

COOK'S COLLAGE

Déjà vu Display for a Home Kitchen

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Abstract: Many people regularly multitask while cooking at home. Juggling household chores, reusing limited kitchen utensils, and coordinating overlapping cooking times for multiple recipes can cause frequent task switching and simultaneous task monitoring while cooking. As a result, the cook occasionally loses track of his cooking progress especially when determining which ingredients have already been added, counting multiple scoops of an ingredient, and keeping watch of cooking times. People compensate for these memory slips by devising memory strategies or deferring to memory aids with varying degrees of success. In this paper, we present a novel memory aid for cooks called Cook's Collage. We describe how the system constructs a visual summary of ongoing cooking activity. Then, we report a task simulation study evaluating the effectiveness of Cook's Collage as a memory aid. We argue that a memory aid is helpful only if it is balanced correctly with a complementary memory strategy and only if the accuracy of the memory aid is trusted. Lastly, we discuss how the six design features of the Cook's Collage suggest a general framework for memory aids in the home, which we term *déjà vu* displays.

Key words: Memory aid, appliance design.

1. INTRODUCTION

Memory slips can occur while cooking at home for many reasons. First, the lack of visual cues may make determining cooking progress problematic. Consider mixing different ingredients of similar color and texture such as flour, baking soda, baking powder, and sugar. Remembering which ingredients have been added and how much of each has been added can be problematic. All the mixed ingredients are available and visible, but they are not easily distinguishable. Second, failures of remembering self-performed

actions can result from routinized tasks that occur automatically without conscious awareness, from memory decline with increasing age, or from confusion between already performing an action and intending to perform an action [4]. Lastly, interruptions and multitasking can create memory slips by overloading memory demands. Juggling household chores, reusing limited kitchen utensils, and coordinating overlapping cooking times for multiple recipes can cause frequent task switching and simultaneous task monitoring while cooking. Gillie and Broadbent [6] showed that interruptions are more disruptive the more they are similar to the interrupted task, the more complex they are, and the more time they consume.

The cook occasionally may forget and question his cooking progress. “Which ingredients have already been added?” “How many scoops of an ingredient have been added?” “How long has this item been cooking?” Not knowing the answers can ruin recipes. Most people compensate for their memory slips with memory strategies and memory aids with varying levels of success. Identifying those who could benefit from memory aids may be paradoxical since [18] shows that those who commit memory slips are also often oblivious of their memory slips.

We present Cook’s Collage, a novel memory aid for general cooking that constructs a visual summary of ongoing kitchen activity. We have demonstrated this memory aid to numerous visitors including researchers, local families, college students, elderly adults, and members of the press and media throughout the past three years. Cook’s Collage receives enthusiastic support from many people who feel that they have memory slips while cooking and understand that these memory slips consequently cause problems. In this paper, we detail the design features of Cook’s Collage. Then, we report a task simulation study evaluating the effectiveness of the memory aid. Lastly, we discuss how the six design features of the Cook’s Collage suggest a general framework for memory aids in the home, which we term *déjà vu* displays.

2. COOK’S COLLAGE

Cook’s Collage is a novel memory aid that constructs a visual summary of ongoing kitchen activity. The system is based on six design features. In this section, we detail the system specifications of the Cook’s Collage with respect to the six design features. Afterwards, we revisit the design features, discussing their rationale and implications for home memory aids in general.

2.1 Distributed Cognition, Capture, and Access

The system components are distributed and embedded within the home kitchen. Capturing devices (e.g., webcams) mounted underneath the kitchen cabinets as shown in figure 1b continually record video of countertop activity. This location hides the devices from casual view, rendering them inconspicuous and innocuous as shown in figure 1a. The system uses two cameras, the minimum number to provide overlapping spatial coverage of one corner of the kitchen countertops. Cook's Collage is presented on a LCD flat panel that hangs from an overhead cabinet, at eye-level with most cooks when standing. To be readily accessible, the 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 (i.e., refrigerator, stove oven, and sink). The LCD flat panel provides a slim encasing snugly infused within the cabinet fixture, physically presenting the output display as framed art or some other home artifact. With the physically dispersed components, the cook is able to cognitively distribute his memory load for the capturing cameras to be later accessed via the display.

2.2 Evanescence of Recent Activity

Cook's Collage aids short-term and working memory, presenting only the most recent activity and not an entire running history. The visual summary retains an evanescence of recent activity by continually updating the display and transitioning the shown actions. As a new action is performed, the system adds its corresponding information to the bottom right corner of the display, marks it as most recent by highlighting a yellow border, and shifts the previous actions one position left. The oldest action rests at the top left corner of the display. Once six actions have been performed, the next action causes the first action to transition off the display. Repeated steps like adding multiple scoops of an ingredient are considered sub-actions, so they transition differently. If the most recent action displayed is repeated, the new action replaces the previous action on Cook's Collage and its new numeric count is annotated appropriately. If a step repeats successively, its prior occurrences are compressed into gray bars (i.e., visual ellipses denoting repeating information without consuming space), and the new action with the accumulating count annotation replaces the previous one.

2.3 Juxtaposition of Displayed Information

The Cook's Collage displays a visual summary of ongoing kitchen activity by juxtaposing the six most recent actions in a relative temporal sequence.

The decorative film reel motif suggests a time flow, and the horizontal film reel borders cluster the rows of images together, suggesting a horizontal reading of the action sequence. Additionally, the 2x3 grid layout commonly used for comic strips suggest a left to right, top to bottom reading. For example, figure 2 retells that the user added the 29th scoop of sugar the last time he was here at the kitchen corner countertop. Before that series of sugar scoops, he had added two amounts of soda pop one after the other; before that, two amounts of ice one after the other; before that a series of sugar count ending with the 25th scoop; before that, a series of powder count ending with the fifth scoop; and before that, two amounts of water one after the other. The layout of the display is essential in interpreting the images.

2.4 Already Known Information

Retrospective memory entails remembering actions one has already performed. To support retrospective memory recall, *Cook's Collage* shows only already seen information. The memory aid uses raw video as visual cues, literally already seen by the user. However, repeated actions are visually ambiguous on video. The memory aid avoids potential ambiguity of visualizing repeated actions by collapsing the repeating action into a single visual representation with numeric annotation. This solution explicitly shows information that otherwise was implicitly already seen.

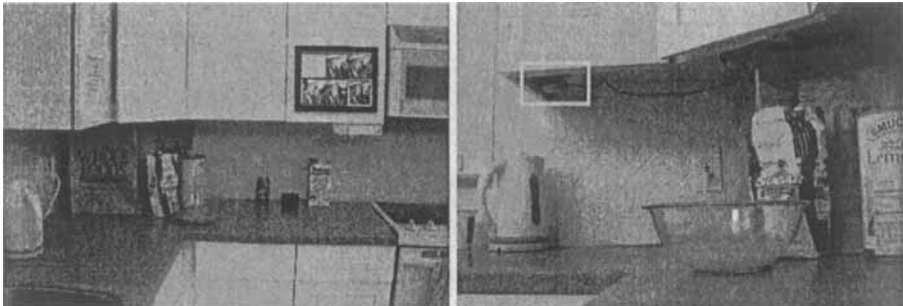


Figure 1. Kitchen setup at (a) eye-level view (b) close-up underneath view of cameras

2.5 Video

The video used for *Cook's Collage* consists entirely of close-up hand shots over the kitchen countertops. This allows the capture of necessary detail and avoids unnecessary occlusions. The positioned camera angles avoid an over-the-shoulder, surveillance view that could induce big brother privacy concerns and wrongly encourage “cooking show” theatrics uncharacteristic

of everyday cooking. The use of unedited raw video accentuates the reality of the cooking experience and personalizes the cooking narrative.



Figure 2. Cook's Collage display

2.6 Units

Cook's Collage represents a single step in a recipe as a unit of action, and shows each unit of action as a snapshot image in the display. Each image is displayed at 322x288 resolution, the minimum required for non-blurry images.

3. WIZARD OF OZ SYSTEM IMPLEMENTATION

The collection of images displayed on Cook's Collage is constructed in real time via a Wizard of Oz approach [9]. In a remote room, a human operator monitors a streaming assembly of image stills captured at a rate of one frame per second from which she hand picks a still image representing the user's action. Upon each image selection, the streaming assembly of captured images pauses so that the wizard can either associate the chosen image with

its corresponding action and document her image selection heuristic or cancel her selection choice. Upon completion, the stream of captured images resumes.

Unfortunately, the image selection causes the system to pause, introducing variable delays into the system's update latency. Network routing between the distributed system components also imposes time latency between when an action is performed to when it is updated on the display. The wizard can commit human errors in interpreting the cook's actions from the streaming video and in operating the interface that builds the collage. Still, the time latency and human error of the current system may be no faster and no more accurate than the computational latency and low confidences of an automated perception system in the future.

In a previous version, Cook's Collage utilized various ingredient containers instrumented with RFID tags that sensed when ingredient bottles were being poured and automatically generated the collage summary. However, the sensing technology restricted the cooking behaviors we are exploring. Cook's Collage could leverage vision tracking, but we use the video medium as raw input. The captured video is not processed or synthesized in any way.

We select the wizard of oz simulation to permit evaluation of how the display designs affect possible user interactions without committing to a fully automated system. We believe Cook's Collage can be realized either by technical breakthroughs which will be years in the future, or by achieving the appropriate balance of human computer interaction, leveraging both human and computer abilities, which may be understood from our simulation studies. Currently, computational perception systems are unable to recognize the variability of everyday cooking that Cook's Collage supports. In a highly variable and dynamic activity such as everyday home cooking, sensing technologies lack precision to physically perceive individual tasks, and inference models lack accuracy to intelligently interpret overall activity. By studying how users interact with the Cook's Collage, our findings suggest that a fully automated system may not be necessary because people willingly adjust their memory strategies and accommodate the memory aid in a collaborate effort to improve overall memory recall.

4. RELATED WORK

Albeit office groupware, [12] is used in a similar manner as the cook's collage. As a team member arrives late to a running conference meeting, he scans video segments from the ongoing meeting to be quickly briefed of the arguments leading up to the current discussion. While there are some

memory support systems for the home (e.g., [5,11]), they investigate software infrastructure to support large-scale archives of multimedia. We have yet to find another memory support system for cooking. Various kitchen gadgets such as egg timers or cooking appliances that turn off after a preset time assist with one of the three potentially problematic cooking tasks we identify, keeping track of cooking times. We also addressed an alternative approach to keeping track of cooking times with an earlier design of Cook's Collage [16]. The other cooking tasks, remembering which ingredients have been added and counting multiple scoops of an ingredient, are not currently supported by memory aids but rather by memory strategies that are prone to error. We note examples of these memory strategies in our experimental findings.

There are many systems that help novice cooks learn new recipes. Although also kitchen applications, the focus of these systems is primarily to assist the cook with navigation through recipes rather than Cook's Collage's focus of supporting memory recall. For example, eyeCook [13] tracks the cook's eye gaze to infer which recipe instruction or ingredient description to read out loud next. Another kitchen system [14] uses foot panels along the bottom kitchen cabinets for the user to explicitly navigate through recipe instructions.

5. EXPERIMENTAL EVALUATION METHOD

A task simulation study is defined as "a laboratory memory test that bears some resemblance, at least in stimulus content, to an everyday memory experience" and is valued as the "best situation" in terms of research with high ecological validity (from using cues or stimuli that have potential utility in real-world environments) and high generalizability (from the laboratory control and potential for programmatic replicability) [17]. A task simulation study was used to evaluate the effectiveness of Cook's Collage as a memory aid. We designed a dual task scenario that consistently produces memory slips for cooks. This experimental setup enables comparison of the cook's memory performance with and without Cook's Collage.

5.1 Dual Task

We designed a dual task to overload working memory. We drew inspiration from our previous experiment's results that rank having an ongoing conversation while performing a separate task as most difficult and annoying to manage [15]. We chose a language learning task to provide a sufficient distraction to the cook. Though things such as spontaneous interruptions

may be more common distractions in the kitchen, they are more difficult to control. We thus decided to use a multitasking situation that is similar to activities cooks perform such as engaging in conversation in the kitchen, talking on the phone, and interacting with their children. Though language learning itself is not a typical activity cooks engage in while multitasking in the kitchen, it does effectively induce cognitive load in the same way as the aforementioned activities. In addition, using the language task allows us to quantitatively measure performance. Directly measuring performance on the language task gives us a fuller understanding of how effectively participants use the memory support system. We counterbalanced for learning effect, language difficulty, and availability of the support system, to compare memory performance quantitatively and user experience qualitatively. All participants received four conditions in the following order: single task, dual task, single task, dual task. 11 participants first did the dual task with Cook's Collage as memory support, then did the same task without memory support. The other 11 participants did the dual tasks in the reverse order.

To encourage a dual task situation, we asked participants to try to pace their cooking task so that they would finish both tasks at approximately the same time. To avoid having the participants ignore the language task, we emphasized the language learning task as the primary task to be evaluated and the cooking task as secondary. No internal or external memory strategies were suggested in order not to prime the participants' behavior; however, they freely initiated and utilized whatever learning and counting strategies felt comfortable.

5.1.1 Primary Task: Language Learning

This task involved learning how to count to ten, five digits at a time in a foreign language (e.g., Vietnamese 1-5, 6-10; Chinese 1-5, 6-10). The learning task was accomplished by listening to an audio tape consisting of an opening welcome, statement overview, one complete counting sequence, instructions to start drilling by repeating each number after hearing a pairing of the English meaning and number pronunciation, four rounds of five number pairings, and finally a closing encouragement. The lesson spanned two minutes, looping once to total four minutes. The tapes contained a fairly consistent audio silence between digits allowing participants time to decipher pronunciation of foreign number and to repeat the digit aloud. The participants were not permitted to pause, rewind, or replay the preset lesson.

5.1.2 Secondary Task: Punch Preparation

The cooking task was to prepare punch. This task comprised of adding ingredients (e.g., $\frac{2}{3}$ cup orange juice, $\frac{2}{3}$ cup water, 5 scoops lemonade powder, 29 scoops sugar, $\frac{2}{3}$ cup ice, $\frac{2}{3}$ cup citrus soda) into a large bowl from a recipe posted on an overhead cabinet (Figure 1). Provided measuring utensils included an arbitrary sized scoop for the powder, a $\frac{1}{3}$ measuring teaspoon for sugar, and $\frac{1}{3}$ measuring cup for the remaining ingredients. Participants could add the ingredients in whatever sequence felt comfortable, and could freely rearrange countertop items excluding the punch bowl that was optimally positioned for the Cook's Collage cameras.

5.2 Participants

22 graduate students (14 male, 8 female) of ages 23-51 participated in this study. None of the participants learned how to count to ten in Chinese or Vietnamese prior to the study. 19 reported having previously used audiotapes to learn a foreign language (e.g., English, French, German, Italian, Spanish, Greek, Japanese, Russian), of which four reported multitasking more than 75% of the time while listening to language tapes. The majority of the participants reported multitasking more than 50% of the time while preparing food and drinks within their kitchen.

5.3 Cook's Collage Introduction

Prior to the experiment, each participant was given an overview of the Cook's Collage and the layout of the kitchen. The display features were debriefed, and a brief demo highlighted how updates of new images and number annotations occurred. The system limitations were also noted. Particularly, participants were told to expect variable time latency per display update. It is important to note that no hints about developing particular strategies for system use were given to the participants. Rather, the intent was to inform participants of the system features and limitations, allowing each participant to decide if and how Cook's Collage could be a useful memory aid. This debriefing constitutes the only introduction to the system that each participant received, thereby rendering each participant as a true first-time user of the system.

5.4 Units of Measurement

We quantitatively and qualitatively compare participant performances across the four conditions. For the language task, participant rated the pace of the tape drills and indicated which numbers they believed they learned and remembered, writing in reasons for numbers they believed they had not learned and remembered. A short oral quiz (e.g., reciting numbers in correct sequence and translating two random numbers) was administered to assess actual learning performance. For the punch task, we conducted semi-structured interviews to gauge user experience qualitatively. We used video record of the dual task to compare actual performance to participants' perceived performance. We used another video record to tally the number of times a user glanced at the display and the time duration of each glance.

6. EXPERIMENTAL FINDINGS

The experimental results produce further evidence that multitasking while cooking does cause memory slips, that memory slips are problematic for certain cooking tasks, and that many existing memory strategies people make use of can be faulty. We report how the cooks used Cook's Collage to cope with the taxing memory demands of certain cooking situations. We argue that a memory aid is helpful only if it is balanced correctly with a complementary memory strategy and only if the accuracy of the memory aid is trusted.

6.1 Did the dual task overload working memory?

Yes. Overall, participants recalled significantly fewer words in the dual task conditions than in the single task conditions, $t = 4.294$, $p < .001$. None of the 22 subjects rated the pace of the single task as too fast. 10 (45.5%) of the participants rated the pace of the task as "just right" on all four conditions. However, 11 (50%) of the participants rated a relative increase in the pace of the audiotape during the dual task conditions. One participant rated the pace of the audiotape on all four conditions as "too slow." Thus, any relative difference in the pace of the tape in the dual task conditions was rated as an increase most likely due to the increased cognitive load of the participants. No significant difference was found between the number of words a participant recalled on the first single task and the second single task, $t(21) = -1.164$, $p = .257$. We can conclude that Chinese and Vietnamese are of relatively equal difficulty level for individuals who do not speak an Asian language.

6.2 Did participants adopt successful memory strategies to aid them in the dual task?

Participants employed a variety of memory strategies in an attempt to externalize the information about the ingredients added and the number of ingredient counts completed, that they would otherwise hold in working memory. For example, some cooks used relative grouping of ingredients on the kitchen countertop to remind themselves which ingredients have been added and which have yet to be added. This however did not externalize information such as the number of counts of a particular ingredient that were added. In fact, most of the strategies participants adopted were not completely successful. As an example, some participants counted on their fingers to aid them in keeping tracking of ingredient counts. However, their timing was often problematic because the repeated numbers on the tape were easily confused with the ingredient count numbers, and this sometimes lead to counting errors. Other cooks used the drilling pattern in which numbers are presented on the language learning task to pace their ingredient additions. This strategy worked very well for this dual task, since the grouping of the numbers on the tape was in fives as well as the grouping of most of the ingredients. However ingenious though, this strategy cannot be generalized to other multitasking scenarios, and thus cannot be considered an effective way for the cook to externalize working memory information into the world in a typical dual task situation. Thus, though people did adopt a variety of memory strategies to aid them in multitasking while cooking, these strategies were often faulty and would not generalize well to all multitasking situations that a person may find himself in while cooking.

6.3 Did first-time users find the memory system useful?

Yes, the memory system can be useful if the user adopts a successful strategy for adding the ingredients and using the memory aid during the dual task. Here we define a strategy as a way of utilizing the memory aid to help in the punch preparation task, allowing the participant to concentrate more on the primary task. We found that participants who had no practice performing a dual task before using the memory aid (i.e., with memory aid, without memory aid order of conditions) had a harder time developing a successful strategy for using the system, and in some cases chose not to use the system at all but rather relied on their own personal memory strategies. 63.6% (7/11) of the participants who received the dual task condition without memory support before receiving the memory support condition did use the memory aid and even developed a successful strategy of interleaving ingredients when they had the memory aid available to them. This strategy

was effective because it allowed the cook to add an arbitrary number of scoops of an ingredient, and then add more scoops later on based on the output displayed on the collage for that ingredient. They let the system first “catch up” with them and then determined what steps remained, rather than keeping track of the counts themselves and adding all of an ingredient at once. On the other hand, only 27.3% (3/11) of the participants who received the dual task conditions in the reverse order developed a strategy for using the system. Thus, participants who were already familiar with the dual task were better able to develop a strategy the second time they were put in a dual task situation. Many of the participants who had prior exposure to the dual task situation openly admitted in the post-task interviews that their own personal memory strategies used when they did not have the aid had been faulty, and they felt that using the aid would be a better alternative to relying on their own memory. This pattern was not observed with participants who had not had prior exposure to the dual task before having the option of using the aid. These participants tended to rely more on their own memory strategies, such as those discussed in a previous section, and did not see a need for the memory aid. In summary, practice with the dual task before being exposed to the memory support system made many participants offload their memory of the running list of used ingredients and the running count of multiple ingredients onto the aid rather than relying on their own memory strategies which had proved faulty in the previous dual task situation. They were also more able to develop a strategy for using the system to help them perform the dual task.

6.4 Following practice performing a dual task, can the memory system improve performance on the primary task?

Many of the participants who did offload their working memory of the running list of used ingredients and the running count of multiple ingredients actually improved their performance on the primary (language learning) task. The number of words recalled on the language quiz given after each condition was used as a quantitative measure of performance. 45.5% (5/11) of participants who received practice performing the dual task prior to introduction of the memory aid, either improved or showed consistent performance on the memory recall quiz. 4 of these participants actually changed their strategy from chunking ingredients (adding all scoops of a particular ingredient at once) on the first dual task condition to a strategy of interleaving ingredients on the dual task with memory support. We found that the participants who showed improved or consistent performance with

the memory aid developed this strategy of interleaving ingredients to use the time latency of the memory support to their advantage. For example, one participant adopted a strategy that took advantage of the memory aid by 1) initially adding an arbitrary number of the 29 scoops of sugar, 2) moving on to those ingredients with a smaller number of steps, 3) referring to the display to see where she left off on the sugar count, and 4) adding the final scoops of sugar. Two participants actually improved their performance by adopting this strategy (e.g., P1, P26). On the contrary, we found that participants who maintained a strategy of chunking ingredients in both dual task conditions (e.g., P9, P22) showed no improvements in memory recall. Due to the latency and transitions of the display updates, chunking did not prove to be a very successful strategy for performing the punch task. Examples of both successful and unsuccessful strategies employed by 5 of the participants are shown in Table 1.

Table 1. Examples of memory strategies in the two dual task conditions.

<i>Strategies adopted by participants in dual task conditions</i>	<i>Without aid</i>	<i>With aid</i>
P1 – improved performance with memory aid	chunking (tap finger on counter after every 3 rd scoop of sugar)	interleaving (add OJ, water, powder, arbitrary amount of sugar, ice soda, then refer back to display and add remaining sugar)
P26 – improved performance with memory aid	chunking (lost count at scoop 6, attempted to restart count, had to guess)	interleaving (add arbitrary amount of sugar, add water, OJ, look at display and add another arbitrary amount of sugar, add ice, soda, powder, look at display and add the rest of the sugar)
P11 – perfect performance on both conditions	chunking (counted sugar in increments of 10)	interleaving (add powder, OJ, water, ice, arbitrary amount of sugar, add soda, refer to display and add remaining amount of sugar)
P9 – decrease in performance with memory aid	chunking (counted on fingers, “stored the most recent count in my head”)	chunking (add OJ, water, powder, add sugar, waiting for display to catch up, add more sugar, add ice, add soda)
P22 – decrease in performance with memory aid	Chunking (tried to make a mental note after each set of 5 scoops were added)	chunking (add all ingredients except sugar, add sugar last, overshoot by 12 scoops)

Another interesting thing to note is that none of the 5 participants who improved or showed consistent performance rated an increase in the pace of the audiotapes on the memory aid task. 3 of the participants rated both dual task conditions as “just right” whereas the other 2 participants actually showed an increase comfort level with the pace of the tapes that they had rated as “too fast” on the dual task where they had no memory aid. This suggests that those who felt comfortable with the pace of the task showed improvements or consistency in memory recall.

6.5 Trust

The memory aid successfully allowed the cooks to offload the running list of used ingredients and the running count of multiple ingredients that are in working memory out into the world. However, Cook’s Collage was only successful when the cook actually trusted the accuracy of the system enough to use it. Results from this study indicate that many people felt they could trust the Cook’s Collage more than they could trust their memory. After performing the task, users were asked whether they trusted the system. Three of the five users who improved their performance when having the memory aid present the second time they performed the dual task reported that they trusted the aid more than their own memory. When asked if she trusted the memory aid, the first of these users commented, “Yes, definitely, I wasn’t as dependent on my own memory.” Another user commented, “I definitely trust it. It’s probably more accurate than my memory.” Yet another participant commented, “I made the decision early on to trust it, because it’s probably better than my own memory.”

7. DISCUSSION: FROM COOK’S COLLAGE TO DÉJÀ VU DISPLAYS

Based on the encouraging feedback from people who used Cook’s Collage, we explore other home activities that could also benefit from a memory aid. Possible household activities include taking medication, getting ready in the morning, and fixing household appliances. We revisit the six design features of Cook’s Collage to define a framework that we term “déjà vu” for memory displays. We conjecture how they contribute positively to the success of Cook’s Collage and discuss how to apply them in the design space for memory aids in the home.

7.1 Distributed Cognition, Capture, and Access

A powerful approach to addressing memory slips is to relieve working memory of keeping “knowledge in the head” by distributing respective information as “knowledge in the world” [10]. By making retrospective memory external, recalling self-performed actions transforms to recognizing information.

Cook's Collage directly uses this approach by capturing information about ongoing events and displaying this information visually within the environment to be accessed later by the cook as needed. Cooks can either offload information in working memory including the running list of used ingredients and the running count of multiple ingredients to the memory aid, or confirm the running counts of ingredients in their head with the running counts displayed by the collage. In similar means, people may complement or confirm their working memory for other household activities or in general with a *déjà vu* display.

7.2 Evanescence of Recent Activity

Short-term memory and working memory are used for activities that are short-lived and evanescent, yielding minimal long-term memory retention. *Déjà vu displays* summarize recent activity based on actions and not based on time. The action-based definition of recent activity complements the otherwise time-based description of evanescent activities common within the home.

Cook's Collage shows that an action-based history readily supports interruption recovery and task switching. The display answers the query “what did you last do here?”, whether recent activity was within the previous minute if heavily active or within the prior week if activity was sparse. We believe that activities at home are continuous, without a definite beginning and end. Therefore, managing interruptions and task switching will be important for memory aids to support.

7.3 Juxtaposition of Displayed Information

Presentation of information is important. Juxtaposition of displayed information helps to compose or to isolate the units of information so that correct interpretation of the recorded narrative is possible. The composition of the display can either maintain structure or can be haphazardly scattered as a collage. Each *déjà vu* display may explore this range to leverage various memory strategies (e.g., temporal sequencing, spatial memory, semantic association).

Using a temporal sequence was fairly successful as a straightforward summary of past actions. This reinforces survey findings that mental retracing is the most frequently used internal memory aid by far for students (97% ever used, 23% use >1 per week) because of its advantages as a pure retrieval strategy, requiring no special encoding effort to use it [7]. The annotations for repeated steps and visual ellipses confused some cooks, who misinterpreted the overall display arrangement as a spatial layout. Cook's Collage could be alternatively redesigned with a different layout (e.g., [1]) under the déjà vu framework.

7.4 Already Known Information

Déjà vu is a memory recall phenomenon defined as “an impression of having seen or experienced something before; the experience of thinking that a new situation had occurred before.” This experience epitomizes the memory slips we seek to address, because memory recall worsens by adding confusion between performing an action and intending to perform an action. The secondary definition of déjà vu is “a dull familiarity and monotony.” The sense of familiarity (i.e., rich context inherent in already seen and felt personal experiences) from déjà vu inspires our scaffolding of retrospective memory support.

Our experimental findings show that cooking involves instances where cooks experience the former definition of déjà vu, especially when questioning which ingredients have already been added and how many scoops of an ingredient have already been added. Our exit interviews indicate that cooks experience the latter definition of déjà vu when reviewing Cook's Collage of their personalized cooking experience. In fact, study participants can quickly query Cook's Collage and easily interpret the informative details, whereas objective viewers study the memory aid at length and are frustrated with the information clutter. This reaction is similar to how daily commuters skim subway maps compared to how foreign visitors study them. There are many examples of both definitions of déjà vu experiences in everyday life that this framework can address.

7.5 Video

The video medium, captured live and unedited, maintains much of the original context, (e.g., first-person perspective, same visual modality) minimizing cognitive effort in interpreting the display of already seen information. The video medium is also rich in context and content. Moreover, the video format invokes an emotional and contextual identification akin to a déjà vu response to the captured personal experience

much more than other formats (e.g., text, abstract graphs, charts) of event logging would.

Surprisingly, people reacted positively to the video used in Cook's Collage. The video was able to capture the necessary details of cooking to be effective as a memory aid without alarming cooks of privacy concerns of having cameras in the house. Our success using video reinforces similar findings [2,3] in the work place that video diaries increased the number of activities that were recalled relative to using only written diaries. We promote the use of video across déjà vu displays.

7.6 Units

To quantify and segment recent activity, the displayed information is parceled into incremental units. Within video medium, these units range from still image snapshots, to animated sequences of compressed video, to the original video replay.

Cook's Collage defines image stills as a video unit representing one cooking action. The memory aid presents a visual summary of image stills rather than presenting an interface to navigate through video replays of cooking actions. Our experiences using the Cook's Collage qualitatively suggest that image stills are sufficient as visual cues for jogging working memory and that the time investment of navigating and replaying video footage is not needed. Our success using image stills reinforces similar findings [2] in the work place that viewing summaries of still images was preferable to viewing video and audio replays of daily self-performed activities. We define image stills as the base unit across déjà vu displays.

8. FUTURE WORK

Future studies currently underway are further examining whether people trust the accuracy of the memory aid, and whether trust increases over time as the user gains more experience using the system. This along with the question of whether a person's reliance on the memory aid, which would effectively cause them to offload the information in their memory onto the aid, increases as a function of trust.

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