AN EXAMINATION OF TWO TYPES OF TIMELINE, LINEAR VS. STAGGERED: A MIXED METHOD APPROACH

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Abstract: This study conducted as follow-up study to evaluate effects of two different time-based interfaces, linear and staggered. This study also tries to reveal users' preferences when they look for information in two different computer-based timeline. Explanatory mixed method design was implemented. In the first part, quantitative, there were 42 subjects. Results shows no significant difference between two types of computer-based time-line in terms of task completion time and answer accuracy. In the qualitative part, there were 6 participants. From this part, it can be concluded that linear arrangement is better when number of the items is low and staggered arrangement is better when scrolling is rare in vertically. However, staggered arrangement is preferred by almost all participants since they want to see whole picture of the system.

Keywords: Staggered timeline; linear timeline; usability, computer-based materials

INTRODUCTION

With the advent of computer, accomplishments of numerous tasks become easier. However, it brings along with a number of problems waiting to be solved such as user interface problems. In this point, it is important to have more information about human behaviors in order to fulfill the information search requirements of individuals in an efficient and effective way. With the increase in computer speed and display resolution, role of the information visualization and graphical interfaces becomes important (Shneiderman, 1999) since a graphic timeline or interactive computer graphics techniques can reduce burden of the human working memory. Complex structure of interface design can lead to overload of the working memory. As pointed out by Sweller & Chandler (1994) if new material contains a large amount of information, it will be harder to learn material than material containing less information. This can be explained by a limited working memory because it may cause difficulty in assimilating multiple elements of information simultaneously (Sweller & Chandler, 1994). Therefore, designers try to prepare learning materials which entail low cognitive load. These problems may be solved by implementing results of empirical research studies and guidelines.

TIMELINES:

A timeline, either graphical or textual display of events in chronological order, is an important technique in which large temporal date sets are represented. Numerous things can be represented by timelines such as wars, technologies, automobiles etc. (Kumar, 1997). Designing appropriate visualization and navigation techniques to present and explore personal history records is especially important in medical and legal professions (Plaisant, Milash, Rose, Widoff & Shneiderman, 1996). Besides these fields, analysis of historical materials with a temporal-spatial perspective plays a critical role in the fields of quantitative economy, socio-economic history, and historical geography (Kuo, Hanashima & Tomobe, 2004). For

instance, visualization of spatial information can play a prominent role in understanding historical earthquake events (Dogru & Ozener, 2005).

Allen (1983) proposes thirteen ways where an ordered pair of events can be judging. All thirteen temporal relationships between events presented in Figure 1 (Hibino & Rundensteiner, 1997).

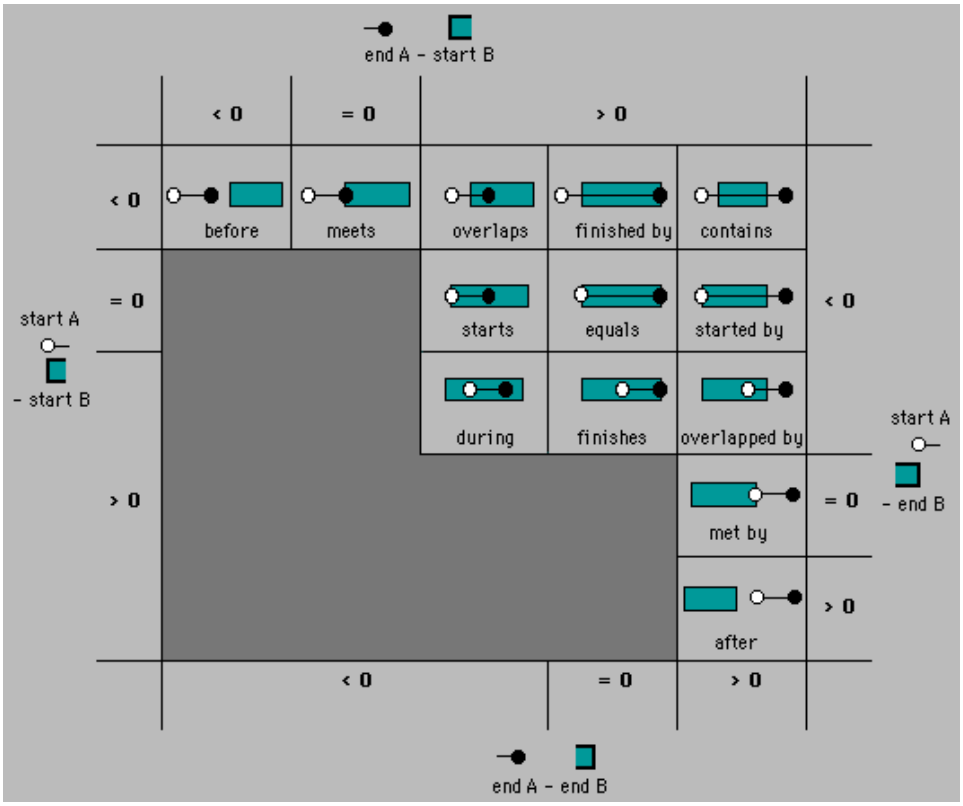

FIGURE 1 POTENTIAL TEMPORAL RELATIONSHIP (HIBINO & RUNDENSTEINER, 1997)

ARRANGEMENT OF TIMELINES: LINEAR AND STAGGERED

In linear arrangement, events are placed successively on higher level on the screen and they are placed further right in accordance with its beginning and ending time (see Figure 2). This type arrangement may provide a direct manipulation interface for the users. However, unlikely in linear arrangement, in staggered type timeline events are placed arbitrarily provided that there is available room for them (see Figure 3). This type of timeline provides users with a power to control large amount of temporal information. As mentioned in previous studies (Boling et. al. 1997, 1998), it is expected that required time for linear arrangement is likely to more than staggered one. On the other hand, users tend to be made more errors in staggered design due to the complex structure of it.

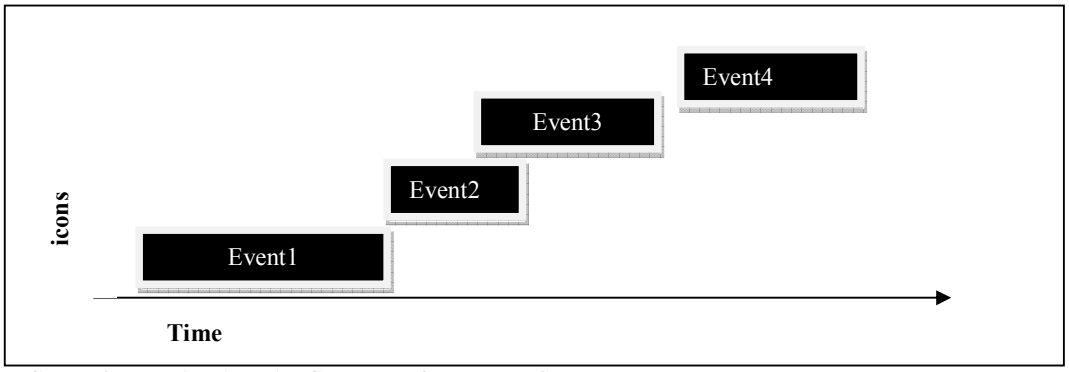

FIGURE 2 LINEAR ARRANGEMENT OF EVENTS

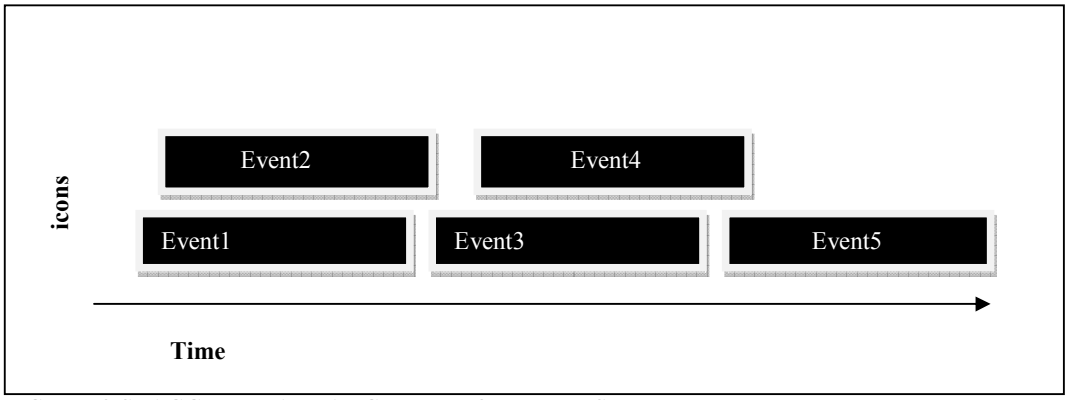

FIGURE 3 STAGGERED ARRANGEMENT OF EVENTS

PURPOSE OF THE STUDY:

In previous studies (Boling et. al. 1997; Cagiltay 2004), two timeline-based information design system, linear vs. staggered, was compared. This study also will compare these two time-based interfaces, linear vs. staggered. In this context, the purpose of this study is to examine the effects of two timeline design, linear and staggered, in terms of task completion time, accuracy of answers while judging temporal relationships between two events on timeline. In line with this aim, users' preferences when they look for information in computer-based timeline will also be examined.

RESEARCH QUESTIONS:

- ✓ Is there a significant difference between staggered and linear interface design in terms of task completion time.
- ✓ Is there a significant difference between staggered and linear interface design in terms of accuracy of answers.
- ✓ Do participants express preferences between timeline representations using a linear or staggered view of the data?

METHOD

GENERAL

This study conducted as follow-up study to evaluate effects of two different time-based interfaces, linear and staggered. This study also tries to reveal users' preferences when they look for information in two different computer-based timeline. However, current study different from previous ones (Boling et al. 1997; Cagiltay 2004) with respect to methodology to be employed, which is mixed-method. It uses strategies of inquiry that involve collecting data either simultaneously or sequentially (Creswell, 2003).

In this research, researcher first collected and analyzed the quantitative data. The qualitative data were collected and analyzed second in the sequence and help explain, or elaborate on, the quantitative results gained in the first step. The rational of implementing this design is to explain or understand the quantitative results (Creswell & Clark, 2006). Creswell and Clark (2006) named this design as explanatory design.

QUANTITATIVE PART:

A one factor within-subject design will be employed in this study. Independent variables were the use of linear and staggered time-based interface. Dependent variables were task completion time, accuracy of answers.

PARTICIPANT:

Twenty-seven undergraduate students and fifteen graduated students participate voluntarily to this study. There were twenty-three male and nineteen female. Undergraduate students were given bonus credit for their participation. Before study undergraduate students were informed in last meeting of a course and a list delivered in class to take contact information of students who want to participate the study. Researcher sent an email to all undergraduate students to arrange available time for the study. Graduate students were informed by individually invitation. Following table shows the demographic information.

TABLE 1. EDUCATION LEVEL OF PARTICIPANTS

	Frequency	Percent
Undergraduate	27	64,3
Graduated	15	35,7
Total	42	100,0

TABLE 2. GENDER DISRIBUTION

	Frequency	Percent
Male	23	54,8
Female	19	45,2
Total	42	100,0

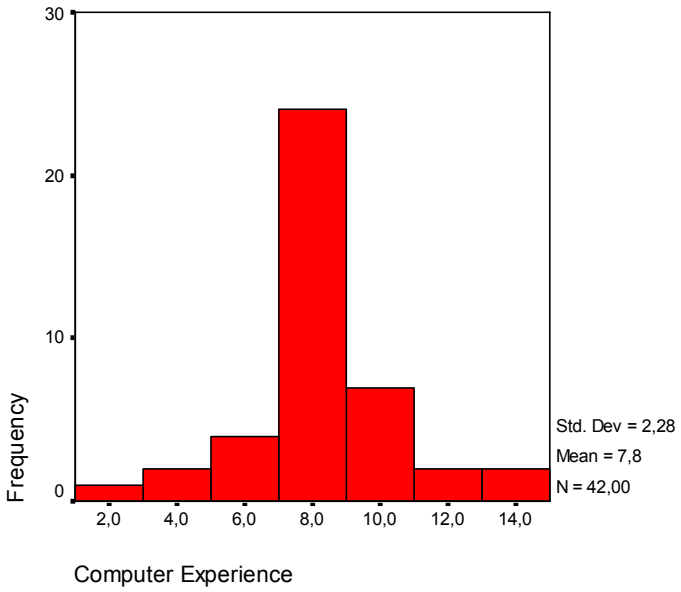

FIGURE 4. COMPUTER EXPERIENCES OF PARTICIPANTS

MATERIALS:

Test sections were conducted in a classroom between 09:00 am to 05:00 pm in 2006-2007 fall semester. Researcher arranged the classroom settings in order to prevent distracting factors in the environment. There was one computer in the classroom running Pentium (R) 4 3.00 GHz processor and Windows XP 2002 operation system with service pack 2. A color 17' monitor at 75 MHz refresh rate was used in this study.

The instrument was designed by the researcher in Adobe Flash Environment and fictional data set, as suggested by Cagiltay (2004), was be used to prevent prior knowledge effect of the participants. As in the previous studies, there were two types of timelines, which are linear and staggered. Material published by using Internet Information Services (version 5.1) and participants accessed the material via Internet Explorer (version 6.0) at 1024 X 768 resolution. Correct, wrong, empty answers, time for each question and total time were recorded with Microsoft Access Database 2003 software.

The material interface included several important features (Figure5, 6).

- A timeline icon display which could be scrolled through both vertically and horizontally.
- Questions to the participants
- Answers to the questions with three option ("Yes", "No", "I can't tell")
- A button to pass the next question

- Clicking on timeline area caused to black line from descends from the clicked point down to the timeline.

- Accompanying every icon was a red bar that stretched from the event's starting point to its ending point in related with timeline below it.

- Two different icons were used to determine female and male

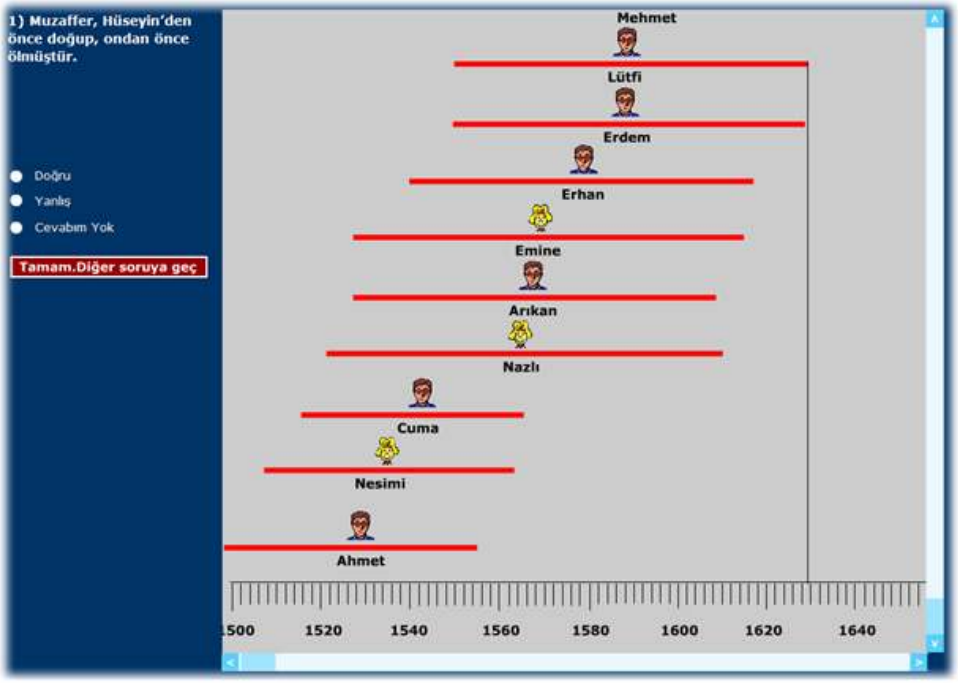

FIGURE 5 LINEAR ARRANGEMENT OF TIMELINE

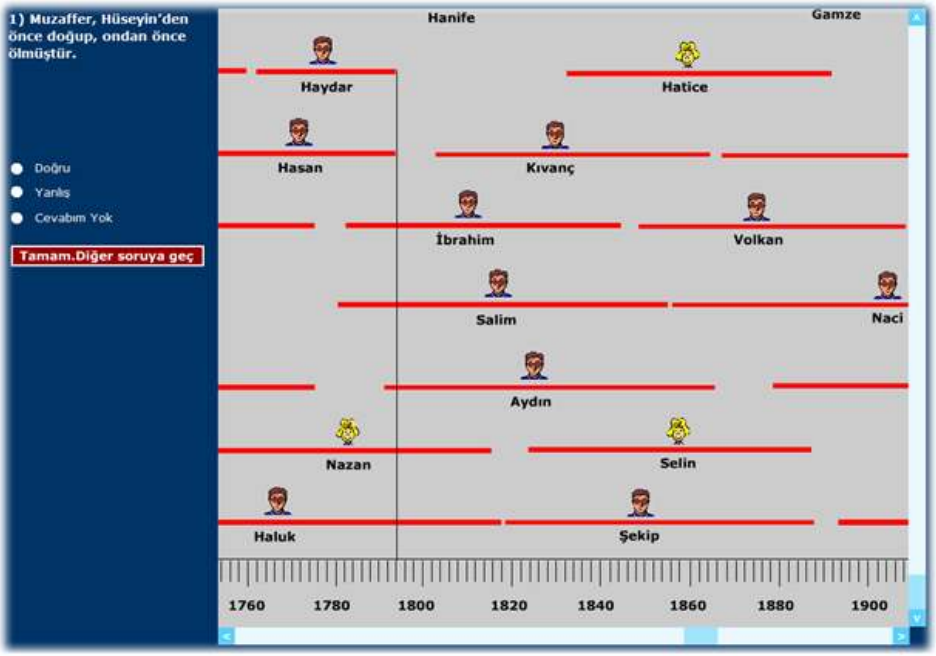

FIGURE 6. STAGGERD ARRANGEMENT OF TIMELINE

PROCEDURE:

Before starting actual testing, a pilot study was conducted with ten participants to eliminate material problems, to test the clarity of the questions and to check the environmental condition of the classroom. After conducting pilot section, actual study initiated. Participants were distributed randomly to each group. When participant arrived at the researcher's room, he took them the classroom in which study will be conducted. Next, participant sit down the computer and researcher gave brief information about the purpose of the study and average time to complete the study. After that participants were given a short demonstration of the basic functionality of the instrument and they answered two questions to better understand the material. If the participants did not have questions regarding the instrument, the actual session was initiated. Before questions appeared on screen, subjects were warned to answer the questions as quickly as possible and the researcher explained that these two interfaces were being tested not the user. Subjects answered thirteen yes/no questions related to the temporal relationship of two events on timeline. The same thirteen questions were asked in both conditions. The instrument recorded demographic information (department, gender, education level, computer experience), the length of time in seconds elapsed for the study, subjects answer for each question and the length of time in seconds elapsed for each question. All the data from the instrument were collected and stored automatically at the conclusion of each subject's session in a database located on a separate computer. Finally, during the study researcher get out the classroom so that subjects feel themselves comfortable while answering the questions.

RESULTS:

COMPLETION TIME:

Completion time data were analyzed using independent sample t-test, and revealed that there were not a statistically significant difference between the linear and staggered displays,

t(40)=-0,156 p>0.5 (see Table 3). When mean scores were analyzed (see Table 2), it can be seen that participants spend more time in staggered display (μ=391038,19) than linear display (μ=387834,67). Further analysis by question type did not reveal any significant differences between the two display modes as found in Boiling et al.'s (1998) study.

TABLE 3. COMPLETION TIME (DESCRIPTIVE STATISTICS)

	Timeline Type	N	Mean	Std. Deviation	Std. Error Mean
Total time	Linear	21	387834,67	61122,59	13338,04
	Staggered	21	391038,19	71647,06	15634,67
Before/After	Linear	21	70049,43	21029,47	4589,01
	Staggered	21	80789,38	29937,70	6532,94
Meets/Met by	Linear	21	78694,38	26251,27	5728,50
	Staggered	21	69596,33	23433,40	5113,59
Equals	Linear	21	35867,33	8719,27	1902,70
	Staggered	21	32735,52	11509,29	2511,53
Contains/During	Linear	21	42589,81	14723,45	3212,92
	Staggered	21	43000,52	18859,04	4115,38
Starts/Started by	Linear	21	64397,43	13488,02	2943,33
	Staggered	21	62224,29	16285,56	3553,80
Overlap/Overlapped by	Linear	21	53308,24	15923,23	3474,73
	Staggered	21	58080,38	19186,37	4186,81
Finishes/finished by	Linear	21	42928,047	14794,571	3228,4401
	Staggered	21	44611,76199	787,7059	2135,8525

TABLE 4 COMPLETION TIME (INDEPENDENT SAMPLES T –TEST)

	Df	Sig. (2-tailed)	Mean	Std. Error
Total Time	40	,877	-3203,52	20551,07
Before/After	40	,186	-10739,95	7983,63
Meets/Met by	40	,243	9098,05	7678,83
Equals	40	,326	3131,81	3150,88
Contains/During	40	,938	-410,71	5221,04
Starts/Started by	40	,640	2173,14	4614,40
Overlap/Overlapped by	40	,386	-4772,14	5440,88
Finishes/finished by	40	,666	-1683,71	3871,01

ANSWER ACCURACY:

Independent sample t-test results indicated no significant difference between two conditions for the correctness of scores t (40) = -0, 819, p>0.5. Means scores indicated that participants

using staggered display (μ=12,38) made more corrects than linear display (μ=12,14) and participants using linear display (μ=0,76) make more errors than staggered (μ=0,52).

TABLE 5. ANSWER ACCURACY (INDEPENDENT SAMPLES TEST)

	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Correct	-,819	40	,418	-,24	,29
Incorrect	,905	40	,371	,24	,26
Uncertainty	,000	40	1,000	,00	,12

DISCUSSION:

COMPLETION TIME:

In contrast the previous study (Boiling et. al, 1997), there was not a statistically significant difference between two types of timelines. However, this result is parallel with the Boiling et al. (1998)' study. In current study subjects using staggered display took approximately 3 second longer to complete the test than subjects using linear display. This is not an expected result. Although it was anticipated that linear arrangement required time is likely to more than staggered one since it require increased scrolling, results did not support this expectation. The first reason of this is that in linear arrangement subjects need to scan only one dimension, in order to locate a target event. In contrast, in staggered arrangement there is not any pattern that can help subjects. This point also highlighted by Boling et al. (1997).

Also subjects using staggered display could not see the pairs of target events in the same time for two questions, but there were not any questions that its pairs of target events could not be seen at the same time in linear display.

In addition, in staggered arrangement, target events are not near for six questions, but there were four questions in linear arrangement that pairs of events are not near each of them. Therefore, subjects using staggered display may have taken more time not only in looking at display, but also in scrolling around the display than did the subjects using the linear display (Boling et al., 1997).

Furthermore, although in previous studies (Boling et al., 1997, 1998) there can be a content problem because in the first study authors stated that a numbering sequence (e.g. Venera 3, Mars 5) was used and in the second study the data set of famous peoples' birth and death dates was chosen. However, although fictional data set was used in current study, no significant difference found.

Finally, although researcher of the present study expected that completion time can be affected by questions type, independent t-test results show that there is no significant difference between two types displays.

ANSWER ACCURACY:

No significant difference between the scores of subjects using the staggered display versus the linear display was found for the results of answer accuracy. Author speculated that number of the icons not only is fewer than the previous studies, but also they are bigger than previous

ones. Also, 1024X768 resolutions was used in current study. Therefore, these can be responsible for the no significant difference between two displays.

QUALITATIVE:

PARTICIPANTS

This study was conducted at a large state university in Turkey. In this study, six participants volunteered to take part in the study (three male graduate students, three female graduate students). The participants were familiar with computers and regularly use them in their daily lives. Sessions were arranged according to their preferred schedule. One of the male students is doing his PhD. in department of Elementary Education (ELE) and he has four years computer experience. Other two male students are doing their PhD in department of Computer Education and Instructional Technology (CEIT). One of them has fourteen years computer experiences and the other has ten years computer experiences. Two female students are PhD. student at Computer Education and Instructional Technology Department. One has nine years and the other has ten years computer experiences. Lastly, one female student is doing her master in Cognitive Science (COGS) and she has eleven years computer experience. The same instrument used in quantitative part of the study was used in this section of the study.

APPARATUS

The sessions were conducted in a professional quality HCI usability lab on a PC running a Pentium processor and the Microsoft Windows XP operating system. Monitor is measuring 17 inches diagonally and set to 1024x768 resolution was used in the study. The session was recorded with two video cameras with different angles.

PROCEDURE

Prior to the actual sessions, the researcher conducted a pilot test with one participant. All participants were tested individually in the usability lab. The researcher gave brief information about the purpose of the research. When participants sat in front of the computer, they first began with a practice screen. At this point, the researcher made a practice with participants by answering two trial questions. After reviewing the practice screen, the participants began the actual test. Before starting actual section, all participants were requested to follow think-aloud protocol. Three of the participants started with linear arrangement and followed by staggered arrangement, the other three followed the reverse order. Also researcher stated that there is no time limitation and it is not important to answer question in a short time.

After the sessions semi-structured interviews were conducted with the participants. Following Questions that are also by Cagiltay (2004) were asked to them: “Please tell me what you think about each of the two interfaces?”, “How do you find function of guiding lines?”, and “Do you prefer one interface to the other? Why?”

ANALYSIS:

After sessions, video records were analyzed to determine participants’ preferences between timeline representations using a linear or staggered view of the data.

RESULTS:

INTERVIEW ANALYSIS:

As stated before, participants followed think-aloud protocol and a semi-structured interview were conducted. Following are the results of think-aloud protocol and semi-structured interview;

- Please tell me what do you think about each of the two interfaces? Do you prefer one interface to the other? Why?

  Two of the participants preferred the linear arrangement since they stated that there is a pattern in linear arrangement and this make you think only one dimension. Other participants although they preferred the staggered arrangement stated some advantages of the linear display. Two of the participants stated that if there were fewer items that can be seen at same time, linear arrangement would be best. On the other hand, all participants who preferred the staggered arrangement stated their preferences' reason for the staggered display is that you can see more items in staggered arrangement than linear one.

- What do you think about icons and guiding lines?

  Three of the participants didn't realize the icons and they wasn't benefit from it during searching events. Three of them find icons helpful while they searching since for example, while they are looking for male icons, they ignore female icons and this makes searching process easier. All participants express that guiding lines are helpful to compare events and to find their location on timeline. But one of the participants stated that if these lines appear when it is clicked at the start and end points of a duration bar, it would be more helpful while comparing events. This suggestion is the same what Boiling et al. used in their study. Also another participant stated that instead of these guiding lines, when mouse over an icon, a colorful fill or pattern descend from start and end points from the duration bar to their points on the timeline at the bottom of the screen. Beside this, he suggested that these guiding lines should be appear from top of the screen to bottom of the screen, not from the duration bar to timeline. Lastly, one of them stated that guiding lines which are appear when click on the displays is more beneficial for staggered arrangement because if there were no guiding lines, it would be difficult to compare the events in staggered arrangement.

- Do you think questions type is make searching process difficult?

  Except for one participant other participants do not think that questions type effect the searching process. Participant who believes questions type effect the searching process claimed that especially to answer "meets/met by" and "equals" type (see Figure 1) question is difficult because you have to make detailed measuring and to determine whether one event equal or not becomes difficult.

LIMITATION OF THE STUDY:

Material used current study has some problems. First of all mouse's scrolling function does not work in material. Also, it is difficult to understand whether present question changed or not. When clicked the track of the scrolling, it does not work. You have to click arrow and

down button or drag scroll faces. Finally, guiding lines do not satisfy the participants' expectations. Besides material's problem, the gap between subjects both in qualitative and quantitative part of the study in terms of computer experience can be seen another limitation of the study. Also there can be some problems with the questions, so they should be examined by an expert. Finally, undergraduate students took extra credit for their participation to the study, but graduate students didn't take any bonus for their participation. Therefore, undergraduate students can be more motivated than graduated students.

DISCUSSION AND CONCLUSION:

In this part of the study it is hard to say one display over another, but it can be said that each has some advantages and disadvantages. In one situation linear arrangement can be advantageous, another situation staggered arrangement. From the qualitative results, linear arrangement is better when number of the items is low and staggered arrangement is better when scrolling is rare in vertically.

One of the most important lessons learned from this qualitative part is that almost all participants want to see whole picture of the system. Just for this reason they preferred staggered arrangement. Therefore, it is safe to say that there should be an option that enables users to see as large body of system as and this can be provided by adding zooming option.

FURTHER RESEARCH:

For the future studies on this research, researcher should be careful about preparing questions for the instrument and placing duration bars in accordance with the questions. Also the author recommends that any future research on this topic should continue with the real timelines.

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