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

Quan T. Tran and Elizabeth D. Mynatt
College of Computing, GVU Center
Georgia Institute of Technology
Atlanta, GA 30332 USA
+1 404 385 1102
{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 prototype, 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.

INTRODUCTION
Everyday memory research ignited in 1978 with Neisser's talk entitled "Memory: What are the important questions?" [8]. In this milestone in the psychology of memory, Neisser argues that all the most interesting and significant problems are those that arise from everyday experience, how memory works in the natural context of daily life at school, in the home or at work. In doing so, he advocates the advantages of "ecological validity" that is lacking in traditional laboratory research.

In this work, we examine everyday memory within the context of 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. By identifying potential limitations of short-term memory recall within the home, we explore information interfaces to better sustain this everyday needed memory recall. One powerful approach is to relieve working memory capacity of keeping "knowledge in the head" by providing respective information as "knowledge in the world" [4]. Compared to people, computers can accurately record and store detailed records of everyday activity. Thus, exploring how a person's everyday memory can leverage a computer's rote recordings is an interesting base for an effective memory aid.

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

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 the added benefit of the video replay. Replaying a video segment cost time to review; consequently, these short-term replays are advantageous only if the review time is shorter in length than the duration of the original event. Moreover, video presents a rich media, advantageous if such thick description is needed 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 for our system prototype.

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 [1]. For example, the Forget-me-not system [7] records the user's personal activities continuously and later try to provide useful indices and summaries of daily information captured. Similarly, the Personal Audio Loop [12] maintains a short audio replay loop to help refocus verbal conversations periodically. Just-in-time information retrieval agents [9] 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 [2].

Conceptually, automated capture and access applications promises to be an ideal balance between people and technology since computers are better at recording and remembering events and facts than people are, and people are better at interpreting and enjoying experiences than computers are. Pragmatically however, designing these applications and tools must be considered carefully to be useful. Since only salient captured information is needed to be accessed afterwards, what exactly constitutes salient information? Which mediums are appropriate in capturing the information? For how much later and in what manner is the captured information to be accessed? In what format should the captured information be presented to be easily interpreted? We are cautioned about these and many other issues inherent in capture and access applications [11] as we extend its use for everyday short-term memory recall.

As information interfaces, ambient displays such as Pinwheels [5] 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.

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.

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.

Distribution: 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.

Evanescence 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.

Juxtaposition 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.

Already 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 as 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 an 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.

Initial 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.

INITIAL 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. Thus, cooking is a cognitively demanding process with a very concrete beginning and ending.

Contrast this 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 very 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.

Hence, the sociality of the kitchen serves to further complicate the already complex task of cooking. 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. This additional complexity is apparent to harried parents who must balance their attention between preparing family meals and attending to the interruptions of their children. However, this balance of attention is potentially problematic to all cooks not solely focused on their cooking task.

This interplay of a specific need (e.g. memory recall) within a dynamic setting (e.g., kitchen) presents a complementary opportunity for ubiquitous computing to be invisibly embedded within the environment, aware of the surroundings, and provide the specific needed service. In this 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.

Augmented Kitchen

Being a ubiquitous computing application, the components of this system are distributed and embedded into the environment (i.e. 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.

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 that delimits 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.

Figure 1. (a) cook's view

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

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 may prove conducive within the noisy kitchen and complementary to busy cooking. In such a noisy setting, an audio output display would compete against background noise. Cooking renders hands busy and messy, thereby limiting direct user input via a tangible interface. Consequently, the visual output provides additional information that the cook may find useful without requiring any direct user interaction. Furthermore, 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 existing environment and further complicating the existing task.

As shown in figure 2, the collage presents a sequence of the previous six 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.

Using a wizard of oz technique [3], 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

User Subjects

The evaluation scenario and cooking task were given to a total of twelve user subjects consisting of three male cooks and nine female cooks. As a control for the system evaluation, five 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."

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 [13]. Following this approach, we constructed a believable real-life scenario in a real home [6] 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.*

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

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 derived at 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

We scripted four types of interruptions for the evaluation 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 walks into kitchen to get candy from overhead cabinet in front of cook.
Interruption 2 "Friend Talking"	Long, within room, medium stress	Friend walks into kitchen, refills drink, and talks about the game with cook.
Interruption 3 "Spilled Coffee"	Short, outside room, minimal stress	Friend spills drink, and calls cook over for a towel.
Interruption 4 "Fix TV"	Long, outside room, medium stress	Friend calls to cook for help fixing TV.

Table 1: Experiment Interruptions

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 and two cups of an ingredient, 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.

Experiment Results

The prototype evaluation was conducted with several hypotheses in mind. A couple showed promising results, a couple showed counterintuitive results, but most remain inconclusive. A summary of the experimental results and conclusions are listed as follows.

We showed that interruptions are problematic. In particular, we showed that maintaining accurate memory recall of repeated iterations within steps is problematic. For example, subjects did inaccurately add multiple amounts of an ingredient. We also wanted to show memory slips between steps, but we were unable to

construct a scenario with enough task complexity within safe cooking guidelines for human subjects.

We wanted to show performance differences between subjects given the Cook's Collage and those without the déjà vu display. However, the initial experimental results were inconclusive due to huge variability of cooking prowess. Inaccurate ingredient measurements could be attributed to memory slips or to inept cooking abilities. Nevertheless, initial experimental results did not show significant difference in resumption time after an interruption for subjects with the collage and those without.

Self-Evaluation

To determine whether these interruptions and multitasking caused any memory slips, we compared how accurately the subjects thought they were following the recipe with how they actually did perform. 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 (1)

Good (8)

Great (2)

Did you think you missed a step?

No (11)

Perhaps (1): "I lost track of ¼ cup count before interruption."

Did you think you repeated a step?

No (12)

The subjects also answered a 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 (4): "I had no idea how to fix it." "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 (5): "I had stuff going through my head while having to answer his questions." "He was watching me cook."

"Spilled Coffee" Interruption (1): "I had to leave the kitchen."

"Fix TV" Interruption (3): "It took me away for the longest."

Interruptions when using ¼ cup measure

How did you find it resuming your task?

Difficult (0)

Bothersome (0)

Manageable (7)

No problem (5)

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. 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 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.

Memory Strategies

During the cooking task, each subject exhibited particular coping strategies in dealing with general interruptions, and offered reasons for these habits. In a demographic questionnaire given after the experiment, the majority of the students explained that they were accustomed to cooking in public dormitory kitchens amidst interruptions.

These interruptions ranged from other residents periodically passing through to share the kitchen, friends helping them do the cooking together and/or carrying on a conversation throughout. Therefore, many of the students claimed that they routinely found themselves multitasking.

During the experiment, a few of the subjects physically rearranged the ingredients to help them keep track of which ingredients have been used. They started by clustering the ingredients closer to the mixing bowl so that they used the ingredients up front and pushed the used ingredients back against the kitchen counter wall. Some of the subjects used a somewhat successful counting scheme noting the repeated amounts of the ¼ measuring cup/spoon into groups of four to mark the completion of an added whole cup/spoon. A few cooks used the compactness of the brown sugar to drop four molds of ¼ cup measures before incorporating them with the rest of the bowl contents. Others used the action of rinsing the utensils before reusing them as a division marker to their cooking progress. Still others hurried through repeated steps as to finish all iterations of that same step before they could be distracted. In short, various subjects were already showing that they had developed coping strategies to help them better remember their cooking status.

Cook's Collage

In a questionnaire following their cooking task, the seven subjects who were provided Cook's Collage were asked for their initial impressions of the memory surrogate.

Did you look at the collage?

Never (0)

A few times (4)

Some (2)

Often (1)

Did you find the collage helpful?

No (3): "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 (2): "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."

Not really (2): "It was scary to trust the collage because of no difference from three cups to four cups of an ingredient."

Did you find the collage distracting?

No (6): "If I didn't need to look at it, I just didn't. It wasn't [distracting] at all."

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

CONCLUSIONS

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

First, interruptions are 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 all 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 families who appraised an earlier prototype of this system at ACM1 [10].

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.

Lastly, 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.

The standing functional challenge is how to incorporate detail information within the overview display. The raw video images alone of repeated actions fail to differentiate themselves from the next; thereby offering minimal assistance for troubled cooks querying further information. In particular, the still visual of adding the sixth cup of flour proved indistinguishable from the seventh cup of flour.

The other standing design challenge is how to infuse more memory recall efficacy in to the felicitous passive displays. Passive display is conducive to the hands and eyes busy task of cooking and noisy kitchen environment, but cannot help a cook who does not believe he needs help. The difficulty of designing an effective passive memory aid can be offset by gradual adoption of a beneficial universal design much like the widespread adoption of word captioning for television.

FUTURE WORK

An important function of everyday memory research is to identify phenomena that can then be followed up more

carefully in traditional laboratory research. We intend to use this experiment setup as a base scenario for our psychology collaborators to conduct more controlled studies with more volunteer cooks, especially elderly cooks since memory recall deteriorates from typical aging effects. In tandem, we will explore other applied scenarios to examine how déjà vu displays can be beneficial by discovering where else interruptions are problematic. Of course, we will iterate the design of Cook's Collage to address its standing challenges. We also will explore other memory strategies (e.g. spatial memory, semantic clustering).

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