

Roles of notes in co-located collaborative visualization

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Fig.1. Examples of note taking activities during our observational study. Note-takers are disconnected from the group activities.

Abstract—This paper focuses on the significant role that note taking plays in collaborative data analysis within the business domain. The discussion of note taking is based on preliminary observations from a user study in which co-located teams of business users worked on collaborative visualization tasks using large interactive surfaces. We propose an initial categorization of note taking activities and propose a list of research questions that need to be discussed and investigated in order to better understand note taking process in the context of collaborative visualization and analysis activities.

Index Terms—collaboration, computer supported cooperative work, Information visualization, note taking

1 INTRODUCTION

We discuss the importance of note taking activities during collaborative visualization on interactive surfaces. The need to support note taking arose from observations during a user study that we conducted to examine collaborative data analysis in the business domain.

Use of information visualization (InfoVis) tools to assist decision-making in the business domain is on the rise [8]. In order to better understand how software tools can support collaborative data analysis, we conducted an exploratory study to examine how people use visual representations of data collaboratively to solve a problem in the business domain and to observe behaviour and processes they use. We used an existing Business Intelligence (BI) application, “Polestar on Demand” proposed by SAP Business Objects. We believed that working with large displays and a specially made application for visualizing business data would help us to re-examine the process of collaborative visualization, as well as problems of current applications and their specific requirements to be customized for collaborative usage. One of the surprising results from this study was the observation that note taking is a critical process in

collaborative data analysis and is not well-supported by current tools.

This paper is not intended to fully document our study and its results. Instead, we highlight some observations regarding note taking, and use them to raise questions about how to best support individual and group note taking activities for collaborative visualization on interactive surfaces.

In the following sections we present a concise review of related work, provide a brief description of our study, report some observations from the study, and finally raise a series of research questions that we believe will need to be addressed by future work on note taking for collaborative visualization.

2 RELATED WORK

While substantial research has been devoted to computer supported cooperative work (CSCW) in general, collaborative visualization is still under explored due to its unique challenges. It is still not fully clear how people collaborate to solve data analysis tasks, or how information visualization techniques and interaction methods need to change to support collaborative work. Recently, some research has begun to address this question. Several studies have identified processes or activities that contribute to the overall group analysis process [4] [7] [9] [10] [11], by using software supporting collaborative work [9] [10] or by using paper-based tasks [4] [11]. Findings of previous studies, regardless of whether the tasks were paper-based or software-based, suggested almost similar lists of processes involved in the collaborative data analysis. It also has been identified that very flexible tools to support co-located collaboration are needed [4] [11] [13]. This includes flexibility to change ordering of activities, work styles (from closely coupled to independent), role assignments, and workspace organization. It has also been pointed out that horizontal and vertical surfaces are suitable for different types of collaborative work [12].

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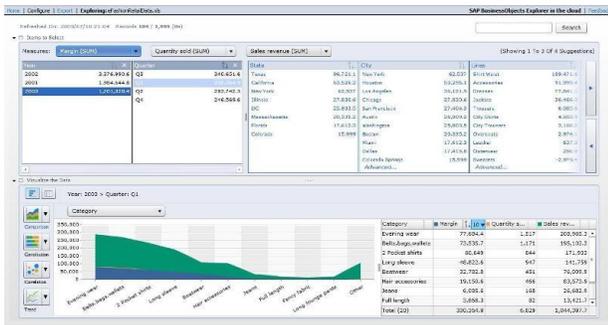


Fig. 2. Screen shot of Polestar, depicting a comparison chart that visualizes margin, quantity sold, and sales revenue over category, filtered based on a specific year and quarter.

To our knowledge, none of the work on collaborative visualization has explicitly focused on the need to support note taking activities. By contrast, this need became explicitly clear during our observational study.

3 OUR EXPLORATORY STUDY

Here we briefly describe our observational study, as background to help the reader interpret our observations and discussion.

3.1 Participants

Twenty-seven participants took part in our study, divided into nine groups of three. To increase collaboration effectiveness and to simulate common work situations, all the group members knew each other. Two of the groups were computer science graduate students and the other seven groups were 4th year BCom or MBA students.

3.2 Apparatus

Our apparatus were two identical Smart DVIT (digital vision touch) screens, one in a wall configuration and the other in a tabletop. Both had four HD projectors with 3840 x 2160 resolution (8.3 Mpixels), and had a size of 61.2" x 34.4" (70" diagonal).

We used "Polestar on Demand" (Fig. 2) as our data visualization and analysis tool. Polestar allows users to upload any data set and then interactively browse through the information. Polestar has been developed as a single user application. It has a straightforward interface and is considered to be reasonably user-friendly. It can be accessed from <https://create.ondemand.com/explorer>.

Four groups used a tabletop display, four used a wall display and one used both displays. This gave us an opportunity to observe and obtain users' feedback on a variety of display configurations.

3.3 Task and Procedure

Each study comprised of two tasks, both using an e-fashion dataset. Task 1 included 6 warm up questions, which were focused questions designed in a way that users could learn important features of Polestar. These included selecting variables, filtering, creating different types of charts and saving. An example question from task 1 was, "How does the 2003 margin compare to previous years?"

Task 2 was a business case. Participants were asked to assume the roles of three top managers (representing different states) and together determine a marketing budget for the next year. Rationale for the budget was based on information within the data set. This task was competitive in nature: participants had to compete to obtain the maximum possible budget for their state.

Styli, paper, and pens were provided to help participants work with the system or to take notes. Initially, we provided a 10-15 minute introduction to Polestar, describing its features. Participants spent approximately 30 minutes on task 1 and 40 minutes on task 2. We offered an optional 5 minute break between two tasks. After task 2, they spent around 10 minutes to sum up and write down their results. We asked our participants to create a report of their results at

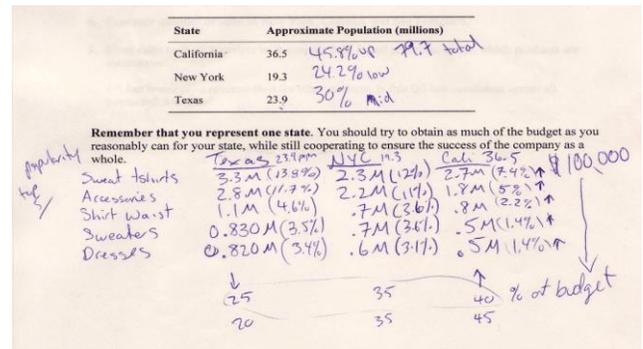


Fig. 3. Sample of notes taken for group use. Content is nicely structured and has a group scope.

the end of task 2. Our rationale was to have a record of how participants used charts to justify their decisions. Then we had an open-ended interview. All the sessions were audio and video recorded and all the screen logs were recorded for further analysis. During all sessions, one observer took notes about users' actions and problems they faced; she also helped them whenever they had a question regarding the tasks or the software.

4 ROLES OF NOTES

Findings presented in this section are based on analysis of our recorded data, notes taken by the observer, as well as all the notes and reports made by users. The huge amount of note taking that we observed suggests that note taking is a significant activity in business data analysis.

4.1 Contents, purposes and usages of notes

Perhaps the most interesting and notable finding from our study was the importance and frequency of note taking. Participants in our study took notes at almost every single step of their data analysis. This might be related to the special requirements of business data analysis, which is usually dependent on numbers, percentages, calculations et cetera. Notes taken by participants often consisted of the following:

- Numbers (e.g. data value)
- Drawings (e.g. flag, chart)
- Text (e.g. question, hypothesis, reminder)
- Symbols (e.g. %, \$)

Figures 3 and 4 are two samples of the notes taken by participants in our study. Figure 3 shows a note taken for group use. It has been nicely formatted and contains some calculated values. The person who took this note was assigned the role of note taking. He was sitting most of the time and observing others (who were exploring data and creating visualizations). He therefore was unable

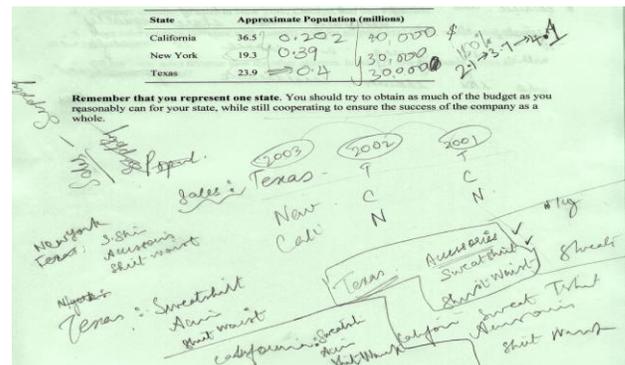


Fig. 4. Sample of a note taken for individual use. It is different in content and form compared to the group note in figure 3.

to work directly with the application a lot of the time. The group needed the content of the notes to help them further analyze data and solve the problem given in task 2. The small yet comprehensive tabular data that can be seen in figure 3 made the analysis task easier by saving important information; it was much more convenient and efficient to have this information recorded rather than revisiting previously created charts. The same person who was in charge of note taking also created the final report. Figure 4 depicts a sample of notes taken for individual use. It can be clearly seen that it has a less structured form compared to the sample shown in Figure 3.

In general, group notes were more carefully organized than individual notes, but this of course varied somewhat depending on the individual's note taking style. Individual notes were not always organized or written legibly or in a way that everybody at a glance could understand them. Again it depended on the individual who took these notes, and in rare cases, individual notes were nicely written, legible and structured. However, mostly individuals did not try to make it pretty or usable for the group. Sometimes they used some abbreviations or symbols that could be interpreted only by the note taker. Possibly they were writing as fast as possible to minimize distraction, since taking notes was not their primary focus.

In most sessions that we observed, one user assumed the role of note taker for the group. This role assignment was usually not discussed explicitly. It also did not necessarily remain fixed throughout the work session; sometimes the note taker changed part way through.

Generally, notes had different characteristics depending on their purpose and intended reader. Based on our preliminary analysis of the notes we suggest characterizing note taking and note use as shown in figure 5. Note creation shows that participants mainly took notes to save a value or artifact (e.g. a chart or the result of a calculation), to remind them to do something (e.g. review a chart) or to emphasize something important (e.g. what he/she or others find valuable). It also shows that both notes taken for group use and notes taken individually for private use can have the same purpose. The scope of notes is typically private when notes are taken for individual and public use when notes are taken for group use. However, in some cases, individual notes were shared with the group. Note use shows that notes' contents could be used for further analysis of data, creating a report, remembering an important artefact or value, or validating previous work. Validation here is mostly concerned with ensuring that a calculation result is acceptable.

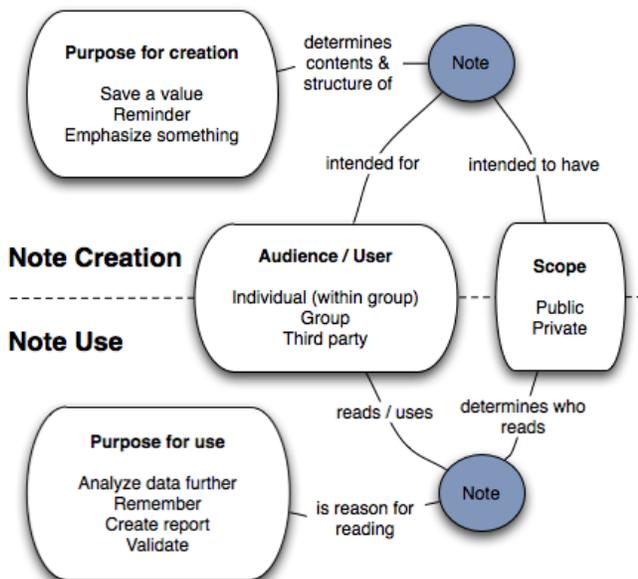


Fig. 5. Taxonomy of note creation and use.

We noticed that the manual note taking process impacted awareness. Participants lost a sense of what others were doing when taking notes, and consequently their awareness level was reduced. Each participant had to catch up with others after finishing taking notes. For example, Figure 1 illustrates how users who are taking notes on paper need to divert their attention from the group and the shared display. This drawback suggests that it may be good to integrate some types of notes with the visualization (as annotations). This feature could facilitate note taking in groups. It is obvious that not all the notes taken by users are appropriate to integrate with charts; we would still need to provide users with means of taking personal notes (e.g. a personal reminder) and notes that do not belong with any given chart (e.g. a “to do” item).

In some sessions where one person was in charge of note taking, others also took notes for themselves separately even though they had to stop working to take notes. This shows that participants needed to take notes individually and separately from the group. However, individual notes were not always solely used by the person who took them; sometimes they were shared by the group. This finding again emphasizes the necessity for software to support both individual as well as jointly coupled activities [5] [11] [14]. We also noticed that in task 1 (in which users were not saving charts), the amount of note taking was much higher than in task 2 (in which users were saving charts for comparison).

4.2 Note Taking in Competitive and Collaborative Situations

Our study suggests that nature of the task can affect both the process of collaboration and division of workspace. Task 1, which involved focused questions, required a highly-coupled collaborative style of work, while task 2, which required participants to compete for resources, led to a loosely-coupled collaborative work style. Here participants wanted to work individually to prepare the best possible arguments for increasing their state's resources. Hence, a competitive situation has a clear impact on user's collaboration style and process. Most of our participants said that they preferred to explore information for task 2 individually and later on share their results with other collaborators to have a discussion. Notes taken in task 1 had a public scope of use, while notes taken in task 2 had a combination of public and private scopes.

5 DISCUSSION

Our findings suggest the importance of note taking for collaborative business data visualization and analysis. These findings raise further questions and issues such as:

How can we best support note taking activities during collaborative work? One probable answer to this question could be integrating note taking mechanisms into the software, which in turn raises issues such as how closely integrated note taking should be with the visualization tool, and whether it should be integrated with a history mechanism or should be a separate component. Some researchers [1] [2] [3] [6] have mentioned use of annotation (textual and graphical) to add information into visualization. But it is still not quite clear what the best strategy is to save information in a collocated collaborative visualization and analysis of business data where intensity of note taking is quite high.

How can we support both individual and group notes? Can this be accomplished by dividing work space into public and private areas?

Does the process of note taking change by changing the underlying data? For instance, working with business data might require larger amounts of note taking compared to working with scientific data. This is currently unclear.

How complete is our list of note contents and purposes of use? Will participants in a different domain or different situation need to save different information as notes, and will they have different purposes in creating and using notes?

6 CONCLUSION AND FUTURE WORK

In this paper, we identified note taking as a process that is intensively used by data analysts. More studies are required to answer questions about how exactly note taking support should be provided in collaborative visualization systems. In addition, we would like to conduct a field study to examine note taking activities in the context of real work. We would also like to explore the design of note taking support for collaborative work on interactive surfaces.

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