Audio-Enhanced Paper Photos: Encouraging Social Interaction at Age 105

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ABSTRACT
Photographs are powerful and pervasive media that facilitate communication and support reminiscence. Adding audio narrations to traditional paper photographs combines the familiarity of paper photos with the nuanced richness of voice. We enable creation of and interaction with audio-enhanced paper photographs through custom software deployed on a digital pen. This paper reports on use of a paper-digital photo album by an older adult (Ethel, age 105), her extended family, and nursing staff over a five-month field deployment. The interactive photo album was found to be easy to use and accessible, effectively engaged Ethel’s and family members’ interest, and provided a focal point for communication and social interaction. Family and caregivers report improvements in Ethel’s social interaction. We discuss the properties of our audio-enhanced paper approach that make it a promising medium for engaging older adults and distill general design considerations for paper-digital photo albums.

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Communication, Digital Pen, Photos, Older Adults, Social Interaction

ACM Classification Keywords
H.5.2 User Interfaces: Input Devices and Strategies

INTRODUCTION
Aging presents challenges in many dimensions of life. One aspect of aging that is well-studied is the relationship between social interaction and late-life satisfaction. A lack of social interaction for older adults may contribute to higher rates of disability, slower recovery from illness, and even early death [27, 1]. While some work suggests that social networking technologies can prevent feelings of social isolation or loneliness [31], such outlets require technical and physical ability as well as access to a computer, presenting challenges for some older adults. Furthermore, intergenerational communication and sharing of memories is complicated by differences in technology access, ability, and interests.

We present a hybrid paper-digital approach to sharing photos that is a tool for intergenerational communication, reminiscence, and social engagement. Through a case study we detail the evolution and use of an interactive audio-enhanced paper photo album. Working with a large extended family, we introduced the photo album to Ethel (age 105) and her extended family. We report on Ethel, her family, and her care staffs’ use of the photo album over five months, describing how the materials engaged Ethel’s interests and supported social interaction and reminiscence.

This research builds on and contributes to the growing literature on social practices of photo sharing [26, 6, 10] as well as techniques that support reminiscence for older adults [15, 24, 42, 46]. In particular, this case study documents improvement in social interaction by the older adult. Practices such as reviewing family and care staff’s names and faces in the photo album seemed to help Ethel better remember these people during face-to-face interactions. The introduction of the album also provided a new focal point for interaction and stimulation, which generally enhanced quality of life. Older adults in the family, including Ethel and her children (in their 70s and 80s), had little difficulty authoring audio content or navigating the interactive photo album.

In order to situate our study we first highlight how current work in different areas informed and shaped our own work. After introducing the research methods and the deployment of the interactive photo album, we describe and analyze the authoring process, user generated content, and usage of audio-enhanced paper photos. We conclude with a discussion of the properties of audio-enhanced paper photos that make them well-suited for reminiscence and intergenerational communication and offer practical insights about deploying this technology in the field. Although derived from an extended case study of usage by one family, we anticipate that the general authoring process we developed as well as the idea of audio-enhanced paper photos for communication and reminiscence might inform a variety of applications with other populations.

RELATED WORK
This project bridges several areas of research: applications of digital pen technology, social interaction involving photographs, the notion of audio-enhanced photos, archiving of family memories, and the implications of these media for older adults. Foremost, a deeper understanding of the affordances of paper are a cornerstone of this research, drawing on studies of paper in office work [40], medicine [28], and...
avation [29, 32]. Digital pens are often used to link paper and digital media [30, 45, 17]. Applications of digital pens include document editing [5], linking handwritten and audio notes [4], scientific notebooks [48], and collaborative annotations [43]. Recent work by Piper et al [36] suggests that digital pens are an appropriate and accessible tool for older adults. Digital pens are also affordable, costing $100 USD.\(^1\)

Our work is not the first to use a hybrid paper-digital approach to support photo sharing and reminiscence. The Memento project introduces a hybrid paper-digital scrapbooking architecture [47]. Memento uses an Anoto pen to allow users to annotate a paper photo album and link these annotations with audio recordings and video files on a nearby computer. While the system does record and replay audio, the digital pen must be coupled with a computer, requiring the users to setup and manage bluetooth connections and ensure Internet connectivity. In contrast to this, we explore the use of a Livescribe pen with an integrated speaker and microphone to enable a stand-alone interactive experience. What is distinctive about our approach is the simplicity of a purely pen and paper interface.

Photographs are a powerful tool for social interaction [19] and provide anchors for discussion [41]. Our approach explores audio-enhanced photos and builds on Frohlich’s extensive work on audiography, which indicates that ambient “sounds-of-the-moment” have potential to bring photos to life and to aid memory of events [12, 13]. Frohlich and Fennell [9] recommend audio photographs rather than video clips as a new media form, again emphasizing the importance of paper photos in contrast to a screen-based viewing experience. An interesting contrast is the idea of a “sonic souvenir” for family remembering [7]. Compared to photos, sounds were found to be more varied, familial, and creative as well as being evocative and generating reflective narrative.

Several projects involve tangible interaction as part of linking audio narrations with physical content. The Memory Box explores recording and attaching stories to memorabilia in a keepsake box [11]. Similarly, Stevens et al [44] examine family archiving as a way of informing the Living Memory Box project. Klemmer et al [22] introduce bar-code augmented paper transcripts linked to digital video interviews.

The present research focuses on supporting photo sharing and reminiscence for older adults, the so called “Kodak culture” [3]. Many digital photo sharing alternatives require a level of technical understanding, often limiting use by older generations [38], whereas paper photos have immediate affordances understandable by everyone [34]. Related work examines new approaches to bridge generational differences in the photo sharing experience (e.g., [23]).

Prior work also examines the design of tools for reminiscence later in life, specifically for individuals with memory loss. Gowans et al [15] introduce a multimedia tool to stimulate long-term memory and encourage conversation for adults with dementia. Kuwahara et al [24] enable remote photo- and video-sharing involving individuals with dementia and their therapists. As part of this literature, there is work on multimedia biographies to support communication and reminiscence between individuals with memory loss and their families [42]. Similarly, Webster [46] and colleagues designed Portrait to serve as a communication bridge between people with dementia and their caregivers.

Aging is associated with a variety of changes in cognitive abilities. After the age of 70, normally aging individuals experience a decline in short-term memory [16]. Semantic knowledge may also decline around this time [33, 39]. Changes in verbal ability generally become increasingly evident after the age of 80 [39]. Some aspects of cognitive functioning, however, remain relatively stable over the lifespan and are central to our approach. Stable aspects include autobiographical memory [14], implicit memory (accumulation of life experiences and learnings) [25], ability to process emotional information [2], and theory of mind (recognizing the viewpoints of others) [18]. Psychomotor skills can also be sustained if they receive dedicated practice [37], and our approach presents one avenue for encouraging this.

### METHOD

This research details the adoption and appropriation of an audio-enhanced photo album by a large extended family, primarily consisting of older adults. As part of this, we examine the system’s usability by older adults as well as how the system changes the older adults’ social interaction and overall wellbeing. A five-month field technology deployment with a single extended family addresses these aims.

Ethel, at age 105, is the oldest member of her family. She does not know how to use a computer nor does she regularly use a cell phone, digital camera, or tablet computer. She enjoys visiting with her family and reading novels. She has trouble remembering people’s names and her relationship to them. Ethel often forgets who extended family members are, whether appearing in a photo or in person. She is also unlikely to know which day of the week it is and generally her ability to understand the passage of time has declined.

Ethel lives in a retirement community along with two of her children. In addition to onsite nursing staff, Ethel’s four children (in their 70s and 80s) help care for her and visit her daily. Alice (Ethel’s oldest daughter, age 78) has been Ethel’s primary caregiver over the past 10 years. For this reason, much of the analysis within this paper focuses on interactions between Ethel and Alice and relies heavily on Alice’s observations of her mother while using the photo album.

Research began with initial observations of Ethel and Alice using existing paper photos in Ethel’s room. Based on these early observations, we identified an opportunity to deploy an interactive photo album with this particular family, and the timing of the study allowed us to introduce it at Ethel’s 105th birthday. The photo album was setup as a guest book at Ethel’s birthday party. A Livescribe digital pens, equipped with the TAP & PLAY software [35] was deployed with the album and allowed family members and friends to author audio messages and link them to the photos. We positioned a video camera nearby the album to capture interaction during

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\(^1\)http://www.livescribe.com
the party. After the party we observed photo album use by a variety of family members and conducted semi-structured interviews with family members and Ethel.

The photo album remained with Ethel after the birthday party. After six weeks of heavy use, the pen’s memory reached capacity for audio recordings. The family returned the photo album and digital pen to the research team. After a few days, the family requested that we return the materials so they may continue to use the materials with Ethel, as it had become an important artifact in her life. We returned the materials to the family, now with the ability to listen to existing recordings but not record new audio. After a total of five months (starting at the birthday party), we collected the photo album and digital pen to perform a final analysis.

Throughout the study we collected field notes and video data of the family using this album (both the authoring process and Ethel’s usage), interviews with the family and nursing staff, email reports from the family, and log file data from the digital pen. We conducted a survey with family members and nursing staff after the initial six week deployment to understand the photo album’s impact on Ethel.

Our analysis of data is informed by theories of distributed cognition [20, 21]. We draw out themes from our field observations, interviews, and the analysis of artifacts and representations over time. There are many dimensions to consider within this complex system of interaction: how family members and care staff create audio-enhanced photos, how Ethel learns to use the album, how others support her in doing this, and how the album changes social interaction and communication involving Ethel. We examine these issues below, but first we describe the role of paper photos for this family.

PAPER PHOTOS

We began research with this family by conducting an interview with Alice and observing Ethel in her room at the retirement community. Alice said of her mother:

“She was 101 when she went into the nursing home and she didn’t want to interact with any of the people there, she considered them ‘old.’ She also didn’t interact with the people taking care of her. If she had a complaint she waited until I came or my brother came and then told us. She didn’t want to eat in the dining room for any of her meals.”

Alice is the family member who interacts with Ethel most frequently, and as such she is a key informant for this research project. She comments on the challenges of engaging her mother in conversation:

“I come in [to Ethel’s room], say a few things. She doesn’t really interact in the conversation, but if you start talking about who someone is in a picture, and ‘do you remember that person?’ It gives a focal point for communicating... It gets real easy just to go in with a book and sit with her.”

While many of Ethel’s interests have waned, she maintains a strong interest in her family and memories captured in photos. She has a bulletin board in her room filled with paper photos of her family (Fig. 1). Alice describes this:

“We have a bulletin board covered with pictures... in her room on the wall. She wants to engage me in a conversation, I know. She’ll say, ‘you know who those people are?’ I say, ‘oh yeah, that’s so and so.’ She says, ‘take those pictures and move them there.’ She wants to get me engaged in doing something with the pictures. It’s her way of communicating.”

Following a human-centered design approach, we leverage the fact that photos are already a means of fostering communication with Ethel and therefore study this family more closely as they use the interactive photo album. It is important to note that Ethel and her children are all part of the “Kodak culture” [3], generations that grew up with and still highly value photos printed on paper. Therefore, our research is most concerned with how the family creates and appropriates audio recordings coupled with the paper photos. The inherent goal is to build upon the familiar nature of paper photos, but now enhanced with audio recordings, to foster interaction between Ethel and her extended family and care staff.

INTERACTIVE PHOTO ALBUM

After observing the family’s use of paper photos, we used the TAP & PLAY authoring toolkit [35] to help the family create a custom interactive photo album. TAP & PLAY runs on a Livescribe™ digital pen. This digital pen has a built-in microphone and speaker that allows users to record and replay audio. TAP & PLAY provides a pen-based interface for linking custom audio recordings to regions of paper printed with a special dot pattern recognized by the Livescribe pen.

The family sent the research team digital photos which we printed on dot pattern paper and gave back to the family as part of the photo album. Additionally, we provided the family with stickers printed with the dot pattern to attach to other paper materials (e.g., traditional photos) and integrate into the photo album. The family assembled the interactive photo album for Ethel’s 105th birthday. Each year, five generations of the family gather to celebrate Ethel’s birthday. Using a Livescribe pen with the TAP & PLAY software, family members recorded and saved messages for Ethel. The family placed a small control panel used for authoring on the inside cover of the album (see Fig 3). After saving audio to a page, tapping the pen on the interactive area plays the associated audio.

FIELD DEPLOYMENT & ANALYSIS

Through a five-month field deployment we observe how this family cooperatively authored interactive photos and inte-
grated this album into Ethel’s daily routine to improve communication and socialization.

Photo Album Authoring
Over the course of the study, the family added 102 photos to the album and linked 104 audio messages to these photos. Authoring began when family members placed the photo album on a table at Ethel’s 105th birthday party for family and friends to add their audio messages. We videotaped interaction with the photo album during the birthday party and conducted follow-up interviews with family members. A total of 36 people (age 2-105) added audio messages to the interactive photo album. As earlier evaluations of TAP & PLAY indicate [35], there is a low learning curve for linking audio content to paper. Family members were able to quickly and easily add custom audio messages to photos within the album.

Partway through the party, the family showed the photo album to Ethel. She watched as people recorded their messages, and she even recorded her voice, with the help of her children and grandchildren (Fig. 2). Family members were particular about the messages they recorded and often revised a message before saving it. Messages could be re-recorded but not deleted from the pen. Although there were 104 audio messages linked to the album, 154 messages were saved to the pen. This indicates that roughly one-third of the audio messages were unlinked from photos and/or not wanted. The TAP & PLAY interface allows for recording, replay, and re-recording of a message. One grandchild (age 62) recorded the same message six times before he was happy with it, making only slight modifications between each version.

Alice took ownership over the album, storing it for the family and bringing it to her mother to use. Two days after the birthday party she revised the paper interface that allows people to add audio to the book (Fig. 3, right). She cut up the authoring control panel and supplemented it with her own more detailed instructions. Here again we note the benefits of paper.

Most people authored content by circling a face within a photo and attaching a message directly to that area (Fig. 4, left). The pen comes with a non-marking pen tip, and several family members requested this; however, they used the marking tip during the authoring process to help Ethel identify interactive regions. Over time Alice improved upon this and learned to put a large “tap here” region lower on the page, closer to where Ethel would sit when tapping the photos:

“I have found that due to her [Ethel’s] limited arm mobility it is better to have the area to be tapped at the bottom of the page so that it is easier for her to reach rather than the faces circled. Of course it is good to have faces circled if that person is actually talking to her.”

Traditional paper photos (without dot pattern) and other paper objects were also integrated into the photo album. Family members added interactive dot pattern stickers that are part of the TAP & PLAY toolkit to regular photos and to greeting cards Ethel received at her party (see Fig. 4, center). Tapping on the card played an audio message associated with that object (i.e., read the birthday card aloud).

As a close caregiver of Ethel, Alice naturally became the main person in charge of the photo album. She worked to improve the album and make it a better experience for Ethel. She supplemented missing material: “I have had to rerecord one picture because part of the sentences were missing.” She even reorganized the photos in the book: “Using the book was a learning experience for me... as time went on, I added new pictures and began to arrange the pictures in better order.” Alice organized multiple photos of the same person into groups (e.g., stacked photos as in Fig. 4, right) and placed immediate family members near each other in the book order.

Ethel is in full-time nursing care at her retirement community and a team of nurses help care for her. Alice took photos
of the nursing staff who work with her mother. She printed
these out on her home printer, added them to the album, and
had each person add a message for Ethel (Fig. 5).

Audio Annotations
Two researchers performed a content analysis of the photo
album and coded each audio recording identifying recurring
features of the audio messages. The coding scheme evolved
and was updated as additional features became salient. We
identified the following features of each audio recording:
speaker name(s), whether multiple people are part of the au-
dio, explicit identification of speaker, identifies others, states
a relationship (“this is your husband”), identifies objects in
the photo, the event captured in the photo, photo location, the
purpose of the photo, a marker of time (“your 101


Figure 6. Audio messages visualized as part of the family tree. Every cir-
cle represents a person, its size is the number of messages recorded, and
its color gradient the average number of features used in the messages.

People used both time and place descriptions to put the photo
in context for Ethel. Twenty recordings included markers of
time such as death of someone in a photo or a past birthday.
For example Ethel’s son David said, “Hi Mom, this is Minnie
and myself quite a few years ago before Nicole passed away,
and these are your grandchildren.” Recordings also identi-
fied the event captured in the photo (24 recordings) and/or
the location (21 recordings). Some recordings were more ex-
periential in that they described details of the environment or
mood during the photo. For example, Mary (Ethel’s daugh-
ter) recorded rich details about a photo taken in the 1940s:
“I can still smell the pine cones. I can remember the water.
I can remember us standing and taking this picture. I don’t
remember a lot about my childhood, but this I do remember.”

While the system only involves a single digital pen, there
were many opportunities for collaboration. The large size of
the photo album enabled sharing between people. The au-
thoring process itself generated new opportunities for inter-
action among co-present individuals. Eighteen audio record-
ings were created by multiple people at once (i.e., two or more
people talking during the same recording). One recording in-
volved nine different speakers, including Ethel. Several of the
multispeaker recordings capture instances of banter and teas-
ing between family members (see Table 1). This dialog about
the photo, also called phototalk [6, 10], is now archived and
associated with the image that was part of the original con-
versation.
Later in the study Alice commented on the need for clear, succinct recordings: "The people speaking need to prepare what they want to say so time is not wasted." Alice made this comment after the pen’s memory filled up, and she indicated to our research team that she would have spent less time on certain recordings, specifically narrating the birthday cards. Currently it is possible to unlink an audio recording from a region on paper, but it is not possible to permanently delete recordings through the authoring toolkit. This facility would be useful in future deployments.

Nearly all audio messages were directed towards Ethel in the second person. Audio recordings address Ethel directly (as mother, grandmother, etc) with personalized greetings. The only two audio messages that spoke of Ethel in the third person were those created by nursing staff. Fourteen recordings provided meta-information about a group of photos, while the individual photos contained more detailed specifics. Two recordings provided Ethel with additional instructions. For example, Alice recorded the following: “This is a picture of you with all four of your children. Tap on the faces that have a circle around them to have them tell who they are.”

**Photo Album Use**

We observed Ethel using the photo album in her room at the retirement community several days after her birthday party. Alice demonstrated how to use the pen to tap on photos. Ethel was able to independently tap throughout the album. During this first experience, Alice helped by turning pages and pointing out interactive regions. Ethel has arthritis in her hands and is now unable to write, but she was able to hold the digital pen and tap on different parts of the page. Ethel listened to the audio played by the pen. Alice asked her mom, “What do you think of it [the photo album]?” Ethel replied, “Well, it’s great! Great to see all the people.” After observing her mother, Alice said, “She did very well, especially for 105.”

An important aspect of this experience is that it is guided by a caregiver but self-paced by the older adult. It is not a passive experience; Ethel’s actions are required for progression through the book. Alice continued to use the photo album with her mother and regularly sent our research team emails about usage. In an email Alice reported:

“I took it to [Ethel] today and started it up for her and she just took off. She tapped on the pictures and listened with delight, smiling a big smile. I sat with her for thirty minutes while she did it all herself and then she continued for another hour, handling it completely by herself... It was a huge success for social interaction. She was the center of attention and loved it. Earlier in the day she was dozing in her chair and not focusing on anything. This brought her to life.”

After one evening session, Alice commented, “She goes over and over it. It was time for her to get ready for bed but she didn’t want to stop.” A few days later she explained that the album was even changing their daily routine: “[Ethel] has been using it daily for the past few days... We used to watch television from six to seven when she goes to bed but now we look at pictures. She often says, ‘oh, yes I remember that.’”

**Logfile Analysis**

After six weeks, we collected the digital pen and photo album to examine the status of the album and the pen’s log files. Ethel and her family used the digital pen for 1054 minutes (17.5 hours). Ethel’s family created 154 audio messages and various messages were accessed 1151 times. Unfortunately the family filled the memory capacity of the pen after just six weeks of use. Surprisingly, the family wanted the photo album back even if it meant they could not add new audio recordings. Alice wrote to our research team: “I missed having the book last evening. [Ethel] seemed lethargic, the book brings her truly alive. It brings back the past and it seems very happy memories.” Observing this change in her mother, Alice attempted to continue the project on her own by printing out paper photos and bringing them to her mother to discuss. Alice explained that this did not work well: “I tried just computer pictures of the family but that didn’t hold her interest.
She wanted me to put them in the ‘book’.” Per their request, we returned the pen and photo album to the family in a “play only” mode that would allow them to access previously saved audio but not add new recordings.

After five months of use, the family returned the album to our research team for a final analysis. The family accessed audio recordings an additional 606 times during weeks 9-22. During this extended deployment use stabilized to roughly 30 minutes per week. Figure 7 illustrates this usage data. Of the 104 linked audio recordings, 95 of them were replayed 10 or more times. Seven audio recordings were accessed 25 times or more (maximum of 33 times). Six of the seven frequently played recordings were directly related to her 105th birthday or a previous birthday. Also, six of the seven recordings were recorded by Ethel’s children (the other was by her grandson).

Cognitive, Social, and Physical Impacts
We surveyed Ethel’s closest family members (n=5) and her nursing staff (n=4) about their observations of Ethel after the first six weeks of the study. All nine respondents said they saw improvement in the quality of conversations they had with Ethel as well as her interest in socializing with others. Eight people reported improvement in Ethel’s overall happiness, responsiveness, alertness, and willingness to interact with others. A certified nursing assistant commented, “She seems to be more interactive in the evenings.” Five people said that they observed improvement in her range of motion of her right arm from tapping the pen on pages in the album. Alice commented, “One physical improvement I have noticed is that she is stretching her arm out to tap the faces and is improving her arm mobility.” The physical consequences of the prototype are interesting and unexpected.

Reflection and Remembering People
The photo album provides a resource for reflecting on the past and remembering people in Ethel’s life. Alice said, “...if the pictured person spoke it made the connections stronger.” Ethel’s photo album contained emotional photos of her deceased husband. The transcript and image shown in Fig. 8 are one example. Here, Ethel taps a photo of her husband. The pen plays back a conversation Ethel and Alice had about this photo several weeks prior. In the immediate situation, Ethel reflects on not only the paper image but also on the archived conversation. This example again demonstrates how phototalk is captured and revisited as part of this technology.

Alice reported a change in Ethel’s behavior: “She doesn’t point to the bulletin board as she used to, asking me if I knew all those people. I took the pictures in question off the board and put them in the book with comments telling her who they were and in some cases the circumstances of the pictures.” One certified nursing assistant (CNA) said that Ethel “will show me family pictures on the wall and tell me who they are. She never did that before.” Ethel’s daughter Mary explained, “The good thing about the album was that it helped her to recognize those family members she does not see often.”

At the end of the study, Alice reported via email: “By repeating the process of looking at the pictures and hearing the recorded comments, she gradually learned who the people were... Now when she sees some of these people, she has something to attach the current people to the pictured people and remembers names much better.”

Supporting Social Interaction & Engagement
One positive effect of the photo album is that it provides a focal point for social interaction. It is evident in Alice’s reports to our research team that the photo album provides an effective way for Alice to engage her mother in interaction. Several weeks into the study Alice explained, “[The photo album] is a wonderful focal point for the hour I spend with her each evening. It serves as a bridge in fostering communication.”

The availability of the photo album also changed Ethel’s interactions with other residents at the retirement community. Alice describes one such situation:

“Last evening one of the residents came to [Ethel’s] door in her wheelchair and wanted to come in to visit. We had just started to use the photo album... [Ethel] was so pleased to show her the pictures and tap on them. She told her who some of them were... She actually talked to her, which is unusual because she doesn’t usually interact with the other residents. The album was the focal point and stimulated interaction.”

Interestingly, Alice called this event to our attention several times and said, “it was unusual behavior for [Ethel]”. On other occasions Ethel’s care staff went through the photo album with her as part of therapy, similar to that done in [36].
**Care Staff Support**

While refinements are required before widespread adoption of this system is possible, the nursing staff was generally positive about the photo album and wanted one for the common area of the retirement community. Alice said of the nurses, “Their response was overwhelming.” One nurse commented, “This interactive photo album is an awesome tool for the elderly... It would help the elderly to work their minds and memories and give them so much pleasure.” Another nurse added, “I think this project is so fascinating and it is such a wonderful tool for anyone to use.” It is encouraging to see nursing staff in strong support of this approach, as many older adults would rely on nursing staff to help them use such a photo album rather than immediate family as in Ethel’s case. The photo album is a cooperative tool that provides opportunities for social interaction and fosters communication, and as such the success of the approach relies on shared use. The dependence on a support person to use the album, however, is also a limitation of the current design.

**Limitations and Challenges of Design**

Based on this field deployment, we identify aspects of the system design that need improvement. The form factor of the Livescribe pen, with its integrated microphone and speaker, worked well in the field. However, the pen’s internal speaker is far from sufficient. Ethel and her children needed volume amplification through an external speaker as done in [35, 36]. Recording, listening to, and revising audio was a common pattern in authoring, and the TAP & PLAY interface enabled this with ease. A challenge is that the system does not allow users to delete audio recordings. This is intentional for research purposes but consequently contributed to the memory shortage that prevented the family from creating additional recordings. Similarly, several family members were concerned about losing the contents of the pen and wanted backup copies to be generated. Our current system does not have a way for end-users to do this, so the research team had to step in and backup the system for the family. While the play-only facilities of the pen (as in the latter part of the study) were sufficient for several months, the family still wanted to generate new content for Ethel. Content needs to be updated and improved upon regularly. This helps engage the older adult and her broader family. Enabling dynamic authoring of interactive paper photos is critical, and we are currently refining our software to allow for longer term use in the field.

**DISCUSSION**

In this paper we present an analysis of how one extended family authored and used an interactive paper-digital photo album to support engagement for the family matriarch. This research furthers our understanding of how people create and interact with audio-enhanced photos as well as how this media may support the unique needs of older users.

Digital tools mediate and may even interfere with the photo sharing experience for older generations [10]. Furthermore, all digital photo viewing alternatives require a certain level of technical ability, presenting potential challenges for older users [38]. Interaction through the digital pen, however, was straightforward for Ethel at age 105 and her children who are in their 70s and 80s. Building on prior work [36], we found that the digital pen integrates selection, recording, playback, and annotation in a way that is appropriate for older users.

This approach is also multigenerational, working well for young children and older adults, and allows for intergenerational expression [8]. Moreover, the interactive photo album presents an opportunity to bridge the “Kodak generation” with younger digital generations. Building on the need to include the practices of younger users as well as enable remote photo authoring, we are currently integrating our system with Facebook photo albums in a printable form.

Uniquely, our system allows phototalk to occur as it often does around traditional paper photos, but now those narratives can be recorded and replayed during subsequent viewing experiences. Lindley et al [26] note that captions, annotations, and digital storybooks elaborate a photo but may not afford true dynamic interaction that happens in face-to-face and in situ viewing experiences. Our approach begins to bridge this divide. Archiving this evolving narrative not only serves as an important family artifact but it may also provide anchors for improving older adults’ memory as described in [15, 24].

The photo album is an interesting artifact to examine for research purposes, but at the conclusion of the study, who owns the materials? The physicality of the album and the fact that it was presented during Ethel’s birthday party gives it properties of a gift item. At the beginning of the study, photos were printed on dot pattern paper with the help of the research team, but after that point the family evolved the photo album on their own. It also became an important part of Ethel’s, and perhaps Alice’s, life. After our final analysis, the family will maintain ownership of the materials and content.

**Recommendations for Authoring**

Our data indicate that the interactive paper photo album is a powerful tool for families, but particularly the primary caregiver (Alice), in that they can design custom photo sharing or reminiscence activities for a loved one. As part of this, the primary care giver plays a critical role in the photo album’s success. This person helps manage the album, organize it, adds and refines content, and then supports the older adult in using it. In our work we observed that Alice took on the role of curator, presenter, and primary author of the album [26]. Based on our analysis, we provide recommendations for authoring subsequent albums with the goal of engaging and stimulating an older adult.

- Photos should be large and clear. Alice suggested, “Big and clear pictures are the best for someone who is old and may have trouble seeing.”
- Interactive regions should be indicated clearly, perhaps with additional labeling (e.g., “Tap Here”). The older adult’s arm mobility should be taken into account when determining the location of the region on the page.
- Audio narrations linked to a person’s face are good if that person is talking and seem most natural when directed toward the older adult using second person language.
The photo-audio combination is most useful when together it includes the person’s name (spoken and written), the context of the photo, and a marker of time.

Large group photos (over 5 people) can be problematic because the faces are typically smaller and there are many people for the older adult to identify within a single scene.

Rather than a chronological ordering of the album, grouping family members and multiple photos of the same person together, may be more valuable for improving recall of names.

Curating and Further Authoring

Alice’s close relationship with Ethel naturally shaped the interaction and authoring of the photo album. After the birthday party Alice became the curator and the keeper of the album. This influenced access to the album for Ethel, but also for other family members, especially in terms of further authoring. This is well visible in Fig. 6, where the family tree outlines how most of the messages have been generated in Alice’s family branch. In fact, while collaborative access to the album with different family members continued throughout the study, family only present at the birthday party did not have opportunities to participate in further authoring after the party. This limited the evolving nature of the photo album.

The role of the curator is a fundamental one for enabling access to the interactive photo album for older adults, however we realized that alternative access for further authoring is desirable and would enable the album to evolve over time independent of the physical location of family members. In our current work, we are exploring ways of enabling remote access for authoring audio enabled printed photos. For example, we are designing a dedicated Facebook application to enable remote authoring, while local software installed on a computer at the retirement community would enable automatic upload to the digital pen of the audio messages recorded through Facebook. A local printer can then print the interactive photos for inclusion in the photo album. The role of the curator becomes therefore even more important.

CONCLUSION

We presented a five-month field study of the use of a paper-digital photo album designed to support late-life social interaction and engagement. We demonstrated that even for a person at age 105, digital pen technology is easy to use as an input device and supports powerful applications such as interactive audio-enhanced paper photos. Family members of all ages were able to add audio messages to the photo album. Messages identified people, described relationships, referenced past events, and had many other features. Personal photos and custom audio recordings provide meaningful stimulation and engagement. After using the interactive photo album for just six weeks, Ethel’s family and caregivers reported improvements in several dimensions of social interaction. Furthermore, our research prototype became a positive part of Ethel’s daily routine. While many factors may be involved in Ethel’s improvements and the family’s attraction to this system, the promise of technology to add personal voice recordings to normally static images is clear. Photographs have always functioned as catalysts for social interaction and anchors [41] for discussion. Making them multimodal and interactive makes it possible to explore new mechanisms for encouraging social interaction and engagement. We see great promise in exploring this approach with additional user groups who may benefit from rehearsal of peoples’ names and faces as well as customized content that facilitates face-to-face social interaction.

REFERENCES


