Studying Group Decision Making in Affinity Diagramming

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ABSTRACT
Affinity diagramming is a commonly used contextual design practice for which many tools have been developed. However, experts and novices alike eschew tool use, instead using traditional paper and whiteboard methods. This paper presents observations of traditional affinity diagramming sessions, focusing on three areas of consideration—*shared awareness*, *cognitive offloading*, and *understanding, organizing and searching*—that are important for collaborative tools. Specific design requirements for each of these three areas are described.

Author Keywords
Affinity diagram, collaboration, shared awareness, cognitive offloading, large screen displays, CSCW.

ACM Classification Keywords
H.5.3 Group and Organization Interfaces: *Collaborative computing.*

INTRODUCTION

Most software engineering and usability engineering endeavors are inherently collaborative, requiring group work to analyze, create, and share work products. Many collaboration tools such as GUNGEN [18], CDTools [1], Designer's Outpost [16], Team Storm [11] and Liveboard [8], have been designed to support such collaborative work. In general, the success of these tools depends on their effectiveness in supporting the group decision-making process without imposing extraneous interaction overheads.

In most software engineering and usability engineering life cycles, designers elicit, analyze, and specify requirements. One popular technique, commonly used in contextual design [2, 13] as well as other business practices, that aids in this process is *affinity diagramming*. In this technique, groups of participants engage in a collaborative decision-making process to identify and consolidate needs and requirements gathered from user interviews or brainstorming sessions into a hierarchy of related categories. Using this technique it is possible to effectively analyze large amounts of data in order to highlight common themes across user populations prior to designing a new product [2]. Often, shortly after creating the affinity diagrams, they are removed due to a lack of dedicated wall space in most software development environments [2, 13]. Moreover, *little is said about the life span of an affinity diagram after it is created*, missing opportunities for reuse and making it hard to share with geographically distributed team members.

Other practical problems with this technique include: notes losing their stickiness and falling off the wall after moving a note around a few times, the cumbersomeness in moving groups of notes around the wall, and the tediousness in searching for a particular note among many. Curtis et al. [6] describe constructing an affinity diagram with 1,800 Post-it notes and printing copies of diagrams for each of the five distributed sites that used it. They point out the difficulty in sharing and maintaining such diagrams.

Although tool support for collaborative work processes such as affinity diagramming has increased, users seem to favor the use of traditional methods such as paper and whiteboard over software tools [20, 23]. This preference is usually more pronounced in early design work where creativity and flexibility is essential. Holtzblatt et al. [13] for instance, encourage participants to build affinity diagrams "on the wall, not in a tool" with a concern that tools would isolate participants, creating a barrier to the communication that is necessary for the grouping and categorization process. Replacing a large workspace—such as a wall for affinity diagramming—with a tool is also thought to restrict users to the confines of a pre-determined space such as a desktop instead of using any and all space available to them [15].

Research Focus and Approach

We argue that technology-based processes for creating an affinity diagram have costs and benefits that must be considered in development and use. For example, digitizing the diagram can eliminate, or at least minimize, the cost of printing hundreds of notes and multiple copies of the diagrams. Furthermore, a digital diagram affords easy sharing by removing the need for transporting copies of the

diagram among distributed design sites [15, 22]. More importantly, creating a diagram digitally provides an opportunity to reuse the information gathered in each session for later projects. Apart from solving some of the practical problems discussed here, a software tool can enhance the process by providing effective search mechanisms [22], ability to annotate notes [15], and capability to automatically record the progression of the affinity diagramming activity [17].

We approached this research using an iterative three-stage process of *observing, understanding* and *supporting* as described by Tang [21]. We describe four observational studies, focusing on three key issues important for a software tool to support the activity of collaborative affinity diagramming: *shared awareness, cognitive offloading,* and *understanding, organizing and searching*. We specifically discuss how these three areas are essential in the group decision-making process of affinity diagramming.

BACKGROUND AND RELATED WORK

The process of constructing an affinity diagram is typically performed using sticky notes and any large wall surface. The first step in this process includes writing or printing qualitative data snippets from user interviews and brainstorming on sticky notes. Each note has one idea or theme, and the team collaboratively places notes with similar ideas into clusters on the wall. Once all the notes are placed into clusters, the team creates category labels for each cluster (now referred to as a group) and defines the relationships among groups [13].

We discuss three existing tools for creating affinity diagrams (GUNGEN [18], CDTools [1], and Designer's Outpost [16] and follow by discussing other relevant groupware tools. This review of groupware tools is presented to illustrate some relevant aspects of group collaboration and is by no means comprehensive.

GUNGEN [18] is a collaborative tool that supports the K-J method (similar to affinity diagramming). Using this tool, participants (collocated or otherwise) use their own PCs to organize their notes. An addition to the original GUNGEN system is Gmemo [19], which is a component that runs on a PDA and can be used to collect and input ideas during the data collection stage. These ideas are later transformed into data notes.

CDTools [1] by InContext provides pre- and post- affinity diagramming support. The tool includes a database for recording raw customer data and transforming it into notes. Notes are then printed onto sticky notes and an affinity diagram is created on a wall without any help from the tool. After completion, the affinity diagram is re-entered into the tool by specifying the positions of each note and their labels.

The Designers' Outpost [16] provides a tangible interface for interacting with Post-it notes on a large screen display. Users can place Post-it notes on a large screen, draw links between notes, annotate, and delete notes if necessary. The tool supports a history capture and retrieval system with three mechanisms for accessing design history [17]. A later addition extended the system to support distributed collaboration and introduced a gesture and presence awareness mechanism [9].

Other groupware tools are presented here to lay the foundation of our work.

PReSS [4] is a distributed groupware tool that provides multiple participants a personal workspace to manipulate notes. It is not used specifically for affinity diagramming but for organizing usability problem descriptions and is called *results synthesis* [4]. The workspace contains an overview pane with shaded rectangles corresponding to each user's current view. A participant can view the actions of others while working within their own workspace.

TEAM STORM [11] enables designers to work on multiple sketches in parallel. Designers create sketches on their tablet PCs that can be shared with others using a large display.

Hilliges et al. [12] explore a similar domain of collaborative problem solving by proposing a table display with pen based input for individual problem solving and a large screen display for collaboration.

One of the earliest collaborative tools, Liveboard [8] is a stylus-based large interactive display that is used for computer- supported meetings. Many applications, called 'planks' are available for users to choose from, the most popular being Whiteboard. Whiteboard is a meeting support tool that emulates an actual whiteboard and allows users to write ideas, print, and save them.

KEY ISSUES

Shared Awareness

In a collaborative activity aimed at creating group consensus, it is important that all participants in the team have a shared awareness of the current state of the product of the activity at any given time. Cox and Greenberg [5] call this emergence. They define emergence as "…a characteristic of the process by which the team interprets and transforms … raw [data] fragments into rich final descriptions."

In the process of creating an affinity diagram, awareness of the notes being added to the wall, the emergence of new clusters, and the movement of notes between clusters provides this emergence or shared awareness to each participant. In the current process of using Post-it notes on a wall, it is not easy for a participant to track recent changes to the affinity diagram and the accompanying rationale for those changes. Also, it is hard to trace the activities of other participants, all of whom are simultaneously engaged in organizing their own notes. In sessions with three or more participants dealing with more than a hundred notes, losing awareness of the changes to the diagram is likely.

Cognitive Offloading

While performing a complex activity like affinity diagramming where participants are required to remember numerous evolving categories, cognition is not limited to the human mind alone. It is offloaded into the objects in the environment that play a role in the completion of a task [14]. In other words, an individual's mind is not the only unit of analysis; cognition takes place in a distributed, socio-technical system involving the users and the space around them.

In the process of creating an affinity diagram, participants need to use objects around them to ease their cognitive load. In sessions with a large number of notes, there is a need for participants to annotate notes and to add temporary labels to clusters. Annotating notes leads to the preservation of an idea that might be helpful later in the process. The creation of temporary labels or the addition of keywords to a cluster helps participants remember the evolving idea in a cluster.

Understanding, Organizing, and Searching

When given a stack of notes with which to build an affinity diagram, participants first spend some time understanding and organizing their notes. The way participants choose to organize their notes determines if they focus on a single note at a time or whether they will be able to look ahead and find notes further in the stack.

As the number of notes in an affinity diagram increases, it becomes more difficult for participants to locate notes on the wall or within their own stack of notes. Once a participant puts a note on the wall and moves on to other notes, he or she might not remember where the earlier note is. If another participant moves a note to a different cluster, it might be even harder for the participant to find it.

Sometimes when the participants perceive the need to reorganize existing categories to create a new category, they need to find all notes that have a particular keyword that are currently in other groups. Searching is tedious in the paper and wall method as participants have to manually scan all existing categories to identify notes that belong to the newer category being created.

OBSERVATIONAL STUDIES OF THE AFFINITY DIAGRAMMING PROCESS

We conducted four observational studies of participants creating affinity diagrams. The studies were performed in an isolated setting to allow us to observe the process without outside interference. The focus of these studies was to observe the collaborative work activity, dynamics of group decision-making, and to identify potential breakdowns during this process. We adapted the affinity diagramming process described by Holtzblatt et al. [13] in each of these sessions.

Participants

We used four teams and conducted four separate sessions in this study. The first session included three participants two male and one female. All three participants were graduate students in human-computer interaction (HCI) with no prior experience in creating affinity diagrams. The second session had seven participants, six male and one female. Three of the participants were graduate students and four were undergraduate students, all in the Department of Art and Art History. Two of the male students in this team had prior experience building affinity diagrams. The third session contained four participants, all male. Three of these participants were graduate students in the Department of Computer Science and one was a graduate student in the Department of Industrial and Systems Engineering. None of the participants in this team had prior experience with building affinity diagrams. The fourth session had two participants, both male. One participant was a postdoctoral associate in HCI and the second was a Professor Emeritus in HCI. All participants were volunteers.

Material

Initially we planned to use the same materials for each team: yellow 3" x 3" sticky notes and a large empty wall for posting the notes. In the first study, there was a large whiteboard at one end of the wall, and to our surprise, the participants chose to stick their notes on the whiteboard instead of the wall. However during the study, the notes kept falling off the board. In the second study, we used a room without a whiteboard, and once again, the notes kept falling off the wall causing frustration among participants. Therefore in the third study, we used a room that had a long conference table. The table was lined with white butcher paper for the participants to stick their notes. Also, we wanted to observe if using a table instead of a wall changed the process in any way (it did not). In the remainder of this paper we refer to this table as a wall. In the fourth study, we reverted back to using a wall and lined it with butcher paper as it provided better reach for participants to the notes. However instead of using sticky notes, we print notes onto pieces of yellow 3" x 3" paper and added a strip of painter's tape to each note to prevent them from falling off. Each team also had a stack of empty notes and some dry erase marker pens. This enabled them to create a duplicate of a note or to edit a note that is not clear.

Method

All sessions were held in conference rooms with long tables in the center, a few chairs, and empty wall space on at least one of the walls. Participants were first given a brief overview of the study in the form of a handout explaining the process of creating an affinity diagram and the first author then walked them through each step in the process.

Next the participants were introduced to a general topic that most people are familiar with. In Session 1 and 4 the topic was creating a shopping list for groceries and household items, Session 2 was about creating a remote control for

senior citizens, and in Session 3 it was about using a calendar management system. Participants were given background information for each topic and were told they can ask for clarifications at any point.

Sessions 1, 2, and 3 each took about 45 minutes to write their ideas on notes, one idea per note. Participants in Session 4 were given pre-typed notes printed on yellow papers (more about this below). After creating the notes each team spent about an hour and a half building an affinity diagram. The number of notes created by each team is shown in Table 1.

Photographs of the progression of the affinity diagram were taken during each session. At the end of each session participants were asked about their experience and feedback on the activity.

RESULTS FROM THE OBSERVATIONAL STUDIES

Similarities in Approaches

In general each team took the same steps towards building an affinity diagram.

Participants in Sessions 1, 2 and 3 first thought about the topic and wrote their notes individually. The idea behind doing this was to have the source (person who wrote the note) present in the session to provide clarification (if necessary) about a note. Writing their own notes also led to more familiarity with the topic. For Session 4, the first author interviewed four graduate students about their shopping habits and transcribed the data from the interview. These transcripts were then printed onto 3" by 3" yellow papers, one idea per paper. During session 4, the first author was present in the room to provide necessary clarifications and context about notes. Notes for Session 4 had identification codes for the user the idea came from (e.g. U1: ___). This helped the source (first author) look at the original transcript of user interviews and locate the context of the note to provide clarifications when necessary.

For all four sessions, the notes were shuffled and divided equally among the participants. Participants then proceeded to read their notes aloud one at a time and stick notes on the wall while others who had similar notes read their note(s) aloud and placed them next to related notes. Early on in the process, placing individual notes on the wall was accompanied by discussion among participants to ensure that their classification was in consensus.

Once a few clusters of notes were formed, participants started placing notes into clusters more quickly and with less discussion. Occasionally a participant would read a note aloud and ask others where they think it should go. After a brief discussion, the note was placed into a cluster. At times if the team could not decide between two clusters, they made a duplicate of the note and placed one in each cluster.

After all the notes were placed on the wall, all participants started with one cluster and silently read all the notes in there. At this point they usually found notes that did not belong in a particular cluster, in which case they moved them. If two or more ideas were emerging from a single cluster, the cluster was broken into smaller clusters. As they rearranged notes and created subgroups, participants came up with ideas for labels for each cluster by typically discussing among themselves. The labels were written on blue notes to distinguish them from yellow data notes.

Session	# of participants	# of notes
1	3	50
2	7	279
3	4	228
4	2	78

Table 1: Number of participants per session and quantity of notes generated

Next, participants worked together on arranging clusters of notes with blue labels under a higher-level category label. The idea here was to organize clusters of notes with a similar theme under a common label. At this point, clusters were moved around the wall to be placed adjacent to another cluster. Participants struggled to move clusters of notes as they had to first clear a space adjacent to the targeted cluster, which meant peeling off each note in that area and moving it elsewhere. Then they moved each note in the present cluster to the cleared space. During this process, notes often fell off the wall and some notes that did not belong to a certain cluster were mistakenly peeled off and moved, while some notes were left behind. Finally the team got together and decided on an overall theme or label that described the entire diagram.

Differences in Approaches

Although participants in all sessions followed the same process, we noticed differences in strategies for creating an affinity diagram. We discuss these differences in terms of their effect on the group decision-making and collaboration process.

Organization of individual notes

As mentioned previously, participants in each session were given a stack of notes. Participants in Sessions 1 and 4 held their individual stack in their hand most of the time, occasionally setting it down to move a note. They took one note at a time from their stack and moved it to the wall. By doing so, they were not able to look ahead and find notes in their stack that might inform a group decision about the creation of clusters in the earlier part of the session. As a result, for about the first 20 minutes, most of the clusters they created had only one or two notes as opposed to Sessions 2 and 3, where participants created fewer clusters with more notes. However there was more discussion among participants of Sessions 1 and 4 as they went through each note that was different than the ones already on the board.

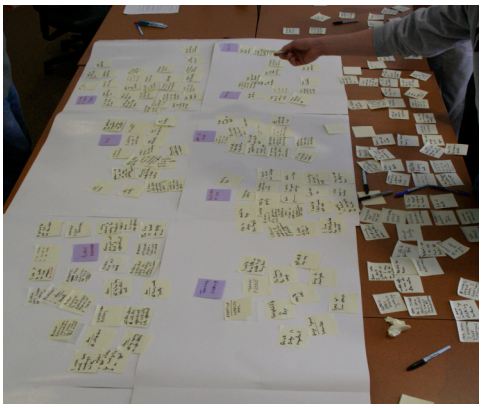

Figure 1: Participants in Session 3 with their notes laid out in front of them

Participants in Sessions 2 and 3 both chose to arrange out their notes to enable quick scanning of note content. Participants in Session 2 each took their stack of notes and put up each note on one area of a free wall. When a new cluster was created, each participant would go back to his or her "cache" and look for notes relevant to the new cluster. Participants in Session 3 had a similar strategy where they each arranged their notes on the table space in front of them and picked out notes for a cluster (Figure 1). This strategy resulted in less communication between participants because once a cluster theme was established they just sifted through their data sets individually looking for relevant notes for that cluster.

Placement of individual notes on the wall and the creation of clusters

The fact that participants from Sessions 1 and 4 spent most of the first half of the session discussing, created a greater shared awareness of the clusters being created. After each participant went through 70% of their notes and a significant number of clusters were created, participants started working on their own by reading their notes and placing them into clusters. Occasionally someone read their note aloud which got everyone's attention and asked "where should this go?" The group then decided together where that note must go.

On the other hand, in Sessions 2 and 3, a few notes were read aloud and some general categories were discussed. In the case of Session 2, after a few notes were read, one participant said, "…we definitely need a category for types of buttons on the remote…" At this point, everyone returned to their individual cache of notes on the wall and picked out relevant notes for the new cluster. This approach resulted in minimum discussion between participants. Discussion did arise when there was uncertainty over a note but in most instances one or two participants replied "let's forget about that for now" at which point the note were placed back in the participant's cache. Participants in Session 2 worked on one cluster at a time. When they were done with it, they read a few unsorted notes and decided on the theme for a new cluster at which point participants looked for relevant notes in their cache. Session 3 had slightly more discussion than Session 2. A few notes were read aloud and the need for clusters was discussed. For instance a participant read a note about using the alarm feature in a calendar management system. Another participant read a note about using search in a calendar management system. Almost immediately a group decision was made to have a cluster about alarms and one about search. Participants then started looking for relevant notes. If a participant had uncertainty about a note, everyone stopped to listen and discussed its placement.

Placement of a note in more than one cluster

With the exception of Session 2 where the participants chose to deal with tricky notes after they were done with the rest of the notes, all the other teams came up with ways to deal with them immediately.

In Session 1, if there was a note that could be placed in two clusters, they placed the note between clusters and drew a line using a colored dry erase marker between the note and the two clusters it could go into. When asked why they did this instead of making a duplicate of the note and placing one in each cluster, they replied they wanted to remember which clusters it could go into and to make the decision once the clusters were more defined. One participant also said that even if they decided to make a duplicate, they wanted to be able to trace where the other copy was, hence the line.

In three instances, a participant in Session 4 wanted to duplicate a note but then changed his mind and stuck the note between two relevant clusters. In these instances the clusters were adjacent. He then drew an arrow on the note indicating that the note belonged in one or both clusters (Figure 2). Both participants then moved on to other notes. After all other notes were placed into clusters, they revisited each cluster and rearranged notes, and at times created new clusters. When they got back to the three notes with arrows, they decided that two of them belonged in a newly created cluster and left the third note in its original cluster. When asked to explain their actions, one participant replied, "… these notes were between clusters but when we came up with better clusters, they got rearranged and fit into the new clusters."

Participants in Sessions 2 and 3 both made duplicates when a note contained more than one idea or if the note could be placed in two clusters.

With regard to the group decision-making process, when there was a note that contained two ideas or could be in two clusters, the participants stopped their activity and took a few minutes to discuss the note. If there was disagreement about putting the note in cluster X as opposed to cluster Y, they resolved the disagreement by creating a duplicate. Notes with two ideas were more easily resolved. Once the note was read and everyone agreed that it had two separate

ideas, the note was split into two notes, each reflecting an idea.

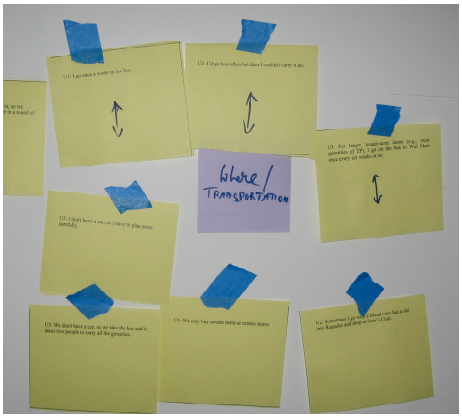

Figure 2: Participants in Session 4 added arrows to indicate a note potentially belonging to one of two clusters

Creation of temporary labels and annotation of notes

Holtzblatt et al. [13] recommend not writing summary labels or labeling the clusters until all the notes are up on the wall. However in our study, we found it was extremely difficult for participants to do so.

In Session 1, which had the least number of notes, participants had a hard time remembering where particular clusters were. For instance one participant said "… it goes in the recipe group, where is the recipe group?" and everyone started reading notes in all the clusters to find the cluster with recipe notes. They commented over and over during the session that it was tedious having to reread notes in a cluster to figure out the main idea of each cluster every time they had a new note to add. Halfway into the process of creating the affinity diagram, one participant took a dry erase marker and started writing simple keywords such as recipe and medium (used to create a shopping list) that represented the idea each group. The session flowed more smoothly after this as participants could easily find and identify clusters.

Participants in Sessions 2, 3 and 4 also decided to write temporary labels for each cluster as the number of clusters grew. These keyword labels helped teams come together at an early point in the session as they decided on temporary keywords. These labels also reduced confusion and helped the group decision-making process to flow smoothly as someone could just say, "…it goes into the X cluster".

Participants in Session 3 had an interesting addition to the keyword labels. They were working with data about an online calendar management system and 27 minutes after they started organizing notes, they had five clusters with keywords. Among the labels were 'Tasks', 'Alarm Reminder' and 'Communication'. The 'Tasks' cluster was by far the largest cluster and participants started noticing multiple ideas within the cluster. A participant started reading notes in the group and adding annotations to the notes. For example the note "Tracks what types of tasks I do" had the annotation 'Feature' added to it. When others noticed what the first participant was doing, they started adding annotations to notes that they were adding to the 'Tasks' group as well. When all the notes were on the wall, they decided to break the 'Tasks' cluster into smaller clusters and picked out notes with the annotations 'Features', 'Sync', etc. and organized them into new groups. Not only did the temporary keyword label inform the creation of the initial cluster, the annotations helped with the creation of sub-clusters. A participant in the team was heard saying "… could not have done it without the temporary topic labels."

It is also important to note that the keyword labels evolved as more notes were added to the cluster. For instance in Session 3, participants had a temporary label "How I use it" which then evolved into the label "Tasks".

Overall the creation of temporary labels and annotations did help with the group decision-making process. Temporary labels created context for group discussion and annotations that were added individually lead to discussion when clusters needed to be broken into sub-clusters.

Obtaining clarification about a note

Although the topic for each group was fairly general and familiar to the participants, there were many instances where a participant needed clarification about the content of a note. In Sessions 1, 2, and 3, participants just shouted out "Who wrote this note? …" and read the note aloud. The author would then clarify. For Team 4, the first author referred to the interview transcript (source of the notes) and clarified the content of the note in question.

It was very important to the group decision-making process to have a means of clarifying the content of a note. In the case of Sessions 1-3, the participant with the note and the author of the note often discussed the meaning and decided on its placement. Without a means to clarify the content of a note, participants run the risk of placing notes in a wrong cluster or losing the data in that note by discarding the note.

Searching for notes

Losing notes on the wall and in a participant's individual workspace has negative effects on the group decision-making process. In one instance a participant in Session 2 picked up a note from her stack and remembered putting up another note with the same theme on the board but could not seem to find it. She was heard saying, "Where did I stick my clock thing?" and spent a few minutes scanning all the notes on the wall. When she could not find the note she was looking for, she changed her strategy by looking at the clusters and finding the best match.

Similarly, a participant in Session 3 read a note aloud, put it on the table to talk to another participant and was not able to find the note again. In his case, he had all his notes

scattered on the table and even though the missing note was somewhere there, he got frustrated when he couldn't find it.

In another instance, a participant in Session 4 decided that a note had two ideas. He took a blank note, wrote the second idea on it and put the original note on the wall. When he came back to the note he had just written, he could not remember the context of the actual note and tried looking for the one he just put on the wall but could not find it.

Although each team had a variable number of notes, there were multiple instances of participants losing notes. Sometimes the notes were already placed on the wall while the participant tried locating the note in their workspace on the table.

Moving a note

Notes were moved from one cluster to another in two situations. The first situation was when a participant added a note to a cluster and noticed that an adjacent note did not have the same idea. In that case he/she either read the note aloud and asked the team where it should go, or just moved the note without consulting the group.

The second situation, which accounted for most movement of notes, was after all the notes were on the wall. Teams often stood back and read all the notes in a particular cluster with the intention of coming up with a label or breaking the cluster into sub-clusters. If a note was misplaced, a decision was made as a group, and was moved to a new cluster.

We noticed an interesting distinction between clusters created in the first iteration (all notes were placed on the wall) and in the second iteration when the clusters were reorganized into groups with labels. Figure 3 shows Session 4's affinity diagram half way into the second iteration. On the left, the clusters have labels (now called groups) and are organized in an orderly manner while on the right; notes in clusters are organized haphazardly. Clusters on the right have not been reexamined and reorganized.

Figure 3: Session 4's affinity diagram half way through the second iteration

Creating a group label and repositioning a group of notes

As described in the previous section, after all notes were put on the wall, teams often re-examined each cluster with the intention of creating a label, dividing the clusters into sub-clusters, or moving misplaced notes.

Group labels for these clusters often emerged in many ways. For most of the teams, the group labels were a variation of the temporary keyword label that they previously created as placeholders. This was especially true in Session 3 that had temporary labels and annotations for certain notes. In other cases, participants suggested a label and others questioned it, added to it, or in some cases suggested entirely new labels. It appeared that teams attempted to reach a consensus at this point by making sure everyone agreed with the changes.

In cases where a cluster was too big and had to be broken into smaller sub-clusters, participants first had to find empty space and move all the notes to a new position on the wall while dealing with notes falling off the wall, being misplaced, or lost between clusters. Participants in Sessions 2, 3 and 4 had a good strategy where they stuck one note on top of another and created a long list of notes stuck together (Figure 4 making it easy to move entire stack together. Participants in Sessions 1 and 4 commented frequently about how tedious it was to move around.

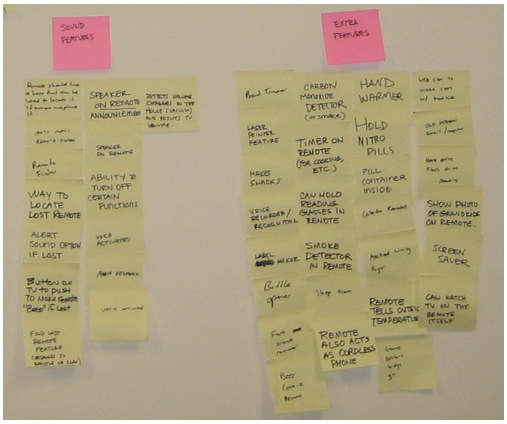

Figure 4: Participants in Session 3 attached notes into strips

Creating hierarchies

After initial labels were added to each cluster to create groups, multiple groups were arranged under a more general category label. In order to arrange multiple groups under a category label, participants first had to identify groups with a similar theme and then add a label that ties them all together.

Participants in Sessions 2 and 3 moved a lot of notes during this step in order to get similar groups close to each other. They commented it was difficult to determine which groups belonged under a single category label.

Participants in Session 1 found a way to work around this problem by drawing lines from labels to groups that belonged under a label (Figure 5). By drawing such lines on the whiteboard, they did not have to move groups of notes around and as commented by a participant "… I can just trace the line and know which groups are under a label."

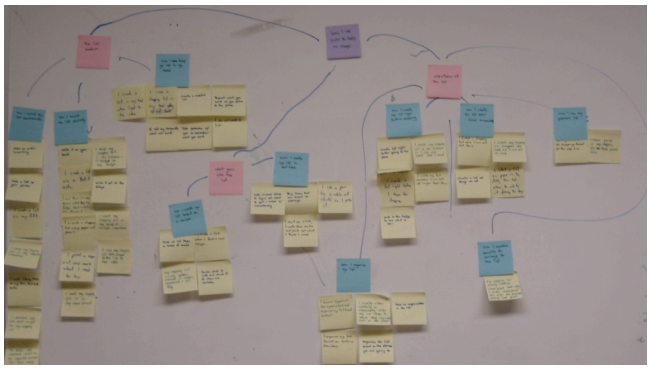

Figure 5: Participants in Session 1 drew lines on the whiteboard to connect labels and respective groups

In Session 4, both participants initially expressed concern over the labels. They wanted a way to convey the relationship between a label and groups that belonged to it. One participant suggested drawing lines on the butcher paper but the other commented that it would not be practical if they had to move groups around. They pondered about using strips of ribbon to connect groups but were not provided with any ribbon. The first participant then suggested cutting up strips of colored paper and taping it to the wall (Figure 6). The strips of paper worked very well to display the relationship between groups and to convey the hierarchy of notes and labels.

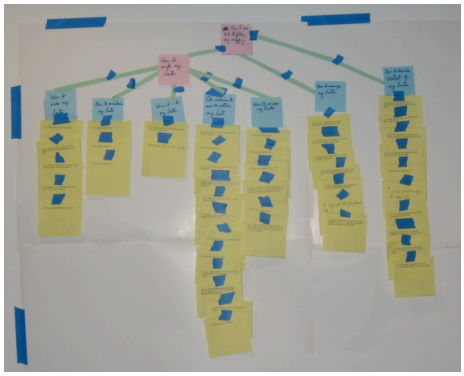

Figure 6: Participants in Session 4 added strips of paper to convey relationships

DISCUSSION AND DESIGN IMPLICATIONS

In this section, we discuss the three key issues introduced earlier in terms of observations from our study.

Shared awareness

In all groups, we observed a need for close physical proximity to the wall. Most participants faced the wall for about 95% of the time while the other 5% was spent reading or organizing their individual notes. The notes on the wall drove conversations about creating clusters, placing notes, reorganizing clusters etc. Even though most participants did not stand in front of the wall at all times, they would pull up a chair or sit on the table facing the wall. The importance of having a large shared workspace such as a wall is essential as the essence of the affinity diagramming process lies in discussion about the notes and clusters.

Our study also showed that participants had multiple foci of attention. Participants at times lost awareness of the activity on the wall while working on their individual notes. This would result in their not knowing about new clusters that were created, notes that were moved, or other activities taking place on the wall. In our observations losing such awareness negatively affected the group decision-making process. Hence awareness of the workspace needs to be cultivated.

Design Implication

Although Holtzblatt et al. discourage using tools they acknowledge that we should "wait for the wall sized display [to be pervasive] so we can move things naturally, communicate simply, and not get stuck in manipulating a tool while we are trying to think."

Emerging technologies offer opportunities to overcome these limitations—particularly large, pixel-dense multi-input displays. With the recent advances in large display technology [3, 10] and our interest in the technology, we would like to explore the benefit of using a wall-sized display to replace the wall. Such a display provides similar affordances as a wall, namely high visual bandwidth, ability for a group of people to simultaneously interact and contemplate, support group decisions, and to provide shared awareness of the activity.

In bridging the gap between observing the process of affinity diagramming and creating a tool to support it, issues of scalability need to be examined. Designers' Outpost [16] uses a 72" diagonal touch-sensitive SMART Board as its shared display. In the three user studies conducted by the authors, participants were pleased with the display as it was similar to using a wall. However it is unclear what the size of the data notes were for each of these studies. Will a tool such a Designers' Outpost be able to handle the creation of an affinity diagram using more than a hundred notes? Our sessions used between 50-280 notes and were not sufficient in uncovering issues of scalability that might occur when a collaborative tool is used for managing a large number of notes. These issues need to be uncovered by conducting further studies where participants are asked to interact with larger number of notes.

A participant in Session 2 commented "… I have not read all the notes that I did not participate in [the decision making process]." To ensure shared awareness, a tool should highlight recent changes to the clusters such as addition of a note, creation of a cluster, creation of a new label etc. Participants should also be able to trace the evolution of a cluster and the movement of a note from its initial to current cluster. Designers' Outpost [17] provides a timeline to help users trace the history of the diagram.

However we believe that in addition to a history timeline, recent changes to the diagram need to stand out in the diagram.

Cognitive offloading

Participants engaged in cognitive offloading by creating temporary labels for clusters and annotating notes. Temporary labels helped participants remember the main theme of a cluster and were created as soon as a cluster had a few notes. The labels kept evolving throughout the process as the clusters became more defined and eventually ended up driving the creation of actual labels once all the notes were on the wall. At times notes were annotated to preserve an idea a participant had about the note and were later used to created new sub-clusters.

Design Implication

Although most literature on creating affinity diagrams do not suggest the need for temporary labels or keywords, based on our study participants needed them. Participants should be allowed to easily create a keyword label for a cluster or to add annotations to a note. Providing each participant with a different colored 'pen' will allow each participant to create annotations and labels freely while combining their ideas with those of others. These keyword labels and annotations can later be translated into cluster labels.

Capturing design rationale as they emerge will also be beneficial [16]. Design rationale, design ideas, and other issues that are thought about during the process should be recorded to enable it to be revisited after the creation of the diagram. Enabling users to write rationale and attach it to a note should be supported.

Understanding, Organizing, and Searching

Participants came up with many ways to understand and organize their individual notes. Among others, they put individual notes on a wall and referred to them as relevant clusters were created, organized them on the table or simply held their notes and worked one note at a time.

We also observed many instances where participants could not find particular notes or their duplicates. The most detrimental instance was when a participant remembered reading and adding a note to the wall, and then not finding that note when a related note was identified later. In most of these instances, the participant just gave up and stuck the note in a different cluster.

Design Implication

In our study participants adopted many unique ways of organizing their notes and moving notes from their personal stack to the wall. Hence it is important to provide a personal workspace for participants to organize and comprehend their notes. We suggest using a PDA or tablet PC [7] that will allow participants to read their notes, search for notes and move a note to the wall sized display with a minimal interaction.

Almost all participants mentioned they were overwhelmed by the number of notes given to them. In view of this problem, Holtzblatt et al. [13] suggest only giving stacks of 20 notes or so to each individual at a time because "smaller piles are less intimidating." We propose giving the users the option of organizing their notes in stacks of a certain size or viewing a list of all notes and working on them simultaneously.

In view of the multiple incidences of notes being 'misplaced' in an individuals' personal workspace or being 'lost' among the notes on wall, we feel it is important to provide search functionality. The search should allow a user to look for notes on the wall-sized display or within his/her own list of notes. Providing additional search options such as searching by author and keyword might also beneficial for users. We suggest using a method such as "brushing and linking" to perform search and display all relevant results.

Other Issues

Besides these three areas, issues of interaction, control, and clarification of notes also need to be addressed. In a process such as affinity diagramming, it is imperative that one should be able to easily move a note from an individual's stack to the wall and around the wall. In a collaborative tool, a user needs to be able to interact with the tool and with objects represented in the tool with minimal overhead to the process.

The issue of control and turn-taking within the process also needs to be examined more closely. Creating a collaborative tool that allows only one person to be in control at a time might negatively affect the process. Giving each user control of the shared space might be a solution but implications of doing so needs to be further studied. Studying the difference in groups with team members who know each other and who are strangers might also inform the design of control mechanisms.

Notes for affinity diagrams are created in many ways. In our sessions, the authors of notes were always in the room, which allowed questions and ambiguities to be easily cleared. However this is not always the case as in most companies, people who conduct interviews with users might not be building the affinity diagram. Even if interview transcripts are available to users, as the number of notes increases, it becomes impractical to look up the meaning and context of notes. Hence it might be beneficial to attach snippets of the original interview transcript to the notes. These snippets will be hidden and can be shown on demand.

CONCLUSION

In this paper, we have focused on three areas, namely shared awareness, cognitive offloading, and understanding, organizing, and searching, which we believe designers should consider when creating a collaborative tool for affinity diagramming.

Given the recent findings that large displays have the potential of becoming pervasive we are interested in researching the effectiveness of such displays. We believe large wall-sized display with appropriate direct manipulations interaction techniques, will provide a high visual bandwidth for sorting and organizing notes, enable participants to collaborate with increased shared awareness, and with enough support for cognitive offloading.

REFERENCE

1. InContext's Contextual Design Tools - cdTools, http://www.incontextdesign.com/cdtools/index.html (Last accessed 4/18/2008).
2. Beyer, H., and Holtzblatt, K. *Contextual Design*. Morgan Kaufmann Publishers, 1998.
3. Bordes, N., Pailthorpe, B. High Resolution Sclable Displays: Manufacturing and Use *Proc. Australasian symposium on Information Visualisation*, ACM International Conference Proceeding Series, (2004), 151-156.
4. Cox, D. Supporting Results Synthesis in Heuristic Evaluation, *Dept Computer Science*, University of Calgary, Calgary, AB Canada, (1998), pages.
5. Cox, D., and Greenberg, S., Supporting Collaborative Interpretation in Distributed Groupware. *Proc. CSCW'00*, (2000), ACM, 289-298.
6. Curtis, P., Heiserman, T., Jobusch, D., Notess, M., Webb, J. Customer-Focused Design Data in a Large, Multi-Site Organization *Proc. CHI '99*, ACM Press, (1999), 608-615.
7. Dourish, P., and Bellotti, V., Awareness and Coordination in Shared Workspaces. *Proc. CSCW 92*, (1992), ACM, 107-114.
8. Elrod, S., Bruce, R., Gold, R., Goldberg, D., Halasz, F., Janssen, W., Lee, D., McCall, K., Pedersen, E., Pier, K., Tang, J., and Welch, B., Liveboard: a large interactive display supporting group meetings, presentations, and remote collaboration. *Proc. CHI 92*, (1992), ACM, 599-607.
9. Everitt, K.M., Klemmer, S. R., Lee, R., and Landay, J. A., Two worlds apart: bridging the gap between physical and virtual media for distributed design collaboration. *Proc. CHI '03*, (2003), ACM, 553-560.
10. Funkhouser, T., Li, K. Large Format Displays *IEEE Computer Graphics and Applications*, (2000), 20-21.
11. Hailpern, J., Hinterbichler, E., Leppert, C., Cook, D., Bailey, B.P. TEAM STORM: Demonstrating an Interaction Model for Working with Multiple Ideas During Creative Group Work *Proc. C&C '07*, ACM Press, (2007), 193-202.
12. Hilliges, O., Terrenghi, L., Boring, S., Kim, D., Ritcher, H., Butz, A. Designing for Collaborative Creative Problem Solving *Proc. C&C '07*, ACM Press, (2007), 137-146.
13. Holtzblatt, K., Wendell, J.B., and Wood S. *Rapid Contextual Design*. Morgan Kaufmann Publishers, 2005.
14. Hutchins, E. How a cockpit remembers its speeds. *Cognitive Science: A Multidiscplinary Journal*, (1995).
15. Klemmer, S., Farrell, R., Newman, M., Meza, R., and Landay, J. A Tangible Evolution: System Architecture and Participatory Design. *Technical Report. UMI Order Number: CSD-00-1116.*, University of California at Berkeley, (2002).
16. Klemmer, S.R., Newman, M.W., Farrell, R., Bilezikjian, M., Landay, J.A. The Designers' Outpost: A Tangible Interface for Collaborative Web Site Design *Proc. UIST 2001*, ACM Press, (2001), 1-10.
17. Klemmer, S.R., Thomsen, M., Phelps-Goodman, E., Lee, R., and Landay, J. A., Where do web sites come from?: capturing and interacting with design history. *Proc. CHI '02*, (2002), ACM, 1-8.
18. Munemori, J., Nagasawa Y. GUNGEN: Groupware for a new idea generation support system *Information and Software Technology*, (1996), 213-220.
19. Munemori, J., Yoshino, T., and Yunokuchi, K., Development of an Idea Collecting System and the Application to GUNGEN. *Proc. Knowledge-Based Intelligent Engineering Systems and Allied Technologies*, (2000), IEEE, 237-240.
20. Newman, M.W.a.L., J. A., Sitemaps, storyboards, and specifications: a sketch of Web site design practice. *Proc. Designing interactive Systems: Processes, Practices, Methods, and Techniques: DIS '00*, (2000), ACM, 263-274.
21. Tang, J.C. Findings from observational studies of collaborative work. *Int. J. Man-Mach. Stud.*, *34* (2), (1991), 143-160.
22. Wellner, P. Interacting with paper on the DigitalDesk. *Commun. ACM 36*, (1993), 87-96.
23. Whittaker, S.a.S., H., Back to the future: pen and paper technology supports complex group coordination. *Proc. SIGCHI Conference on Human Factors in Computing Systems* (1995), ACM Press, 495-502.