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Category-Based and Association-Based Map Displays by Human Subjects

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1. INTRODUCTION

Visual displays are important for information retrieval. A good visual display should not only help the viewer to see and sense the information, but also abstract and present the semantic structure of the underlying information to facilitate searching and browsing. Depending on the type of structures shown on the display, visual displays for information retrieval can be classified as hierarchical displays, network displays, scatter displays, and map displays (Lin, 1993).

In previous research (Lin et al., 1991; Lin, 1992), we applied a neural networks learning algorithm, Kohonens self-organizing feature map algorithm, to generate map displays for documents. The map displays generated were found to be a good visual display for a document collection: they preserved and showed the underlying statistical relationships of the input data (thus potentially showing semantic relationships of the documents); they provided meaningful neighboring relationships to support associations and visual inferences; and they showed hierarchies and clusters through geographical features of the displays.

To evaluate such visual displays, and to continue searching display formats that facilitate information seeking, we investigated how human subjects would generate map displays for documents. Given a grid and a collection of document titles, we can ask subjects to make a map by putting the titles on the grid. What kind of maps do they generate? Do maps generated by the subjects have properties similar to properties of maps generated by the algorithm? What are the subjects main concerns in performing such a task? How do they decide which documents should be put close together, which should be put far away? Are there any relationships between the processes underlying the algorithm and the procedures that the subjects follow to complete the task? Finally, how do maps generated by subjects help one browse and make relevance judgments on documents shown on the maps? These questions led to the experimental study described in this paper.

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2. EXPERIMENTAL PROCEDURE

To define an experimental procedure, a pilot study was first conducted with two subjects. It was found that generating a map display by arranging document titles on a two-dimensional grid was a significant challenge to the subjects. While the subjects performed the assigned job reasonably well, they often found themselves in difficult decision-making situations during the experiment. They were often uncertain when classifying and organizing the document titles on the grid. At the end of the two hour session, they felt mentally exhausted.

Based on the pilot study, we decided that we should choose subjects who had good knowledge of the content of the experimental data, and who were interested in participating in and completing the experiment. Having good knowledge of the content not only made the experimental results more reliable but also helped keep subjects interested in the experiment, particularly when they faced difficulties. Thus, we selected a collection on library automation as the experimental data for this experiment and looked for library school students for subjects. By advertising in a class on computer applications for library and information systems, eight subjects who were knowledgeable about library automation were recruited for this experiment. Six of them were MLS students and two were Ph.D. students. Three were male and five were female. Most of them had library work experience, and none of them were first year library school students. These subjects were volunteers; their willingness to participate in this experiment was on account of their enthusiasm to test their knowledge on library automation and to learn more about the research. They were also enthusiastic about participating in a research study.

To conduct the experiment, we prepared a large 10 by 14 grid (31 by 40 inches), and put each title of the 133 documents related to library automation on a small card. The cards were designed so that the titles can be read clearly and three or four cards could be put in one cell of the grid without overlapping one another.

The following experimental procedure was derived after the pilot study and before the experiment:

1) Make an appointment with each subject for a two-hour block of time. Invite each subject to the experimenters office individually. Describe the purposes of the experiment and ask him or her to sign a human subjects permission form.
2) Explain the overall procedure to the subject. State the task clearly using statements such as: Assuming that we are going to have an interface for a document retrieval system that displays all these 133 documents (pointing to the cards with document titles stacked on the center of the grid), we would like you to design a reasonable structure for such an interface to assist the user in locating documents. The structure should reflect, as much as possible, how these documents are related to each other. You will design and show the structure by putting these titles on the grid.
3) Start the experiment by asking subjects to put the cards on the grid based on the similarities they perceive among the documents. Instruct the subject that titles can be put on any location on the grid, and relative relationships among the documents are more important than absolute locations of the documents. Encourage subjects to think aloud throughout the whole experiment.

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4) Observe subjects decision-making process. Ask questions from time to time for the purpose of understanding their thought process. Audiotape all discussions during the experiment.
5) Encourage subjects to name (orally) any groups or clusters they perceives during the process. When they finish placing all the titles, 39 words selected based on occurrence frequencies (as used by the feature map algorithm) are given to them for labeling clusters, groups or areas on the map. Subjects can use all or part of this set of words, but they cannot add any other words. At the end, subjects are provided with sticks to bound the clusters or to identify separate areas by placing the sticks on the grid.
6) Select ten titles from the collection randomly before the experiment. Present these titles, one at a time, to the subject. Ask subjects to first identify the position on a blank 10 by 14 grid based on their memory of where they put the title, and then to find the title on the map. Record the time the subject uses for the two tasks. Ask the subject to identify 3 related titles for each of the titles presented and record the time required.
7) Ask for any general comments that the subject might have about the experiment and the procedures.

3. RESULTS

Results of this experiment are presented in the following three sub-sections. The first describes the maps that the subjects generated, the second summarizes procedures that they used to generate the maps, and the third is about searching on the maps.

3.1. Maps Generated by the Subjects

All the subjects constructed a map with a reasonable structure for the given document collection. The maps, however, were all different even though the subjects followed the same instructions. In general, these maps can be divided into two types, the category-based and the association-based. The category-based maps are arranged in columns. Categories are represented by more or less distinct groups. The association-based maps maintain clear associations among clusters and groups, but the boundaries for the clusters or groups are not clear. Although all the maps would fit at different places on a continuum from purely category-based to association-based, we can roughly divide them into two groups: four are predominantly category-based and four are predominantly association-based. Figures 1 and 2 show the four association-based maps and the four category-based maps, respectively. These maps were re-drawn based on the table-size maps that the subjects generated. Compared to the original maps, these re-drawings emphasized the resulting map structures and neglected individual document titles and their local relationships.

While the maps were made by relationships among individual titles, the overall organizations of the maps reflect different styles of arrangements by the subjects. The subjects could often explain the organizational schemes developed while they were organizing the maps. These organizational schemes were a high-level abstraction of the document collection, and represented the subjects

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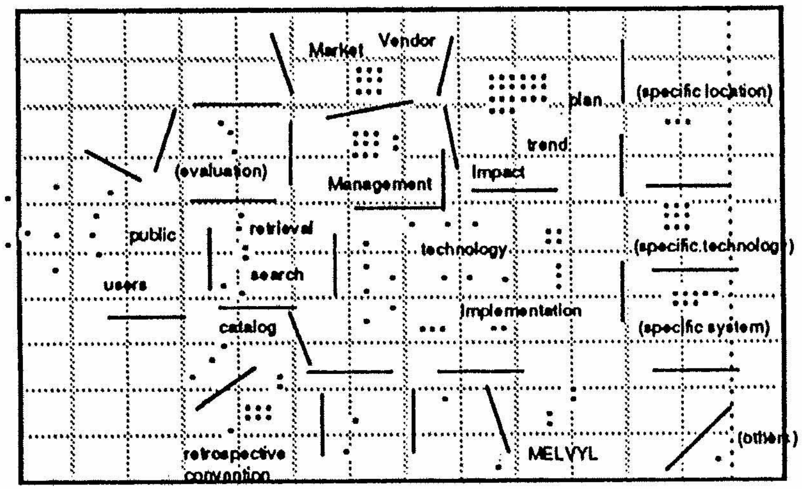
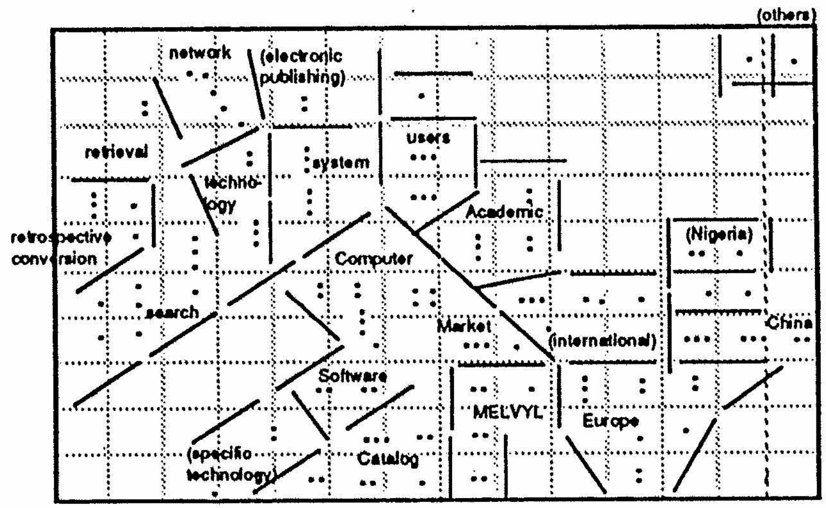


"The two centers are 'management' and 'technology'. Near the management side are 'human relations,' 'user evaluation,''planning,' and 'vendors,' which are also close to the technology side. Near the technology side are 'specific systems,' 'library functions' (which are also close to 'user' and 'system evaluation'). ...... The [horizontal] dimension I have here is from 'being things' to 'doing things'."

(a) The map and comments by subject 1



"I pretend that the grid is unlimited in size. I put titles that are the most important, the largest, and have the most connections to others in the center. Other titles are then spread out along the diagonal lines, with the extremes [that seem to fit nowhere with any others] on the corners, or far away."

(b) The map and comments by subject 2

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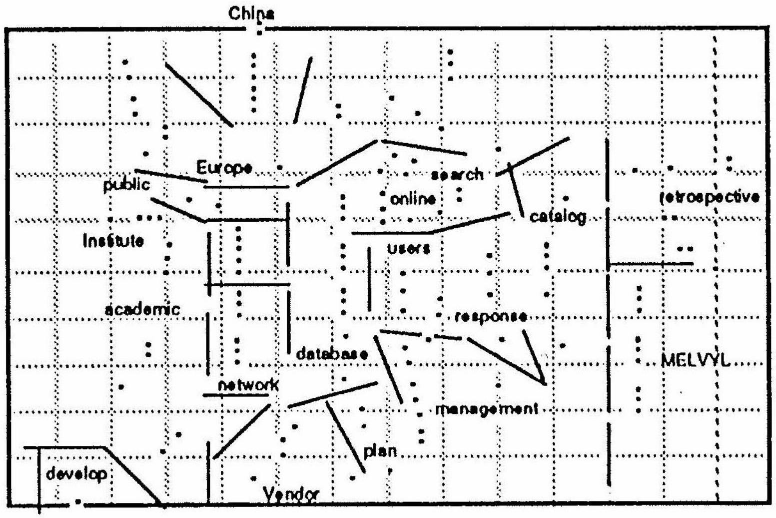
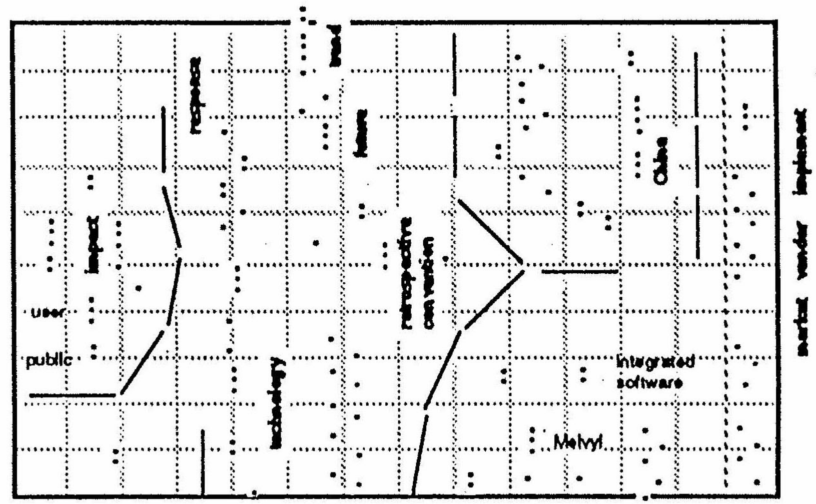


"I did not intend to do so, although it is kind of natural from 'cataloging', to 'management', to 'general' (or 'overviews'), then to 'specific systems' " [the subject put titles on the map starting from the "cataloging group". When deciding which group should be next, he always tried to find links that "tied up" one another; this was done typically through finding a few titles that had relationships with both groups.]

(c) The map and comments by subject 5



"I feel that I am trying to have a hierarchical-tree-like structure. But I am not really getting there. ...... I am putting all the high level topics — for example, text retrieval --- over the top. Down on the bottom, I put specific commercial systems, specific examples, and case studies, There seems to be quite a few human-related articles, so I group them here [on the left]".

(d) The map and comments by subject 7

Fig. 1 Association-based Maps generated by human subjects.

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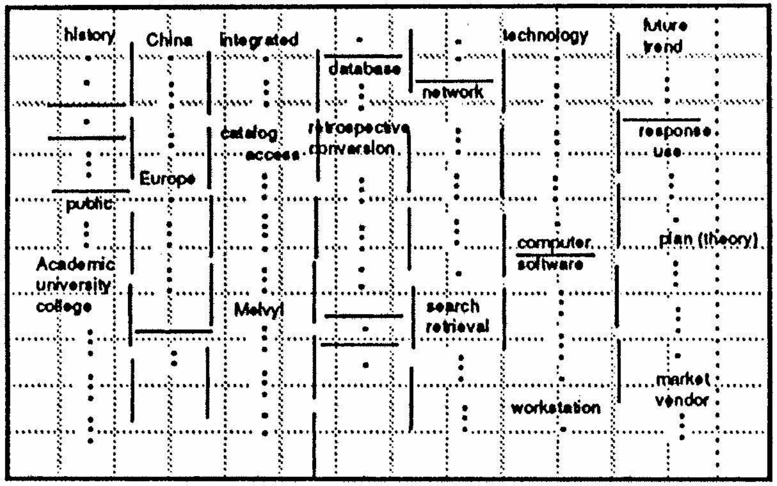
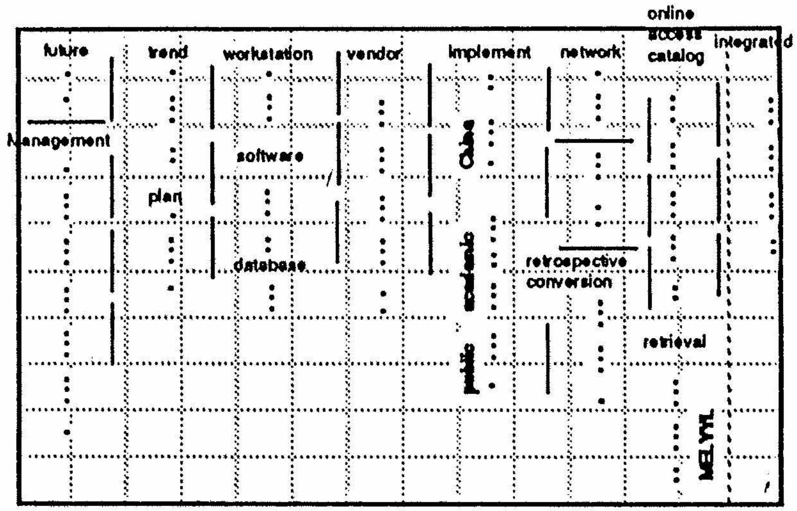


"Categories are arranged horizontally, and within each category titles are linearly arranged from top to bottom, usually from general to specific." [The map by this subject seems to observe two distances: the horizontal distance and the vertical distance. It could be seen as a double-linear map, rather than a two-dimensional map]

(a) The map and comments by subject 3



"Each column is a category. ...... Related columns are put next to each other. Within each column, I prefer to put titles alphabetically, particularly when there are no clear relationships among the documents." [The experimenter tried to discourage the use of alphabetical lists, but she insisted that alphabetical lists would be much easier to browse when the category was small.]

(b) The map and comments by subject 4

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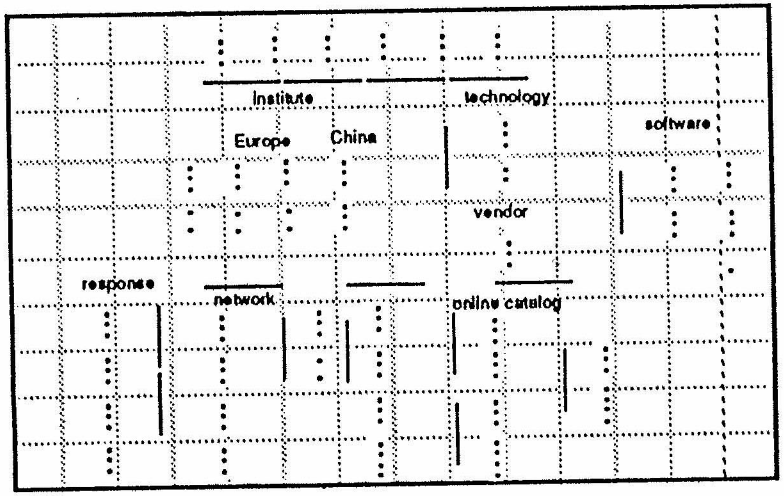
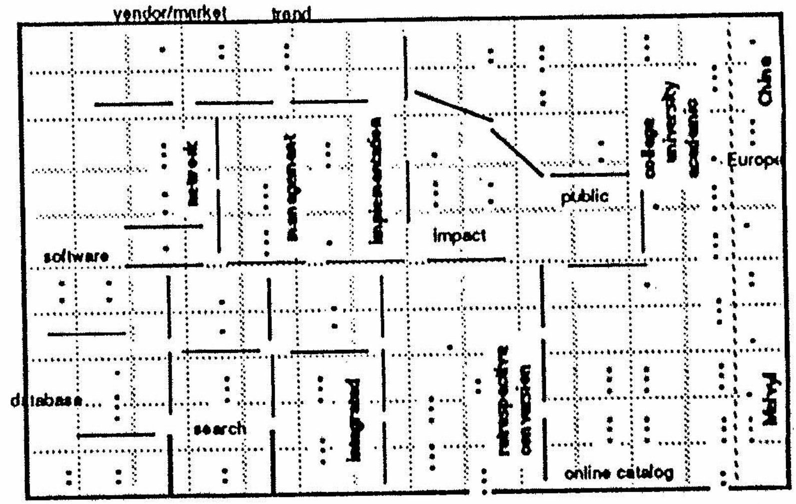


"It's kind of overwhelming at first. ...... These are kind of general articles that I started with. ...... This arrangement is not in any way scientific, it just happens to be like this."

(c) The map and comments by subject 6



"Whatever I have found first is what I have found lots of. Then it is a matter of 'divide and conquer'. ...... What's going through my mind is that there are so many specific aspects within each group. If I try to divide them, many [titles] could go very easily either way, to one cluster or the other. If I try to say [pointing to a title] it is half way between here and here and put it there, I would get totally lost. ...... So what I have here are very rough divisions, it is not exactly what I have in mind when I try to put these together."

(d) The map and comments by subject 8

Fig. 2 Category-based Maps generated by human subjects.

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views on the collection and the maps they made. Comments included in Figure 1 and 2 reflected how the subjects mentally visualized the collection.

Subjects built the maps based on their understanding of the document titles. They often read keywords in each title aloud, made judgments about content, and sometimes made comments on the content as well as their own judgments (such as Oh, this is sort of big picture of library automation, I guess this is about technologies, Here is another one about sub-systems, and How does this have anything to do with library automation?). Subjects applied their knowledge of library automation to make sense out of the titles and put them in the proper place. For example, when they read online claiming, they thought about the serials module of library systems. It would be very difficult for an algorithm or a computer system to account for this unless some specific knowledge base is built for the algorithm or the system.

The subjects final task was to visualize the map structure. This task has two parts: using those words provided to label clusters or groups, and using sticks to set their boundaries. Because this process was done after they had finished organizing the titles (based on document similarities), results of this process may not actually represent the structures they created, but may rather reflect rationalizations for the organizations produced. They explained that although the words provided were supposed to label the clusters and groups, the words were better seen only as a lead-in entry that helped direct the eyes to related documents. The same is true for the sticks. In the subjects minds, the sticks did not represent clear cut, but rather fuzzy boundaries. Placing the sticks seemed to be more difficult on the association-based maps, as these subjects often treated the maps as a continuous space when they located a place for each title. On the other hand, using the sticks for the category-based maps seemed not to be very helpful. The sticks were used either to emphasize the columns that were already clear on the map, or to break off columns, which could also be done by placing extra spaces between the rows. Even though there was only one type of stick, the sticks, in fact, represented different kinds of separations. Some subjects suggested that the maps would be more clear if the sticks were in different sizes and different colors. These results indicate that much richer relations existed in their mind than the relations that could be represented on the maps using the tools provided.

As seen from these maps, some subjects were comfortable using as many labeling words as possible, while other subjects seemed to use as few as they could. The ways they put the labels on the maps often carried different meanings. For example, one subject commented, when I put the labels on top of those titles, that means the labels exactly represent the groups; when I put the labels aside nearby the groups, that means the labels are only partially correct. They felt that if they had known beforehand that these words would be the labels, they might have organized the maps differently. The oral naming categories they used during the process indicated that if they had been allowed to choose words for labels freely, they would very often have used abstract or summary-type words such as general, specific, overviews, sub-systems, international (or geographical), theories, management, and application, even though these words might not appear in the titles. For example, they preferred using specific systems, rather than the names of individual systems, to label clusters related to systems, using specific hardware/software, rather than network, workstation, unix, etc., to group hardware/software-related titles together. The two words most often mentioned by the subjects were general and specific.

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It is important to reflect on the results of such an abstraction process on the maps. The subjects seemed to be able to accomplish this by adding the abstract words they came up with during the process of generating the maps. This might be difficult for the machine to do. The feature map algorithm can classify and group titles together. It can also map related words to the groups to identify them. While some phrases may show up as the result of mapping two or more words into the same group, no summary-type words can be generated automatically. For this purpose, augmentations with a thesaurus-approach or an expert-system-approach may be needed. That is, a database of human experts knowledge, either in the form of a thesaurus, or in the form of if-then rules, could be used to improve the labeling process of the machine-generated map. For example, if many words in a lower level hierarchy of a thesaurus are mapped to a group by the algorithm, the higher level word in the hierarchy should be used to replace the lower level words as the label for the group.

3.2. Procedures Used by the Subjects

The subjects appeared to demonstrate two different approaches, which we called the group approach and the individual approach (Fig. 3). The group approach is a top-down approach. The subjects first went through all the titles and divided them into several groups. A new group was created when a title did not fit any existing groups. Groups sometimes were combined or dissolved when the subjects went over the titles a second or third time. When deciding on the title locations on the maps, they first decided on locations for the groups, then arranged the clusters within each group, and then adjusted the locations for individual titles. The process could lead to rearrangement or relocation of titles and clusters on the maps, but few relocations of the groups. Constrained by the two-dimensional grid, they were often not able to put the clusters and groups on the locations that made most sense to them (as reflected by comments such as this group should be here, but it also has relations to that group, I really don't know how to satisfy both, and I don't like to put [this group] here, but I have no other better choices). Positions for the individual titles that seemed to fit many groups were particularly hard to determine. Such positions were sometimes just determined arbitrarily. The final maps, as some subjects pointed out, were in the end reached by compromise.

The individual approach is a bottom-up approach. The subjects tried to arrange individual titles as early as they could. They immediately stopped reviewing the titles when they felt that they had a basic idea of what was in the collection, or when they had identified one or two major groups that they could start placing on the maps. Their initial review was to find a starting place, rather than to divide them into groups as did the group approach subjects. They put the titles on the grid one by one, instead of group by group, starting from a place they identified on the maps (for the category-based maps, the starting category usually was the left-most column). They then gradually continued from that starting place, adding titles, one by one, to the map. Because they did not thoroughly review all the titles and did not divide the titles into groups, they often needed to go back, again and again, to those titles that had not yet been put on the map, selecting titles to fit current locations where they were working. Each titles position was determined by its relationships with those already on the map. Once the titles were on the map, they were only subject to minor adjustment as new titles were added to the map. Any new groups or clusters were located in the remaining space, even though that might not be the location that the subjects would like the groups or clusters to be. The final results were often different from what they had thought before, but they

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Individual approach	Group approach
1. Go through the stack, or part of the stack, to make sense of the content and identify a starting group.	1. Quickly go through the whole stack, several times if necessary, to divide the titles roughly into several groups.
2. Put titles of the starting group on a selected location of the grid, one by one, based on their relationships,	2. Mentally form several criteria on organizations of the groups.
3. Go back to the rest of the stack again and again and organize the map	3. Systematically go through the stack again and again and organize the map
Bottom-up	**Top-down**
a. select title or titles that might fit current working group,	a. locate a position for each group
b. add titles to the map based on their relationships to titles already on the map	b. arrange clusters within the group, using titles in the group, or from other groups, if necessary.
c. adjust titles and their neighboring relationships when clusters or groups become apparent on the map	c. adjust titles and their neighboring relationships within and between clusters of the group.
d. find titles that can be used as links to go to the next group . Return to step a whenever necessary.	d. select a new group to add to the map, adjust group positions if necessary. Return to step a whenever necessary.
4. Refine the structure, move a few titles to different locations, add those titles left after step 3.	4. Refine the groups, move a few titles to different clusters or groups, add those titles left after step 3.

Figure 3. A summary of the procedures used by the subjects to generate the maps.

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felt that the result was what they got by following the instructions. This seems to be a major difference between the group approach and the individual approach. While the group approach always tries to reach an ideal map structure through reaching a compromise on all constraints of group arrangements, the individual approach let the map structure emerge from individual title arrangements.

3.3. Searching on the Map

Quantitative data collected in this experiment were (1) M-time — the amount of time subjects used to mentally locate a title on an empty grid, (2) P-time — the amount of time subjects used to physically locate the title on the map they themselves had just produced, (3) R-time — the amount of time subjects used to identify three titles most relevant to the title given, and (4) MP-diff — the number of cells separating the locations identified mentally and physically for each title. Table 1 gives descriptive data on the variables.

Variables	Mean	Standard Deviation	Minimum	Maximum
M-time	6.7 (sec.)	3.26	2 (sec.)	21 (sec.)
P-time	11.53 (sec.)	9.26	3 (sec.)	51 (sec.)
R-time	36.33 (sec.)	18.74	7 (sec.)	87 (sec.)
MP-diff	2.19 (cb.)	2.09	0 (cb.)	10 (cb.)

(There are 8 subjects, each of them searched 9 titles, for a total of 72 cases.
cb. = city-blocks.)

Table 1. Descriptive data on the selected variables.

M-time: time a subject used to identify the location for a title mentally (by marking a cell on a blank grid to indicate where he or she thought the title was on the map).
P-time: time a subject used to identify a title physically (from the map the subject generated).
R-time: time a subject used to select three titles relevant to the title given.
MP-diff: the difference between two locations (identified mentally and physically for each given title) as measured by the "city-block distance."

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Variables	Types	Mean	Standard Deviation	Standard Error	t value	2-tail Prob.
		(in seconds)				
M-time	Assoc.-map	6.37	3.41	.58	-.94	.403
	category-map	7.03	3.11	.53		
P-time	Assoc.-map	12.6	11.61	1.96	.85	.397
	category-map	10.5	9.30	1.57		
R-time	Assoc.-map	31.9	20.15	3.41	-2.01	.048
	category-map	40.7	16.32	2.76		
		(in city-blocks)				
MP-diff	Assoc.-map	2.36	2.41	.40	.67	.502
	category-map	2.03	16.32	.29		

Table 2. Comparison of the two types of maps on the given variables. (36 cases each row.)

In general, the subjects were able to identify very quickly locations for the titles given, both mentally and physically (with mean values of 6.7 seconds and 10.1 seconds, respectively). Locations identified mentally for each title were usually within an immediate neighborhood of the actual location of the title (12% of the two locations matched exactly (i.e., MP-diff=0), 36% differed by a cell, and 21% differed by two cells). This confirmed our assumption that the subjects could remember the maps well (or, as the subjects commented: I have a kind of visual memory when I search). The subjects remembered the orientation of the maps particularly well. Out of the total of 72 cases, there were only 3 cases (less than 4%) where the locations identified mentally were opposed to the physical location (one on the up portion and the other on the lower portion of the grid, or one on the left and the other on the right).

Comparing the two types of maps, there were no statistically significant differences in time used for identifying locations for titles on the two types of maps, both mentally and physically (Table 2). The results for retrieval time indicate that subjects who generated association-based maps identified three relevant documents more quickly than subjects who generated category-based maps. The difference is significant at a level of 0.05.

We also observed the effect that the semantic maps have on relevance judgments. Our assumption was that, with the map, it should be easier to identify relevant titles, and most of the relevant titles identified would be in an immediate neighborhood of the title given. The procedure we designed to test this assumption was to let subjects select the three most relevant titles to each title given. The results clearly showed that the subjects did identify relevant titles very quickly, and most of

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the relevant titles identified are within an immediate neighborhood of the given titles on their maps. There are only a few exceptions: out of the total of 202 cases, 26 exceptions were made by six subjects. Two of the subjects (subject 3 and 4) made no exceptions: all relevant titles identified are very close to the given titles, and the relevant titles and the given titles are all in the same column (both of the subjects generated category-based maps). Of the 26 exceptions, five are still nearby their corresponding given titles, although they are not in the same group with the given titles. The rest of them (21) are not in the immediate neighborhood of the given titles. The reason that they are far from the given titles, as we found by analyzing the titles, was that they were relevant to the secondary concept of the given titles. This result appears to indicate that, on the maps, the secondary concept of a title may not be nearby the major concept of the title.

We expected that there would be a high degree of agreement across subjects for relevant titles they identified, even though the maps they generated might look different. The results (Table 3), however, did not confirm our expectations. Relevant titles identified are, most of the time, different from subject to subject: there was no single title identified by all of the eight subjects as a relevant title to any of the given titles; 40 titles, out of the total of the 89, were selected by just one subject as relevant titles to the given titles. In other words, there was no general agreement on relevant titles across subjects. This, on one hand, may be due to the inherent problems of making relevance judgments, particularly for such a coherent group of titles — it is quite possible to have more than

Number of subjects in agreement	Number of titles	Percent	Cum. percent
8	0	0	0
7	0	0	0
6	2	2.2	2.2
5	6	6.7	8.9
4	7	7.9	17.0
3	15	16.8	33.8
2	19	21.3	55.1
1	40	44.9	100.0
Total:	89	100.0	

Table 3. Frequency of agreement among the eight subjects in selecting relevant documents.

Every subject selected three titles for each of the 9 titles given. A total of 89 titles were selected by the eight subjects. The number of subjects in agreement is the number of subjects who selected the same relevant title for a given title.

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	Self	Association-based					Category-based				
		S1	S2	S5	S7	Avg.	S3	S4	S6	S8	Avg.
Subject 3	0.8	3.9	4.0	2.8	4.4	3.8		2.3	4.4	2.7	3.1
Subject 5	1.4	4.8	3.1		2.5	3.5	3.2	4.5	3.8	2.7	3.6

Table 4. Comparison across maps.

Relevant documents identified by subject 3 and subject 5 are used to compare across all the maps. The average distance between a query document and the identified relevant documents (as measured by the city-block) were computed for each map. The results showed that average distance is within 4 city-blocks across all the maps.

three titles equally relevant to a given title in this collection. On the other hand, it may show that different maps would lead to different judgments of relevance.

Finally, we cross-checked document distributions of the maps using relevant documents identified by subject 3 and subject 5. For each of the 9 titles given, the two subjects identified three relevant documents on their own maps. How far away are these three titles from the given title on the other subjects maps and on the machine-generated map? Table 4 gives the results. On average, the distance between a query document and any of its relevant documents identified by the two subjects are within four city-block distances. These results lend further support to the similarities among the maps across subjects.

4. DISCUSSION

This experiment explored how human subjects arrange document titles on a two dimensional-grid to visualize a document collection. We were particularly interested in how the subjects approached the problem, what resources they relied on, and what display formats they generated. In this section, these aspects are discussed and the map displays generated by the subjects are compared with the map displays generated by the algorithm.

4.1. Mapping and Classification

Kohonens feature map algorithm generates a map through recursive learning. The algorithm organizes the map gradually by dealing with one document at a time, and using every document

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many times. It is the ultimate bottom-up approach. For human subjects to generate a map, it is a problem of classifying, clustering, and categorizing. It is a matter of (or a degree of) choice between the top-down approach and bottom-up approach. During the process of map generation, subjects needed to find out what the collection was about, how the titles were related to each other, what clusters could be formed to represent them, and how these clusters should be organized on the maps. In other words, not only did the data need to be classified but also the classified data needed to be organized on the two-dimensional grid. All the subjects felt that they were very constrained by the two-dimensional grid. They had to make compromises when deciding on a location for a group, a cluster or a title. They often wished they could put a title in more than one place. They often found that there were several different ways to classify a title, and a title could belong to several clusters and should appear in several locations on the maps. Because of all these additional constraints, the maps they generated were fuzzy. In fact they did not correctly and completely represent the semantic relationships perceived from the collection. The final maps were just one of the best maps they could generate within the given time--given more time, the resulting maps would still be imperfect.

Both the algorithm and the subjects did much more analysis on the data than can possibly be displayed on the maps. During the self-organizing process, the algorithm repeatedly maps the input data to the two-dimensional grid and gradually reinforces neighboring relationships detected during the mapping. However, not all the relationships detected are displayed on the map due to the limit of the two-dimensional grid and the limited number of cells on the grid. Similarly, the subjects repeatedly went through the data to create a map structure based on their understanding of how these things should be put together. They even read through the titles to judge the contents of the documents, using their knowledge in this area. While the organizing process benefitted from these activities, the maps did not accurately reflect the depth of such analysis. Thus, the subjects could explain their high-level organization schemes, but it would be difficult for the viewer to recognize such high-level organization schemes since the viewers structure would reflect their own labels and concept mappings. Therefore, a problem for both the algorithm and the human subjects is how to display the analyzed results more accurately, and especially how to let the viewer recognize explicitly the high-level organizational schemes that were implicitly built into the maps. An evaluation method for the human-generated maps could be whether viewers of the maps perceive the same or a similar organization scheme as did the maps creators.

4.2. Resources of Map Generation

Kohonens feature map algorithm is based on word occurrence and co-occurrence data to generate the organizational structure on the map for a document collection. It is relatively objective. Once titles are coded into vectors, their structure on the vector space is defined. The process of the algorithm is to let this structure emerge from the underlying data, independent of selected neighborhood or convergence functions.

The human subjects worked directly from the contents of the titles. To organize the maps, they depended upon understanding the words, the titles, the contents of the documents (even though they did not get a chance to read the documents), and their general knowledge of the area related to the document collection. These various resources served as a basis upon which the maps were

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built. This basis is critical for map generation, particularly for the subjects taking the top-down approach. One of the subjects noted that having a basis for the map construction was analogous to the Dewey classification approach. The Dewey approach is to form the schema first and then try to fit the documents into the schema. In contrast, the LC (Library of Congress) classification approach is to create the schema from existing documents. While the top-down approach can be analogous to the Dewey-approach (except that the subjects can modify the schema during the process), the bottom-up approach can be analogous to the LC approach. Kohonens algorithm seems to follow the LC-approach to create a structure from the input data.

Besides direct knowledge related to the collection, there are other factors that influence the map construction. The following is an analysis of some of these factors, based on our experimental data.

Existing classification scheme. Geographical classification seemed natural to the subjects. Once they decided there should be a geographical group, there were no questions, such as which country was in which continent, or how these continents were related to each other. Clusters in this group naturally followed the relations of the geographic relationships such as the continents of Asia, Europe, and North America. Similarly, when the subjects decided to have a group organized by library functions, they often clustered them by functions such as cataloging, serials, acquisitions and reference; when they decided to have a group organized by library types, they clustered them into academic, public and special libraries. These divisions reflect the common knowledge of library school students, but nothing in the data would suggest such divisions. That means it will be difficult for the algorithm to create such divisions on the map based on the data alone.

Personal view. Because many titles involve more than one aspect that can be used for grouping, the subjects had to select which aspect of each title would be classified. Such a selection often depended on their knowledge, but was also influenced by their personal views. For example, while most subjects treated electronic publishing as a topic related to new technology, one subject associated electronic publishing with text retrieval. When asked why, she explained that electronic publishing dealt with organizing text and text retrieval dealt with retrieving text, it was the text that associated them together.

Current experience. Some subjects suggested that they would probably generate a different map if they were to do it again a few weeks later, because their knowledge and their interests in this area was changing. One subject stated that he was currently interested in library automation and networking, so he treated that as a major category. That might not be a category if I did it two months later and I were no longer interested in the area, he said.

4.3. Display Formats

The subjects generated two types of maps, the association-based maps and the category-based maps. The machine-generated maps are association-based, which was also what we had in mind when we asked subjects to generate maps. We emphasized that the subjects should use document similarities to lay out a structure on the grid. However, the subjects seemed to have difficulties directly associating their perceived document similarities to any distance measures on the two-

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dimensional grid. Instead, the similarities were used for the judgment of neighboring relationships — their maps were based on more general topological rather than Euclidean relationships. Related documents were put together, but how close the documents should be put together or how far they should be apart depended upon how many documents were in their immediate clusters or groups. A third document was sometimes inserted between two documents because the third document was seen as relating to both of the two documents, or because it was judged more relevant to the first document than was the second document. The size of areas for each group seemed to correspond to the number of documents in the group, rather than to the frequencies of words that appeared in the group as it is in the machine-generated maps. One of the reasons for this difference is perhaps due to the fact that the subjects were working on a table-size grid; they could spread out all the titles and did not need to overlap one title over another. The algorithm often maps several titles to a single location.

Different people may prefer different types of display formats. Just as research on organizing personal information found that some people preferred to have files on their desks and others preferred to have piles on their desks (Malone, 1983), we found that some subjects needed to put all the titles in some physical order (such as columns or neat linear organization) before ever reading them, other subjects spread them out as much as possible in no particular order. Similarly, some subjects put groups or clusters they identified in a very neat order before they were put on the maps, other subjects just piled them together. For the same reason, the subjects generated different types of maps because of their different preferences, not because of the data.

5. SUMMARY

It is common knowledge that we need geographical maps to navigate in the physical space. It is a complete unknown territory how we can have a map to support navigation in the information space. As a first step toward understanding issues related to information maps for navigation, this experiment investigated how human subjects would like to have a map display that could show both the contents and the structures of a document space.

It was found that the task of organizing a document collection on a two-dimensional grid was challenging. Issues related to the task included understanding the coverage of the collection, identifying groups, recognizing semantic relationships among the groups, and organizing the groups on the grid. The subjects generated the maps based on their knowledge of the contents, their knowledge of existing classification schemes, their personal views and their recent experience at the time they participated in the experiment. They did much more analysis on the data than could be possibly displayed on their maps. While they could elect to use either a top-down approach or a bottom-up approach, each approach relied on going through the data iteratively to adjust for the best possible display. They emphasized the neighboring relationships among documents.

All the map displays generated by the subjects look different. Comparing these maps was difficult. Nevertheless, the types of display formats seem to be clear: they are either category-based or association-based. Through the categories, associations, and the overall organizations of the displays, the subjects attempted to show the high-level abstraction of document relationships that they perceived during the organizing process. The fact that they intuitively built one or the other

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type of the maps suggests that a certain type of visual display may appear more to certain people than to other people. It is also quite possible that a certain type of display would be favorable to certain kinds of retrieval tasks. Therefore, it is important to consider different display formats for different people and different tasks when designing and implementing map displays for information retrieval systems.

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