Less May Mean More:

Understanding How Different Life-Logs Support Our Memory for the Past

A Honors Thesis Paper by

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1 RATIONALE OF RESEARCH PROJECT

Life-logging technologies, such as ActivityTrails, SenseCam, and the LiveScribe Pen enable capture of our daily experiences, offering us an incredibly rich record of our past. Existing research has explored two types of concerns, one being, how these life-logging technologies may benefit individuals who have trouble recollecting their past, such as patients with Alzheimer's disease {2, 3} and another being, how to manage and make use of the large amounts of data these technologies capture on a day-to-day basis. However, very minimal research has been done specifically on understanding how our interactions with our own life-logging data support specific recollections of our own past. Therefore, the main motivation behind my Honors Research was to understand *what* it is in particular about life-logs that allow us to remember, and also understand *how* we use life-logs to help recollect details about our past.

2 INTRODUCTION

Human memory is powerful, yet very fragile. While forming new memories is an active process, losing them seems to happen quite passively as time elapses and new information enters our brain. We experience forgetting because not everything in our working memory is encoded into long-term memory {7}—a lot of times, we don't necessarily know what we need to remember in the future, and thus, forget things we once had access to in our working memory {10}.

Moreover, even when past events are encoded into long-term memory, we sometimes have trouble accessing this information without the aid of a visual reminder. Post-it notes, calendars, and daily planners are all cultural examples of visual reminders we use to help us remember. A visual reminder is one technique we use to help reinstate the context of our past activities, allowing us to get back to things we want to resume in the future. Reinstating the context of a past-encoded memory of a particular event through visual cues helps bring the details of this memory to the surface because traces of these memories remain even when we forget {7}. This is strong evidence against the analogy that "forgetting" is information deleted from our memory, and instead, evidence that confirms forgetting is the difficulty we have when retrieving information {7}.

While we may hope for human memory to evolve into a more robust system to keep us from "forgetting," counterintuitively, forgetting actually helps us remember. Forgetting is very beneficial for our brain because it successfully suppresses unimportant memories, placing fewer demands on our cognitive resources to help us focus on remembering relevant memories. For example, this makes it easier for you and I to vividly recall significant events that took place on our sixteenth birthday, rather than remember trivial details about the name of our grocery bagger at the grocery store, or the specific color of coffee tables at a café.

The act of remembering is a complex cognitive activity because memory is associative. If someone were to think about what they ate for lunch the day before, it is likely that this would tap into their memories of other lunches. For instance, they may recall that they ate a much-craved chicken pesto sandwich at a local café, which in turn, may also trigger a flood of memories about a conversation they recently had with a colleague at the same café. Because remembering may accompany things that are irrelevant, forgetting acts as a helpful mechanism that selects and targets the memories we need so that they that won't compete with irrelevant memories. This suggests that forgetting is a fundamental counterpart to remembering, since forgetting helps to conserve our neural energy and improve our efficiency in accessing information we really need.

Though forgetting is a natural phenomenon we all experience in order to reduce the resource intensive demands placed on the attentional mechanisms in our brain, regrettably, we do not have influence over deciding what we want to and what we don't want to remember. Consequently, the nature of forgetting comes at the expense of sometimes not having access to essential information we need, such as where we last placed our car keys. To support the challenges of retrieving certain memories for the past, the invention of various life-logging devices have emerged in recent years.

3 LIFE-LOGGING

A life-log is a personal digital archive that contains data from many diverse sources, such as photos, emails, webpages viewed, a calendar of events, memos, music, videotaped lectures, voice recordings, etc. Such collections are automatically collected as users go through their daily activities, thereby offering rich insight into their own lives. Gordon Bell, author of "Total Recall," refers to these digital records of our life as our "e-memory" {1, 14}. Since 2002, acting as his own guinea pig, Bell has been attempting to digitize almost everything in his life by scanning everything from personal documents (i.e. email, bills, legal documents, etc.) to scanning personal artifacts (i.e. posters, paintings, medals, plaques, etc.) to recording his conversations and meetings. As a result, Bell has now stored over 44 gigabytes worth of personal information. To support Bell's lifetime store, MyLifeBits, a project led by Microsoft Research designed a system to store and manage a lifetime's worth of information. The MyLifeBits system was inspired by Memex, a personal store envisioned by Vannevar Bush in 1945 to store documents, photos, and audio {15}. Similarly, the MyLifeBits system supports capture, storage, management, and retrieval of many media types.

The vision that comes with the invention of life-logging technologies is that these devices will allow us to capture everything that has ever happened to us, to record every event we ever experienced, and to save every bit of information we have ever touched {1}. By capturing data about our daily activities, life-logging devices can offer effective support for memory of our own personal past {e.g. 2, 3, 4}. As a consequence of minimal research attention given to life-logging technologies, there are very few, but very significant studies that define the literature of life-logging technologies. In particular, examples of these work are by Abigail Sellen et al., which has demonstrated that life-logs, specifically SenseCam images, can facilitate people's ability to connect with their past {2}. This study provides evidence that passively captured images by an automatic camera like SenseCam can cause people to remember more events than they would with images they have actively captured themselves. In addition, year-long clinical trials conducted with patients suffering from amnesia by Emma Berry et al. have reported that reviewing SenseCam images on a regular basis results in significant recall of the events captured in these images by the patient—something that was previously regarded as impossible {13}.

Implications from Berry's study encourage researchers to pursue future work in finding SenseCam's applications for a wider audience, such as those diagnosed with Alzheimer's disease, a neurodegenerative condition, which impairs people's ability to remember their recent experiences (i.e. episodic memory).

Different from what existing studies have focused on, for my Honors Thesis, I have chosen to conduct a preliminary study using a variety of life-logging technologies: ActivityTrails, SenseCam, and the LiveScribe Pen; to understand *how* different life-logs support our memory of the past. Because all three life-logging devices are characteristically different from each other, the purpose of the preliminary study is to confirm whether different life-logs support our memory for our past in different ways. In addition, this study will also be looking at what cues in these life-logs are responsible for supporting our past memory. These topics drive the motivation of my research. The following sections describe the life-logging technologies selected for this study in detail:

3.1 SENSECAM

Microsoft Research's SenseCam is a life-logging device that archives a wealth of information on personal life history (see Figure 1). SenseCam consists of a camera, data storage chip, and electronic sensors that can capture and store about 3,000 images. It is encased in a lightweight case about the size of a corporate ID badge. Photos are taken with a wide-angle "fish-eye" lens to capture an image likely to contain most of what the wearer can see (see Figure 2). It is typically worn around the neck, capturing traces of activities users are engaged in from a "first-person" point of view. The electronic sensors on the SenseCam detect changes in light levels, motion, and ambient temperature to determine when it is appropriate to take a photo (ie. when the user moves from indoors to outdoors, the change in light levels will be detected, triggering the SenseCam to take a photo). SenseCam is a wearable digital camera, which performs automatic capture that can serve as a pictorial diary from a user's visual perspective.

Figure 1. Latest Microsoft Research's SenseCam device.

Figure 2. SenseCam images are characteristically concave, visually capturing peripheral information about the environment

Novel life-logging devices like SenseCam have been found to benefit those who have memory impairments by acting as a memory prosthesis {2}. SenseCam is a life-changing device for those who have memory impairments because the details captured in SenseCam images support episodic and autobiographical memory {13}.

3.2 ACTIVITYTRAILS(LITE)

Like SenseCam, ActivityTrails is another life-logging device, though it records onscreen user activity. ActivityTrails is a software prototype created by UC San Diego graduate student, Gaston Cangiano that captures desktop activity screenshots during instances that are "interesting." Interesting activity is calculated using an algorithm that denotes changes in desktop activity, such as by the number of keystrokes made, number of applications open or closed, and the number of windows open or closed. ActivityTrails also prompts users to log events or activities in a dialogue box when users feel the information is worth noting for the future. During instances where users do not want their desktop activity recorded, ActivityTrails can be temporarily disabled to suspend recording.

ActivityTrails runs on a computer transparently—only a small icon is visible on the task bar to indicate that the software is running (see left image, Figure 3). Though ActivityTrails features are still in development, currently, users are able to search through their desktop activity recordings through keywords (see right image, Figure 3), viewing thumbnails of screenshots (Figure 4), and reviewing a video summary of selected segments of desktop activity. Thumbnails of desktop activity will include a wide range of information, such as, images of websites viewed, typed text on a Microsoft Word document, computer games played, and Facebook profiles visited. When users are viewing thumbnails of screenshots, ActivityTrails also provides a word cloud that displays keywords to help describe what the thumbnail includes (see Figure 5).

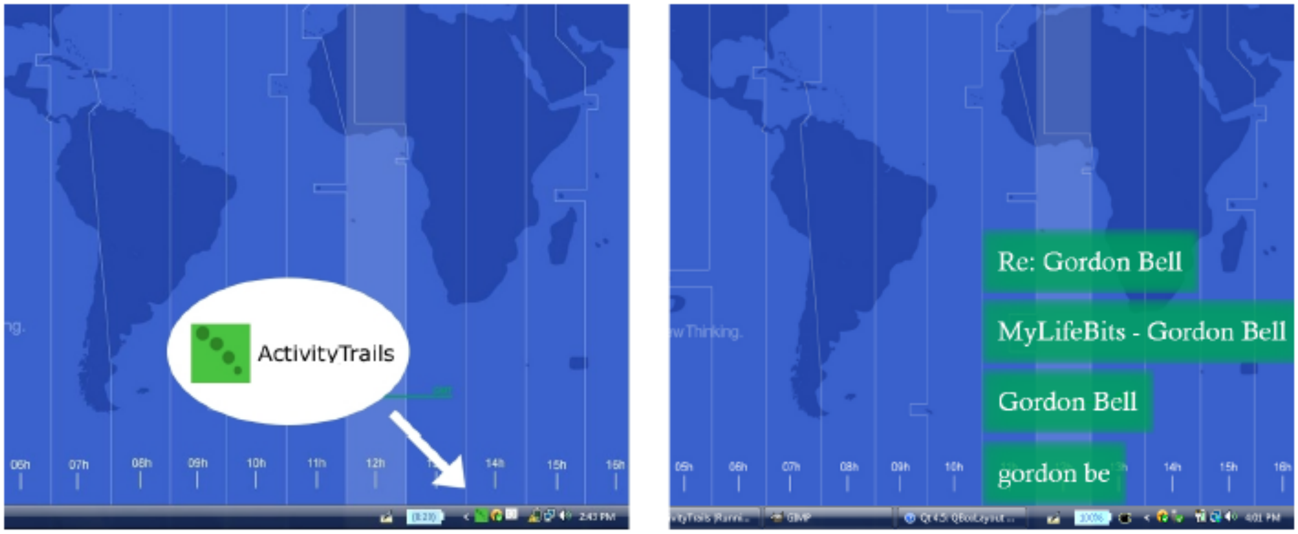


Figure 3. ActivityTrails interface: (left) ActivityTrails icon on the task bar shows ActivityTrails is active. (right) Users can search for thumbnail recordings through keywords.

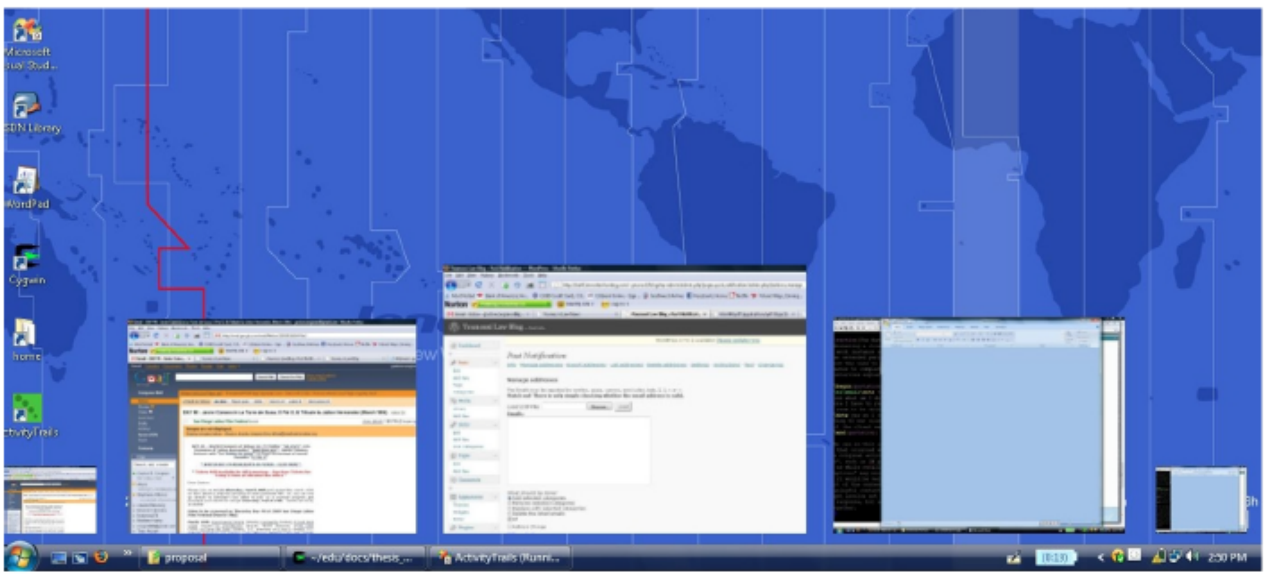


Figure 4. ActivityTrails interface: Preview of summary thumbnails expands to a viewable size with mouse rollover. Thumbnail expands to a full-screen video summary when clicked.

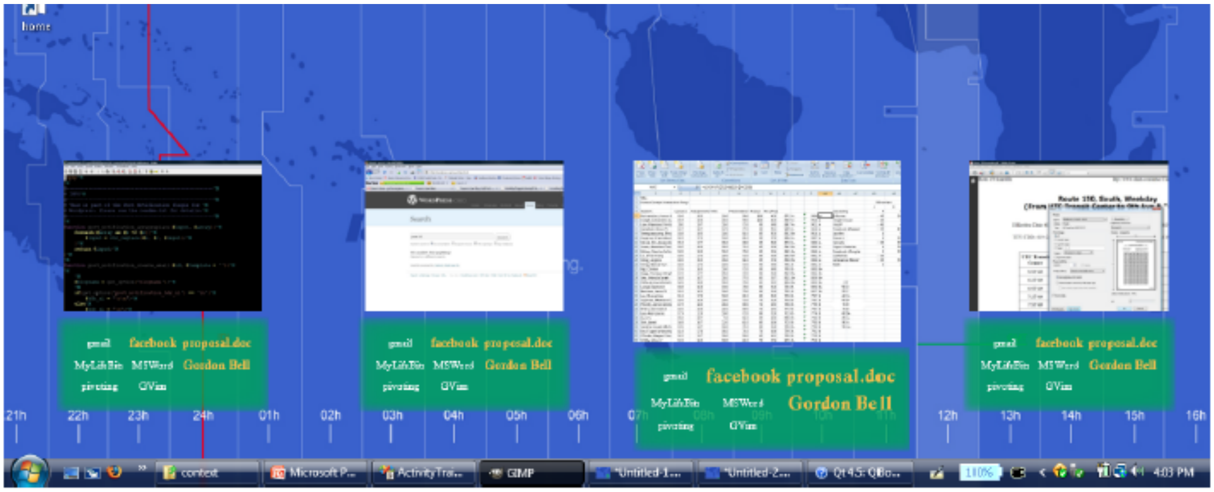


Figure 5. ActivityTrails interface. Extra information about thumbnails is provided by word clouds that appear below.

Cangiano developed ActivityTrails to allow users to navigate and search their past history on their computers through screenshots of desktop activity. Specifically, Cangiano conducted an ethnographic study of law office workers using the ActivityTrails software to help them recall information such as, the exact name of their client, the details of an interaction they had with a particular client, and information on a past viewed document they need for a case they are working on [9]. Preliminary findings from Cangiano's study has shown that for multitasking individuals like the law office workers, ActivityTrails is very helpful in reinstating the context of situations that occur in the law office [16]. Cangiano's research has large implications for research topics like context reinstatement. Context refers to aspects of an environment in which an event has taken place. Context *reinstatement* refers to the process of physically returning to or creating a mental representation of a learning context, which allows us to use contextual information we know as a source for memory cues to enhance our memory performance [18]. Specifically, Cangiano hypothesizes from his research findings that ActivityTrails images help law office workers reinstate contextual information about their past.

Currently, because the ActivityTrails software can only run on PCs, this presented a difficulty for my study because most of the selected parpticipants used Macintosh computers. However, this issue was overcome by creating a simple desktop recording device that would run on Macintosh computers. Graduate student Adam Fouse was able to create a simple recording device, named ActivityTrailsLite, that would run on Macintosh computers and capture screenshots of desktop activity at five-second intervals. Though, ActivityTrailsLite was not as sophisticated as ActivityTrails because it lacked a developed interface, keyword search, summary of thumbnails, and other functions. However, since ActivityTrails was essentially a desktop recording device, for the purposes of this study, using ActivityTrailsLite was an appropriate alternative.

3.3 LIVESCRIBE PEN

The LiveScribe Pen is another life-logging device, which is a computerized ballpoint pen that has an embedded computer and digital audio recorder (see Figure 6). It is equipped with a removable ball-point ink cartridge, a microphone to record audio, a speaker for playback, a small OLED display, and internal flash memory that captures handwritten notes, audio, and drawings. The pen records what is written and synchronizes the written notes with any audio that was recorded at the same time. Recorded audio is kept indexed with the handwritten text and drawings, which allows users to replay segments of a recording by tapping on specific parts of the notes with the tip of the pen.

Figure 6. LiveScribe Pen

The LiveScribe Pen must be used with special dot-patterned paper (see Figure 7). Though invisible to the human eye, the dot pattern consists of numerous small black dots that can be detected by the pen's software. The pattern indicates the exact position of the digital pen on the page, allowing the pen to know which page the user is on, for example. In addition, each page has a unique identity in order to be distinguished from other pages. At the bottom of the dot-pattered paper are command buttons that can be used to instruct the pen to begin, pause, or end audio recording (see Figure 8). This can be simply done by tapping the end of the pen on the command buttons.

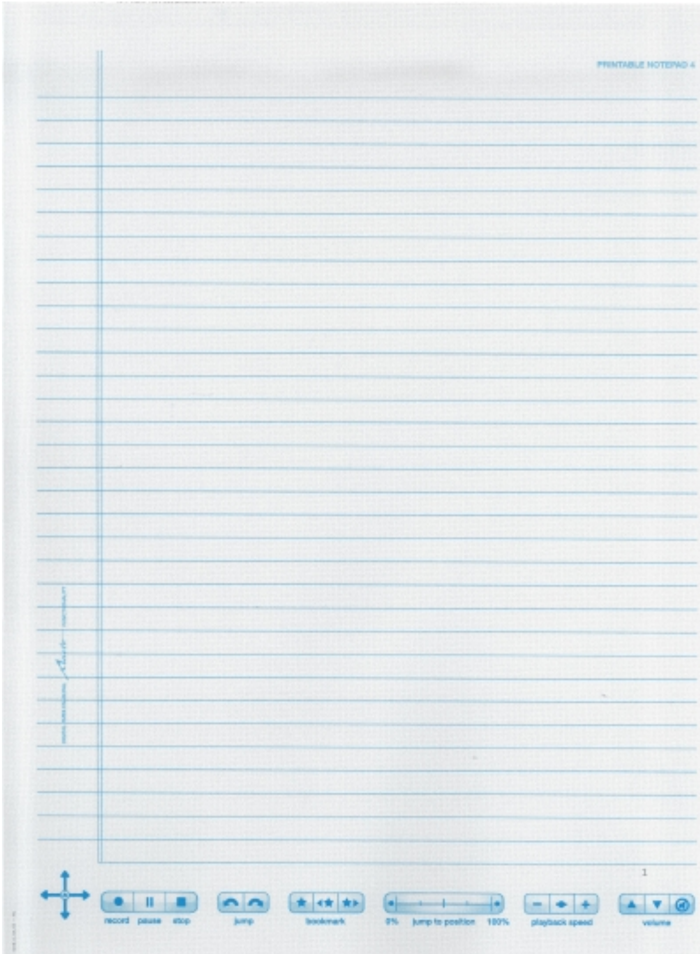


Figure 7. Dot-patterned LiveScribe paper

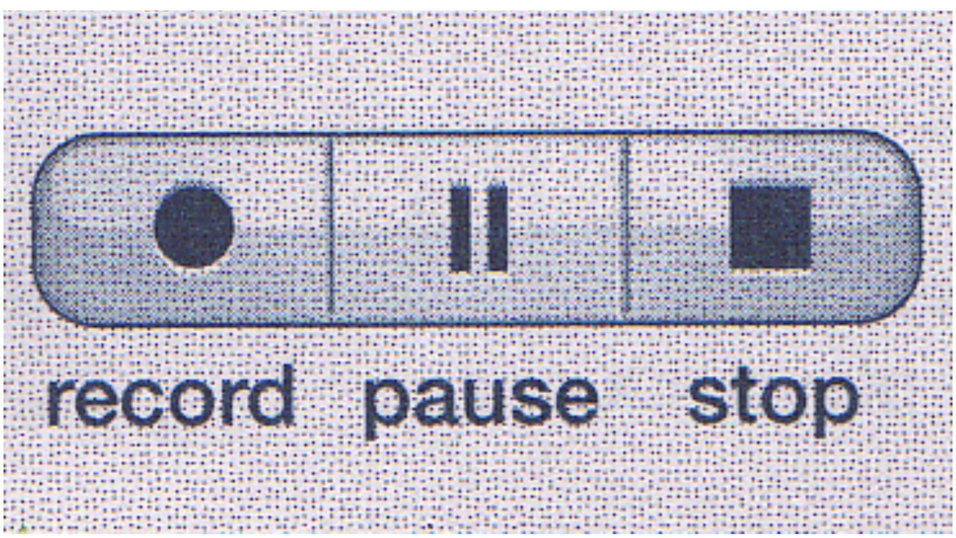


Figure 8. Command buttons are to be tapped by the pen to begin, pause, or stop recording.

Different from SenseCam and ActivityTrails, the LiveScribe Pen is commercially available for consumer use. However, instead of using the LiveScribe Pen for its suggested uses (i.e. taking notes in class, writing a journal entry, etc.) researchers, like Dr. Nadir Weibel at UC San Diego are using the LiveScribe Pen to discover how interactive paper technology can be extended to aspects of cognition and Human-Computer Interaction. For example, Dr. Weibel has exploited the LiveScribe Pen in the project, PaperProof, a paper-digital proof-editing application that allows users to edit digital documents by means of gesture-based mark-up of printed versions {11}. In addition, Dr. Weibel has pursued other projects, like PaperPoint, a presentation tool for giving PowerPoint presentations controlled by a paper-based user interface {17}.

4 EPISODIC AND AUTOBIOGRAPHICAL MEMORY

Episodic memory and autobiographical memory is a type of long-term memory of temporally unique events. What makes these memories autobiographical is that they are a personal representation of our past events {8}. Specifically, the context surrounding events and spatial information encoded in our episodic memory {8} is different from other forms of memory in the sense that episodic and autobiographical memory is accompanied by the feeling of remembering in comparison to what we know as fact. Episodic and autobiographical memory access the context and personal participation in an event, such as the "who," "what," "where," and "when" details of our past {8}. Thus, a life-log containing a digital record of our e-memories may be able to provide a richer recollection of life by providing context and content to help support episodic memory of humans. Life-logs will most likely provide the opportunity of reviewing and reflecting on information about who we have encountered, when and where we were encountered, how long we were encountered for, what activity we were engaged in, etc. and aid in the recollection of our past activities {5, 6}.

Reviewing one's digital record may help with the recollection of past events for the sake of reinforcing feelings of continuity and supporting a sense of self {4}. Not only may individuals have a clearer memory of events, times, places, associated emotions, and other conception-based knowledge in relation to a past experience, but may also be able to reinstate the context of past experiences to remember something important that may have been forgotten. Empirical evidence shows that access to our memory is biased around landmarks—memory landmarks are the entry points to our mental representations of the past, and also increase the accuracy of our long-term and episodic memory {5, 6}. Upon identifying what cues or landmarks are crucial in helping individuals "recollect" in SenseCam images, ActivityTrails recordings, and LiveScribe Pen images, how it supports their memory for past events may be identified. Individuals may gain utility from reviewing and reflecting on SenseCam, ActivityTrails, and LiveScribe Pen data because it may give them access to information from the past that they might need in the present. For example, individuals will be able to resume where they last left off on an robotics project, recall the name of the restaurant they dined at last Monday, or reexperience the emotional context of a conversation with an old friend at their high school reunion by virtue of potential cues that exist in the recordings of all three devices.

5 METHODS

5.1 SPECIFIC AIMS

The goal of this study was to understand how our interactions with our own life-logging data support specific recollections of our past—specifically by characterizing how SenseCam, ActivityTrails, and the LiveScribe Pen support remembering and by characterizing how we engage in this recollection process.

In addition, members of the Distributed Cognition and Human-Computer Interaction Laboratory are interested in understanding how lifelogs and past activity records support our memory for the past. The ability to record human activity in real-world settings with these life-logging technologies drives our lab's interest in not only understanding *how* these data support our past memory, but also in understanding if having a past record of our life enables us to resume our past activities. To investigate these topics, a preliminary study was conducted to behaviorally understand how participants interact with their past records.

5.2 APPROACH

A preliminary study was conducted with 17 participants. The participants were asked to record one activity (i.e. working on a group project, playing video games, filling out a job application, etc.) with ActivityTrails, SenseCam, or a LiveScribe Pen. Participants were instructed to only record with the device when they were participating in or engaging in the selected activity that was chosen from an initial interview conducted. The recording duration was limited to one activity with the consideration of the limited availability of life-logging devices (there was only one working SenseCam and one LiveScribe Pen), the privacy issues concerning life-logging devices (participants only recorded activities they were comfortable recording), and the amount of time available for analysis of recorded data (data analysis needed to be completed in less than 10 weeks).

Prior to having participants record their activity with SenseCam and ActivityTrails, participants received a brief training on how to use the chosen device to become familiar with the functions. The training informed participants on how to turn on and turn off the device, and how to wear, use, and/or install the device. In addition to this training, participants were given user guides (see Appendix) to take home with them in case they forgot how to operate the life-logging device. After participants were trained, the experimenter gave the participants the device to bring home with them so that they could record their activity.

Because this study relied on having the life-logging devices to have participants record with, only 1-3 participants were asked to record each week to allow for the sharing of devices amongst participants. Within the 1-3 participants that were selected to record each week, participants were scheduled to record on different days of the week to avoid scheduling conflicts that could occur for participant interviews that needed to take place a week after each participant's recording date. This allowed for sufficient time to interview all participants exactly a week after their recording date. The time frame of a week was selected because it was a reasonable amount of elapsed time since each participant's recording date to test their memory for recorded events.

Data collected were in the form of images that were captured by SenseCam, ActivityTrails, and the LiveScribe Pen. After recording with the devices for the selected activity, the participant returned to the laboratory within a couple days with the SenseCam, LiveScribe Pen or a USB stick with their uploaded ActivityTrails data so the images could be downloaded onto a designated computer within the laboratory. At this time, one of the life-logging devices was given to a new participant for them to record with. In addition, if there were images that participants wanted to be erased from our records, I deleted, without seeing, any images falling in a time period that participants have marked for deletion. After uploading their data, participants were reminded at this time to come back to the laboratory a week after their recording date to be interviewed.

5.3 PRIVACY

Life-logging technologies raise some privacy issues and concerns. To ensure that the privacy of participants was not violated, the selected activity for each participant was an activity that each participant was comfortable recording. To further ensure this, the following question was asked: Would you feel uncomfortable recording any of these activities with a recording device?

In addition, to ensure that the privacy of participants were being respected during the data-capture period, participants were instructed to turn on the life-logging devices only when they were engaging in or participating in their chosen activity. Instructing participants to have the recording devices turned on only during the selected activity would help avoid most content considered as "private" from being captured by either devices. Likewise, participants who wore the SenseCam for this study only put the SenseCam around their neck and activated the "on" switch to record during their activity. Similarly, participants who recorded with ActivityTrails only turned on ActivityTrails when they were engaging in their chosen activity by selecting, "start recording" on the menu bar. In the same way, the LiveScribe Pen was only turned on when engaging in the written activity. Though participants were instructed to only record with the device during their chosen activity, participants were also informed that they were able to turn off the SenseCam device, ActivityTrails software, and LiveScribe Pen temporarily during instances they did not want to have captured (i.e. when entering the restroom, entering a highly confidential environment, writing a personal email, etc.). In the case that SenseCam, ActivityTrails, or the LiveScribe Pen was left on during a time when participants would have preferred for the devices to be deactivated, but forgot to deactivate it, participants could request that a certain time period be deleted without being seen by anyone. Images could be deleted without it being seen by the researcher because each image from SenseCam, ActivityTrails and LiveScribe because is time-stamped with a date and time. In these situations, participants were informed to note the approximate time period so the researcher could delete all images from this period.

5.4 PARTICIPANT RECRUITMENT

Participants for this study were recruited from within my social network group. Participants were recruited in this manner because reliable participants were vital to this study. This relies on the assumption that friends or colleagues that were asked to participate in the study were more likely to consider the safe handling of the SenseCam and LiveScribe Pen and have more motivation for participating in a comprehensive study in comparison to randomly selected individuals.

Because this study was investigating how life-logs are helpful for memory recollection in people with no memory impairments, participants selected did not have any history of, or current memory impairments. This was ensured by directly asking participants if they had any memory impairments. In addition, because this study relied on recruiting participants that participated in an activity that could be recorded with one of the three devices, the following questions were asked to help the experimenter identify an activity that would be appropriate to record using SenseCam, ActivityTrails, and/or the LiveScribe Pen:

1. Describe your daily activities in a typical weekday.
2. Do you work? If so, where, what do you do, and for how many hours at one time?
3. Do you regularly engage in sports or other physical activities? If so, what type of sports or physical activities and for how many hours at one time do you engage in this activity?
4. Are you involved in any extracurricular activities? If so, what activities and how long does this activity typically last?
5. Do you have any hobbies? If so for how long do you do these activities?
6. Do you have a computer? If so, is it a PC or Mac?
7. How many hours a day do you use your computer for?
8. What kinds of activities do you use your computer for? How many hours do you spend doing these activities?

The type of recording device each participant recorded with was contingent on the type of activity that was chosen with the experimenter. This was because ActivityTrails, SenseCam, and the LiveScribe Pen are different kinds of recording devices that are appropriate for different types of activities. For example, because ActivityTrails is an onscreen recording device, participants who participated in activities like, playing computer games, surfing the web, and filling out an electronic job application were chosen to record with ActivityTrails. Likewise, because SenseCam is a device that can be worn for off-screen activities, participants who participated in activities like working on a group project and working at a daycare were chosen to record with SenseCam. Since the LiveScribe Pen was a writing utensil, participants who drew or took handwritten notes in class were selected to record with the pen. Though initially it was planned to have an equal number of participants record with one life-logging device and with both life-logging technologies, the majority of the 17 participants recorded with only one life-logging device. It was very difficult to find participants who engaged in an activity that would allow both onscreen and off-screen recording, and therefore, only one participant out of the total number of participants recorded with both life-logging devices. However, because this participant's data was corrupted, I am unable to report any findings. When participants were interviewed a week later at the lab, participants fell in one of the three following categories based on life-logging device(s) they recorded with:

1. Participants recorded and reviewed only SenseCam data
2. Participants recorded and reviewed only ActivityTrails data
3. Participants recorded and reviewed only LiveScribe Pen data

5.5 SENSECAM VIEWER

Participants were scheduled to return to the lab to review their recorded data exactly a week after their recording day. SenseCam Viewer (see Figure 10), a browser developed by UCSD graduate student, Adam Fouse was used for reviewing SenseCam images, ActivityTrails data, and the LiveScribe Pen data. The SenseCam Viewer allowed participants to browse through large amounts of images easily and within a reasonable amount of time with a dial-interface (see Figure 9). The buttons closest to the periphery of the dial did not have a function for the purposes of this study. However, the center dial and the dial that surrounds the center dial (outer dial) were both used by the participant to scroll through their images. The center dial allowed participants to scroll through their data image-by-image. In contrast, the outer dial allowed participants to fast-forward through images at a faster pace. For both dials, rotating the dial clockwise scrolled through images forward in time, while rotating the dial counterclockwise scrolled through images backwards in time.

Figure 9: Dial interface: Both dials allow participants to easily scroll through their life-log data.

Figure 10: SenseCam Viewer: The yellow vertical line indicates which image is currently being viewed with respect to all other life-log images.

5.6 AUTO CONFRONTATION

Participants' memory for their recorded activity was tested by asking participants to narrate the details they remember from their life-log data through auto confrontation. Auto confrontation was a method used by researchers that would reveal the cognitive processes that underlie participant's activities {12}. Auto confrontation was used as a method for reflection because it allowed participants to confront their own activity by "thinking aloud." Because the goal was to discover the natural interaction participants engaged in when looking at their own life-log data, subjects were given open-ended instructions to "think aloud," and narrate what comes to mind when looking at their life-log data. Thus, it was important that participants were not asked specific questions, such as, "what," when," where," and "who," was remembered for each life-log image to avoid probing.

Participants were asked to explore their life-log data on a computer using SenseCam Viewer (see Figure 11). Instead of a traditional mouse, participants were asked to use a dial interface to navigate their data.

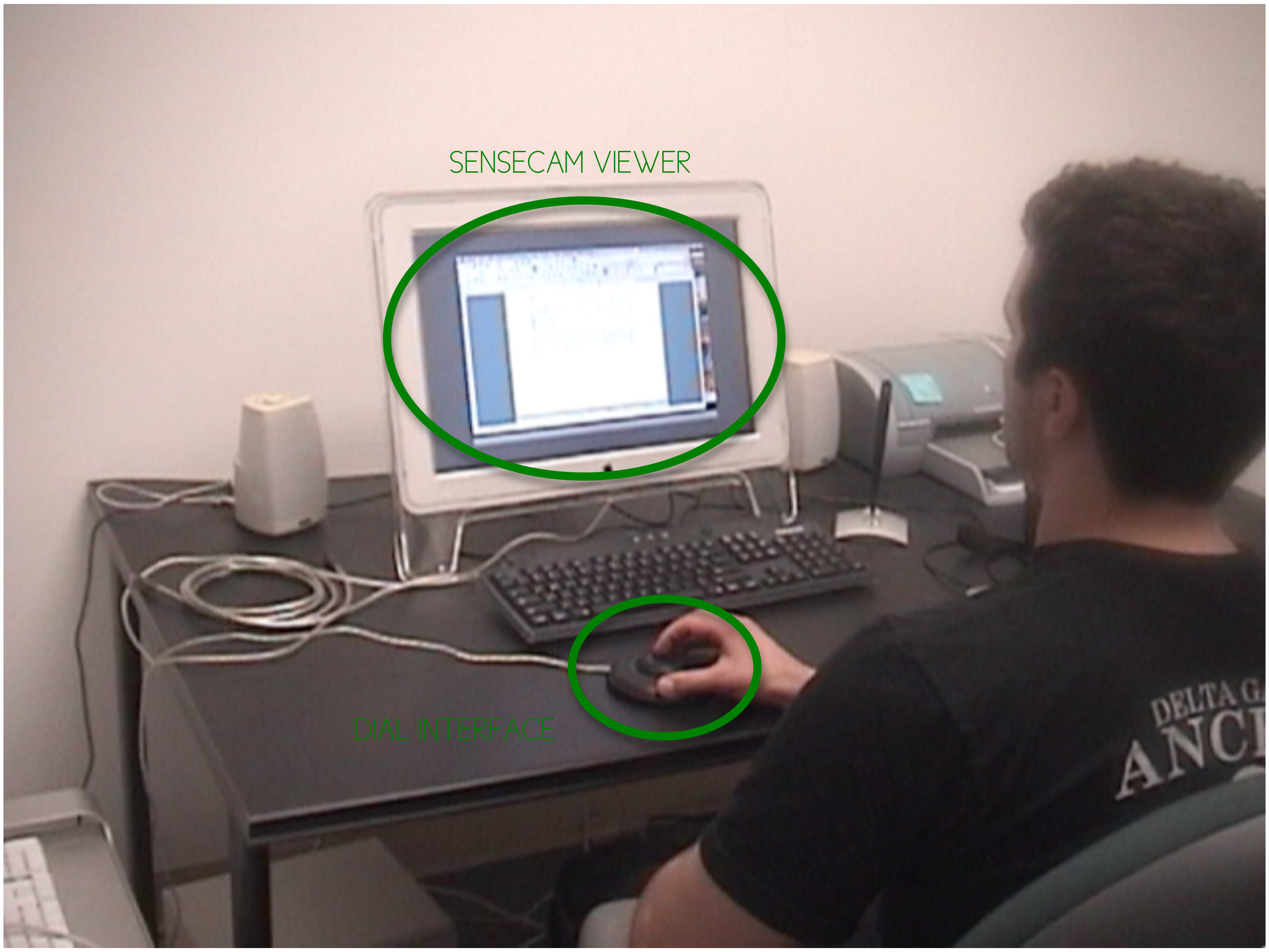


Figure 11: Experimental set up, using auto-confrontation

At this time, participants were video recorded. Recording participants' responses in video form allowed me to note significant "recollection" moments through the indexing of audio and visual data the video provided. Because it was not possible to understand all that happened when participants were narrating details they remembered in real-time, reviewing video recordings of participants allowed me to review word-for-word what was articulated by the participant that revealed subtle insights about how life-logging technologies aid in the recollection of past events. Capturing activity through video recordings was fundamental to the success of this project because this study was a behavioral study that relied on understanding every aspect of the participant's interaction with their life-log data. Video data allowed me to intricately code specific moments of the video. At any point and for any reason, the subject may have asked to have the video recording turned off and/or erased, and at which point, the researcher would have ceased video recording and taken adequate steps to remove the participant's data from the camera.

5.7 DATA MEASUREMENTS

This study was conducted to understand how life-log data support the phenomenon of "remembering."

Because data was collected in the form of video through the method of auto-confrontation, video recordings needed to be coded with standardized measurements to reach accurate and reportable findings. The video data gathered from each interview was coded on two levels to characterize each participant's narrative: 1. The type of memory experienced, 2. The type of detail(s) remembered.

While it was the case that some participants who looked over some parts of their data did not stimulate any form of recollection, in other parts of their data, participants recollected various details about their past. Thus, in each participant's activity, the recollected detail were all qualitatively different, distinguished by four types of memory:

1. *Remember:* this was defined as an event that can be re-experienced in the "mind's eye," where one can mentally place oneself in the scene described.
2. *Know:* this was defined as an event which one infers must have occurred that day, perhaps because it was a routine event (i.e. going to class on a Tuesday), or perhaps because 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.
3. *Guess:* this was defined as an event that participants were uncertain about, where nothing much was remembered, though participants make some effort to recall what was going on at the time.
4. *Don't Know:* this was defined as an event that was not remembered at all.

In addition, the types of details recollected were also measured by categorizing them into different groups of details. The following are five different categories that encompass the wide variety of details remembered by each of the participants. These categories were defined based on the frequency of these details remembered by the majority of participants.

A. People (i.e. name of person, things associated with people, faces, etc.)
B. Object (i.e. material items)
C. Place (i.e. description of environment)
D. Action (i.e. activities)
E. Time (i.e. specific times of the day)

Coding all videos using two levels of measurements allowed for a more complete characterization of each participants' recollection process. In addition, it allowed for qualitative findings to be quantitatively reported.

5.8 EXPECTED RESULTS

I hypothesized all three life-logging devices would support memory for different types of details because all devices record different kinds of activities, which involve different kinds of contextual information. Because the SenseCam device is more appropriate for recording off-screen activities (i.e. playing soccer, meeting with a group of people, cooking etc.) I predicted that participants' memory would be high for their interaction with people and what was going on in their environment. In comparison, I predicted ActivityTrails would be better for remembering personal details (i.e. tasks that need to get done, email conversations with friend, what they were eating for lunch, etc.), because onscreen activities, in which ActivityTrails records, involve more personal activities than SenseCam activities. Because writing notes and drawing pictures are personal activities, my prediction was similar for the LiveScribe Pen—I hypothesized more personal details would be remembered from reviewing LiveScribe Pen data.

In terms of my hypothesis for the details remembered, I predicted SenseCam to be the most helpful for recalling details such as people, places, and actions because SenseCam images already contain these visual details. In addition, activities recorded with SenseCam would most likely involve interactions with people in specific environments, leaving memory for people and places very high. I predicted ActivityTrails will be most helpful in recalling actions and time/date because activities recorded on a computer may be limited to information such as what application or browser is being used. Because most of our activities on screen are influenced by the time of day, depending on when we are using our computer, (i.e. class time, work time, leisure time, etc.) I expected temporal details to be the most salient detail recalled when reviewing ActivityTrails data. Similarly, because the LiveScribe Pen is another device that we use at specific times of the day, I predicted memory for time would be highest, compared to all other details.

In addition, I hypothesized that there was something special about the types of details that could be recalled by participants who reviewed images from more than one of the devices. The reason being, the combination of all life-logs would provide comprehensive information to the participant because each device is useful for different kinds of activities, which in turn, would help the participant recollect details from people to objects to places to action to time.

Though participants may recall different details by reviewing SenseCam, ActivityTrails, and/or LiveScribe Pen recordings, I hypothesized that there would be more high-level recollections in SenseCam images. My prediction comes from the understanding that SenseCam images are rich in detail, which I predicted to better support higher recollection of details that are at the level of "remembering," rather than "knowing." Because SenseCam images have more details in comparison to ActivityTrails and LiveScribe Pen recordings, I hypothesized that participants had a higher chance of re-experiencing an event. In contrast, because ActivityTrails and LiveScribe recordings are abstract representations of an activity (i.e. images are of desktop screenshots or written notes) I hypothesized that participants would only be able to guess what must have occurred that day because details are minimal, compared to SenseCam recordings. This in turn, would leave lower-level recollections for ActivityTrails and LiveScribe Pen users.

6 RESULTS

I will begin the discussion of my results in regards to the research question, how SenseCam, ActivityTrails, and LiveScribe Pen images support our memory for our past. The data from this study provide evidence for an initial understanding about how lifelogs help make connections to our past.

Extensive video analysis through coding segments of recorded video reveal that participants use different types of cues available in their lifelog data depending on whether they were viewing SenseCam, ActivityTrails, or LiveScribe lifelogs. When participants were reviewing their SenseCam data, they were likely to recollect events based on people and object cues. By this I mean, when participants recognized a person or an object (i.e. a book, a computer, a tree, etc.) in the SenseCam image, they were likely to recall relevant events associated with these cues. For example, one participant saw an image with their friend pictured, which jogged his memory for a conversation he had with his friend (see Figure 12).

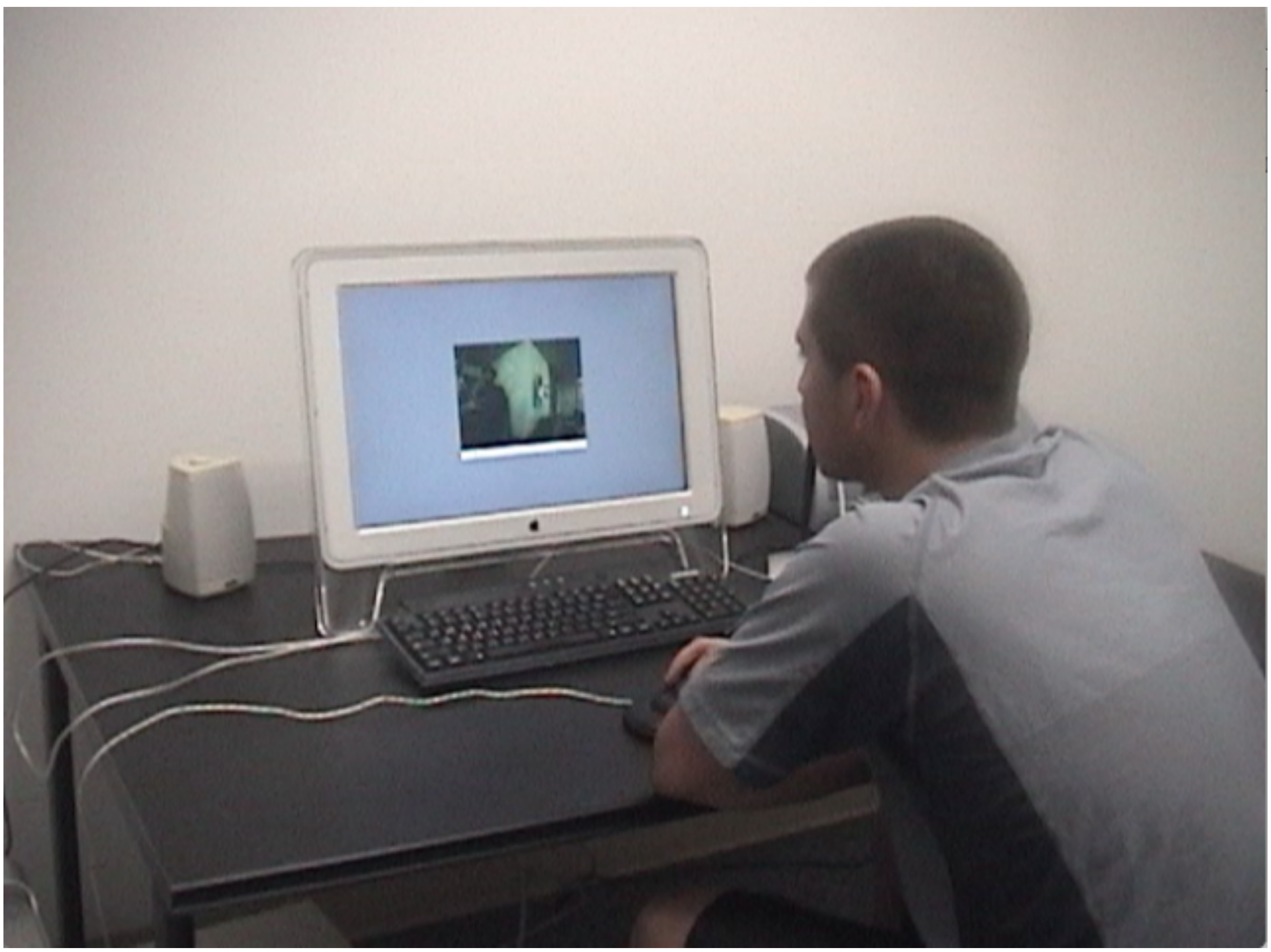


Figure 12: A participant sees his friend pictured in a SenseCam image, which helps him recall a conversation he had with him.

For another participant, seeing an image of an Ice Cream Truck (object) taken from his SenseCam allowed him to recall not only the unique Ice Cream Truck song playing during this event, but also remember what the children around him were talking to him about (see Figure 13).

Figure 13: A participant sees an image of an ice cream truck, which brings back a flood of memories regarding a song that was played by the ice cream truck and the context of the conversations he had with the children around him.

In contrast, when participants were reviewing their ActivityTrails data, they were likely to recollect events based on desktop configuration cues. Because ActivityTrails data were more abstract than SenseCam images, participants used the layout of application windows arranged on their desktop as an indication of what activity they were engaged in. For example, one participant (see Figure 14) was able to recollect a very specific conversation he had with his good friend when he looked at the specific arrangement of his windows on his screen. Specifically, this participant was working on a job application on his computer, and realized he had stopped working when a friend came over to his apartment. As a consequence of his friend being over, this participant was not able to work on his application and left his screen in the configuration pictured in Figure 14. Therefore, this participant recalls contextual information based off of what he can infer from his screen configuration.

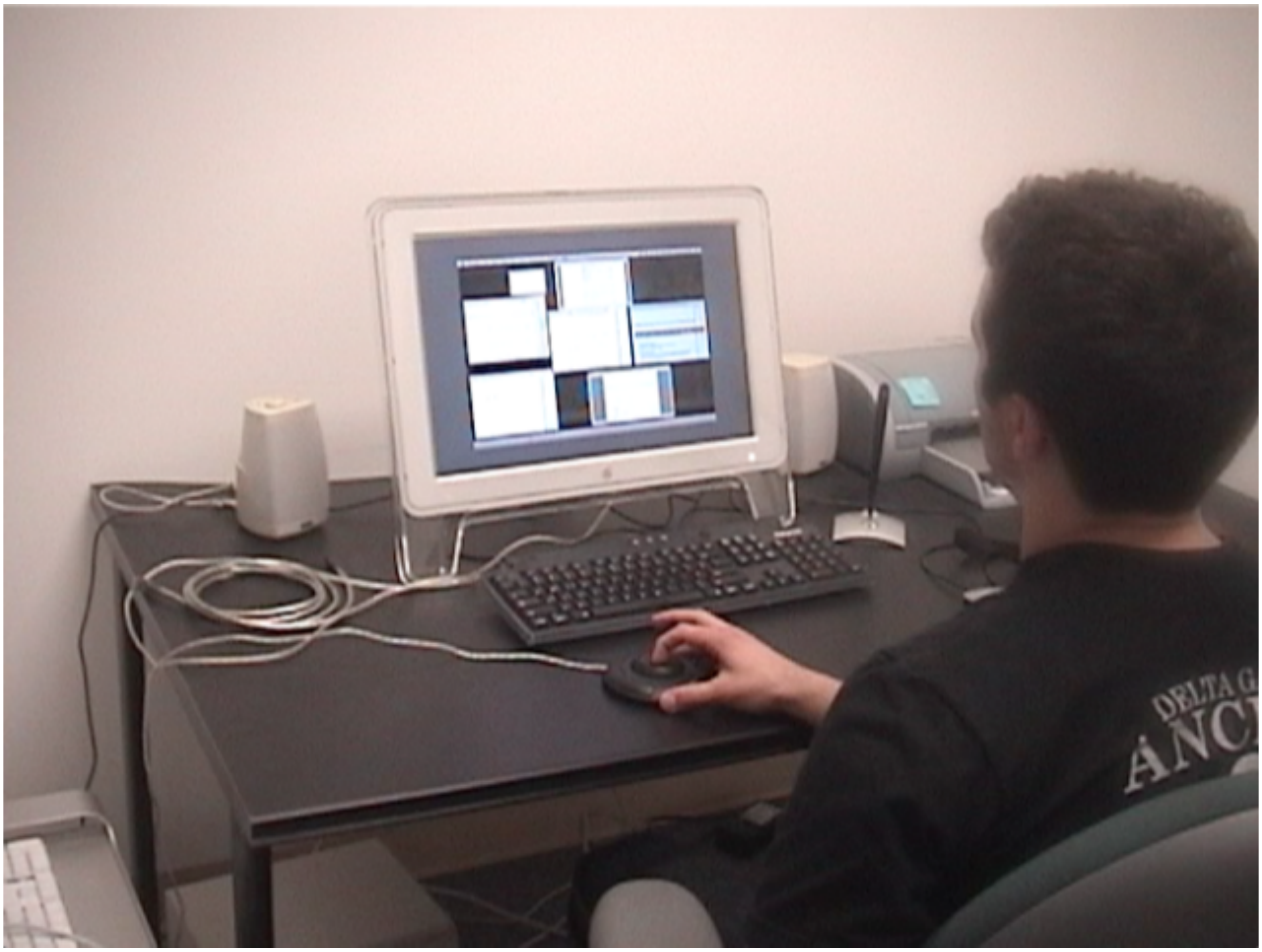


Figure 14: A participant recalls a specific conversation he had with his friend by looking at his current screen configuration.

Similarly, in another interview, based on screen configuration, a participant was able to recall that she was studying for her chemistry exam (see Figure 15). Like the participant in Figure 11, her screen configuration was an indication of what activity she was doing off-screen at the time.

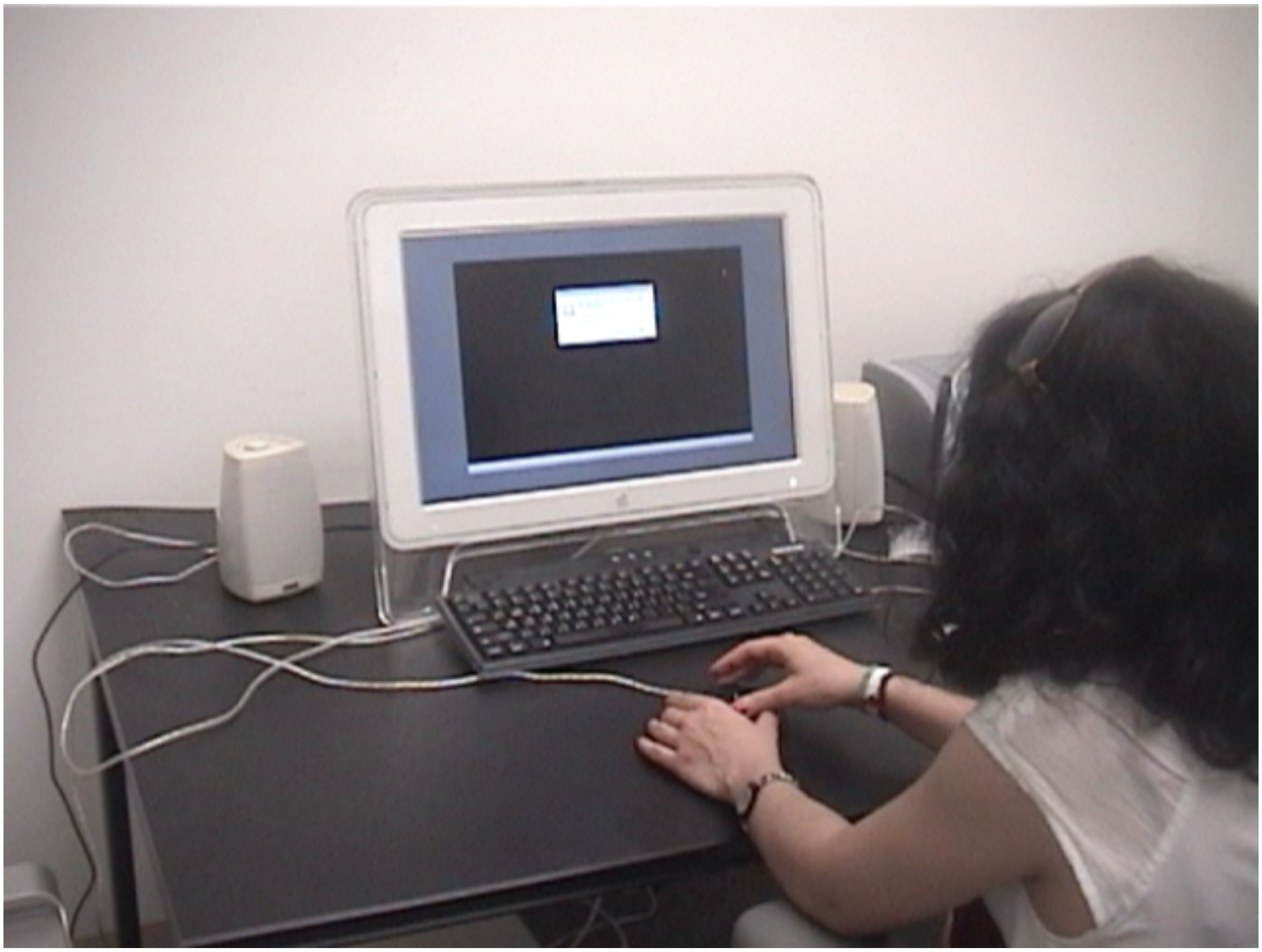


Figure 15: Participant recalls that she was studying for her chemistry exam while her screen was in this specific configuration.

Initially, this preliminary study was going to be conducted using only two life-logging devices, SenseCam and ActivityTrails. However, there was motivation to include an additional life-logging device, the LiveScribe Pen, because this study would explore the use of this device differently from other research centered on the LiveScribe Pen. Therefore, because the LiveScribe Pen was a life-logging device later considered, we only had two participants use the LiveScribe Pen. Of the two participants, one participant was asked to use the LiveScribe Pen to write notes during a biology lecture, while the other participant was asked to draw sketches and draw comic strips. Both activities were activities that both participants engaged in on a regular basis, which was ensured during the initial interview process.

Similar to ActivityTrails data, the LiveScribe Pen data is very abstract. The LiveScribe life-log data is composed of successive images of what was written with the pen (see Figure 16). In this case, the life-log was composed of sequential pictures and drawings that progressed through time. When interviewed, this participant was able to recollect a lot of information about conversations that took place while he was drawing, the people he had conversations with, what magazine articles he was reading, etc (see Figure 17). These recollections are not explicit just from looking at the LiveScribe Pen images—like ActivityTrails data, this participant seemed to be reflecting a lot of what was going on at the time he was drawing and sketching based off of what was available in the LiveScribe data.

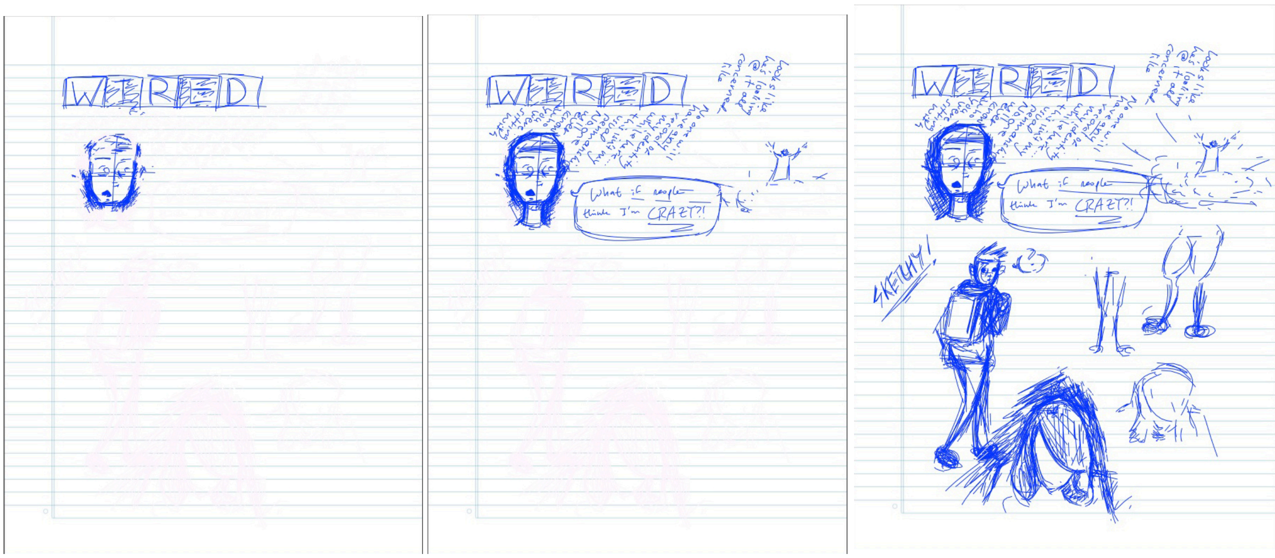


Figure 16: LiveScribe Pen data: presented to participant in stages, like so.

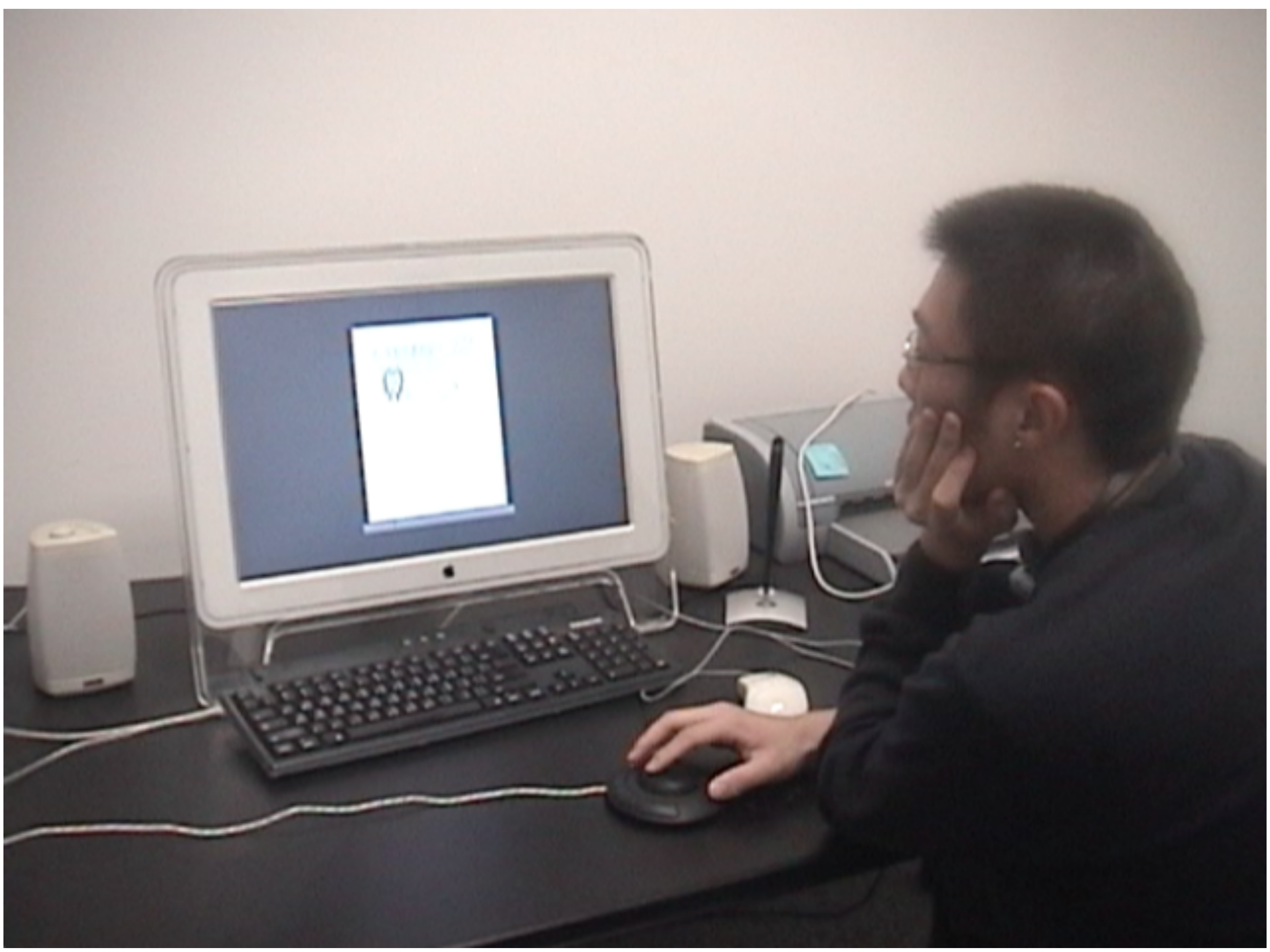


Figure 17: From looking at his past sketches and drawings, this participant was able to recollect a lot of contextual information, which surrounded his activity.

Unfortunately, data gathered from the second LiveScribe Pen participant was inconclusive. When asked to "think aloud," and narrate her activity during the auto-confrontation process, this participant remained silent for the majority of the time. This made it difficult to arrive at reportable findings from her interview. We assume this participant remained silent for the majority of the auto-confrontation process because she was uncomfortable talking about her own data and "thinking aloud." For auto-confrontation to be successful, participants must be vocal. Though the majority of our participants did not have trouble auto-confronting their data, one thing that could majorly improve the quality of our data is if all selected participants were given a practice auto-confrontation task. This would allow us to filter out individuals who are not comfortable with auto-confrontation. Thus, because this participant did not speak during her interview, we can only make conclusions about the LiveScribe Pen based on the reported findings of the first LiveScribe Pen participant.

Analysis of video data of the 17 participants show that they use cues available in life-log data as a way to help support their memory of specific instances of their past. It's a phenomenal finding that some of these participants (particularly ActivityTrails and LiveScribe Pen participants) were able to use the very limited and abstract cues in ActivityTrails and the LiveScribe Pen data to remember very specific contextual information about their past, such as in the case of participants described in Figure 14, 15, and 17.

In addition, it was a surprising finding that among ActivityTrails and SenseCam participants, recollections were at a higher-level. Specifically, their recollections reflected the memory category, "remember," which was defined as an event that can be re-experienced in the "mind's eye," where participants can mentally place themselves in the scene described. For SenseCam participants, participants' recollections were in the "know" or "guess" category. Participants recalled details that were inferred from immediately available cues in SenseCam images. Thus, SenseCam narratives were very low-level compared to ActivityTrails and LiveScribe Pen narratives because available cues in SenseCam images made it easy for participants to describe something that was a routine event or guess what was going on at the time without really "remembering."

Though I had expected that there would be more that is remembered for certain types of details depending on the life-logging device, this was not the case. All details, people, object, time, place, and action were details that were remembered by all participants in almost equal ratios. However, it was the case that approximately 70 percent of ActivityTrails and LiveScribe Pen participants experienced "remembering," while approximately 30 percent of the time, participants experienced the other three levels of memory. In SenseCam participants, about 60 percent of the time, participants experienced "knowing," experienced "guessing" 20 percent of the time, leaving 20 percent of the time for the experience of "remembering."

The findings of this study are very counterintuitive, and are the exact opposite of my expected findings. What this preliminary study seems to suggest is that participants are able to recount more about their past using ActivityTrails and SenseCam images. ActivityTrails images seem to support "remembering," more than the memory category of "knowing," and "guessing." What can be inferred from this finding is that participants seem to be engaging in a more perceptual memory process when reviewing SenseCam data. This may because SenseCam images are very rich in detail already, that there is less detail to construct. In support of this assumption, data reveals SenseCam participants' recollections were more in the "know" and "guess category. However, participants who reviewed ActivityTrails images are more likely to be engaging in a reflective and inferential process. By this I mean, ActivityTrails participants were able to develop a rich narrative from looking at ActivityTrails images most likely due to the fact that these images are stripped in detail because images are very abstract and conceptual. Thus, allowing participants to reconstruct more about their past by engaging in a higher-level memory process when developing their past narrative.

One flaw in the experimental design, though still an interesting result is that simply wearing and using the SenseCam and ActivityTrails device helped subjects recall events. For example, participants used the time they turned on or turned off the device as a landmark for remembering what had occurred around this time. The interviews conducted confirm this result. In fact, many subjects reported on occasions in which people commented on their wearing or using the device, or could remember interesting or funny details of occasions in which they turned off ActivityTrails or the SenseCam. In a future study, it would be advisable to control for the "novelty effect" of recording with ActivityTrails and SenseCam to eliminate any confounding data.

7 CONCLUSION

Life-logging tools can both promote reconstructive inferences, as well as support genuine recall {13}. This study serves as just the beginning of theoretical insight into *how* life-logging technologies might support everyday memory processes. This study provides preliminary evidence that life-logging technologies, in this case SenseCam, ActivityTrails, and the LiveScribe Pen support our memory in fundamentally different ways because all three devices have different available cues. Details were discussed extensively during the analysis of results, and thus it can be concluded that ActivityTrails and LiveScribe Pen data, compared to SenseCam data have different implications for how and what we remember.

While there is evidence to suggest that SenseCam, ActivityTrails, and LiveScribe Pen images provide effective links to events in people's personal past, participants reconstructed memory for their past less when reviewing SenseCam data. This was interpreted to be because SenseCam images already have richness in detail in most images, that it does not allow participants to explore detail that is not immediately obvious from looking at the images. SenseCam images, compared to ActivityTrails and LiveScribe Pen images, are images we are more familiar with because most of us typically take pictures with a digital camera that produces similar kinds of images. On the other hand, participants who reviewed ActivityTrails images were more likely to provide a richer narrative of their past. Different from SenseCam images, ActivityTrails and LiveScribe Pen images are more abstract, in that we are not used to seeing images of our activity on our desktop computer (i.e. a Word document window, instant messaging screens, an email viewer, etc.) to infer details about our past. In fact, with regard to the recollection of past events with ActivityTrails and SenseCam images, less richness in the actual image itself (in this case, ActivityTrails and LiveScribe Pen images) may lead to a richer narrative because participants are able to reconstruct more about their past when there is less available detail. This may be because seeing abstract images require participants to reflect and reconstruct what was going on at the time. Unlike SenseCam images, ActivityTrails and LiveScribe Pen participants don't have much perceptual detail to use to reconstruct their memory of what was going on.

But beyond the particular results here, this study highlights important implications about how we may be engaging in different memory processes when looking at different types of stimuli, and more generally, what these memory implications mean for practical and useful applications of life-logging technologies. This study raises the possibility that providing less richness in detail may actually help people reconstruct their past with more detail. We might interpret this as an important design aspect to software that are created for people to recall precise information from their past, or help people jog their memory about the past to help resume an interrupted activity (i.e. resuming the writing of a partially completed project paper). Perhaps, providing less detail in software applications is an important design decision for these goals. However, further studies need to be carried out to substantiate these claims. This study was a preliminary study for much larger experiments that will be conducted in the future to understand a deeper understanding of the relationship between life-logging technology and human memory.

8 REFERENCES

{1} Bell, G. and Gemmell, J. (2009). Total Recall.

{2} Sellen, A., Fogg, A., Aitken, M., Hodges, S., Rother, C., and Wood, K. (2007). Do Life-Logging Technologies Support Memory for the Past? An Experimental Study Using SenseCam.

{3} Lee, M. and Dey, A. Providing Good Memory Cues for People with Episodic Impairment.

{4} Conway, M. (2001). Sensory-perceptual episodic memory and its context: autobiographical memory. Phil. Trans. R. Soc. Lond., 356. 1375-1384.

{5} E. F. Loftus and W. Marburger. Since the eruption of mt. st. helens, has anyone beaten you up? improving the accuracy of retrospective reports with landmark events. Memory and Cognition, 11(2):114-120, 1983.

{6} M. Shum. The role of temporal landmarks in autobiographical memory processes. Psychological Bulletin, 124(3):423-442, 1998.

{7} Vogel, E. and Drew, T. (2008). Why Do We Forget Things?

{8} Clayton, N., Salwiczek, L., and Dickinson, A. Episodic Memory

{9} Cangiano G. R. and Hollan J. D. The context of modern work: a study at a law office using activity recordings. 2009.

{10} Doherty, Aiden R. and Smeaton, Alan F. (2008) Automatically segmenting lifelog data into events. In: WIAMIS 2008 - 9th International Workshop on Image Analysis for Multimedia Interactive Services, 7-9 May 2008, Klagenfurt, Austria. ISBN 978-0-7695-3130-4

{11} Nadir Weibel, Adriana Ispas, Beat Signer and Moira C. Norrie, PaperProof: A Paper-Digital Proof-Editing System, *In Proceedings of CHI 2008, 26th SIGCHI Conference on Human Factors in Computing Systems: Interactivity Track, Florence, Italy, April 2008*

{12} Faizon, P. and Mollo, V. Auto and All-Confrontation as Tools for Reflective Activities, Abstract, 2004.

{13} S. Hodges, L. Williams, E. Berry, S. Izadi, J. Srinivasan, A. Butler, G. Smyth, N. Kapur, and K. Wood. SenseCam: A retrospective memory aid. In *UbiComp "U 8th International Conference on Ubiquitous Computing*, 2006.

{14} G. Bell and J. Gemmell. A digital life. *Scientific American*, 2007.

{15} V. Bush. As we may think. The Atlantic Monthly,July 1945.

{16} Cangiano, G. ActivityTrails: Support for Episodic View of Personal Digital Activity. Dissertation Proposal, UC San Diego, 2009.

{17} Nadir Weibel, A Publishing Infrastructure for Interactive Paper Documents: Supporting Interactions across the Paper-Digital Divide, *Dissertation, ETH No. 18514, Zurich, Switzerland, 2009*

{18} Williams, M. W. & Hollan, J. D. The process of retrieval from very long-term memory. *Cognitive Science*, 1981, 5, 87-119.

APPENDIX

SenseCam USER GUIDE

How to WEAR SenseCam

The SenseCam should be worn around the neck, positioned near the upper portion of your chest (use the strings to adjust the length)

How to Turn ON SenseCam

Press the small, round button on the top of the device. (The power button must be pressed for several seconds before the camera will respond). A rising tone indicates that the camera is switching on. The SenseCam will take several seconds to power up, during which the yellow light will be on. When ready for use, the SenseCam will beep and the green power light will come on.

When SenseCam is OPERATING

During operation, the yellow light will blink whenever SenseCam is busy recording a photograph or sensor data. The green power light will be on continuously if the battery has plenty of charge and it will blink occasionally if battery is getting low.

How to MANUALLY TAKE A PICTURE with SenseCam

In order to explicitly take a picture, press the manual shutter button (the bottom of the two side buttons) at any time. Note that the camera takes several seconds to save the picture, during which further pressing the manual shutter button will have no effect.

How to TEMPORARILY TURN OFF SenseCam

The top of the two side buttons is a do-not-disturb button. Pressing this button will cause SenseCam to stop taking pictures for 5 minutes. During this time, a red light will turn on. Fifteen seconds before the SenseCam resumes taking pictures, there will be a beep and the red light will flash. The SenseCam can also be re-enabled by pressing on the manual shutter button

How to Turn OFF SenseCam

Press the small, round button on the top of the device. (The power button must be pressed for several seconds before the camera will respond). A falling tone indicates that the camera is switching off. When the SenseCam has been successfully turned off, all lights will turn off.

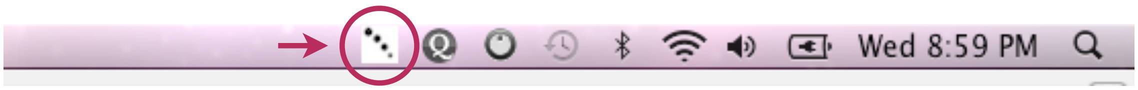
Having Trouble? Contact me at ntan@ucsd.edu.

ActivityTrailsLite
USER GUIDE (FOR MAC USERS ONLY)

HOW TO START RECORDING ACTIVITY ON ACTIVITYTRAILSLITE

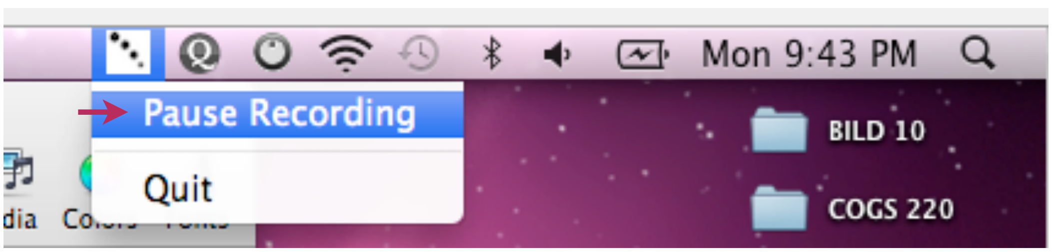
1. ActivityTrailsLite is automatically enabled once application icon is double-clicked. This means, the program starts recording your desktop activity as soon as the program is enabled.
2. When the program is enabled, a small icon should appear on your dock bar, like the following:

**Because ActivityTrailsLite runs transparently, the icon will only appear in the menu bar and NOT in your dock bar.*



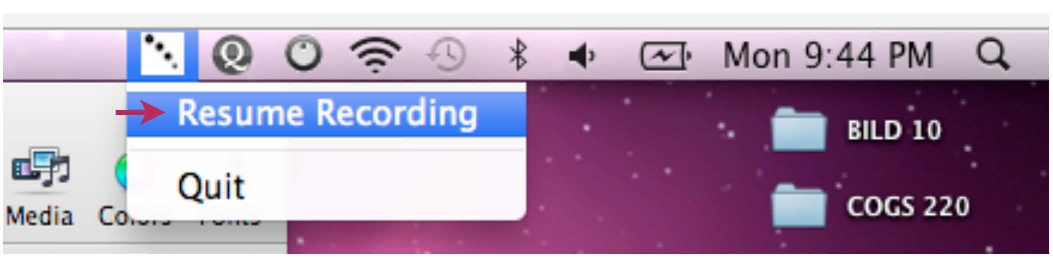
HOW TO STOP RECORDING ACTIVITY ON ACTIVITYTRAILSLITE

1. To stop recording, click on the ActivityTrailsLite icon and select “Pause Recording,” on the drop-down menu, like the following:



HOW TO RESUME RECORDING ACTIVITY ON ACTIVITYTRAILSLITE

1. To resume recording, click on the ActivityTrailsLite icon and select “Resume Recording,” on the drop-down menu, like the following:



HOW TO LOCATE RECORDED DATA ON ACTIVITYTRAILSLITE

1. Go to your Desktop.
2. There should be a folder called “ActivityTrails” located on the Desktop.
3. Right-click on the “ActivityTrails” folder, and select “Compress ActivityTrails” to create a zip folder.
4. Please drag this folder to the provided thumbdrive. :)

Having Trouble? Contact me at ntan@ucsd.edu.

USER GUIDE

HOW TO TURN ON THE LIVESCRIBE PEN

1. Press on the power button to turn on the LiveScribe pen. The button is located near the top of the pen in the shape of a semicircle.
2. When the LiveScribe pen has been successfully turned on, the current time should appear on the display of the pen like the following:

USE DOT-PATTERNED PAPER TO RECORD WHAT YOU WRITE

1. You MUST use dot-patterned paper to write on when using the LiveScribe pen because the microdots printed on the dot paper enable the infrared camera at the tip of the pen to track everything you write down.

HOW TO TURN OFF THE LIVESCRIBE PEN

1. Press on the same power button to turn off the LiveScribe pen.

Having Trouble? Contact me at ntan@ucsd.edu.