Now Let Me See Where I Was: Understanding How Lifelogs Mediate Memory

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ABSTRACT

Lifelogging technologies can capture both mundane and important experiences in our daily lives, resulting in a rich record of the places we visit and the things we see. This study moves beyond technology demonstrations, in aiming to better understand *how* and *why* different types of Lifelogs aid memory. Previous work has demonstrated that Lifelogs can aid recall, but that they do many other things too. They can help us look back at the past in new ways, or to reconstruct what we did in our lives, even if we don't recall exact details. Here we extend the notion of Lifelogging to include *locational* information. We augment streams of Lifelog images with geographic data to examine how different types of data (visual or locational) might affect memory. Our results show that visual cues promote detailed memories (akin to recollection). In contrast locational information supports inferential processes – allowing participants to reconstruct habits in their behaviour.

Author Keywords

Lifelogging, memory, remembering, SenseCam, GPS, geo-visual Lifelogging, wearable data capture, psychology.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Experimentation, Human Factors

INTRODUCTION

Now that we can record almost every moment of our everyday lives visually [12, 21, 26], spatially [35, 1], or verbally [37, 39, 34], we can potentially store every second of our lives in a digital archive [2]. Such extensive capture of everyday events has created a Lifelogging culture and a vision of the future in which a vast store of personal data can provide us all with a kind of "prosthetic" memory.

Many Lifelogging approaches are passive; systems are designed to automatically record data without the need for user effort or intervention. This eliminates the burdens of users having to decide whether a particular incident is worth capturing, as well as the need to manually prepare and operate a capture device. The advantages are obvious – no important moment gets missed, and users aren't taken "out of the moment".

Lifelogging could radically transform mnemonic activities such as writing personal diaries, note-taking or other practices intended to address everyday forgetting, as well as reminiscing activities involving photos. While there have been many demonstrations of Lifelogging technology, with some exceptions [19, 32] rather less is known about how it will be used in everyday life. We also lack theoretical insights into exactly *how* such tools might support everyday memory processes.

Such insights should allow us to design better tools to access Lifelogs. The design space here is complex: e.g. there are multiple *types* of data that we might collect about our past, as well as different ways that we might present logged data. These might have different implications for how and what we remember. In this study, we specifically wanted to examine the effects on memory of providing *locational* as well as *visual* records of everyday activity.

Figure 1. (a) "SenseCam" from Microsoft Research in Cambridge: a wearable digital camera, and (b) Garmin eTrax Legend HCx model GPS unit.

There are various ways that psychological theory might inform the design of Lifelogging technologies. Some theories argue that our memory for everyday events is mediated by *visual images* [4, 10]. And studies of domestic photography also observe the evocative power of such images in supporting reminiscence [7, 6, 16]. These accounts argue for the utility of technologies such as SenseCam (see Fig 1 and 2), which captures a series of still images of one's everyday life. Capture is triggered by user activity such as movement, or changes in light. Indeed, recent work has shown that such images can help people with severe amnesia to consolidate recent memories [3].

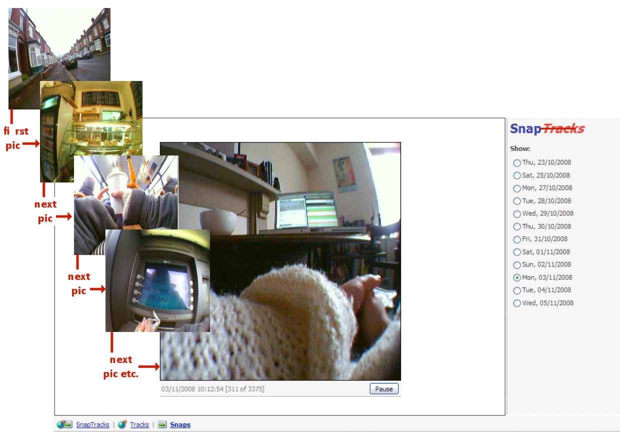

Figure 2. ***Snaps*** **visualization showing sequential images of everyday activity.**

It is also well known that human memory is a reconstructive process mediated by cues, and in particular that *location* cues can be important in triggering everyday recall [25, 38]. There are now many widely available geotagging tools that provide such information. Abstract location information might also support different *types* of memory, offering a high level view of the everyday. Showing spatial tracks or patterns on a map might allow people to infer their habits (see Fig 3).

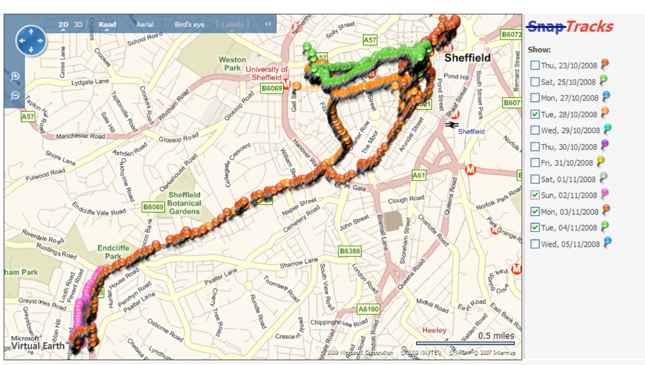

Figure 3. ***Tracks*** **visualization showing locational information.**

Reflecting on habitual aspects of our past has been shown to be crucial for reminiscence [29]. And of course combining location information with visual images might allow people to better situate past activities in context. Combining images with location information might also address criticisms of technologies like Sensecam: that they accumulate multiple images of the mundane [31]. Providing contextual data for visual images could facilitate focusing on the important or unusual [18]. Finally, different types of Lifelog data might also have different evocative effects. Prior theory [4,10] argues for the evocative power of images, whereas it is not necessarily the case that locational information has the same effect.

Prior work [11, 32] concerning memory processes argues that memories are often *inferential* rather than involving mental re-experiencing or recalling of the original event. True recall means recollecting or mentally reliving an event from the past, including the details of that past. This is often referred to as "episodic" memory [36]. Inference, on the other hand, is about deducing that one *must* have participated in some event even if one can't actually recollect it. So, for example, I might infer I had attended a meeting because I have my notes about it, even if I don't actually recall being there. Prior work [32] suggests that Lifelogging tools can both promote such reconstructive inferences, as well as support genuine recall. A further question for this study, then, is whether there is a difference between image versus locational Lifelogging data in the extent to which they support true recall versus inference.

Approach

To investigate these issues, we asked 18 participants to passively capture image and locational information about their daily lives over a two week period. Their memories of everyday events were then tested using three types of Lifelogs: (a) *Snaps* (a Lifelog based on visual images, Fig 2); (b) *Tracks* (a Lifelog based only on locational data, Fig 3); and (c) *SnapTracks* (a combination of both visual and locational data, Fig 4). All of these Lifelogging tools were compared to memory of events when memory is unaided (which we will call Organic Memory or OM).

The specific research questions were as follows:

- How effective are different types of Lifelogs? Do visual images, locations, or a combination of both promote better recall of past events?
- Exactly how are events remembered with Lifelogs? Are they *inferred* on the basis of the Lifelog data or do people experience true recollection? Does this process differ for image versus locational information?
- What are the other characteristics of memory that different types of Lifelogs evoke? In particular, which types of Lifelogs are seen as the most emotionally evocative, and which are preferred?
- What do these results imply about how different types of Lifelogs might be used? How might this affect the design of future Lifelogging systems?

Given the importance of images for everyday memory [11, 4], we expected the image-centric tools, *Snaps* and *SnapsTracks,* to promote greater recall than locational tools (*Tracks*) or OM. With regard to the second research question, we expected that the image-centric tools would provoke more real recall rather than locational tools or OM. On the other hand, we expected locational tools (*Tracks* and *Snaptracks*) to allow people to infer typical patterns in their activities better than purely image-centric (*Snaps*) tools or OM. With regard to questions about other characteristics, and issues of preference, we treated these as exploratory.

RELATED WORK

Providing digital cues about past events generally improves recollection [22]. However such studies do not determine whether these recollections are inferred or actually remembered. In fact, few studies have examined the ways in which Lifelogging data might cue memory for normal people in the course of their everyday lives. One exception [32] showed that automatically captured visual cues can effectively cue recall of the past, but in the longer term (longer than three months) these cues act more to support people's inferences about their past, rather than to support true recollection. Other work [20] has shown that Lifelogging tools should be considered more broadly as not just for memory support, but for helping people look back at the past differently and creatively. Together, these studies show that, while Lifelogging data may sometimes help us recollect the past, equally such cues may cause us to see it, or reconstruct it, quite differently.

At the same time, we know that people remember visual information very well [8], and a number of Lifelogging tools have focused on using visual information to support memory archiving [17]. It is evident that visual Lifelog data can be complex, with thousands of often similar images being generated. There have therefore been attempts to cluster Lifelogs into meaningful events [13] to help make sense of large streams of visual information. Other work has investigated the use of a "digital compass" to group captured images into clusters that share a geographic directionality, as a means to provide users with additional visual cues for recognising their events [5].

New personal Lifelogging services such as Nokia's vine [27] and ReQall [30] allow users to continuously record their geographic location. However, it is not clear what additional benefit locational logging contributes to visual Lifelogging practices, or its ability to effectively act as a cue for organic memory. Psychology research suggests that people tend to remember places or events better than, for example, temporal event information [9], making this an interesting topic for research. A number of sophisticated systems have been developed to help organise geo-visual data [17, 35]. However, there is little evidence of systematic evaluation investigating geo-visual Lifelogging and its effects on remembering.

Furthermore, psychology research suggests that atypical and emotionally rich memories tend to be more durable [28]. Locational data could, potentially, be used to highlight the *atypicality* of individual events. New methods that aim to identify atypicality from individual locational trails also known as "novelty detection" [23] have been developed.

On the other hand, studies investigating individual human mobility patterns have revealed that there is a high temporal and spatial regularity in individual's mobility patterns [18]. This raises the question of whether, even when people have very similar everyday spatial and temporal patterns, the augmentation of locational data with images might add a distinctive layer of information to Lifelogs to further support memory.

Taken together, the literature both from psychology, and from HCI poses many unanswered questions about the nature of memory support for these different kinds of data.

METHOD

We begin by describing the Lifelogging tools used in the study, both for data capture, and for visualizing the data. Then we describe details of the study itself.

Lifelogging Capture Tools

SenseCam: *SenseCam* [21] is a wearable digital camera(Fig 1(a)) which has been widely used in prosthetic memory aid research [3], visual data segmentation [13] and as an educational tool [15]. It has two picture capture modes: temporal and sensor-based. In temporal mode, SenseCam captures pictures at specified regular time intervals. In sensor mode, it captures pictures when one of the sensors (light, motion or temperature) is activated, e.g. when the wearer gets up to leave the room. In this study, we used SenseCam in sensor mode. On average this generates about 4000 images per day for each active participant.

GPS: For the *GPS Unit*, we used the eTrax Legend HCx model (Fig 1(b)) for automatically capturing GPS co-ordinates. All devices had the Wide Area Augmentation System (WAAS) enabled. This allowed each GPS unit to maximise the satellite accuracy to less than 3 metres [33]. Each unit also had an additional 2GB micro SD card to ensure that there was enough space for a 2 week continuous log. Rechargeable batteries with chargers were provided for powering the GPS unit.

Lifelog Visualisation Tools

Snaps: is a SenseCam picture viewer embedded in a web browser (see Fig 2). *Snaps* allow people to view their pictures sequentially on a day by day basis. When the user selects a day they want to remember, their pictures are played in a temporal order from the beginning of that day. Users can pause or replay their pictures. Fig 2 illustrates a sequence from one user's morning (from left to right). It starts with them leaving their house (1st picture), popping into the coffee shop (2nd picture), drinking their coffee on the bus to work (3rd picture), stopping to check their bank balance at the next ATM (4th picture) and finally reaching their work place (main picture).

Tracks: *Tracks* (Fig 3) takes the GPS data and shows user routes on a real-time custom Microsoft Virtual Earth map. The GPS units were set to sample location every minute. We used a map visualisation to show users a high level overview of their whereabouts. *Tracks* can be filtered by days showing users' daily routes depicting each day in a different colour. Users can choose to display multiple days on the same map at once. Furthermore, each waypoint of the GPS route is time stamped. Timestamps are displayed when users hover over individual waypoints. Users can access these timestamps to identify their whereabouts during different parts of the day (e.g. morning or evening) to help them identify the locations and potentially remember activities at these locations.

SnapTracks: Fig 4 illustrates the *SnapTracks* interface. *SnapTracks* combines GPS co-ordinates and SenseCam data temporally on a map visualisation that displays user routes. The goal is to use the map as an overview method allowing users to drill down into more detailed personal images. For instance when a person walks down a street, their position is automatically logged every minute on their GPS unit with an accompanying a time stamp. At the same time, SenseCam automatically captures pictures and assigns a time stamp. *SnapTracks* compares the two timestamps and pairs GPS and SenseCam data based on a +/-25 second range. Thus if a SenseCam timestamp falls within 50 seconds of a GPS timestamp, that picture and the GPS point will be paired together. Again data are displayed on the custom Microsoft's live Virtual Earth map as a pin showing that picture as illustrated in Fig 4. Individual pictures pop up one by one, as the user hovers over the relevant GPS point pins on the map, see Fig 4. Complete routes and pop-up pictures from SenseCam can be activated from the map by selecting a day(s) from the right hand side of the *SnapTracks* interface.

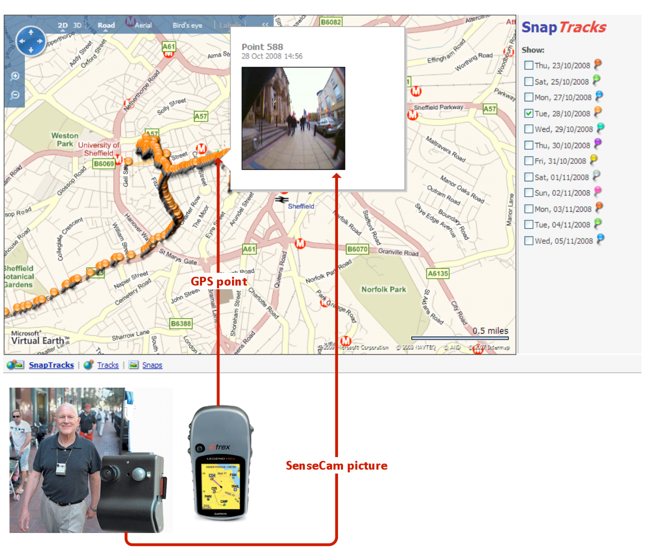

Figure 4. *SnapTracks* visualization.

Participants

Eighteen participants took part (4 female and 14 male, aged 25 - 56). Participants were volunteers from a wide variety of backgrounds: researchers from industrial and academic laboratories, sales people, civil servants, management and administrative staff, as well as other professionals from public and private sectors. None of the participants had prior experience of wearing SenseCam or using GPS units. Participants received a 20-pound book voucher on completion of the experiment.

Procedure

The study consisted of two stages: 1) *capture* and 2) *recall*, each of which are described in detail below. At the *capture* stage, we asked each participant to wear both lifelogging tools (Sensecam and the GPS unit) for *two* consecutive weeks. At the *recall* stage we conducted a controlled within-subject experiment where our participants used each type of Lifelog. We compared their recall with unaided memory as a control condition. Participants were tested on their retrieval of information about everyday events that took place during those two weeks of logged activity.

Capture Phase

We began the capture session with a general description of the study, handing out the Lifelogging tools and giving hands-on instruction about how to use these tools. Participants were instructed to wear the SenseCam and the GPS unit every day during the 2 week period. They were asked to keep both of these devices switched on as long as they could during the day, but obviously there were times when they had to switch them off; confidential meetings and visits to the bathroom are better left un-captured. Nothing was said in advance about the purpose of the experiment, but participants were informed that their memory would be tested at the end of the study.

Recall Phase

Recall took place an average of 5 weeks after the two capture weeks had ended. Participants were first given a general description of the Recall Methods they would use – i.e. whether they would use *Snaps*, *Tracks*, *SnapTracks* or *OM* to remember. We also told them about the different types of questions they would be asked. We then gave them a brief web-based, hands-on tutorial providing detailed descriptions of the different Recall Methods and procedures for the experiment.

For a specific Recall Method, we asked users to recall all events during one of their logged days (e.g. morning, afternoon or evening). We excluded weekends, as we thought these may be highly atypical. We asked them to answer the following memory question: *'What did you do, where did you go and who did you meet on [Monday][morning], [November 22nd]?'*. They did this using *SnapTracks*, *Tracks*, *Snaps* or unaided memory (OM), depending on the experimental condition. They were given as long as they liked to answer. This recall probe is typical of those used in prior studies of everyday memory [11, 32].

With the same Recall Method, we then asked the same recall probe for a different period, changing the day, time-of-day and date specified. Overall, we gave each participant 2 probes for all 4 Recall Methods. This led to a total of 8 memory questions per participant, covering 8 different periods out of their 2 weeks of logs. To control for parts of the day/recall method, we counterbalanced the order in which users were asked about specific days and times of the day, and the different Recall Methods they used to answer each memory question. Participants answered questions on both paper-based forms and verbally. Paper-based forms contained questions on emotion, typicality, inference and cuing effect for each study question. The verbal answers were recorded and transcribed by one of the experimenters.

Again following prior research [11, 32], we classified recall into different *events*, e.g. 'went to lunch', as well as *details* pertaining to those events: e.g. people, 'Dave and Emma were there', places 'we went to East One', times 'we were there until 2', or associated details 'we talked about their new house'.

Recall versus Inference Test

In addition to describing the event, participants were asked, for each event, to state *how* they were recalling it, and whether they remembered, knew, or guessed (a common distinction in memory tests (see [32] for a review)). It was explained to subjects that rather than a scale of well-remembered to badly-remembered, these three options represented qualitatively different types of memory which we defined as follows:

Remember – We defined this as when an event can be re-experienced in the 'mind's eye', where one can mentally place oneself in the scene described.

Know – This was defined as an event which one infers *must* have occurred that day. This can be because it was a routine event (e.g. I *always* play tennis on Tuesday), or because other remembered events indicate it must have happened, e.g. they 'remember' spending time with someone later in the day, so therefore *must* have spent time with them in the morning as well, even though they are not able to mentally re-experience doing so.

Guess – We suggested the use of this option to allow subjects to fill in events they were uncertain about (perhaps out of a desire to comply when nothing much was remembered).

Questionnaire

After recalling the events and answering the inference questions, we gave each participant a brief questionnaire, asking them to compare each Recall Method they used and contrast it to their unaided OM.

Participants were asked to rank each Recall Method on a scale for each of three aspects:

- *Emotion* it engendered ("Recall Method X made me feel emotional when browsing through my logs") (Emotion).
- *Typicality* of the experience promoted ("Recall Method X helped me observe typical patterns in my behaviours") (Typicality).
- *Overall preference* for one of the recall methods ("Which tool did you like the best?") (Overall Preference).

We also recorded spontaneous comments made by participants as they recalled their experiences. In addition we asked open-ended questions about what people perceived to be the main differences between each recall method and why they preferred one type of Lifelog to another. We present these as quotes below.

Measures and Variables

To sum up, we collected the following data:

- *Events*: The number of events reported in each condition - e.g. 'went to lunch' is an event, and details pertaining to that event: e.g. people or places associated with that event;
- *Reconstruction rating*: The extent to which each reported event was a *reconstruction* (something they inferred or guessed) rather than a *re-experiencing* of the original event (something they claimed to have remembered). This was collected through self reports when users where asked to say how they remembered each event, e.g. remembered, knew or guessed. This was calculated by combining 'know' and 'guess' answers and dividing it by the total number of events recalled;
- *Comparative evaluation ratings:* for the different Recall Methods and unaided memory, in terms of emotions, typicality and overall preference.

RESULTS

Before doing the analysis, we checked the distribution across all our data. Kurtosis values ranged between +1 and -1 which indicates normal distribution. We therefore used parametric statistics.

Number of Events Reported

For each Recall Method, we counted the number of distinct events that each participant described. These are shown in Fig 5. Overall recall was low, with a mean of 0.96 events recalled per probe. However this finding is consistent with similar studies [32]. We compared different Recall methods using paired t tests, applying the Bonferroni correction. In each case we compared mean number of recalled events for the two retrieval probes corresponding to each Recall method.

We found benefits for the locational information provided by the *Tracks* visualisation: both *SnapTracks* and *Track*s led to better event recall than OM ($t(17)=3.90$, $p<0.005$, t(17)=5.74, p<0.001, respectively). In addition, *SnapTracks* led to greater recall than *Snaps* (t(17)=4.51, p<0.001) - again indicating the benefits of providing locational context for SenseCam images. Somewhat surprisingly, given the importance of images for everyday memory [4, 10] *Snaps* was no better than OM alone (t(17)=0.69, p>0.05). No other significant differences between pairs of conditions were found.

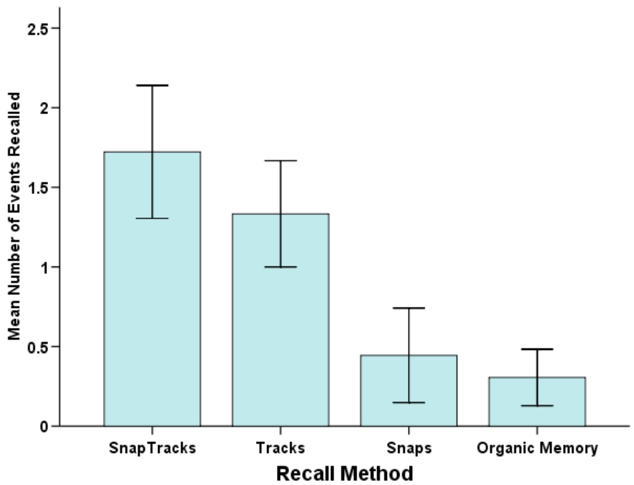

Figure 5. Mean number of *events* recalled per probe for different types of Lifelogs and OM.

Recall versus inference

But just how was it that these different types of data were operating? To what extent were these different cues triggering true recall versus simply promoting inferences about what must have happened on the day in question? Here we can look at the difference between "remembering", "knowing", and "guessing" based on users' judgments about how they remembered each event.

We classified both: 'know' or 'guess' judgments as reconstructions. A high reconstruction rating corresponds to a guessing or "inferring" that something happened, rather than true recollection of that event. We expected that the cues provided by SenseCam data would promote greater inferencing than OM alone.

Fig. 6 shows the prevalence of inference and the utility of Lifelogs for promoting high levels of reconstruction. As we expected, there are significant differences in reconstruction ratings for the different Recall Methods.

Again we compared means for the two retrieval probes, across the different Recall conditions using Bonferroni corrected t tests. We were unable to obtain inference judgments for 8 cases where users had failed to recall any events – these all occurred with OM.

All Lifelogs, *SnapTracks*, *Tracks* and *Snaps* induced more reconstruction than OM (t(9)=4.74, p<0.005, t(9)=3.85, p<0.005, t(9)=2.26, p<0.05, respectively). Similarly, if we look at the proportion of events classified as "remembered" divided by the total number of events recalled, we find that OM events are more likely to be true recollections. Bonferroni corrected paired t test comparisons showed that a higher proportion of OM events are true recollections than both *SnapTracks* and *Tracks* (t(17)=5.00, p<0.001, t(17)=4.59, p<0.001). In addition *Snaps* (visual information only) are more likely to be true recollections than Recall methods that provide locational information, i.e. *Snaps* has a higher percentage of true recall than *Tracks* (t(17)=3.20, p<0.005) or *SnapTracks* (t(17)=3.34, p<0.005). Also there is no difference between OM and *Snaps* in the percentage of remembered events (t(17)=1.72, p>0.05).

Together these two analyses suggest that Lifelogs engender inferencing but that this is more prevalent when locational information is provided. Consistent with [32], Snaps led to some inferencing, but events recalled with *Snaps* were more likely to be true recollective memories than either *Tracks* or *SnapTracks*.

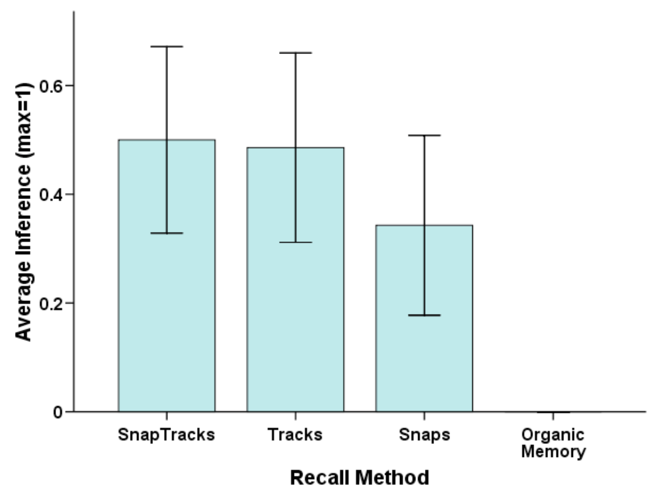

Figure 6. Mean Percentage of Events rated as Inferences for different types of Lifelogs and OM.

User comments also bear this out. One user noted that seeing images tended to promote real recall whereas location promoted inferencing:

"[Snaps] usually made me remember. [SnapTracks and Tracks] made me figure out something must have happened in a particular way e.g. I must have gone home by taxi."

Event Details

If images are more powerful as a trigger for true recollection, we would also expect that participants would report more *details* for those events. We therefore examined our data further looking at the number of *details* that participants provided for each event (see Fig. 7).

Again we analyzed these data using corrected paired t tests. Visual images induced higher recall of details compared with unaided memory: both *Snaps* (t(17)=4.19, p<0.005) and *SnapTracks* (t(17)=5.77, p<0.001) generated more details than OM. We have already seen that OM is heavily reliant on real recall, and visual data seems to sharpen our ability to recall the details of those remembered events.

Visual images also led to more detailed recall than locational data. Both *Snaps* ($t(17)=3.73$, $p<0.005$) and *SnapTracks* ($t(17)=4.74$, $p<0.001$) had more detailed recall than *Tracks*. Finally *Snaps* alone led to more recall of details than *SnapTracks* ($t(17)=2.41$, $p<0.05$). This last finding may result from the fact that in the *Snaps* interface, multiple images are directly visible without user intervention. This contrasts with *SnapTracks* - where users are first presented with the map visualization, which they then use to navigate to the images – making access to images less direct.

One user talked about the value of visual images for promoting detailed recall: *"I found [SenseCam] pictures really useful for those small micro events that happened over these days…."*

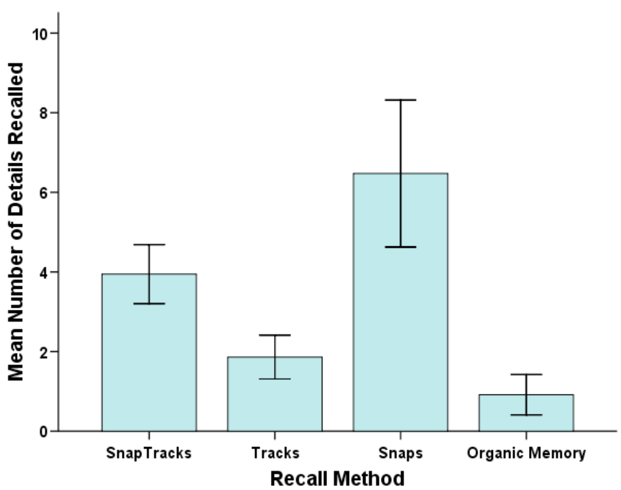

Figure 7. Mean number of *details* recalled per probe for different types of Lifelogs and OM.

To summarise, these results suggest that images and locational information work quite differently in supporting people's ability to report events from their past. Images tend to trigger true recollection of the experiences, complete with the details that one might expect if an event is really remembered. In contrast, locational information supports inference whereby participants are able to deduce what they *must* have been doing even if they can't actually recall the events in question.

Questionnaire Results

The questionnaire data and user comments also suggest that the different types of Lifelog support looking back at the past in very different ways.

Participants' comments confirmed that the different tools were used in different ways. Specifically, participants noted that images were evocative and specific, whereas locational information suggested patterns: "*I see SnapTracks and Tracks showing different things to Snaps. Pictures show micro details, but are evocative. SnapTracks shows patterns. I see Snaps and SenseCam as reminder of a time and SnapTracks and GPS as patterns from that time."*

We now turn to the questionnaire data. Participant judgments for *Emotion*, *Typicality*, and *Overall Preference* for each Recall Method are shown in Fig 8 - 11. We performed Bonferroni corrected paired t tests to determine perceived differences between Recall methods. Again we were missing some data, as subjects could not judge the emotions associated with a memory for those probes where they failed to remember anything.

Emotion

Participants ranked each recalled event on a scale where 0 indicates 'no emotion' and 1 'strong emotions'. The rankings suggest that images were seen as more emotionally evocative (see Figure 8). This is what we might expect if such cues trigger more true recollection as opposed to inference. And one participant noted the evocativeness of image-centric tools, in particular *Snaps* compared with OM: *"[OM] was useless – I could have no emotional attachment to those memories … but the tools, especially [Snaps] were very good at reviving accurate memories."* However t test comparisons between *SnapTracks* and OM, and *Snaps* and OM, did not reveal significant differences between visual images and OM ($t(9)=1.14$, $p>0.05$, $t(9)=0.80$, $p>0.05$, respectively). This may have been the result of large variances we observed in user judgments of emotion.

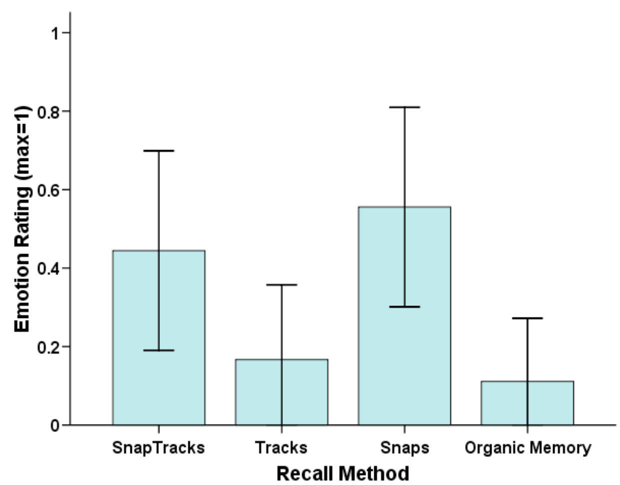

Figure 8. Emotion Rating for events recalled with different types of Lifelogs and OM.

Typicality

Locational information should help with abstraction and inference about the past, in this case about the habits and routines of daily life (see Figure 9). Participant comments from both *SnapTracks* and *Snaps* suggest that locational information supports habit spotting: *"[SnapTracks] - this is me going to the gym…I always go there on Thursdays after* *work…this is the only day I drive"* and "[looking at Tracks] *It looks like I was late again…and I went home an unusual way…I wonder if I took a taxi back home, because it is not the way I would go home by bike*". Participants ranked each event for typicality where 0 meant 'atypical' and 1 'very typical'. Again, we found that although user comments were suggestive, there were no statistical differences for these rankings between locational information and OM ($t(9)=1.0$, $p>0.05$ for *Snaps* versus OM and $t(9)=1.0$, $p>0.05$ for *SnapTracks* versus OM).

Preference

What might we then expect participants to say about which method they preferred and why? Here it is probably most helpful to first consider participants' comments. These suggested an overall preference for *SnapTracks* because this interface allowed people to see rich information but in context/overview format: *"[I] got some cues from tracks with [SnapTracks] and some cues from pictures with [SnapTracks]…[SnapTracks] was good as a way to browse and find relevant snaps – I remember the day when I nearly had a crash [on a bike], I used [SnapTracks] to browse to the place where it happened and then I could see the actual pictures of the person I nearly crashed into."*

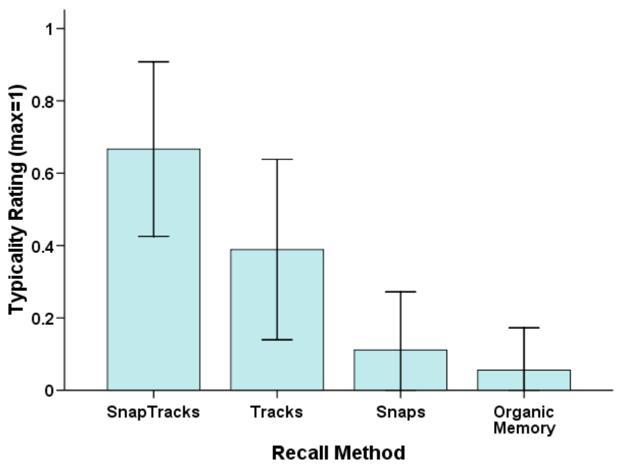

Figure 9. Typicality Rating for events recalled with different types of Lifelogs and OM.

We evaluated users' overall preference ratings for different Recall Methods, where a 1 represents a strong positive preference, and a 0 a strong negative preference (see Fig 10). We found that image-based methods were preferred over OM, ($t(9)=3.0$, $p<0.008$ for *SnapTracks* and $t(9)=1.8$, $p<0.05$ for *Snaps*) but to our surprise *Tracks* wasn't preferred to OM ($t(9)=0.6$, $p>0.6$). This may be because people wanted to have concrete evocative images presented in their Lifelogs. As predicted, *SnapTracks* was rated more highly than *Tracks* ($t(9)=3.34$, $p<0.004$, but not higher than *Snaps* ($t(9)=0.9$, $p>0.4$).

Overall user comments showed greater preference for *SnapTracks*:*"I am good at visualising routes I have taken, so [Tracks] was useful, but with the added pinpointed photos, [SnapTracks] was excellent at jogging my memory."*

We should also add that preference must really be considered in the context of the users' goals. Although the subjects in this study duly answered this question, ultimately preference must be a function of what a user's goal is (for example if they want to make inferences about their activities or to truly recall them). In this case, it appears that participants recognise that different kinds of cues support different kinds of activities. They may therefore have been expressing the view that having both kinds of cues available is the best possible situation.

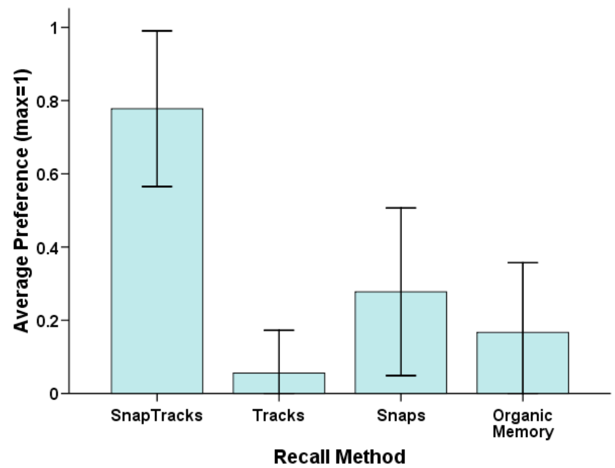

Figure 10. Overall Preference for different types of Lifelogs and OM.

CONCLUSIONS

This study extends the notion of Lifelogging. The majority of past studies have tended to view Lifelogs as single sources of data that trigger simple processes of authentic recall. Instead in this study, we show that there are multiple types of data that we might collect about our pasts, as well as multiple ways of presenting this data. Different data types and views promote different acts of remembering, including ones which might be more properly called inference rather than memory.

More specifically, the study increases our knowledge of *how* Lifelogs might support looking back on the past, and the processes by which cueing operates. Images and locational data clearly function differently: Images promote more genuine, detailed recall, whereas locational information promotes inferencing. While we lack clear data on this point, there is some suggestion too that images may also be more evocative than locational data - presumably because they are associated with authentic recall. Interestingly, images also promoted more recall of details than unaided memory. In contrast, locational data support inferences about one's habitual patterns, providing, when combined with images, a useful context in which to look back at the past. This was confirmed when examining participants' preferences. Participants in this study judged as optimal a combination of locational and image data: so that they could rapidly navigate through large amount of data about their past and then zoom in on details of interest.

There are two further contributions of this work. First, these findings add to theory on everyday memory. Prior work argues that everyday memory is reconstructive. Our study showed inferencing was prevalent, in particular with locational cues. In addition current theories argue for the central role of images in everyday memory [10]. Our results showing the authenticity and detailed nature of image-mediated recall provide further support for this view when we are talking about true recall.

Second, there are important design implications that follow from this study. The most obvious is that image data should be the cornerstone of Lifelogs that aim to support true recollection (although this is not to rule out other forms of data not explored in this study such as ambient audio data). But the findings also suggest that while it is important to collect rich recordings about our past, it is also critical to consider how to present this data. Different views on the data will support different types of remembering.

For example, critics [31] of Lifelogging argue that such systems simply accumulate huge collections of mundane data. Our study shows that providing *abstractions* over that data can potentially address this criticism. These abstractions work best if they can be directly linked to detailed data. More specifically, we saw that people recalled more events when they had locational abstraction combined with the ability to drill down into the detailed images if needed.

Future work needs to provide both different *methods* for abstraction as well as different *types* of abstraction. For example, new interfaces might be built to capitalize on machine learning work that infers different patterns in locational data and identifies unusual patterns [24]. We might use this to provide different styles of *SnapTracks* or *Tracks* interfaces, based around different types of locational patterns. Another approach might be to provide *image* abstractions. Other work has used vision processing techniques, e.g. scene detection or object recognition, to spot patterns in personal image data [14]. These might be used for navigation. In addition, our participants viewed their Lifelogs by date, but there are clearly other types of temporal abstraction that could be explored. Finally, we might want to combine other user activities with Lifelogging data. Calendar data about salient personal events could be linked to Lifelogs allowing people to explore detailed aspects of their past, triggered by those calendar events, e.g. 'what was I doing just before I went on holiday?'

Finally we might explore the benefits of abstraction in medical settings. We know that images consolidate memory in Alzheimer's patients, but could such patients also benefit from more abstract information such as we provided here?

These are just some of the technical and design possibilities that are opened up by a deeper understanding of how different kinds of data support looking back at our own personal pasts. With this in mind, our hope is that future work will continue to more systematically examine the ways in which Lifelogging data interacts with memory and other cognitive, creative and expressive human capacities.

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