FamilyStories: Asynchronous Audio Storytelling for Family Members Across Time Zones

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ABSTRACT

Family members who are separated across time zones can easily miss out on feeling connected. We designed and studied the usage of an asynchronous storytelling system, called FamilyStories, to explore the use of audio-based sharing. FamilyStories allows family members to share activities and experiences over distance in different time zones using three different devices that contain different contextual features. To evaluate the design, we conducted a five-week long field study with two family member pairs. Our results show the value of slow, flexible, and non-suggestive interfaces for asynchronous audio communication. We also found ephemerality helped in the sharing of 'instant' feelings, while large time zone differences could be 'synchronized' with time delayed messages. We raise these as design opportunities for asynchronous audio storytelling systems.

Author Keywords

Family Communication; Domestic; Audio; Asynchronous Communication; Slow Technology

ACM Classification Keywords

• Human-centered computing ~Human computer interaction (HCI) ~HCI design and evaluation methods ~Field studies

INTRODUCTION

Family members often use technology for connecting over distance, especially when time zone differences are present [6,36,51]. Typically, this consists of using a range of synchronous communication tools, such as video chat and phone calls, as well as asynchronous systems like instant messaging [6,7,51]. Despite these technologies, communication can still be challenging. When using synchronous systems, it can be hard to find times when both people are free and available. For example, schedules may be misaligned across time zones (e.g., daytime vs. nighttime) [6,7,28]. Asynchronous communication systems are typically flexible to use and overcome some of these challenges, yet the shared content and exchanges may not be as rich as synchronous exchanges where people can have conversations, share stories, and react to them [6,28].

For these reasons, we explored ways to enliven asynchronous communication through audio storytelling. Audio narratives have been shown to allow people to capture the sentimental value of a moment and stimulate people's imaginations to mentally rebuild past moments [41]. This is because audio contains characteristics of people's voices such as pitch, intonation, range and loudness, which connects people to a moment socially and personally [44]. Audio also helps people characterize others based on their voice [44].

We designed three technology probes called *Spark, Kinetic, and TimeKnot.* Together we call them FamilyStories. Each probe allows a person to record an audio story and send it to another family member that has the same device. When received, the family member can listen to the story and send one back. As an exploratory tool, the technology probes differ in how people can listen to the recordings. We were interested in exploring how context and varying degrees of access to the stories would impact the experiences of family members. *Spark*, one of the probes, makes stories have a temporary lifetime so they have to be played back in a short amount of time. *Kinetic* tries to enforce an idea of 'shared activities' where stories can only be listened to if the recipient is doing a physical activity that is similar to the sender's activity. For example, if the sender is going for a walk while recording a story, the recipient must also be walking while listening. *TimeKnot* restricts the playback of stories to the same general time of the day for both family members. For example, if a story is recorded in the morning, it can only be played back in the morning. We used the technology probes to help us identify what factors are important for designing systems to connect family members across time and distance with shared audio stories.

We conducted a field study with two pairs of family members over five weeks to evaluate the technology probes and understand the design context better. Each member lived

CHI '20, April 25–30, 2020, Honolulu, HI, USA

ACM ISBN 978-1-4503-6708-0/20/04…$15.00
https://doi.org/10.1145/3313831.3376486

in different time zones. Our study contributes insights into how asynchronous technologies can be designed for families to communicate more richly through audio storytelling. This includes the benefit of scattered and delayed responses; how ephemerality can help users express a range of emotions; the specialness of dedicated in-home devices; how time delayed messages can help synchronize people across large time zone differences; and the potential for movement triggered messages to trigger focused and thoughtful engagement.

RELATED WORK

Family Communication over Distance

The family communication literature is rich with explorations of technology design and usage. Family members face many challenges when trying to stay connected, especially when separated by distance. Some challenges are efforts for communication [51], creating a balance between desirable amounts of communication, and feelings of obligation to respond to family members [48]. People also have varying needs for how much they want to connect with different members depending on where they live and what their relationship is like [33].

Family members tend to prefer synchronous communication technologies, such as video chat, due to its real-time nature [7,28,51]. For example, because it can be hard to maintain children's attention over phone calls, video chat is desirable for communication between grandparents and grandchildren [13]. Current video communication technologies (e.g., Skype, FaceTime) are typically designed for face-to-face communication and have been shown to be challenging to use for sharing activities in the home or outdoors [5,14,30]. Sometimes people are also concerned about their privacy, the way they look on camera [5], or challenges with multitasking while communicating with a family member [5]. This is because people often feel obligated to stay in the camera view during a video call [17].

Asynchronous communication systems are designed to bring flexibility to communication by allowing people to communicate with each other at different points in time. Asynchronous video communication has been studied in home contexts [2,53], including connecting children to friends or remote family members [12,53]. We know that asynchronous video can support self-expression and playful communication [12]. Asynchronous video applications have also been studied for mobile phones. Results showed such systems are able to support communication that is similar in nature to synchronous systems with the added benefit of flexibility around when video messages could be sent [53]. Asynchronous systems have even been studied for connecting family homes with shared video snapshots, recorded video, and images [3,22,25]. They were also used for sharing specific activities such as shared dining across different time zones [32,52], which made participants feel more connected with their loved ones while dining. Researchers found value in this type of sharing but sometimes privacy challenges emerged [25]. That is one of the reasons why we chose to focus on asynchronous audio sharing. Audio allows engagement during mundane activities [20,21]. Audio also can be used almost anywhere and anytime with relatively few privacy issues.

Audio as a Medium

Research has shown that sharing audio between two people over distance can play an important role in making them feel connected [41,46]. Audio has been shown to feel less 'staged' and more spontaneous, it also can create sentimental feelings when they are heard back [41]. Several studies have explored the effect of soundscapes in the domestic realm [24,29,41,42,43]. These studies have shown that families value hearing specific sounds in their home such as ambient sounds, voices, spoken words and everyday domestic sounds, which represent life as people experience it [29,41].

Lottridge et al. [29] studied sharing music playlists and background sounds of mundane activities. They studied couples in long distance relationships separated across time zones. The study highlighted the importance of soundscapes for connecting couples through ambient sounds and shared music. Other studies have investigated audio clips recorded within homes. This included the archiving of soundscapes within the home or recording people's voices [41,42,43]. For example, Oleksik & Brown highlighted the importance of timing in home recordings, and the power of audio in creating strong visual and emotional reactions across time and space. One of the works focused on using audio clips for asynchronous communication between children and parents through a plush toy [24]. The study found that audio clips can help parents know more about the personality of their children. As part of our design work, we also explore the emotional value of audio for sharing experiences over distance. The difference, compared to these works, is an emphasis on storytelling, shared contexts (e.g., similar activities, time of day), and aspects of slow technology.

Dedicated Devices and Connections for Family Members

Computing artifacts have been designed for connecting family members during one-to-one communication where a single device is designed for a user to connect with just one other person [8,9,11,15,50,31,55]. This includes a strong emphasis in the literature on connecting long distance couples. For example, Gooch and Watts created three prototypes to simulate holding hands over distance [15]. Singhal et al. created a prototype that allowed couples to connect through touch over distance using vibrating gloves [50]. Studies have shown that people value the intimacy and emotional connection of dedicated devices and simulated touch [15,50]. Computational artifacts have been used for connecting children with their parents and grandparents by focusing on one-to-one connections [1,48,49,57]. Systems such as PlayPals [4] allowed children to have synchronous video communication with their friends with systems embedded in figurines. FamilyStories uses a similar idea of a device that supports a dedicated, one-to-one connection between two people, yet differs from this work by using audio as the medium for communication.

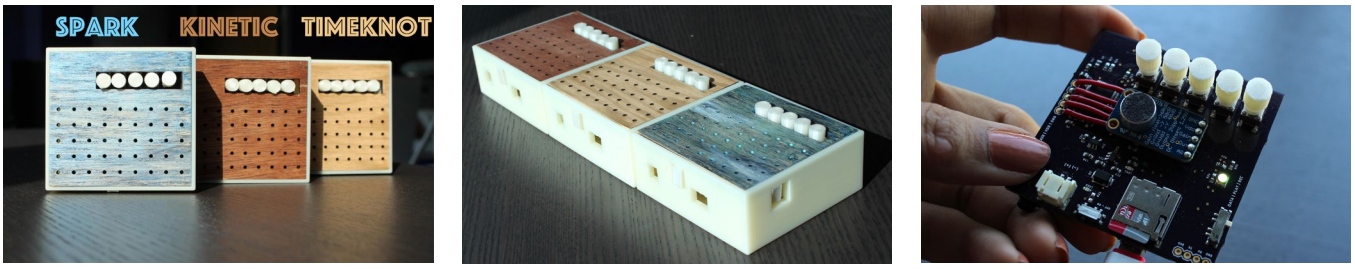

Figure 1. Left: The three devices of FamilyStories. Middle: All inputs and switches shown including On/Off and buttons for record, play, and share. Right: The interior Printed Circuit Board (PCB) designed to easily fit in one hand.

Slow Technology and Reflective Designs

Slow technologies aim to create a more meaningful connection between people and computational artifacts [16,38,39,47]. They are designed in a way that allows users to engage in acts of reflection while using a design [16]. Slow technologies can allow family members to have time to reflect, revisit and create anticipation before and during interactions with a system [38,39]. There have been a variety of slow technologies designed over the past two decades for purposes such as sending messages to family members in the future [18], sending photos and short videos as presents in time [26], reminding people to relax and reflect during a day [10], and connecting users with their photo archives through the use of a tangible stand-alone device [38]. Odom [36] explored how the FutureMe system was used by people to connect with themselves, or their friends and family members, through emails that have been sent to a specific time in the future. King et al. [27] suggested the use of slow audio messaging for couples in long distance relationships, however, no systems were designed or studied.

Building on the related work, we aimed to explore and learn more about asynchronous audio storytelling systems inspired by slow technology with the goal that the system might be able to support conversations that lead to reflection and a sense of anticipation for communication. We began with the design of a series of technology probes described next.

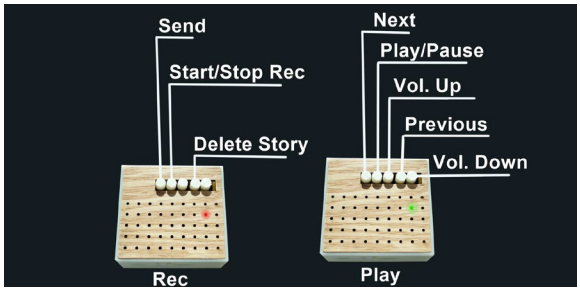

Figure 2. Record and Play mode buttons.

FAMILYSTORIES

FamilyStories consists of three technology probes named *Spark*, *Kinetic* and *TimeKnot*. Each probe is designed to allow family members to connect over distance by sharing audio stories asynchronously. Technology probes are open ended designs that allow researchers to explore how people use and interact with a new type of technology in real world settings [22]. We created FamilyStories through an iterative design process that involved sketching, brainstorming, and creation of several low fidelity prototypes. We were inspired by the appearance of vintage personal radios. We created several mockups of physical artifacts that could be used as a communication device, ranging from prism shapes to cylinders. We ended on a simple, yet minimal look of a cuboid shown in Figure 1.

All three technology probes have the same basic design that consists of a small object that can be carried with a user or set down, e.g., placed in the home. In Figure 1, you can see the exterior of the three probes. The style is minimalistic and purposely does not suggest a type of communication. The exterior design of all three probes is the same, but they differ in the color of the wooden lid on top such that they can be identified easily. We tested several materials prior to choosing the combination shown. Our initial designs were created using cardboard, then simple 3D printed prototypes, and, at the end, we chose to use a 3D printed case with a wooden lid (Figure 1). We chose wood as it has been shown to be durable and valued [37]. We wanted to keep the box light to carry, hence we made the switches, circuit bed and the body of the box through 3D printing. We kept the colors neutral so that they could blend into most homes.

Participants can choose to record or play by using a switch on its side (Figure 1, middle). In the first mode they can record, send or cancel the recording (Figure 2). To record a message, the user pushes the 'record' button on each device (Figure 2) and then tells their story. When the story is done, they push the 'record' button again to stop. Next, they push a 'send' button to send the message. Sound is recorded through a built-in microphone inside each of the probes. The recorded sound could not be played back for the sender. This was to keep the communication similar to a conversation in-person or on the phone. To listen to the stories, users put the device into play mode with the switch on the side. The buttons now allow users to move to the next Story, play/pause, adjust the volume up, move to the previous story and adjust the volume down (Figure 2). In Record mode, when 'record' is pushed, a notification LED turns red to signal to the user that audio is being recorded (Figure 2, left). In Play mode, when the 'play' button is pushed, the LED will turn green to signal playback of the story (Figure 2, right). Each device connects to the server to download new messages every 15 minutes or by user request.

To listen to an audio story, family members use their matching probe. For example, if a family member sent a message on *TimeKnot*, the receiving person must play it on

TimeKnot. There is no limit on the length of a story. We wanted to let users choose what made sense given their situation. Stories can be from several minutes to as long as the family members would like to talk about a subject. Our goal was for family members to listen to the audio stories individually with headphones so as to create a more intimate experience with the remote family member. Next we describe each of the FamilyStories probes.

1. Spark: Ephemerality and Ambient Notification

The first probe is called *Spark.* Given a prominent focus on ephemerality in social media [56], we were inspired to explore the influence of ephemerality on family communication. This device is just like a 'spark', a conversation starter with a short lifetime: stories are automatically deleted after one week, regardless of whether they are listened to. We decided to use a metallic blue color for *Spark* so that it can catch the attention of family members and encourage them to listen to its media before messages are deleted. We used ambient notifications [45] to increase the sense of ephemerality of the messages. For *Spark*, a white light pulsates when new stories are available, similar to the frequency of a heartbeat, indicating each message has a life of its own. When the message is near to being deleted, the intensity of the light is lower, and the pulsating has a lower frequency until it stops beating and the message is deleted.

With *Spark*, users have minimal control while stories are being played. This contrasts with many existing technologies where the content is almost always accessible. Family members are only able to stop, pause, and play stories, and messages are played from oldest to newest without being able to change this order. This limited control was meant to engage people 'in the moment.' We also wanted the conversation to feel similar to in-person conversations.

As an example, consider Luna, a 56-year-old mom and her 22-year old son Daniel. *Daniel moved to Italy for work and his mom lives in the USA. They have a nine-hour time difference. Luna wants to send her son an update of her week while she is relaxing at night. She records an audio clip on Spark and sends it to Daniel's device. Daniel comes home (at his house in Italy) and notices that Spark is indicating a new message. He decides to listen to his mom's message tomorrow morning since it's his day off and he knows he has a week to listen before its deleted. This will allow him to both listen and reflect on their connection and the subject which his mom talked about. In the morning, he picks up Spark and presses the play button. He uses headphones to listen to the message. FamilyStories reminds him of the closeness that he and his mom share and makes him feel comfortable since he chose to listen to the message during his free time. While he is listening to the message, he engages in different activities at home. He presses record on Spark and records what he wants to tell his mom in return.*

2. Kinetic: Activity-based Sharing

The second probe is called *Kinetic*. It was created to promote a sense of shared moments while engaging in a physical activity. For example, to simulate a shared walk, if a person records a message while walking, this probe will only play the audio if the other family member is engaging in a physical activity like walking. The device detects movement with an accelerometer inside the probe and does not categorize based on type of activity. While somewhat overly simplistic for mapping two activities, this does enforce the idea that if a person is moving while recording a story, movement is similarly needed while listening on the receiving end. *Kinetic* was designed so that it could be used for sharing walks, hikes, and activities which the user can do while listening to the audio stories.

As an example, consider Elena as an individual who likes to share a walk with her mother, Rose, while being apart. *Elena decides to use Kinetic to share a moment and conversation around it with her mom who is living in a different time zone. Elena goes for a walk and uses Kinetic to record a story about her workday and how her family is doing. She finishes her walk and the recording is sent to her mom's device. Her mom looks at Kinetic and notices the new message LED is on. She puts on her headphones and takes Kinetic with her outside for a walk so she can listen as well. After listening to the message, her mom records a reply for Elena and sends it to her. The exchange continues across a series of days and weeks while both Rose and Elena go for walks.*

3. TimeKnot: Context of the Day

To explore the effect of the context of the day on communication, we created *TimeKnot* which only plays messages during the same time period of the day for family members. That is, messages sent during the morning can only be played back in the morning, etc. We created four time slots, morning (6 to 11:59am), noon (12 to 5:59pm), night (6 to 11:59pm) and late night (12 to 5:59am).

As an example, consider George and his sister living in different time zones. *George sends his sister a message about his new goals and visions about life. He has recorded the message at night. His sister will only be able to play this message during her night time. The message is not playable at other times of the day. The notification only turns on during that specific time period.*

STUDY DESIGN AND METHODS

We designed and conducted a field study with FamilyStories to understand the potential benefits and challenges of sharing audio stories over distance. We wanted to understand how the three probes would be used and how the design factors including ephemerality, sharing tied to physical activity, and the context of the day would impact the experience.

Participants

We recruited participants who had family members in different time zones to participate in a five-week field study of the system. Two pairs of family members were recruited for this study through word of the mouth. Each pair had a family member who lived in Vancouver, Canada and the other family member lived in a different time zone. We asked basic background information from our candidate

participants to make sure they met the requirements of the study. For example, we checked to see if they had a 'good' relationship with the family member (e.g., desire to stay in contact, active communication) and comfort with using new technology. We only focused on recruiting pairs of immediate family members such as parents and their adult children, couples, and siblings for this study to scope the targeted audience. We felt these types of relationships would be most likely to find FamilyStories as being valuable. We recruited two different types of close relationships, romantic and familial, to see how people in each type of relationship would use the probes.

Pair 1: Benjamin and Joyce - Couple

Benjamin and Joyce were in their late 20s. At the time of the study, Benjamin was a PhD student who had been relocated to the UK for a three-month internship. The study started in the middle of his internship. He lived in a shared home with another person and so did Joyce. Joyce was a software engineer who was working in Canada. The time difference they were experiencing was eight hours. They had been in a relationship for more than a year. When they were living near each other they loved to do many things together, including cooking, walking, watching TV, and just spending time together. Now that they were in a long-distance relationship, they used video chat every day at a fixed time when Joyce came back from work and Benjamin had just woken up. They loved video chat because they could see each other's face and express their emotions easily. Joyce liked voice memos too and preferred to leave voice memos in messaging applications rather than typing text.

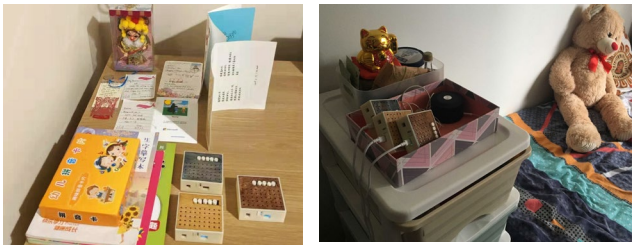

Figure 4. Left: Benjamin' spot for keeping the devices. Right: Joyce kept the devices either in her living room or her bedroom.

Pair 2: Shea and Ayla - Sisters

Shea and Ayla were two sisters in their early 30s who lived in Canada. Shea lived in Vancouver with her husband and their cockatiel pet and Ayla lived in Ottawa with her fiancé and her puppy. They were separated by a three-hour time zone difference. Shea was a business development manager for a pharmaceutical company and Ayla was a cancer researcher. They had a close relationship and managed to stay in touch where they lived in different cities and time zones throughout a ten-year span. They had experienced living in different continents with a 12-hour time zone difference. They usually kept in touch daily. They mostly enjoyed talking over the phone or leaving voice memos on text messaging applications, and usually had one video chat call on the weekends. When they used to live near each other, they would do many things together such as shopping, taking a walk and meeting in different restaurants and coffee shops. Now that they were away, their conversations focused on updates about health, major events, opinions about different purchases, and family related topics.

Figure 3. Left: Ayla placed the devices on her desk. Right: Shea kept FamilyStories on her night stand in her room.

Method

After recruiting the participants, one of the researchers performed a home visit and met the local person. Then, the FamilyStories devices were setup to connect to the participants' Internet connection and participants were shown how each device worked. The researcher had a video call with the remote participant and walked them through how to setup and use the devices. During the first two weeks of the study, participants were suggested to send at least four messages with each of the probes, two each week. This was so that they would be sure to try out each technology to see how it might benefit them, or where they felt it created challenges. During the second week, participants were asked to choose a device and send a 'life event'. After the first two weeks, participants were told they could use the probes as frequently as they liked, without restrictions.

Participants were asked to complete an online diary either in the form of an online document or voice memos soon after using a probe. They could document their thoughts on their interaction and communication. Their usage data, such as the number of their messages and their length, was logged by the system. A group message thread was created through text messaging applications by one of the researchers as a medium to be connected with both partners. The group chat was used for sharing general information about the study or issues participants might be experiencing.

During the study, we conducted four semi-structured interviews. The first interview was at the start of the study before they used the probes and was meant to be an introduction for us to learn more about our participants' experiences with communication and connectedness over different time zones. Questions focused on collecting background information and for understanding the process of how participants currently use technologies for connecting over distance. Questions such as "*What are the technologies you prefer to use to connect with your family member? Why*", "*How much time do you think you spend communicating with each other each week*?" The first interview lasted on average 1.5 to 2.5 hours. Interviews were conducted over video chat with family members at the end of Week 2, and end of Week 3 or start of Week 4 depending on the availability of the

participants. Interviews explored how participants used each of the probes and how the probes influenced their connection with their study partner. Questions such as "*Tell me about your recent communication with FamilyStories*", "*Can you walk me through your experience with <Name of the specific probe>?"* were asked in these interviews. The field study was concluded with a summative interview. A group video chat with both study partners was done as a closing interview. These interviews lasted from 20 to 60 minutes.

DATA COLLECTION AND ANALYSIS

All the interviews were recorded and transcribed. The data log was collected. We used open, axial and selective coding to explore how the system was used as part of participants' regular routines. This included exploring the influence of each of the major design factors found in the technology probes. We also investigated whether audio storytelling could help with creating more meaningful and reflective communication compared to current communication technologies. The data was analyzed by one researcher and then codes were discussed as a group and refined. Lastly, we used a combination of selective coding and affinity diagramming to analyze the data and extract main themes such as *general usage, non-urgent and expressive from the heart, ephemerality and importance of the longevity, dedicated devices,* and *triggered accessibility.*

LOCATIONS AND GENERAL USAGE

Each of our participants chose a spot for all three of the FamilyStories devices. Figure 3 shows the locations for Pair 1. Benjamin put the devices in a special location for him that reminded him of Joyce, next to all her gifts and postcards. Benjamin usually carried two of the devices with him when going out. He left *Spark* at home since the messages on that device were more personal to him. Joyce setup her devices on a nightstand in her room (Figure 3, right) so she could listen to the messages privately. Joyce changed the location from the living room, to next to the kitchen, and then managed to set them up in her room.

Figure 4 shows the locations for Pair 2. Ayla setup FamilyStories on her desk in her room. Shea put the devices in her room next to the nightstand because she loved messaging her sister before going to bed.

All four participants would carry some of the devices around the house while multitasking and listening to the stories. The timing was usually when they wanted to relax.

"You might find this funny, sometimes I take a lot of it in a box and take it to the living room and have my cup of coffee. Listen to it all." – Pair 2, Shea

Although the devices were portable and easy to carry, three of our participants rarely took the devices outside of the home. This was because they were either busy at work or they faced connection issues with the Internet.

SCATTERED PATTERNS OF USAGE

All of our participants listened to the messages on the FamilyStories devices whenever they saw them. None of them experienced the deletion of a message on *Spark* without being able to listen to the messages within a week. We had envisioned FamilyStories to be an always-on device at home; however, the sisters from Pair 2 would only turn on FamilyStories when they had some time to listen, usually before or after work, and before going to bed.

We had anticipated that FamilyStories would lead to a lot of back-and-forth conversations but at a slower pace. Yet this was not what we generally saw. Back-and-forth messaging did occur, however, it tended to be much slower and less than what one may see with other asynchronous technologies where conversations are nearly real time and in the form of long threads [40]. Sometimes participants chose to even wait a day or two to respond, or not respond at all. This was particularly the case with Pair 1. If it was an emotional message needing reflection, they would wait and gather their thoughts and respond later or mention it in their daily video chats. This 'scattered' pattern of answering did not usually cause frustration for our participants if it was just a couple of days. However, Shea from Pair 2 said she sent a few messages in Week 3 and did not get any response or acknowledgment from her sister within a week. This disappointed her and caused her to not use the devices for a while, since she was not sure if her messages were being sent.

Our participants used FamilyStories to share stories for a variety of topics, including greetings such as wishing each other a good night sleep, or a good start to the day. They also used it for important information about their everyday life, such as loss of a family member (will be discussed more later), asking each other how they handled a stressful situation at work, reflecting on good memories, or light topics such as decorating a new place, and general daily updates. Sometimes they used the devices to encourage each other for projects at work, or just to encourage each other to enjoy their time during weekends.

Table 1:Messages sent per week and their avg time in min:sec.

Device: Participant's Name	**W1**	**W2**	**W3**	**W4**	**W5**	**Total**	**Avg Time**
Pair 1, Benjamin and Joyce							
Spark: Benjamin	1	1	1	1	1	5	5:41
Spark: Joyce	4	1	1	1	1	8	0:49
TimeKnot: Benjamin	3	2	1	1	1	8	0:26
TimeKnot: Joyce	6	1	0	3	2	12	0:22
Kinetic: Benjamin	3	0	2	1	0	6	1:47
Kinetic: Joyce	1	2	1	0	1	5	0:47
Pair 2, Shea and Ayla							
Spark Shea	1	3	1	1	1	7	0:33
Spark: Ayla	6	2	1	4	1	14	0:17
TimeKnot: Shea	3	2	1	0	1	7	0:29
TimeKnot: Ayla	2	1	1	1	2	8	0:27
Kinetic: Shea	4	2	1	0	0	7	0:40
Kinetic: Ayla	2	2	1	1	1	8	0:20

Table 1 shows the number of messages sent on each device per person during each week and the average length of the stories. As can be seen, messages were generally quite short,

most often less than a minute in length. The minimum time for messages was 5 seconds and the maximum time was 20 minutes. *TimeKnot* was used most frequently by Pair 1, with 20 messages in total, and *Spark* was most frequently used by Pair 2, with 21 messages in total. However, these numbers also include messages sent per our directions for the first two study weeks to try out each device. Even still, after Week 2, *TimeKnot* was used most often by Pair 1, and *Spark* was used most often by Pair 2. Thus, frequency of use tended to stay the same for the devices.

We asked participants why messages tended to be short in duration. They said this reflected their habit of sending short voice messages on mobile applications and feeling that longer topics needed real time discussion. Longer messages usually went into more detail and included people reflecting on their life events. The couple in Pair 1, sent longer messages after the first week that included more of their thoughts about what was happening. Short messages usually included daily greetings, expressing instant feelings of joy or tiredness, reminders, and quick updates about daily life.

We asked participants how they chose between the devices and found they followed their own patterns with some shared similarities. We describe these in the following sections.

NON-URGENT AND EXPRESSIVE FROM THE HEART

Participants felt that their overall communication with their loved one improved with FamilyStories, and that it allowed them to feel a variety of emotions. First, all our participants used the devices as a non-urgent method for communication. In contrast with their usage of mobile phone applications and phone calls, audio messages sent on FamilyStories did not require one's immediate attention. Since the messages were not urgent, family members had an opportunity to talk about things that they might have not spoken about or shared if it was through the use of existing technologies. This was because the timing of the messages might have been inappropriate for the other time zone, or the content may have felt trivial, sometimes emotional and not urgent. Thus, they did not want to interrupt the other person's day.

For example, in Pair 2, Shea usually would record audio stories late at night before going to bed while in Ayla's time zone it would be past midnight. Shea used FamilyStories so she would be sure she was not interrupting Ayla's sleep. Just like when they lived together, she updated her on 'everything' that happened. Shea found that FamilyStories helped her to be aware of what was going on with her sister's life and feel included even while both were experiencing very busy weeks at work and in their personal lives. Shea from Pair 2 and Benjamin from Pair 1 found that communication was similar to exchanges through handwritten letters, since they were also not shared in real time. For Shea it was like she always had something to talk with her sister about, just like when writing a letter.

"Remind me of my childhood when we used to write letters ... so it was overall a really fun experience. It made it like easy to share our daily, you know, what's happening with her. So yeah, it was definitely something very close to my heart." – Pair 2, Shea

Because conversations were 'one way', participants felt they were more apt to share things that they might not have been comfortable or able to share fully synchronously. They were able to let out their feelings without feelings of being judged or interrupted by the other person. They liked the fact that it was audio and not text or video because, for them, it conveyed emotions easily, and they did not have to worry about their appearance while recording an emotional message. These conversations ranged from a deep self-reflective message about life, and the role of the partner in it for the couple in Pair 1, and the range of emotions felt in losing and then finding a pet for Shea in Pair 2.

"Sometimes when a conversation is one way it looks like you have more freedom to express your feelings. The other person doesn't stop you or interrupt you or they don't tell you what they think! It's like easier I think, when your telling your story…It was comforting to just talk about it and then know that she's going to probably understand the way I feel and the way I felt." – Pair 2, Shea

In Pair 1, the couple used the devices to express their love and emotions for each other. This was specifically the case for *Spark* due to its ambient notification feature that was seen by the couple in Pair 1 as romantic as it was like a heartbeat.

EPHEMERALITY AND IMPORTANCE OF LONGEVITY

The longevity of the messages was a major factor for choosing between devices for both pairs. This manifested in different ways depending on the pair and specific situations that emerged across the study. For example, during the first two weeks, the couple in Pair 1 did not consider the ephemerality of the messages as a factor when choosing between the devices. They started using *Spark* for instant messages that were mainly expressing a feeling such as excitement, affection, tiredness from work, etc. They started thinking about considering the role of ephemerality and longevity of the messages after a particular incident. Here Benjamin sent a romantically reflective message, which was precious for Joyce to keep on *Spark*. Yet she started to worry about the message being gone forever and asked the researcher if there was a way they could still have the audio story. This happened after she experienced the deletion of her first two weeks' messages. After this experience, the temporality of the messages was highlighted for them.

"Stuff close to my heart I send on Spark, although stuff that's close to my heart that I want Joyce to be able to keep, like as a gift, I should send some other way." – Pair 1, Benjamin

Joyce from Pair 1 said in her diary that she experienced hearing the bad news of a family member passing away. She felt heartbroken but did not want to interrupt Benjamin's day at work. In order for him to see the message when he got home, she used *Spark* to express the sorrow she was feeling at the moment. She used *Spark* because she also did not want bad news and sadness to linger for a long time, and she wanted the message to be heard once and be gone.

For the sisters in Pair 2, longevity and the temporal nature of the messages was valuable from the beginning until the end of week two of the study. In the first two weeks both Ayla and Shea used *Spark* for instant and short messages. Story topics mainly revolved around "catching up" and seeing how each of them was doing. The sisters used either *Kinetic* or *TimeKnot* to share stories important to them. That was because they wanted to be sure their family member would hear them eventually, and the stories would not be deleted without them knowing about it. Thus, the sisters thought carefully about which device to use. They wanted a device that offered longevity for messages that were important for them to get a reaction from each other.

"… sometimes, it is possible that I miss a message, so I definitely want them to stay longer… I know that I could always go back and listen to the previous one. I think that's definitely something that matters." –Pair 2, Shea

Shea's usage of the devices started to shift during Week 3. She mainly started using *Spark,* since she noticed they both were able to listen to the stories in a week's time period of messages being available. Another major reason for the shift toward using *Spark* more often was that listening to *Spark* messages was more effortless, real-time and with less limitations. In conclusion, she could listen and relax. If she wanted to listen to the messages again within a week, she had learned a workaround that involved restarting the device so that its list of played messages would reset.

Ayla's preferences did not change and she mainly used the ephemeral messages of *Spark* when she had something of lesser importance to talk about with her sister. She mentioned in her diary: "*My sister could listen to them just once and that was not a big deal if she missed some of them.*"

DEDICATED DEVICES

All participants liked the dedicated nature of FamilyStories. That is, they liked that each device was for communication between only two people. This made the connection and each of the devices special for our participants. For example, in Pair 1, Joyce liked the fact that the messages were always from Benjamin. This was different from when she would have a notification from her mobile text messaging application, since the notification could be from anybody in her contact list. When a message came in on FamilyStories, she always knew it was from Benjamin and that made it special for her. To her, this was like receiving gifts each time she had a new message on the device.

"It's so specific... it's kind of like a signal telling me that it's from Benjamin because I use, WeChat I use whatever, everyone can send me a message. but that box is like Benjamin only can send me a message" –Pair 1, Joyce

For our participants, the devices earned a special value since they were a direct representation of their loved ones in their home. This is in contrast to the all-purpose devices that they currently used for communicating with family members.

"…if it was on my phone, they'll be all clustered together and it just wouldn't be as fun I think either."– Pair 1, Benjamin

In Pair 2, Shea talked about spending a great deal of time composing and recording her messages. She crafted each message carefully when she wanted to connect with her sister. This made the communication with the devices more special for her, because it was direct time that she put into her relationship with her sister. Shea also felt that the dedicated nature of FamilyStories made the conversation "their moment". Since she knew the messages were only from her sister. Looking at the spot where the devices sat reminded her of Ayla. Her sister also expressed similar feelings about how she enjoyed sharing this exclusive method of communication with just her sister.

"I had this special feeling being in contact with my sister very exclusively, so it was like me and her had a moment of our own" – Pair 2, Shea

TRIGGERED ACCESSIBILITY

Two of our devices set a limitation on how participants could listen to the audio stories. One limitation was on time (*TimeKnot*) and the other was on activating the newest message based on a specific amount of movement (*Kinetic*). Each feature had benefits and challenges which we describe in the following subsections.

Time Limited Access to Messages

Waiting for the same context of the day to play stories on *TimeKnot* was both rewarding and valued. For example, the couple in Pair 1 liked the idea of playing messages during the same context of the day. Joyce said *Timeknot* had diminished the time zone difference they had with each other and created a fantasy of Benjamin living near her. This caused her to feel like they had synchronized their timing. Benjamin said that with their other methods of communication he would always do a mental calculation of what time it would be for Joyce, or would mention in his text or voice message what time it was for him when sending the message. It was different when he used *TimeKnot* though. Because he knew she would receive his message when she was in the same time as him, he did not worry about interrupting her (e.g., while sleeping).

"It like creates a fantasy that Benjamin, the 'remote Benjamin', is not remote but also still I know that behind the fantasy it's a fact that we are remote." – Pair 1, Joyce

The couple in Pair 1 usually used *TimeKnot* for encouraging one another for starting the day, and sometimes for sharing an experience that they were having in a specific location or time. For example, Benjamin was visiting a new city. He was in the outdoors enjoying the sun and wanted to share the atmosphere and the state of mind he was in. He decided to use *TimeKnot* to share the experience. He thought the focus on audio would allow Joyce to both listen to him and immerse herself in the background sound and imagine his surroundings. He also debated if it would have been good to attach the story to a photo for her. Benjamin and Joyce both felt *TimeKnot* took away the awkwardness in sending messages that were related to time in different time zones.

For example, saying good night to a loved one while in their time zone the day had just begun.

The sisters from Pair 2 usually used *TimeKnot* for nightly messages, reminders, discussing their plans for the night, or even celebratory messages such as wishing a Happy Birthday on time. Yet *TimeKnot's* limited playback time window and the anticipation for waiting until the correct time of the day sometimes led to impatience by the sisters. We feel this may have been because Pair 2 experienced a much smaller time zone difference than Pair 1 (only 3 hours compared to 8). As a result, the sisters in Pair 2 had more overlapping time windows during the same context of the day.

TimeKnot showed notification only when the user could access the message. However, participants would have liked to know in real-time if there were any messages that were set to be playable in an upcoming time window and when.

Movement Triggered Messages

Pair 1 used *Kinetic* to link light activities, similar to what we expected. For example, they used it while taking a walk or during short workouts at home while listening to the messages. For workouts, one person would act as a coach to try and encourage the other person to 'keep going.' Pair 1 felt like they were able to multitask and engage in an activity with *Kinetic*. This was due to the stories being audio-based, and not needing to focus on writing an answer, or looking at the screen to comprehend the topic. Benjamin thought it was nice to hear stories when he was walking in the peaceful, quiet night coming back from work. Sometimes he would even walk a little more than what he anticipated to trigger the message to play. This is similar to how others have reported listening to podcasts while doing a physical activity [21].

Rather than use *Kinetic* to link the same activities, the sisters in Pair 2 used *Kinetic* to share important topics that they needed each other's opinion about. The added effort of having to get the device moving in order to listen meant that they knew the other person was focused and ready to engage with the message. To get *Kinetic* to play, they would do simple activities at home such as doing some chores, playing with the puppy, etc. Ayla said that since *Kinetic* was real-time and she did not experience delays or technical issues with it, it made her use it for important messages which she wanted her sister's feedback on. She also talked about how the movement feature caused her to be sure that her sister was ready and in the right mindset to listen to the messages.

"You know it's my favourite [Kinetic]! I usually leave those messages I really care about, and I really want my sister to listen and answer them for Kinetic." – Pair 2, Ayla

However, the movement triggered method was interesting for Shea for the first two weeks. She experienced two very busy weeks of work and wanted to relax when she was at home. She did not want to move much to play an important message. That's when she would start shaking *Kinetic* for a couple of minutes or walk around the home a little to be able to listen to the messages. She also said sometimes she was not sure if the required time of movement was met. That is when she started to use *Spark* more often. Since *Spark* was also real-time but required less effort for listening.

DISCUSSION

Our overall goal was to explore the usage of asynchronous audio storytelling systems for families in different time zones. To achieve this goal, we designed three technology probes, and deployed them in a five-week study. Our findings indicate a diversity of perspectives. Next, we reflect on this variety and propose ideas for how designs could address peoples' varied needs and perspectives with asynchronous audio sharing systems.

First, we learned that asynchronous audio systems can benefit from using a non-persuasive platform that does not emphasize a thread of back and forth communication. Instead, designs that embrace flexibility and delayed responses in time can be beneficial. In our study, participants felt open to expressing a range of emotions, from sadness and grief to excitement and happiness. Our study showed that this was, in part, due to the asynchronous and slow nature of the audio story sharing. Another reason was that our devices did not have features built in that encouraged quick responses or the need for constant attention, which might create feelings of obligation to connect [28,40,51]. Communication also did not manifest itself in the form of an ongoing thread of responses, unlike the current usage of asynchronous systems such as WhatsApp [40] or WeChat [58].

Second, we learned about the role that ephemerality can play in asynchronous communication systems and ways in which it could be designed for. For example, the ephemerality of messages in *Spark* helped participants use the system to express 'instant' feelings or give short updates to one another. However, such features did not seem to play a major role in encouraging family members to share more. This is in contrast with what has been seen in current trends around the use of social media for sharing temporal pictures and videos with friends on a daily basis where exchanges are frequent [56]. Yet the ephemerality of *Spark* encouraged participants to listen to messages earlier. Participants also used this quality of ephemerality for talking about upsetting feelings or sadness. The length of stories was mainly short, similar to existing patterns when using voice notes or social media. This could also be accounted for by the fact that our participants were already frequently in contact and longer stories may not be needed. However, for family members who are not as close as our participants, the ephemerality of audio stories may encourage them to create stories that are longer where they have enough time to not feel pressured when recording them and communicating.

Third, when designing audio storytelling systems for usage of close family members, our study results reveal design opportunities for further exploring asynchronous audio story telling devices that are suitable for in-home environments. Although the technology probes were portable and could be used outside, family members mainly used them at home. This was in harmony with the non-urgent nature of the

content as it did not require immediate attention. As a result, most of our participants usually played or recorded messages when they wanted to relax, and this happened to be in their homes most of the time. Participants did not feel compelled to *need* to take the devices outside of the home, which contrasts largely with mobile device usage more generally. It could be the case, however, that other participants beyond our small sample may wish to listen to stories while doing other things like traveling or commuting. This could be similar to the way people listen to podcasts [21]. Future designs could explore technologies that would include an in-home dedicated object for connecting family members and, perhaps, different designs and forms for usage outside of the home. It would also be interesting to investigate how asynchronous systems for connecting close family members could be integrated within existing home systems, such as voice assistant devices like Google Home, or Alexa.

Fourth, we learned how building a time-delay into a design can help to add excitement and meaning to communication, while also artificially 'synchronizing' time zones. With *TimeKnot,* because messages were playable only during a specific time window, the couple with a larger time zone difference was able to better synchronize their exchanges for appropriate times and 'forget' that the time zone existed when sharing a message. Yet this could also cause impatience for those who only have short time zone separations. This is similar to what has been seen in the literature as an issue of balancing the control that the user has over the slow technology [19,26,38,39]. Future time-delayed asynchronous audio storytelling systems may benefit from having a real-time indication of an incoming message and when it would be playable. Such features could allow anticipation to grow, while alleviating frustrations about knowing when messages may be playable. Sometimes our devices blended into the background and participants would forget to check them for new updates. This was especially the case if the devices were not on constantly. Future designs could explore different types of ambient notifications, either through sound or actuated motion on devices.

Lastly, we learned that synchronizing activities (e.g., shared walking) during recording and playback may not be for everyone. Our participants rarely performed the same type of activity while using *Kinetic*. However, they did engage in light movement activities such as listening while exercising at home, walking outside, cooking, or doing chores around home. The benefit that we saw in our design was its ability to allow participants to concentrate on the content while engaging in an activity. This was a possibility because we used audio and it was easy to do other things while listening. This is similar to how people have been shown to use other asynchronous audio systems [21]. The movement triggered feature of *Kinetic* was highly desired for some and, for others, it was seen as merely an extra step to listen to the stories. During busy times, people wanted to listen to messages with little effort. Of course, we tested out only one method for triggering playback based on activity. Future asynchronous designs could explore other possible methods for enabling messages to play such that value could still be added to the listening experience.

Our research is limited in that participants only used the devices over a five-week long period. While we feel we were able to understand uses beyond an initial novelty period, longer field studies would help to uncover knowledge of what sustained usage over time may look like. It could also help to reveal more information regarding how family members cope with the slowness of the devices. Our study is also limited in that we were not able to conduct observations of usage while it happened, given the sporadic usage of the technology and the widespread locations of our participants. To counter this challenge, we asked participants to describe the context and content of their messages to us.

Our results are also naturally limited in that we only had two pairs of family members use the system during the field study. We recruited only two pairs since we wanted to closely study their usage of the system. This can be extremely challenging to do with a broader set of participants in a field study. It can also be challenging to manufacture and produce larger volumes of research prototype devices. We chose two different types of pairs and, of course, future research would find value in studying other types of relationships. For example, future studies can explore the usage of audio storytelling systems between parents and their adult children. Overall then, our research helps to open up the design space of asynchronous audio-based storytelling systems and suggests areas where there may be value in focusing future design and user research.

CONCLUSION

Our work contributes the proposal and exploration of three design probes and, within them, design factors for creating asynchronous audio storytelling systems inspired by slow technology design ideas. We created three corresponding technology probes to investigate the effect of each factor—ephemerality, sharing tied to physical activity, and the context of the day—on family communication across time zones. The study helped us understand people's behaviors and patterns of usage of such technology. It also helped us understand the benefits and challenges of each design feature. Family members used the devices for sharing non-urgent yet important, and sometimes reflective audio stories. They also used the system for synchronizing their time across different time zones, and for expressing a variety of emotions using the system. These results illustrate the value of designs that promote delayed communication without an emphasis on instant responses. We see how ephemerality can help with expressing emotions; the specialness that can come with dedicated in-home devices; how a synchronization of time zones can be achieved with time delayed messages; and, ways in which movement triggered stories can suggest changes in engagement with audio stories.

ACKNOWLEDGMENTS

This work was funded by NSERC.

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