Providing Good Memory Cues for People with Episodic Memory Impairment

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ABSTRACT

Alzheimer's disease impairs episodic memory and subtly and progressively robs people of their ability to remember their recent experiences. In this paper, we describe two studies that lead to a better understanding of how caregivers use cues to support episodic memory impairment and what types of cues are best for supporting recollection. We also show how good memory cues differ between people with and without episodic memory impairment. We discuss how this improved understanding impacts the design of lifelogging technologies for automatically capturing and extracting the best memory cues to assist overburdened caregivers and people with episodic memory impairment in supporting recollection of episodic memory.

Categories and Subject Descriptors

K.4.2 [**Computers Milieux**]: Social Issues – *Assistive technologies for people with disabilities*; H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – User-centered design

General Terms

Design, Experimentation, Human Factors

Keywords

Episodic memory, elders, cues, caregiver burden, Alzheimer's Disease

1. INTRODUCTION

Recent experiences provide a rich, intimate source of information for making important decisions on our own, planning out our future actions, thinking about the pleasant experiences of our lives, interacting meaningfully with others, and living in comfort and security. However, Alzheimer's disease (AD) causes episodic memory impairment (EMI) and progressively robs people of their ability to remember their recent experiences. Approximately 18 million people worldwide have been diagnosed with Alzheimer's disease, with this number expected to double within the next 20 years [1]. Caregivers (CGs) of people with AD are overburdened with the duty to provide episodic memory support. Caregivers experience great strain as they are required to support the increasing episodic memory needs in addition to the physical needs of normal aging. As a result, caregivers may develop depression and caregiver burnout [3].

Episodic memory is the memory of specific experiences that you can replay in your head, in contrast to semantic memory, the memory of facts about the world. Recent episodic memory is important for maintaining quality of life. It reinforces feelings of continuity and supports a person's sense of self [7]. Episodic memory impairment can lead to feelings of uncertainty, irritation, frustration, and fear. Providing support for episodic memory has the potential not only to improve the quality of life [5, 25] but also to reduce caregiver burden. A better understanding of how caregivers provide episodic memory support can help identify opportunities for technology to assist this process and ultimately reduce the burden on the caregiver while helping them provide better care.

Lifelogging technologies are systems that automatically record the user's experiences and provide ways for the user to review and reflect on them. These technologies can provide rich multimedia memory cues to help users remember their experiences better [20]. Advances in sensors (*e.g.*, [13]) are making it easier to record personal experiences completely and unobtrusively to provide people with EMI and their caregivers with a rich source of cues. A better understanding of what good cues are can help improve the ability of lifelogging systems to extract and present the best cues for memory recollection.

Our contributions in this paper are two studies that lead to a better understanding of the caregiver's role in supporting episodic memories and what cues are best for supporting recollection. We first report the results of an observational field study that describe how caregivers of people with EMI use a cueing process to support episodic memories and the breakdowns that occur. We discuss a second study that investigates what types of cues are most helpful for supporting recollection of older people's personal experiences. We also discuss how these findings differ between people with and without EMI. The results of these studies lead us to design implications for lifelogging technologies that provide rich multimedia cues to support recollection of personal experiences. We start with a brief overview of caregiver and technology support for people with EMI.

2. RELATED WORK

Caregivers provide support for the informational and memory needs of people with EMI. Hawkey *et al*. [11] analyzed how

caregivers provided support for a person with AD's continual need for *current* information (*e.g,.* time, current events) and *future* information (*e.g.*, scheduled activities). Our work focuses instead on how caregivers support the need of the person with EMI for information about their *past* experiences.

Recent technological support for reminiscence therapy for EMI use era-specific [10] and personalized [6] multimedia as memory cues to aid recollection and to facilitate social interaction. However, while promising, these burden caregivers with recording photographs or videos to use as memory cues.

Lifelogging technologies automatically record information about the user's life and can also support episodic memory. Some systems use video [14, 17] or audio [23] to continuously record a comprehensive account of the user's experiences. For easier retrieval, captured media can be indexed with other contextual sensor data such as GPS, accelerometer, and body sensors [22]. Instead of continuously recording, lifelogging systems can also record when triggered by a sensor. The Microsoft SenseCam [13] is a wearable digital camera that automatically takes photos of the wearer's experiences from a first-person perspective. The SenseCam has various sensors such as light, temperature and accelerometer that determine when to take a picture. Reviewing photos taken by SenseCam enabled a person with EMI to remember her experiences better. However, these systems generate a lot of data for the caregiver to sort through that may not be helpful for supporting recollection. To better understand how caregivers provide support for EMI and to understand the role of such technology in providing support to caregivers, we conducted two separate field studies of people with EMI. We report on the first study in the next section.

3. USE OF MEMORY CUES

A significant portion of the responsibility of a caregiver of a person with Alzheimer's disease (AD) and other EMIs is to provide support for memory of recent experiences. As a first step in developing technology that can reduce this burden, we conducted an ethnographic field study to understand how caregivers provided support for episodic memory. We conducted interviews with people with EMI and their caregivers and observed them in their normal routines.

3.1 Method

We observed and shadowed participants from the late morning to early evening for two consecutive days in their homes and followed them wherever they went on their normal daily routines (*e.g.*, shopping at the market, going for a walk, or eating out). We did not interfere with their activities aside from occasionally asking them to explain what they were doing. The goal of the first day was to get a first hand account of that day's experiences. On the second day, we observed how the caregiver reminded the person with EMI about what happened on the previous day. We also asked the person with EMI about a recent experience (*e.g.,* what they did last weekend), and observed the response and how the caregiver provided assistance for recalling these episodic memories. We also conducted separate interviews with the person with EMI and caregiver, asking what kinds of information served as good memory cues.

3.2 Participants

We interviewed five dyads of people with EMI and their caregivers and shadowed four of them, all recruited from caregiver support groups at the local chapter of the Alzheimer's

Association. Their diagnoses ranged from Mild Cognitive Impairment (MCI) (2 participants, age 70 & 75) to mild AD (2, age 50 & 75) to moderate AD (1, age 72). People with MCI, a precursor to AD, have the EMI associated with AD but none of the language or reasoning deficits of AD. People with mild AD have trouble remembering recent experiences, finding the right words to express themselves, and remembering multi-step processes. People in moderate to severe stages of AD may also forget memories from the distant past, become disoriented in familiar places, and forget how to perform basic activities of daily life such as dressing and bathing. We limited our study to participants in the earlier stages of the disease because they are more concerned about their failing episodic memory than those in the later stages who struggle more with basic activities of daily living. We focused on family caregivers (*e.g.,* spouse or child) because they typically have a long history with the person with EMI, allowing them to develop effective, personalized care strategies. They also take on tremendous burden due to familial responsibilities. We wanted to identify opportunities to reduce this burden on family caregivers by providing them with tools to support their loved ones' episodic memories.

3.3 Results

To help people with EMI recall past experiences, we found that caregivers engaged them in a dialog using *cues*, or small details of an experience that help people with EMI recall more of the memory. We observed that caregivers provide cues only when there is a reasonable chance of successful cued recall, for example, when they see the person with EMI struggling to recall a particular experience. When the person with EMI has no chance of successful recall, providing cues will only prolong the agony of unsuccessful recall. When the person with EMI confidently believes in an incorrect memory, caregivers will often just "let it go" because it can be too laborious to correct it or too distressing for the person with EMI to be corrected.

After the need for cues has been identified, caregivers usually reveal cues in a piecemeal fashion until persons with EMI can recall the rest of the episode with their own memory. The person with EMI responds to the cue by either recognizing it or not. The cueing process continues as the caregiver proceeds to give cues until the memory is recalled at an adequate level of detail. Caregivers shared that their loved ones find it rewarding when they receive just the right amount of cueing assistance so that they can recall most of the memory themselves. For example, one participant took pleasure in successfully recalling watching a baseball game on television last night when her husband casually mentioned that "they" (their favorite team) won:

Caregiver [looking at the newspaper]: *"They won another one."*
Person with mild AD: [looks confused]
Caregiver: *"…last night."*
Person with mild AD: *"They did? Oh yeah! I remember yelling at the TV cheering for them."* [smiles proudly for remembering it]

In fact, there is clinical evidence that engaging in such cognitively stimulating mental exercise can slow the progression of cognitive decline [25].

However, caregivers do not always complete the cueing process. We observed instances of *cue shortcutting* where caregivers gave only one or two cues, and when the person with EMI was not able to come up with the rest of the memory, the caregiver gave up and just told the person with EMI all the necessary

details of the experience. Instead of going through the process of incrementally providing cues to aid recollection, caregivers prematurely terminated the cueing process, eliminating the opportunity for people with EMI to recall the memory on their own by thinking hard about the cues. For example, a caregiver wanted to remind her mother with moderate AD about the last time she had chocolate during a recent trip to her sister's home. Instead of incrementally providing cues, the caregiver simply told her mother all the relevant information without giving her a chance to recollect the details on her own:

"It was at [Mary's] house and she doesn't have air conditioning so it was really hot and all the chocolate melted." – Caregiver

Overburdened caregivers may be motivated to shortcut the cueing process because they are unable to think of appropriately rich, salient, or specific cues to trigger recollection. They may also be impatient and not want to take the time and effort to engage the person with EMI in a laborious cueing process that may have been repetitively performed many times before [18]. This leads to the question of whether technology can assist the overburdened caregiver in identifying and patiently presenting good cues. We conducted a second study to investigate what are good cues for triggering memory recollection to understand the role of technology in supporting EMI.

4. IDENTIFYING GOOD MEMORY CUES

We conducted a study to identify the best cues for triggering memory recollection. Current lifelogging systems use various capture techniques to automatically record memory cues such as digital photography [13, 17], video and audio recordings [16] [23]. These systems record an overwhelmingly large amount of data that is daunting to review. The caregiver is burdened with reviewing all the captured data and selecting out the best cues to present to avoid cognitive overload in the person with EMI. Automated summarization techniques [2] such as key frame extraction for videos and sets of images are helpful at reducing the amount of data to review. However, with an understanding of what good cues are, these extraction techniques can be better designed to automatically select good cues and reduce the burden on the caregiver.

When we asked what were good memory cues in our first study, participants were not able to think of them. For this second study, we used a card-sorting technique with photos automatically taken by a wearable digital camera [13] during a personal experience to provide both participants with and without EMI a concrete way to articulate what are good cues for triggering memory recollection. Psychological models of autobiographical memory [4, 19] have shown that information about an experience such as participants, locations, and time periods can be used as cues to retrieve *generalized* experiences from one's history. We extend this work by identifying the best cues for *specific* types of experiences that not only help to recall the experience but also help to mentally relive the experience.

4.1 Participants

Five individuals with EMI (referred to as M1-5) (Table 1) and their caregivers and four individuals without EMI (N1-4) over the age of 65 were recruited through local community centers and retirement communities. M2, M3, and M4 did not have a clinical diagnosis of MCI or AD, but their caregivers described that they had EMI symptoms similar to MCI. A family caregiver accompanied each participant with EMI during the study

Table 1: Participants with Episodic Memory Impairment

Participant	Sex	Age	Condition
M1	Male	72	MCI
M2	Male	81	EMI
M3	Male	89	EMI
M4	Male	70	EMI
M5	Female	85	Moderate AD

experiences and provided an objective account of what occurred. The four participants without EMI had their memory assessed at a local clinic at most 6 months prior to the study and were found to have good memories for their age. We used these two groups to identify the differences between participants with and without EMI in terms of what cues help trigger recollection.

4.2 Method

Participants went on one or two experiences of their own choosing while using SenseCam [13], a small digital camera worn at chest level that automatically took a snapshot every two minutes. No other sensors on the SenseCam were used to trigger capture aside from the timer. Participants were told to choose experiences that they wanted to remember in good detail. The experiences ranged from two to eight hours long. Examples include visiting a museum, attending a wedding, going to a dinner party, and visiting relatives out of town. During the experience, they were told to carry on normally as if they were not wearing the camera. Within two days of each experience while the details were still fresh in their mind, participants reviewed the SenseCam photos, at most 100 for each experience. From the experiences with more than 100 photos, we took a time-distributed sample of 100 photos from the larger set, so as not to overwhelm our participants.

The review process (Figure 1) began with the participant looking at each photo and describing what the picture reminded them of. Participants were able to use the photos, presented in chronological order, as cues to help them mentally walk through and describe the experience. Caregivers provided additional assistance in grounding the person with EMI in the original experience and describing the photos only when a participant had difficulty recognizing them. After looking through the photos, we asked participants to imagine they were making a personal photo album for the experience that would not be shown to anyone else and to select half the photos to include in

Figure 1. Participants sorted photos according to how well they reminded them of the original experience.

Table 2: Top six photos selected as the best cues for four experiences.

Subject	Experience	Photo #1	Photo #2	Photo #3	Photo #4	Photo #5	Photo #6
N2 (none)	Memorial service & Family Dinner	Person *(widow & daughter)*	Object *(birthday cake)*	Person *(an old friend)*	Person *(nephew)*	Person *(old friends)*	Person *(relative)*
N4 (none)	Church performance	Action *(hands clapping)*	Action *(audience getting into the spirit)*	Person *(pastor)*	Action/Person *(unexpected speech)*	Action *(presentation of family)*	Object *(stained glass windows)*
M1 (MCI)	Trip to Philadelphia	Place/Object *(tall ceilings in house)*	Place/Action *(walking through town)*	Place/Action *(BBQ in backyard)*	Place *(walking into town)*	Place / Object *(backyard with treehouse)*	Action *(ice cream on drive back)*
M5 (AD)	Visit to History Museum	Object *(furniture exhibit)*	Object *(photography exhibit)*	Object *(kitchen exhibit)*	Object *(photograph of slave trade)*	Object *(artifact exhibit)*	Object *(letters exhibit)*

the album such that when they look at the photos, they will be able to mentally relive the experience. We told participants to ignore image quality and instead focus on the content's ability to trigger recollection. Then we had them iteratively select a subset roughly half the size of the previous set until only one photo remained. For example, starting with 100 photographs, participants would select the 50 photos that best helped them mentally relive the experience, then down to 25 and so on until finally there was only 1 photo left. Participants explained why they chose to keep or discard each photo. The basic rationale behind this card sorting technique was to allow our participants to iteratively refine their selection of what they considered good memory cues. Photos (and the information they contain) sorted into the later smaller subsets are considered better cues by participants than those discarded earlier in the task.

We validated this card sorting technique in a follow-up session at least one month after each experience. We had participants list as many important details from each experience as possible without the help of any photos. This served as the baseline level of recall. For one experience (randomly chosen), we showed them the *top six photos* chosen in the sorting task, and for the other experience, we showed them *six photos randomly selected* from those they discarded earlier in the sorting task. We tested two participants: one with (M4) and without EMI (N4). M4 was able to recall more additional details (beyond what was remembered at baseline) when presented with the top six photos chosen in the sorting task than when presented with the randomly chosen photos. Furthermore, a greater proportion of the additional details were classified as vividly "remembered" instead of simply "known" or "guessed" according to the R/K/G metric [9]. N4 remembered all the details captured in the top six photos in his baseline recall, which indicates that his choice of photos is a good representation of the important points of the experience.

Sessions were videotaped to capture people's verbal descriptions of each photo. Based on the participant's descriptions, we coded each photo with the information contained in the photo and any other details of the experience it reminded the participant of. From these sorted sets of coded photos, we can determine the types of information that are particularly good cues for memory recollection. After the sorting task, we interviewed the participants and asked them to reflect upon what they thought were good cues for their memory.

4.3 Results
Analysis of the participants' selection of photos along with their descriptions revealed the characteristics of good memory cues.

We found that cues must first be either memorable or at least recognizable so that they can be used as an anchor into the original experience from which the individual can explore and recollect other details. More memorable cues tend to be either distinctive or personally significant to the individual. Photos selected by participants as good cues often exhibited a combination of these characteristics. The primary cues in each photo were categorized into four types of cues: people, objects, places, and actions, and we found that cue type matched well to experience type. We also found some qualitative differences in selection strategies and abilities between participants with and without EMI.

4.3.1 Types of Cues
Based on our participant's descriptions of what was the main content in each photo that triggers recollection, we were able to categorize the cue(s) in each photo into four categories: Person, Object, Place, and Action. A *Person* cue is a specific person(s) (*e.g.,* daughter, grandchildren) that was highlighted as important for their recollection. An *Object* cue is some significant object (*e.g.,* birthday cake, stained glass window). A *Place* cue describes the physical setting of the experience (*e.g.,* the façade of a visited store, the dining room). An *Action* cue describes some motion or physical action that may involve people, objects, and places (*e.g.,* driving home, playing the piano).

Based on the participant's own descriptions, we categorized the cues in photos from the last few rounds of the sorting task. See Table 2 for examples showing the top six photos selected as good memory cues. We found that every experience had more of one cue type than any of the other cue types. However, every event did not have the same majority cue type. Of our 14 captured experiences, seven had a majority of *Person* cues, four had a majority of *Action* cues, two had a majority of *Object* cues, and one had a majority of *Place* cues.

We characterize each experience in terms of its majority cue type, for these cues are particularly well-suited to help individuals recollect the experiences. *People-based* experiences such as family reunions and weddings are best cued by the people interacted with. *Object-based* experiences such as a museum visit and a shopping trip are cued by the objects encountered. *Place-based* experiences such as a vacation to a new town are cued by the places the individual went. *Action-based* experiences such as attending a church performance and rehearsing a play are best cued by referencing the actions that occurred. Through the photo sorting task, our participants demonstrated that the most important details of a particular experience can be represented by one type of cue, the majority cue type. The sorting task results also showed that aside from

the majority cue type, the other three types of cues were still considered helpful for recollection but were judged as less important. After the sorting task, when asked if other incidental types of cues such as the weather, clothing worn, or daily mood were important cues for the experience, all replied that they were not important. These incidental cues may not have been sufficiently distinct or significant to be good cues. Nevertheless, good cues for a particular experience must match their type with what is expected from the experience. In the following sections, we discuss other characteristics of good memory cues.

4.3.2 Recognizablity

At a fundamental level, memory cues are only effective if they can be recognized as part of the original experience. Even in our first observational study, we noticed that the caregiver's verbal cues were effective at helping the person with EMI recollect more from the experience *only if* the patient first recognized the cue and could mentally situate themselves in the original experience. In our subsequent photo sorting study, we noticed that participants (both with and without memory impairment) often discarded or skipped photos that they did not recognize from the original experience. For example, M4 discarded pictures of a woman because M4 did not remember speaking with her, who she was, or what they talked about, even though the photos showed them talking for around ten minutes. Because this photo was not recognized, it could not act as an anchor into the experience from which to explore and retrieve related details from memory. In contrast, participants could use pictures they recognized or freely recalled from the original experience as talking points to describe related details from the experience. Associative models of episodic memory *e.g.*, [15] demonstrate that a detail recognized or recalled from an experience can be used as a cue to retrieve other temporally or semantically related details of the experience. In the following sections, we discuss the factors that make details more recognizable or memorable.

4.3.3 Distinctiveness

Participants chose photos that uniquely represented the experience, so that when they looked at the photo, it would cue a recollection of that unique experience and not some other experience. Distinctive details, especially those different from people's normal expectations, are usually more memorable than less distinct details. This is consistent with psychological understandings of the distinctiveness effects in memory [24].

Distinctive cues can be *unusual* or unexpected details of the experience. Unusual cues are most helpful for distinguishing a particular experience from similar experiences that fit the same general schema. For example, participant M2 chose a picture of his spilled water glass to remind him of this particular dinner because it distinguished this dinner from other times he ate out. Participant M1 chose a picture of unusually shaped windows to remind him of a visit to his son's house and to distinguish this house from other houses. M3 chose a picture (Figure 2) of the surprisingly large variety of food served at a dinner party to remind him of how this dinner party was different from all previous dinner parties. In our interviews after the photo sorting task, our participants expressed that good cues are details that "stand out" indicating that the unexpected details are good for triggering memory.

Distinctive cues do not always have to be unusual but can also be *prototypical* of a distinctive experience. Prototypical cues are the cues that one would expect in the schema of the experience

Figure 2. Good cues are distinctive (so much food!) and personally significant (participant is a widow like the hostess).

and useful for distinguishing an experience from dissimilar experiences and normal everyday life. For example, participant N1 chose a picture of the snow-covered parking lot to remind her of a one time visit to a ski lodge. Participant M4 selected a picture of the award his wife won to remind him of attending a special luncheon where his wife received a service award. Participant N2 chose a picture of the widow to remind him of a cousin's memorial service. The details represented in the chosen pictures are typical of what one would expect for those experiences. A prototypical detail can be an effective cue to recollect other prototypical aspects of the experience and to remember a particularly distinctive experience.

4.3.4 Personal Significance

Good cues for recollecting the experience also tend to hold more personal meaning for the individual. We saw that participants chose pictures of important people in their lives and discarded pictures of people whom they just met. Participant N4 chose pictures of people he met at a dinner party whom he found out had a personal connection to his father. Personal significance makes a cue more effective in triggering memory recall because it makes the cue more recognizable and memorable, a basic requirement of an effective cue, as discussed previously. People tend to pay more attention to personally significant details of an experience. Participant M5 paid more attention to a 1950's kitchen exhibit and a chose to keep a photo of that to remind her of a museum visit because she once had a kitchen like that. More attention expended during the initial encoding of the experience results in a richer, more deeply encoded memory trace in the brain, making it easier for subsequent retrieval [8].

Once remembered or recognized, a more elaborate memory trace can in turn be used as a powerful cue to retrieve other aspects of the experience. Participant N1 selected a picture of an old friend who worked at a garden center instead of choosing pictures of the plants because remembering the friend helped her remember how he helped her find the plants she wanted and how nice it was to see him again. Participants expressed the importance of remembering how they felt during the experience. Cues that are personally significant are more effective cues at triggering a rich recollection of the experience.

We even observed that caregivers chose personally significant details of the experience when verbally situating the participant in the experience when they had trouble recognizing the photos.

To remind M3 of who hosted the dinner party, M3's caregiver reminded him that the hostess was the woman who lost her husband in 9/11.

4.3.5 Differences between participants with and without Episodic Memory Impairment

We wanted to understand whether older individuals without EMI would be good proxies for older individuals with EMI when designing systems that provide memory cues. The photo sorting task helped us to identify some key differences. In addition, individuals without EMI (young or old) can still forget important experiences so understanding their needs and abilities is valuable for designing technology to support them.

Participants with EMI were more likely to be cognitively overloaded. While participants repeatedly said it was pleasant to review photos, sorting more than 50 photos proved to be taxing for some individuals with EMI. In two cases, we had to shortcut the sorting task and had participants simply choose 1, 2, or 3 photos that best reminded them of the experience and stopped the sorting task (after making it clear that they could quit the task anytime if they felt uncomfortable). Re-testing these participants starting with a reduced number of photos at a later date was unfeasible because their residual memory of the initial sorting process may affect their cue choices. People with EMI often have other cognitive impairments that limit the number of cues they can utilize. This reinforces the need to identify and present only the most effective cues to avoid cognitive overload.

Unlike our participants without EMI, those with EMI had difficulty remembering the original experience even when looking at the first few photos. The caregiver had to explain to the participant when the experience occurred and a few details that the participant could recognize. Once situated, participants were able use the photos to jog their memory for details. Individuals with EMI need basic orienting cues before more specific cues for details are effective.

The content of the cues chosen was also different between our two groups. We observed that participants with EMI chose photos that represented the important highlights of the experience such as the important people met and actions that occurred. Highlights convey the gist of the experience and are helpful for re-learning the experience in the absence of recollection. In addition to the highlights of the experience, participants without EMI chose photos that reminded them of the smaller details or a feeling because they had confidence in their ability to remember the highlights of the experience without cues. Participant N4 chose a photo showing nothing but clapping hands during a church concert to remind himself of the lively atmosphere. Good cues for individuals without EMI can be more subtle and less central to the experience, whereas good cues for those with memory impairment need to cover the important highlights of the experience so that they can re-learn and re-construct the forgotten experience. In the following section, we discuss how these differences and the characteristics of good cues can influence the design of technology to reduce the caregiver burden.

5. DISCUSSION

5.1 Design Implications

In supporting episodic memory, caregivers of people with EMI are overburdened and shortcut the cueing process because they face two challenges: (1) a lack of rich cues in addition to caregiver's verbal descriptions and (2) the recurring need to engage in this cueing process again and again. Technology has the potential to address both these challenges. For the first challenge, automated lifelogging technologies can provide rich cues to support episodic memory recollection. Caregivers no longer have to rely solely on their own memory of the experience to generate verbal cues, but instead they can use the multimedia cues captured by the system to help people with EMI recollect their experiences. For the second challenge, technology can reduce the burden of repetitive support for episodic memory by allowing the caregiver to select multimedia cues from an experience and create a digital narrative that the person with EMI can review on their own to help recollect that experience. Instead of needing to provide the same cues for the same experience again and again, the caregiver can refer the person with EMI to the digital narrative that can patiently provide rich cues selected and annotated by the caregiver, akin to the information appliance described in [11] but focused on recollection instead of current information. Caregivers can greatly benefit from the reduced burden to come up with cues and to repetitively provide reminders about the same experience.

However, lifelogging technologies usually err on the side of comprehensiveness which results in much more data than the caregiver needs to support episodic memory. In addition, people with memory problems often have limited cognitive resources to devote to reviewing. For current lifelogging technologies to be effective, caregivers are burdened with sorting through copious amounts of data to pick the best cues. Using the findings from our second field study about the characteristics of good memory cues, automatic summarization techniques have the potential to reduce the amount of data to review by automatically extracting only the most effective cues. For example, a system could automatically extract key frames from a video stream, particular photos from a large photo set, and/or soundbytes from an audio stream to produce cues that when reviewed can trigger a maximally detailed recollection of the original experience.

We now consider whether the characteristics of good cues can be automatically identified, the relevant data extracted and presented as good memory cues. We point out when the caregiver (or some other human) would likely need to intervene to recognize and select the most effective cues when computer systems are unable to make that distinction.

From our photo sorting task, we found that participants chose a set of cues that were of the same type as their experiences. Thus, knowing the type of experience can help determine what types of cues are most appropriate to be captured and presented to best support recollection of the experience. In other words, instead of weighing all cue types equally for all experiences, systems should automatically highlight or extract cues of a particular type that will most likely represent the important aspects of the experience and be good cues for recollecting the experience.

More directed and lightweight capture approaches can be used to target particular types of cues when the type of experience is known beforehand. For example, visiting a new town on a vacation is a place-based experience, which means that capturing and presenting the places visited are likely to result in good memory cues for recollection. Instead of needlessly capturing days of video recordings to capture place information, a lightweight tracking device such as a GPS-equipped mobile phone may be sufficient for capturing cues that will be effective

at triggering recollection of the place-based experience. For a people-based experience like a family get-together, simply knowing who else was there or whom you spoke with are probably good cues to help you remember the experience. Monitoring Bluetooth signals from other people's mobile phones is one way to sense the presence, proximity, and identity of other people. Systems such as the iBracelet [21] can also sense identity, as well as monitor people's activities and the objects they encounter. With an understanding of which cue or combination of cues is most important for a particular experience, more lightweight, less invasive capture systems are more likely to be adopted because they produce less overwhelming accounts of people's experiences that are still effective (or even more effective) for triggering recollection.

Thus far, we have highlighted opportunities for technology to automatically capture the appropriate types of cues for particular experiences. In all these cases, the caregiver can depend on the technology to automate some aspect, but the technology, at the same time, must rely on the caregiver to identify important cues which it cannot identify.

Our study showed that memory cues first need to be memorable or at least recognizable so that individuals can use them as anchors to retrieve other details. Two factors that contribute to being more memorable are distinctiveness and personal significance. Identifying distinctive details is difficult for technology, for they can be either unusual or prototypical details of the experience. Personally significant details are also difficult for technology to identify because it requires an understanding of personal histories and interests, something that only the user (and caregiver) may be aware of. Attempts to automatically identify personally significant details to guide the capture or presentation process have focused mainly on sensing the physiological arousal of the user such as monitoring galvanic skin response [12] or brain wave activities [2]. However, these techniques are rather invasive or embarrassing, requiring the user to attach awkward looking devices to themselves that may not be socially acceptable. When using lifelogging technologies as a source of cues, the caregiver needs to play an important role in identifying the distinctive and personally significant details. We observed that caregivers when describing a photo often used verbal cues that were more distinctive or personally significant. For any assistive technology that supports memory, the caregiver must be involved to remind the person with EMI to use, operate, or turn on the system. Therefore, lifelogging systems should be designed to leverage the expertise of the caregiver in identifying good cues to support the person with EMI.

Another important role for the caregiver is to correct any errors made by the system. Two types of errors can occur: false positives and false negatives. To recover from a false positive error (*e.g.*, a bad cue identified as a good cue), caregivers can use their ability to judge the effectiveness of a cue for triggering memory. To recover from a false negative error (*e.g.*, a good cue identified as a bad cue), caregivers can use their own memory of the experience to draw out important cues and retrieve them from the system by quickly searching or browsing.

Our results also show that needs and abilities differ between individuals with and without EMI, with respect to how technology should be designed to provide episodic memory cues. Individuals with EMI are more easily cognitively overloaded, which leads to a need for systems to present a smaller number of only the most powerful cues. Systems also need to provide grounding for those with EMI to know what experience they are reviewing, perhaps by first playing a short recorded verbal description from the caregiver before starting the cueing process to trigger their recollection. From a sensing perspective, the episodic information needs of people with EMI which include the basic highlights of the experience (people, objects, places, and action) are actually more tractable to sense using technology than the more subtle cues and abstract feelings that individuals without EMI want to remember from the experience. Despite these differences in needs, we want to note that using lifelogging technologies actually *before* people with EMI develop memory problems can lead to later benefits once they do experience memory loss or progress to a more severe stage, for intelligent systems may be able to use this captured personal history to figure out what details of new experiences are distinctive or personally significant.

A potential concern with any lifelogging technology is a loss of privacy for the individual using the technology and also those who interact with the user. Lifelogging systems need to provide users or their caregivers with the ability to delete any captured data. Limiting the amount of information captured by using more focused, lightweight capture technologies can also mitigate the potential for privacy problems.

5.2 Methodological Issues

We encountered some challenges when conducting our studies. Our first study involved a researcher closely observing participants. While we told participants to carry on normally, the presence of an observer would initially affect how they behave. We mitigated this concern by spending a longer amount of time (two days, instead of just a few hours) with them so that they would become accustomed to the observer and behave more normally. Nevertheless, a more detailed ethnography would require much more time than two days.

In our second study, to ensure participants with EMI were actually recollecting their experience when reviewing the photos, their caregiver was always present to point out incorrect recollections. We assumed that caregivers and our participants without EMI would remember the experience correctly because the reviews occurred at most two days after the experience.

We validated our participants' selection of good cues by comparing their choice of photos with those not chosen. We were only able to test the choice of cues with two individuals but the results so far indicate that the selected photos are indeed better at triggering recollection of the original experience. We plan to perform a similar validation with our other participants. It is also possible that one experience may simply be more memorable than the other. We tried to control for these differences by considering only the additional details recollected after seeing the photos sets. These details reveal how effective the cues are, rather than how memorable the experience was. The variability of experiences is one tradeoff when working with real-life experiences.

One limitation of our studies is the small number of participants. However, we spent many hours with each participant, and in the case of the second study, we recorded our photo sorting sessions and spent hours reviewing and analyzing them. We feel that the length and depth of these studies and analysis give us deep insight into the issues of EMI facing our participants.

6. CONCLUSION AND FUTURE WORK

As more people are struggling with episodic memory impairment associated with Alzheimer's disease and more caregivers are overburdened with providing support, the need for lifelogging technologies that can assist both the caregiver and the person with EMI in providing cues for recollection becomes clear. To aid the design of such technologies, we have developed an understanding of what cues best help trigger recollection and thus what details lifelogging technologies should present as good cues. We observed that experiences were usually well represented by one dominant type of cue (person, place, object, or action). Good memory cues must be memorable or at least recognizable and that more distinct and personally significant details of an experience are more memorable. To the extent that technology can automatically sense these characteristics, future lifelogging systems can leverage this understanding of good memory cues to optimize which details of a recorded experience to select as cues to support episodic memory. These systems have great potential to not only support the person with memory impairment but also to relieve a substantial amount (but not all) of the burden on the caregiver in providing cues for episodic memory impairment.

Our future work will further investigate the relationship between different cues and types of experiences. We want to identify the most effective modality to capture and present these cues, for this influences not only *what* information lifelogging technology should capture but also *how* it should capture and present these cues, taking social and aesthetic issues into account. We will investigate the order to present more or less supportive cues to understand the amount of support people with EMI actually need to recollect their experiences. Finally, we will use our understanding of good cues to build and test a lifelogging system that assists the caregiver in providing episodic memory support.

7. ACKNOWLEDGEMENTS

8. REFERENCES

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