Elisabeth Kolmayer, Jacqueline Lavandier, Danielle Roger  
ENSSIB-CERSI, Villeurbanne, France

**Conceptual Maps: Users Navigation through Paradigmatic and Syntagmatic Links**

**Abstract:** This experiment, focused on the users' behaviour, aims to study the search topic representation they build and to highlight the role of a graphical thesaurus on their mental models and searching behaviour. The users' expertise in the field is considered. The results show how difficult it is to structure a field; they also point out how much a graphical thesaurus could contribute to such a task, but also its restricted role in the query task. They urge us to think over which shape is proper to the conceptual interface and the variety of links that have to be taken into account.

1. **Introduction**

The development of the World Wide Web and of different kinds of hypermedias gave a new impulse to the browsing process but also showed how difficult it can be. The cognitive overload and the disorientation users are commonly facing (Tricot, 1995) urge us to analyse the domain representation they build, and to study what could be done to ease the searching task.

Knowledge organization considered both in cognitive psychology and in information science highlights two different ways for knowledge organization:

- categories based on paradigmatic links (Piaget and Inhelder, 1959),
- frames and scripts, based on various syntagmatic links (Markman, 1978; Galambos, 1982).

Both modes are present in the user's mind and even closely fitted together in the categorization process (Kolmayer, 1997). The fact that one of the modes has precedence over the other varies with the user's perspective and the situation he is faced with. Information systems also use these two types of organizations and they all emphasize either the first type or the second: hierarchical organizations predominate in thesauri whereas syntagmatic relationships dominate in subject headings. In researches, the experimental conditions lead to forms of organization based on partition and inhibit the constitution of embedded classes and of term-to-term relationships. Besides, they do not make possible to assess the part played by the thesaurus and subject headings in the user's representations and their role on the searching behaviour. Such are the questions raised by the experiment that we are going to present. We will first introduce the experiment, then present the procedure and the suggested hypotheses, and then we will analyse the results.

2. **The Experiment: Domain and Population; Documentary and Computer Technology Tools**

The experiment was carried out in the field of paramedicine. Two areas have been selected: nutrition and motivity. The two experimental groups are experts and beginners in this field: on the one hand, nineteen third-year students of a nursing school; on the other hand, twenty second-year students (undergraduate in humanities). As for the use of information retrieval systems, both groups are beginners.
The database was required to satisfy four conditions: to include documents relevant to the topics of the searches which were to perform in the experiment; its size and the variety of fields must be large enough to allow a realistic experiment; it must be adapted to the nursing students group needs and level (topics of interest, specificity level, language) and, finally, include subject indexation terms based on a thesaurus. They led us to disregard the MEDLINE and PASCAL databases, and build a specific one made up of 7732 references drawn from the "Bibliographie nationale française" database on CD-ROM, relative to books, conference proceedings and dissertations in the field of medicine and paramedicine. All the references of the database include subject indexation terms based upon the RAMEAU subject headings list which offers both the hierarchical relationships of thesauri and pre-coordinated syntagmatic relationships. We retained the first ones and removed the latter by splitting the pre-coordinated subject headings. RAMEAU as a thesaurus is incomplete (isolated terms, irregular links, disparities between terms at the same level); so, further modifications were necessary: additional links between terms, reorganization of some parts of the structure. Polyhierarchy was preserved. The resulting thesaurus (793 terms) enables us to situate terms within their close semantic environment.

From the thesaurus, 206 graphical maps have been drawn and scanned. In order to achieve a good level of legibility, the number of terms has been restricted to twelve in a card (with a minimum of 5); hierarchical relationships were represented by arrows (from generic to specific terms) and association relationships were written in boxes (mentioning See also). The research system has been adapted from a commercial one, TAURUS, which allows the display of a search session and images (graphical maps) both on the same screen. It includes classical search functions (input of the request from the keyboard or by selecting a term from an alphabetical index, boolean operators, right truncation). We added a new function, THESAURUS, which allows, while elaborating the request, to display the graphical map containing the close semantic environment of the selected term. Then, it is possible to navigate from map to map: terms on maps have buttons and clicking on a term causes the display of the associated map. When a map is displayed, it is possible, too, to reformulate the query by adding new terms picked from the thesaurus.

3. Procedure and Hypotheses

The experimentation consists of two tasks. The first one - documentary -, is specially designed to elicit the role played by the graphical thesaurus in the setting up of requests. The other one consists in connecting items (building cognitive maps) in order to analyze the domain representations set up by the users and the role the thesaurus has played in the process. We make the following hypotheses:

a) In the construction process of a cognitive map, we expect to find
- a larger use or partition as an organization mode for the beginners in the field, whereas the experts will proceed with a more tree-like and closely connected organization;
- the setting up of more diverse, precise and detailed links by the experts, particularly schematic links;
- the influence of the graphical thesaurus on the connections which are made.

b) In the retrieval task, we expect that the thesaurus:
- help reformulation, as it brings knowledge on the indexation language, what should help finding more terms and more relevant ones;
- extend the levels of denomination in both generic and specific directions in the topic representation.

We expect too that such helps be larger for the beginners than for the experts.
The experiment was conducted individually and was carried out in four stages:
- The student is asked to make a first cognitive map. He has to connect 20 items belonging to the field of motivity. These items have been selected so that various hierarchical levels were represented and various types of relationships (including cross relationships) could be found. This task is carried out with paper only material: the student is given 20 cards, on which an item is written and he has to arrange them on the table; he also has at his disposal a small heap of cards with arrows.
- The search system is demonstrated to the students (still in the field of motivity); thus, all of them view the same conceptual maps.
- Two search topics are then given to the students, both related to nutrition. Before the online search, the students are asked to give four terms which could be used in the search session. Then they are asked to make the search online; they are strongly encouraged to obtain a minimum of 10 hits. During the online session, the experimenter intervenes only to solve possible technical problems.
- At last, the students are asked to make a second cognitive map for the same items as the first one they have done; the comparison between the two maps is expected to show the impact the graphical thesaurus had on the domain representation.

4. Results and Discussion

4.1. Construction of Cognitive Cards

The results confirm the hypotheses made on the general structures of the organizations that were effected and the influence of the graphical thesaurus. But those about the types of links which were used were not as significant.

The beginners in the field found it more difficult to connect the items and use partition than the experts did. As for the experts, their representations were more closely connected. The use of the graphical thesaurus diminished the differences between the two groups. A comparison of the average number of isolated blocks of items in each group for the first and for the second cognitive map highlights these phenomena in a rather significant way.

<table>
<thead>
<tr>
<th>Group</th>
<th>1st pass: average</th>
<th>sigma</th>
<th>2nd pass: average</th>
<th>sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanities students</td>
<td>3,65</td>
<td>2,03</td>
<td>1,8</td>
<td>1,32</td>
</tr>
<tr>
<td>Nursing students</td>
<td>2,84</td>
<td>2,11</td>
<td>1,79</td>
<td>1,75</td>
</tr>
</tbody>
</table>

Average number of isolate blocks for each group

But even in the group of experts, tree-likeness is far from being the only form of representation to be used and, between neat partition (with the isolated blocks) and tree-likeness, we can notice the presence of a whole series of intermediary structurations (setting up of subcategories, two-dimensional arrays).

At the second stage, the number of isolated blocks was reduced and we observed an increase of hierarchical representations. The position given to the most generic item (Appareil locomoteur) gives indication about the structurations done by the students. If - in both groups - the item received very few links, it generated more or less connections with different targets.
The item was given a more generic status by the nursing students than by the beginners and, here again, the thesaurus helps limit the gaps during the second stage. However, an analysis of the target items shows that differences remain between the two groups. For the beginners, the target items are essentially the specific terms proposed by RAMEAU (26 out of 33 established links) whereas they only account for 60% in the group of experts. In the second group the reference role of the maps seems more restricted.

It is very difficult to express clearly the nature of the links set up by the subjects since the students performances are often in contradiction with the verbal expression. The links that have been set up seem weak and lacking in precision. The hypothesis of more diverse, better differentiated links in the expert group does not seem valid. A few recurrent types can be observed, and also a mixture of these types, together with "miscellaneous" links, as "it has something to do with" or "it can be related to". The elements made explicit are the classic hierarchical links "is-a", "compound-of", "element-of", "part-of". Beside these elements, others can be found which are proper to the field - for instance, relationships such as

- The organ → the disease, or
- the disease ---> the organ, and
- the disease ---> the therapy, or
- the therapy ---> the disease.

Opposite to what was expected, these relationships were used indifferently by both groups.

Links of various nature often come together under a same item and graphs such as the following one are rather common.

![Diagram](Image)

Differences between the two groups appear when the items receiving more than one link are analyzed. Although there are differences in quantity, these items are more numerous with
the experts group than with the beginners group. The most interesting ones have to do with the nature of the target and source items. In the group of nursing students, when several links are received by an item, they are usually associative links more than GT-ST links. So, for instance, Col du fémur receives links connected with Orthopédie, traumatologie, Appareil locomoteur-maladies, Ostéochondrite and Ostéoporose, more than with Os, articulations or Hanche. This confirms the fact that the expert group emphasizes schematic links.

Although they may seem vague, even puzzling, all these results should be interpreted and discussed in terms of a learning process about structuring, of roles played by hierarchical and schematic relationships, or of conceptual models and representation conflicts. We will take them up again in our conclusion together with the results given by the interrogation task itself.

4.2. The Retrieval Task

As for the retrieval task, the terms proposed before the beginning of the search show several differences between the two groups:

- The important number of vague terms for some of the beginners ("problèmes", "méthodes", etc.) contrasted with the precise terminology of the nursing students. The latest used a specialized vocabulary (for instance, terms such as Gastrostomie, or Colopathie), more elaborate expressions and a larger number of words per term (2,13 and 1,33 for the experts in the first and second search; 1,22 and 1,19 for the students).

- The links connecting the terms to the topic are more schematic for the experts than for the beginners. Some of the links did not show up in the group of beginners (for example, they never mention the patient).

- If the experts are globally more schematic than the beginners, the latter appear to be more heterogeneous. Beginners show very different profiles (expression mainly schematic; exclusive use of generic and specific subjects; or combined solution).

During the online search, we observed that the graphical thesaurus was under-used. There was not any difference between the two groups (15 experts and 15 beginners called the thesaurus in the first search, 13 experts et 13 beginners in the second). Browsing was limited (an average of 2 cards were displayed by the experts and 2,15 by the beginners during the first search; 1,63 and 1,75 during the second one). As for the links followed, no orientation (from generic to specific, or the reverse) seemed to predominate. When used, the thesaurus was rather well mastered. However, as for the difficulty of understanding that the use of a generic term does not allow the retrieval of references indexed with specific terms, the maps did not seem to be helpful.

The thesaurus maps, when consulted, allowed some query expansion, especially with specific terms, more specialized and usually less known, such as Maladie de Crohn or Diverticulite. Maps also re-oriented the initial search on connected topics that many searchers, especially beginners, did not have in mind at start (Cancer du colon, Diarrhée). Some verbalizations brought us to think that beginners also use the thesaurus in order to check the meaning of an unusual term or to infer the sense of a term (Alimentation parentérale).

Other reformulations are done from the alphabetical index. The use of the alphabetical index which is more direct than the use of a thesaurus, seemed to be sufficient to some of the searchers. As the domain is well defined, an index is more precise and its use more efficient. Therefore, the observed reformulations come from words taken out of the thesaurus as well as from the index.

The reformulations generated with the use of the thesaurus are mainly hierarchical. On reverse, the terms given before the search but that were not used in a query were mostly terms

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refering to a schematic representation (for instance: *handicap, tuyau, causes, adulte*). Reformulations obtained through browsing were limited reformulations. The searchers had either to use indexing terms or titles of the retrieved records, or to rely on their own knowledge and medical schemes. Syntagmatic reformulations are rare. But even when the thesaurus was not used, the reformulations usually went from a schematic representation to a hierarchical representation and not the reverse.

Experts showed better performances than beginners. They went directly to the subject, selected faster the terms indexed in the thesaurus and the alphabetical index. They all found without too much problem the three most relevant terms for the first topic, whereas only 12 out of the 19 beginners succeeded. The beginners that obtained the best results were those who moved from a combined relationship (schematic/hierarchical or pure schematic) towards a schematic/hierarchical relationship. That move, even eased by the use of a thesaurus, was possible without its help too.

5. Conclusion

This study is a first approach to the various navigation behaviours adopted by users. It was carried out on a limited number of users. It leads to further interrogations and possible directions. Here are some of them.

Spontaneous organizations differ rather widely from those implicitly present in thesaurus with its term-to-term links. The difference is especially significant when the users are beginners in the field. Even with a graphical display, is a thesaurus the best way to present the conceptual layer constituted by a navigation interface? What other forms could be considered? Here it should be interesting to have comparative approaches.

The links established by the users themselves seem vague. We can observe that schematic links are more frequently used by experts and allow richer reformulations. That would lead us to define and present these types with more variety and rigour than proposed by a thesaurus. It would be interesting to allow the display, on demand, of either the hierarchical or the schematic environment of a term. New experiments should be elaborated.

Even if a graphical thesaurus is not the best of the browsable interfaces, it brings a help to users and facilitates the structuring task that is basically required by searches. But the graphical thesaurus is helpful under two conditions: not to bring too many new concepts and not to get into conflict with the previous mental models of the users. The question is now: how could it be adapted to the users?

We would like to stress a final point on the requirements of a behaviour oriented research: a good search and navigation device, a documentary collection of a realistic size and scope, significant experimental groups and an appropriate documentary device are needed. Numerous prototypes are developed, but their connections with a real documentary environment are difficult. Most of the time, they are not tested with real users. How then could research carried on prototypes and research on users behaviour could be combined so that tools developed by the first group of researchers could be used by the second group?

Notes

I According to Borgman (1986), conceptual maps are related to the model of the thesaurus; cognitive maps are related to the mental model of users.
References