MemTable: An Integrated System for Capture and Recall of Shared Histories in Group Workspaces

Seth Hunter[1], Pattie Maes[1], Stacey Scott[2], Henry Kaufman[3]

[1]Fluid Interfaces Group
MIT Media Lab
Cambridge, Massachusetts, USA
{hunters, pattie}@media.mit.edu

[2]University of Waterloo
Waterloo, ON
N2L 3G1, Canada
stacey.scott@uwaterloo.ca

[3]Tactable Inc.
20 Walker St.
Cambridge, Massachusetts, USA
henry@tactable.com

ABSTRACT
This paper presents the design, implementation, and evaluation of an interactive tabletop system that supports co-located meeting capture and asynchronous search and review of past meetings. The goal of the project is to evaluate the design of a conference table that augments the everyday work patterns of small collaborative groups by incorporating an integrated annotation system. We present a holistic design that values hardware ergonomics, supports heterogeneous input modalities, generates a memory of all user interactions, and provides access to historical data on and off the table. We present a user evaluation that assesses the usefulness of the input modalities and software features, and validates the effectiveness of the MemTable system as a tool for assisting memory recall.

Author Keywords
meeting support, history, memory, capture and recall, surface computing, memtable, ergonomics.

ACM Classification Keywords
H5.3. Information interfaces and presentation (e.g., HCI): Group and Organization Interfaces – Computer-supported cooperative work.

General Terms
Design, Human Factors

INTRODUCTION
MemTable began with a simple proposition: What if the environment we work in was capable of having a memory? Vannevar Bush's design for the Memex or "memory extender" [2] in 1945 presented the notion of personal histories shared with others through a memory desk. As computational hardware has evolved, our computers and laptops have enabled us to save extensive personal histories, but have not supported the creation of a distributed group memory on large a multi-user surface.

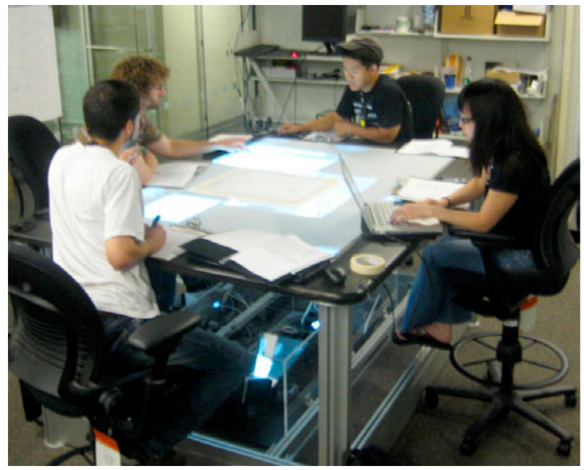

Figure 1. MemTable During a Meeting

Evaluative studies show that episodic recall decreases dramatically over time in small groups [1]. Cognitive scientists postulate that memories are triggered by means of retrieval cues and that the most effective cues are those stored in context with the experience being remembered [33].

The primary function of the MemTable is to encapsulate the content of small group discussions while they are happening, and organize this content for searching and browsing at subsequent times. The system supports co-located meeting capture with digital and physical tools: keyboards, image capture, paper-based note taking, audio recording, drawing on screen, and laptop screen sharing. It utilizes the potential of a large multi-touch surface to allow workgroups of 4 to 6 people to simultaneously capture, discuss, and recall information relevant to their discussions.

An extensive number of tabletop systems have been developed in research labs [4,14,13,26,30] that demonstrate the utility of bridging physical and digital boundaries for co-located collaborative work. These systems present novel interaction techniques, but do not extend the scope of their development to incorporate memory augmentation with the design principles and infrastructure required for extended use in small groups [31]. Our research suggests that an integrated meeting capture environment is a meaningful context for utilizing technologies that support simultaneous physical inputs.

In order to support historical capture and review MemTable contributes several novel elements: adaptable menus that link content to each individual, an extensive tagging system, on and off the table review applications, and unique archiving strategies for each input modality.

Overall we emphasize an integrated design approach to support extended use. We consider critical ergonomic elements of the hardware, user interface design for seamless archiving, and integrating the history with existing collaborative tools. We describe the hardware and software design and present an analysis of twenty-four user evaluations and conclude with observations for researchers developing collaborative applications with recall functionality.

BACKGROUND AND RELATED WORK

During the last forty years a variety of technologies have been developed to support the collaborative generation and archiving of digital information. MemTable builds on the history of tabletop design, meeting support systems, and memory augmentation and visualization software. We based our research on guidelines provided by these fields to develop a meeting support platform that is integrated with the work patterns of a small group.

Tabletop Systems

Pierre Wellners DigitalDesk [36], integrated paper based information from the environment seamlessly with a computer by using a camera system to capture and recognize information. Wellner presented a vision of an office where the surfaces adapt to existing paper based practices and augment their function.

Jun Rekimoto and Masanori Saitoh expanded the possibilities for interaction by introducing hyper-dragging in the Augmented Surfaces [26] project. Bill Buxton's research on bi-manual input at Xerox and Alias/Wavefront with projects like the Active Desk [3], introduced a rear projected surface where users can draw and use their hands to manipulate data in more natural ways.

Systems that have incorporated smart surfaces into collaborative offices and design studios for brainstorming, meetings, and presentations during the last ten years include the iRoom [10], IteracTable [30], Designer's OutPost [19], DiamondTouch [6] and other interactive brainstorming environments [15]. Commercial systems include Microsoft Surface [25], The Philips Entertainable [16], and the SMART Table [39].

The two closest systems in motivation to the MemTable are the Philips LiMe Table [24] and the MERL PHD [29] (Personal Digital Historian). The LiMe Table builds social awareness by augmenting hubs in a public café where people leave messages for each other on the surfaces. MemTable has enrolled users and builds a historical visualization specific to that group, incorporating the system into their digital work processes. The PHD is a tabletop system that allows users to explore tagged digital archives of media in order to provide material for storytelling. MemTable incorporates a similar notion of "who, what, when" approach to the retrieval of information, while also supporting the creation of the material in the archive.

Systems that support creative design that informed the MemTable are Shared Design Space [13] and Pictionarre [14]. We corresponded with the designers of these projects in order to build on their research. Shared Design Space emphasizes the importance of a large screen space, combining virtual and 2D drawings in the same space, and using the Anoto Pen as a precise input for drawing in tandem with a multi-touch screen. Pictionare incorporates a high-resolution camera, multiple keyboards, and allows users to build digital collections of creative design inputs. MemTable merges many of the modalities supported by both projects in a more ergonomic and integrated environment. It adds audio logging capability, an interactive timeline which tracks "who, what, when", and the ability to review data off the table via a Google Wave application.

Meeting Support Systems

The CaptureLab [22] system developed at the University of Toronto in 1988 had eight personal workstations, which could switch control of a larger vertical screen. Researchers reported that the scribe rotated frequently, especially when users were given feedback about participation. Mantai noted that it is necessary to build software to support human communication and group dynamics in meeting support systems.

The Session Capture and Replay System [23], and the Intelligent Collaborative Transparency System [21], focused primarily on developing workspace awareness by recording the histories of asynchronous activity in small workgroups. The Dynamo [17] cooperative sharing system supported the public exchange, display, and archiving of files during ad hoc meetings.

Group awareness systems [29,11], and behavioral feedback systems [7, 27] demonstrate effective methods of providing feedback to groups through visualizations of the historical data.

Memory Augmentation and Visualization

Endel Tulving, a scientist who devoted his career to the study of memory, introduced the distinction between "episodic memory" (stories) and semantic memory (vocabulary of things). His theory of "encoding specificity" postulates that memories are retrieved from long-term memory by means of retrieval cues. The theory states that the most effective cues are those that are stored along with the memory of the experience [32].

Evaluative studies show that episodic recall decreases dramatically over time in small groups [1]. Memory Augmentation software such as the Remembrance Agent [28], iRemember [34], and capture software like Evernote [9] have contributed techniques to assist with the retrieval problem that is the motivating factor behind the MemTable software.

Temporal visualizations such as History Flow [38], and PostHistory [35] demonstrate effective visual means of understanding and interacting with digital histories.

GENERAL SYSTEM DESIGN PRINCIPLES

Based on prior research, system guidelines for tabletop displays [31], and our observations from previous groupware development, we set the following design goals for the MemTable project:

1. Support heterogeneous types of input during group meetings for different contexts and user styles.

2. Protect the privacy of users by only recording explicit actions.

3. Design the interface to be efficient and consistent as possible, with a minimal number of steps to input and recall information from the system.

4. Support the coexistence of physical and digital content as much as possible.

5. Record the context of events: who, what, and when something is created and modified for subsequent recall.

6. Prioritize the ergonomic, spatial, and social aspects of the hardware design over technical features.

7. Integrate the content generated at the table with existing personalized software accessible offline.

Observations of Social Work Patterns

We began by documenting observations of how people use space in our work environment, which consists of 30 small workgroups with differing tools and styles (Figure 2).

Figure 2. Observations of work patterns

We noted that: (a) people use the larger tables as the primary places for meetings and discussion, (b) physical artifacts are almost always included in meetings and are often a primary means of communicating (c) people typically utilize the edges of tables more than the center (d) the use of personal laptops is ubiquitous throughout the workplace (e) the role of the scribe is usually not assigned. Personal note taking is expected of each individual involved in the meeting.

Physical Table Design

The need for a more comfortable table to work at on a daily basis, a larger more collaborative space for groups of 4-8 people, and open hardware that can be modified mandated that we build our own physical platform. Although we had access to platforms like Microsoft Surface, we found that the physical form factor did not accommodate multiple people and artifacts at the same time. (Figure 3)

Figure 3. Leg Ergonomics of a Microsoft Surface (left) and MemTable (right)

To address ergonomic concerns we consulted with experts at Steelcase Design in Michigan and obtained components from their design firm. Our final design added the following (Figure 4) improvements:

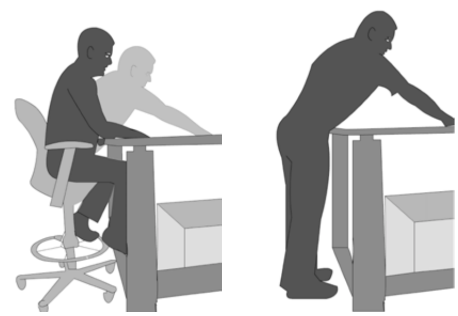

Figure 4. Sitting and standing ergonomics, note footrests

a) Adjustable chairs and table designed for each other, b) an eight inch footrest to support feet, c) centering the sensing and projecting equipment so users can put their legs underneath the table, d) an eight inch border around the table to support laptops and other objects, e) a height of forty inches which is optimal for reaching to the center of the table when sitting or standing.

General Specifications

A key difference between the MemTable layout (Figure 5, 6) and other surface computing systems is that all the components for sensing (the cameras, projectors, and mirrors) are housed in the middle of the table and calibrated to not conflict with the legs of the users. This was accomplished by installing a clear acrylic housing around the projection area, and adding a border around the surface to accommodate the projectors underneath.

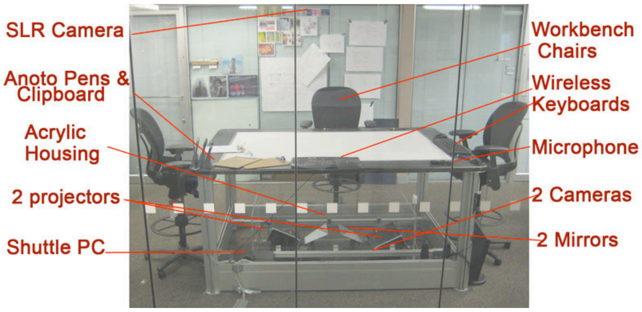

Figure 5. Diagram of key physical components

Placing the mirrors (Figure 6) in the center of the unit and inverting the display calibration the images from both projects results in a screen resolution of 1024 x 1536 which can be treated as a single display.

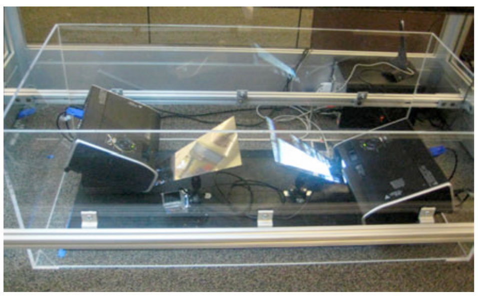

Figure 6. Cameras, Projector, and Mirrors in Acrylic Housing

A material called EndLighten [5] illuminates the multi-touch surface, with surface mount IR Leds in a clear rubber housing. We used aluminum channeling to reduce heat and focus the light (Figure 7). When used in combination with

Figure 7. Aluminum channel, EndLighten, and 1.5 inch frame

.04 mm Vellum, the surface is lit diffusely and can be used to track fingers, objects, pens, and fiducial markers. We found that this arrangement was robust and has natural ventilation. This eliminated the need for additional fans, and enhanced the auditory recording capabilities of the table.

The centered sensing and projection works well when combined with chairs, footrest, a workbench height, and an eight-inch border. Our intention is to demonstrate initial guidelines for an appropriate table that meets industry ergonomic standards. It is likely that in the next five years these displays will not require projectors or cameras because the sensing will be embedded in a large LCD. On a scale from 1 to 7 from uncomfortable to comfortable users in our evaluation rated comfort at 6.1 with a STD of 1.2. From 1 to 7 between not enough screen space and adequate screen space users averaged 5.3 with an STD of 1.3.

Software Implementation

The diagram in Figure 8 illustrates the software modules that link the hardware inputs to the graphic front end.

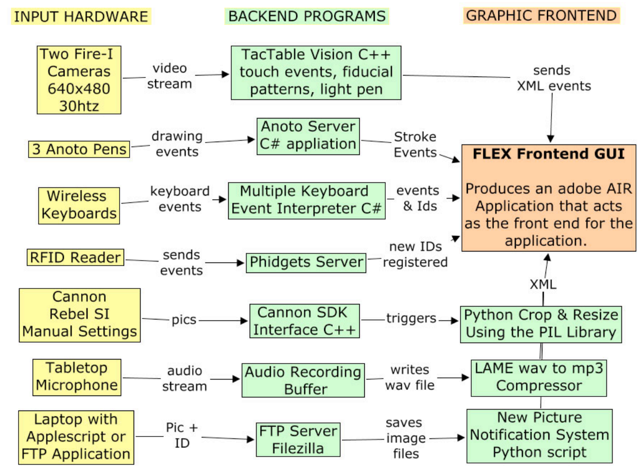

Figure 8. System architecture for the MemTable

The system runs on a quad core shuttle PC running Windows Vista located under the table. All communication is formatted in XML socket format similar to the TUIO protocol, with separate ports and identifiers for each hardware input. We developed a set of classes for each widget on the table with Flex 4 as and Adobe AIR desktop application in order to use vector graphics and animation for the interface. A detailed description of the software implementation is available online [17].

User Interface

The layout in Figure 9 shows a screenshot of the projection surface with the basic components of the user interface.

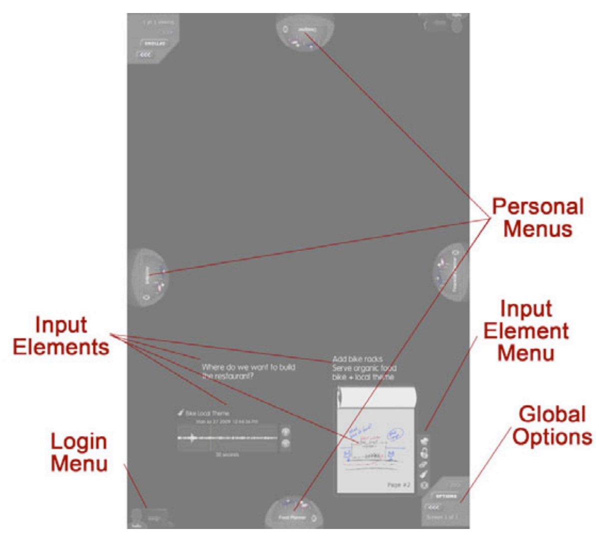

Figure 9. User Interface Elements

The interface consists of five major elements: a login menu, individual menus, input elements, a recall timeline, and global options. In a typical meeting scenario, users join a meeting by sliding a login menu on one end of the table. (Figure 10a). The users touch their profile in a lineup to get a personal menu. Personal Menus behave like textured air hockey pucks, sticking to the side of the table when thrown.

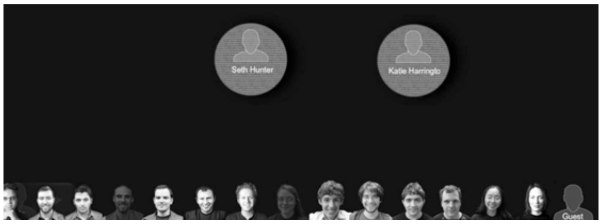

Figure 10a. Choosing a profile and personal menu pucks

Personal menus have two buttons, input information into the system (blue), or recall information from the table (red).

Figure 10b. Docking a menu and a personal input menu

When the input button is selected (Figure 10b) the user touches one of the input modality icons to activate the hardware which links that input to their identity.

Input Modalities

The input modalities supported by our system are intended to accommodate heterogeneous styles of collaboration. The system supports simultaneous drawing, audio annotation, text entry, image capture, and screen capture. All inputs generate an input element with pinning (stays in one place), locking (locks editing), and tagging (adds keywords) options. Items can be scaled, rotated, and thrown across the table to other users with bi-manual gestures supported in standard surface computing applications.

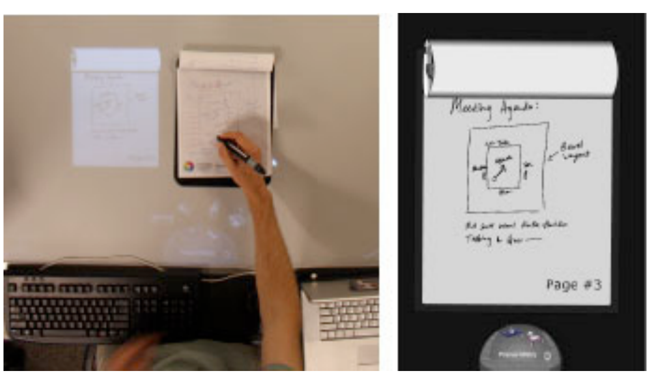

Figure 11. Anoto clipboards and digital counterpart

Drawing on Physical Paper

Three clipboards and three Anoto Pens are provided for users to draw and take notes during a meeting. The notepads are printed with a unique set of IR reflective dots that allows them to be synched in real-time with a digital counterpart (Figure 11). Each pad has three unique pages with color and brush selection at the bottom of the page. As users take notes they are recorded in the history of the system. The Anoto system refreshes at 70 hertz and records with an accuracy of 360 dpi. This outperformed all other drawing technologies we tested.

Text Input

Four wireless keyboards are placed around the exterior of the table. They are color-coded (red, yellow, blue, and green) and connect with separate ids to a USB hub. Users confirm the keyboard they are using by choosing their color from the text input button (Figure 12).

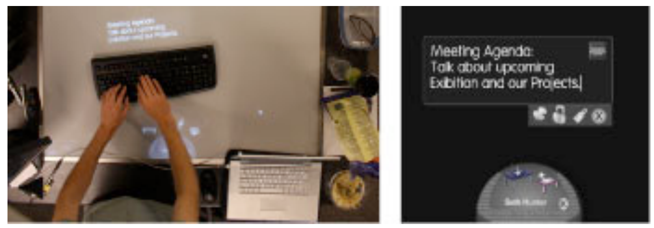

Figure 12. Example of text input

We observed that users preferred physical keyboards to multi-touch versions and typed mostly on the exterior border. Adding multiple color based keyboard support increased the overall input by group members.

Image Capture

We added two cameras to the MemTable, a high resolution SLR Camera on the ceiling above the table and a pocket sized Canon camera with an EyeFi wireless memory card on the exterior of the table for close up shots.

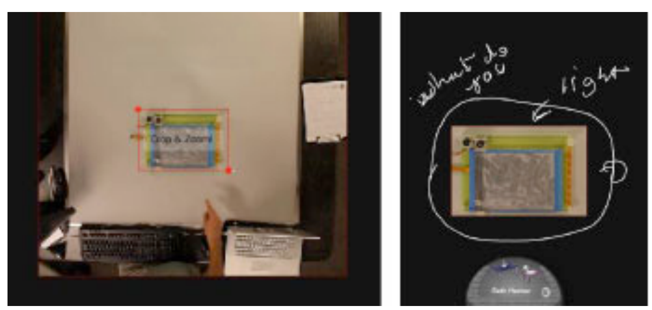

Figure 13. Image capture of a physical prototype

One benefit of the overhead camera was that objects on the table were consistently in focus and users could choose to include the projected screen or have it fade during the image capture. However, even at the highest resolution of the camera, written text sometimes remains blurry. The pocket size camera allowed users to take pictures of each other and take close ups of objects for documentation and scanning purposes. Basic cropping and annotation functions were provided in the image elements (Figure 13).

Saving Audio

An audio buffer of the previous sixty minutes is saved in memory. If a significant event occurs, users can choose a window of prior audio data to save. (Figure 14)

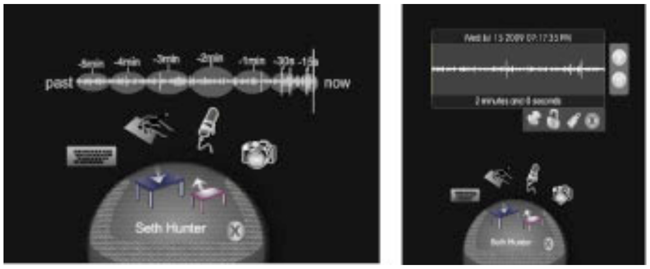

Figure 14. Audio saving and playback

During our evaluation we observed that audio features are more useful if embedded with other types of content like drawing, image capture, or text input. During meeting review visual input is enough to establish a context and audio is rarely reviewed unless it is needed for verification purposes.

Recall Timeline

The most immediate benefit of saving a history is recalling information from a previous meeting during a subsequent meeting. Research on memory recall [33] indicates that users rely on both temporal and semantic methods of association. The MemTable supports semantic searching and temporal browsing with a timeline.

Figure 15. Tagging an input for searching later

The search functionality is made possible by parsing text entries, and tagging (Figure 15). Tagging is an explicit user action and can be done during a session with a keyboard or after a session using the Google Wave review application.

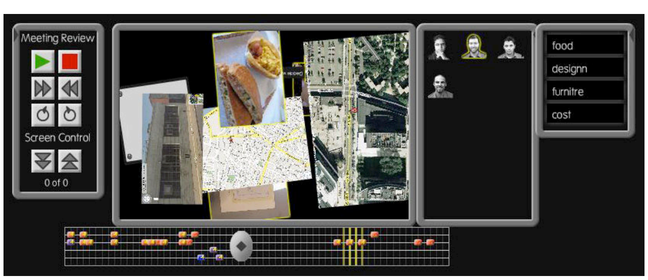

Figure 16. Session recall timeline with participants and tags

The recall timeline (Figure 16) provides a view of "who, what, when" of each meeting. Clicking on a user highlights content on the timeline and in the preview pane with a yellow outline. Tags from selected items are displayed on the right. Input types are coded by color on the timeline. If an item is selected it can be dragged out of the preview window onto the stage. At this point it becomes part of the current meeting session (Figure 17).

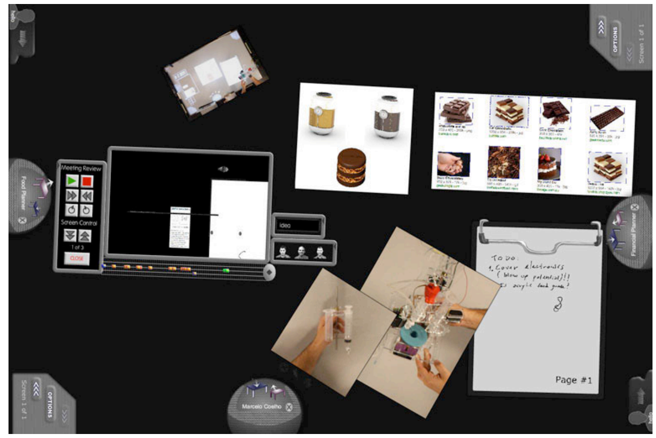

Figure 17. Recall timeline and content from a meeting

Changes in position, size and content of items are recorded in the database every 30 seconds. Recall elements are oriented to the position of the reviewer. Searching for items brings up a results panel on the right of the timeline. Selecting the item will change the position of the cursor in the timeline.

Asynchronous Collaborative Editing System

During development of the MemTable it became evident that users in our lab wanted a record of the meeting they could review and edit from their personal computing devices. We choose Google Wave (Figure 18) as our platform because of its development API, real-time collaborative editing support, and integration with Gmail.

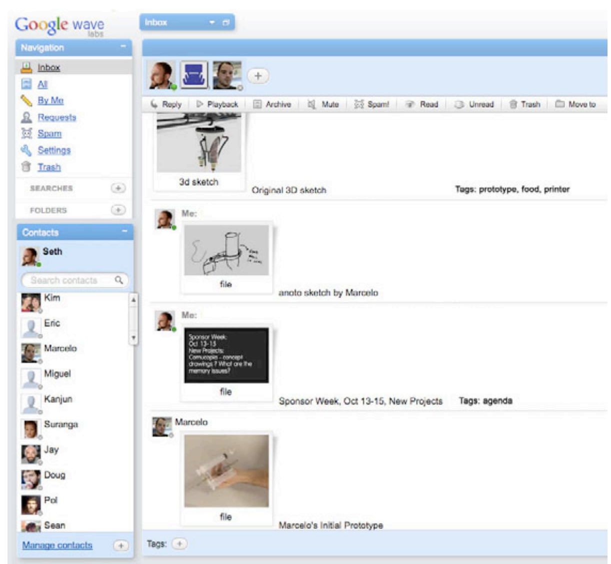

Figure 18. Google Wave screenshot of review application

Other similar internal collaboration platforms could also be synced with the system. Inputs are added to a chronological list at their start time. Audio and drawing clips are played using a flash gadget. Users can search the wave for tags, and add tags to previous meetings. If an entry is modified in the Wave application it is updated on the MemTable server. Detailed implementation details of the database design and tagging integration are available online [17].

USER EVALUATION

The user study consisted of 24 participants divided into 6 groups of 4. Participants were 11 females and 13 males between the age of 18 and 42 with an average age of 25.

Figure 19. User study group categories

There was a high variance of experience with touch tables; users rated their experience from 1 (no experience) to 7 (very experienced). The groups had a 4.2 mean with a 2.5 standard deviation.

The objectives of the study were to: a) gather feedback on the usefulness of the input modalities (text, audio, camera, screen sharing, and drawing), b) observe the use of user interface elements (menus, elements, tagging, global tools), c) assess differences between paper based meetings and digital meetings on social dynamics, participation, contribution, effective note taking, and memory recall, d) observe the if the role of the scribe rotates among group members in the digital scenario, e) test the effectiveness of the MemTable as a tool for assisting memory recall.

Groups were divided into three categories to reduce any bias introduced by the technology or the facilitators. Two groups used only paper-based tools to meet at the table, and the technology remained off during their study. Two of the groups were trained to use the table for twenty minutes, and introduced to all available tools. The final two groups were

input	usefulness	actual use	observations
audio	4.5 (1.3)	1.6 (1.4)	*not used frequently*
text	5.5 (1.4)	4.4 (2.3)	*used by select users*
laptop	6.7 (0.5)	6.1 (1.6)	*universally used*
camera	5.7 (1.2)	4.3 (1.6)	*used for physical props*
drawing	5.7 (1.8)	4.2 (2.7)	*some groups used extensively, some not at all*

also trained but were also given ten minutes of individual training on one input technique and asked to act as a scribe during the meeting. Participants were interviewed during the initial meeting and at subsequent intervals of one week, one month and three months. Eight of the participants completed an online survey to assess the usefulness of the Google Wave applications six months after their initial meeting at the table.

User Study Procedure and Scenario Description

All groups were presented with a version of the following general scenario:

Four people in a small design group are meeting over the course of the next 16 weeks to develop a plan to renovate a building in their community and turn it into a restaurant. The group consists of an architect, a chef, a designer, and a food planner. Each week they meet to make progress on their project and resolve issues such as floor plan layout, food choices, financial implications, and decor choices. At the end of the 16 week period, they plan to review and evaluate the merits of contents of their discussion and collaboratively agree on an investment plan.

Each individual chose a role (chef, architect, designer, or food planner) and was given a dossier with pertinent information specific to their role. We used a location in the community that would be familiar to all the participants to help catalyze the group discussion. We also gave groups a hypothetical budget of 400K to allocate, blue prints of the building layout, sample menus, and laptops with a connection to the Internet for searching and screen sharing.

Individuals were given an Active Badge [37], a device worn around the neck with an accelerometer, radio, and microphone designed to assess group dynamics such as who is talking when, how loud, and to whom they are talking. We observed that the groups liked the scenario and were animated during discussion. Data from video transcriptions of the meetings, user surveys, and active badges verifies this observation.

Study Analysis

We present the results of the study in order of the objectives. Four primary data sources were analyzed:

1) Video recordings and a transcription of key events.
2) Data from the MemTable history database.
3) User feedback and evaluations from surveys at the initial session, and subsequent meetings with surveys to determine if key events could be recalled by participants.
4) Data from the Active Badges regarding speaking levels and speaking times to assess participation.

Meeting Capture Features

Users were asked to report for what purpose they chose to use the table. The users answered as follows:

58% used it for capture purposes.
54% used it record significant events.

54% used it to record thoughts as others were speaking.
50% used it to arrange content.
50% used it to alter content for others.
47% used it to refer to a previous point.
38% used it to compare alternatives in discussion.
5% used it because they lost interest in the discussion.

Users were also asked to rate the usefulness and the amount they actually used the inputs during the meeting. Ratings are based on a scale of 1 to 7 from "not useful" to a 7 being "very useful".

General User Interface Analysis

The ease of use of the interface was rated as 6.28 (1.1). Many users reported that the interface reminded them of an mobile phone on a larger scale. Users rated the usefulness of interface features as follows: personal menus 6.09 (0.9), movement of elements 5.81 (1.2), pinning 4.9 (1.5), locking 4.81 (1.6), and tagging 5.21 (1.5). Pinning was considered less useful to groups that generated less content than to groups with more content on screen. Tagging was only used by 43% of the users and generally occurred only at the end of a session. Locking and pinning were differentiated in the text elements where feedback was given about active status but were occasionally misused in drawing and photo elements where no feedback of the editing status was indicated.

Group Dynamics: Observations and Analysis

Group performance, outcome satisfaction, individual contribution to discussion, and efficiency ratings were not significantly different between paper based groups and groups using the table. There was a general trend towards higher ratings of satisfaction with the group process in groups that used the table more frequently. In the two paper-based groups they tended to gather on one side of the table to arrange content. This limited the interaction of some of the participants.

Question	paper mean	table mean	general mean
Familiar with group	4.87 (1.5)	5.0 (1.7)	4.95 (1.6)
Difficultly: group task	4.12 (1.4)	4.59 (1.3)	4.43 (1.4)
Group performance	5 (1.0)	5.21 (1.2)	5.14 (1.2)
Satisfied with outcome	5.5 (1.0)	5.5 (1.1)	5.5(1.1)
Group efficiency	4.93 (1.0)	5.03 (1.3)	5 (1.2)
Satisfied with group process	4.75 (1.1)	5.31 (1.1)	5.12 (1.1)
Contribution to group decision	5 (0.9)	5.62 (1.0)	5.41 (1.0)
Your contribution to capture	3.75 (1.6)	4.31 (1.3)	4.12 (1.4)
How much: contribute to discussion	4.87 (1.1)	4.71 (1.3)	4.77 (1.1)
Awareness; changes in the table		5.56 (1.0)	5.56 (1.0)
Table disruptive during discussion		2.43 (1.5)	2.43 (1.5)

Memory Recall Results

The follow up studies consisted of asking participants to answer questions after meetings about key events. An assistant who was not present during the sessions consulted the videos and database before choosing the questions. The groups were asked seven questions about each session, the accuracy of their answers was rated by the assistant where 1 could not be remembered, 3 is remembered vaguely, 5 is remembered some details, and 7 is remembered accurately. The 16 users who used the MemTable features averaged 6.11 (0.34) and paper based groups 5.05 (0.47). This is not a substantial enough difference to make claims about accuracy, however the general trend of the groups who recalled with more accuracy was to do so with significantly more descriptive details about the content of the meetings. Groups using the table wrote an average of 27 words in their responses, and groups in the paper-based study wrote an average of 14.5 words.

User Feedback and Suggestions for Improvement

In general, participants enjoyed using the table and 85% said they would return to use it for subsequent meetings. Participants suggested the following: remove on screen keyboard and only support physical keyboards, share laptop screens on an additional vertical surface, include a timer to improve meeting efficiency, increase the screen resolution, and include a touch based internet browser on the table surface.

Asynchronous Editing Follow Up Study

Over time the frequency of use of the Google Wave application decreased. Only eight of the participants reporting using it for recall purposes after the second meeting. These participants also used the table for other purposes after the user study. Participants who used both systems reported reviewing more content with the Google Wave application than on the table and requested the ability to send items from it to the current session on the table. Factors such as Google's decreased support for the Wave platform and its frequent emails to participants about Wave updates were sited as reasons some users chose not to use the platform. Users rated the application as useful 5.8 (1.2) but 67% indicated that the platform needed to be used universally by all participants to be beneficial.

Summary of Study Results

General feedback from our participants, observations of capture during meetings, and comparisons of statistical data between group populations indicate a number of findings that may be relevant to other researchers:

1) Participants found the user interface legible and intuitive. Personal menus and capture elements were used frequently. Advanced features such as tagging, cropping, locking, and pinning were used selectively but rated as useful.

2) Users found the physical dimensions of the MemTable to be comfortable and ergonomic during meetings. Users indicated they had sufficient space to use the screen and collaborate with others.

3) Training of 20 minutes is sufficient for user studies, and encouraging users to utilize the system in their own way seems to increase group participation.

4) The perceived usefulness of capture modalities corresponded with their actual use except in the case of the audio feature. Features that connect laptops to the tabletop were rated as the most useful. Features that require more time to review were the least useful.

5) The frequency of use of input modalities was contextual to each group's individual skill-sets, and the context of their discussion. Modality choices were diversified among groups.

6) There was a general correspondence between frequency of use of the capture features and satisfaction with group process.

7) The role of the scribe rotated frequently between group members depending on who was speaking.

8) Groups using the MemTable recalled significantly more information about the discussion with moderately higher accuracy.

DISCUSSION

The arrangement of the personal menus on the MemTable resulted in an unexpected formality during the digital meetings. Users stayed near their personal menus and listened more to other group members. Note taking was visible to all users and this sometimes catalyzed the discussion.

The general trends that indicate the benefits of the MemTable to small groups were an increase in the amount of captured information, a greater distribution of the role of the scribe, and significantly more detail reported when recalling key events from meetings.

Our research is limited by the constraints of our scenario and the population enrolled in the MemTable. Testing the system in the context of workgroups with mission critical planning and recall needs, or communities with transient populations but clear missions (such as schools, churches, and community centers) would provide more concrete data about the factors required for long term integration and memory recall.

CONCLUSION

As hardware for sensing simultaneous inputs becomes more pervasive and displays approach higher resolutions we will see larger surfaces integrated into our environments that are capable of supporting collaborative work. The significance of these applications will depend on the human factors supported by the platform and how content is saved and integrated for future use.

The MemTable provides an initial evaluation of a system that emphasizes the social, ergonomic, and historical aspects of a meeting support system. We argue that for a platform to be adopted and broadly utilized it should incorporate appropriate ergonomic hardware, support heterogeneous physical and digital inputs, and integrate memory storage and recall.

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