What Was I Cooking? Towards Déjà Vu Displays of Everyday Memory

Quan T. Tran & Elizabeth D. Mynatt

Georgia Institute of Technology, Atlanta, GA, USA

{quantt,mynatt}@cc.gatech.edu

Abstract: The recall of information associated with recent actions is problematic for all people, especially when one is prone to be distracted or interrupted. In this paper, we introduce Déjà Vu Displays as resources for everyday memory recall. These displays augment "knowledge in the head" by visually displaying recent events as "knowledge in the world." As an initial study, we present the design and evaluation of the Cook's Collage, a memory aid for cooking. Our initial studies indicate that people can benefit from this everyday memory aid, and that further exploration of the design and implementation of these displays is warranted.

Keywords: Everyday memory aid, passive display, cooking, home, déjà vu.

1 Introduction

In this work, we examine everyday memory within the home. We posit that remembering recent actions throughout the day can be problematic for anyone, but especially those prone to distractions and interruptions. Indeed, we discovered evident memory slips in our initial study of interrupted cooks. We note that one powerful memory strategy is relieving working memory capacity for keeping "knowledge in the head" by distributing the respective information as "knowledge in the world" (Hutchins, 1995). Furthermore, we explore how a person's limited working memory can leverage a computer's detailed recordings. In short, we explore how information interfaces better reinforce everyday memory recall.

In this paper, we propose a framework for passive information displays of short-term memory. We term these devices déjà vu displays, and present one particular example, Cook's Collage, in an initial study. We discuss the design and evaluation of the system prototype, and motivate further exploration of these short-term memory displays for everyday use.

2 Related Work

One straightforward solution for a short-term memory aid is to maintain a continuous or on-demand video loop that replays the previous few minutes of captured recent activity. However, this technological solution presents more shortcomings than added benefit. Replaying a video segment cost time to review, thereby, rendering these video replays advantageous only if review time consumes a shorter duration than viewing the original event. Moreover, video presents rich media, advantageous if such thick description is appropriate but at the cost of exposing extraneous information arousing privacy concerns. We acknowledge these functional and affective influences to more carefully design an effective short-term memory aid. Furthermore, we draw inspiration from the following successful applications.

Video replays have been used effectively as memory recall interfaces in two widespread applications with very different purposes: On one hand, television series present video montages from previous episodes to segue into the current show. These compressed video replays present an overview synopsis highlighting past events in sequential order. On the other hand, televised sporting events employ instant replay to investigate some particular information detail in question. These replays provide an augmented review to discern more detail than was viewed originally as events unfolded. Views with different angles, slow motion, and annotations direct attention to better illustrate and explain the sought after information detail. Other times, sound enhancements accompany instant replay to draw detail attention to

another modality. In our work, we explore similar techniques for both overview and detail purposes. Specifically, we employ the television segues' technique of presenting overviews and the instant replays' annotations of highlighting specific details.

A large amount of ubiquitous computing applications has explored automated capture of live experiences and flexible and universal access to these recordings at a later time (Abowd & Mynatt, 2000). For example, the Forget-me-not system (Lamming & Flynn, 1994) records the user's personal activities continuously and later tries to provide useful indices and summaries of daily information captured. Just-in-time information retrieval agents (Rhodes & Maes, 2000) offer a suite of memory aids for an individual user at particular instances from a text editor that refers to previously written documents corresponding to the working document, an internet browser that is annotated with current browsing paths, and a wearable device that maintains context of physical surroundings. Automated capturing of live experiences has also extended into summarizing video recordings. For example, Video Manga constructs a visual summary of a video recording in the popular Japanese Manga style (Boreczky et al, 2000). We recognize the fundamental issues of capture and access applications (Truong et al, 2001) as we extend its use for everyday short-term memory recall.

As information interfaces, ambient displays such as Pinwheels (Ishii et al, 2001) present nominal yet dynamic information. These always-on displays passively broadcast information such that only informed users will correctly interpret the abstract data mapping and casual bystanders will just appreciate their seemingly random aesthetics as they blend in with the surroundings. Inspired by the balance of aesthetic and function that define ambient displays, we incorporate these design techniques into our information displays.

3 Déjà vu Displays

We introduce Déjà Vu displays as passive resources for memory recall of recent activity on a continuous basis. These always on, at-at-a-glance, passive displays serve solely as an output media and require no explicit input from the user. By passively presenting recent activity information, déjà vu displays prove conducive to memory support. Passive displays do not undermine supporting a multitasking, distractible, or forgetful user by additionally vying for attention away from his current task. Moreover, passive information displays can be easily integrated as a meaningful home artifact as well as a utility device, making them viable in home settings. A wall clock serves as a prime example of a passive information display since it establishes presence within the house décor while maintaining its functional use as a passive information display of time.

3.1 Design Dimensions

As passive information displays of recent activity, déjà vu displays possess the following defining characteristics that will be further explored along each respective design dimension.

***D**istribution: Capture and Access*

Being a ubiquitous application, the distribution of system components for both capture and access should be distributed and integrated into the physical setting. Moreover, both the capture of live video and the subsequent access to the information display should afford the user with a natural interface. That is, the system should interact transparently with the user; the users need not alter their existing habits for the system to function properly. In particular, the capturing of salient live experiences should not require explicit input or assistance from the user. The details of how to implement these high-level goals of system distribution and interaction can and should vary greatly with respect to the respective physical settings.

***E**vanescence of Recent Activity*

Being a passive short-term memory display, the information posting of recent activity is itself evanescent. That is, the length of retrospection into the past is limited to a fixed number of prior actions, and the duration of the posted information is also limited. The optimal decay time of the recent past and delay time of showing the past should vary between applications supporting different memory needs and different situations.

***J**uxtaposition of Displayed Information*

Being an at-a-glance information display, juxtaposition of the collected captured data provides needed organization to correctly interpret the narrative of the posted recent activity. Otherwise, the motley of information appears scattered as a haphazard collage with no structure.

***A**lready Seen Information*

Being a retrospective memory aid, the display presents already seen information to invoke a sense of déjà vu from the user. Expediting functional memory recall, the already seen information presents a first-person perspective and same modality (e.g. video), retaining much of the original context to

minimize cognitive effort in interpreting the captured experience.

Video

To maximize effective and affective memory recall, the displayed information consists of raw video images captured from live experience. The images present needed detail information in a concise and compact form to maximize memory recall. Moreover, the raw video of recent events seems to invoke a positive emotional reaction to the personal experience.

Units

To quantify and segment recent activity, the displayed information must be defined in some incremental units. Using the video media, these units can range from still image snapshots, to animated sequences of compressed video clips, to the original video replay.

3.2 Scope Constraints

Everyday memory research is an active area, and is as variable as individual differences. Thus, we simplify the problem scope to ground our initial work of déjà vu displays. In general, we examine retrospective memory as opposed to other forms of memory (e.g. prospective memory). We focus on short-term or working memory, providing support for recent events as opposed to supporting long-term memory (e.g. autobiographical history). We restrain this memory aid to support a single user per activity episode. We constrain the domain of this memory support within the home setting. We do allow for exploration of everyday memory, emphasizing "stream of consciousness" memory activity. In this presented initial study, we impose specific domain constraints. We examine one particular activity, cooking, within one room, the kitchen.

4 Study: What was I cooking?

Cooking is a cognitively demanding task delimited by definite beginning and ending stages. Cooking, the practice or manner of preparing food to make suitable for eating, follows the specific task sequence of a script from memory (e.g., family recipe) or a written recipe; cooking may also involve a haphazard series of random steps. Either way, performing a task in itself requires maintaining a sequence of actions in some form of short-term memory. However, short-term memory, with its typical limitations, cannot hold all the needed information to complete a complex task; therefore, steps may be missed or forgotten. This problem is apparent to absent-minded and preoccupied cooks in particular but indiscriminately applies to all cooks because preparing food requires focus of attention and memory to remember the completed tasks, monitor and execute current tasks, and anticipate or decide upon subsequent tasks.

Contrast this description to the characteristics of a home kitchen. Although a kitchen is defined as a room or an area equipped for preparing and cooking food, within the home, the kitchen is a busy, noisy, and open multipurpose space. The open space and central location of the kitchen within the home makes it prone to high traffic, and with it, distractions from other rooms. The home kitchen normally serves as a public common area where anyone may drop in and out to share cooking facilities. The kitchen is also thought of as a social area where people loiter and chat. In short, the auxiliary functions of the kitchen contribute to the continual ebb and flow of everyday social activities.

The kitchen's dual function as a cooking utility area and as a social common area presents a confounding dichotomy. As a result, the working memory needed for successful cooking is susceptible to memory slips from interruptions, forgetfulness, and multitasking. With a naturalistic experiment, we examine how an augmented kitchen and déjà vu display (e.g. Cook's Collage) can support the working memory of a cook within a real-life scenario of intermittent interruptions.

4.1 Augmented Kitchen

The components of this system are distributed and integrated within a traditional home kitchen such that the system is invisible and the interface transparent to the user. First, the input sensors, standard PC cameras, are tucked underneath the kitchen cabinets overlooking the countertops as shown in figure 1b. Thus, these cameras are hidden from the casual viewer, rendering the sensors inconspicuous and thus innocuous as shown in figure 1a. The resulting camera footage reveals the close-up hand shots of cooking activity upon the kitchen countertops, capturing the detail needed and minimizing occlusions. Moreover, the camera angles avoid an over-the-shoulder, surveillance view that would induce big brother privacy concerns and wrongly encourage "cooking show" theatrics uncharacteristic of everyday cooking. The raw camera footage, however, accentuates the reality of the captured cooking narrative and personalizes the cooking experience.

Figure 1: (a) cook's view

Figure 1: (b) close-up view of camera setup

Second, the system infrastructure is physically embedded within the kitchen environment. Two computers driving the capturing cameras and output display are hidden behind closed doors of the overhead kitchen cabinets. Lastly, the output display, Cook's Collage, is presented on a LCD flat panel that hangs from one of the overhead cabinets, at eye-level with most cooks while standing upright. The collage display is positioned at the center of the kitchen triangle, a conceptual area understood by kitchen designers, delimiting the three main components of a kitchen, namely the refrigerator, stove oven, and sink. In doing so, the output display is positioned within the environment where it will be most easily accessible. The LCD flat panel affords a slim encasing for the Cook's Collage so that it is snugly infused within the cabinet fixture, and physically presents the collage as framed art or other home artifact.

4.2 Cook's Collage

The Cook's Collage serves as an always-on, passive, output display in the augmented kitchen. Restricting the Cook's Collage to using only visual output is appropriate within the noisy kitchen and complementary to busy cooking. In such a noisy setting, an audio output display would compete against background noise. Cooking produces busy and messy hands, thereby rendering a tangible interface vying for the user's limited direct input. Conversely, the visual output provides supplemental information that the cook may find useful without requiring any further directed interaction. Moreover, the collage display is designed not as an active reminder or instructional assistant, alerting users when to perform particular tasks. On the contrary, the collage serves as a passive memory recovery aid, seamlessly mirroring a summary of recent cooking actions that the cook could choose to reference at anytime. Designed as an always-on, passive, output display permitted the Cook's Collage to provide an added service to the cook in the kitchen without detrimentally interfering with the environment and further complicating the task.

As shown in figure 2, the collage presents a sequence of the six previous cooking actions. As each cooking step is performed, the collage inserts the most recent action image in the bottom right corner and shifts each of the action images one position left such that the oldest action image rests at top left corner image. The bottom right corner image is highlighted to help focus the searching eyes of a cook. The decorative film reel motif suggests a time sequence flow. The horizontal film reel borders cluster the rows of images together, suggesting a horizontal reading of the action sequence. The 2x3 grid common to comic strip panels suggest a left to right, top to bottom reading of the action sequence. Each action image is displayed at 322x288 resolution, the minimal resolution to produce non-blurry images. A repeated step is annotated with its highlighted number of iteration.

Using a wizard of oz technique (Dahlback et al, 1993), a human operator simulates the functionalities of the system. She hand picks each image to post on the Cook's Collage on-the-fly as she monitors the simultaneously streaming video from the cameras in real-time. As a result, we were able to evaluate the system prototype even though it is not fully functional with robust activity recognition and image selection algorithm. The wizard also records via a popup menu the motivating heuristic for each image selected. In doing so, the

wizard's heuristics and experience will serve to inform and provide insight to how the system prototype can be automated as a smart environment.

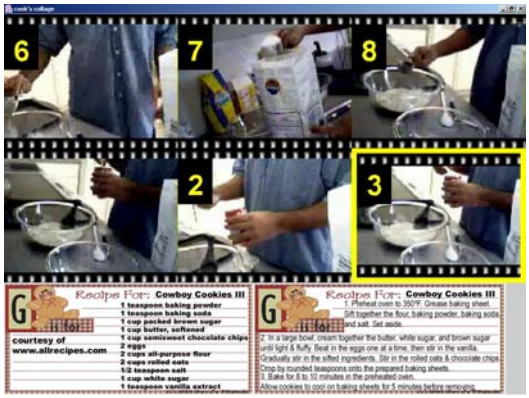

Figure 2: Cook's Collage

4.3 User Subjects

The evaluation scenario and cooking task were given to a total of sixteen user subjects comprising of six male cooks and ten female cooks. As a control for the system evaluation, four subjects were not given the Cook's Collage. They were only provided with the recipe. All user subjects were undergraduates currently enrolled in a psychology class. All subjects voluntarily responded to an advertisement to "prepare cookie dough in the 'aware' kitchen that remembers your actions and helps you recover from annoying interruptions."

4.4 Experiment Scenario

Naturalistic experiments of memory in everyday life generally try to devise memory tests which are more or less analogous to practical memory tasks in real life situations, but it is always necessary to make a compromise. Exercising experimental control over the relevant variables entails sacrificing some degree of ecological validity, while maintaining strict equivalence to everyday life entails abandoning some control (West, 1986). Following this approach, we constructed a believable real-life scenario in a real home (Kidd et al, 1999) which to evaluate the system prototype as the user went about his assigned cooking task.

> *Your friend is nursing a sprained ankle injury and is moping at home watching a football game. You've decided to come over and cheer him up by making him cookies and keeping him company. Your main task is to make cookies. During this task; however, you might be interrupted by your friend. Please be attentive and courteous to your friend as he asks for things, but otherwise keep a comfortable pace of cooking.*

Each cook was then introduced and acclimated to the kitchen and the system prototype. The cooks were told to expect interruptions, but were not cautioned further on what particular interruptions to expect or when to expect them.

Interruptions

We scripted four types of interruptions to evaluate as listed in table 1. The sequence of the interruptions was chosen at random per experiment for controllability between subjects.

Interruption	Projected Effect	Description
Interruption 1 "Get Candy"	Short, within room, minimal stress	Friend hobbles into kitchen to get candy from cabinet in front of cook.
Interruption 2 "Friend talking"	Long, within room, medium stress	Friend hobbles into kitchen, refills drink, and talks about the game with cook.
Interruption 3 "Spilled drink"	Short, outside room, minimal stress	Friend spills drink, and asks cook for a towel.
Interruption 4 "Fix TV"	Long, outside room, medium stress	Friend calls cook for help fixing TV.

Table 1: Experiment Interruptions

In order to provide strong evidence whether interruptions do cause memory slips for cooks while cooking, we timed the interruptions to occur during particularly cognitively demanding cooking tasks in which the standard kitchen environment could not provide context or progress clues. We focused on situations where the difference of the before and after state of a completed step is hardly discernable (e.g., when accumulating seemingly uniform ingredients such as baking powder and baking soda into the same bowl, adding multiple amounts of the same ingredient into the same bowl, or incorporating ingredients completely into a mixture before proceeding). Thus, we selected these four general cooking actions as strong candidates for problematic interruptions.

- After having added two dry ingredients
- While adding the white sugar
- While adding first dry ingredient
- In between adding multiple eggs

Cooking Task

In addition to accentuating the effects of the untimely interruptions, we increased the complexity of the cooking task by providing inconvenient cooking utensils and a less than straightforward version of the cookie recipe as shown in figure 2. First, we rearranged the list of ingredients in alphabetical order instead of the customarily sequential order as directed by the recipe. Next, we limited the measuring units to smaller divisions that the cook had to add multiple amounts of. For example, a ¼ cup measure was provided where one or two cups of an ingredient was required, and a ¼ teaspoon measure was used where one teaspoon was needed. We provided butter sticks labeled with tablespoon conversions for the cook to compute two-cup amounts instead of allowing them to literally measure out two cups of butter. Lastly, we doubled the yield of the original recipe. As lab subjects tend to focus more attentively on a task than they would in a everyday setting, these modifications to the cooking task help compensate by requiring that the cookie preparation would demand a substantial amount of time and nontrivial amount of attention and working memory to complete.

4.5 Experiment Results

We were interested in evaluating the effectiveness of the Cook's Collage. Thus, we first needed to know whether memory slips indeed occur while cooking and if so, why? Furthermore, to determine whether these interruptions and multitasking were noticeably problematic, we compared how accurately the subjects thought they were following the recipe with how they actually did perform. Lastly, we asked for initial impressions and comments about the memory aid

The strongest and most interesting correlation arose between the cooks' perceived accuracy and the actual quantitative accuracy. The subjects who seemed most confident about their memory skills strategies were the very same who committed measurement mistakes. The subjects who maintained a slower pace of cooking were more methodical in attending to the interruptions, following the cookie recipe, and reviewing the collage itself. Additional results of the study are fully noted as follows.

Self-Evaluation

Most of the subjects gave themselves favorable ratings, and were confident of their interruption management skills even though a few of them were skeptical of their general cooking abilities. When debriefed after the cooking task, the subjects were asked to rank their own cooking performance along a Likert scale.

How did you think you did with your cookies?
- Poor (1)
- OK (3)
- Good (10)
- Great (2)

Did you think you missed a step?
- No (15)
- Perhaps (1): "I lost track of ¼ cup count before interruption."

Did you think you repeated a step?
- No (15)
- Yes (1): "When I came back from turning on the TV, I may have added more than the right amount of flour."

The subjects also responded to an open self-evaluation survey of their interruption management.

Which interruption did you find most annoying?
- "Get Candy" Interruption (1): "I had to step back when he cut in front of me."
- "Friend Talking" Interruption (1): "It messed up the script of cooking."
- "Spilled Coffee" Interruption (4): "I had to get something and bring it to him."
- "Fix TV" Interruption (9): "I had no idea how to fix it." "I didn't know how to work the remote." "He could have fixed it."
- "Spilled Coffee" and "Fix TV" Interruption (1): "I had to leave the kitchen."

Which interruption did you find most distracting?
- "Friend Talking" Interruption (6): "I had stuff going through my head while having to answer his questions." "I was trying to count." "He was watching me cook." "I had to talk back."
- "Spilled Coffee" Interruption (1): "I had to leave the kitchen."
- "Fix TV" Interruption (8): "It took me away for the longest." "I was in the middle of adding the flour and forgot how many cups I had already added."
- Interruptions when using ¼ cup measure (1)

How did you find it resuming your task?
- Difficult (0)
- Bothersome (0)
- Manageable (8)
- No problem (8)

Cooking Performance

The collected experimental data, however, revealed that the subjects sorely underestimated the effects of

the interruptions. The most disastrous measuring error was the omission of half the required amount of flour by two subjects (one male, one female). Another subject added ¼ cup too much flour. Adding too much salt was also noticeable. One subject added twice the amount of salt needed. Another subject added one-third too much baking powder. One subject added only half the amount of rolled oats and forgot to add the salt entirely. These errors were evident in taste tests of the baked cookies.

Data about the interruptions were also archived. The length of the interruption and the time needed to recover from the interruption were clocked in seconds. The cooks handled all the interruptions in an efficient manner and pushed onward in their cooking task, so recording resumption time proved somewhat of a misnomer. The recorded times showed that the interruptions were consistently executed, and that the cooks quickly resumed their cookie preparation. The current cooking task in which the distraction interrupted was also noted. This annotation provided insight to the causalities of memory slips. For example, one of the cooks who forgot half of the flour was indeed interrupted while she was adding the flour, implying that the external interruption directly caused her uncompleted task of adding flour. However, the data archive showed that the other cook who forgot half of the flour was interrupted after he had decided to proceed onward with the next step of adding the baking powder, implying that he either forgot that he had only added half the flour or had not realized that the recipe required more flour.

Cook's Collage

In a questionnaire following their cooking task, the subjects were asked for their initial impressions of the memory aid. We should note that out of the twelve subjects who experienced Cook's Collage, only four were exposed to the number annotations of repeated, multiple steps whereas the first eight test subjects worked with the initial version of Cook's Collage which did not include the annotation feature.

Did you look at the collage?

Never (2): "I forgot it was there until the end."
A few times (7)
Some (2)
Often (1)

Did you find the collage helpful?

No (5): "Just interesting." "I can remember what I do but I could see how it would be beneficial for someone who forgets stuff especially the elderly. "I wasn't interested in what I looked like; I saw a bowl- that's not useful."

Yes (4): "It kept track of what I had last done." "It helped remind me exactly what I already had done. The collage's benefit is more valuable when I am forced to depend on it more due to a lot of distractions." "Kept count. I looked at the cups and numbers." "Helped with remembering which steps after a distraction."

Not really (3): "It was scary to trust the collage because of no difference from three cups to four cups of an ingredient."[1] "I kept count of my procedure- I have a good memory."

Did you find the collage distracting?

No (11): "If I didn't need to look at it, I just didn't." "It wasn't [distracting] at all." "I was able to keep my concentration."

Yes (1): "I wanted to see it because it was new, but it just slowed down the script [of cooking]."

5 Conclusions

From the initial study, we show preliminary evidence for a number of items that warrant further examination. Most of which are encouragingly successful although one remains a challenge.

First, interruptions are indeed problematic. We focus on finding these cognitively problematic occurrences and strive to understand what properties make them problematic. We refrain from imposing strict structure upon the recipes to automate activity recognition, and from offering officious assistance to the cook by predicting his next task. In understanding memory recall pitfalls instead of scrutinizing the supported cooking task, we can accommodate individual differences by not restraining cooking styles but instead permitting free form cooking.

Second, through careful consideration of camera positioning, Cook's Collage achieved the desired déjà vu effect without jeopardizing privacy concerns. The posted video images did not present any extraneous information that the cooks felt uncomfortable sharing. The cameras were positioned to be out of sight, thereby out of mind. In fact, all but one stated that they completely forgot about the cameras. The one expressed her concern that the cameras were indeed able to capture her cooking activity adequately. We noted a similar sense of ease with the cameras from the hundreds of

[1] The second version remedied this visual ambiguity with number annotations for repeated steps.

families who appraised an earlier prototype of this system at ACM1 (Tran, et al, 2001).

Third, the déjà vu effect proved poignant. The raw video images personalize the cooking experience such that the cooks know exactly what happened when. On the other hand, the same video images appears too busy and noisy to the casual observer.

Fourth, a temporal sequence provides an acceptable overview of past actions. All test subjects readily approved of the quick memory recall achieved by the at-a-glance information display.

Lastly, the number annotations seem to remedy the visual ambiguity of repeated steps and furthermore facilitate the at-a-glance readings for repeated steps. The four test subjects who experienced the annotated collage did not criticize the visual ambiguity the earlier test subjects had expressed concern about.

The main standing design challenge is how to empower the passive display to effectively present serendipitous information to cooks who fallaciously ignore the needed memory aid. Fortunately, the difficulty of designing an effective passive memory aid can be offset by gradual adoption of a universally beneficial aid much like the widespread adoption of word captioning for television.

6 Future Work

This experimental design is being refined into a more controlled study. We will extend this study to elderly cooks, investigating if and how this memory aid reinforces memory affected from typical aging deterioration. In tandem, we explore other applied scenarios, discovering where else interruptions are problematic and examining how déjà vu displays can compensate.

References

Abowd, G.D. and Mynatt, E.D. Charting Past, Present, and Future Research in Ubiquitous Computing. *ACM Transactions on Computer-Human Interaction* (TOCHI). Volume 7, Issue 1 (March 2000) 29-58.

Boreczky, J., Girgensohn, A., Golovchinsky, G. and Uchihashi, S. An Interactive Comic Book Presentation for Exploring Video. CHI 2000 Conference Proceedings, ACM Press, pp. 185-192, 2000.

Dahlback, Nils, Jonsson, Arne, and Lars Ahrenberg. Wizard of Oz Studies: Why and How. Proceedings of Intelligent User Interfaces, 1993. pp. 193-200.

Hutchins, E. Cognition in the Wild. MIT Press, 1995.

Ishii, H., Ren, S. and Frei, P. Pinwheels: Visualizing Information Flow in an Architectural Space. In Extended Abstracts of Conference on Human Factors in Computing Systems (CHI 01), ACM Press, pp. 111-112.

Kidd, C., et al. The Aware Home: A Living Laboratory for Ubiquitous Computing Research. In *Proceedings of Second International Workshop on Cooperative Buildings* 1999.

Lamming, M. and Flynn, M. 1994. "Forget-me-not" intimate computing in support of human memory. Tech. Rep. EPC-94-103. Rank Xerox, EuroPARC, Cambridge, UK.

Rhodes, Bradley and Pattie Maes. Just-in-time information retrieval agents. IBM System Journal Special Issue on the MIT Media Laboratory, Vol 39, Nos. 3 and 4, 2000, pp. 685-704.

Tran, Q., Truong, K. Mynatt, E. and Abowd, G. What Was I Cooking? Part of the "As We May Live" Demo invited to: ACM2001 (March 12-14, San Jose, CA), ACM.

Truong, Khai N., Abowd, Gregory D. and Brotherton, Jason A. Who, What, when, Where, How: Design Issues of Capture and Access Applications. In Proceedings of Ubiquitous Computing 2001. (2001) pp. 209-224.

West, R.L., (1986). Everyday memory and aging. Developmental Neuropsychology, 2, 323-344.