 and 5). Interestingly enough, both participants were also involved in the pre-study and agreed to participate in the long-term study because they liked mob and were interested to continue using it. However, after only a couple of weeks P3 stated that she was overwhelmed by the newly designed *Android* application that now featured a lot of new options for data capture. She preferred the much simpler software of the pre-study and primarily captured photos and some videos. P3 switched from MRM2 to the native *Android* camera app and took hundreds of photos. According to her, the reason for not using the mob app was that the regular camera app was faster to open and from a conceptual perspective much simpler ("Touch one button and you are done" (P3)). However, in the end she regretted that she fell back into her old habit of accumulating a vast number of unsorted or unrelated photos that she found hard to access and make sense of. P5 dropped out of the study, because he was happy with his current photo taking and sorting practices and decided that he did not need new strategies for capturing resources for and getting order over his photos. He was the only participant who stated that he would always sort and annotate his images after capture and never just dump them into a *DCIM* folder. P5 impressively proved his photo sorting behaviour by giving us a short tour of his well-organized holiday photos collection after the interview. The other extreme is represented by P7 who is also interested in having photos etc. as souvenirs but was not ready to invest any more effort in capturing them besides a quick button touch for releasing the trigger. P7 would then store the images away without revisiting them. For him the prospect to have the images on disk to maybe one day be able to revisit them was all that counted:

"I have been six weeks in Asia and captured tons of images, which I have never looked at again. I haven't even sorted them out. Maybe this will happen one day in 10 years when you think: hey this was a cool vacation! - It would be fun to see some pictures. Maybe I will sit down then [and deal with them…Photos] is something of which I think: ok, I do possess them and I can work with them one day later […]. And doing a mob is even more work than taking a photo" (P7).

We denote a subset of our participants as *undecideds* (P6, P9). While these mob users created quite a number of Media Objects (n = 35), their usage frequency was either sporadic or they stated that they would not continue to use our software in its current state after the study. Still, they clearly indicated that they would consider continuing to use it after improvements. Their main criticism centred around the fact that reviewing mob files on the phone was not convenient due to the screen's size and due to the fact that MRM2 was designed for capturing experiences and not for revisiting them. (This comment reflects back to an earlier design decision we made to avoid implementing a *Flickr* for mobs to reduce complexity from the study; this would also have required us not only to provide phones but also to provide data contracts including Internet traffic to 10 persons for 24 weeks, which was not feasible.) In addition the 2 undecided participants (P6, P9) stated that they would rather not have all the features of MRM2 on the main screen, but preferred a solution where uncommon buttons were hidden in some sort of menu or secondary screen. Also there appeared to be a need for decreasing the startup time of the software, that is, participants (P4, P6) wanted a reduction in the time or number of clicks it took until photo capture could begin. P6 suggested, for example, to open MRM2 in camera mode by default and overlay the photo preview with the remaining features of this app. Finally, undecided participants requested some sort of mob editor that would allow for easy and convenient editing of existing mob files.

Table 9.3. Distribution of mob content by participant (long-term study). Key: img…regular photos, vid…videos, play…photos made with a playful photo app, text…text annotations, aud…audio annotations, mu…music, int…Internet / network content (email, Webpages, *SMS*), gps…*GPS*. coordinates.

P	img	vid	play	text	aud	mu	nt	gps
1	478	17	50	42	27	4	2	1
2	131	13	19	9	10	0	0	4
3	8	1	0	0	1	0	0	0
4	35	12	38	10	15	0	1	7
5	10	1	5	2	1	1	0	0
6	57	2	16	4	16	0	0	17
7	5	4	5	11	2	0	0	0
8	409	19	5	5	9	1	1	0
9	85	4	25	90	4	0	2	0
10	105	4	19	38	3	3	3	0
Σ	**1323**	**77**	**182**	**211**	**88**	**9**	**9**	**29**

9.4.2.4 Opportunities Afforded by MEO

While there are clearly the improvement opportunities listed above, there were a number of features and characteristics that were still quite appealing to the undecided users. This leads to the third subset of participants that we refer to as *mob enthusiasts* (P1, P2, P4, P8, P10). We go on to highlight why this group enjoyed the software and sometimes even gave enthusiastic feedback. In doing so, we will also refer back to the four design challenges from the literature. The *undecideds* or even *mob rejecters* also reported some of the same merits, but we will use examples here taken from the third user group.

Freedom of choice, holistic impressions of the moment

The *mob enthusiasts* made extensive use of the different tools provided by MRM2 for capturing digital resources and stated that the availability of these tools spurred their creativity (see also next section for specific reflections on creativity), a term often used unprompted by them, and encouraged them to try to capture a situation in new but meaningful ways:

"Often I started a mob by taking a photo and was then inspired to try out something else. This is my playful nature. Also my motivation was to capture not only photos but having other media for the same context as well. Often my motivation was to document intentionally and well. […T]his can give a more eclectic impression later on, a more holistic impression " (P4).

This participant went on to further reflect on his video capturing behaviour:

"Usually I never do videos. However, when I am doing a mob and I have – say – three images, then I will also do a video, because it is a nice complement and unlike earlier times I can be sure that it will be played back again in the course of revisiting the mob file" (P4).

Figure 9.10. Four instances of row snap mosaic images. Each image is comprised of a series of four photos arranged along one line (row). Row snap is one of the more playful possibilities to capture photos by means of MRM2 and gives photos a *lomographic* appeal.

Similarly P2 said:

*"I try to depict things in a more specific fashion compared to when I only do normal photos. It is the variety of information…this is one of [*MRM2*'s] most attractive features" (P2).*

She went on to elaborate on one specific feature in more detail (see Figure 9.10):

"What I like best is the photo app with the four images in a row and the little time delay. In my opinion it is perfect for capturing a thing and everything that surrounds it. […] I think its special charm is about being able to see that things belong together albeit you are capturing distinct motifs at a time. I think it is livelier than a normal panorama image. […] I think precisely because things don't fit together perfectly it is more personal than one of those perfect photos, because I know that I don't take perfect pictures. In my opinion it opens whole new perspectives" (P2).

MRM2 was also compared to an empty "virtual memory album" (P3) that invites one in to fill it with memories (e.g., "A Media Object is like an empty album that is inviting me to fill it […] and showing me all the tools and possibilities at the same time" (P1). Having all of the tools on display on the main screen was repeatedly reported to be inspiring. Table 9.3 shows in detail what kind of media content has been captured. From this distribution it is obvious that photos was the most important resource during the long-term study. It also shows that a relatively large number of 299 text or audio annotations were added to the files. Still, participants reported that at times they wanted to do more annotations but were not able to, because of the time it took, for example, when they were travelling in a group and needed to keep the pace.

Creative Engagement

As briefly addressed above, the participants demonstrated creative engagement in different fashions: they showed interest in putting playful and artistic mobs together, they deliberately constructed their resources for memories and they also took their time in doing so and invested quite some efforts (see also the subsequent section). While P7, a *mob rejecter*, noticed that "[MEO] can demand quite some creativity of its users", the *mob enthusiasts* experienced exactly this feature as a big advantage of the system: "The many different buttons [= different apps] inspire me to be creative in framing the moment that I want to capture" (P1). Figure 9.10 can serve as an example of the participants' interest in creating original or experimental content. Figure 9.11 demonstrates creative engagement of a different kind. Here, P10 deliberately assembled a mob to capture the holistic impression of a visit to a park.

Efforts in Creating Mobs And (Re-)construction of Memories

The participants – in particular the *mob enthusiasts* – showed great interest, passion and willingness in putting effort into the creation of mob files. However, at least the *mob enthusiasts* did not perceive it as a burden or real work. They acknowledged that creating mobs was more effort than taking regular pictures and a "slower process" (P8). Nevertheless, to them MRM2 still had a "low-threshold" for taking it out and using it (P2). While they reported it was more work, they regarded it as was well worth the extra effort since they used it to capture important or pleasant events. In addition, all of the participants stated that having the MEO container or folder in the beginning made obsolete the task of later sorting and hence seemed to be a promising solution for getting order over their digital souvenir collections.

Figure 9.11. "Schönbrunn-Park.mob" (excerpt, P10).

Reconstruction of Memories, Rich Media and Context

Solely the fact that a number of files were bundled into one mob file supported the participants in recreating memories. As would be expected, dedicated and associated annotations, for example, for images, were identified by the participants as potentially good memory cues. However, the awareness alone that a bunch of files belonged together (because they were part of one mob file) and hence were created within the same context stimulated the participants:

"If you have many different memory-formats, they can re-assemble much more lively memories. You have various sources of information which cover various aspects …emotions as well as side information such as what I have done at this moment or where. The photos or things don't have to explicitly refer to each other. It is enough that I know that they were intentionally put into the same container together […]. Knowing all of this again creates images within the head [pauses]. Everything assembles into one colourful memory-aggregate" (P1).

Mobbox

In the final interviews, when those participants who did not capture a lot of mobs were confronted with a Mobbox that included their own and some prepared demonstration mob files, they regretted not having realized the potential of MEO or having created more mob files. P7 who showed mistrust towards his creative capabilities during the interviews noted:

"I enjoy watching mobs and you can do great things with it. But to me it is some sort of art to put everything together, to make everything one big thing" (P7).

The fact that a Mobbox automatically plays a kind of slide show including overlaid annotations was well received by all participants and it reinforced their impression that MEO can in fact save time and effort in preparing resources for memories. In addition, not only did the rich media content give more details, it also made the mobs more interesting to look at compared to regular slide shows, for example, as displayed by digital photo frames or photo albums according to our participants. P9 made the following ironic comment during his play with Mobbox:

"I think the overall concept is great … the sorting beforehand and so forth … However, the things and souvenirs that I craft with my premium tools at home are even better than the Mobbox *slideshow. They do only have one small drawback: I never finish them and hence they do not exist" (P9).*

P1, P2 and P4, who had access to a Mobbox for a month, reported that it was an appropriate way for "dwelling in the past" (P1) or "sharing experiences with friends" (P2). The larger form factor was an important advantage over mobile phone screens. Having a device that does not look like regular technology or even like a PC helped them to "put them into the right mood" (P1) when revisiting mob files. All 3 participants reported that they used their Mobbox very frequently during the test period, both alone and with friends. In P1's words this was also due to the "permanent presence of the device", reminding and inviting her to occasionally "just press the button and view a mob file."

9.4.3 MEO.3 Content Relation

A total of 80 Media Objects (M = 4.44, STD = 2.20, Range = [1; 10]) were created by all participants (n = 18) of the MEO.3 study. These data aggregates contained all together 681 media files across the 18 students (M = 37.83, STD = 25.92, Range = [11; 86]). Table 9.4 details the precise distribution of this content across the different mini-apps. From these numbers, it is clear that photo was the preferred medium for documenting the household tasks (see Section 9.4.3). Still, a significant amount of text was also created by the participants, providing further information on the visually captured data. Video and audio played a minor role, but were readily used to audio-annotate the Media Objects or to illustrate dynamic aspects of the design space.

Table 9.4. Distribution of media file types captured by all participants. Key: mobs…Media Objects, img…images, m.img…multi-images (e.g., row snap).

n mobs	n img	n video	n audio	n text	n m.img	others
80	348	13	35	241	19	25

Table 9.5. Distribution of different file relations (a-g) in all Media Objects.

a)	b)	c)	d)	e)	f)	g)
80	3	22	227	10	48	11

Figure 9.12 provides one of the student submissions as an example. It shows an excerpt of a Media Object dealing with the household task of cleaning the dishes in a shared apartment. The student chose to use the photo-mosaic mini-app (row snap) for capturing four different locations involved in storing the dishes. This photo was ac-

Figure 9.12. Excerpt from a Media Object. A photo-mosaic (row snap) of different storage places.

companied by an audio file portraying the typical soundscape of washing dishes in this kitchen for providing designers with a more holistic impression of the design space. The same Media Object also contained additional photos pointing to critical spots in the kitchen regarding untidiness and a text file describing the problem of fairly assigning cleaning task between the household members and their different levels of conscientiousness.

The feedback of the students about the MEO experience was very positive in general. They had minor reservations about the usability of the software, but acknowledged it was a working prototype. They thought the principle of aggregating multimedia data in a lightweight fashion was very useful in the dynamic and complex context of ubiquitous design and liked the exercise. Detailed analyses of their submissions, while an interesting opportunity for future work, are out of the scope in this thesis. Instead, in the next section we explore the emerging relations between the different files contained within Media Objects. The motivation is to carve out possible mechanisms that might account for MEO's potential in giving structure to rich media captured by mobile phones.

9.4.3.1 The Underlying Structures of Media Objects

From our data analysis, we found seven different types of file relations (related by: *same container*, *common label*, *defined subgroups*, *annotations*, *indirect annotations*, *shared similarities*, *annotated subgroups*). These relations are captured in Figure 9.13, where different media entities are illustrated as circles with different colours. A statistic of the occurrence of the different file relations is depicted in Table 9.5.

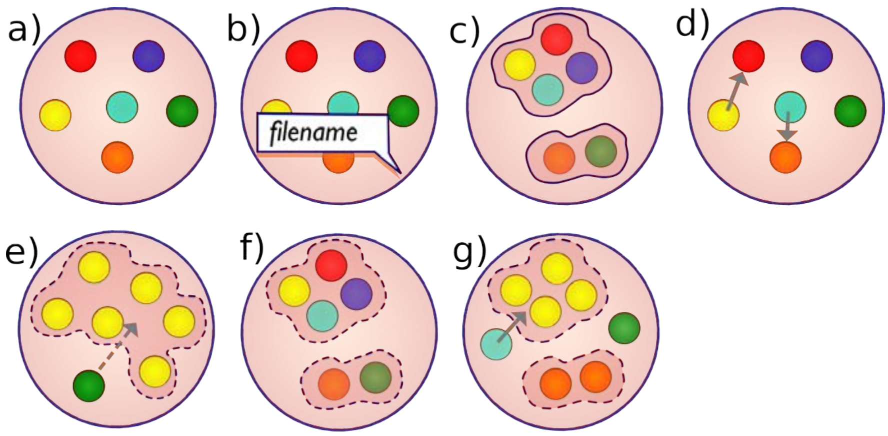


Figure 9.13. Schematic illustration of different entity (file) relations within Media Objects.

As mentioned above, entities can be related to other objects. The seven relations identified in the participants' data are the following:

a) All files were situated within the *same container* (n = 80; i.e., they were all part of the same Media Object). This gave them a common reference frame for their interpretation. They all belonged together and this grouping was supposedly done by intention. This relation is necessarily given in any MEO file, as the implementation of the software is based on a container concept.

b) Media Objects were given a name (n = 3). This name then served as a *common label* for all files within the container and thus referred to all entities.

c) Within a Media Object there were clearly *defined subgroups* of related information (n = 22), for example, a photo-mosaic (row snap) with four related pictures or even another Media Object contained within this Media Object.

d) MRM provided the option to annotate files (n = 227; e.g., a photo with a caption). These *annotations* then referred to the primary entity and complemented it (indicated by the arrows).

e) There were also *indirect annotations* (n = 10). For instance, if a Media Object contained a series of clearly related files (e.g., a series of photos) and one entity that was different to some regard (e.g., text), this single file could then be interpreted as an annotation for the subgroup of related files.

f) At times (n = 48), entities were related, because they seemed to *share certain similarities*. For instance, two series of photos on two topics. These were implicit relations and implicit groupings then (indicated by the dashed border; see also e) indirect annotations).

g) In some instances, an entity was referring to files that were members of a subgroup (n = 11). Thus, this reference then became an *annotation* to the complete *subgroup*.

To illustrate the identified file relations, we present one illustrative Media Object as created by a participant and indicate the particular entity relations. This exemplar file was named "Household exercise" (relation b) and contained a larger number of files (relation a). Among other things, it included additional Media Objects (relation c) named "Residents" (relation b), "Tasks" (relation b) and "Challenges" (relation b). Each

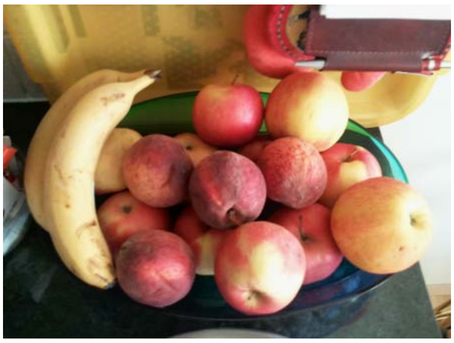


Figure 9.14. "Problem1" – "Several people went out to buy fruit, which resulted in an excess supply being at risk to go to waste". (Student explanation in an audio annotation).

one of them again contained a number of different media files. Figure 9.14, Figure 9.15, and Figure 9.16 originate from the inner "Challenges"-Media Object. Each one of these images was annotated with an audio recording (relation d). Through these annotations the student explained that he identified the bad coordination between the housemates with regard to doing the food shopping as one of the main challenges of his household. In addition, "Challenges"-Media Object contained a text file that did not explicitly refer to an image, but which was instead summarizing the content of this particular object. Thus, the text file implicitly referred (relation e) to the images and audio recordings, which defined their own subgroup (relation f) due to their similarity both in file type (all images/audio files) and in content (all about a specific kind of food (over)supply). Below, we present an excerpt from this summarizing text file:

"This 'package' contains issues that can rise in my household […]. A great challenge, for instance, is that at times no one feels responsible for going shopping […]. At times, however everyone goes at the same time brings the same stuff. We than have way too much of food […]. So, a challenge is to coordinate" (Excerpt from a student-created text file).

The remaining inner MEO files "Residents" and "Tasks" were structured in a similar fashion to detail accompanying information about the inhabitants of the households and the tasks they regularly have to perform.

Figure 9.15. "Problem3" – "Housemates did not coordinate and bought drinks separately" (Student explanation in an audio annotation).

Figure 9.16. "Problem6" – "The freezer is used to save food, which has been bought uncoordinatedly in excess" (Student explanation in an audio annotation).

9.5 Chapter Summary and Thesis Contribution

9.5.1 Revisiting the Initial Research Questions

We designed a digital capture system for mobile devices named Media Object (MEO), with the longer-term aim of supporting remembering. This concept of *asynchronous entity composition* (*AEC*) and corresponding devices allowed us to study the needs, desires and usage patterns of 10 participants (t = 24-28 weeks) around capturing digital resources for memories in everyday life situations (MEO.1 and MEO.2). In particular, the *mob enthusiasts* (5 out of 10 individuals) produced many mob files (n = 104) at a constant rate and hence related closely to the MEO concept. The feedback of these 5 participants point to the importance and value of mobile phones for capturing durable digital testimonials of life for some people.

We return now to the initial research questions (see Section 9.3.3), which occurred in the context of the four design challenges from the literature, and discuss them in relation to the findings of the field studies. We draw in particular on findings of MEO.1-2, and also point out implications for the design of future memory systems as we revisit these research questions.

9.5.1.1 Will the participants embrace the MEO concept?

As seen in the data set, there was a polarity between users and MEO appears to be something that is 'not made for everyone' or for every occasion. While 5 users strongly embraced the concept, 3 participants either dropped out of the study or did not use the provided phone until the end. However, this polarity can be valuable to us as researchers, since it contains information: It points at features that are especially appreciated and disliked at the same time and highlights aspects of remembering systems that are delicate or hard to design for (see following paragraphs). Van Dijck (2007) observed a general tendency of photos no longer being deliberately captured as memories, but being shot to give fast report of experiences to be posted on a social network and soon to be forgotten. We think this goes in parallel with society's general longing for fast and easy experiences or entertainment and hypothesise that MEO received mixed feedback, because its concept of slowing things down a bit and requiring a priori effort might appear provocative for some people in a time of short-lived smartphone photography, automatic tagging and life-logging.

9.5.1.2 Is MEO useful for creating order over digital memorabilia and how effortful is this?

A point that every participant agreed upon (across the *mob rejecters*, *undecideds* and *enthusiasts*) and in line with the literature on challenges in augmented memory design, was that getting order over digital souvenir collections is an effortful and burdensome process. In addition, all of our users recognized in the end that the MEO concept has the potential to remove at least of some of this burden. Nevertheless, MEO comes at its price. There are certain efforts that also have to be invested in planning and creating the mob files. Interestingly, not all of the participants (especially the *mob enthusiasts*) perceived this as a problematic effort. Instead, it was regarded as beneficial in two ways: first, as said before, the digital data gets sorted on-the-fly and also keeping everything in one aggregate can assist in making sense of the material compared to having completely loose collections of data. Second, the study data hints that creating such mob content can be a pleasant experience and spur creativity or playfulness or even lead to a more mindful and deliberate data capture. This again could lead to better memory performances, since a more mindful encoding of cues has been shown to result in better memory performances (Schacter, 1996).

As we saw with our participants however, not every user is prepared or willing to make this investment. Let us cite P7 one last time for characterizing an exemplary user for whom MEO might not be a suitable solution:

"To me creating souvenirs is work that I don't enjoy doing […]. Yes, you do have all the apps right there and you don't have to do it afterwards. Still, for me it is also work to – say – choose some music and add it to the mob […]. I think this also involves some sort of creativity. Snapping regular photos is one thing, but assembling a complete mob that is nice and contains good information and that will lead to a good result - this also involves creativity. And well, creativity is not really my area of interest" (P7).

Nevertheless, those who made the investment did by no means regret their decision and it might well be possible that their mobs will even be more valued as time passes by.

One thing that might also be of value for certain groups of users is to integrate mechanisms that deliberately slow them down when capturing memories and result in a more mindful engagement when framing their world. This could not only lead to more valuable, but also to a decreased number of digital materials that is already presorted and hence support tackling the problem of information overload and to make sense of digital material as well as provide enhanced cues. The mechanism that we have proposed for this purpose is the reversing of the process of data capture, namely creating the container first and then filling it. This mechanism is strongly connected to the concept of the bundling of data and this might be also of value for future memory systems. We assume, pointing at the general laws of Gestalt Psychology, that one reason why this worked for our participants is that the human mind cannot help but to make sense of the things that have been seen together and the intentionality entailed in putting these collections together enhances this effect.

9.5.1.3 How will the participants make use of the different possibilities to capture data and can this spur creative engagement?

From our observations it is clear that people are very diverse regarding the way they want to capture their digital souvenirs and this should be taken into account for the design of future systems. This is illustrated, for example, by P2 who considered the fact that mob images were not perfect and highly individual as a great benefit, while P5 decided to switch back to his *DSLR* camera, because it allowed him to capture more brilliant photos. Table 9.3 gives further evidence of how differently people adapted the integrated apps or functions of MRM2. Thus, we conclude that certain users can benefit strongly from tools that support their creativity and suggest that designers should consider providing a variety of tools for digital crafting. Interestingly, quite many images (n = 182) have been captured with MRM2's built-in playful photo apps, for example, with row snap (see Table 9.3 and Figure 9.10). Participants repeatedly stated that those apps were suitable for self-expression. In addition, they liked using them, because this enabled them to draw an easy and playful picture of the past event, that is, they used them to create mobs that were appealing and accessible and hence recreated a pleasant or enjoyable memory.

As outlined in the section above, some of the participants (especially the *mob enthusiasts*) were ready to invest efforts in the creation of mob files. This kind of deliberate and committed act of creating or building can also be understood as creative engagement next to the more artistic or playful actions, described earlier in this section.

9.5.1.4 Can MEO and in particular the Mobbox increase the visibility of digital data?

As MEO is a file type definition, the technology operates cross-platform. This means that any device with corresponding software implemented can interpret mob files. For this purpose, we introduced the Mobboxes as an example of devices for playing mob files. They were perceived positively, since they brought MEO away from the PC (Stevens et al., 2003). Concluding from our observations and participants' feedback, we would like to add to this design recommendation by Stevens et al. (2003) that researchers should consider implementing portable file designs. This would not bind the user-generated data to particular systems, for example, to the technology probes in (Kalnikaité & Whittaker, 2011; Kirk et al., 2010; Stevens et al., 2003; West et al., 2007) but would ensure that digital memories can be played on different devices and are interchangeable. This again would increase the visibility and accessibility of digital resources for memories.

The concept of bundling data into one aggregate also had an influence on the visibility of virtual data. It came along with two interesting side findings: First, from the participants' perspective Media Objects received a kind of personality – they talked affectionately about their "Paris.mob" (P2), their "graffiti.mob" (P9, see Figure 9.7) or their "dogs.mob" (P10) and so on. This indicates that they closely related to their mob files, in which they invested quite some effort when putting them together them. Hence, they created digital souvenirs that they could cherish more than regular files such as digital photos (Golsteijn, Hoven, Frohlich, & Sellen, 2012). Second, we found that people tended to capture different media content than they usually did. In our study this was primarily video. Participants stated that before MEO they had no big interest in video, because of its bad visibility ("Usually I never look at them again", in P8's words). With MEO this was different since they knew that they would revisit the videos again when dealing with their mob files. More common formats (photo) and less frequent modalities (video) were mutually supportive.

Furthermore, designing MEO in a way that mobs can be *unzipped* by regular software turned out to be a wise decision, because participants were not afraid of 'locking' data in the mob files. Thus, the likelihood of MEO's long-term visibility or accessibility was increased. This suggests a design guideline, that engineers of digital memory systems should consider a sustainable design of their technology that grants the user independent long-time and secure access to their precious data.

9.5.1.5 Do the participants see a potential in MEO for providing valuable future memory retrieval cues?

According to our participants they saw great potential in MEO for delivering valuable memory cues. During the interviews we also observed them employing the content of the mobs step-by-step (or file-by-file) to re-establish their memory of a certain event and tell us the story of a specific mob file. To put it once more in P1's words: "If you have many different memory-formats, they can re-assemble much more lively memories". Thus, despite being out of scope of this study's evaluation, we assume that MEO is able to provide potent memory retrieval cues. Participants also thought that the mob files' value as memory cues will grow, as they get older.

9.5.2 Broader reflections on MEO

9.5.2.1 MEO.1 and MEO.2: 'Crafting' and Recreating the Moment

We sum up now by reflecting on a number of issues and approaches to digital memory systems that were brought up by MEO and its underlying concept of *asynchronous entity composition* (*AEC*, see also Section 9.5.4), and that might also be relevant for the design of future remembering technologies.

As outlined in the preceding sections, in studies MEO.1 and MEO.2, we did not instruct the participants to use the MEO app for any particular purpose. In addition, we carefully chose the name Media Object (instead of, e.g., *Memory Object*) to have a neutral label and to not suggest any particular types of remembering. Our primary objective therefore was to provide a technology probe (open to the participants' interpretation and appropriation) to support the recording of experiences and to gain insights about the wicked problem space of designing for supporting human memory by means of newly available technologies. Our first observation then was, as apparent from the collected data (mobs) and interviews, that the participants' primary use in MEO and its rich sensors/capture capabilities was to capture events (e.g., parties or journeys) and not to record, for example, practical facts. According to them, they created the majority of material for later reminiscing, that is, revisiting the mob files and re-experiencing the captured moment. At least to the *mob enthusiasts* and some of the *undecideds*, MEO did particularly well in providing tools for this.

This leads to our second observation. The concept of carefully crafting one's mob files, along with the side effect of being slowed down, was highly appreciated by some of our users. This is in line with recent concepts of slow technology and alternative frames to efficiency or productivity in interactive system design that were brought up by the HCI community, for example (Sengers, 2011). The deliberate and manual work involved in MEO is to some extent opposed to current automated approaches of *lifelogging*, automated facial extractions, automated semantic processing and tagging, and so on. There seems to be a space for the crafting of digital materials, creative engagement and even effortful work in everyday remembering systems besides smart or efficient storage and retrieval algorithms. This was already indicated by the study of Petrelli and colleagues (Petrelli et al., 2009), where the participants were willing to invest time and originality in the creation of their time capsules. There was also some evidence that this manual engagement and investment can give personality to virtual materials and make them more cherished, a design challenge that was brought up in literature only recently (Golsteijn et al., 2012).

MEO was targeted early in the process of creating a rich archive of memory cues, namely when the participants attempted to assemble a holistic impression of the moment. As a number of systems attempt to *get the data set right*, for example, by automatically adding tags and preparing the digital material for optimal later retrieval (as proposed, e.g., by Whittaker et al. (2012)), MEO tries to *get the focus right* when framing and capturing resources for memories. In future it will become apparent if this strategy leads to valuable memory retrieval cues, however, earlier research showed that psychological stimulation or activation (e.g., being focused, motivated and interested, filtering irrelevant information, etc.) as demanded by the process of creating mobs leads to better memorization (Schacter, 1996). For the assemblage of the mobs a blend of tools or apps were necessary, which were adapted by the participants to their own ends. This contrasts to some extent with current approaches in HCI, where remembering systems are often engineered towards one particular purpose, for example, supporting reminiscing or reflecting. Hence, it might be of value to provide remembering tools that are flexible with regard to their end goals. This can also be useful in accounting for another observation made during the study. Our participants differed greatly in the way they captured and wanted to capture experiences. The MEO studies indicate that supporting this diversity with regard to digital memory systems might be crucial.

Of great importance to the participants was also, that the mob files could be *unzipped* and thus a durable access to the content was granted. (They had confidence in having future-proof access to their data.) This was because the technical implementation of the container envelope was basically a *ZIP* file, which meant that all mobs could be extracted by a common *ZIP* unpacking program.

This is related to the (potentially) cross-platform capability offered by the mob files. Taken together this can provide more visibility of the digital materials that otherwise easily can end up locked away on some storage medium or being scattered across multiple incompatible locations (Van House & Churchill, 2008).

9.5.2.2 MEO.3 Sensemaking

In study MEO.3 we aimed to explore the structure of Media Objects, as collated by the user, and what the consequences of this structuring were from a sensemaking perspective. Through analysis of the relations between the media entities, we identified seven different relations. We now discuss possible reasons for the occurrence of the relations within the Media Objects of MEO.4 and how these structures can serve information foraging and sensemaking.

It is not surprising that relation (a) (all entities are in the same container) occurred 80 times, as this is enforced by the implementation of MEO. What is surprising though is the fact that only three mob files were given a name (b). This could be due to a number of reasons, of which the following three speculations might be most obvious. First, the naming function of the software could have been hidden or too complicated. Second, participants were satisfied with the generic Media Object 'name' given by the current date. Third, to assign a descriptive name was not necessary as a large number of mobs also used other ways for detailing and explaining its content.

Relation (c) (clearly defined subgroups) is made possible through specific implementations of MRM2 (e.g., row snap or the possibility to aggregate mobs within mobs). With 22 occurrences, these possibilities were quite popular. In contrast to relation (f) (implicit grouping), relation (c) is easy to identify and not dependent on human interpretation.

We were surprised, however, that the direct annotations relation (d) (n = 227) was employed so many times. One possible reason might be that MRM2 automatically asked after each newly captured file, whether the user wanted to annotate it. Indirect annotations (e) (n = 10), on the other hand, occurred less often. Still, populating Media Objects with, for example, five photos and one text as an indirect annotation was not uncommon. Relation (g) (annotations to subgroups; n = 11) is a combination of the cases (d) and (f).

Overall, the importance of being able to rely on defined structures is essential to both information foraging and sensemaking (Kittur, Peters, Diriye, Telang, & Bove, 2013). We suggest that MEO can facilitate a fusion between both processes: while the user (in this case study, the interaction designer) is seeking information for capture, at the same time a sensemaking process is initiated through having an a priori container and setting up the content relations.

As stated in the study description, the MEO exercise was intended to help the students to sharpen their view and focus on relevant aspects of a design problem space (household tasks). While this particular aspect was not at the focus of this research and not evaluated, our impression from the content relations analysis was that MRM2 indeed was helpful in supporting this objective. The student-created data presented in Figure 9.14, Figure 9.15, and Figure 9.16, for instance, witnesses a certain confrontation of the student with the targeted design space. The structure of the Media Objects hints at a proceeding analysis to capture the design context in a meaningful way.

Having found seven different relations and hence possibilities to structure data, we propose that this affordance for aggregating information makes MEO an interesting and effective concept for creating order over, and making sense of, data that can be captured so extensively in these days of modern mobile phones and ubiquitous computing. At this point we highlight once more, that MEO is a general concept for aggregating rich media collections (mob files), which can be instantiated into different software, if the implementation described in this thesis may appear not suitable towards particular needs.

9.5.3 MEO.1-3 Conclusion

MEO revealed a couple of interesting trade-offs between easy capture and presorting. While the *enthusiasts* of MEO.2 appreciated the possibilities offered by MRM2 to capture holistic impressions, other participants rejected the idea of prospectively organizing materials, because it was too much of effort for them and they were not able to anticipate the benefits that mob files will provide in the future. Likewise there have been certain situations in which capturing a Media Object was not practical even for the *enthusiasts*, for example, when there was a lack of time to record a mob and things had to go very quickly. Nevertheless, when there was a specific event to be recorded or some sort of media collection on a topic to be made, the MEO concept received very good or even 'enthusiastically' feedback from a number of participants.

In our opinion, addressing the needs and wishes of the participants (especially of the *enthusiasts*) for capturing digital resources for memories identified by the MEO study will have a great prospect, because many chances afforded by modern mobile phones for recording meaningful memorabilia are still not fully exploited.

In summary, MRM2 proved to be an appropriate tool for capturing experiences in MEO.1 and MEO.2. Although not of primary research interest, our findings in MEO.3 also indicate that the software was valuable in documenting and analysing contextual factors in the course of an interaction design project. This reassures us that the overall concept of MEO is a useful 'mini' file management system for rich media collections on mobile phones.

In understanding how people used the file management structures, we identified seven relations between entities, which serve as important anchor points for making sense of the aggregated MEO data. Relations can be explicit (relations a-d) or implicit (relations e-g). The latter relations leaves more room for speculation by the user, while also demanding more 'sensemaking work'. We propose that the possibility to establish or create these relations, contributes to the software's ability in creating order over its entities and providing a frame for both creating and making sense of mob files.

From this perspective, MEO supports two processes, namely the capturing of data and the review of this recorded information. In study MEO.3 we were concerned with the second process from the perspective of the researcher on third-party Media Objects.

9.5.4 MEO in Relation to the CuDe Framework

With respect to the CuDe Framework, MEO contributes an in-depth exploration of a particular kind of *entity linking* that we named *common factor* (L2). Necessarily, this kind of interaction *linking* is located at the *multiple entity level* of analysis and intervention, since it demands the interplay between multiple media files. MEO constitutes the extension of Duography, which made use of two synchronously combined photos (SEC). In contrast to Duography, however, MEO allowed the aggregation of entities in an *asynchronous* fashion (AEC).

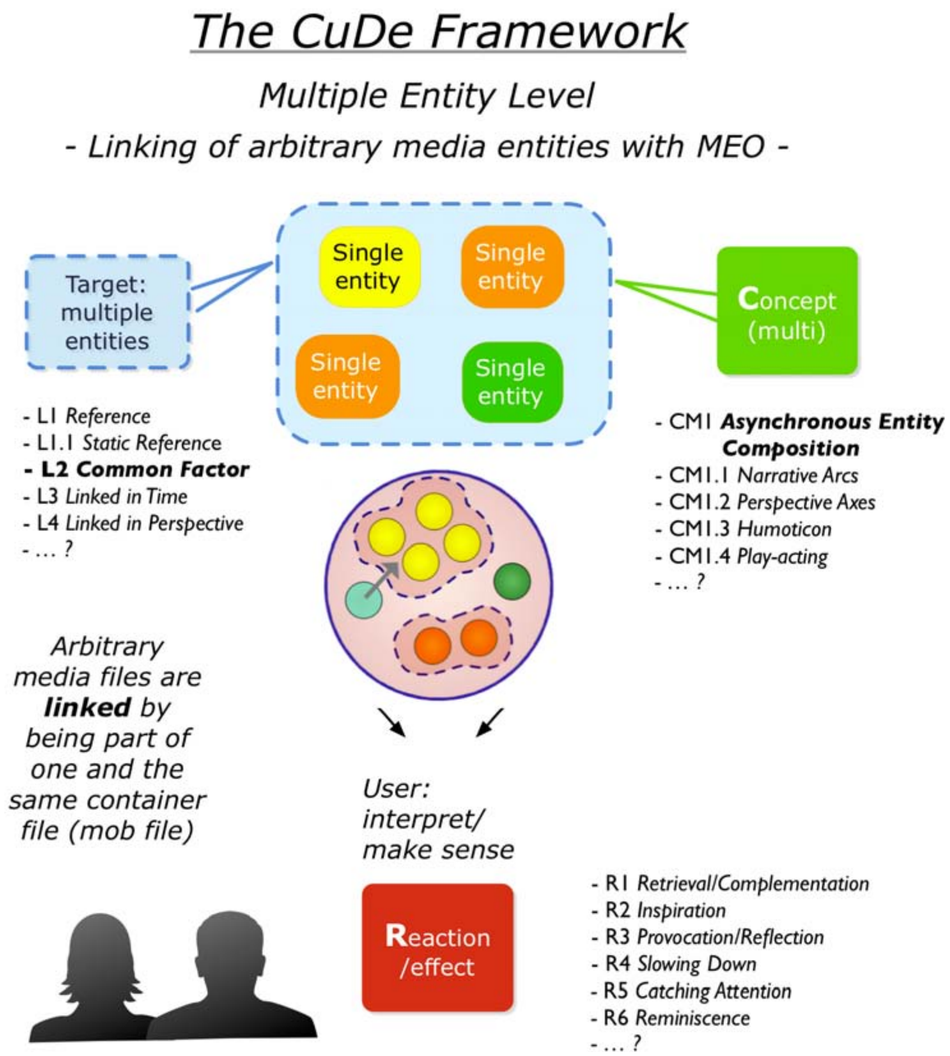


Figure 9.17. The Media Object (MEO) illustrated by means of the conceptual framework CuDe.

On a theoretical level, we suggest that the concept of *synchronous* and *asynchronous entity composition* (*SEC/AEC*) is the facilitator for the common factor linking or the interaction design mechanism, which is afforded by this particular entity relationship. The consequence of this common factor linkage is that the users can exploit this fact when making sense of the presented memory retrieval cues. In the case of MEO, all files are contained within the same mob container structure (the common factor is the container), consequently these files relate, as they are part of a common file aggregate. This is comparable, maybe, to photos in the same album, or on the same page of an album, even. They belong together by their shared room of storage and this is how we interpret them. We try to bridge them with a *narrative arc*. Figure 9.17 employs the CuDe Framework to describe MEO, its underlying concepts and possible effects for the user. As outlined before, the main concept of MEO is to provide a tool for *asynchronously combining arbitrary entities* (CM.1 AEC). This was accomplished by means of the integrated 'mini apps' available thorough the user interface of MRM2.

When revisiting mobs, on the other hand, the user's awareness of all entities being part of the same container (that is, sharing the common factor L1 of being part of the same mob), allowed them to relate the contained entities to each other, and finally to re-establish their memory of the depicted moments or information. This led to a variety of different reactions or effects for the user (R1-R5), depending on how the user employed the MEO application. In other words, as MEO featured many different options for recording, the application could easily be adapted to different ends such as complementation (R1) or slowing down (R4). However, in studies MEO.1-3, the participants appeared to primarily make use of MEO for data complementation.

Part IV: Reflections on the Single and Multiple Entity Studies

10 Discussion: CuDe from Designer, User, and Science Perspective

In this thesis, we conducted design-based research (DBR) leading to the evolution of the *Memory Cue Design Framework* (*the CuDe Framework*). This framework synthesizes our work on a number of technology probes (EyeOfDetail, ForgetMeNot, ContextShaker, Audio Peephole, Duography version 1) and more advanced prototype systems (Hearsay, Duography version 2 and MEO). The work targeted the design space of digitally augmented memory systems and in particular sought to explore the following research questions:

> **RQ1:** How can people be engaged in meaningful remembering experiences when dealing with digital files and souvenirs? ('Meaningful remembering' is defined here in providing the user with opportunities for reflection, reminiscing or other forms of 'sentimental' recall that go beyond plain *factual* recall.)
>
> **RQ1.1:** (Sub-question) How can properties of emerging digital technologies be exploited to meet some of the challenges identified in the literature?

Throughout the user studies on the individual prototypes, the participants demonstrated a high level of engagement when dealing with our design proposals. Eventually, we articulated a set of interaction design concepts, which promise to be of high potential in augmenting the user's experience when dealing with their digital souvenirs (e.g., slowing them down and making them pay attention to details, etc.). These interaction design concepts or mechanisms for engaging the user are connected strongly to the properties of emerging digital technologies (see RQ.1.1). For this reason, and to increase comprehensibility/readability, we divided the thesis into two separate parts: one was dealing with single digital entities (Part II), that is, prototypes, which employed one digital file at a time only. The other part (Part III) featured inventions and devices, which made use of multiple entities to create meaningful remembering experiences for the user.

We now state more precisely what we have learnt when illuminating these research questions through the deployment of the prototypes during the user studies. In order to do so, we will revisit the interaction design concepts, which we have proposed and which are at the core of the CuDe Framework (refer to Section 4.3 for the description of the framework including illustrations of its components). In the course of this, we will look at CuDe from three different viewpoints: the designer perspective, the user perspective and the science (or epistemology) perspective.

First, we start with the designer perspective, as one primary contribution of this thesis is a practical one and aims at providing guidance for practitioners in designing augmented memory systems. Thus, addressing and answering the research question 'how can people be engaged in meaningful remembering experiences?' is of particular relevance to interaction designers, and the CuDe Framework is provided as a conceptual tool for gaining inspiration in fulfilling this task. The conceptual layer of CuDe (see also Section 4.3) deals with the 'drivers' that make successful digital systems work and, thus, is supposed to assist designers in understanding and creating novel mechanisms of interactive memory systems. When taking the designers' perspective in discussing CuDe, we also briefly return to the four design challenges identified in the literature review.

Second, we revisit crucial findings from the user studies in order to recapitulate what aspects of our designs were valuable to our participants in reliving their recorded experiences. Most importantly, users are affected by the user interface layer and by the cognitive layer (see also Sections 4.3.1 and 4.3.2) of CuDe. We reflect on different factors such as different kinds of facilitated user experiences (e.g., deep engagement, reflection, reminiscence, etc.) and different kinds of user groups or user preferences.

Third and finally, we discuss the CuDe Framework from the perspective of science. The intention here is to reflect on the thesis work from an epistemological viewpoint, that is, to make a final judgement on the contributions' scientific value. This final assessment is important, as the approach of this thesis is based on design (DBR, see Section 3.3) and thus differs form the more conventional and 'rigorous' modes of scientific inquiry.

10.1 Designer Perspective: 'How-to use CuDe'

The CuDe Framework is a synthesis of the lessons-learnt throughout the user studies of this thesis. Its intention is to be a practical guide to designers, who plan to develop their own augmented memory system. As it is a conceptual and not a prescriptive framework (see Section 10.3), it is supposed to inspire new designs as opposed to providing a strict set of rules.

10.1.1 Single Entity Level

CuDe suggests to either look at a *single* or at a *multiple entity level*, when considering the development of a new interactive memory system. The *single entity level* contains the items or dimensions *entity processing* (digital file manipulations, see Figure 10.1), *concept* (see Figure 10.2) and *reaction/effect* (cf. Section 4.3.1). In practice, designers are invited to, for example, use *entity processing* as a starting point for their considerations. This dimension contains a number of possible file (entity) manipulations such as filtering, blurring (one specific filtering technique) or masking (cf. Figure 10.1.). As with any other aspect or dimension of the framework, CuDe is not finalized here. That is, it is not a closed system and might be extended by, for example, additional types of file processing. In this thesis, however, we proposed the abovementioned three file manipulations.

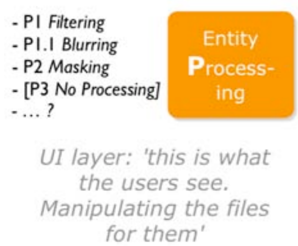


Figure 10.1. Entity Processing dimension for single entities.

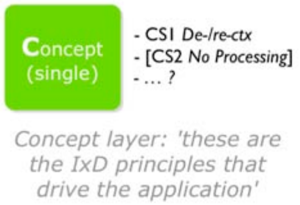


Figure 10.2. Concept dimension for single entities.

In our user studies, we found evidence for certain reactions or user experiences, which can be created by means of these single entity manipulations. For instance, EyeOfDetail (see Chapter 5) *masked* certain parts of a photo and hence made the user carefully explore their digital souvenirs (photos in this case). Thus, the effect in the user was to focus their attention, to slow them down when revisiting the photo, and consequently to make them explore their memory retrieval cues in unconventional ways (see also next Section 10.2 User Perspective). Other possible user reactions resulting from entity manipulations were enhanced/improved retrieval of facts (e.g., by providing complementary information), provocation, reflection or reminiscence (cf. Section 10.2). Nevertheless, as stated before, CuDe is not a 'rule tool' with formulated combinations of 'action and reaction'. Thus, the dimension *reaction/effect* should be considered as a collection of possible user experiences instead of a set of parameters or outcomes that are assigned to specific interventions. Likewise, all other dimensions (*entity processing*, *concept*) also comprise collections of important aspects in augmented memory design, but they do not depict relations of cause and effect.

Designers might also start their considerations from the *concept* perspective (cf. Figure 10.2). This dimension entails more theoretical constructs or concepts, which are hypothesised to be responsible for the success of *entity processing* in creating user *reactions*. That is, the concept dimension offers a collection of 'driving mechanisms', which can account for the success of applications featuring certain file manipulations.

In the case of the *single entity level*, we proposed one theoretical concept. This concept is closely related to the manipulation that we called *masking* (and *de-masking*), and was then further explored by means of the Hearsay public installation. Finally, these explorations resulted in the proposal of *de-/re-ctx* as a *Strong Concept* candidate (see Chapter 6).

10.1.1.1 De- and re-contextualization (de-/re-ctx)

The formulation of *de-/re-ctx* as a concept for interaction design offers explanations for the success of the applications, which used masking (in first line, Hearsay and EyeOfDetail) for presenting digital data (single entities) in an evocative fashion. Understanding the core drivers or the mechanisms behind these systems is supposed to help designers in creating applications, which employ similar but independent underlying interaction concepts for offering meaningful remembering experiences.

Figure 10.3. Illustration of *de-/re-ctx*. The dog is still visible, but the surroundings have been removed/blurred.

De-/re-ctx suggests removing a (sub)set of memory retrieval cues from their original context, for instance, those contained within parts of a photo (EyeOfDetail, compare Figure 10.3) or an online news story (Hearsay). As a consequence, the user is not presented all available memory cues immediately ('on a silver platter'). Instead, the original context of the information fragment has to be reconstructed or re-established (re-contextualized). Therefore, the user might more deeply engage with the digital souvenir (entity) on display and discover aspects, which would have been omitted in favour of faster and more conventional habits of quick data consumption.

As a more concrete example, designers might consider extracting a short video snippet out of a longer holiday video and present it to the user. This short snippet, maybe a clipping of only 3 seconds, would then provide the user with a limited number of memory cues. As the remainder of the home video is not shown immediately, the user has to use the cues as available within the 3 seconds for bringing back to life the holiday. In our Hearsay study (see Chapter 6), this was compared to 'putting a jigsaw back into place', and led to deeper engagements with the digital recordings.

In this Hearsay study, we used publicly available digital material as cues. In contrast to the other larger empirical studies (see Duography, Chapter 8, and MEO, Chapter 9), there was no demand for capturing user-generated digital files to examine Hearsay and the concept of *de-/re-ctx*. This opened the possibility to 'reuse' digital material found on the Internet (online news stories). Nevertheless, we argue that because of two reasons this principle of *de-/re-ctx* can also be transferred to biographical remembering. Firstly, we explored this interaction mechanism by the EyeOfDetail probe (see Section 5.3.2). This first exploration involved private photos and thus personal memory, and it delivered promising results. Secondly, we can assume that publicly available information such as news stories can also trigger memories relating to personal experiences and hence, Hearsay has to do more with personal memory than one would guess at the first glance. In fact, personal (e.g., as captured by private photos) and collective memory (e.g., as being formed by shared knowledge such as important events covered by the news) is likely to be strongly interwoven. For instance, van Dijck (2006) investigated the relationship between personal and collective remembering in listening to popular music on the radio.

10.1.2 Multiple Entity Level

The second level of analysis and intervention as proposed by CuDe describes the interplay of multiple entities. That is, in contrast to the *single entity level*, where we dealt with single digital files in greater detail ('how can we process them to enhance remembering?'), we now consider the use of multiple entities at a time to create meaningful remembering experiences ('can multiple files mutually amplify their content and potential as memory cues?').

Most importantly, at this level of investigation, the single entities were not analysed and processed. Rather, we suggest to consider what it might mean to the user, if they have available a number of files simultaneously to make meaning, and to reconstruct the depicted event. From the designer perspective, this raises the question of how to assemble the files, which have been captured previously and how to incorporate them into a user interface.

For this reason, we propose to clearly indicate what the files presented have in common, that is, what the *link between these entities* is (see Figure 10.4). Thus, we labelled one dimension or item of the *multiple entity level* as *entity linking* to indicate that the common factor or *link* between the files plays a crucial role. Again, the CuDe Framework is not a static and closed system, but open to extensions. Consequently, there might be additional useful devices for using multiple entities to augment remembering. For instance, multiple photos might be arranged into a meaningful photo-collage to foster reflection. Still, in this thesis we focus on *entity linking* only and leave it for future work to propose further possibilities for exploiting multiple digital files in augmented memory systems.

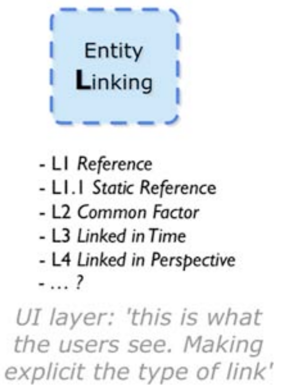


Figure 10.4. Entity linking dimension (detail illustration from Section 4.3).

Entity linking has a direct effect on the properties of the user interface, as designers have to clearly indicate what the relation (*link*) between these files is. This allows the user to make sense of the material on display. As a 'trivial' example, if a text file is marked as an annotation to a photo, the user can relate this text to the photo and use this information to infer meaning from both files. In other words, both entities mutually complement each other and allow the observer to use them as building blocks for the reconstruction of the depicted moment or information. In CuDe, we labelled such annotations as *references*, as on file is referring and complementing another one.

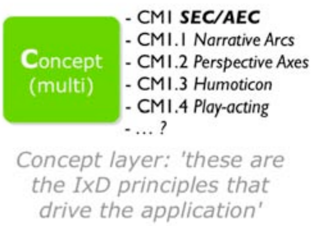


Figure 10.5. Concept dimension for multiple entities (detail illustration from Section 4.3).

In the work of this thesis, we made use of *references*, however, the main contributions involved other kinds of links. In the case of MEO, mob files defined a container structure to be populated with a multitude of different digital files (e.g., photo, video, text). Hence, these mob containers depicted a *common factor* shared by all contained digital files. This sole information (about their link) was used by our participants to recreate the moment captured by the mob file and its content. As the participants knew that these entities belonged together, they employed them as pieces to a puzzle, which could be reassembled to the original memory.

We hypothesise that other *common factors* can help in recreating memories as well. For instance, a set of photos presented along with the information that these were captured by the same person, or on the same date, will also have an influence on the observer's imagination. Two photos, which have been captured by the same photographer will lead to a different perception than two random pictures without this note on their authorship.

In the course of the thesis, we proposed two additional types of *entity linking*: *linked in time* and *linked in perspective*. Both originated from the studies of Duography (see Chapter 8).

Linked in time describes a linkage that is based on a temporal relationship. In the case of Duography, this means that both sides of the 2sided photos were captured at the same time, resulting in a Duograph. This fact might sound rather simple, but being aware of the fact that both entities (photos) are part of one Duo, has important implications for the observer. This implies that both pictures were captured *simultaneously* and the user can use this information to bridge both photos by constructing a narrative across these entities. Similarly, both sides of a Duograph are *linked in perspective*, as the recording involved two cameras capturing two opposite perspectives. Thus, being aware of this spatial configuration allows the observer to reconstruct the photographed location.

In practice, designers might consider to take advantage of temporal and spatial links when designing for remembering. For instance, a series of four pictures together with the information that they were captured with a delay of 10 seconds between each photo might spark the user's imagination and invite them to 'mentally fill in' the missing 'frames' between these sequential pictures.

References, *common factors*, *linked in time* and *linked in perspective* depict the four different kinds of links as proposed within CuDe. Other links might be added into the framework in the course of future research.

In line with the *single entity level* of analysis and intervention, the *multiple entity level* also features a *concept* dimension (compare Figure 10.5). Again, the purpose of this component is a deeper engagement with the proposed interventions (i.e., linking entities and making explicit these links) from a theoretical perspective.

10.1.2.1 Synchronous and Asynchronous Entity Composition

The core concepts, which enabled, for instance, *linking in time* or *common factors* in this thesis work were *synchronous* and *asynchronous entity composition* (*SEC* and *AEC*). While the preceding sections primarily dealt with data presentation and the user interface layer, SEC/AEC at first denotes a process of data capturing. In contrast to, for example, Hearsay, our novel interaction design concepts of Part III (Duography, MEO) demanded the recording of digital entities. Duography *synchronously* captured two photos resulting in a Duograph and MEO allowed mob containers to be populated *asynchronously*. The resulting data, that is, Duographs and mob files, were presented to the user along with the information of how they were recorded. This process of recording, hence, was the precondition for the user's ability to exploit the knowledge about the *entity linking* and to make meaning of the media files.

On this conceptual level, we suggested four interaction design principles, which originate from the process of SEC/AEC and which can be valuable in augmented memory design: *narrative arcs*, *perspective axes*, *humoticon* and *play-acting* (see also Figure 10.7).

Narrative Arcs

Links in time and *links in perspective* can potentially be employed by the observer to unfold a story between entities and to 'weave together' a number of digital files. This is what we inferred from our observations of the Duography user studies and what we called a *narrative arc* (see also Section 8.4.2.1). In the Duography studies, some participants made use of the phenomenon of *narrative arcs* to capture a story between the front and back image of the Duo. Both photos setup the frame of this story. However, bridging them and finally connecting them was up to the imagination of the observer. The same mechanism, that is, users establishing a story between entities, could also be observed in our MEO studies, where participants were reliving the recorded experiences by matching and connecting the media files. Thus, *narrative arcs* could not only be seen within the context of *links in time* and *links in perspective*, but also in *common factors* (as established by a common mob container).

Perspective Axes

Similarly, Duography afforded *perspective axes* (see also Section 8.4.2.1). This interaction design concept primarily relates to *links in perspective* and suggests that different digital photos or videos, which share a particular spatial configuration, can be used by the observer to mentally reconstruct the scene of capture. This concept is most illustrative in Duography, as this rather simple application captured two photos simultaneously with two opposite facing cameras. The information that both pictures show opposing perspectives enabled our participants to relate both entities (both photos) to each other and to make conclusions about the surroundings of the Duograph. Hence, *links in perspective* and the concept of *perspective axes* enabled the users to infer extra information from the two sides of the Duo, which would not have been inferable from two unrelated photo entities.

Humoticon

We included *humoticon* into the *conceptual* dimension of the *multiple entity level* as a minor, but still powerful conceptual device that occurred in the Duography studies (see Section 8.4.2.2). For the sake of developing augmented memory systems, we hypothesise that *humoticon* can be of particular value. Sticking to the terminology of CuDe, a *humoticon* is a *reference* where the annotating entity is comprised of a portrait picture. This concept is best illustrated by means of the Duography application. In the user study, in multiple instances participants used the app to capture some motif by the front image, for example, a delicious dish of food. At the same time they employed the back image of the Duograph to comment on the motif by showing a corresponding facial expression (see Figure 10.6). Hence, the second entity contained emotional information targeted at the primary entity, leading us to label this occurrence as *humoticon* (human and *emoticon*). In the DUO studies, this was a quick and powerful means for expressing emotional valence and might serve as a valuable memory retrieval cue in the future.

Attaching an emotionally laden portrait picture naturally is not restricted to Duographs. For instance, a mob file or any other accumulation of media entities is also suitable for the augmentation by a *humoticon*. According to one of the primary messages or recommendations of CuDe, however, it is crucial to make explicit the link between these entities in the user interface (i.e., explicitly state that the *humoticon* refers to certain entities).

Figure 10.6. Duograph featuring a *humoticon*. The user (right) is commenting on the dish of food by means of his facial expression. *Is it delicious?*

Play-Acting

On a conceptual level, we additionally highlight that *synchronous entity composition* (*SEC*) has the potential to facilitate an occurrence, which we named *play-acting* (see also Section 8.4.2.3). This concept or phenomenon is related to *humoticon* and was observed in the study of Duography in the art class (DUO.4). It is also tied closely to *narrative arcs* and describes the fact that Duography worked out well for capturing the social interplay between two individuals. That is, participants enjoyed staging interactions with one protagonist on the front image and one on the back picture.

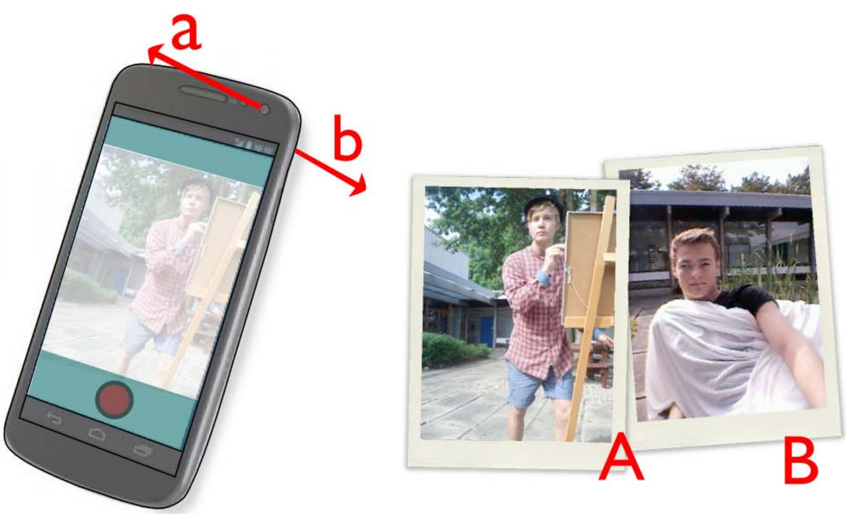


Figure 10.7. Illustration of *perspective axes* (a,b), *narrative arcs* (A,B) and *play-acting* using a Duograph of DUO.4.

This is illustrated in Figure 10.7 where two participants were acting out to be painter (A) and model (B). This example also shows how Duographs result in *perspective axes*, facilitated by the configuration of the cameras (a) and (b). In addition, the Duo tells the story of a model (B) being painted by an artist (A). In other words, picture A and B a bridged by a *narrative arc*.

10.1.3 Design Perspective Summary

From a design perspective, the CuDe Framework is a conceptual device for systematic inspiration in augmented memory system design. To the best of our knowledge, in the HCI literature, there is no *systematic frame* for using digitally recorded *memory retrieval cues* in order to create meaningful remembering experiences. Surely, in HCI we have seen numerous valuable explorations and ideas of exploiting digitally recorded information to augment remembering. Hoven and Eggen (2008) drew attention to the reconstructive nature of memory and the importance of retrieval cues, and Sellen and Whittaker (2010) suggested distinguishing between different facets of remembering such as reminiscence and reflection. Moreover, Whittaker et al. (2012) created a set of design guidelines proposing, for example, to carefully highlight significant digital cues, and finally Kalnikaité and Whittaker (2011) used knowledge from psychology to inform their design and selection of retrieval cues. CuDe extends this prior work by focussing on memory retrieval cues, while at the same time taking a technical perspective. That is, the framework fully acknowledges previous research and the psychological importance of retrieval cues, but also has its focus on technical feasibilities. Modern technology such as smartphones affords the convenient capturing of vast amounts of digital retrieval cues. In the words of Kalnikaite et al. (2010) "there are multiple types of data that we might collect about our pasts, as well as multiple ways of presenting this data. Different data types and views promote different acts of remembering, including ones which might be more properly called inference rather than memory" (p. 2052). In their research they showed that spatial information (*GPS* coordinates) is more likely to facilitate recall based on inference, while photos enabled "more genuine, detailed recall".

In CuDe these data are named *entities* and constitute the basic building blocks of augmented memory systems. The framework addresses the question of how these blocks can be configured to accomplish effects such as reflection or reminiscence.

To this end, CuDe offers support by highlighting different kinds of starting points for initiating the design process. More precisely, the framework features two levels of investigation and intervention: the *single* and *multiple entity level*. Either level, again, offers loose, non-directive advice for working with digitally recorded memory retrieval cues in an evocative fashion. On the *single entity level*, the design strategies primarily had a *reductionist* character, that is, starting from one single entity, digital information was masked or removed to support meaningful remembering. Working with multiple entities, on the other hand, involved *additive* strategies: a number of digital entities mutually complemented each other and increased their potential in evoking memories.

The framework both features concrete suggestions such as entity filtering or more abstract concepts as, for example, *de-/re-ctx*. It is hoped that the different dimensions of CuDe will be useful in creating valuable augmented memory systems based on the intelligent application of digital memory cues. This is a most delicate task, as large portions of the final activity in memory applications (i.e., the final act of making meaning of the cues) naturally is out of the reach of the designers, and the challenge is to sensitively support the user with the best digital material possible (including digital processing, etc.) prior to the actual remembering experience.

10.2 User Perspective

We briefly reflect on the proposed designs and strategies in this thesis from the perspective of the user. As stated earlier, the main contribution of this thesis is provided by the formulation of the CuDe Framework including the individual prototype systems and the findings from the user studies. This framework is primarily addressed at designers or developers and consequently we started this chapter with reflecting on the designer's perspective. Nevertheless, the user perspective is also inseparably connected to the framework and needs to be recapitulated as part of this discussion.

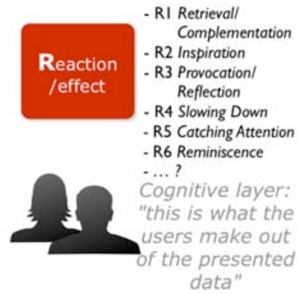


Figure 10.8. *Reaction/effect dimension* (shared by *single* and *multiple entity level*). Detail illustration from Section 4.3.

Single and *multiple entity level* of CuDe share the *reaction/effect* dimension as depicted in Figure 10.8. This dimension comprises a number of user responses to our technology probes and prototypes. We stated before that our framework is not to be interpreted as a 'cause and effect' prescription. Rather, we freely documented user reactions as they were observed throughout our studies and we give this to designers to state that these effects might be accomplished working with single or multiple entities.

Retrieval and *complementation* are the most 'basic reactions' that were generated by using the prototypes. When MEO was employed, for instance, to capture a photo and then to annotate it with text or a *GPS* location, this primarily served for complementing the photo entity with additional information, potentially leading to a better retrieval.

More 'complex' cognitive user reactions were *inspiration*, *provocation*, *reflection* or *reminiscence*. By this we denote processes of meaningful remembering, which contained deeper or 'less mechanical' engagements with the presented data. That is, the applications did not serve the plain and functional recall of facts (retrieval), but they functioned as facilitators of experiences that go beyond the simple recognition of what had been captured. For instance, by means of Hearsay and its underlying concept of *de-/re-ctx*, the users were inspired to further reflect on the presented text messages and to ponder about their origin. A similar interaction mechanism can be found with *FM Radio* (Petrelli et al., 2010) in the literature. Here, the researchers explored alternative approaches to record and embody experiences. They proposed an audio recording device, which played voice recordings on the touch of a button. Petrelli et al. (2010) demonstrated how this unconventional system for digital souvenirs created curiosity in their participants and made them carefully think about the recorded messages. Hence, these researchers found their own way of creating curiosity and reflection when working with single digital entities. However, their objective was to explore this novel form of "sonic souvenirs" and consequently they were not interested in fitting the processing of entities into a broader theoretical frame such as CuDe. Nevertheless, we propose that the *FM Radio* concept can seamlessly be positioned with CuDe.

This research thematically leads to the next occurrence, which we observed during the user studies: the effect of the prototypes of slowing the participants down, focusing their attention and fostering play or creativity.

10.2.1 Slowing Down, Play and Creativity

As confirmed by our participants, one of the main reasons for taking photos is to *remember* the depicted event. This seems to be the most prominent cause in why we see so many people taking photographs, for instance, at tourist sights or during significant events. Still, this raises the question whether we influence our memories, if we 'inject' a digital camera into all of these significant moments. In other words, do we remember differently, if we are occupied by holding a camera when *living* the moment?

Henkel (2014) addressed this question and found a "photo-taking impairment effect" in her psychological experiment. That is, the memory performance of participants was diminished, when they used a camera to create an external memory aid. When they did not use a digital recording device, on the other hand, they were able to recall more information afterwards. These results indicate that photo cameras might have negative effects on the formation of our memories. Interestingly, in a second experiment where the participants were asked to explicitly capture specific details, Henkel (2014) found that the "photo-taking impairment effect" diminished.

This suggests that we might benefit from mechanisms, which help us frame our memories in a less 'mechanical' but more *mindful* way. Automated 'pointing and shooting', conversely, might lead to the contrary effect than we actually wanted to achieve: to remember better.

The prototypes we introduced in this thesis featured a number of elements, which deeply engaged the user, slowed them down and put them in a more mindful frame of mind. Elements of play and creativity also contributed to participants being contented with our products and let them create their souvenirs in an unconventional, but sustainable fashion.

The study by Henkel (2014) showed that taking some time during recoding might well pay off. We suggest that our proposed systems can serve as a starting point for designing novel technologies that respond to the current shortcomings in our habits and uses of recording technologies as revealed by this author.

10.2.2 Putting the Pieces Together, Coherence, Sensemaking

Along with the observations on mindfulness, play, or creativity, we also found notions of curiosity in the behaviour and user experience of the participants. This is little surprise, as we deliberately conveyed information and parts of memory retrieval cues only to later reveal them again. As a final judgement, these strategies for evoking curiosity worked out very well in the context of designing augmented memory systems. We have seen this in particular, when employing *de-/re-ctx* as a concept of interaction design. Moreover, in the MEO studies we observed the participants employing the content of mob files as building blocks for reconstructing the original 'story' or moment captured by this container file. In other, more metaphorical words, mob files can contain the pieces to a memory puzzle, and it is the user, who puts it back into place.

For this activity, the users sought to establish a sense of *coherence*. The entities presented by MEO were interpreted in such a way to *make sense* or to be *coherent*. The story behind the two sides of a Duography or the content of a MEO container was brought together mentally by the participants to form a coherent whole.

In MEO.3, we were particularly interested in what kind of *structure* the participants imposed on the data when capturing information by means of our lightweight mobile tool for data collection and how these structures can serve foraging and *sensemaking*.

Structured data plays a significant role in sensemaking support systems[26], as it enables the information seeker to get control over this data more easily and "helping them to build a coherent model of the information space" (Kittur et al., 2013, p.2990). *Sensemaking* is an umbrella term for describing people's efforts in assigning meaning to the experiences they make, that is, attempts to create order over sensory input. In particular, this process is related to dealing with complex problems. Therefore, we suggest that looking at augmented memory system design through the prism of sensemaking might be a fruitful approach. However, even though sensemaking has attracted the researchers' interest 'for ages', (at times described with different labels), it has rarely been applied to digital remembering in our sense. Instead, the term *sense-*

[26] The remainder of this section on sensemaking is based on a conference publication (Güldenpfennig, Fitzpatrick, et al., 2014).

making with relevance to HCI was coined in particular in the context of organizational research, library and information science, educational research and decision support (Klein, Moon, & Hoffman, 2006).

One recent exception is marked by an application for supporting general practitioners doctors (GPs) in remembering and later sensemaking of informal experiences during their work (Tomberg, Al-Smadi, Treasure-Jones, & Ley, 2013). According to these authors, the hectic day-to-day business of GPs would waste a lot of opportunities for reflecting on the daily incidents of the clinic and, thus, they propose the recording of digital memory retrieval cues:

"The collected information does not capture the entire learning experience but rather provides cues that allow the person to retrieve the episode from episodic memory to make sense of it at a later stage" (Tomberg et al., 2013, p.55).

While the notion of *sensemaking* is broad, this process is generally considered to be comprised of two phases: *foraging* (collecting and collating information) and *sensemaking* (integrating information, creating representations) (Kittur et al., 2013). While the *ContextCatcher* tool of MEO.3 at first glance seems to be intended for information gathering, its affordances for organizing the collected data can also be supportive in *sensemaking*. Having seen recent research as proposed by Tomberg et al. (2013), and having observed our participants 'working' with their digital entities, we suggest that the perspective of sensemaking might by an appropriate and valuable tool for supporting the design of novel memory applications.

10.2.3 Diversity and Different User Preferences

Remembering is a very personal activity. It takes place within one's mind. Hence, a larger fraction of the user experience and interaction in augmented memory systems is happening privately and out of the reach of the designers. As outlined above, it is the user, who has to make sense of the presented data on the last instance.

As a consequence, in the user studies, each participant had their own 'style' and preferences of remembering. When it came to recording digital souvenirs, for example, there were great differences among the participants of the MEO study. While several people clearly identified with the concept of the application of providing tools for manually and carefully crafting digital objects, others did not enjoy this activity at all. Features for which the MEO application was appreciated most by one fraction of the participants, led to the rejection by other users. These features primarily had to do with creativity and the amount of work that was required by the application. Other differences manifested in features such as playfulness or production value of the products.

The following case exemplifies the strong effect of user preferences and different tastes on our proposed systems. We had one participant in a Duography study

(P2.2 of DUO.2), who enjoyed the application a lot and who created 'tons' of Duographs. Consequently, we asked him to also join a MEO study (P7 of MEO.2), which he happily did. To our great surprise, this participant captured very few mob files and turned into a *mob rejecter*. Our assumption was that he appreciated the playful elements of the Duography application (2sidez), and hence, so would also buy into MEO; however, it was more the convenient way of capturing unconventional photos, which motivated him to use the Duo app. His experience of MEO, in contrast, was that it demanded much more effort and inspiration, and was consequently rejected.

In summary, from this example and all the other observations, we have learnt that users differ greatly when it comes to the creation of digital souvenirs. We assume that this user group of people who are potentially interested in recording moments is very heterogeneous. We suggest taking people's diversity into consideration, especially when designing for augmented memory systems.

10.2.4 Duographs and Mob Files in the Course of Time

Our studies on Duography and the Media Object depict the longer-term investigations of this thesis, and we now reflect on the quality of the memory cues as created by these applications in the course of time.

Our findings indicate that Duography and MEO can support revisiting past events in novel ways. Interestingly, their potential as good memory cues is likely to evolve over time.

In Duography, there were indicators in our studies showing that the back image may take on more importance than the front as time passes. While only a relatively short time had passed since the participants captured their Duographs, even for the first participants, they still used the back image extensively as a memory aid to reconstruct the story of the event. Moreover, our participants made statements regarding the increased value of Duography for prospective memories. Participants also explicitly noted that the future could bring a shift in the importance of the images and that in many instances the back image will be more valued than the front, for example (P2.1 of DUO.2):

"If I take pictures of a lake during vacation, I will have a nice scenery…maybe captured a thousand times, but one will not find much of fascination in it in a couple of years. It will have no further information at all. It cannot reproduce any personal memories. - Who took the picture? In what mood? How old? Maybe therefore one day the lake will be the add-on and the back image will be the main statement" (P2.1).

We hypothesise then that in the future Duographs will be valued more because of the additional context information (generally a picture of the photographer and some background details). This is supported by Schacter (1996) who argues that the affective quality of a memory cue can highly influence what we will remember. Van

Dijck (2007) also states that technology can change the way people remember their past. We suggest that capturing the dialogue between photographer and motif can be useful in supporting memory and recollection.

Similarly, our participants saw great potential in MEO for delivering valuable memory cues. During the interviews we observed them employing the content of the mobs step-by-step (or file-by-file) to re-establish their memory of a certain event and tell us the story of a specific mob file. To repeat P1's (of MEO.2) words: "If you have many different memory-formats, they can re-assemble much more lively memories". Thus, despite being out of scope of this study's evaluation, we assume that MEO is able to provide potent memory retrieval cues in the longerterm. Participants also thought that the mob files' value as memory cues will grow, as they get older.

10.3 Science Perspective

From a scientific perspective, it is important that the hypotheses and ideas presented in this dissertation are more than mere *personal opinions*. What we need are reasonable explanations with strong theoretical foundations. This is closely tied to the claims that we make about our data: does it generalize, can it be applied in situations that go beyond the settings of the studies?

With an eye on HCI, Rogers (2012) summarized that a "[t]heory works at an abstract level, enabling understandings and generalizations to be made about specific phenomena" (p.16). At the same time, she acknowledged that "it has proven difficult to say with any confidence the extent to which a system or particular interface function can be mapped back to a theory" (p.13). Therefore in HCI, theory often comes in the shape of frameworks, which summarize "a set of core concepts, questions or principles to consider when designing for a user experience" (p.5). In the case of CuDe, the framework is conceptual, that is, it doesn't prescribe or predict specific situations. Rather, CuDe is a collection of well-tried concepts that might serve for inspiration. The user experience to be designed for or its domain is that of augmented memory systems.

The knowledge synthesized into CuDe does not spring from experiments under controlled conditions, as often conducted within ('hard') natural science. Moreover, we don't claim any predictions or generalizations based on our empirical data. As opposed to the classic paradigm of controlled experiments in science, we employed a design-based research methodology (DBR). According to Gaver (2014)

"[s]cience is defined by epistemological accountability, in which the essential requirement is to be able to explain and defend the basis of one's claimed knowledge. Design, in contrast, works with aesthetic accountability, where 'aesthetic' refers to how satisfactory the composition of multiple design features are [...]. The requirement here is to be

able to explain and defend – or, more typically, to demonstrate – that one's design works" (Gaver, 2014, p.147).

Our interpretation of DBR is in line with the above statement. In order to argue *why one's design works*, we additionally employed a theoretical device as proposed by Höök and Löwgren (2012). According to them a *Strong Concept*

"… is generative and carries a core design idea, cutting across particular use situations and even application domains; concerned with interactive behavior, not static appearance; is a design element and a part of an artifact and, at the same time, speaks of a use practice and behavior over time; and finally, resides on an abstraction level above particular instances" (Höök & Löwgren, 2012, p.1).

We proposed *de- and re-contextualization* (*de-/re-ctx*), *synchronous* and *asynchronous entity composition* (*SEC/AEC*) as *Strong Concept* candidates. These concepts play a fundamental role within the CuDe Framework and are localized its concept dimensions. While these design principles do not depict generalizable knowledge, the device of *Strong Concepts* (Höök & Löwgren, 2012) enable us to create a repertoire of interaction design elements, which can be applicable across different application domains and thereby can be useful to fellow designers or researchers.

Strong Concept candidates, however, need time to evolve and to prove their usefulness (Höök & Löwgren, 2012). This can be accomplished in the course of time, if additional applications successfully employ, for example, *de-/re-ctx* as an interaction design strategy. For this reason we cannot claim to have identified 'full-grown' *Strong Concepts* within this thesis work. Instead, we suggest that the concepts as proposed in this work are candidates for *Strong Concepts*, which seem to be promising, but which also have to pass the test of time.

Instead of strong claims regarding generalizability, we put more importance of the coherence of our work. CuDe is, as mentioned before, an open system. Nevertheless, it is self-contained and works as a sound construction of knowledge. To some extent, it is a "dependent and localised" theory (Gaver, 2014), as the conclusions made depend mainly on the observations on a relatively small number of participants in different everyday situations.

If we interpret CuDe and its components as a 'localized' and self-contained theoretical construction, there is an interesting parallel to the method employed in this thesis and the understandings of current memory research (and memory is what CuDe seeks to support): memories are not retrieved copies, they are an individual's mental and hence mouldable constructions of a lived moment, according to the constructivist perspective. For the individual these memories are coherent, and they support them in dealing with their past. Similarly, the knowledge contained within the CuDe Framework is a coherent construction, moulded by us as researchers through reflective practice and serving the purpose of better designing. Thus, from a constructivist perspective, there are certain parallels between the researcher employing design-based research and the individual, who remembers. "The investigator and the object of investigation are assumed to be interactively linked so that the 'findings' are literally created as the investigation proceeds", (Guba & Lincoln, 1989, p.111) to cite from constructivist epistemology.

10.4 Chapter Summary

In this chapter we reflected on the findings of the empirical user studies, and on the learning from the act of creating the corresponding interactive prototypes. In this course, we took the perspective of the designer, the user, and we assessed the research conducted from the viewpoint of science.

We conclude this chapter with a final recapitulation of the four design challenges identified during the literature review.

10.4.1 Four Design Challenges in the Literature

During the literature review we identified four challenges or opportunities in current augmented memory system design. This preceding research motivated the initial prototypes as well as the more elaborated applications. Therefore, we go on to revisit these challenges step by step to formulate our final judgement about the success of our interventions and to summarize the new knowledge that we can contribute.

10.4.1.1 Information Overload and the Effort to create Order

As outlined in Chapter 2, the accumulation of digital souvenirs, in particular photos, is a significant challenge as potentially precious information is scattered across different places (different hard disk drives, *USB* sticks, phones, the *cloud*, etc.) and finally lost. For this reason, our intention was to create applications that help stem information overload and assist in creating order over these files. To tackle this problem, we started off with applications, which aimed at slowing the user down and focussing their attention (EyeOfDetail, ForgetMeNot, Audio Peephole, Hearsay). In other words, these apps were meant as an alternative plan to the predominant habit of quick and easy media capture or consumption.

Certainly, we cannot claim to have solved the problem of information overload. Neither have we brought the media data into order for a guaranteed and secured retrieval. (This has never been the ambition of the proposed prototypes, anyway.) However, we have demonstrated a number of systems, which embody alternative proposals to the automatic and less reflected ('point and shoot') modes of digital souvenir capture. The Duography application, and in particular, the Media Object offer interactive systems that let users assemble or 'craft' their mementos. This had an effect on both quantity and quality of the digital souvenirs. While, the number of MEO containers was manageable, the amount of effort put into them and the attachment for them was substantial. It is important to note, that at least a subset of the participants did not perceive this effort of recording as a burden or disadvantage. On the contrary, they enjoyed 'crafting' their reservoirs of memory retrieval cues. As a positive side product, the concept of MEO resulted in a collection of pre-sorted digital files and reduced the need for sorting out material afterwards.

As a solution to information overflow and an overburdening effort to create order, often automatic and smart computer algorithms are proposed, for instance, by Egorova and Safonov (2013). The prototypes and studies of this thesis, on the other hand, indicate that a certain group of users exists, which is willing to reduce this problem by going the opposite direction: investing effort *a priori* and manually creating valuable digital souvenirs. Hence, while improving the algorithms clearly is a promising option, the research community might also consider designing concepts as represented, for instance, by MEO.

10.4.1.2 The Invisibility of Digital Resources

Digital souvenirs (e.g., photos) are perceived as invisible compared to their physical counterparts and are thus often forgotten or overlooked. Therefore, researchers recently built hybrid devices, which give digital data a physical home, for instance FM Radio (Petrelli et al., 2010). Projects like this is what van den Hoven (2014) summarized as "Materialising Memories", that is, projects, which combine "[…]physical designs with computing, facilitating the use of material and digital memory cues for creating remembering experiences in real-life situations" (p. 375).

The proposed Mobboxes clearly gave a home to the MEO containers and this idea was also accepted by the participants. In fact, the concept of having an aggregated multimedia format (the Media Object), which can be recorded and played by a larger family of devices (e.g., MRM2, different Mobboxes, etc.) was quite unique in the literature. Certainly, basic file formats such as *JPEG* can be played by many different digital photo frames. More complex records of digital souvenirs such as administrated by the Living Memory Box (Stevens et al., 2003), however, are usually not interchangeable and cannot be transferred to additional systems.

Based on our learning we therefore recommend considering the "materialization of memories" in a way that they can be easily transferred to alternative devices.

Another observation, which relates to the invisibility of digital data or to the presentation of this information, relates to the immanent characteristics of 'the digital'. These properties allow for the creation of (digital) souvenirs, which feature advantages as compared to physical objects. In our Duography studies we convincingly found that the application facilitated original user experiences during capture, but also when revisiting Duographs. It was quite easy to implement a flip animation, which enabled to virtually turn the two-sided photos around to reveal one side after the other. Creating physical photo prints with a front and back side would likely be much harder. Thus, we assume that exploiting advantages like this can compensate the invisibility of 'the digital' and make this information more prominent in our life.

10.4.1.3 Supporting the (Re-)constructive Nature of Memory

The notion '(re-)constructive nature of memory' expresses our assumption that human memory cannot be compared to a 'static recording machine'. It is not a precise 'copy' of a memory that we keep in our minds. Rather, according to the majority of current research in psychology, it is hypothesised that memories can be moulded into different shapes, depending on various factors such as our current mood or the availability of memory retrieval cues. These cues are employed to reconstruct the original past event, leading to a dynamic remembering experience (compare Chapter 2).

Basically, the core of the CuDe Framework is considered with this reconstructive nature of memory. CuDe suggests working with digital entities in specific ways to provide valuable memory cues to the user for reconstructing whatever was captured by these entities. We suggest that following some of the advice or inspiration of the framework can support designers in delivering the right kind of 'retrieval cue substrate' to our minds.

10.4.1.4 Supporting Creativity

We have seen that a number of participants did not hesitate to invest effort and inspiration in creating digital souvenirs. Others, on the contrary, were reluctant to invest any extra work in crafting their mementos. This readiness or reluctance was related to their fondness to engage in activities involving creativity. Basically, those participants, who demonstrated a high level of creativity, were also those, who invested more time in the crafting of their files.

Therefore, in analogy to *the effort to create order*, we suggest to support user groups in augmented memory system design, who enjoy creative activities and use this preference as a driving force for generating valuable digital souvenirs.

While we saw some participants clearly rejecting extra efforts, we did not observe participants, who did completely reject creativity or original content. In fact, we hypothesise that most people do appreciate unconventional, original or interesting souvenirs. One participant, for instance, who wouldn't use the MEO application (well suitable for digital creative engagement, but requires some effort and thinking), still enjoyed Duography and created original photos, because it was so quick and easy to use. Thus, it might be worth to consider supporting both kinds of users: creative people might find value in more demanding and complex applications such as MEO. Others, might also be interested in creating original content, but demand more rigid and guided structures such as provided by Duography.

11 Conclusion

In this thesis we were concerned with the augmentation of human memory. Remembering processes such as reminiscing and reflecting were of particular interest, and we aimed at supporting this by providing digitally captured *memory retrieval cues*.

We discussed related work and a *design-based research* methodology (thesis Part I) in the course of proposing a number of interactive systems targeted at the memory processes mentioned above. We divided the empirical body of the thesis into two parts: one part dealing with systems that involved singular digital files (Part II) and the other part considering multiple digital files (Part III). That is, we proposed a number of applications, which supported memory by either processing one single file (e.g., filtering a photo) – we called these files *entities* in the course of the thesis – or making use of multiple files (e.g., combining multiple entities such as a photo and a text message).

We collated the synthesized learning of the user studies conducted on these applications into the CuDe Framework (Memory Cue Design Framework) and subsequently reflected on our research in Part IV of the thesis.

In conclusion, the thesis work entails the following contributions: we developed five technology probes (EyeOfDetail, ForgetMeNot, Audio Peephole, ContextShaker, Duography version 1) and three more advanced prototype systems (Hearsay, Duography version 2, Media Object including Mobboxes). The more advanced systems were studied empirically (eight user studies: HPI, DUO.1.4, MEO.1-3) and we gathered both long-term (e.g., MEO.2, up to 28 weeks) and large-scale user data (e.g., DUO.1, more than 115 thousand installations). Drawing on this feedback and on the reflection of our practical design experience throughout the development processes, we proposed a set of *Strong Concept* candidates (Höök & Löwgren, 2012) (*de-/re-ctx*, SEC/AEC) to conceptually account for some of the working principles of our successful prototypes. These concepts and additional related interaction design principles were then integrated with the CuDe Framework, which depicts the synthesised learning of this thesis.

In summary, we hence offer a set of (a) practical contributions (prototypes developed), (b) conceptual contributions (prototype ideas and their more abstract underlying concepts), and (c) advanced theoretical contributions (theorization based on empirical user studies and summarized by CuDe).

More details on the contributions of this thesis can be found in Chapter 1.

Chapter 1 also addressed the limitations of our work. Here, we remind of the most significant general conditions:

The work presented in this thesis dealt with the recording of digital resources for remembering. Thereby, in terms of targeted user groups, the individual in the western hemisphere was at the centre of our research interest. With regard to memory, we focussed one more sentimental or 'subtle' forms of remembering such as reminiscence or reflection. 'Plain factual' remembering (e.g., number of details remembered) was not at the focus of this thesis. Moreover, the work presented does not constitute long-term observations on memory processes. Rather, our design proposals were studied in the field under 'realistic' conditions (as opposed to lab conditions).

From a technological perspective, this research primarily dealt with interactions that are facilitated by modern mobile phones (smartphones). Also, in some instances, physical computing prototypes were developed. The interactions were locally restricted to the corresponding devices ('they are offline'), that is, the research on hand did not investigate augmented memory in conjunction with concepts of the Internet such as cloud computing, social networks, instant sharing of data, and so on.

The scientific approach in this thesis can be labelled as related to *research through design* or as a *design-based* methodological stance. Most significant findings in this thesis are based on qualitative data such as interviews, collected digital recordings (e.g., photos) or observations. From this is evident, that the conclusions drawn in this work are not understood as generalizable knowledge. Instead, we provide a rich and descriptive account of individual design cases that are theoretically structured by means of the CuDe Framework, and that might provide inspirations to fellow researchers. CuDe is not a closed system. Instead, researchers and designers are invited to extend and also to modify it.

11.1 Future Work

There are many options for connecting to the presented work. For instance, the limitations outlined above might be addressed. Given that this thesis dealt with memory, most obviously, it would be interesting to revisit some of the collected user data in the future and to investigate long-term effects of our applications and interventions. Considering the growing importance of the Internet, it would also be interesting to explore our prototypes in networked settings. That is, how will the user make use of the Media Object, for example, if they are able to easily share mob files over their social networks.

On a more theoretical level, it will be interesting to see whether our *Strong Concept* candidates (e.g., *de-/re-ctx*) can also be employed in different situations or domains, and hence can mature as concepts for interaction design. On a higher level, the CuDe Framework as a whole has to prove its usefulness. We would like to create further augmented memory systems, which are inspired by the guidance of the framework, and we would love to see others take advantage of it. In addition, we believe that it is possible and worth the effort to develop CuDe further, and to add in, for instance, additional types of *entity processing*.

A Duography Complementary Material

A.1 2sidez for Android

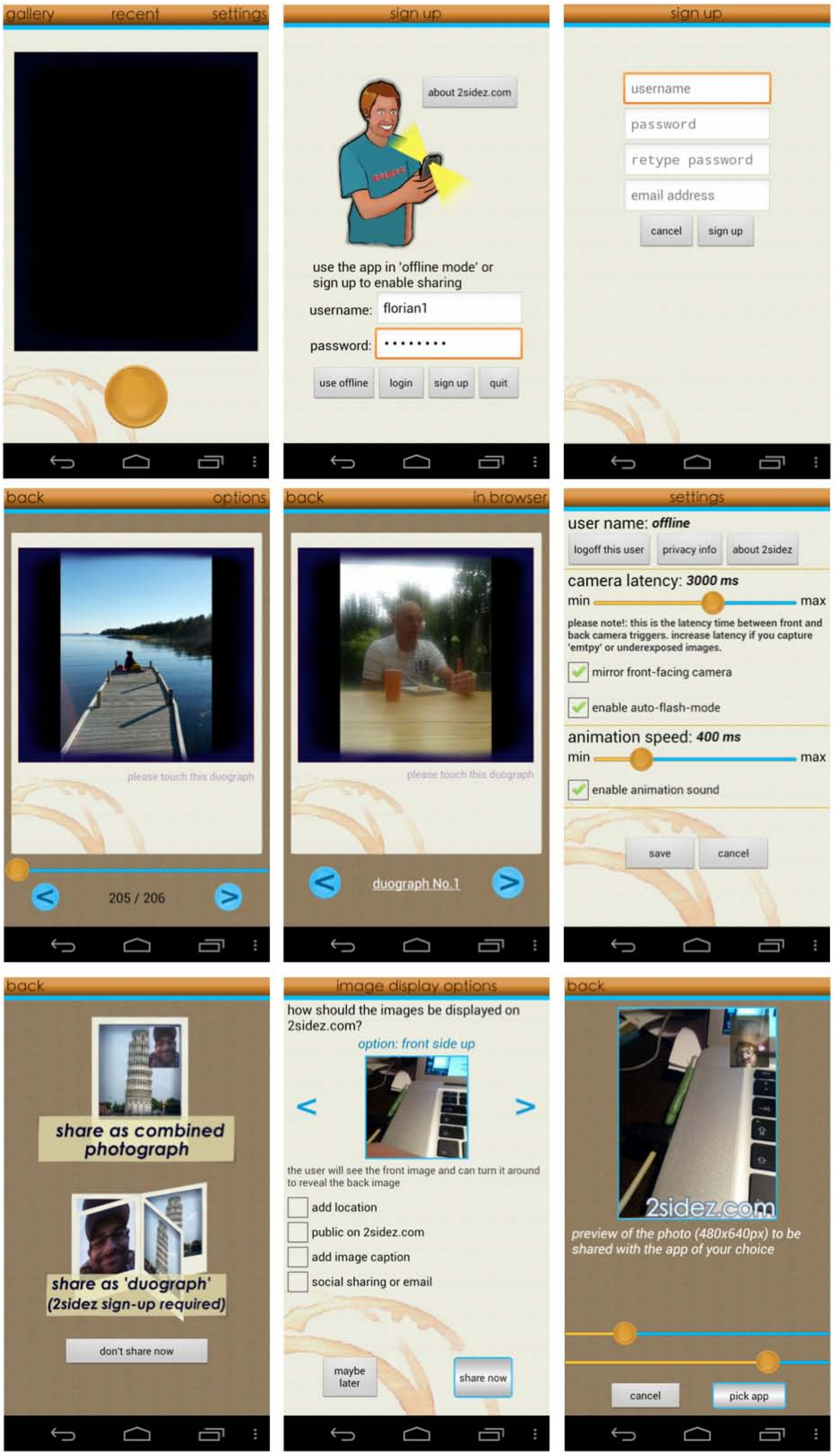


Figure A1. 2sidez app for *Android*. Left to right and top to bottom: main screen for taking Duographs, login screen, sign-up screen, gallery, recent community Duographs, settings, share as combined photograph or as Duograph, Duography upload options (to 2sidez.com), creating a combined photo/photo collage for sharing the Duograph via email or social networking sites. (*Facebook*, *Tumblr*, *Twitter*, etc.).

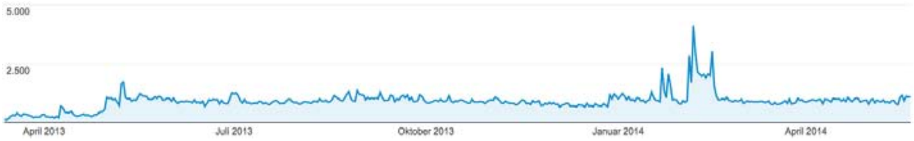


Figure A2. Daily 2sidez for *Android* sessions worldwide during the study period of 433 days. (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

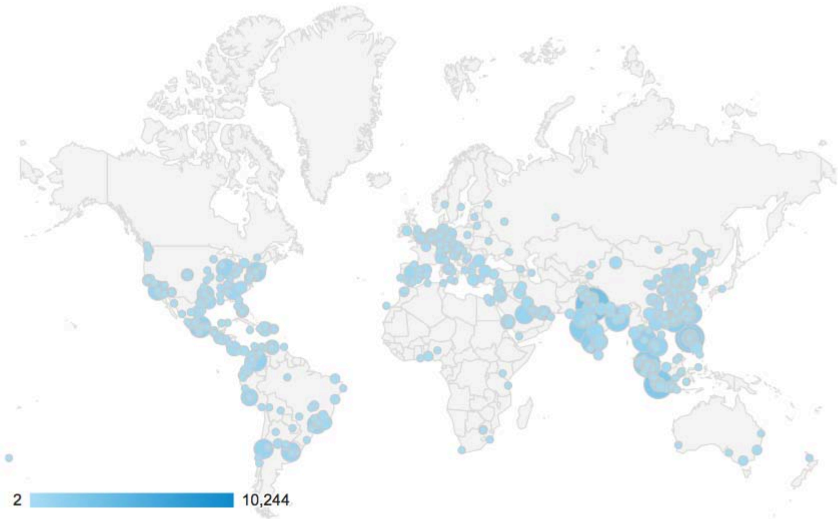


Figure A3. Cities with most 2sidez users: 'Not set' (10,244; 6.50%), New Delhi (3,167; 2.01%), Jakarta (2,767; 1.75%), Pune (2,515; 1.59%), Manila (2,360; 1.50%) Kuala Lumpur (1,862; 1.18%), Mumbai (1,831; 1.16%), Makati (1,754; 1.11%), Hong Kong (1,677; 1.06%), Bangalore (1,622; 1.03%). (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

	Mobile Device Info	Sessions	
		392,038 % of Total: 99.96% (392,176)	
1.	(not set)	63,949	(16.31%)
2.	Samsung GT-I9300 Galaxy SIII	26,026	(6.64%)
3.	Samsung GT-N7100 Galaxy Note II	23,079	(5.89%)
4.	Samsung GT-I9300 Galaxy S III	14,352	(3.66%)
5.	Samsung GT-I9100 Galaxy S II	13,453	(3.43%)
6.	Samsung GT-I9082 Galaxy Grand Duos	11,933	(3.04%)
7.	Samsung GT-I9500 Galaxy S IV	11,340	(2.89%)
8.	Samsung GT-I9152 Galaxy Mega 5.8	9,350	(2.38%)
9.	Samsung GT-N7000 Galaxy Note	8,126	(2.07%)
10.	Samsung GT-S7562 Galaxy S Duos	5,970	(1.52%)

Figure A4. Most common *Android* devices for 2sidez. (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

Screen Resolution	Sessions
	392,176 % of Total: 100.00% (392,176)
1. 480x800	115,473 (29.44%)
2. 720x1280	99,683 (25.42%)
3. 320x480	42,253 (10.77%)
4. 540x960	33,136 (8.45%)
5. 480x854	19,884 (5.07%)
6. 1080x1920	17,187 (4.38%)
7. 800x1280	12,098 (3.08%)
8. 1080x1776	10,319 (2.63%)
9. 720x1184	9,325 (2.38%)
10. 600x976	7,303 (1.86%)

Figure A5. Most common screen resolutions of 2sidez for *Android*. (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

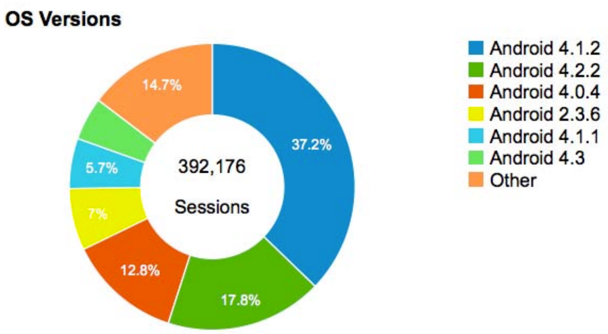
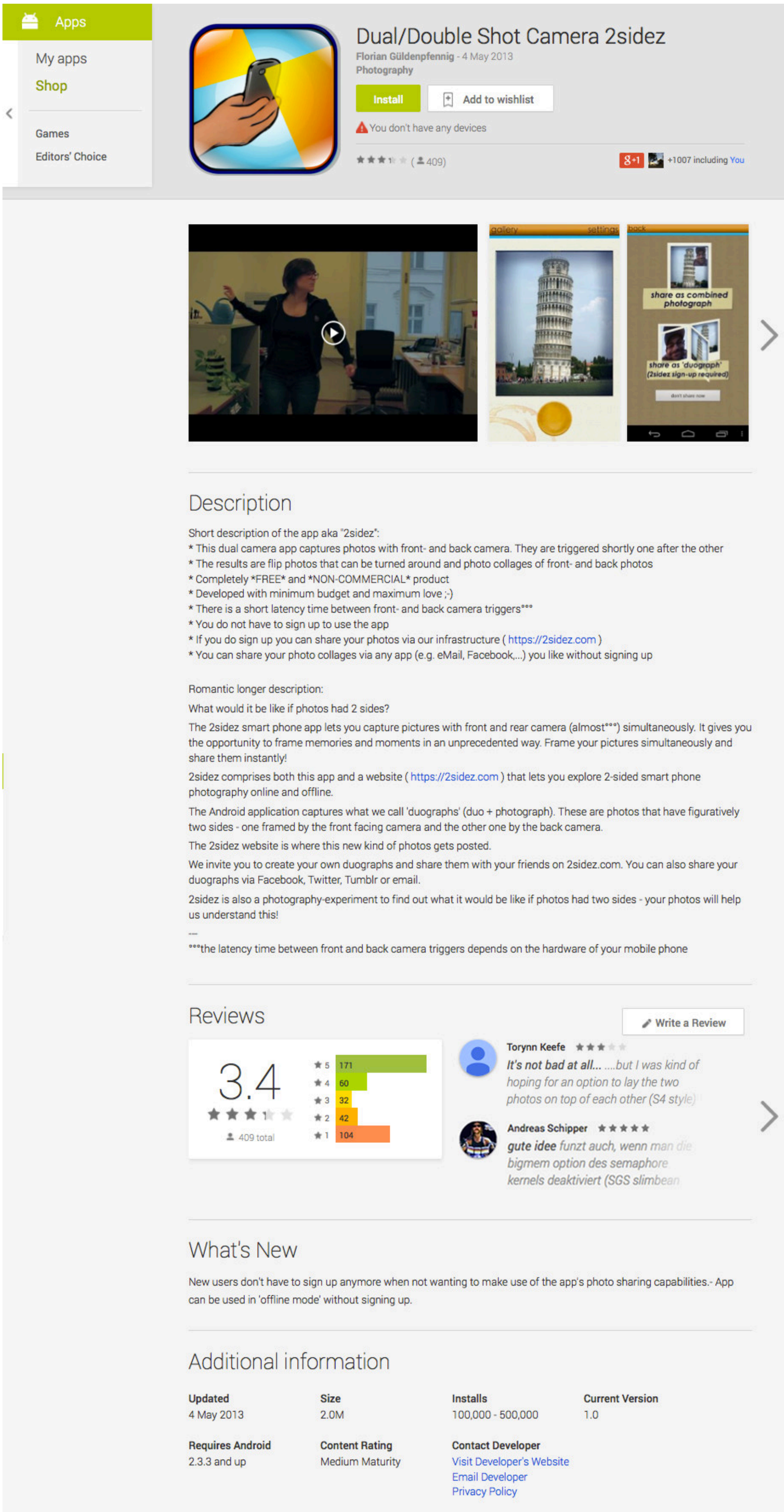


Figure A6. Most common *Android* Versions for 2sidez. (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

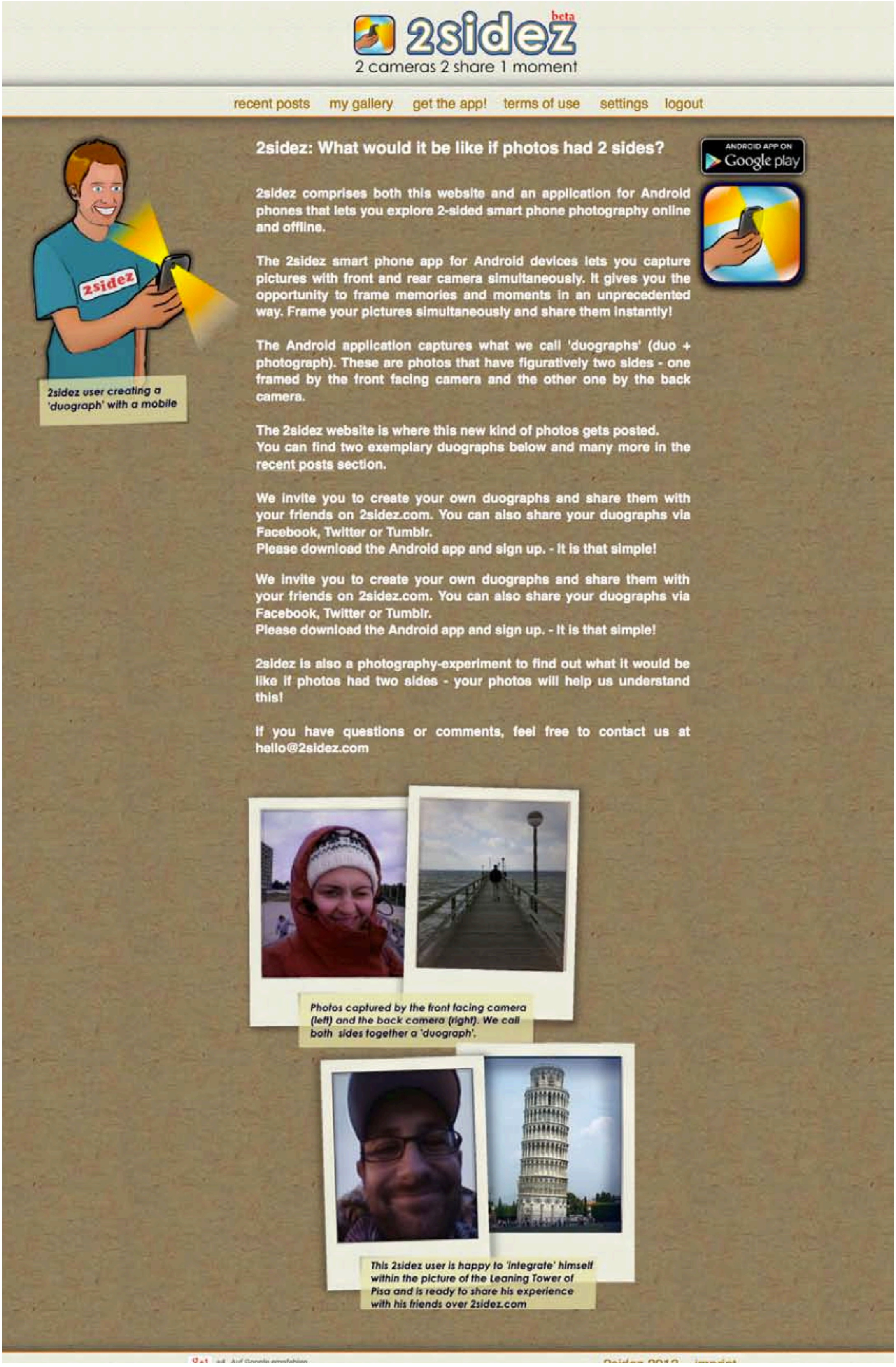
Figure A7. *Google Play* entry of 2sidez for *Android*. (Retrieved 20 July 2014 from https://play.google.com/store/apps/details?id=com.behind.the.camera)



A.2 2sidez.com Web Application

On the following pages we present complementary material for the 2sidez web application 2sidez*.com*.

Figure A8. 2sidez web application teaser text ("get the app!" tab). (Retrieved 20 July 2014 from https://www.2sidez.com)



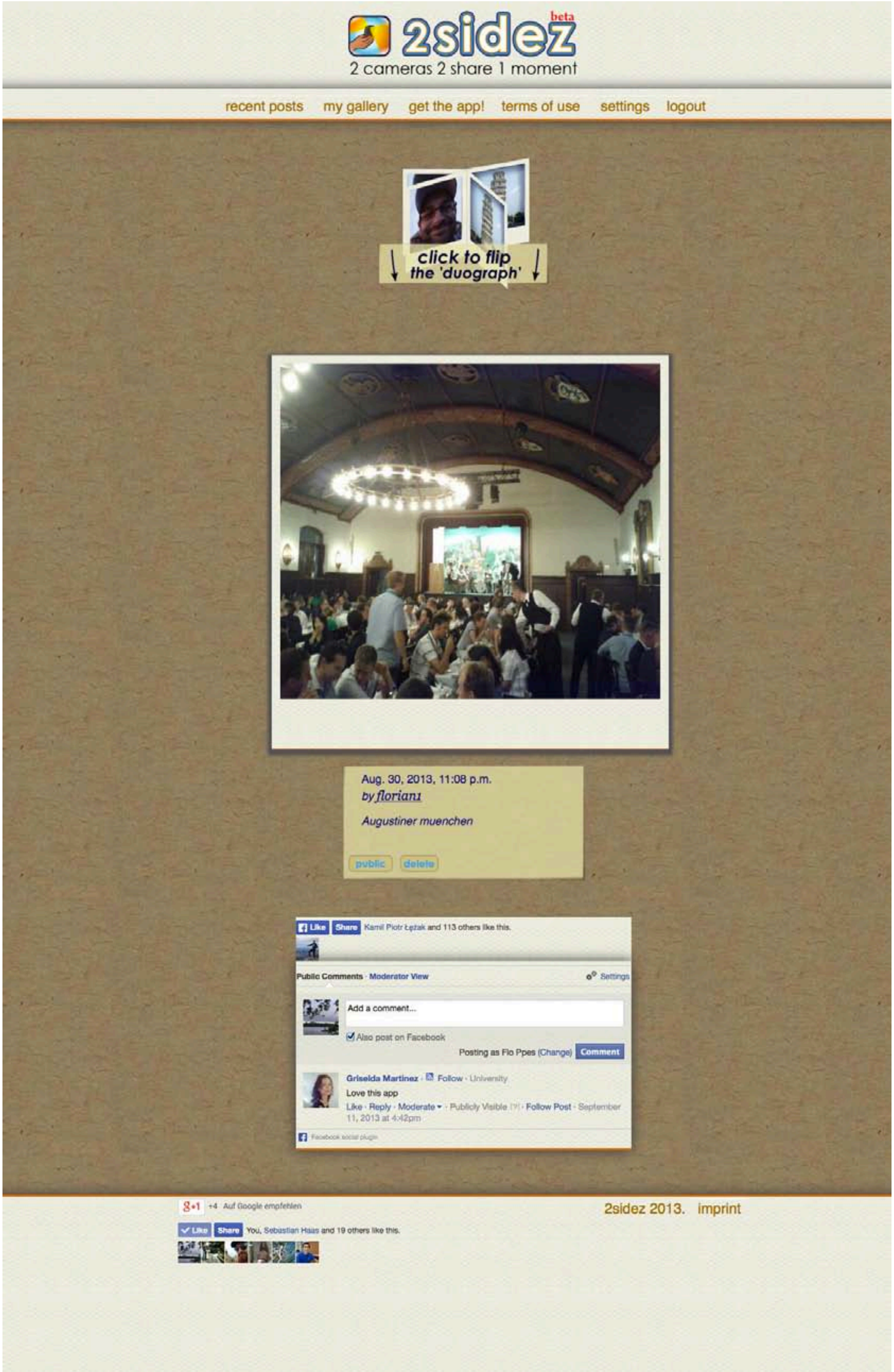


Figure A9. 2sidez detail view of one Duograph. Users can post cross-referenced comments to *Facebook*, if they have a corresponding *Facebook* user account. (Retrieved 20 July 2014 from https://www.2sidez.com)

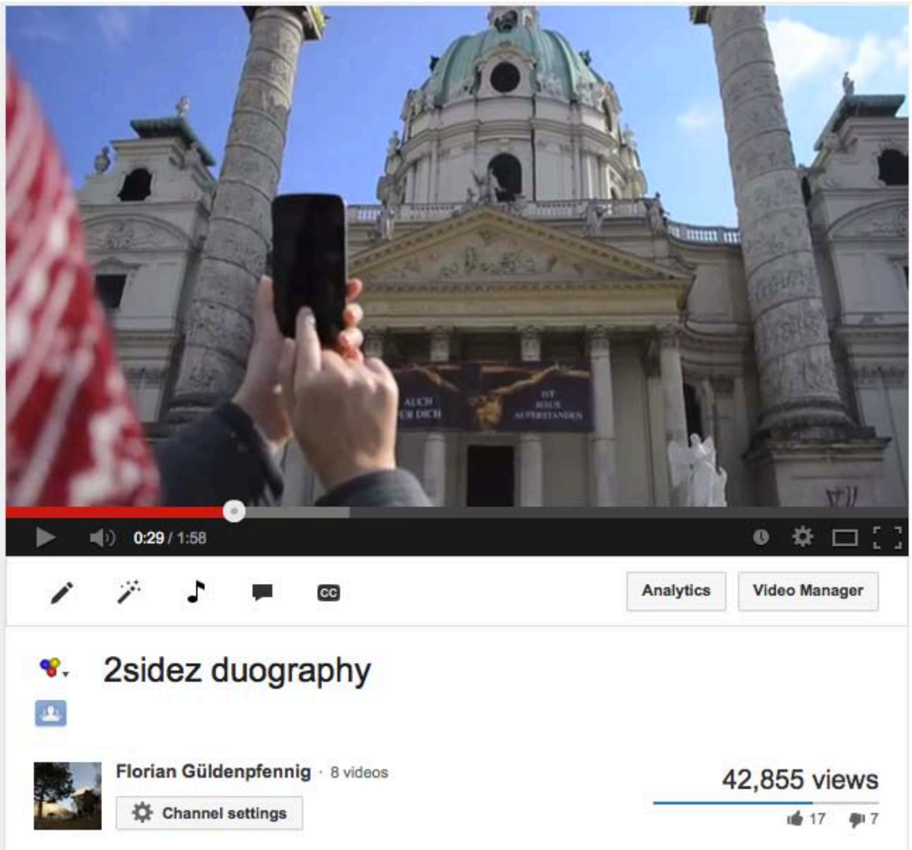


Figure A10. Video still from the 2sidez demo video on *Google Play/Youtube*. (Retrieved 20 July 2014 from https://www.youtube.com/watch?v=voSQI0_XGnA)

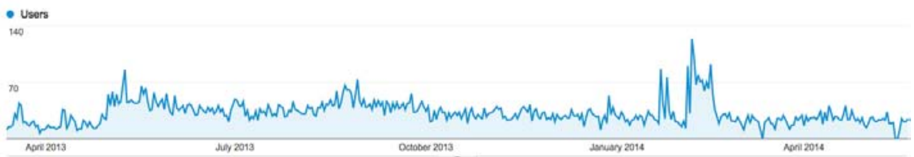


Figure A11. Daily users on the 2sidez.com website. (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

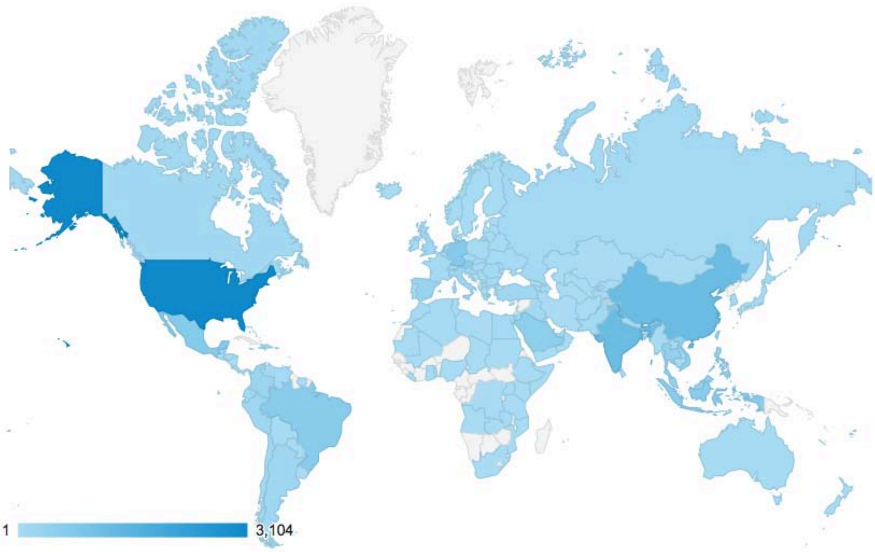


Figure A12. Distribution of 2sidez.com users (sessions). United States (3,104; 18.62%), India (1,185; 7.11%), China (1,180; 7.08%), Germany (664; 3.98%), Mexico (661; 3.97%), Brazil (605; 3.63%), Indonesia (591; 3.55%), Austria (574; 3.44%), Saudi Arabia (487; 2.92%), Vietnam (432; 2.59%). (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

		% of Total: 100.00% (16,667)
1.	Android Browser	11,446 (68.67%)
2.	Chrome	3,040 (18.24%)
3.	Firefox	664 (3.98%)
4.	UC Browser	496 (2.98%)
5.	Opera Mini	356 (2.14%)
6.	Safari	303 (1.82%)
7.	Internet Explorer	115 (0.69%)
8.	Opera	74 (0.44%)
9.	Safari (in-app)	28 (0.17%)
10.	Maxthon	12 (0.07%)

Figure A13. Most common browsers that have 'visited' 2sidez.com. (Retrieved 20 July 2014 from http://www.google.de/intl/com/analytics)

A.3 2sidezLogger

A Total of 1,914,877 user interactions were recorded by 2sidezLogger. This makes a daily average of 4,419.30 interactions during the 433 days period. The daily average of installations was 348.62. Table A1 displays the distribution of all recorded interactions across the monitored user interface elements of 2sidez. (Note that Table A1 refers to Figure 8.3 of Chapter 8.)

Table A1. 2sidezLogger-record of all registered user interactions. The corresponding user interface elements are depicted in Figure 8.3 of Chapter 8.

Log Code	Description	Number of Interaction Records
1	Main screen (*d. take* Duo) opened	884,221
2	*Take* Duograph button touched	395,373
3	*Delete* Duograph button touched	114,298
4	Save Duograph	212,412
5	Share Duograph *maybe later* button touched	9,998
6	*Share* Duograph *via* 2sidez.com *button* touched (upload to 2sidez.com server initiated)	3,933
7	Gallery opened	31,296
8	*Close gallery* button touched	30,203
9	*e. recent* postings screen opened	58,401
10	*Open* 2sidez *web application in mobile browser* button touched	8,078
11	Share link to specific recent posting	340
12	*Rotate* Duography button touched	12,291
13	*j. social and email* screen closed	99,825
14	*Pick app* button touched to share combined Duograph via email or any other external *Android* application that can process images (e.g., *Facebook*, *Twitter*, *Tumblr*, etc.)	54,208
		1,914,877 records total

Figure A14 shows a bar diagram of the *top-100* 2sidez users regarding the amount of Duographs taken and plots the count of the interaction *gallery opened* against the count of *Duographs shared* (via email, *Facebook*, *Tumblr*, *Twitter*). As this group of 'heavy' 2sidez users shared a total of 40,777 Duographs, the *top-100 users* accounts for 75.22% of all Duographs that were shared via an external client across all users (e.g., email, *Twitter*, *Tumblr*, or *Facebook* app). While this is a relatively large number, only 6 Duos were uploaded to 2sidez.com by these *top-100* 2sidez users (i.e., this user group was highly interested in sharing Duographs, but only via external clients and not via the provided 2sidez.com service).

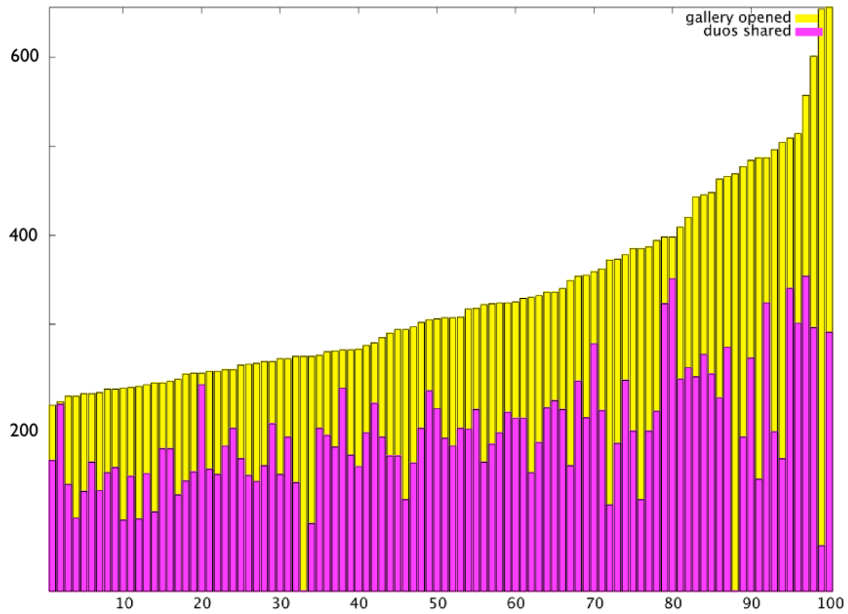


Figure A14. Top-100 2sidez users (in terms of most 'Duographs taken'): total count 'gallery opened' versus 'Duograph shared' as logged by 2sidezLogger**.**

Figure A15 presents an additional statistic of the top-100 users. Here, we can see that in contrast to a large number of Duographs taken (count = 33,125; i.e., 8.38% of all Duos across all user groups), relatively few Duos were deleted (count = 3,722; i.e., 3.26% of all Duos that were ever deleted across all user groups) by this particular user group of 'heavy' customers. This number is relatively low, as the average rate of Duo deletion across all users is 28.91%.

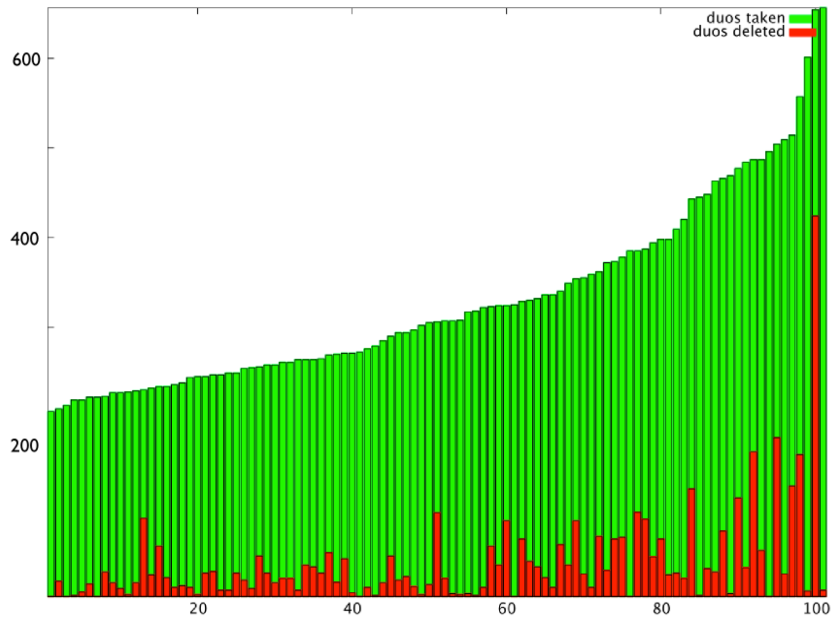


Figure A15. Top-100 2sidez users (in terms of most 'Duographs taken'): 'Duographs captured' versus 'Duographs deleted' as logged by 2sidezLogger.

A.4 Duography in Everyday Life – DUO.2 Study Details

- The following detail information is extracted from (Güldenpfennig et al., 2012b). It describes the interview and Duography *review situation for the participants of DUO.2. We implemented a specific procedure (as detailed below) to study the participants' experience with and reactions to* Duography -

The specific sequence of Duograph presentations during the image review activity of DUO.2 is outlined in Table A2. These activities were used as diverse ways to open up a conversation about the Duographs, given that there is no established convention for how to review such image pairs.

To warm up we let the interviewees start off with a 'jigsaw' exercise (round 1, see Table A2): we printed out a small random set of Duos from the whole data pool and the participants were asked to match front sides with back sides (see Figure A16). This gave us the opportunity to observe the participants looking at other peoples' images in a playful way. Also, we hoped to evoke interesting reactions by contrasting our 'novel kind' of photography with classical printouts for presentation.

Then, the person moved over to the Desktop computer to review their own images with a Duography Desktop viewer software (*SimpleDuoView*) where they were asked to talk loud about what they were thinking or remembering when they see the images. This was conducted in two rounds with two different subsets of their own data: first, the participants were presented with the front side of their Duos and could turn to the back side (round 2). Second, the back side was presented first and they could flip it over to the front side (round 3).

Finally, the participants used the same viewer software to examine a set of the other participants' images (round 4). For this time they could choose, whether they wanted to see first the front side, back side or both images next to each other. Table A2 summarizes the sequence of image viewing activities. Round 2 and 3 were for studying the participants reviewing their own Duographs in two different orders. In the last round, (4) we wanted to confront the users again with foreign material and probe their reactions.

Table A2. Image presentation during re-visiting activity in study DUO.2.

Image presentation round	Image source
1. Jigsaw (physical printout; see Figure A16)	Everybody's images, random selection across the categories (size: two pairs per participant)
2. Front first, then back (*SimpleDuoView*)	Random subset of own images (size: ~85%) across the categories
3. Back first, then front (*SimpleDuoView*)	Random subset of own images (size: ~15%) across the categories
4. Choice of order up to the participant (*SimpleDuoView*)	Radom subset of the other participants' Duographs across the categories (size: ~30 Duographs)

The interviews lasted between 70 and 150 minutes and were audio recorded, video taped and transcribed. Once all of this qualitative material was present the researchers employed the transcripts in conjunction with the videos to analyse the participants' view of 2sidez and Duography. Again, the attention was paid to re-occurring patterns and themes, this time within the participants' direct account.

Figure A16. Participant trying to match front side and back side of Duographs.

A.5 ImgCoder Duo Analyzing Software

To evaluate the vast amounts of pictures as generated during the studies efficiently, we created a coding tool for analysing Duographs (and also conventional photos). ImgCoder supports the fast browsing of pictures, zooming, assigning labels (label names can be customized; one primary and additional secondary labels), filtering of specific labels or flagged pictures, and displaying of statistics (distributions of pictures across categories).

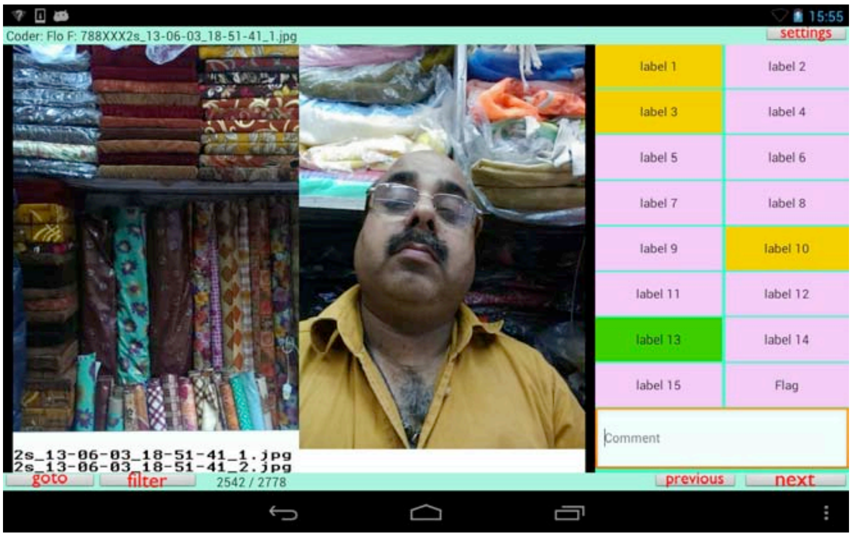


Figure A17. ImgCoder user interface. Picture to be qualitatively analyzed and coded (left). Buttons with different labels for assigning categories (right).

B MEO Complementary Material

B.1 MEO Design Rationale

In this section[27] we provide additional information about how the *four design challenges* identified in the literature review influenced the design of MEO.

(1) Information overload and effort to order: A common problem noted in literature on digital archives is information overload and information being scattered across multiple locations, for example (Churchill & Ubois, 2008; Sellen & Whittaker, 2010; Van House & Churchill, 2008). In connection with archives for personal remembering this means that a large number of users take vast numbers of digital images, but don't get to sort or label them properly and don't revisit them. Whittaker et al. (2010) asked participants to locate personal digital photos of salient family events older than one year. They found that participants failed to find approximately 40% of the photos, even though they were from important events. The authors conclude that the newly gained abilities to take and collect large numbers of images is not matched by the ability to create order over them. They identified a couple of factors accounting for their participants' poor performance in retrieving important photos. These comprise: taking too many images, poor organization (on multiple file systems), the inability to maintain collections and an overoptimistic belief in being able to relocate them (Whittaker et al., 2010). This predominant problem of unsorted, lost, scattered and too many digital images led to one primary concept of MEO. Here the process around capturing photos is reversed. Since the mob file (the container) is created first and the digital material is filled in afterwards, we hypothesise that this will result in pre-sorted rich media aggregates and remove the need for later sorting.

(2) The invisibility of digital resources: A drawback of digital souvenirs compared to their physical counterparts is that they are perceived more and often as invisible (Whittaker et al., 2012). Recent work has highlighted the importance of providing the virtual a physical home to know where these materials are and to have quick access (Odom et al., 2012). While our MEO software is designed in particular for capturing data on mobile phones, display can be on any device. This opens up the possibility to comply with a specific recommendation for designers of digital memory systems: to move away from the PC (Stevens et al., 2003). MEO enables us to explore more integrated devices that bring the mobs into everyday spaces in engaging and highly visible ways. For this particular purpose we designed dedicated Mobboxes, which should aid the user in revisiting and narrating their memories via (automatically) generated slideshows. The Mobboxes constitute some sort of physical complement to the digital mob files and hence provide the virtual with a fixed and visible place. We chose wood for building

[27] This section is based on prior publication (Güldenpfennig & Fitzpatrick, 2014).

them, since this material is often connected with intimate places such as the home, and picking the right kind of material can have significant effects on the success of an interaction design (Gaver et al., 2010). In particular, these devices have been designed to give the participants an idea of different options for replaying mob files and to demonstrate to them that the interaction in fact has not to be restricted to the PC or mobile phone. Admittedly, these Mobboxes have some similarity to digital photo frames. The primary difference is, however, that our devices are made to play mob files and hence depict a counterpart to MEO recording software (e.g., MRM2). Thus, Mobboxes play multimodal slideshows (photo, video, accompanying audio comments, etc.) without the need to prepare (e.g., assemble a set of images) such a slideshow in advance, as needed with digital photo frames, because this work is eliminated by the MEO concept.

(3) Enable and encourage creativity: A recurring theme in the remembering systems literature is creativity or the power of creative engagement and activities that are related to creativity. We use the term *creativity* to describe two distinct things here. Firstly, a creative act can denote constructive activities such as setting up folders, organizing photos or even bringing old memories back to mind - things are (re-)created, moments are captured and memories are reconstructed. Secondly, the term creativity can also be used in a more artistic sense. For instance, there might be a lot of originality and engagement in the way people are using their camera to capture a moment. The following studies further exemplify what we mean by stating that there is a lot of creativity involved in memory (systems).

As an example of the first, Petrelli et al. (Petrelli et al., 2009) conducted workshops with respect to *lifelogging* and let participants create time capsules. This is a container to be sealed and not to be opened for the next 25 years. Participants were asked to put "long-term mnemonic representations of their lives" (p.1723) into that container and had free choice of objects. The aim of the study was to find out what kind of things people want to be able to remember. One key insight from their work is that the participants showed little support for the passive *lifelogging* paradigm. That is, they were not interested in vast auto-created archives of a captured life, but preferred a highly customized and personal selection of mnemonic representations:

"To our surprise, participants put a lot of effort in assembling new content: 37% of objects were created for the sole purpose of being included in the time capsule, a further 26% were deliberately collected for this reason. This is an important result not only because it challenges the lifelogging notion of passive event capture, but also because it shows the level of commitment and interest that the overall project engendered in our participants." (Petrelli et al., 2009, p.1725)

However, the participants valued physical objects a lot more than digital ones and chose almost solely physical artifacts for their time capsules. Where digital souvenirs are used, Goldsteijn and colleagues noticed that digitally crafted ones are more cherished compared to raw, unedited digital objects (Golsteijn et al., 2012). Relating to this, within this thesis we also understand creative engagement as taking the time and making an effort in fulfilling an action.

Creativity is also important in our second sense. A principal resource for digital souvenirs is the photo camera and there is a history of people using their cameras for self-expression. In fact, in recent years more and more non-professionals are observed engaging in art photography (Van House, 2011). Camera phones often catch more mundane motifs and often with humour being involved. In a *SenseCam* study (using an automatically triggered camera about the size of a mobile phone and worn around the neck with a string) centring on capturing digital memories for later narrative Harper et al. (2008) found that the participants appreciated uncommon and arty pictures and enjoyed using *SenseCam* in a creative fashion.

Inspired by the observations listed above, we hypothesise that having to create a mob container *a priori* can put users into an anticipatory frame of mind since this is inviting to plan their digital souvenirs beforehand. Further, this may also trigger more active creative/artistic engagement with how the material is gathered. To this end, MRM2 offers the user a variety of different choices, that is, a variety of integrated apps or functions that allow for mimicking the creation of the physical time capsules and for supporting other sorts of creative self-expression and digital crafting if demanded.

(4) The (re-)creation of memory and retrieval cues: This leads to the next point relating creativity and memory cues. One of the most predominant understandings in psychology is that memories have to be *re-created* or *re-established* by *retrieval cues* (Hoven & Eggen, 2008; Schacter, 1996) and that successful recall depends heavily on our access to appropriate memory cues (Schacter, 1996). From a media studies perspective van Dijck characterizes "products of memory [to be] first and foremost creative products, the provisional outcomes of confrontations between individual lives and culture at large" (Van Dijck, 2007, p.7). She highlights that a prerequisite of a memory is that resources for later recall have to be created in the present moment. Furthermore, she reminds us that photography has always been a tool for the construction of identity, that is, we capture photos that represent us in the way that we would like to be remembered. In HCI literature van Hoven was among the first authors to emphasize that it is not memories that can be stored to disc, it is retrieval cues for recreating that experience:

"A cue (or trigger) is a stimulus that can help someone to retrieve information from long-term memory, but only if this cue is related to the to-be-retrieved memory. The stimuli most often used in studies are photos, smells or text labels. But anything could be a cue […], as long as there is a link between the cue and the to-be-remembered event. A combi-

nation of cues increases the chance of retrieving a memory […].” (Hoven & Eggen, 2008, p.435)

Reflecting similar perspectives, others also criticized that the archive metaphor is used too often as a reference model for the design of digital remembering or *lifelogging* systems (Petrelli et al., 2009; Sellen & Whittaker, 2010).

Regarding MEO and MRM2 our aim in the longer-term is that the various integrated options of capturing digital memory cues will not only support the users in their self-expressiveness but also that the different modalities and the resulting rich Media Objects can serve as appropriate memory cues. To this end, we also assessed the participants’ judgment on the potential of the mobs as cues in the course of the study.

As already mentioned, it is not the goal of our prototype to (automatically) capture excessive repositories with cue data. Rather, we seek to slow the users down a bit and invite them to carefully plan and design their mob files that may then become useful resources for memories. Finally, these resources might then be used by the human brain one day to reassemble and reconstruct memories. Hence, today is the time to take care of an appropriate quality of this material and potential memory cues.

B.2 MEO mobRecMobile (MRM) User Interface

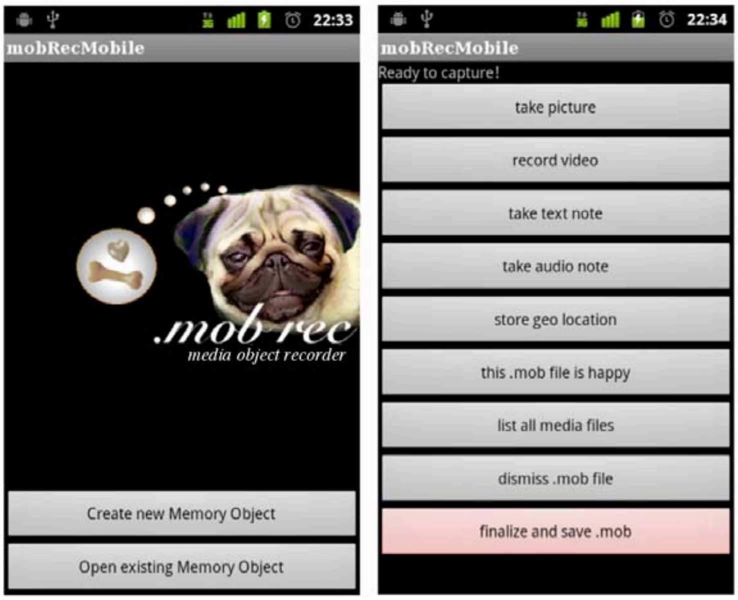


Figure B1. User Interface (two of the main screens) of mobRecMobile as used in MEO.1.

C Visual Segment Analysis

In this section we briefly contrast the interesting concept of “visual segment analysis” (Breckner, 2012) to the CuDe Framework to illustrate, what kind of analysis CuDe attempts to support and what problems are out of scope.

The CuDe Framework describes relations between digital media entities and how users of augmented memory systems make use of them and inscribe meaning when (re-)creating memories. Background knowledge about the specific relations or links between these entities, enables the users of such systems to draw certain conclusions. For example, if it is a known fact that several photos are part of a time series (time lapse photography), the user can fill in the missing frames between the single photos by her imagination and make up a story, which connects the individual pictures. However, the CuDe Framework is quite abstract and is interested in different styles in the presentation of media entities and in the consequences of such presentation. The elementary unit of the framework is the media entity or file. It does not investigate the content of the specific entities, for example, it does not provide guidance in analysing single photos and interpreting their meaning.

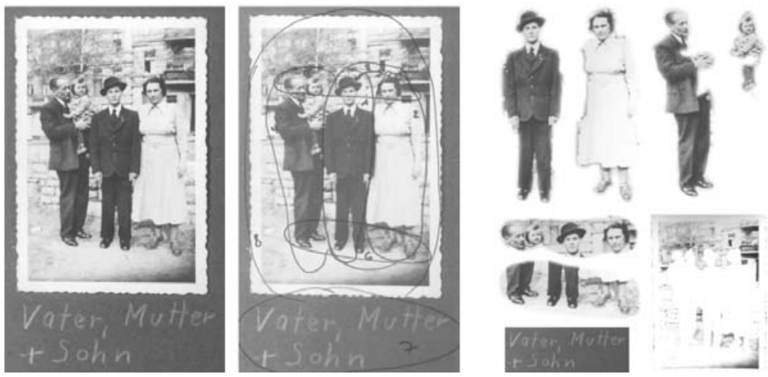


Figure C1. “Segment analysis” of an old private photo (Breckner, 2012, p.152 and p.155).

Breckner (2012) and her “segment analysis”, on the other hand, aims to transform pictorial information into textual or verbal forms of communication without omitting the specific expressional qualities of the visual. To this end, she introduces the “visual segment analysis”, which breaks the visual composition down to pictorial elements (see Figure C1) and interprets them one by one and in relation to each other. In a later phase of the analysis, Breckner (2012) also considers the broader context of the photo and examines the page in a photo album where the picture was found (see Figure C2).

“In the context of the photo album, where on one page the picture can be found in line with two additional photos, the staging of the picture on the occasion of a ceremony is reinforced: a confirmation in the year of 1950” (Breckner, 2012, p.160).

The latter kind of analysis (considering the photos on the same page including image captions) relates closely to some of the ideas, which are formalized by CuDe for augmented memory systems. In this particular instance (Figure C2), 3 photos and 4 captions can be found on one page. Thus, these entities have one thing in common (one shared factor): they belong to each other as they are displayed next to each other on a shared page. More precisely, they feature a total of 4 annotations, which are complementing the photos. It can also be speculated, whether the photos are ar-

Figure C2. Page from an old photo album (Breckner, 2012, p.160).

ranged in a (temporal) sequence. The CuDe Framework does not deepen the analysis to interpret these specific entities and their meaning. Rather, this 'task' is left to the user. Instead, the framework describes certain ways of arranging and combining entities, which can probably engage the user in certain kinds of thinking. Conducting in-depth analyses of particular instances, as the visual segment analysis does, is not within the scope of the CuDe Framework.

D Prototypes (Designed for this Thesis)

All concepts, designs and prototypes that were studied in this thesis have been created by the author with the exception of the technical backbone of the 2sidez.com web application. Many thanks go to Martin Sereinig who was of great assistance in setting up the 2sidez server and implemented the 2sidez backend (application design and database schemes) using the *Django* web framework.

Table D.1. Prototypes created for this thesis.

Prototype / software	Description	Implementation / system requirements
2sidez *for Android*	2sidez is a mobile phone application for *Android*. It was launched on the *Google Play Store* (>115,000 installations). 2sidez makes use of both front- and back-facing camera to create Duographs. These are 'two-sided' photos, which result from the synchronous triggering of both cameras of the mobile phone (front- and back-facing camera). In publications prior to this dissertation 2sidez was originally named *BenindTheCamera* (*BTC*). For deployment *on Google Play Store* it was renamed to 2sidez as this title is shorter and intended to be more 'catchy'.	The first version was implemented for *iPod Touch*. Subsequent and more elaborated versions were implemented for *Android 2.3* and higher.
2sidezLogger	Custom web analytics software/logging tool implemented for monitoring the users' interaction with the 2sidez app for *Android* in real-time.	*Android, Php, MySQL*
2sidez web application	Associated web application for the 2sidez mobile phone app. This constitutes a service for uploading Duographs and possibly sharing them with friends. Users can post comments about Duographs and 'like' them by means of social networking sites plugins.	The backend was implemented by Martin Sereinig using the *Django* web framework. The frontend is based on *HTML/JavaScript*. The server is powered by *Debian Linux* and *Nginx*.

Prototype / software	Description	Implementation / system requirements
Audio Peephole	Audio Peephole is an interactive installation, which downloads trending text messages from *Twitter*, that is, *Tweets* and messages that currently attract wide attention. These *Twitter* trends are downloaded (by means of the web service *whatthetrend.com*) as text messages and then converted into a voice message by a commercially available text-to-speech engine. The installation was available in a (semi-public) space and users could listen to the trends by plugging in their own headphones.	Implemented in *Java*, ran on *a Mac Mini 2006* (2^{nd} Gen.), and housed in a wooden box with a headphone jack.
ContextShaker	ContextShaker presents random Internet photos (from *Flickr*) altogether with random online newspaper headlines on a small display built into a wooden frame.	*Android 2.3* and higher
EyeOfDetail	EyeOfDetail is a Desktop image viewer application, which displays blurred photos with the exception of a small, movable pane. The content of this pane is not distorted. The intention is to make the user pay attention to a photo's details by moving the pane. For user studies and analysis, this application can log and later visualize the movement of the pane as caused by the user.	Implemented in *Processing* and using a *Wii Nunchuck* controller attached to an *Arduino* board, which again was serially connected to a PC.
ForgetMeNot	ForgetMeNot is a screen saver, which displays random and blurred photos. The older the images are, the clearer the photos are presented to the user (rendered with less distortion). The intention is to provide the user with more retrieval cues, as the photos get older.	Implemented for *Ubuntu Linux* in *C/C++*.
Hearsay	Interactive installation that presents random audio comments on news stories downloaded from the Internet.	Implemented in *Java*, ran on a *Mac Mini 2006* (2^{nd} Gen.), and housed in a wooden box with headphone jack.

Prototype / software	**Description**	**Implementation / system requirements**
ImgCoder	Qualitative analysis tool for coding large sets of digital images. Created for handling the large amount of photos from resulting from the Duography studies.	*Android 2.3* and higher.
Media Object Recorder Mobile 2 *(*MRM2*)*	Media Object Recorder Mobile 2 is an iteration of the MRM application (see next item), considering user feedback and study insights from pre-study MEO.1. The set of functions was extended significantly (increased from 5 to 19), as MRM2 allows capturing more and different file types.	*Android 2.3* and higher
MobRecMobile *(*MRM*)*	MobRecMobile is a mobile phone application for capturing mob files. That is, the app allows the user capturing digital data (e.g., photo, video, text, *GPS* coordinates) and aggregating this individual data into one mob file or container.	*Android 2.2* and higher
Mobbox	Mobboxes are physical devices consisting of a wooden box with a screen for replaying mob files. Three different Mobboxes were made. Two of them feature physical buttons for opening a random mob file.	Implemented for *Android 2.3* and run on *Android* tablets. Physical pushbuttons were added by means of the *Arduino* platform. The first Mobbox used a *Motorola Xoom 2 Android* tablet as the computing device. Later versions used a *Galaxy Tab 8* and *Prestigio MultiPad 5080 Pro*.
SimpleDuoView	SimpleDuoView is a Desktop viewer for Duographs. It can show both front and back side at the same time or show one of these sides only, respectively. For user studies and analysis, this application can also log all user interactions.	Implemented in *Java* and run on *Mac OS*.
SimpleMobView	SimpleMobView is a Desktop viewer for mob files. It was implemented to replay mob files as captured by MRM. The user is enabled to browse a list view of the mobs and open all media content. For user studies and analysis, all interactions can be logged.	Implemented in *Java* and run on *Mac OS*.

E Further Information on Methodology

E.1 Exemplar Consent Form (German)

Smartphone Schul-Studie

Moderne Mobiltelefone bzw. Smartphones ermöglichen es, mit ihren Sensoren wie z.B. Kamera, Mikrophon und GPS-Antenne viele Daten aus dem alltäglichen Leben schnell und einfach aufzuzeichnen. Dabei ist wohl die Handy-Kamera eine der beliebtesten Funktionen eines Smartphones. In der „Smartphone Schul-Studie" soll exploriert werden, inwiefern Mobiltelefone mit ihren praktischen Eigenschaften und Möglichkeiten innerhalb des Schulunterrichts – insbesondere innerhalb des Kunstunterrichts – als **gestalterisches Werkzeug** eingesetzt werden können. Von Interesse ist vor allem, ob und wie die Handykamera von SchülerInnen verwendet werden kann, um sich **kreativ** und **gestalterisch** auszudrücken. Hierfür werden den SchülerInnen Smartphones zur Verfügung gestellt mit Hilfe derer sie vom Kunstlehrer vorgegebene Aufgaben lösen sollen.

Einverständniserklärung
Ich bin damit einverstanden, dass ausgewählte Bilder und andere Mediendateien, die im Rahmen des Kunstunterrichts entstanden sind zwecks Analyse von dem Kunstlehrer Tobias Köstlin an die TU Wien (Florian Güldenpfennig) weitergeleitet werden. Des Weiteren erlaube ich es, dass einzelne Bilder im Rahmen eines wissenschaftlichen Kongresses veröffentlicht werden dürfen.

Unterschrift & Datum

Ich danke herzlich für Ihr/Dein Interesse bzw. Aufmerksamkeit und beantworte eventuelle Fragen sehr gerne (siehe Kontaktinformationen).

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Figure E.1. Exemplar consent form as used in the Duography school study (in German). Variants of this form were given to the participants throughout all of the user studies to make sure that they understand that they participate in an study/ 'experiment' conducted by an employee of Vienna University of Technology.

F Glossary of Terms and Explanation of Important Notions

*- In this Glossary[28] we give additional explanations for important notions and concepts of this thesis. To some of these notions, we provide rather detailed and extended complementary information (**hence, we deviate to some extent from the classical form of a glossary**). -*

2sidez and 2sidez.com

2sidez (Güldenpfennig, 2013) is an *Android* application for creating Duographs. These Duographs can be revisited locally in the app's Duograph gallery. Alternatively, they can be shared via the 2sidez.com web application (Güldenpfennig & Sereinig, 2013), or via known social networks such as *Tumblr*, *Twitter*, *Facebook*. Sharing via email is also supported.

Augmented Memory System

Systems for supporting memory have a long history. In HCI, Vannevar Bush's *memex* (Bush, 1945) is often referenced as the first visionary device for archiving personal data on a very large scale. Today a number of succeeding systems have been researched or implemented. These systems go by many names and have been engineered for partially different but related purposes, going in line with and beyond the memex agenda. In this thesis, we name these applications or devices, which are built for supporting human remembering *augmented memory systems*. However, this is just one 'random' label that can be exchanged by other meaningful terms. In the literature, researchers inter alia speak of *lifelogging* (Sellen & Whittaker, 2010), *digital life memories* (Olsson et al., 2008), *digital mementos* (Bowen & Petrelli, 2011; Kalnikaité & Whittaker, 2011), *digital memorabilia* (Kirk et al., 2010), *recording experiences* and *personal digital archives* (Stevens et al., 2003), *personal memory systems* [ibid], *augmented memory systems* (Hoven & Eggen, 2008), and *technologies for personal remembering* (Bowen & Petrelli, 2011), to name just a few terms. The systems have been conceptualized among other things to provide users with resources for reminiscence (West et al., 2007) or reflection (Bowen & Petrelli, 2011; Kalnikaité & Whittaker, 2011), to try automatically record an individual's complete life on digital record (Gemmell et al., 2006), or to recall simple facts. Lately, systems solely relying on a mechanical archive model have been critiqued (Petrelli et al., 2009; Sellen & Whittaker, 2010; Whittaker et al., 2012) and researchers have started building remembering tools based on the psycho-

[28] Parts of this glossary are based on prior publications (Güldenpfennig & Fitzpatrick, 2014; Güldenpfennig, Fitzpatrick, et al., 2014).

logical understandings of the (human) memory. The many names for 'digital memory' listed above demonstrate the high level of interest in this topic in HCI. We see a particular potential for mobile technologies and mobile phones to contribute to these efforts and investigate this rather novel possibility within this thesis.

Context

The notion of context has a long history in HCI and the related field of CSCW; however, there is nothing such as one unique definition for this concept. Most HCI research from ubiquitous computing or on context aware systems employ a more technological perspective with an emphasis on features that can be recorded by sensor technology (Chalmers, 2004) (e.g., the position of the user, objects surrounding the user or the current state of a smart house). An often-cited definition from context-aware computing is provided by Dey:

"Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves" (Dey, 2001, p.5).

More recently, Zimmermann, Lorenz and Oppermann (Zimmermann, Lorenz, & Oppermann, 2007) reviewed recent definitions for context and conceptualized an extension to these definitions to further facilitate the engineering of context-aware systems.

Many works in CSCW, on the other hand, have a broader (going beyond technological implications) and less 'computational' understanding of context, focusing on "intersubjective aspects of context, constructed in and through the dynamic of each individual's social interaction, and defends against reductionism and objectification" (Chalmers, 2004, p.223) or on past user experiences that might influence the way in which current contexts and situations are perceived (Chalmers, 2004). Dourish incorporates the viewpoint of *embodied interaction* to complement design practice in context-aware systems with ideas and insights from the social sciences (Dourish, 2004). Thereby, Dourish raises the question of "how and why, in the course of their interactions, do people achieve and maintain a mutual understanding of the context for their actions?" (Dourish, 2004, p.22) This question implies that this author does not consider context as a "representational problem" (how can we track relevant data and represent certain properties of an interactive system?), but as an "interactional problem" (context emerges from interactions and is negotiated by the subjects) (Dourish, 2004). Consequently, Dourish regards context not simply as information, but as a "relational property" between entities. Moreover, this relational property is not defined a-priori, but emerges dynamically. Thus, context is not stable, but an "occasioned property". Finally, Dourish argues that context and content cannot be separated, as context is created through the user's performance of an activity (Dourish, 2004).

In this thesis we refer to the latter conceptualization of context and see it as something that is established by the user in the course of interaction. What we try to do here is to provide examples of interactive systems that employ a very specific or particular accentuation of context. While most systems that are typically examined through Dourish's embodied interaction lens feature loops of user-system-interactions (from which context eventually emerges), the proposed applications (in particular the Hearsay installation) are restricted with regard to explicit interactions and interaction loops. Instead, the most significant processes are mental or internal and only triggered externally by providing a stimulus/cue (a 'riddle' or 'jigsaw puzzle' to be solved). More precisely, our proposed systems do not feature many direct user interaction loops, instead, information has to be put together by cognitive work, the puzzle has to be solved by establishing or re-establishing context. Usually, designers try hard to assist the users in negotiating context and minimizing the effort for doing so (see, e.g. (Gaver et al., 2003)). Here, we deliberately play with the users' desire to establish context for the sake of creating engaging and at times thought-provocative experiences.

Duograph

Duograph (short: Duo) is a term we coined to describe photos, which have figuratively speaking two opposite-facing sides (Güldenpfennig, Reitberger, et al., 2014). Duography as a novel form of digital photography is enabled by modern mobile phones, which have two built-in cameras (one camera facing towards the device's owner and the other one into the opposite direction). When triggered synchronously, a photo collage (= Duograph) can be created that provides unconventional perspectives.

'Digital Memories'

'Digital memories' is used within this thesis as an abbreviation for 'digital resources for memories'. The latter and longer expression accounts for the assumption that it is not directly memories that can be captured digitally, but media data that might trigger the reconstruction of memories.

Digital Souvenir

In this thesis we regard all different kinds of digital mementos or keepsakes (e.g., photos, videos, email texts, etc.) as *digital souvenirs*.

Entity

Digital media files (e.g., photos, videos, text, *GPS* coordinates, or *SMS* messages) are named *entities* within this thesis. *Entities* constitute the building blocks or modular units of all of the applications and prototypes. We employ these *entities* to capture and work with memory retrieval cues.

Lifelogging

Lifelogging is one particular type of an augmented memory system. Its basic idea is to overcome the fallibility of human memory by technological means. In the broadest sense, paper and pen can also be used to create a paper-based *lifelog* (a *lifelog* is the result of the activity of *lifelogging*) similar to a diary. However, *lifelogging*, as it is studied within HCI, refers to applications that employ advanced computerized technologies. A typical *lifelogging* system, for example, captures sensor readings (e.g., *GPS* coordinates) from the user's mobile phone and logs it on the same device to create a history of all locations been to.

Memory (Retrieval) Cue

Memory cues or memory retrieval cues are stimuli that 'bring memories back to life'. Almost everything can function as a cue. For instance, an old photograph, a name of a street, or the smell of a fresh *madeleine* might trigger memories. Today, a widely acknowledged assumption is that memories are not stored in the human brain as 'a whole event' or as a *copy* of that particular event (as if it was put into a drawer, so to speak). Rather, researchers assume, that cues allow for the *reconstruction* of past events and facts. That is, these triggers are used to put some sort of 'jigsaw puzzle back into place'. However, this memory jigsaw puzzle doesn't have fixed pieces. Instead, memories can be reconstructed in many different ways, depending on different factors such as the current mood, alertness, or available memory retrieval cues.

Within this thesis, retrieval cues are represented by digital files, that is, we regard one media file as one memory retrieval cue or as the carrier of multiple cues (e.g., a photo or audio recording is regarded as one cue or regarded containing a number of cues). We call these files *entities* within this work and provide them to support the user in reconstructing memories.

Note that by *reconstruction* we denote a process of *making sense* of available cues or entities. This can also involve 'subtle' processes such as reflection or reminiscing, and *reconstructing* doesn't necessarily involve *exact* and 'mechanical' recreation (as indicated above).

Memory (Retrieval) Trigger

See *Memory (Retrieval) Cue.*

Sensemaking

Sensemaking is an umbrella term for describing people's efforts in assigning meaning to the experiences they make, that is, attempts to create order over sensory input. In particular, this process is related to dealing with complex problems. Sensemaking has attracted the researchers' interest 'for ages', however, at times described with different labels. The term *sensemaking* with relevance to HCI was coined in particular in the context of organizational research, library and information science, educational research and decision support (Klein et al., 2006).

While the notion of *sensemaking* is broad, this process is generally considered to be comprised of two phases: *foraging* (collecting and collating information) and *sensemaking* (integrating information, creating representations) (Kittur et al., 2013). While the Media Object Recorder Mobile 2 (see MEO.3) at a first glance seems to be intended at information gathering, its affordances for organizing the collected data can also be supportive in sensemaking. In MEO.3, we are particularly interested in what kind of structure the participants imposed on the data when capturing information by means of our lightweight mobile tool for data collection and how these structures can serve foraging and sensemaking.

Structured data plays a significant role in sensemaking support systems, as it enables the information seeker to get control over this data more easily and "helping them to build a coherent model of the information space" (Kittur et al., 2013, p.2990). One classic example from web content structuring is the *Clan Graph* (Terveen, Hill, & Amento, 1999), which aims at revealing the underlying structure of websites by grouping related pages.

References

Abrams, D., Baecker, R., & Chignell, M. (1998). *Information archiving with bookmarks: personal Web space construction and organization*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Los Angeles, California, USA.

Alallah, J., & Hinze, A. (2011). *Feeding the digital parrot: capturing situational context in an augmented memory system*. Paper presented at the Proceedings of the 23rd Australian Computer-Human Interaction Conference, Canberra, Australia.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A Pattern Language: Towns, Buildings, Construction*: Oxford University Press.

Ames, M., Eckles, D., Naaman, M., Spasojevic, M., & House, N. (2010). Requirements for mobile photoware. *Personal Ubiquitous Comput., 14*, 95-109.

Ames, M., & Naaman, M. (2007). *Why we tag: motivations for annotation in mobile and online media*. Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems, San Jose, California, USA. http://doi.acm.org/10.1145/1240624.1240772

André, P., Sellen, A., schraefel , m. c., & Wood, K. (2011). *Making Public Media Personal: Nostalgia and Reminiscence in the Office*. Paper presented at the BCS HCI 2011.

Assmann, J. (1997). *Das kulturelle Gedächtnis. Schrift, Erinnerung und politische Identität in früheren Hochkulturen*. München: C.H. Beck Verlag.

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation* (Vol. 2, pp. 89-195). London: Academic Press.

Baddeley, A. (2003). Working memory: looking back and looking forward. *Nature Reviews Neuroscience, 4*(10), 829-839. doi: 10.1038/nrn1201

Banks, R. (2011). *The future of looking back*. Redmond, Washington: Microsoft Press.

Banks, R., Kirk, D., & Sellen, A. (2012). A Design Perspective on Three Technology Heirlooms. *Human–Computer Interaction, 27*(1-2), 63-91. doi: 10.1080/07370024.2012.656042

Bardzell, S., Bardzell, J., Forlizzi, J., Zimmerman, J., & Antanitis, J. (2012). *Critical design and critical theory: the challenge of designing for provocation*. Paper presented at the Designing Interactive Systems Conference, Newcastle Upon Tyne, United Kingdom.

Bardzell, S., Gross, S., Wain, J., Toombs, A., & Bardzell, J. (2011). *The significant screwdriver: care, domestic masculinity, and interaction design*. Paper presented at the Proceedings of the 25th BCS Conference on Human-Computer Interaction, Newcastle-upon-Tyne, United Kingdom.

Barreau, D., & Nardi, B. A. (1995). Finding and reminding: file organization from the desktop. *SIGCHI Bull., 27*(3), 39-43. doi: 10.1145/221296.221307

Bayazit, N. (2004). Investigating Design: A Review of Forty Years of Design Research. *Design Issues, 20*(1), 16-29. doi: 10.1162/074793604772933739

Bederson, B. B. (2001). *PhotoMesa: a zoomable image browser using quantum treemaps and bubblemaps*. Paper presented at the Proceedings of the 14th annual ACM symposium on User interface software and technology, Orlando, Florida.

Bhömer, M. t., Helmes, J., O'Hara, K., & Hoven, E. v. d. (2010). *4Photos: a collaborative photo sharing experience*. Paper presented at the Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries, Reykjavik, Iceland.

Bluck, S., & Alea, N. (2009). Thinking and Talking about the Past : Why Remember ? *Applied Cognitive Psychology, 1104*(8), 1089-1104.

Bluck, S., & Levine, L. J. (1998). Reminiscence as autobiographical memory: a catalyst for reminiscence theory development. *Aging and Society, 18*, 185-208.

Boardman, R., & Sasse, M. A. (2004). *Stuff goes into the computer and doesn't come out: a cross-tool study of personal information management*. Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems, Vienna, Austria. http://doi.acm.org/10.1145/985692.985766

Bødker, S. (2006). *When second wave HCI meets third wave challenges*. Paper presented at the Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles, Oslo, Norway.

Bowen, S., & Petrelli, D. (2011). Remembering today tomorrow: Exploring the human-centred design of digital mementos. *Int. J. Hum.-Comput. Stud., 69*(5), 324-337.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. doi: 10.1191/1478088706qp063oa

Breckner, R. (2012). Bildwahrnehmung – Bildinterpretation: Segmentanalyse als methodischer Zugang zur Erschließung bildlichen Sinns. *Österreich Z Soziol, 37*, 143-164.

Brewer, W. F. (1988). Memory for randomly sampled autobiographical events. In U. Neisser & E. Winograd (Eds.), *Remembering reconsidered: Ecological and traditional approaches to the study of memory* (pp. 21-90). New York, NY, US: Cambridge University Press.

Brown, K. W., & Ryan, R. M. (2003). The benefits of being present: mindfulness and its role in psychological well-being. *Journal of Personality and Social Psychology, 84*(4), 822-848.

Buchanan, T. W. (2007). Retrieval of emotional memories. *Psychological Bulletin, 133*(5), 761- 779.

Bush, V. (1945). As we may think. *Atlantic Monthly, 176*(1), 101-108.

Carroll, J. M. (2003). Introducing: Toward a Multidisciplinary Science of Human-Computer Interaction. In J. M. Carroll (Ed.), *HCI Models, Theories, and Frameworks: Toward a Multidisciplinary Science*. San Francisco: Morgan Kaufmann.

Chalfen, R. (1987). *Snapshot versions of life*. Bowling Green, OH: Bowling Green State University Press.

Chalmers, M. (2004). A Historical View of Context. *Computer Supported Cooperative Work, 13*(3-4), 223-247.

Churchill, E., & Ubois, J. (2008). Ps AND Qs: Designing for digital archives. *interactions, 15*(2), 10-13.

Conway, M. A. (1990). *Autobiographical Memory*. Milton Keynes, U.K.: Open University Press.

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The Construction of Autobiographical Memories in the Self-Memory System. *Psychological Review, 107*(2), 261-288.

Cosley, D., Akey, K., Alson, B., Baxter, J., Broomfield, M., Lee, S., & Sarabu, C. (2009). Using technologies to support reminiscence *Proceedings of the 23rd British HCI Group Annual Conference on People and Computers: Celebrating People and Technology* (pp. 480-484). Cambridge, United Kingdom: British Computer Society.

Cosley, D., Mulvenna, M., Schwanda, V., Peesapati, S. T., & Wright, T. (2011). *Bridging practices, theories, and technologies to support reminiscence*. Paper presented at the CHI '11 Extended Abstracts on Human Factors in Computing Systems, Vancouver, BC, Canada.

Cosley, D., Sosik, V. S., Schultz, J., Peesapati, S. T., & Lee, S. (2012). Experiences With Designing Tools for Everyday Reminiscing. *Human–Computer Interaction, 27*(1-2), 175-198. doi: 10.1080/07370024.2012.656047

Crabtree, A., Rodden, T., & Mariani, J. (2004). *Collaborating around collections: informing the continued development of photoware*. Paper presented at the Proceedings of the 2004 ACM conference on Computer supported cooperative work, Chicago, Illinois, USA.

Czerwinski, M., Gage, D. W., Gemmell, J., Marshall, C. C., Pérez-Quiñonesis, M. A., Skeels, M. M., & Catarci, T. (2006). Digital memories in an era of ubiquitous computing and abundant storage. *Commun. ACM, 49*(1), 44-50. doi: 10.1145/1107458.1107489

Dey, A. K. (2001). Understanding and Using Context. *Personal Ubiquitous Comput., 5*(1), 4-7. doi: 10.1007/s007790170019

Dib, L., Petrelli, D., & Whittaker, S. (2010). Sonic souvenirs: exploring the paradoxes of recorded sound for family remembering *Proceedings of the 2010 ACM conference on Computer supported cooperative work* (pp. 391-400). Savannah, Georgia, USA: ACM.

Dillet, R. (2014). Photo-Sharing App Frontback Comes To Android. Retrieved 29.05.2014, from http://techcrunch.com/2014/04/16/photo-sharing-app-frontback-comes-to-android/

Doherty, A. R., Tolle, K. M., & Smeaton, A. F. (2009). *Utilising contextual memory retrieval cues and the ubiquity of the cell phone to review lifelogged physiological activities*. Paper presented at the Proceedings of the 1st international workshop on Interactive multimedia for consumer electronics, Beijing, China.

Dolcourt, J. (2013). The everything phone for (almost) everyone. Retrieved 29.05.2014, from http://www.cnet.com/products/samsung-galaxy-s4/

Dourish, P. (2001). *Where the action is: the foundations of embodied interaction*. Cambridge, MA: MIT Press.

Dourish, P. (2004). What we talk about when we talk about context. *Personal Ubiquitous Comput., 8*(1), 19-30. doi: 10.1007/s00779-003-0253-8

Dourish, P., Edwards, W. K., LaMarca, A., & Salisbury, M. (1999). Presto: an experimental architecture for fluid interactive document spaces. *ACM Trans. Comput.-Hum. Interact., 6*(2), 133-161. doi: 10.1145/319091.319099

Dumais, S., Cutrell, E., Cadiz, J., Jancke, G., Sarin, R., & Robbins, D. C. (2003). *Stuff I've seen: a system for personal information retrieval and re-use*. Paper presented at the Proceedings of the 26th annual international ACM SIGIR conference on Research and development in informaion retrieval, Toronto, Canada.

Durrant, A., Taylor, A. S., Frohlich, D., Sellen, A., & Uzzell, D. (2009). *Photo displays and intergenerational relationships in the family home*. Paper presented at the Proceedings of the 23rd British HCI Group Annual Conference on People and Computers: Celebrating People and Technology, Cambridge, United Kingdom.

Eagle, N., & Pentland, A. (2006). Reality mining: sensing complex social systems. *Personal Ubiquitous Computing, 10*(4), 255-268. doi: 10.1007/s00779-005-0046-3

Ebbinghaus, H. (1885; reprint 1964). *Memory: A Contribution to Experimental Psychology*. New York: Dover.

Egorova, M. A., & Safonov, I. V. (2013). Algorithms for photo book authoring. *Pattern Recognit. Image Anal., 23*(1), 57-67. doi: 10.1134/s1054661813010045

Erve, D. v., Vos, G.-W., Hoven, E. v. d., & Frohlich, D. (2011). *Cueing the past: designing embodied interaction for everyday remembering*. Paper presented at the Procedings of the Second Conference on Creativity and Innovation in Design, Eindhoven, Netherlands.

Eysenck, M. W., & Keane, M. T. (2005). *Cognitive Psychology. A Student's Handbook* (5th ed.). Hove and New York: Psychology Press Ltd.

Fallman, D. (2003). *Design-oriented human-computer interaction*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Ft. Lauderdale, Florida, USA.

Fitzmaurice, G. W., Ishii, H., & Buxton, W. A. S. (1995). *Bricks: laying the foundations for graspable user interfaces*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Denver, Colorado, USA.

Fivush, R. (2008). Remebering and reminising: How individual lives are constructed in family narratives. *Memory Studies, 1*(1), 49-58.

Fleck, R., & Fitzpatrick, G. (2009). Teachers' and tutors' social reflection around SenseCam images. *Int. J. Hum.-Comput. Stud., 67*, 1024-1036.

Fleck, R., & Fitzpatrick, G. (2010). *Reflecting on reflection: framing a design landscape*. Paper presented at the Proceedings of the 22nd Conference of the Computer-Human Interaction Special Interest Group of Australia on Computer-Human Interaction, Brisbane, Australia.

Frayling, C. (1993/94). Research in Art and Design. *Royal College of Art Research Papers, 1*(1), 1-5.

Frohlich, D., & Fennell, J. (2007). Sound, paper and memorabilia: resources for a simpler digital photography. *Personal Ubiquitous Comput., 11*, 107-116.

Frohlich, D., Kuchinsky, A., Pering, C., Don, A., & Ariss, S. (2002). *Requirements for photoware*. Paper presented at the Proceedings of the 2002 ACM conference on Computer supported cooperative work, New Orleans, Louisiana, USA.

Frohlich, D., & Murphy, R. (2000). The Memory Box. *Personal Ubiquitous Comput., 4*, 238-240.

Frohlich, D., & Tallyn, E. (1999). Audiophotography: practice and prospects *CHI '99 extended abstracts on Human factors in computing systems* (pp. 296-297). Pittsburgh, Pennsylvania: ACM.

Gaver, B., Dunne, T., & Pacenti, E. (1999). Design: Cultural probes. *interactions, 6*(1), 21-29. doi: 10.1145/291224.291235

Gaver, W. (2012). *What should we expect from research through design?* Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Austin, Texas, USA.

Gaver, W. (2014). Science and Design: The Implications of Different Forms of Accountability. In J. S. Olson & W. A. Kellogg (Eds.), *Ways of Knowing in HCI* (pp. 143-165): Springer New York.

Gaver, W., Blythe, M., Boucher, A., Jarvis, N., Bowers, J., & Wright, P. (2010). *The prayer companion: openness and specificity, materiality and spirituality*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Atlanta, Georgia, USA.

Gaver, W., Boucher, A., Bowers, J., Blythe, M., Jarvis, N., Cameron, D., . . . Wright, P. (2011). *The photostroller: supporting diverse care home residents in engaging with the world*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Vancouver, BC, Canada.

Gaver, W., Boucher, A., Law, A., Pennington, S., Bowers, J., Beaver, J., . . . Wilkie, A. (2008). *Threshold devices: looking out from the home*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Florence, Italy.

Gaver, W. W., Beaver, J., & Benford, S. (2003). Ambiguity as a resource for design. *Proceedings of the conference on Human factors in computing systems - CHI '03*, 233-233. doi: 10.1145/642611.642653

Gemmell, J., Bell, G., & Lueder, R. (2006). MyLifeBits: a personal database for everything. *Commun. ACM, 49*(1), 88-95.

Gemmell, J., Bell, G., Lueder, R., Drucker, S., & Wong, C. (2002). *MyLifeBits: fulfilling the Memex vision*. Paper presented at the Proceedings of the tenth ACM international conference on Multimedia, Juan-les-Pins, France.

Golsteijn, C., Hoven, E. v. d., Frohlich, D., & Sellen, A. (2012). *Towards a more cherishable digital object*. Paper presented at the DIS'12, Newcastle Upon Tyne, United Kingdom.

Good, J. (2011). http://blog.1000memories.com/94-number-of-photos-ever-taken-digital-and-analog-in-shoebox. Retrieved 2013, October 20

Gossler, M. (2005). Schlagwortkatalog. Retrieved 11.04.14, from http://commons.wikimedia.org/wiki/File:Schlagwortkatalog.jpg

Gouveia, R., & Karapanos, E. (2013). *Footprint tracker: supporting diary studies with lifelogging*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Paris, France.

Guba, E. G., & Lincoln, Y. S. (1989). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: SAGE.

Güldenpfennig, F. (2013). 2sidez mobile phone and tablet application. Retrieved 29.05.2014, from https://play.google.com/store/apps/details?id=com.behind.the.camera

Güldenpfennig, F., & Fitzpatrick, G. (2011). *Getting more out of your images: augmenting photos for recollection and reminiscence*. Paper presented at the Proceedings of the 25th BCS Conference on Human-Computer Interaction, Newcastle-upon-Tyne, United Kingdom.

Güldenpfennig, F., & Fitzpatrick, G. (2014). Personal Digital Archives on Mobile Phones with MEO. *Personal and Ubiquitous Computing*. doi: 10.1007/s00779-014-0802-3

Güldenpfennig, F., Fitzpatrick, G., & Reitberger, W. (2014). *Making Sense of Rich Data Collections on Mobile Devices*. Paper presented at the European Conference on Cognitive Ergonomics.

Güldenpfennig, F., Reitberger, W., & Fitzpatrick, G. (2012a). *Capturing rich media through media objects on smartphones*. Paper presented at the Proceedings of the 24th Australian Computer-Human Interaction Conference, Melbourne, Australia.

Güldenpfennig, F., Reitberger, W., & Fitzpatrick, G. (2012b). *Of unkempt hair, dirty shirts and smiling faces: capturing behind the mobile camera*. Paper presented at the Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design, Copenhagen, Denmark.

Güldenpfennig, F., Reitberger, W., & Fitzpatrick, G. (2012c). *Through two different lenses: a tool for new perspectives into context*. Paper presented at the Proceedings of the 24th Australian Computer-Human Interaction Conference, Melbourne, Australia.

Güldenpfennig, F., Reitberger, W., Ganglbauer, E., & Fitzpatrick, G. (2014). Duography in The Classroom: Creative Engagement with Two-sided Mobile Phone Photography. *International Journal of Mobile Human Computer Interaction*.

Güldenpfennig, F., & Sereinig, M. (2013). 2sidez - 2 cameras 2 share 1 moment. Retrieved 29.05.2014, from https://2sidez.com/

Gulotta, R., Odom, W., Forlizzi, J., & Faste, H. (2013). *Digital artifacts as legacy: exploring the lifespan and value of digital data*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Paris, France.

Gye, L. (2007). Picture This: the Impact of Mobile Camera Phones on Personal Photographic Practices. *Continuum, 21*(2), 279-288. doi: 10.1080/10304310701269107

Håkansson, M., & Gaye, L. (2008). Bringing context to the foreground: designing for creative engagement in a novel still camera application *Proceedings of the 7th ACM conference on Designing interactive systems* (pp. 164-173). Cape Town, South Africa: ACM.

Håkansson, M., Gaye, L., Ljungblad, S., & Holmquist, L. E. (2006). More than meets the eye: an exploratory study of context photography *Proceedings of the 4th Nordic conference on Human-computer interaction: changing roles* (pp. 262-271). Oslo, Norway: ACM.

Halbwachs, M. (1985). *Das Gedächtnis und seine sozialen Bedingungen* (L. Geldsetzer, Trans.). Sinzheim: Suhrkamp.

Hangal, S., Lam, M. S., & Heer, J. (2011). *MUSE: reviving memories using email archives*. Paper presented at the Proceedings of the 24th annual ACM symposium on User interface software and technology, Santa Barbara, California, USA.

Hansen, M., & Rubin, B. (2002). *Listening post: giving voice to online communication*. Paper presented at the International Conference on Auditory Display, Kyoto, Japan.

Harper, R., Randall, D., Smyth, N., Evans, C., Heledd, L., & Moore, R. (2008). *The past is a different place: they do things differently there*. Paper presented at the DIS'08, Cape Town, South Africa.

Harper, R., Randall, D., Smythe, N., Evans, C., Heledd, L., & Moore, R. (2007). Thanks for the memory *Proceedings of the 21st British HCI Group Annual Conference on People and Computers: HCI...but not as we know it - Volume 2* (pp. 39-42). University of Lancaster, United Kingdom: British Computer Society.

Hebb, D. O. (1949). *The organization of behavior*. New York: Wiley.

Henkel, L. A. (2014). Point-and-Shoot Memories: The Influence of Taking Photos on Memory for a Museum Tour. *Psychological Science, 25*(2), 396-402. doi: 10.1177/0956797613504438

Hilliges, O., Baur, D., & Butz, A. (2007, 10-12 Oct. 2007). *Photohelix: Browsing, Sorting and Sharing Digital Photo Collections.* Paper presented at the Second Annual IEEE International Workshop on Horizontal Interactive Human-Computer Systems.

Hodges, S., Williams, L., Berry, E., Izadi, S., Srinivasan, J., Butler, A., . . . Wood, K. (2006). SenseCam: A retrospective memory aid *Proc. 8th International Conference on Ubicomp* (pp. 177-193).

Holleis, P., Kranz, M., Gall, M., & Schmidt, A. (2005, 6-10 June 2005). *Adding context information to digital photos*. Paper presented at the Workshops of 25th IEEE International Conference on Distributed Computing Systems.

Höök, K., & Löwgren, J. (2012). Strong concepts: Intermediate-level knowledge in interaction design research. *ACM Trans. Comput.-Hum. Interact., 19*(3), 1-18. doi: 10.1145/2362364.2362371

Hoven, E., & Eggen, B. (2008). Informing augmented memory system design through autobiographical memory theory. *Personal Ubiquitous Computing, 12*(6), 433-443.

Hoven, E., & Eggen, B. (2009). The Effect of Cue Media on Recollections. *Human Technology, 5*(1).

Hutchinson, H., Mackay, W., Westerlund, B., Bederson, B. B., Druin, A., Plaisant, C., . . . Eiderbäck, B. (2003). *Technology probes: inspiring design for and with families*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Ft. Lauderdale, Florida, USA.

InfoTrends. (2011). Worldwide Camera Phone Installed Base to Near 2 Billion by 2015 Retrieved 29 April 2014, from http://www.capv.com/main/public/Content/Press/2011/06.23.2011.html

Isaacs, E., Konrad, A., Walendowski, A., Lennig, T., Hollis, V., & Whittaker, S. (2013). *Echoes From the Past: How Technology Mediated Reflection Improves Well-Being*. Paper presented at CHI.

Iyengar, S., & Hahn, K. S. (2009). Red Media, Blue Media: Evidence of Ideological Selectivity in Media Use. *Journal of Communication, 59*(1), 19-39. doi: 10.1111/j.1460-2466.2008.01402.x

Jones, W. (2007). Personal Information Management. *Annual Review of Information Science and Technology, 41*(1), 453-504. doi: 10.1002/aris.2007.1440410117

Kalnikaite, V., Sellen, A., Whittaker, S., & Kirk, D. (2010). *Now let me see where i was: understanding how lifelogs mediate memory*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Atlanta, Georgia, USA.

Kalnikaité, V., & Whittaker, S. (2011). A saunter down memory lane: Digital reflection on personal mementos. *Int. J. Hum.-Comput. Stud., 69*(5), 298-310. doi: 10.1016/j.ijhcs.2010.12.004

Kindberg, T., Spasojevic, M., Fleck, R., & Sellen, A. (2005). The Ubiquitous Camera: An In-Depth Study of Camera Phone Use. *IEEE Pervasive Computing, 4*, 42-50.

Kirk, D., Sellen, A., Rother, C., & Wood, K. (2006). Understanding photowork *Proceedings of the SIGCHI conference on Human Factors in computing systems* (pp. 761-770). Montreal, Quebec, Canada: ACM.

Kirk, D. S., Izadi, S., Sellen, A., Taylor, S., Banks, R., & Hilliges, O. (2010). *Opening up the family archive*. Paper presented at the CSCW'10, Savannah, Georgia, USA. http://doi.acm.org/10.1145/1718918.1718968

Kirk, D. S., & Sellen, A. (2010). On human remains: Values and practice in the home archiving of cherished objects. *ACM Trans. Comput.-Hum. Interact., 17*, 10:11-10:43.

Kittur, A., Peters, A. M., Diriye, A., Telang, T., & Bove, M. R. (2013). *Costs and benefits of structured information foraging*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Paris, France.

Klein, G., Moon, B., & Hoffman, R. R. (2006). Making Sense of Sensemaking 1: Alternative Perspectives. *IEEE Intelligent Systems, 21*(4), 70-73. doi: 10.1109/mis.2006.75

Kodak. (1889). You press the button, we do the rest. Retrieved 04. 07. 2014, from http://en.wikipedia.org/wiki/Kodak#mediaviewer/File:You_press_the_button,_we_do_the_rest_%28Kodak%29.jpg

Koskinen, I., Zimmerman, J., Binder, T., Redström, J., & Wensveen, S. (2011). *Design Research Through Practice: From the Lab, Field, and Showroom*: Morgan Kaufmann.

Kregel, U. (2009). *Bild und Gedächtnis*. Berlin: Kulturverlag Kadmos.

Kuhn, A. (2010). Memory texts and memory work: Performances of memory in and with visual media. *Memory Studies, 3*(4), 298-313.

Langer, E. J. (1989). *Mindfulness*. Cambridge, MA: Da Capo Press.

Laurel, B. (Ed.). (2003). *Design research: methods and perspectives*. Cambridge, Massachusetts: MIT University Press.

Leong, T., Howard, S., & Vetere, F. (2008). FEATURE: Take a chance on me: using randomness for the design of digital devices. *interactions, 15*(3), 16-19. doi: 10.1145/1353782.1353787

Leong, T. W., Harper, R., & Regan, T. (2009). Nudging towards Serendipity : A case with personal digital photos *Burns*.

Leong, T. W., Vetere, F., & Howard, S. (2006). *Randomness as a resource for design*. Paper presented at the Proceedings of the 6th conference on Designing Interactive systems, University Park, PA, USA.

Li, I., Dey, A., & Forlizzi, J. (2010). *A stage-based model of personal informatics systems*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Atlanta, Georgia, USA.

Lindley, S. E., Durrant, A. C., Kirk, D. S., & Taylor, A. S. (2008). *Collocated social practices surrounding photos*. Paper presented at the CHI '08 Extended Abstracts on Human Factors in Computing Systems, Florence, Italy.

Lindley, S. E., Glancy, M., Harper, R., Randall, D., & Smyth, N. (2011). "Oh and how things just don't change, the more things stay the same": Reflections on SenseCam images 18 months after capture. *International Journal of Human-Computer Studies, 69*(5), 311-323. doi: http://dx.doi.org/10.1016/j.ijhcs.2010.12.010

Lindley, S. E., Marshall, C. C., Banks, R., Sellen, A., & Regan, T. (2013). *Rethinking the web as a personal archive*. Paper presented at the Proceedings of the 22nd international conference on World Wide Web, Rio de Janeiro, Brazil.

Lindley, S. E., & Monk, A. F. (2008). Social enjoyment with electronic photograph displays: Awareness and control. *International Journal of Human-Computer Studies, 66*(8), 587-604. doi: http://dx.doi.org/10.1016/j.ijhcs.2008.04.002

Lindley, S. E., Randall, D., Sharrock, W., Glancy, M., Smyth, N., & Harper, R. (2009). *Narrative, memory and practice: tensions and choices in the use of a digital artefact*. Paper presented at the Proceedings of the 23rd British HCI Group Annual Conference on People and Computers: Celebrating People and Technology, Cambridge, United Kingdom.

Ljungblad, S. (2009). *Passive photography from a creative perspective: "If I would just shoot the same thing for seven days, it's like... What's the point?"*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Boston, MA, USA.

Ljungblad, S., Håkansson, M., Gaye, L., & Holmquist, L. E. (2004). Context photography: modifying the digital camera into a new creative tool *CHI '04 extended abstracts on Human factors in computing systems* (pp. 1191-1194). Vienna, Austria: ACM.

Loftus, E. F., & Loftus, G. R. (1980). On the Permanence of Stored Information in the Human Brain. *American Psychologist, 35*(5), 409-420.

Löwgren, J., & Stolterman, E. (2007). *Thoughtful interaction design. A design perspective on information technology*. Cambridge, Massachusetts: The MIT Press.

Lyubomirsky, S., Sheldon, K. M., & Schkade, D. (2005). Pursuing happiness: The architecture of sustainable change. *Review of General Psychology, 9*(2), 111-131. doi: 10.1037/1089-2680.9.2.111

Maderthaner, R. (2008). *Psychologie*. Vienna: Facultas Verlags- und Buchhandels AG.

Mangold, R. (2007). *Informationspsychologie: Wahrnehmen und Gestalten in der Medienwelt*. Wiesbaden: Springer VS.

Mann, S. (1997). Wearable computing: a first step toward personal imaging. *Computer, 30*(2), 25-32. doi: 10.1109/2.566147

Mann, S. (2004). *Continuous lifelong capture of personal experience with EyeTap*. Paper presented at the Proceedings of the the 1st ACM workshop on Continuous archival and retrieval of personal experiences, New York, New York, USA.

Marshall, C. C. (2008). Rethinking Personal Digital Archiving, Part 1 *D-Lib Magazine, 14*(3/4).

Mayall, J. E. (c. 1860). Queen Victoria. Retrieved 04. 07. 2014, from http://en.wikipedia.org/wiki/Carte_de_visite#mediaviewer/File:Queen_Victoria.jpg

Mayer-Schönberger, V. (2009). *Delete: The Virtue of Forgetting in the Digital Age*. Princeton, New Jersey: Princeton University Press.

Miller, A. D., & Edwards, W. K. (2007). *Give and take: a study of consumer photo-sharing culture and practice*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, San Jose, California, USA.

Miller, G. A. (1956). The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information. *The Psychological Review, 63*, 81-97.

O'Hara, K., Helmes, J., Sellen, A., Harper, R., ten Bhömer, M., & van den Hoven, E. (2012). Food for Talk: Phototalk in the Context of Sharing a Meal. *Human–Computer Interaction, 27*(1-2), 124-150. doi: 10.1080/07370024.2012.656069

Odom, W., Harper, R., Sellen, A., Kirk, D., & Banks, R. (2010). Passing on & putting to rest: understanding bereavement in the context of interactive technologies *Proceedings of the 28th international conference on Human factors in computing systems* (pp. 1831-1840). Atlanta, Georgia, USA: ACM.

Odom, W., Sellen, A., Harper, R., & Thereska, E. (2012). *Lost in translation: understanding the possession of digital things in the cloud*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Austin, Texas, USA.

Okabe, D. (2004). *Emergent social practices, situations and relations through everyday camera phone use*. Paper presented at the International Conference on Mobile Communication and Social Change, Seoul, Korea.

Olsson, T., Soronen, H., & Väänänen-Vainio-Mattila, K. (2008). *User needs and design guidelines for mobile services for sharing digital life memories*. Paper presented at the MobileHCI'08, Amsterdam, The Netherlands.

Peesapati, S. T., Schwanda, V., Schultz, J., & Cosley, D. (2010). Triggering memories with online maps *Proceedings of the 73rd ASIS&T Annual Meeting on Navigating Streams in an Information Ecosystem - Volume 47* (pp. 69:61-69:64). Pittsburgh, Pennsylvania: American Society for Information Science.

Peesapati, S. T., Schwanda, V., Schultz, J., Lepage, M., Jeong, S.-y., & Cosley, D. (2010). Pensieve: supporting everyday reminiscence *Proceedings of the 28th international conference on Human factors in computing systems* (pp. 2027-2036). Atlanta, Georgia, USA: ACM.

Petersen, M. G., Ljungblad, S., & Håkansson, M. (2009). Designing for playful photography. *New Review of Hypermedia and Multimedia, 15*(2), 193-209. doi: 10.1080/13614560903204653

Pethes, N. (2008). *Kulturwissenschaftliche Gedächtnistheorien. Zur Einführung*. Hamburg: Junius Verlag.

Petrelli, D., Bowen, S., & Whittaker, S. (2014). Photo mementos: Designing digital media to represent ourselves at home. *International Journal of Human-Computer Studies, 72*(3), 320-336. doi: 10.1016/j.ijhcs.2013.09.009

Petrelli, D., van den Hoven, E., & Whittaker, S. (2009). *Making history: intentional capture of future memories*. Paper presented at the CHI'09, Boston, MA, USA. http://doi.acm.org/10.1145/1518701.1518966

Petrelli, D., Villar, N., Kalnikaite, V., Dib, L., & Whittaker, S. (2010). *FM Radio: family interplay with sonic mementos*. Paper presented at the Proceedings of the 28th international conference on Human factors in computing systems, Atlanta, Georgia, USA. http://doi.acm.org/10.1145/1753326.1753683

Petrelli, D., & Whittaker, S. (2010). Family memories in the home: contrasting physical and digital mementos. *Personal Ubiquitous Comput., 14*, 153-169.

Petrelli, D., Whittaker, S., & Brockmeier, J. (2008). AutoTopography: what can physical mementos tell us about digital memories? *Proceeding of the twenty-sixth annual SIGCHI conference on Human factors in computing systems* (pp. 53-62). Florence, Italy: ACM.

Rawassizadeh, R., Tomitsch, M., Wac, K., & Tjoa, A. M. (2013). UbiqLog: a generic mobile phone-based life-log framework. *Personal Ubiquitous Comput., 17*(4), 621-637. doi: 10.1007/s00779-012-0511-8

Renals, S., Hain, T., & Bourlard, H. (2007, 9-13 Dec. 2007). *Recognition and understanding of meetings the AMI and AMIDA projects.* Paper presented at the IEEE Workshop on Automatic Speech Recognition & Understanding.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4*(2), 155-169. doi: 10.1007/BF01405730

Rodden, K., & Wood, K. R. (2003). *How do people manage their digital photographs?* Paper presented at the Proceedings of the SIGCHI conference on Human factors in computing systems, Ft. Lauderdale, Florida, USA. http://doi.acm.org/10.1145/642611.642682

Rogers, Y. (2011). Interaction design gone wild: striving for wild theory. *interactions, 18*(4), 58-62. doi: 10.1145/1978822.1978834

Rogers, Y. (2012). *HCI Theory: Classical, Modern and Contemporary*: Morgan and Claypool.

Sarvas, R., & Frohlich, D. (2011). *From snapshots to social media - The changing picture of domestic photography*. London: Springer.

Schacter, D. (1996). *Searching for memory: The brain, the mind, and the past*. New York: Basic Books.

Schacter, D. (1999). The seven sins of memory: Insights from psychology and cognitive neuroscience. *American Psychologist, 54*(3), 182-203.

Schön, D. A. (1983). *The reflective practitioner: how professionals think in action*. London: Temple Smith.

Sellen, A., Rogers, Y., Harper, R., & Rodden, T. (2009). Reflecting human values in the digital age. *Commun. ACM, 52*(3), 58-66. doi: 10.1145/1467247.1467265

Sellen, A. J., Fogg, A., Aitken, M., Hodges, S., Rother, C., & Wood, K. (2007). Do life-logging technologies support memory for the past?: An experimental study using sensecam *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 81-90). San Jose, California, USA: ACM.

Sellen, A. J., & Whittaker, S. (2010). Beyond total capture: a constructive critique of lifelogging. *Commun. ACM, 53*(5), 70-77.

Semon, R. (1921). *The Mneme*. London: G. Allen & Unwin LTD.

Sengers, P. (2011). What I learned on Change Islands: reflections on IT and pace of life. *interactions, 18*(2), 40-48. doi: 10.1145/1925820.1925830

Sengers, P., & Gaver, B. (2006). *Staying open to interpretation: engaging multiple meanings in design and evaluation*. Paper presented at the Proceedings of the 6th conference on Designing Interactive systems, University Park, PA, USA.

Siemaszko, C. (2013). Cell phones fill St. Peter's Square to capture history — a far cry from the virtually camera-free piazza eight years ago. Retrieved 09.02.2014, from http://www.nydailynews.com/news/world/check-contrasting-pics-st-peter-square-article-1.1288700

Sippel2707 -*User name Wikipedia*. (2005). Wachstafel Selbst photographiert. Retrieved 11. 04 .2014, from http://commons.wikimedia.org/wiki/File:Wachstafel.jpg

Stevens, M. M., Abowd, G. D., Truong, K. N., & Vollmer, F. (2003). Getting into the Living Memory Box: Family archives & holistic design. *Personal Ubiquitous Comput., 7*, 210-216.

Stewart, A. (2013). Evolution of Wearable Computing. Retrieved 04.04.2014, from http://en.wikipedia.org/wiki/File:Wearcompevolution2.jpg

Stolterman, E. (2008). *The Nature of Design Practice and Implications for Interaction Design Research*.

Stolterman, E., & Wiberg, M. (2010). Concept-Driven Interaction Design Research. *Human–Computer Interaction, 25*(2), 95-118. doi: 10.1080/07370020903586696

Stoneburner. (2010). Arduino Uno. Retrieved 09.04.2014, from http://commons.wikimedia.org/wiki/File:ArdurinoUno.jpg

Sturken, M. (2008). Memory, consumerism and media: Reflections on the emergence of the field. *Memory Studies, 1*(1), 73-78. doi: 10.1177/1750698007083890

Terveen, L., Hill, W., & Amento, B. (1999). Constructing, organizing, and visualizing collections of topically related Web resources. *ACM Trans. Comput.-Hum. Interact., 6*(1), 67-94. doi: 10.1145/310641.310644

Tieben, R., Bekker, T., & Schouten, B. (2011). *Curiosity and interaction: making people curious through interactive systems*. Paper presented at the Proceedings of the 25th BCS Conference on Human-Computer Interaction, Newcastle-upon-Tyne, United Kingdom.

Tomberg, V., Al-Smadi, M., Treasure-Jones, T., & Ley, T. (2013). *A Sensemaking Interface for Doctors' Learning at Work: A Co-Design Study Using a Paper Prototype.* Paper presented at the ECTEL meets ECSCW 2013: Workshop on Collaborative Technologies for Working and Learning.

Tulving, E. (1984). Precis of Elements of Episodic Memory. *Behavioural and Brain Sciences, 7*(2), 223-268.

Tulving, E. (2002). Episodic Memory: From Mind to Brain. *Annual Review of Psychology, 53*(1), 1-25. doi: 10.1146/annurev.psych.53.100901.135114

Tulving, E., & Pearlstone, Z. (1966). Availability versus accessibility of information in memory for words. *Jounral Of Verbal Learning And Verbal Behavior, 5*(4), 381-391.

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review, 80*(5), 352-373. doi: 10.1037/h0020071

Van den Hoven, E. (2014). A future-proof past: Designing for remembering experiences. *Memory Studies, 7*(3), 370-384. doi: 10.1177/1750698014530625

Van den Hoven, E., Sas, C., & Whittaker, S. (2012). Introduction to this Special Issue on Designing for Personal Memories: Past, Present, and Future. *Human-Computer Interaction, 27*(1-2), 1-12. doi: 10.1080/07370024.2012.673451

Van Dijck, J. (2006). Record and Hold: Popular Music between Personal and Collective Memory. *Critical Studies in Media Communication, 23*(5), 357-374. doi: 10.1080/07393180601046121

Van Dijck, J. (2007). *Mediated memories in the digital age*. Stanford: Stanford University Press.

Van Dijck, J. (2008). Digital photography: communication, identity, memory. *Visual Communication, 7*(1), 57-76.

Van House, N., & Churchill, E. F. (2008). Technologies of memory: Key issues and critical perspectives. *Memory Studies, 1*(3), 295-310. doi: 10.1177/1750698008093795

Van House, N., & Davis, M. (2005). The social life of cameraphone images. *Media*, 1-10.

Van House, N., Davis, M., Ames, M., Finn, M., & Viswanathan, V. (2005). *The uses of personal networked digital imaging: an empirical study of cameraphone photos and sharing*. Paper presented at the CHI '05 Extended Abstracts on Human Factors in Computing Systems, Portland, OR, USA.

Van House, N. A. (2007). *Flickr and public image-sharing: distant closeness and photo exhibition*. Paper presented at the CHI '07 Extended Abstracts on Human Factors in Computing Systems, San Jose, CA, USA.

Van House, N. A. (2009). Collocated photo sharing, story-telling, and the performance of self. *International Journal of Human-Computer Studies, 67*(12), 1073-1086.

Van House, N. A. (2011). Personal photography, digital technologies and the uses of the visual. *Visual Studies, 26*(2), 125-134.

Verghese, P., & Pelli, D. G. (1992). The information capacity of visual attention. *Vision Research, 32*(5), 983-995.

Wagenaar, W. A. (1986). My memory: A study of autobiographical memory over six years. *Cognitive Psychology, 18*(2), 225-252. doi: http://dx.doi.org/10.1016/0010-0285(86)90013-7

Want, R., & Hopper, A. (1992). Active badges and personal interactive computing objects. *IEEE Transactions on Consumer Electronics, 38*(1), 10-20. doi: 10.1109/30.125076

West, D., Quigley, A., & Kay, J. (2007). MEMENTO: a digital-physical scrapbook for memory sharing. *Personal Ubiquitous Computing, 11*(4), 313-328. doi: 10.1007/s00779-006-0090-7

Whittaker, S., Bellotti, V., & Gwizdka, J. (2006). Email in personal information management. *Communications of the ACM, 49*(1), 68-73. doi: 10.1145/1107458.1107494

Whittaker, S., Bergman, O., & Clough, P. (2010). Easy on that trigger dad: a study of long term family photo retrieval. *Personal Ubiquitous Computing, 14*, 31-43.

Whittaker, S., Kalnikaité, V., Petrelli, D., Sellen, A., Villar, N., Bergman, O., . . . Brockmeier, J. (2012). Socio-Technical Lifelogging: Deriving Design Principles for a Future Proof Digital Past. *Human-Computer Interaction, 27*(1-2), 37-62.

Whittaker, S., & Sidner, C. (1996). *Email overload: exploring personal information management of email*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Vancouver, British Columbia, Canada.

Whitten, W., & Leonard, J. (1981). Directed search through autobiographical memory. *Memory & Cognition, 9*(6), 566-579. doi: 10.3758/BF03202351

Winston, J. (2013). Photography in the Age of Facebook. *Intersect: The Stanford Journal of Science, Technology and Society, 6*(2).

Wolf, T. V., Rode, J. A., Sussman, J., & Kellogg, W. A. (2006). *Dispelling "design" as the black art of CHI*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Montreal, Quebec, Canada.

Zimmerman, J., Forlizzi, J., & Evenson, S. (2007). *Research through design as a method for interaction design research in HCI*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, San Jose, California, USA.

Zimmerman, J., Stolterman, E., & Forlizzi, J. (2010). *An analysis and critique of Research through Design: towards a formalization of a research approach*. Paper presented at the Proceedings of the 8th ACM Conference on Designing Interactive Systems, Aarhus, Denmark.

Zimmermann, A., Lorenz, A., & Oppermann, R. (2007). An Operational Definition of Context. In B. Kokinov, D. Richardson, T. Roth-Berghofer & L. Vieu (Eds.), *Modeling and Using Context* (Vol. 4635, pp. 558-571): Springer Berlin Heidelberg.

Zugaldia, A. (2012). Google Glass detail. Retrieved 04.04.2014, from http://www.flickr.com/photos/azugaldia/7457645618

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