

# Time-Turner: Designing for Reflection and Remembrance of Moments in the Home

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## ABSTRACT

Families preserve memories of their special and everyday experiences, though it can be hard to capture all these moments in everyday life. We explore the concept of automated forms of capturing family life and presenting them through situated, tangible everyday artifacts in the home. We designed Time-Turner, an always-on video recording system along with a set of three drink coasters that allow family members to easily search, filter and replay videos to connect to their past. We engaged households in speculative enactments and interviews to explore the design space. Our findings point to the value of witnessing real rather than staged moments and the ways in which the affordances of everyday artifacts can allow media to be ‘lived with’ as a part of everyday life. Yet our design also revealed tensions around sharing and changing perceptions across time and generations. This points to design challenges around safeguarding this media and capturing ‘reality’ as opposed to curated content.

## Author Keywords

Families; Remembering; Memories; Home; Always-on Video; Domestic Computing; Co-Speculation.

## ACM Classification Keywords

H.5.3 [Computer-supported cooperative work]: Group and Organization Interfaces

## INTRODUCTION

Capturing shared activities, special events, and everyday life experiences is an essential part of preserving precious family moments for many people. The challenge is that it might be hard to capture such moments amidst the busyness of everyday life. Indeed, it is not feasible for a household member to always have a camera ready-at-hand. This motivated us to explore the idea of automated video technologies, such as always-on video recording [14,20,21,41], to capture the range of everyday experiences that unfold in the home. Naturally, the idea of continuously

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Figure 1. Time-Turner: a set of three drink coasters along with an always-on video recording camera (not shown).

recording a family’s life at home is still somewhat radically new as it presents a very different way of capturing everyday life than many people are used to and have grown to expect. The creation, exploration and resurfacing of digital memories has been an active research topic over the years [16,28,40,42–44,51]; however, the majority of prior work has focused on the on the privacy issues with ubiquitous capture in the home [41] or the capture and replay of special events or important experiences with much less focus on how always-on video recording and replay might impact domestic life [21]. The challenge is that such emerging technologies come with social effects that are hard to predict or anticipate.

Thus, to better understand this design space, we designed and fabricated *Time-Turner*—an always-on video recording system paired with a set of three drink coasters (Figure 1)—as a series of exploratory artifacts. We wanted to understand if and how a wider range of experiences might be opened up over time with always-on video data by placing data about domestic life within everyday domestic artifacts. We did this by presenting data and media within drink coasters, a common artifact found in many homes. Rather than predetermining what might be a meaningful moment, our design provides openness that might enable people to reflect on their past lives and sift through traces of time to discover unseen moments or everyday life experiences that might be valuable later. Time-Turner is similar to a digitized video diary used for life logging with ease of access to a family’s archive of video memories.

Next we wanted to explore how family members might react to Time-Turner as a part of their everyday life, what benefits they might see, and what social tensions, if any, might exist when living with such objects. Given the exploratory nature of the work and the paradigm shift encapsulated in Time-Turner, we purposefully did not want to conduct a field deployment of the technology in families’ homes. We felt this would be risky and privacy intrusive at best. For these reasons, we used Time-Turner as a part of a co-speculative approach with family members to explore

and discuss a range of future scenarios and uses with family members [15,38]. This allowed research participants to operate as co-speculators that could play a more active role in (co)designing these radically new emerging future technologies in ways that might be better guided on social, ethical, and practical levels. Our results point to the importance of authentic forms of capturing, benefits and challenges around the affordances of domestic artifacts when used with data and media, and tensions around sharing representations of everyday life over time and across generations. This points to design challenges around safeguarding perspectives and beliefs and capturing ‘reality’ as opposed to curated content.

## **BACKGROUND AND RELATED WORK**

### **Photo and Video Management in the Home**

Research has clearly shown that people find it challenging to manage their digital photos and videos [30,31]. This includes capturing, editing, storing, and sharing them [30,31]. Problems arise from having multiple people and multiple devices capture and share media, the distinction between the management of digital and physical media (e.g., print vs. digital photos), and tensions between household members who are sometimes unable to retrieve photos organized by others [13,33].

Given these problems, a variety of research has focused on supporting users in organizing and retrieving media from digital collections. Early research utilized the metadata available on cameras [6], color analysis [7,45], face recognition [62], movement detection [47], and tags and social uses [50] to categorize and organize media. While seemingly valuable, studies have found that people still face challenges when trying to retrieve media from their collections [60]. Instead, media from one’s past tends to be revisited out of serendipity or accidental encounter [42]. Techniques such as content analysis may fail to capture what is truly significant to users since important memories are actively selected by people using highly subjective criteria [44]. As such, our research explores alternative ways for people to encounter media from their past with a focus on the use of everyday domestic artifacts that attempt to draw users into their digital collections through aesthetically-pleasing visualizations embedded within the artifacts themselves.

### **Reminiscing and Sharing Media**

Usually family and friends share memories with each other in a collocated fashion using physical printed copies of their photographs [5,32]. When separated, sharing activities are commonly done via emails [16] and online web sites [32]. Typically sharing is done as a social act to reminisce about one’s experiences [8,16]. The transition from print to digital media provoked a generational shift in the curation of memories from physical copies to digital storage mediums [13]. However, the sharing of media through websites has created questions around control and privacy in terms of who can see people’s media [49,60]. New technologies

such as interactive surfaces [22,42,56], domestic artifacts [2,18,58], and new forms of digital frames [12,55] offer promising ways to support media sharing where there is a focus on the earlier practices of collocated sharing and viewing in the home. However, one must consider an object’s placement, location, and space in the home, its symbolic meaning, and usage with guests and children [28]. Studies around domestic photo displays, similarly, illustrate the importance of location for design [14,55].

Thus, it can be seen that despite the transition from print to a digital medium of storage, online sharing of digital media has not removed the importance of co-located sharing in the home. We also see the importance of designs that adhere to the aesthetics of the home while supporting personal and social practices. We explore this idea directly by discussing such practices as a part of our conversations.

The domestic roles of family members also play an important part in the display of media in the home. The person usually in charge of curating the home’s photo frames is the one who decides whom to display and where, and sometimes this happens without other family members’ contribution or question of choice [12,55]. Past studies have found that the curator of both printed photos and the aesthetics of the home is generally the mother when families have children [12,13,28,33]. We explore the importance of domestic roles when considering always-on capture and memory display in the home, in particular, how roles and perceptions of roles affect the sharing of content across time and generations.

### **Automated or Ubiquitous Capturing**

There have been a few systems designed with an emphasis on automated or ubiquitous capture of media in the home, which is similar to our design work. The Other Brother [20] captured unplanned or spontaneous photos based on ambient sounds in the home. Studies found that family members appreciated the capture of surprising moments but there were privacy concerns during usage in terms of capturing sensitive moments [20]. SenseCam was designed as a lifelogging camera to capture images throughout one’s day [3,4] and has been shown to allow people to connect to their past as well as aid memory during challenging situations [3,23,51]. The Human Speechome Project presents a similar concept of capturing video for a long period of time in the home but the focus was on understanding children’s speech development patterns [48,59]. Thus, they do not focus on the collection of family memories. Moments [21] was designed as an always-on video recording system for the home, and through an autobiographical design study, researchers found the family was able to gain a valued perspective on their life yet there were tensions around not being able to access media from specific points in time. The Helsinki Privacy Experiment was a long-term intervention with households to explore the privacy issues of an invasive ubiquitous surveillance system using multiple sensors in the home [41]. In contrast, our

work focuses on the capture of audio and video in the home and the potential benefits of these recordings for family members.

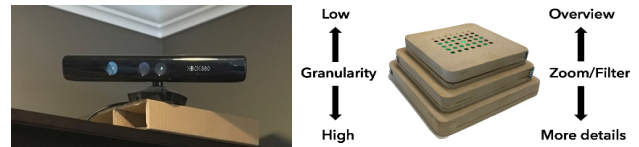
As we can see, most of the previous automated forms of capture [20] and retrieval of family memories [21,23] were not effective for family members to remember and search through their archives to reflect on their past, perhaps given the manner in which media was made accessible. We explore these ideas further through our own design efforts and a speculative study around media embedded within domestic artifacts.

### Designing for Domestic Technologies

Many studies have examined the development of technologies specifically for the home [19,26], addressing the practical everyday organization of domestic activities [34,57] and highlighting the importance of grounding technology design in domestic practice. This includes the use of domestic artifacts to shape and communicate our identities and social relationships [11,61] given their ability to be embedded within our lives and sometimes even unremarkable [9,32]. Previous studies have looked at the role of physical [10,27,29,36,44] and digital objects [27,29,37,39,43] and how they can operate as a valued resource for memory purposes [44], home archiving [29], digital possessions [39], and holding onto cherished memories over time [27,36]. We build on this crucial aspect by focusing on the design of physical artifacts containing digital media for families that are meant to be lived with and experienced in the context of domestic routines over time. In contrast to past design work, which tends to focus on collections of purposely captured media, our work explores vast amounts of media collected automatically through always-on video recording.

### TIME-TURNER

Time-Turner relates to the term *Ecphoria* which refers to remembering a memory that has previously been forgotten. This is often prompted by sensory actions (sight, in our case). Time-Turner is designed as an always-on video recording system in the home accompanied by a set of three drink coasters that enable the replay of videos based on the time of the video recorded [53]. Our goal was to explore how family members' practices of reflecting and remembering their past could be supported by embodying household data within everyday domestic artifacts. The design of Time-Turners' interaction and form draws inspiration from the use of everyday objects in the home, and their location, mobility, access, and sharing amongst family members. For example, drink coasters are typically highly mobile in the home and, given this affordance, they do not prescribe any one particular location or context of use. As such, people often gather around them for different shared activities such as conversing, watching television, or playing a game. This contrasts many digital technologies that are often much less mobile and accessible. We present the details for the two components of our system next.



**Figure 2. a) Kinect camera placed in the corner of the home  
b) Drink coasters and their granular stacking**

### Video Recording

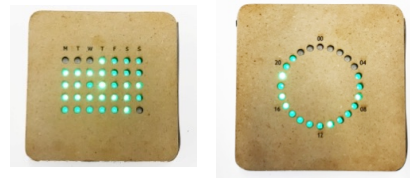
First, Time-Turner records video data of a home using one or more cameras that are set to be always-on and placed in one or more locations of a home. We used a Kinect camera placed at the top of a kitchen cabinet to capture the video in the home (Figure 2a). The system captures video and processes it in real-time to acquire metadata such as the specific location in the house, the number of people in the view, and the activity level of the location. The activity level is calculated using a pixel-wise comparison to see how much of the image has changed. We selected activity level as the variable to be presented to family members in our drink coasters to help them sift through time and know what periods in the past had the most or least activity.

### Drink Coasters

Time-Turner consists of a series of three drink coasters—showing glowing lights and video—that are wirelessly operating and communicating to each other. The coasters present the metadata and video from the always-on video recording system. The coasters represent information that it is viewable at-a-glance, yet is not visually obtrusive and demanding of one's attention. Time-Turner was designed to invite curiosity and drive anticipation around why different days' glow brighter than others.

### Granularity and Fidelity of Data

Each coaster represents data at a different granularity based on Shneiderman's visual information mantra of overview first, zoom and filter, then details on demand [52] (Figure 2b).

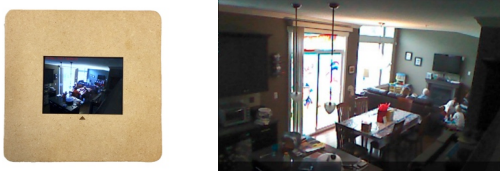


**Figure 3. Coaster 1 and 2 data representation**

**Coaster 1** (stacked at the top) presents data for an entire month. The layout of the LEDs is like the layout of a calendar, placed in a grid of 5x7 (7 days of the week and max 5 weeks in a month) as shown in Figure 3, left.

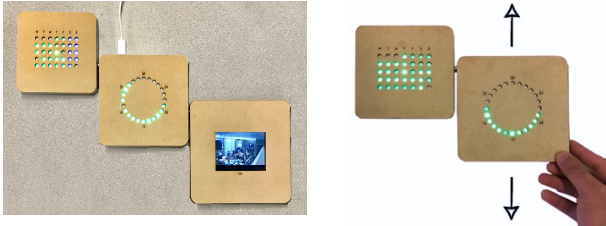
**Coaster 2** represents the data for the entire day like a 24-hour clock aligned in a circle as shown in Figure 3, right. Both coasters depict the activity level by month and a particular day of the month. We decided to use luminance to embody and represent ordinal data associated with activity levels in our data. We used LEDs for this purpose on Coasters 1 and 2. Our design rationale echoes Janesen et al. [25] where users can quickly identify which physical variables convey information and how. High luminance

represents high activity levels and low luminance represents values close to zero. The off state represents no activity. We converted this ordinal data into three bins to help users easily distinguish the changes in luminance.



**Figure 4. Coaster 3 showing the recorded video and content**

**Coaster 3** contains the most detailed and rich data in the form of videos from the always-on-video system as shown in Figure 4. We use a blinking LED to depict the selected date and hour on Coasters 1 and 2. The selected date/time determines what video is shown on Coaster 3 indicated by a date-time stamp at the bottom of the video. By default, the selected date/time is exactly one year ago (same date and same time). This can be changed by interacting with the coasters, which we describe next.



**Figure 5. Interaction with attaching and sliding coasters**

#### *Exploration by Interaction*

To support interactivity, we added spatial sliding to the Coasters 1 and 2. A user can change the data point on a coaster by magnetically attaching the coasters along their edges and sliding a coaster upwards or downwards as shown in Figure 5. This allows users to query and filter their data by the same granularity level of the coasters: a) date and b) time of the day. For example, if Coaster 1 slides alongside Coaster 2 in an upwards direction, the data point on Coaster 1 moves backward in time (to one day earlier) while sliding downwards causes it to move forward in time (by one day ahead). If Coaster 2 slides alongside Coaster 3, the selected time adjusts similarly. The current selection of date/time on the coasters is indicated by a blinking LED on each coaster. As soon as the coasters are magnetically separated from each other, they return to their default state of displaying the current date and current hour from one year ago. This was purposeful as we wanted users to reflect on what was happening at that point in time one year earlier as many family rituals (e.g., birthdays, anniversaries, festivals) are celebrated annually. This way, if today was a birthday, one could glance at the coasters and see what happened last year for the same birthday.

#### *Location Awareness*

Lastly, the coasters change what data is shown as users move them to different areas of the house, making them

spatially aware of the home environment. The coasters show the data for the nearest camera, detected using Bluetooth beacons. Our goal was to allow users to gain additional insight and attach value to the location. Previous research has suggested that playing video back in the same location it was recorded can add an emotional connection to the video [14,54], which might enhance the experience.

#### **STUDY DESIGN AND METHOD**

We conducted a study of Time-Turner with the goal of exploring the design space of always-on video recording and playback within the home. Importantly, it was not meant to be a design evaluation study where a research team might test the efficacy of a design idea in a home deployment. We felt that the research was not yet ready for such long-term evaluations in the home given the developing state of the design space and the potential consequences that come with it. Field deployments would also involve collecting large amounts of video data (e.g., months to years) prior to families being able to review past moments with the system. This might place the family's privacy at risk with the researchers. As such, we conducted a study where we used Time-Turner as a conversation piece in order to provoke discussion around the future of always-on recording and display devices, their possibilities, and implications that might arise. Our co-speculative approach is informed by several methods, including user enactments [38], speculative enactments [15] and scenario-based designs.

#### **Participants**

We recruited a total of 18 participants from 9 different households (H1-H9) through word-of-mouth, snowball sampling, and advertisements on university mailing lists. All participants resided within a major metropolitan city in Canada. All households contained two adults living as partners or married couples, with the exception of H7, which contained a mother and her 24-year-old son. All adults from the households participated in the study (9 males, 9 females) and ranged in age from the early 20s to 50s. 7 of 9 households had 1-5 children, with the exception of H1 and H4. Children ranged from toddlers to teenagers to young adults. We did not interview children and teenagers as our initial focus was on the perspective of adults. We purposefully included a large amount of households with children as we suspected that technologies such as Time-Turner might be best targeted at this demographic given people's desire to capture memories of their children [5,33]. The occupations of the participants covered a range of jobs and professions (teachers, graduate students, artists, architects, engineers, finance, federal workers, business owners). Overall our participant pool offered a diverse set of families—young and older parents, with and without kids, and single parents. For participant quotes, we refer to each household member who participated by H#[gender], age. # denotes the household number followed by their gender and age. We specify the



role of family members in the case of H7 to distinguish the only adult child who participated.

### **Procedure**

**1. Introduction:** Visits began in each family's home with an informed consent process followed by a tour discussing their typical practices of capturing, storing and accessing photos and videos. This discussion lasted between 10 and 15 minutes. Next, we moved to a more public area of the house (in most cases a dining table) to demonstrate Time-Turner and conduct the next steps.

**2. Initial Interview:** We conducted an interview to obtain family members' initial reaction to the concept of always-on video recording and playback. We used Time-Turner as an example technology where our conversation was less about the design specifically and more about the overall concepts it embodied. We interviewed family members together so that their thoughts could build on one another's. This interview lasted between 15 -20 minutes.

**3. Scenario-Based Discussion:** In order to provide contextual richness and allow participants to better relate to the idea of living and interacting with technology like Time-Turner, we developed six scenarios of family members using and interacting with the technology where the coasters were populated with digital content matching the scenarios. The scenarios were meant to engage participants in critical exploration around the concepts being presented. For the scenarios, we described an imaginary family to our participants and asked them to imagine they were in the family with a specific role (e.g., father, mother). In cases where a person did not match the roles within the scenarios (e.g., a scenario contained only parents but the participant did not have children), participants speculated and shared their reactions if they were in that role in their past or future.

The scenario family consisted of fictional parents, Anna and Bob, with their two kids, Emily and her younger brother, Sam. When creating each scenario, we tried to ensure that the scenarios were open to interpretation (in terms of one's emotional response) in order to better support discussions. We designed the scenarios to map to various kinds of situations in the home where we considered the user (family vs. non-family members), the intent (purposeful or unintentional), the time-indirection (short term vs. long term memories), type of memories (mundane vs. special events), location, and privacy risk. Our scenarios were heavily informed by our previous work on the use and experience of a similar system capturing family life over two years [21]. Overall our six scenarios (themes listed below) explored various possibilities of these aspects of family life.

**A) Unexpected Moments:** *Children accidentally re-surface the video of their late grandmother playing with their puppy while searching for photos of their dog as a puppy.*

**B) Revisiting Celebrations:** *Co-workers are over for Thanksgiving dinner and interact with the device and see the family's celebrations at last Thanksgiving.*

**C) Social Tensions:** *A visiting friend accidentally sees a verbal argument between parents on the device.*

**D) Child Milestones:** *Parents happen to notice their children's grandmother holding their newly born son arriving for the first time at their home.*

**E) Unpleasant Moments:** *A child reviews a 10-year old video of herself and sees when she accidentally burnt her hand on the stove.*

**F) Embarrassing Moments:** *Children accidentally interact with the device and see their father naked in the dining room ten years ago.*

Next, we enacted these scenarios by producing pre-recorded videos on Coaster 3. These videos contained an exemplar family and participants were asked to imagine themselves as the people in the family. The scenarios were shown to the participants progressively without interacting with the coasters after narrating the scenario aloud to the participants. Next, each scenario was followed by a semi-structured interview to elicit family members' reactions to that scenario. We interviewed all family members together so that their thoughts could build on one another's reactions. Questions included, for example, what would you do if this scenario happened to you? What do you think about capturing and replaying these moments? What do you think about people being able to access this situation? Would your reaction change if this happened a short time ago vs. a long time ago? The overall scenario-based discussion and interviews lasted between 60-80 minutes.

**4. Final Interview:** Lastly, we conducted a final group interview with all the family members in their homes. We started by asking them how their perspective regarding the technology changed, if at all, after going through the scenarios. We probed about accessing such technology in the home, domestic roles in relation to the technology, curation of content, ideal places to use such technology in the home, and perspectives on passing similar devices on across generations. This lasted between 20-30 minutes.

### **Data Collection and Analysis**

Study sessions were audio and video recorded with participant consent. Audio was fully transcribed. We collaboratively and iteratively coded and reviewed the data amongst two researchers. We reviewed our video recordings in conjunction with our reviews of the transcripts. We coded transcripts to form high-level themes and created affinity diagrams to organize our findings across families and with-in different scenarios to reveal unexpected connections among households. In analyzing the data from our scenarios and interviews we found five main themes: 1) reality over memory; 2) the role of embodying data in everyday artifacts; 3) challenges around conversations related to death; 4) changes with oneself over time and evolving roles; and 5) passing down the system to

future generations. Our analysis reflects the shift in thinking of our participants from their initial reactions to how the scenarios helped them imagine the possibilities with the technology including both positive and negative situations.

### REALITY OVER MEMORY

During the initial interview, many households related the concepts within Time-Turner to CCTV cameras and reality TV shows meant for monitoring and analyzing people's behavior. After experiencing and relating to the scenarios, participants began to think more broadly about the design, its capacity, implications, and tensions around capturing and replaying family life.

### Watching vs. Recall

Participants could easily relate themselves to the fictional actors and the enacted scenarios. They related this to their own memories 'unfolding' on Time-Turner providing them with a richer description than their mental ability to recall moments from their past. Participants with young children felt that their children might possess inaccurate perceptions about their past since they usually constructed partial memories at young ages.

*It would be interesting to see them (children) going back and reliving a memory and going "What...that's not what I thought happened." - H3F, 42*

Four parents related this to their own forgotten or uncaptured childhood achievements, which they said might provide a sense of accomplishment at a later stage in their life.

*I remember when I first tied my shoelace, I was so proud, and I wanted everyone to know that I tied my shoelace, and it would've been dope to have a video. - H1M, 31*

The ability to watch past video also exposed the salient aspects of these memories, such as other family members present, their voices, and even minor details in the scene (e.g., the color of the carpet, floor tile pattern, etc.). Participants said that these mundane yet salient aspects made the viewing experience much richer.

*You also get the extra memories of things that are like on the fridge... I love looking at photos at our old house with my family because it's like "Remember that floor we used to have? Remember the shag carpet?" - H1F, 30*

Despite these positives, participants also talked about the negatives of having a somewhat exact record of their life. They felt that this could take away from their ability to re-create family stories where they might change details to hide sensitive or troubling memories in order to not expose children to particular realities of life. For example, when describing the 'shoe lace tying' story, H1M would describe the success of the act, but avoid a crying episode after.

*I think as I recall, after I tied it the first time, the woman who was babysitting me untied it and I cried. So, I don't know how much I'd actually want to relive. - H1M, 31*

### Storytelling with Resurfaced Memories

Participants felt that the candid nature of the video recording in the home made the viewing experience more evocative. They compared this to their existing practices of taking pictures, which required them to mentally fill-in gaps at a later stage through storytelling with other family members. Seven participants told us that they valued watching the spontaneity of their past without disruption or alteration revealing their stories in a candid fashion.

*There are moments that would be ruined by picking up the camera, or to start record. It ruins it, it stops being a special moment. - H9F, 38*

*It's not just Christmas or holidays that you remember, it's the normal days, which matter the most. Because those days are only 10% of your life I guess. But 90% of your life you get a regular setting on the table. - H5M, 33*

Audio and video played an important part in experiencing memories. Generally, audio was found to break down the context for memories involving conversations, while the videos made the overall experience more vivid and richer by allowing people to connect to their memories. Participants said that audio was the most powerful aspect for memories containing departed ones or family members who were not heard in a long time. For example,

*H6M, 24 (Son): The only voice recording I have of dad are the voice machine when I call the house, and then it picks up the answering machine or his recorded voice...I'll remember exactly how he looks like, but sound is something that'll get lost more...*

*H6F, 52 (Mother): Yeah, I agree...We had African grey parrots, and they spoke in my husband's voice, and when he died, the house suddenly went very quiet.*

### Tensions with Capturing Everyday Life

Naturally, all participants had concerns around capturing certain activities in the home, such as parties, private conversations, and vulnerable moments (arguments or nudity). They disliked having to explain and obtain consent from guests that might come to their home and be captured by such a system. They also did not wish to alter their behavior in their home. As such, most households desired to turn the capturing device off or have the option to erase or block certain time periods. Yet when describing such features, many participants struggled with coming up with ideas around when and how capturing should be turned off and referred to such time periods as "rewriting family history" or "memory alterations". They felt that public areas in the house would be the ideal locations for technologies like Time-Turner since most of the family interactions and shared activities would occur in the in these areas. They also wanted 'blind spots' or private areas in the home that would purposefully be off-camera. Similar tensions with capturing disturbing moments, turning off, and avoiding the capturing have been reported by previous long-term studies in the home [21,41].

*The things I don't want to remember. I definitely don't want to remember that fight and I want to forget and continue, so that is something I don't want to see. - H7F, 40*

Participants talked about having different access modes for viewing the video within Time-Turner, such as guest mode, children mode, and private mode. Alternatively, some participants wanted to act as the access providers for the data within the objects such that they had to be present to show others the video within the system.



**Figure 6. Households interacting with Time-Turner**

### EMBEDDING TECHNOLOGY IN DOMESTIC ARTIFACTS

The embodiment of digital content in everyday artifacts provoked conversations across our sessions. Households spoke about the affordances of the form of these objects (coasters), which they felt made them always visible and present to encourage interactions amidst their daily activities in the home. They spoke about the randomness and unpredictable nature of interaction with Time-Turner and felt these interactions could cause them to reflect on their past or start family conversations. They felt that the presence of these objects in the home might consciously or subconsciously replace the time they spend on their mobile phones in the home.

*I can see myself picking up coasters and saying, "Oh let's see what's going on" rather than picking up my mobile phone, I can easily see this technology replacing that. This technology can start conversation, stir emotion. It can become part of your life. - H5F, 33*

Households compared Time-Turner to picture frames on their walls, and some wanted the video coaster to be placed vertically to support better visibility (Figure 6, right), although we observed some participants covering Coaster 3 with their hands or turning it upside down when they saw unpleasant instances during our scenarios as shown in Figure 6 (left and center). Through video analysis, we observed that households interacted most with Coaster 3 (containing the videos) and used Coasters 1 and 2 primarily to go back and forth in time if they saw something interesting on Coaster 3. Thus, they tended to not look very long at the colored LEDs on Coasters 1 and 2 as a means to understand past activity levels.

Participants liked how easy it was to slide the coasters to see past memories. They felt this would be a good way to share their videos with other immediate family members without posting them on social media platforms and making them more public. But the ease at which one could control the time and location of memories turned into a negative with the presence of extended family members, friends or

guests in the home. In these cases, it became too easy for 'outsiders' to access the family's past if they started touching the coasters. This concerned participants. Participants were also concerned that if they wanted to search for specific moments by sliding the coasters, it would be easy to come across moments that were less desirable to be shown in front of children or inappropriate audience.

*We would have to scan through everything to get to...And that's not cool...I'm not comfortable exposing my kids' private lives to even our close friend. - H3F, 42*

Apart from reflecting and revisiting their memories, households speculated on a range of possible uses for designs like Time-Turner. These included:

**1) Connecting the past to the present:** Seeing memories with a strong link to their present lives. This included seeing past moments that related to current events or moments of reminiscence (e.g., dealing with memory loss, ancestor's living, tracking conversations). They also thought of using the design to communicate to their future selves or others (e.g., leaving messages for future events or generations).

**2) Developmental:** Memories that highlighted developments or milestones in the home such as kids' or plant growth patterns, kids' day-to-day achievements, or their learning lessons (e.g., learning to walk).

**3) Social bonds:** Memories reflecting social bonds with family members and guests such as during family celebrations, events, and social gatherings.

**4) Introspective:** Memories that would help them analyze their character, behavior, or personality in everyday situations, such as arguments or parenting decisions.

**5) Everyday domestic use:** Memories around accidental meal recipes, finding lost items in the home, or for security.

### CONVERSATIONS AROUND DEATH

Participants talked about Time-Turner revealing unpleasant memories leading to undesired situations in the present. One of the most influential instances of this was conversations with young children about death, evoked by seeing videos of deceased family or friends. Six parents said they might find it challenging to approach or explain such memories with young children (~ages 1-7), especially when it came to grandparents that had passed away either before or during the child's life. Parents were concerned about the nature of questions that their children might ask about the absence of these people. They also felt that such recorded memories might lead to questions about death more broadly, e.g., "When are you going to die?"

Parents felt that developing children lacked notions of time and as time passed and they developed new experiences, further explanations regarding deceased family members would be needed. That is, with a system like Time-Turner, moments about deceased family members could continue to resurface, even accidentally. Parents thought that children

could lack an understanding of time and accidentally pick and choose moments being unaware of tragic family incidents. They compared this to their existing practices of watching memories of departed ones by deliberately playing VHS tapes to serve as a reminder.

*They (kids) would pick times after [grandma] was already dead or they would pick times... they would just keep going back... Like it would be random if they found her whereas before it was on a VHS tape and it would almost have to be deliberate. - H3F, 42*

The developmental stage of their children's understanding also played an important role in conversations about death. Parents said that young children (less than five years) tended to see death as temporary or reversible because they had watched cartoon characters suddenly rising and living again after being killed. Thus, they lacked the ability to recognize what was real versus on-screen characters.

*They don't know what death is or we show them so many things on-screen that are real and then so many things completely made up...So they would have to have a very clear understanding that that was real, that was your grandmother. She is no longer with us. - H7M, 42*

*"There's grandma?(on-screen)" That sounds like a whole conversation, I know you see her and ...I know you remember that dinner, but she's gone. That's a different kind of conversation than a normal death conversation with a child, so that might be confusing. She's gone but here she is.- HIM, 31*

### **THE EVOLVING SELF, ROLES, & RELATIONSHIPS**

Most participants reflected on how they had changed over the years in terms of their own self-identity, their roles, and their relationships. Systems like Time-Turner were seen as being able to enhance such reflections. Many participants said that it would be an amazing experience to watch their own early childhood days, growing up from a baby to a toddler. Yet they preferred to not re-live certain phases of childhood such as their teenage years, which were referred to as being embarrassing and awkward due to their changing appearances, development of their body, their erratic emotions, and their lack of maturity. They also felt that some phases might include lies to their parents as a means to 'cover their tracks'.

*It's painful...my mom keeps photos of me when I was growing up, for the most part, I don't want to see any of them. Because there's a huge, like most of my childhood except for very, very young where I'm just like super awkward, string bean, huge glasses, bad haircut, giant head...You don't necessarily wanna relive that stuff. - H4M, 42*

Some parents felt that designs like Time-Turner would cause them to start analyzing or questioning their parenting skills and watching their mistakes with their first kids. Many felt this would not be useful for them or their

growing children since, with each kid, and the passage of time, they grew and learned a lot as a parent.

*Most people go through a period when they find it really difficult to handle the responsibilities and they grow as a parent...and why would you want to go back and then have your kid be like "Oh my God, you were horrible."- H3F, 42*

Participants felt that memories of children with their grandparents would become richer with the passage of time because their relationship evolved as the children and grandparents grew older. For this reason, they felt that designs like Time-Turner might be more beneficial for children as they aged and could look back at their relationships with their grandparents.

### **PASSING DOWN THE SYSTEM**

When we asked participants how they felt about passing on systems like Time-Turner and their video archive over time to future generations or alternatively having access to their ancestor's everyday life, participants' comments revealed many tensions. This included seeing their attitudes towards life and behaviors that may not always be positive. They felt that family members create a mental representation of a person that often focuses on the positives. Yet systems like Time-Turner could take away from this image. Participants were afraid of their future generations or grandchildren seeing large amounts of their life because it could take away from the 'special or perfect image' that some grandchildren might have created when thinking about them.

*People want to be remembered as something special. There might be some regular folk to them, but there is no charm to being regular fold. Even me, I am a regular dad and I do a lot of regular things. But I want her to remember things that I am proud of. - HIM, 33*

Four participants felt that the recorded video might reveal their moralities, hardships, and social views. Some participants related this to their grandparents or parents who were homophobic in the past or abusive to their children (e.g., spanking). They recognized that different time periods saw society with different social norms and expectations around behavior. Yet they did not want to be judged negatively because of it. Having access to see bad traits, habits, or social behavior was considered harmful for future generations. Participants were concerned that their current behaviors might seem fine now, but could easily be considered inappropriate in the future if attitudes and behaviors evolved.

*My grandparent were like super homophobic and hated other types of people, you know, it was the way things were I guess 100 some years odd years ago...Right now, we're like kind and beyond that, but who knows in another 100 years what we are gonna be doing that they're gonna feel awful about. - H2F, 33*



Even still, households did see the value in passing on systems like Time-Turner. They also expressed interest in having access to their ancestors' archives to better understand their roots, family traits, ancestral home, appearances (i.e. hairstyles, clothes), voices, technologies, and traditional food at special occasions. They valued revisiting the lives of people who were part of their families but who they had never met physically during their life.

*I keep telling my husband about all these fantastic memories of going to village and spending time with her (grandmother). Even if I go back there today, nothing is same as it used to be. If I had something of that sort, it would be very precious. - H5F, 33*

Most households preferred to not share their entire life and, instead, wanted to present selected moments. Participants saw one of the parents in the family acting as the curator of content. Yet this raised challenging questions in our conversations with the families. Participants were concerned with the amount of time and effort required to curate videos on an everyday basis, where they speculated that future systems could provide a summary at the end of each day to filter moments and provide users with a choice to keep or discard moments. A small number of participants raised questions around the right of every family member to act as a curator. They wondered how conflicts would be handled during curation with multiple family members and how curation processes would work as children grew older and became adults. They wondered if they would be able to change the media that was available if their perspective on life had changed, or if they could curate their own content, even if it had previously been curated by their parents.

*Kids grow really fast. I think I would start needing [my son's] consent on the videos or moments. If he allow me to share those with somebody outside the family, then I think he would need similar control to his content as what I have as a parent. I can easily see going forward ... 10 years down the line, your children have the access, ability and all right to decide what content they want to share. - H5F, 33*

## DISCUSSION AND DESIGN DIRECTIONS

We now discuss and interpret our results in terms of benefits of the design ideas embodied in Time-Turner, the tensions that were revealed through our study, and opportunities for future work to address them. The fidelity of our prototype helped our participants to critically reflect on the overarching idea and think more broadly about the design, its capacity, implications, and tensions.

### Designing for the Social Norms of Everyday Objects

The concept of Time-Turner produced a range of reactions from our participants. On the one hand, Time-Turner opened up a range of possibilities for supporting casual interactions around the objects because their content could be easily and subtly interwoven in their daily routines and domestic settings. On the other hand, they revealed tensions that can surface from embedding new kinds of information

and technologies in the form of familiar household objects that have established social norms. Typically, when people place objects throughout their home as décor and for everyday use, they are meant to be just that; they are naturally open to being used and seen by others, including guests. Photo displays are similar in that they are typically very purposefully placed throughout the home and show what people are comfortable in revealing to others [33,55]. Similar results were found with parents sharing and managing the identity and privacy of their young children when posting to a larger audience on social media [1]. Our design challenged this idea of placing carefully curated content on display in an attempt to invite spontaneity and curiosity in past moments. The 'everyday-ness' of the design artifact and its public accessibility in the home raised questions around who had access to content and when. Tensions became particularly amplified when considering the presence of guests and the accessibility of 'static' digital content persisting over long periods of time in everyday life while people and situations continue to change. Participants were used to personal data being more inaccessible, on computers or devices and not 'out' in the open.

One way to approach this problem is to further explore how objects are placed and used in the home, and how such interactions might shape data access. Family members should not be required to hide or move designs like Time-Turner to private locations when guests are over. Instead, it would be fruitful to explore how the data in objects might change based on a social awareness of who is around or where they are located. For example, if guests are present and near designs like Time-Turner, designs might change to show content that only contains the guests (if such moments exist) or content that is more generic in nature such as scenery without people. They might also simply just turn into regular coasters showing no data.

There are also opportunities for future design research to consider the increasing progressive disclosure of digital content. For example, video may first be shown in a blurred state until further interactions by the user indicate that it is okay to reveal a higher fidelity form of the video. Users could then progressively decide if a moment is fine for viewing by others that are around. While perhaps somewhat crude, the importance of these ideas is that they build on the notion that designs should be easily integrated within the everyday routines of domestic life and they should respect the social norms and moral order of family life. These ideas build on and extend prior work ([e.g., [52]]) by concretely demonstrating how they apply to situations where domestic data could be embodied in everyday artifacts in the home and how family members react to this.

### Designing for Everyday Capture

We also found benefits in the design's ability to capture a more accurate representation of everyday life that could become valuable in retrospect. Previous work showed

similar results with constructing life stories with picture collections [17] and we illustrate a similar point with videos. Yet our work also reveals the tensions associated with the always-on nature of the video recordings. Participants valued the ability to revisit the “reality” of their everyday lives, but there were undesirable instances (i.e. arguments, nudity, death) and time periods (i.e. teenage years, accidents) that produced uncomfortable emotions for participants. Similar results were found through the autobiographical study of a single family using always-on video recording [21]. Our study points out that such concerns are more widespread amongst a diverse set of families. Families want two ends of a spectrum: the capture of everyday moments, but, for the most part, not those that elicit negative emotions. The challenge is that their emotions, fears, and understanding can change over time and across people as discussed in our results. This raises the design challenge of how one can balance these competing needs among different family members in the home.

One way to approach this problem is to further investigate the types of information that are revealed through everyday artifacts prior to seeing actual video content from one’s past. In retrospect, our coasters offered representations of past moments at a fairly ambiguous level (activity levels embedded within LED luminance) and the progressive disclosure of what a month, day, or moment entailed was somewhat coarse. One could consider additional levels of granularity such that people could make informed decisions as to whether or not they actually wanted to review a past moment. For example, additional coasters might provide information such as who was in a video before a person sees it. This could help them decide if it may be a negative memory that they might not want to look at, similar, to how parents manage and curate their children’s TV viewing. Of course, we realize there might be benefits of revisiting difficult moments in one’s life at a later stage in life. The advantage of such an approach is that it likely can support the changing needs of people across time and experiences. It also points to the tradeoffs between designing for ambiguity in order to increase anticipation in reviewing past moments and the value in knowing specific information about a moment before seeing it in more detail.

#### **Designing for Information to be Passed On**

Finally, our design revealed the value that participants attributed to seeing their ancestors in a somewhat ‘raw’ form of life. However, they were uncomfortable sharing their own life in this same manner with future generations due to changing social values over time (e.g., homophobia, parenting styles) and a due to desire to protect their identity (e.g., retaining their special image) with future generations. This is in line with previous work around passing down legacy and life stories that shows that people want to leave behind an impactful and enduring legacy by only passing down core values and curated stories of their life [24,46]. This raises questions around how designers should create

designs to be passed on to future generations while still protecting and safeguarding previous generations. In this realm, prior work has suggested supporting multiple social roles and representations of identity over time [29,35].

Our research builds on this past work by suggesting possible approaches to alleviate such problems. For example, one way to approach this problem for always-on video in the home is to explore the level of effort that is needed by future generations to access the memories of their ancestors’ lives. Currently, Time-Turner has a somewhat low barrier to access the data within it; one simply has to slide the coasters to ‘move through time’ and they will have access to media captured by the camera that is nearest to the coasters. However, designs could more broadly explore ideas around location and time as a means to regulate access across generations. For example, designs might only ‘unlock’ content if the design is brought to the actual location in which it was captured. This might include the city, neighborhood, or even the specific home location of capture. After finding one’s way to the ‘data destination’, the media might then be allowed to be ‘brought back’ to one’s own home. Thus, the effort and desire to see the past life of generations would require thought and effort, rather than be instantaneously accessible. This is, in some ways, how heirlooms are passed on across generations.

In relation to time, one may have to wait until they are of the same age as the person in the media in order to have access to it. This might cause a person to wait until a point when they may be at the same level of maturity or life experience. Of course, these ideas are speculative and require further design work exploring temporal interfaces and appliances that enable people not only to grasp and explore the richness of data generated now, but well into the future. Time-Turner served as a starting point, but it is clear that data could quickly out scale and outpace the current design, which points to open area for future work.

#### **CONCLUSION**

We designed Time-Turner to critically explore how digital memories might be captured through an always-on video recording system and then embedded in everyday objects in the home for supporting family practices around reflecting and remembering the past. Our findings revealed the opportunities, possibilities, and the tensions of this new paradigm of capturing and playing back family life. We provide new insights on how always-on video systems in the home can open opportunities for households to construct value with video archives as well as the social tensions that could emerge. Future work should explore non-Western ways of accessing time and include a range of family members (kids, grandparents). Our work provides an example of new kinds of connected devices that can automate aspects of our lives while helping to fit within the social fabric of domestic life and home environments.

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