Memory Karaoke: Using a Location-Aware Mobile Reminiscence Tool to Support Aging in Place

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ABSTRACT
Episodic memory exercises such as reminiscing and storytelling have been shown to provide therapeutic benefits for older adults by prolonging their ability to lead an independent lifestyle. In this paper, we describe a mobile reminiscence tool called Memory Karaoke, which facilitates episodic memory exercise through contextualized storytelling of meaningful experiences by using contextual cues such as location, time, and photos. We present results from two studies we conducted with Memory Karaoke to explore which contextual cues contribute to best exercising a person's episodic memory. Our findings suggest that while viewing photos do exercise episodic memory to some extent, additional contextual cues (e.g. location and time) can solicit a greater amount of episodic memory exercise. This suggests that Memory Karaoke's selective capture process and its ability to contextualize memories while users retell stories are two effective features which help it to support episodic memory use. These results, together with positive qualitative feedback, provide promising evidence for Memory Karaoke as a viable mobile alternative for helping older adults to exercise their episodic memory and, in turn, assist them in successfully "aging in place".

ACM Classification Keywords
H5.2. Information interfaces and presentation: User Interfaces

General Terms
Design, Human Factors

Author Keywords
Mobile computing, location-aware, assistive technologies, phones

1. INTRODUCTION
In 2003 adults over 50 represented 28% of the U.S. population. In 2050 it is projected to increase to 37% of the population [26]. For these older adults, an important goal is to maintain an independent lifestyle as long as possible [29], a phenomenon we refer to as successfully "aging in place" [17].

A critical part of supporting older adults in this endeavor is to minimize age-related memory loss. In this paper, we are specifically interested in age-related *episodic* memory loss. Episodic memory allows individuals to mentally transport themselves back in time to recollect an event or experience from their personal past [25]. Previous work has shown that episodic memory is tightly correlated with an individual's awareness of their past self [28]. Thus, by focusing on ways to minimize episodic memory loss, we can help older adults to age in place by maintaining a positive sense of their self and identity.

However, coping with episodic memory loss can be an uphill battle. Previous studies suggest that episodic memories are often the first type of memories to suffer impairment in adults [24] and that the sharpest rate of decline typically starts around the age of fifty [19]. Fortunately, there is growing evidence that preventative measures can minimize age-related cognitive decline [30] and that these benefits can be maintained over time [4].

One memory loss prevention method is to rely on memory therapists, who typically employ cognitive stimulation exercises to improve memory. Exercises targeted for episodic memory include diary exercises [5], scrapbooking [15], and *reminiscing*. Clinical evidence has shown that reminiscing helps aging in place by improving discourse patterns [16] and boosting self-esteem [5, 8]. However, attending specialized memory therapy sessions can be cost-prohibitive or simply unavailable for many older adults. Thus, we believe that technological alternatives can better facilitate aging in place by making the benefits of episodic memory exercises available to a wider audience in a more cost-effective manner. To demonstrate this, we present *Memory Karaoke*, a mobile reminiscence tool that selectively captures contextual cues during a user's experience and uses storytelling to present these cues as a type of episodic memory exercise.

In this paper, we present results from two studies we conducted using Memory Karaoke. Our goal is to determine which contextual cues solicit more episodic memory use and to explore what features are most useful in an episodic memory tool. Our results suggest that Memory Karaoke's contextual cues solicit a greater use of episodic memory than other alternatives. These results, together with positive qualitative feedback, provide promising evidence for Memory Karaoke as a viable mobile alternative for helping older adults to exercise their episodic memory and, in turn, prolong their independent lifestyle by successfully aging in place.

In the next section, we describe related work, focusing on systems that serve as external memory aids. We then present an overview of Memory Karaoke, followed by details of our two studies.

2. RELATED WORK

External memory aids can generally be classified as being either prospective (those that provide reminders of future events) or retrospective (those that help recall past events). In this paper, we specifically focus on retrospective memory aids, as episodic memory is explicitly linked to reliving past experiences. While traditional paper-based retrospective memory tools (such as scrapbooks and photo albums) are still prevalent, many prior work have looked at adding technology enhancements to these paper-based tools to maximize their retrospective memory benefits.

One type of enhancement is to automate the collection of past memories. Forget-me-not [14] provides fully automated and continuous capture of daily context streams (of location, people, and workstation activities) and allows users to form queries based on these contextual cues in order to access the captured information. The Remembrance Agent [22] also continuously captures context streams, but uses its contextual cues to automatically form queries which then continually present suggestions to the user in their daily activities. Both these systems focus on information retrieval, and thus aim to maximize the number of search parameters (contextual cues). In our work, Memory Karaoke is not designed for information retrieval. Instead, we envision Memory Karaoke as a mobile reminiscence tool that uses contextual cues to exercise one's episodic memory.

SenseCam [10] is an example of a configurable and continuous capture system that uses contextual triggers. The key scenario for SenseCam is its use as a pictorial diary for users to consolidate their autobiographical memories, and is designed to be particularly effective for users already demonstrating clear signs of memory loss [10]. In contrast, Memory Karaoke is not meant to be used as a diary. Instead, as users engage in a social sharing of experiences via storytelling, Memory Karaoke presents its contextual cues to help users exercise their episodic memory. One aspect of our work in this paper is to see if Memory Karaoke's selective capture and access features can provide comparable positive results as SenseCam's continuous capture schemes.

Another class of enhancements looks at how to convert captured information into meaningful chunks or episodes (vs. just a stream of information). With brute force, users can manually collate their captured memories into chunks (e.g. by sorting printed photos into albums or filing digital photos into folders). PEPYS [18] introduced automatic categorization of context streams into daily chunks. However, PEPYS's chunking often wasn't accurate and typically defaulted to chunking by day. However, a meaningful episode could span just a few hours, in which case PEPYS's daily chunking would not work well. Thus, Memory Karaoke lets users define the boundaries of an episode through a simple interface that allows easy start and stop modes for capturing information. Since different experiences result in different episode sizes, the user can best define the boundaries consistently and accurately.

Memory Karaoke relies heavily on photos. Brewer found that autobiographic memory is most likely rich in visual imagery [3]. Photos are also helpful for reflection [11] and narrative storytelling [27]. Existing systems which try to leverage these aspects include Fotofile [12], a PC application that helps users organize their photos into "scraplets" (stories), and Balabanovi's work [2], a handheld system that facilitates collocated storytelling of photos. Project Nightingale [21] organizes photos using a digitized scrapbook. Memory Karaoke is distinct from these systems as its focus is not for organizing or accessing photos gathered over an extended period. Instead, Memory Karaoke avoids access time problems by implicitly organizing photos into episodes (stories) at capture time. Users can then easily share these episodes with others through contextualized narrative storytelling and, in turn, exercise their episodic memory.

This paper makes two important contributions. First, it introduces Memory Karaoke as a location-aware mobile reminiscence tool that allows easy capture and access of episodic memories. Second, it presents results from two studies along with qualitative feedback, showing Memory Karaoke as a mobile alternative to help adults age in place by supporting episodic memory exercise.

3. MEMORY KARAOKE

The following depicts an ideal scenario for Memory Karaoke:

Suzanne is a retired schoolteacher who decides to spend her morning visiting the art museum. Though she's an avid art fan, she's hasn't been to the museum in awhile and is looking forward to the exhibits. As Suzanne arrives at the museum, she takes out her phone and with one click starts capturing her experience with Memory Karaoke. As she explores the museum, she uses Memory Karaoke to snap photos of her favorite exhibits. When she's done, Suzanne effortlessly stops capturing with a single click. A few days later while Suzanne is waiting for the bus, she decides to call her friend Darlene, a fellow art lover who hasn't seen the exhibits yet. Suzanne selects the art museum episode from her list of stories. The phone plays back her photos along with its capture contextual cues Having these cues alongside her photos helps Suzanne as she tells Darlene about her art museum visit.

In this paper, we are primarily interested in determining which contextual cues enable retrospective memory aids to better exercise episodic memory. To do this, we use Memory Karaoke to selectively capture timestamps, places, and photos of a user's experience. As our scenario suggests, Memory Karaoke has two components: a Capture module and a Storytelling module. While the ideal scenario depicts an end-to-end mobile system, for the purposes of our comparative studies we used a modified version of Memory Karaoke which we describe in the next section.

3.1 Capture Module

The Capture module consists of a location-aware phone application (*PhoneCapture*) that runs on an Audiovox 5600SMT Windows Mobile 2003 Smartphone. The PhoneCapture application was designed with three features in order to better support reminiscing and episodic memory usage: 1) photo reminders, 2) place detection, and 3) easy episode creation.

Because we know that photos are helpful for narrative storytelling [27] (and thus for reminiscing and exercising episodic memory), PhoneCapture provides an occasional prompt to encourage users to take photos (see Figure 1a) of their experience. While the application does not require a minimum number of photos to be taken, it does recommend a certain number of photos so that users can maximize Memory Karaoke's utility as a reminiscence tool. Prompts are provided by vibrating the phone or sounding an alert every few minutes to remind users to consider taking a photo.

To compute an estimate of the current location on the phone without the need for extra hardware (such as a GPS unit), we rely on a software-implemented place detection algorithm based on Intel's Place Lab [13]. This algorithm relies on recognizing

nearby GSM towers [9]. When the software detects that the phone has been stationary for a certain amount of time, it assumes the user is at a place and not just passing through. The software then attempts to find the best match to the current GSM tower readings from a local database of known GSM fingerprints. This information is collected from previous places the user has visited or from a database built a priori. For our study, we visited nearby locations and manually collected GSM fingerprints for several different places within these locations (e.g. different areas on different floors of a museum) to build our own database a priori.

After taking a photo, PhoneCapture asks the user to provide a place label. Using the place detection algorithm, PhoneCapture calculates the most likely place label based on a set of previously labeled places and presents the choices as a sorted list with the most likely name at the top (see Figure 1b). If the correct place label is not listed, users can manually type in the correct place name. But because typing on the phone can be difficult, users can also opt to take a picture of a sign that has the name of the place. This photo is then inserted into the user's photo stream along with their other photos. After labeling a photo with a place name, the phone's database of GSM fingerprints is updated with that location's information so that PhoneCapture can later automatically recognize that place if the user returns. We follow a similar process to remember previous pictures of place signs.

For episode creation, PhoneCapture has a user-initiated capture process that only records contextual cues (i.e. photos, places, and time) when a user explicitly clicks a button to start capturing. Likewise, when leaving an event, she can stop capturing with a single click. PhoneCapture packages the captured context as a single episode that contains the event she attended ("art museum"), the arrival & departure times for each place she visited while attending that event, and a list of the photos she took.

3.2 Storytelling Module

The Storytelling module runs on a PC and uses a slideshow format to display the captured contextual information from PhoneCapture's episode log onto a projector screen for playback. Each photo is scaled appropriately, shown in its original orientation (portrait or landscape), and augmented with the appropriate context cues above the photo (see Figure 1d).

To ensure that users know to look at the contextual cues during playback (an issue that may be more prominent given the large screen real estate in a PC vs. mobile implementation), the slideshow starts off with a placeholder image alerting users to the different content areas on the screen (see Figure 1c). From there, a single button click starts the playback of the photos in sequential order based on the time the photos were taken. Users were given a 2-button (forward & back) remote control to have full control of the pacing and navigation of the slideshow. As the user watches the slideshow, she is encouraged to use the contextualized photos to help her tell a story about her experience attending that particular event. By observing each photo within its corresponding context, we propose that users can better reminiscence and exercise their episodic memory.

We note that the Storytelling module can also support other types of views (both on the PC and on the phone). However, we have focused on this particular type for the purposes of our studies.

4. METHODOLOGY

We hypothesize that Memory Karaoke's location cues are important and necessary for users to exercise their episodic memory more so than would be possible using other tools with fewer context cues. To evaluate this claim, we conducted two studies using Memory Karaoke. While these studies have different experimental conditions, they share the same methodology and evaluation metrics, which we describe next.

Each study lasted approximately 3 weeks. Participants were randomly assigned to different conditions. The studies consisted of 5 different parts (see Figure 2): a short initial session which explained the study logistics, two weekends where participants attended various events, and two follow-up sessions following those. Participants were compensated based on the number of sessions they attended and all participants received the same compensation regardless of their assigned condition.

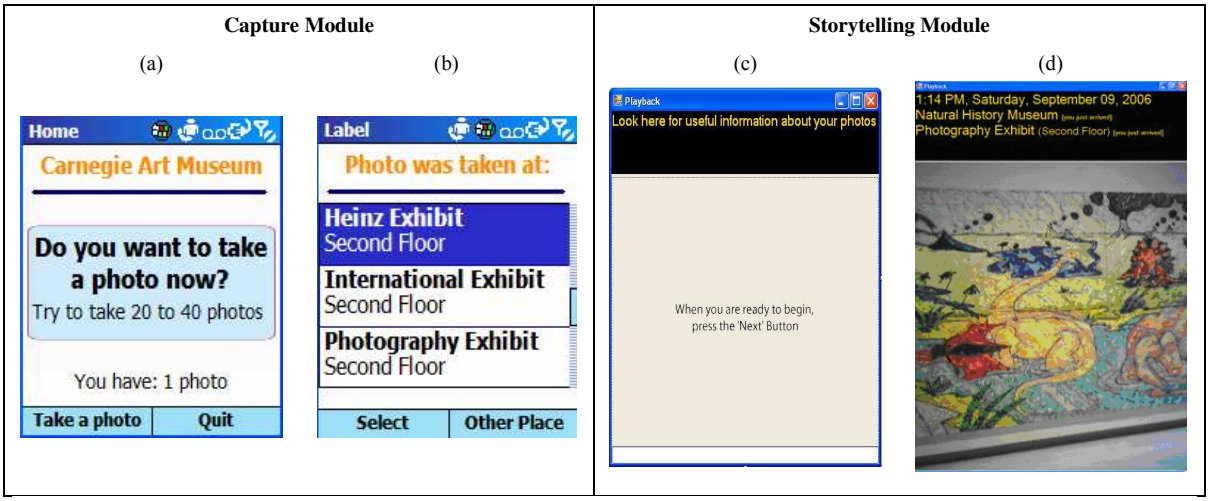


Figure 1. Memory Karaoke screenshots: (a) PhoneCapture's photo reminders, (b) PhoneCapture's place labels list shown after taking a photo, (c) initial view for the PC slideshow application, (d) PC slideshow application showing photo with contextual cues

Table 1. Storytelling scheme used during the follow-up sessions for all participants, in all experimental conditions

Follow-up Session	Storytelling from …
Session #1	1st weekend *(storytelling of the first event)*
Session #2	Both 1st & 2nd weekend *(storytelling of the second event, followed by storytelling of the first event)*

4.1 Event Attendance

When dealing with episodic memory, most psychology research conduct controlled lab studies (e.g. [6]) to elicit somewhat contrived memories that can later be experimentally manipulated. In our studies, we opt for a more realistic evaluation where users generate their own memories and reminiscing patterns from actual events they choose to attend (see Figure 2, blue blocks).

To provide consistency across participants, we provide an event list that is used for both weekends. This provides us four assurances. First, we avoid situations where participants claim they don't have any "worthy" experiences to share. Second, since participants will probably pick events they find most interesting, we ensure that the participants will have a meaningful episode (experience) that they will be motivated to share later on. Third, by controlling the types of events on our list, we minimize potential bias resulting from participants choosing their own experiences, which might result in vast differences between participants. Lastly, we can control for the descriptiveness of the place labels that participants will use. We can do this because, prior to the study, we manually collected GSM fingerprints and their associated place labels for all the locations on our event list. The ten events on our list were chosen based on:

- *Cost*: While we reimbursed participants at the follow-up sessions, we wanted upfront admissions costs to be low.
- *Location*: Event covers multiple "places" within the main location; this way we can capture interesting location cues.
- *Event Type*: Choosing monumental events (e.g. weddings, once-in-a-lifetime concerts) can prematurely bias participants to take extra measures to remember those experiences. Instead we focus on *"ordinary, out-of-the-ordinary"* events which aren't regular enough to be routine or boring, but also aren't extra-ordinary enough to warrant special attention. Adults are arguably still interested in remembering these episodic memories, but simply forget about them due to episodic memory decline.
- *Time & Duration*: All events took place on weekends and participants attended their events for at least 1.5 hours.

4.2 Follow-up Sessions

Follow-up sessions lasted 30-60 minutes and occurred on Monday or Tuesday immediately following the weekend (see Figure 2, green blocks). During these sessions, participants retold stories about the events they had previously attended to the experimenter.

To make our comparative studies as realistic as possible, we simulated typical adult memory interference and memory decline by following the storytelling scheme shown in Table 1. In the first follow-up session, participants shared their story about the first event they attended. Two weeks later at the second follow-up session, participants once again shared stories about their most recent event. Afterwards, participants were asked to share a story about the first event they attended two weeks ago. Participants were not required to tell the exact same story and were asked to assume that the experimenter had not heard the first storytelling.

Figure 2. Our study's timeline: orange blocks indicate when participants could sign up for their initial session; blue blocks indicate when participants could attend events; green blocks indicate when participant could come in for follow-up sessions

It is important to note that participants were unaware of any sort of memory manipulation on our part, as this would prematurely bias participants in the follow-up sessions. Instead we described the study as a "storytelling exercise". Thus, after the first session, participants expected that we would only ask for stories based on the most recent event, when in reality we were also interested in evaluating the first storytelling across both sessions.

4.3 Primary Evaluation Metric: R/K/G

To determine if someone is using their episodic memory (vs. other types of memory), we borrowed a non-invasive evaluation metric, called the *R/K/G metric,* that is often used in cognitive psychology literature (e.g. [6, 7, 20]). The R/K/G metric assesses the distinctions between "Remember", "Know", and "Guess". *Remembering* refers to a person's ability to recall a memory as if she were mentally reliving that moment and is evidence of episodic memory usage. *Knowing* occurs when a person simply recites things from rote memory without actually reliving the moment; this is thought to represent semantic (but not episodic) memory. To *guess* implies that the person does not "remember" or "know" a memory. Instead, the person retells the moment based on what they believe most likely would have happened.

By borrowing this terminology from psychology literature, we can use the R/K/G metric to determine whether or not a participant is exercising their episodic memory. We can make this inference based on the understanding that episodic memory usage is the ability to recall an experience within its original context by *reliving* the event [23]. Thus, it is the ability to relive the experience that suggests the participant is exercising their episodic memory. In other words, when a participant can actually see the event through their "mind's eye" while they are sharing their story, then it qualifies as a "remember" response; otherwise a "know" response indicates that while the participant is certain the event did occur, they cannot recall any relevant contextual

information during their storytelling [23]. A "guess" response would occur when neither of the above conditions is true.

At the follow-up sessions, we applied the R/K/G metric immediately after each storytelling. To ensure participants clearly understood the distinction between the R/K/G terms, we first presented participants with precise definitions (along with examples) of each term. Participants were then asked to classify their preceding storytelling experience accordingly, as remember, know, or guess. Participants also justified their response with a brief explanation. This is the same procedure used in [20].

4.4 Second Evaluation Metric: Story Length

While the R/K/G is a standard metric used for measuring episodic memory, we also decided to include a second evaluation metric as an alternative to using subjective self-reports by recording the length (in minutes) of each storytelling. To control across participants, we recorded story length after processing each storytelling by removing any "dead time" (e.g. pauses, silence, and/or filler words such as "uh", "um"). Our hope is that using an objective metric can produce similar trends when compared to using the self-reported R/K/G metric.

5. EXPERIMENT 1

For our first study, we deployed Memory Karaoke to young adults as an initial proof of concept to see if it could help exercise episodic memory. Then if the study provided positive evidence of Memory Karaoke's success, we would proceed to the more difficult task of recruiting older adults for a second study.

5.1 Experiment 1 Conditions

In the first study, we followed a within-subject design with eleven participants, ages 18-28, divided between two conditions:

- *Control (CO):* In the CO condition, participants use Memory Karaoke's PhoneCapture while they attend their events. However, in the follow-up sessions, they do not use any contextual aids during their storytelling.
- *Memory Karaoke (MK):* In the MK condition, participants use Memory Karaoke's PhoneCapture while they attend their events. In the follow-up sessions, they use Memory Karaoke's contextual slideshow during their storytelling.

Each participant attended two events per weekend (due to the within-subject design) and followed the methods in Section 4.

5.2 Experiment 1 Results

We evaluated each participant's storytelling experience using self-reported R/K/G responses and story length. Some participants reported multiple R/K/G responses. For our analysis, we categorized R/K/G responses as either: *remember* (R) or *not-remember* (NR). To avoid double-counting, the R category includes responses that are solely "remember" (and not coupled with "know" & "guess" responses). The NR category combines responses with any combination of "know" or "guess" responses. Using this R-NR analysis, we intend to evaluate Memory Karaoke's ability to better exercise episodic memory by soliciting more R responses. We present our findings below (see Figure 3).

MK solicits significantly more R responses. Because we used a within-subject design, we rely on McNerman's Test to evaluate

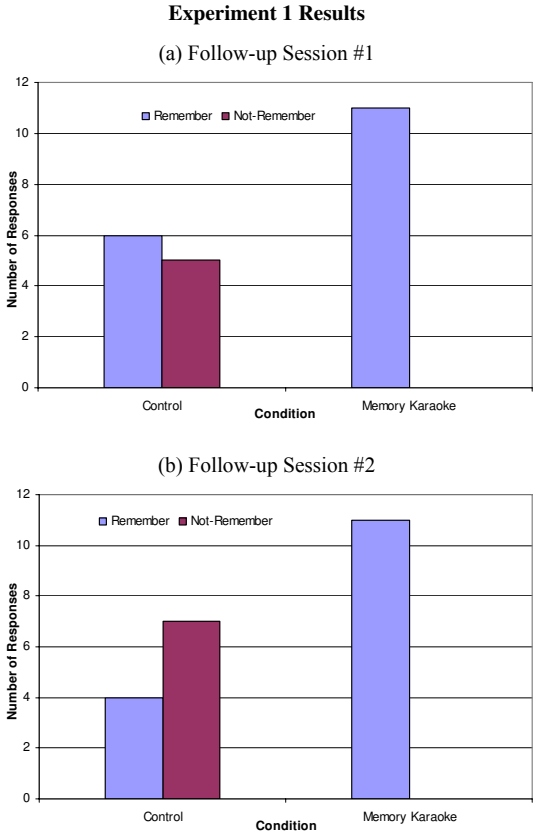


Figure 3. Experiment 1 results for *remember* & *not-remember* responses across Control & Memory Karaoke conditions in (a) 1st & (b) 2nd sessions. Memory Karaoke condition has more *remember* responses than Control condition.

statistical significance using a contingency table of our dependent within-subject data. Our results show that the Memory Karaoke (MK) condition solicits significantly more R responses than the Control (CO) condition in both first ($\chi^2(1)=5.00$, $p<0.02$) and second ($\chi^2(1)=6.00$, $p<0.01$) follow-up sessions. This finding suggests that Memory Karaoke's contextual cues are useful and effective in helping to exercise episodic memory.

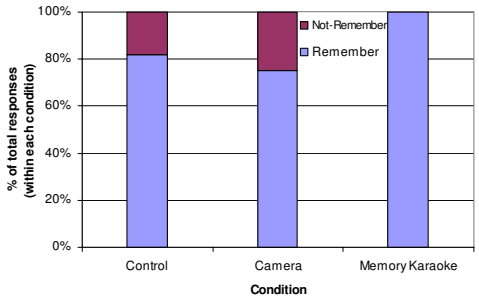
MK does not solicit any NR responses. There were no NR responses in the Memory Karaoke (MK) condition in either follow-up session. In contrast, over 50% of the responses in the Control (CO) condition (across both sessions) were NR responses.

MK solicits significantly longer stories. Using Wilcoxon signed-rank tests, we found that the MK condition solicits significantly longer stories than the CO condition in both the first ($z=-2.93$, $p<0.003$) and second ($z=-293$, $p<0.003$) follow-up session.

Story length is correlated to R/NR responses. We used regression analyses to examine if there was a relationship between our primary and secondary evaluation metrics. We found that story length and R/NR responses are correlated ($r^2=0.62$, $p<0.001$) and that story length can predict R/NR responses in that the

Experiment 2 Results

(a) Follow-up Session #1



(b) Follow-up Session #2

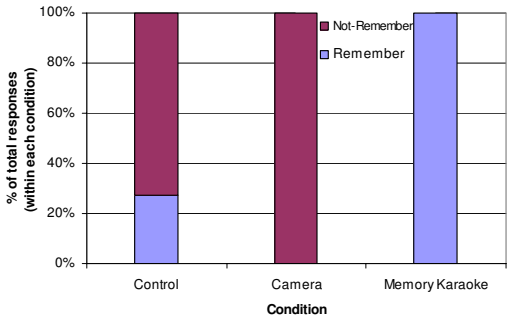


Figure 4. Experiment 2 results showing remember & not-remember responses across all conditions for (a) 1st & (b) 2nd follow-up sessions. Result show the MK condition has more R responses than the CA condition in the 2nd follow-up session.

shorter the story the more likely it is that the participant will provide a NR response (β=-2.20, p<0.002).

6. EXPERIMENT 2

The results from our first study suggest that Memory Karaoke can be an effective mobile reminiscence tool to help exercise episodic memory. Given this positive evidence, we proceeded to conduct a second study to see if our results would carry over to our target audience with older adults.

6.1 Experiment 2 Conditions

We used a between-subjects design across three conditions:

- *Control (CO):* In the CO condition, participants do not use external aids while attending their events. In the follow-up sessions, they also do not use any storytelling aids.
- *Camera (CA):* In the CA condition, participants use a camera while attending their events. During follow-up sessions, they use a standard slideshow for storytelling.
- *Memory Karaoke (MK):* In the MK condition, participants use Memory Karaoke while attending events. In follow-up sessions, they use a contextual slideshow for storytelling.

Experiment 2: Average story length across all conditions

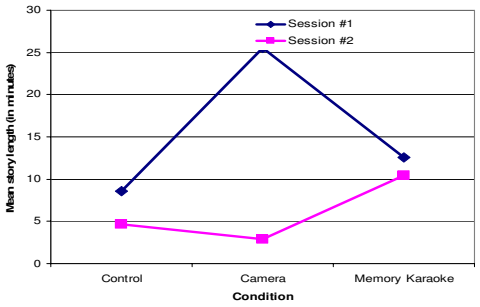


Figure 5. Experiment 2 results for average story length (in minutes) across all conditions in both follow-up sessions.

We originally recruited about 30 older adults who were randomly assigned to one of the three conditions. However, due to unexpected scheduling conflicts that arose during the study, several participants had to drop out. Thus, we do not include them in our analyses. In the end, 15 participants, averaging 61.8 years old, completed the study. Six participants were in the control (CO) condition, four were in the Camera (CA) condition, and five were in the Memory Karaoke (MK) condition. Each participant attended one event per weekend; we used the same methods as described in Section 4. Some CO subjects participated in multiple iterations, and thus the CO condition has a total of 11 responses.

6.2 Experiment 2 Results

Like the first study, we evaluated each participant's storytelling experience using self-reported R/K/G responses and story length. We followed the same type of analyses by categorizing R/K/G responses as either *remember* (R) or *not-remember* (NR) to avoid double counting combination responses. Recall that a *remember* response indicates evidence of episodic memory usage. We present key findings from our second study below (see Figure 4).

MK outperforms CA condition in 2nd session. We found the Memory Karaoke (MK) condition solicits significantly more remember (R) responses than the CO condition in both the first ($\chi^2(4)=18.10$, $p<0.001$) and second ($\chi^2(4)=24.73$, $p<0.0001$) follow-up sessions. However, only in the second follow-up session does the Memory Karaoke (MK) condition solicit significantly more R responses than the Camera (CA) condition (continuity corrected $\chi^2(1)=5.41$, $p<0.02$).

These first two findings suggest that Memory Karaoke is a better mobile reminiscence tool than a camera since it can solicit more remember responses when used over an extended period of time (in our case, two weeks). This provides positive evidence that Memory Karaoke's additional contextual cues (place & time) are useful and necessary to help exercise episodic memory.

MK does not solicit any NR responses. There were no not-remember (NR) responses in the Memory Karaoke (MK) condition in either follow-up session. In contrast, over 50% of the responses in the Camera (CA) condition and nearly 50% in the Control (CO) condition (across both sessions) were NR responses.

Story length is somewhat correlated to R/NR responses. Using a one-way ANOVA, we found a significant effect of the three conditions on the story length in the first ($F(2,17)=8.99$, $p<0.001$)

and second ($F(2,17)=3.36$, $p<0.06$) follow-up session. The Camera (CA) condition solicits significantly longer stories than the Control (CO) or Memory Karaoke (MK) condition ($p<0.001$ and $p<0.01$) in the first session. In the second session, Memory Karaoke (MK) solicits somewhat longer stories than the Camera (CA) condition ($p<0.08$), but not the CO condition (see Figure 5).

We used regression analyses to examine if there was a relationship between our two evaluation metrics. We found story length can somewhat predict R/NR responses in that the shorter the story the more likely it is that the participant will provide a NR response ($\beta=-0.15$, $p<0.07$), though the correlation strength is not strong. Recall that we saw a similar trend in the first study.

MK solicits more complete and interesting stories. We asked each participant to self-report how complete they thought their story was, on a 5-point Likert scale (5 being most complete). In prior work ([10]), completeness has been evaluated by having a second person attended all the events along with the participant. In [10], this requirement is reasonable, as their target audience focuses on individuals with significant memory impairments who typically are already accompanied by someone they know. However, in our study, participants were not required to visit their events with other people, which we felt better represented our target audience who are older adults who have not yet reached a stage where they require close supervision from a caregiver. Our results indicate that the Memory Karaoke (MK) condition solicited significantly more complete stories than either the Camera (CA) or Control (CO) condition ($p<0.005$; $\mu_{mk}=3.91$, $\sigma_{mk}=1.02$; $\mu_{ca}=3.10$, $\sigma_{ca}=1.05$; $\mu_{co}=3.25$, $\sigma_{co}=1.01$).

We also asked each participant to self-report how interesting they thought their story was, on a 5-point Likert scale (5 being most interesting). A significant part of Memory Karaoke's effectiveness as a mobile reminiscence tool relies on its integration into the social aspect of storytelling and sharing experiences. Thus, while Memory Karaoke may help older adults exercise their episodic memory, users will not continue to use the system if they find the storytelling experience less than ideal. Our results indicate that the Memory Karaoke (MK) condition solicited more interesting stories than the Control (CO) condition ($p<0.01$; $\mu_{mk}=3.43$, $\sigma_{mk}=1.23$; $\mu_{co}=2.79$, $\sigma_{co}=1.08$). The Camera (CA) condition solicited only slightly more interesting stories than the CO condition ($p<0.10$; $\mu_{ca}=3.17$, $\sigma_{ca}=0.86$; $\mu_{co}=2.79$, $\sigma_{co}=1.08$). Stories produced in the MK condition were just as interesting as those produced in the CA condition.

7. DISCUSSION

We have presented our work to demonstrate that Memory Karaoke can be a viable mobile reminiscence tool to help older adults exercise their episodic memory so that they may better age in place. In this paper, we presented results from two studies conducted with Memory Karaoke using young and older adults. In these studies we evaluated episodic memory exercise using two different metrics. Though the story length metric did not provide the same richness as our primary evaluation metric (R/K/G), there seems to be cursory evidence that story length may partially indicate episodic memory use. However, we acknowledge its limited application insofar as we have observed in our data.

Our goal for conducting comparative studies was to determine which of Memory Karaoke's contextual cues were useful and necessary to solicit more episodic memory use. Our results suggest that: 1) a camera is better able to exercise episodic memory than without any external aids, and 2) Memory Karaoke's additional contextual cues solicit a greater amount of episodic exercise than a camera condition over extended time periods. As older adults are among the fastest-growing age group of cell phone users [1], our findings suggest that Memory Karaoke is well positioned to be a better mobile reminiscence tool than a camera since, since users will be more likely to carry phones with them than cameras. Furthermore, Memory Karaoke also provides more episodic memory exercise benefits over longer time period when compared to doing the same exercises with a camera.

Upon further analysis, there are several key features we believe enabled Memory Karaoke to outperform the camera condition to better facilitate exercising episodic memory. First, Memory Karaoke's capture module supports semi-automatic tagging of photos (with place and time) so that Memory Karaoke can show users a contextualized view of their memories during their storytelling experiences. Second, Memory Karaoke's capture module provides periodic photo reminders. Since the prompt only suggests to (but does not obligate) the user to take a photo, this ensures that the photos that users actually take are meaningful and interesting. This minimizes access-time problems often seen in continuous capture systems, where several photos may not be meaningful to the user and thus will not help the user to exercise her episodic memory. With selective capturing, photos will usually be more meaningful and thus carry more useful and distinguishable contextual cues which will help users better exercise their episodic memory. Third, Memory Karaoke provides episode packaging at capture time, instead of at access time. Often with continuous capture systems, users are forced first manually organize their photos prior to beginning their storytelling experience. This upfront task can curtail users from storytelling, especially as the number of photos increase. To alleviate this concern, Memory Karaoke uses a series of simple one-click interactions to allow for episodic chunking during the capture phase. Thus, when users want to engage in storytelling, they do not have to bother with organizing photos at access time, since their episodes have already been packaged for them. This makes later accessing, viewing, and most importantly sharing these experiences (episodes) much easier than with a continuous capture system where the contextual streams may not be well organized and may require additional work to first sort through.

Because Memory Karaoke is intended to exercise one's episodic memory through storytelling, it is critical to also address whether our system detracts for natural storytelling experiences (as observed in the control condition). Fortunately, our data suggests that Memory Karaoke in fact enhances storytelling by soliciting more complete stories that are just as interesting, if not more so.

It is also worth noting that we observed several pain points during our second study. Interestingly, we found several participants experienced problems with the cameras versus Memory Karaoke. Most camera problems involved slow or unresponsive picture taking, a problem that did not seem to occur with Memory Karaoke. This may be because we only recruited older adults who were existing mobile phone users for the MK condition (though none were smartphone users). Thus the learning curve for using Memory Karaoke might be less than for the participants in the CA condition, who were not all previously active camera users.

Otherwise, all participants in the MK condition reported that the interface was easy to use. We also observed that Memory Karaoke participants took about the same amount of photos as those in the CA condition. This provides initial evidence that Memory Karaoke's user-initiated capture process may be does not detract for its usefulness as an episodic memory exercise tool.

8. CONCLUSION AND FUTURE WORK

In conclusion, we believe several Memory Karaoke features are important for other mobile developers to consider when developing tools to help older adults exercise their episodic memory and thus prolong their independent lifestyle in order to better age in place. Benefits from Memory Karaoke's capture module become clear when Memory Karaoke users engage in the social sharing of their experiences with others. During this storytelling, Memory Karaoke's additional context cues help users to exercise their episodic memory as shown in our R/NR analyses.

For future work, we hope to run more longitudinal studies to determine if Memory Karaoke can sustain its episodic memory benefits beyond two weeks. It may also be worth exploring how much other Memory Karaoke features, such as photo prompting and easy episodic creation, contribute to its success, as well as if other contextual cues might strengthen its benefits. Using our findings along with the suggested future work, our goal is to provide guidelines to better inform the design of future mobile tools that can help older adults in their endeavor to age in place.

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