Older Adults' Usage of Web Pages: Investigating Effects of Information Structure on Performance

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Abstract. This study focuses on older adults' usage of web pages. An experiment consisted of three information structures (the net structure, the tree structure, and the linear structure) was conducted to investigate effects of information structure (IS) on older adult's performance. Three findings were found. First, the number of clicks was the fewest in the net-structure web page among three web pages. Older participants spent less time to complete the tasks in the linear-structure web page than the other two web pages. The number of clicks and the accuracy of participants answered the questions in the tree-structure web page were the highest among three web pages. Second, older participants' performance of card sorting was positively correlated with the task completion time. And there was a positive correlation between spatial ability and the performance of older participants. Third, older participants showed the highest preference of the linear structure among three information structures. They always lost task targets in the tree-structure web page, especially when they needed to transfer from one branch of the tree structure to another branch. This indicated that a simple IS was better used and understood by older participants than a complicated one.

Keywords: Information structure · Older adults · Web pages · Navigation

1 Introduction

Older adults have some disadvantages in effectively utilizing the Internet as an information resource (e.g., shopping or reading news on the Internet) compared with young adults. For instance, older adults easily get lost in the deep hierarchical menus of mobile phones because of the declined spatial ability [1]. And other information structures such as the net structure and the linear structure are wildly used in the design of web pages or mobile devices. Previous studies have shown that users would have problems navigating the information in the website when the information structure did not match users' mental model [2]. To know which information structure(s) will be better used and understood by older adults is important for practitioners.

This study aims to investigate how information structure influences older adults' navigation performance on web pages. Specifically, older participants would use three

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web pages built with the net structure, the tree structure, and the linear structure in an experiment. Results of this study help older adults have good user experience of technology products.

2 Literature Review

It is important to display the content according to how people access information when organizing the content of a website [3]. Since a meaningful information structure will promote efficient navigation, to ensure that information is organized in a way that is meaningful to its target users is essential when designing websites [4].

Compared with younger adults, it was difficult for older adults to find a function in a broad menu. Furthermore, it was also not a simple job for them to remember the interaction steps in a deep menu. Therefore, a mobile phone' menu which had fewer functions and was shallower than one which had broader functions and was deeper would be better used by older adults [5]. Zaphiris et al. (2003) had also found that shallow hierarchies were preferred to deep hierarchies by both young adults and older adults in a hierarchical online information system [6]. However, detailed information about the relationship of different branches in the tree structure is little known.

Previous studies indicated two solutions to reduce older adults' menu disorientation. One solution was to provide information about the position in the hierarchical menu. The "tree" aid with the parent categories and the "category" aid were tested. The results of the test showed that this solution was helpful for older adults [7]. The other solution was to use a circular menu in a smart phone for older adults' healthcare support. Older participants who evaluated the usability evaluation could rotate the wheel at the side of a smart phone to select menu items, and this circular menu was better used by them [8].

3 Methodology

An experiment was conducted to investigate which information structure(s) would be better used and understood by older adults. The net-structure web page, the tree-structure web page, and the linear-structure web page about Chinese history which were not widely known by older adults (e.g., those great poets in Tang dynasty such as Li Bai, Du Fu, and Bai Juyi were commonly known while Lu lun and Gu kuan were not) were utilized in this experiment. Older participants' performance among three web pages was observed.

3.1 Participants

A total of 12 older adults from Yuzui Citizen School in Jiangbei District of Chongqing, China were recruited as participants. Older adults who were literate and aged above 60 were eligible for this study. The age of the participants ranged from 60 to 75 years old (Mean = 64.3, SD = 5.46). In total, there were five male participants and seven female participants.

3.2 Task

In this experiment, three web pages about ancient invention, ancient books, and ancient historical character of different Chinese dynasties were presented to participants. There were eight tasks for each information structure. Each participant was required to read three web pages and complete the tasks separately. In each web page, participants firstly watched the task specification, secondly they found the target according to the task specification by touching the hyperlink in the web page, and finally they answered two questions according to the content which was shown in the web page (see Fig. 1).

Here is the explanation of the task specification provided by Morae Recorder which is shown in Fig. 1.

Fig. 1. Interface of the net-structure web page used in this experiment

*Please find the message of **Daitian Method** in this web page. Click the "**Start Task**" button to begin this task. Click the "**End Task**" button to finish this task and answer the question.*

**Only the Chinese characters were displayed in this experiment.*

3.3 Dependent Variables

The dependent variable was participants' performance of using three web pages. It was measured through task completion time, the number of clicks, and task effectiveness. Both of the task completion time and the number of clicks were recorded by Morae Recorder. The number of errors of participants' answer was analyzed by Morae Manger.

3.4 Independent Variables

The independent variables were three information structures: the net structure, the tree structure, and the linear structure. Besides, demographic variables including age, spatial ability and computer experience were considered as covariates in this experiment. Age and computer experience of participants were measured through a questionnaire. Participants' spatial ability was tested through the spatial location-memory span tester. Under the display of the tester, red buttons would randomly appear, and participants were required to press the buttons in the sequence as they appeared. After that, the number of red buttons increased and participants would repeat this process. Participants' spatial ability was measured through the maximum number of digits, the highest scores, and the number of errors (see Fig. 2).

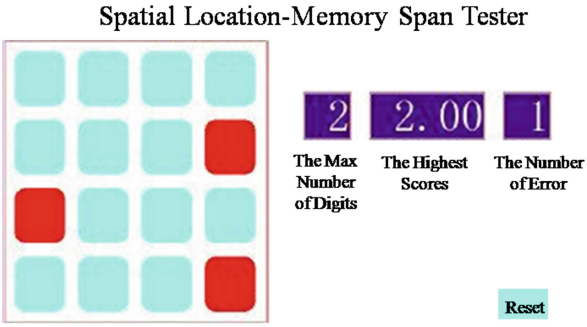

Fig. 2. Instruction of spatial location-memory span tester

The number of nodes for the net structure, the tree structure, and the linear structure is 40, 37, and 24 accordingly. Nodes of the vertical navigation bar and the horizontal navigation bar are connected by hyperlink. The depth of the tree structure is four, and the breadth of the tree structure is three. Figure 3 has shown one of the groups of the net structure, one of the branches of the tree structure and part of the linear structure.

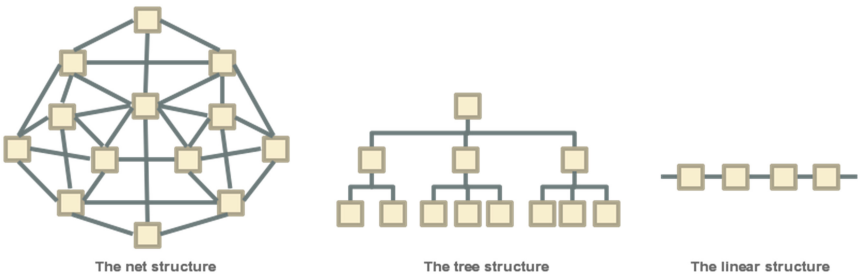

Fig. 3. The information structure of three web pages

3.5 Experimental Design

Within-subjects design was used. Each participant read three web pages built with the net structure, the tree structure, and the linear structure (see Fig. 4) and completed the tasks. In order to prevent the "learning effect", the order of presentation of three web pages was counterbalanced.

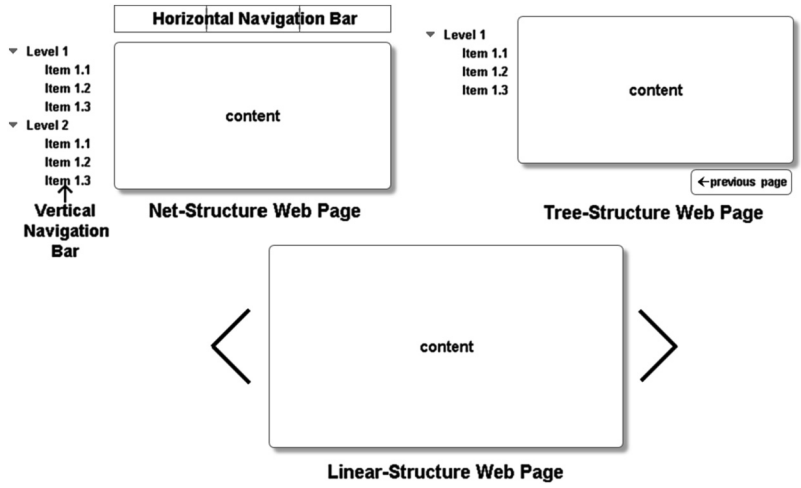

Fig. 4. Three web pages built with concept model

3.6 Equipment and Procedures

A notebook computer (ThinkPad S1 Yoga) with Microsoft's Windows 8.1 operating system and Google Chrome (version 37.0.2062.120m) Browser was used for the experiment. Since novice older adults have difficulty in using a mouse, a computer with a touch screen is a better choice than a mouse. The experiment was conducted in a separate room in the Yuzui Citizen School in Jiangbei District of Chongqing, China. Each participant was encouraged to complete the experiment individually. They could ask for help but it would be recorded.

The experiment took each participant about 60 min. Firstly, each participant began the experiment by filling out a consent form and a general questionnaire about his/her demographic information and experience with computers and mobile phones. Secondly, a spatial ability test was conducted by using a spatial location–memory span tester. Thirdly, a brief introduction and practice about the experiment was given to each participant. Fourthly, participants completed tasks of each web page and then went on with card sorting. The cards were the titles of each node in the information structure. Morae Recorder (version 3.3.3) was used to present the task specification for participants. At the end, the experimenter conducted a five-minute exploratory interview with the participants to know their thoughts and feelings about using three web pages. The question in the interview included "In three web pages, which was the most comfortable one and the worst one for you? And why?".

4 Results and Discussion

4.1 Descriptive Statistics

There were a total of 12 participants in this experiment (five males, seven females). 83.3 % of the participants earned 300–1200 RMB per month; 50 % of them had more than two-year experience of using smart phones; 34 % of the participants had more than two-year computer experience.

4.2 Effect of Information Structure

The influences of information structure on older participants' performance of using three web pages were tested. Repeated ANOVA was used to analyze data.

As to average completion time, the standard deviations were very large, making the interpretation of the results different. Table 1 indicated that there were significant differences among three information structures in task 2 and task 3. One possible reason was that participants accidently touched the end button immediately after the task began.

Table 1. The influences of information structure on task completion time

Task	Task completion time (s)						df	F	*p*
	Net structure		Tree structure		Linear structure				
	Mean	SD	Mean	SD	Mean	SD			
1	59.92	29.70	65.70	37.00	69.50	58.75	2	1.777	0.193
2	52.53	17.44	45.74	24.33	28.54	20.79	2	3.666	0.046*
3	64.12	30.93	55.99	22.73	29.89	21.51	2	4.528	0.026*
4	46.00	13.96	48.40	26.10	38.17	23.50	2	0.628	0.545
5	42.06	19.57	31.75	23.78	30.44	17.54	2	1.753	0.199
6	38.50	22.30	26.63	24.87	34.03	29.61	2	0.452	0.643
7	43.56	17.89	34.54	22.79	29.20	16.28	2	2.296	0.127
8	38.47	24.66	27.71	17.55	26.70	15.55	2	1.726	0.203
Average	48.14	22.06	42.06	24.89	35.81	25.44	2	2.322	0.114

Note: *Significant at 0.05 level

Table 2 indicated that information structure had significant influences on the number of clicks. Older participants clicked fewer to complete the tasks in the net structure than the tree structure and the linear structure, and this may because they could use the horizontal bar in the net structure to have an overview of the content in the web page. And the number of clicks to complete the tasks was the highest in the tree-structure web page among three web pages. One possible reason was that participants easily got lost when they found the target in the tree-structure web page.

Table 2. The influences of information structure on the number of clicks

Task	The number of clicks						df	F	*p*
	Net structure		Tree structure		Linear structure				
	Mean	SD	Mean	SD	Mean	SD			
1	6.83	3.81	9.67	6.86	12.75	12.82	2	1.777	0.193
2	6.70	3.23	6.60	5.40	5.20	3.65	2	0.330	0.721
3	7.20	4.80	11.20	5.07	6.40	6.90	2	1.598	0.230
4	4.90	2.38	12.20	10.86	11.50	10.66	2	2.793	0.087
5	7.27	6.52	9.55	7.42	5.18	2.63	2	2.055	0.154
6	4.90	2.72	8.50	6.29	6.50	3.97	2	1.211	0.321
7	5.82	2.31	10.00	7.52	7.00	3.71	2	3.629	0.045*
8	4.34	2.34	6.18	2.23	7.45	4.87	2	11.723	0.003*
Average	5.99	3.51	9.23	6.40	7.75	6.15	2	12.143	0.0008*

Note: *Significant at 0.05 level

As to the net-structure web page, older participants spent more time to complete tasks on the net structure than the tree structure and the linear structure. Meanwhile, it was easier for participants to find targets in the net-structure web page than the other two web pages. The number of clicks of the net structure was fewer than the tree structure and the linear structure.

As to the tree-structure web page, the number of clicks of the tree structure was higher than the net structure and the linear structure. Only one older participant preferred the tree structure to the net structure and the linear structure. Other older participants easily got lost in the tree structure. They stayed in a page for a long time or staying in a cycle of going and returning back of one page in the tree structure. Particularly it was difficult for them to cross one branch to another branch in the tree structure.

As to the linear-structure web page, older participants spent less time to complete the tasks than the other two web pages. 58 % of the older participants preferred the linear-structure web page to the net-structure web page and the tree-structure web page.

As to the task effectiveness, older participants completed the tasks with a higher accuracy in the linear structure than the net structure and the tree structure. The accuracy of participants answered the questions for the net structure, the tree structure, and the linear structure was 63 %, 67 %, and 87 % accordingly. And the total number of errors of participants' answer was 35 in the net structure (Mean = 2.92, SD = 1.505), 31 in the tree structure (Mean = 2.58, SD = 1.564), and 12 in the linear structure (Mean = 1.00, SD = 1.279). The results of repeated ANOVA indicated that information structure had significant influences on task effectiveness ($F = 7.654$, $df = 2$, $p = 0.003$).

4.3 Effect of Card Sorting

The total number of errors of participants' card sorting was 21 in the net structure (Mean = 1.75, SD = 1.423), 38 in the tree structure (Mean = 3.16, SD = 0.935), and 10 in the linear structure (Mean = 1.91, SD = 1.514).

As the results of correlation analysis between performance and the card sorting indicated, the performance of card sorting was positively correlated with the task completion time. However, it was not correlated with the number of clicks. The correlation coefficient between card sorting and performance are shown in Table 3.

Table 3. Correlation coefficient between performance and card sorting's result

	Task completion time	The number of clicks
Correlation coefficient	0.453*	0.302
p	0.006	0.074

Note: *Correlation is significant at the 0.05 level

4.4 Effect of Covariates

Three demographic variables (spatial ability, computer experience, age) were considered as covariates. The correlation between the demographic variables and older participants' performance are shown in Table 4. As to the spatial ability of participants, the maximum number of digits was ranged from five to seven (Mean = 6.16, SD = 0.572). The highest scores were ranged from 3.66 to 5.66 (Mean = 4.67, SD = 0.691). The number of errors of participants was ranged from three to nine (Mean = 6.00, SD = 1.852).

Table 4. Correlation coefficient between performance and demographic variables

	Task completion time			The number of clicks		
	Age	Computer experience	Spatial ability	Age	Computer experience	Spatial ability
Correlation Coefficient	0.481	−0.162	−0.758*	0.419	0.102	−0.585*
p	0.113	0.614	0.004	0.175	0.753	0.046

Note: *Correlation is significant at the 0.05 level

The results of this test showed that older participants would make more mistakes when the maximum number of digits was more than six. The number of errors of spatial ability was selected as the variable for the correlation between the performance and spatial ability. And participants who completed the spatial ability test with fewer errors may complete the tasks faster.

As to computer experience, four participants had more than two-year computer experience while eight participants had not used computer before. Older participants who had experience of using computer spent less time to complete the tasks than those who had not the experience.

4.5 Discussion

First, older participants completed tasks efficiently when finding targets in the net-structure web page. They clicked the web built with the net structure less frequently than the tree structure and the linear structure. However, older participants felt lost in the net structure. This was because the relationship between the vertical navigation bar and horizontal navigation bar in the net structure (see Fig. 4) was difficult for them to understand. Specifically, older participants could easily find the target with horizontal navigation bar while could not catch the detailed information of this target by the vertical navigation bar in the net structure. Therefore, they spent more time to complete the tasks in the net-structure web page than the tree-structure web page and the linear-structure web page.

Second, older participants felt confused at the second or third level of the tree structure in this experiment. They stayed in a page for a long time or staying in a cycle of going and returning back of one page in the tree structure. And it was difficult for older participants to transfer from one branch to another branch in the tree structure.

The experiment's results indicated that older participants could easily turn to the next page, but it was not a simple task for them to turn to the front page in the tree structure. Therefore, the design like the home button used in a smart phone may help older adults to understand technology products well.

Third, the linear structure was the easiest one to use for older participants among three information structures. Therefore, a design like a horizontal navigation bar continuing with a linear structure (e.g., the tree structure with eight items on each of two levels) may be accepted by older adults.

Fourth, older participants tended to focus on the content of the web page while always ignore the relationship between each page in this experiment. Therefore, a hint about the relationship between each page (level) in the web page may be better used by older adults.

5 Conclusion

This study investigated older adults' performance of using three web pages built with three information structures. To help older adults have good user experience of technology products, three web pages built with three information structures were tested. Based on the results, three main findings were derived:

First, the number of clicks was the fewest in the net-structure web page among three web pages. Meanwhile, older participants spent less time to complete the tasks in the linear-structure web page than the other two web pages. The number of clicks and the accuracy of older participants answered the questions were the highest in the tree-structure web page among three web pages.

Second, older participants' performance of card sorting was positively correlated with the task completion time. In addition, there was a positive correlation between spatial ability and the performance of older participants' usage of web pages.

Third, most of the older participants preferred the linear structure to the net structure and the tree structure. Meanwhile, most of the participants thought the tree

structure was difficult to use, and they always lost task targets in the tree-structure web page, especially when they needed to transfer from one branch of the tree structure to another branch.

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