How to find information on CD-i

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How to find information on CD-i; a question of a quest?

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Summary

This report describes an investigation into the way users work with information structures in a typical CD-i infotainment title. Focus is on three specific aspects:

- exploration strategies (what is accessed and when?),
- conceptual models of the information structure (how does the user see the structure?),
- the use of navigation tools (which buttons are pressed?).

We set up an experiment involving a CD-i title ('De Vliegende Hollander') with some 150 information items arranged in an irregular tree structure, at places 9 levels deep. The 17 subjects were asked to explore the title freely, to perform a series of drawing, information search, image search and composition tasks, and to answer a series of questions in an interview. The results are interpreted in terms of a navigational model proposed by Edwards and Hardman (1989), and generally agree with their reports. More specifically, we find:

- that it takes some 20-30 minutes before the subjects start to feel at ease about the information structure and to pay more attention to the information contents of the disc.
  After more than one hour only a small portion (25%) of the information was explored, and many of the deeper levels had not even been accessed at all, while the interest of the subjects was diminishing already.
- that knowledge about local information structure elements is established prior to global knowledge, where the change from local to global occurs after some 20-30 minutes.
  Some interface elements (as the visibility of hotspots, the presence of parts of previous environments, the time interval between subsequent items, and semantic coherence between items) contribute to the feeling of distance or nearness between information items on the disc, probably more than the actual number of steps (button presses) between them.
- that there is no noticeable development over time in the usage of the various available navigation buttons (back, main menu, etc.), except that people stop using buttons that give unexpected results. Thus navigation means must be self-explaining, consistent and suitable for the situation.

Contents

1 Introduction

The experiment described in this report was done in the context of contract research for Philips Media Systems. The general topic of this research program is to improve the user-interface of CD-i, compact disc interactive.

One of the aspects of the user interface is navigating through the contents of a disc. Literature about navigation mainly considers task-oriented environments like hypertext. This literature supplies us with useful insights about navigational strategies that humans use and how these can be matched with various hypermedia topologies (Van Dyke Parunak,1989) or with methods to describe how users move around in information structures (Canter, Rivers and Storrs, 1985).

CD-i differs from hypertext being an entertainment-situated medium and having users that range from persons that are highly skilled on this platform to absolute novices that also may lack any background in using computers or handling large amounts of information. All of them must be able to find their way in the available information. Therefore an experiment was designed to find out more about navigation in CD-i.

A major aspect of navigation is the organization of the information that is on the disc, further referred to as the information structure (Majoor and Westerink, 1994). The understanding of this information structure probably contributes to feelings of comfort or discomfort of a user.
The experiment was focused on the development of the user's internal representation of the information structure while he[1] explores a new title. From literature a model was adopted that describes the development of insight in information structures in terms of a physical environment. More about this model can be found in section 2.
Section 3 gives an overall description of the set-up of this experiment. Section 4 describes the elements of the experiment in more detail, including the hypothesis that were tested, the method of data collection and the results of the analysis of the data.

Most of the collected data were the results of assignments, designed to answer specific research questions. However during the experiments other topics turned up as well. They did not contribute to a quantitative analysis but on the other hand they were interesting enough to discuss them here. These additional observations can be found in section 5.

This experiment was meant to give a first impulse to further research on navigation in complex data structures. The set-up that was used here had an explorative nature. The conclusions and the recommendations that were induced by this experiment are discussed in section 6.

1. Throughout the document we'll refer to the anonymous subject as he, while we'll refer to the experiment leader and the experiment assistant as she.

2 Navigation model

When users explore an information structure they gradually develop an internal representation of this structure. In the literature about navigation in physical environments, like cities or buildings, this development of an internal representation is called cognitive mapping. From this physical domain we adapted a model that describes four developmental stages in the growth of cognitive maps (Edwards and Hardman, 1989), each stage being superior to the preceding one.

1. In the first stage a person will describe his environment by means of landmarks: notable objects like a church, a beautiful tree, a statue, etc.

2. The next stage concerns the development of knowledge about routes. In this stage a person knows where to turn left or right, related to the previously acquired knowledge about landmarks.

3. In the third stage a person combines previously gained knowledge into the creation of minimaps. The minimaps represent survey-type knowledge of small areas of the domain.

4. The last stage finally results in the acquisition of a total survey of the area.

The knowledge about navigation in physical environments like cities or buildings is used to gain insight in how people navigate in data structures, particularly in hyper-text (Edwards and Hardman, 1989, Dillon, McKnight and Richardson, 1990). Here we want to apply this model to consumer-oriented data on CD-i. As many other consumer applications, the particular CD-i title we chose for the experiment ('De Vliegende Hollander') makes use of a spatial metaphor for its data structure, so it is even more related to a physical environment than is the text-oriented environment of hyper-text. Therefore we expect that the navigation model, described here above, can be very useful to support the main goal of this experiment: gaining insight in the development of the internal representation of an information structure on CD-i.

3 Experiment description

3.1 Materials

For this experiment an existing CD-i title was selected that is representative for information-type titles. It was the Dutch spoken title 'De Vliegende Hollander' about the large Dutch trade empire the 'Verenigde Oostindische Compagnie' the VOC, that operated in the far east during the golden centuries. The title uses the 'point-&-select' paradigm and consists of an information section, with short documentaries about the VOC, and a game that is based on the knowledge that can be gathered from the information section. The disc makes use of the metaphor of a submarine that contains a corridor with general information and a number of guided tours, a control room where the game can be played and a study that contains all documentaries (information items) about the VOC and other related topics.

The information on the disc is organized in a simple but somewhat irregular tree structure, that is depicted in appendix A. There was one 'hyperlink' available between the control room and the study. In the rest of this report the whole game section will be considered to be a single node in the total tree structure as we didn't look further into it. The depth of a level in the tree structure will be indicated as level n, where n can be found in the scheme of the structure (see appendix A).

3.2 Equipment and environment

The equipment consisted of a consumer CD-i player, a Philips CDi205, and a 27" television set, Philips Matchline. A CD-i trackball was used as input device for the CD-i player.
The experimental sessions took place in the cognitive laboratory at IPO. To simulate sort of a living-room situation the television was placed on a low table and comfortable armchairs were available for the subject and the experimenter. The distance between the chairs and the television set was about 2 m.
Two miniature cameras and a microphone were used to record on video tape both the subject's actions and comments and the output of the CD-i player on the television screen.

3.3 Subjects

17 Subjects participated in the experiment, 9 male and 8 female, aged between 20 and 44 years. They were selected from the institute's subjects pool. This pool contains a relative high percentage of students, but it was made sure that also non-students were participating so that eventually there were 9 students and 8 non-students. Before subjects were invited to take part in the experiment it was verified that they would like to be busy for about two hours with a CD-i title about the VOC. Earlier experiences showed that without interest in the content of a title no serious results can be expected (Westerink and van den Reek, 1994)

3.4 Procedure

Here we discuss briefly the outline of the experiment. More details, e.g. on exact questions and tasks in assignments and interviews, will be given in section 4.

Introduction
The subject was put at ease by presenting coffee and with chit-chat about other experiments they had earlier been involved with. Then a user profile checklist was filled in. The experimenter informed the subject about the presence of cameras and microphone to which no one objected.
A short introduction was given on the background of the experiment and the CD-i title 'Sesame Street, numbers' was used to introduce the subject with CD-i and the way it works. When the experimenter had the impression that the subject could handle the trackball and the point-and-select paradigm of CD-i, 'Sesame Street' was exchanged with 'De Vliegende Hollander'.

Browsing and assignments
The subject was instructed to imagine that he just had bought 'De Vliegende Hollander' and that he now is at home and wants to find out what it is all about. The subject was allowed to explore the CD-i title for 10 minutes, during which the experimenter left the room (browsing task). Then the experimenter came back and gave the subject some assignments like: find information about topic A (information search task), how far do you think that information is from your current position (distance estimation); do the same for information about topic B; try to draw what you know at this moment about this CD-i title (drawing task).
The procedure described here above was repeated 5 times.

Image search task
The subject was given a folder with 16 multiple choice questions, numbered from 1 to 16, about 'De Vliegende Hollander'. The questions were illustrated with prints of screens from the CD-i title. The subject was asked to answer 4 of these questions, indicated by their number on an answering sheet. He was instructed to search until the illustration of the question occurred on the screen, even if he knew the answer without searching,. The subject was informed about time limits: max. 5 min. per question. When it was made sure that the subject understood the instructions the experimenter left the room.

Interview
In this part of the experiment the subject was given the opportunity to ventilate comments on aspects that caught attention. Open questions were used to inquire about strengths and weaknesses of the title and to elaborate on topics concerning navigation. Some 15 minutes were used for this part of the experiment.

Composition task
The subject was given two large sheets. One of them contained the labels of all information items that are in 'De Vliegende Hollander' as well as small photographs of the screens from which the items can be selected. Each label or photo was printed or glued on a post-it note, so that they could be moved freely around. The other large sheet was empty. The subject was informed that this material represented all the information that was on the disc and was asked to make a representation of the information structure of 'De Vliegende Hollander' on the empty sheet. The subject was free to use only labels, only photos or to combine labels with photos,. and was instructed to draw lines or arrows to make connections. A small example of a possible (but faulty) composition was given. It was emphasized that we were especially interested in the connections between the elements that were used. The subject was installed on the floor with the two large sheets and was given 20 minutes to make the composition while the experimenter left the room.

Debriefing

The whole procedure took between 2.5 and 3 hours. All subjects were very cooperative and, in an highly informal debriefing conversation, expressed afterwards that they had enjoyed participating in the experiment.

4 Results

In this section the parts of the experiment are presented in more detail. For each part the underlying assumptions are discussed as well as the parameters that are manipulated to find out more about the mechanisms that may play a role. A description is given of what data is collected and, if necessary, how it was derived from the raw data. Finally the data is analysed and interpreted.

4.1 Statistical methods

The following methods are used to analyse the (raw) data. First MANOVA repeated measures is used to analyse variables that are composed of a hierarchical structure of factors, measured several times. A two-way anova is used to compare the scores between groups. The non-parametric Man-Whitney U test is used as a two way anova for variables with no normal distribution. Sometimes the non-parametric Friedman test is used to compare related variables with no normal distribution as well. The non-parametric Wilcoxon test is used to compare pairs of variables with the same assumption. The chi-square test is used to compare categories within a variable. For all these tests the hypothesis is, that there is no difference between the variables or groups that are compared. To measure the exact correlation between two variables with integers, the pearson correlation coefficient is used.

4.2 Browsing task: description & results

Task description
The subject was asked to imagine that he is at home in a lazy chair and that he is going to explore his just-bought CD-i disc. It was emphasized that the subject should not try to anticipate on possible questions, but just to do as he pleased and to have fun. Five periods of 10 minutes each were used for this task, interleaved with periods with more specific tasks, that will be described in the next few sections (4.3, 4.4 and 4.5).

Hypothesis and parameters
This part of the experiment is meant to get an impression of the explorative strategies that users apply when they are confronted with an unknown information structure. The assumption is made that the subject is eager to find out more about what information is available (in this case stories and a game about the VOC). The data from this section can give an overview of the penetration of the information structure. It is expected that the number of items that are seen increases over time and that the penetration of the information structure will become deeper as time develops.

Parameters that can be of importance for the browsing behaviour are the shape of the information structure itself and the factor time. Here only one information structure was used. However it is a very irregular structure with deep, shallow, broad or small parts in it. Maybe these sub-structures can give information about the likeliness of penetration of such structures. The other factor, time, is introduced here in the shape of time periods. Development over time will be expressed here as development over time periods.

Data collection
While the subject explored the information structure, the menus and stories that were seen were annotated by the experiment assistant on the representation, or map, of the information

structure of the title (see appendix A). This did not include double paths. Each time period was marked with an other colour which after five time periods resulted in an overview of the development over time of the penetration in the information structure.

To obtain quantitative data the annotated items were labelled with entities from the navigation model (see section 2). Two entities were used:

- Content items (stories) are entities with a high uniqueness and specificity and moreover, they are indicated with a name. We therefore thought it acceptable to view these items as landmarks. Landmarks were classified according to their level in the information structure (appendix A). A landmark was considered to be accessed by the subject if he had actively selected the item in a menu (and thus had seen at least the beginning of the story).
- Minimaps give a local view of part of the information structure, and so do menus. We therefore considered a menu to be a minimap, with the convention that a landmark (content item) and the minimap that followed it were considered to be at the same level in the information structure (appendix A). A minimap was considered to by accessed by the subject if he scanned the menu involved for at least 2 of its options.

Subsequently these entities were counted for the browsing task only and for the browsing task plus information search task (see sections 3.4 and 4.3). Counting was done per time period per level of the information structure.

Data analysis

After 5 periods of browsing (50 minutes), the subjects explored about 20 landmarks and 7 minimaps. Respectively, this is only 14% of the total available landmarks, and 22% of the total of available minimaps.

Figure 4.2.1 shows the percentage of visited landmarks and minimaps per level of the information structure (see appendix A) after five browsing periods. As we can see, the landmarks on the first level were fully explored by all subjects. The percentage of the explored landmarks within the deeper levels of the information structure, declines significantly ($p<.01$). None of the subjects came as far as level 9.

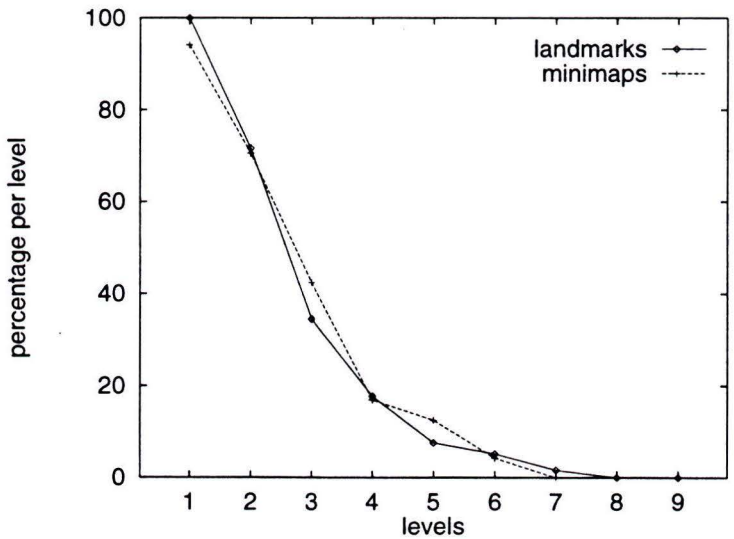


Figure 4.2.1 The percentage, per level of the information structure, of landmarks and minimaps that was browsed during the 5 time periods.

The data of the minimaps shows a similar trend. Level 7 was the deepest level reached, so subjects did not come as far as level 9 either. However, a higher percentage minimaps than landmarks was explored at the levels 3 and 5.

Per time period about 3% of the total of available landmarks is explored. The variation over the periods is significant ($p<.01$), but this is only due to the first time period, in which more landmarks are accessed. Apparently there is no effect of fatigue or of raised interest during the following time periods of browsing (see figure 4.2.3a).
In contrast with the landmarks, relatively more minimaps, about 4.5% of the total of available minimaps, are explored per time period. A slight, but significant ($p<.01$) decline of new minimaps over periods is found, indicating a change in the exploration behaviour (see figure 4.2.3a).
Considering the proportion of visited landmarks and visited minimaps, a change over time can be observed as well. Per time period about 3 landmarks per minimap are visited. However, in the first two periods, not even 2.5 landmarks per minimap are explored, whereas 4 landmarks per minimap are seen in the third period, and 3 in the last two periods. So, in the first two periods, the subjects are more concerned looking for minimaps that tell them about the structure of the title. The content, reflected in the landmarks, is more carefully explored in the third and following periods.

A significant interaction is found between the landmarks seen per level, and the landmarks seen per time period ($p<.01$). This is illustrated in figure 4.2.2a. The curves for the time periods 1 to 5 have maxima that lie respectively on levels 1, 2, 2, 3, and 3. These maxima indicate that the exploration of the available landmarks shifts slowly over time into a deeper level of the information structure.
Also for minimaps, an interaction is found between the percentage of minimaps seen per level and minimaps seen per time period ($p<.01$), as well (see figure 4.2.2b). The curves for the time periods 1 to 5 have maxima on level 1, 3, 5, 4 and 3. Thus period 3 appears to be the critical period of behaviour change: after 2 to 3 time periods, subjects tend to change the browsing behaviour from a depth search into a width search. Comparing the maxima of the landmarks with the maxima of the minimaps, periods 2 and 3 seem remarkable as well: in these periods subjects searched the minimaps at a deeper level than the landmarks. This behaviour can be interpreted as looking for the structure. Figure 4.2.2 shows that it is much less outspoken for the later periods. Summarizing, the first 2 -3 periods can be characterized as looking for structure into increasing depths.

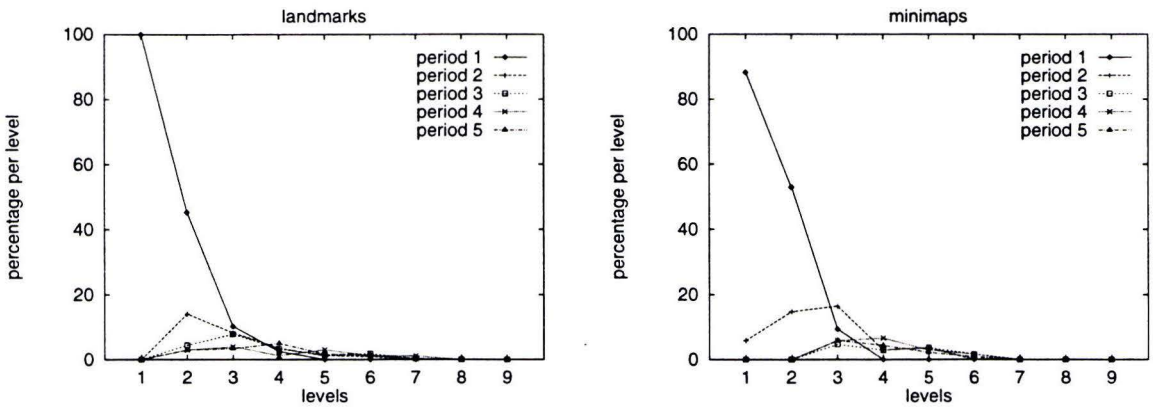


Figure 4.2.2 Percentage, per level of the information structure, of landmarks (a; left) and minimaps (b; right) that was browsed per time period.

After each browsing period, subjects have carried out an information search task using the same information structure (see sections 3.4 and 4.3). Adding landmarks and minimaps accessed to the browsing data, the influence of the information search task can be calculated. At the end of all browsing and information search tasks, the subjects had explored 37 landmarks and about 10 minimaps, which is 26 and 30%, respectively, of the totals available. So, 17 landmarks and 3 minimaps are due to the information search task. The information search task enhances the exploration of the landmarks mostly at levels 4 and 6 (compare figure 4.2.1 with the appropriate curves in figure 4.8.1). These levels correspond with levels of solution (destination) of the task and the ones prior to these. During the information search task, the minimaps are visited mainly at levels 3 and 5. This is not a surprising result: the minimaps at levels 3 and 5 are visited, because their menus give direct access to the levels of solution.

We have tried to measure the browsing behaviour of the subjects during the navigation. According to Canter, Rivers and Storrs (1985) different *exploration behaviour patterns* can be distilled, depending on the target that the subjects have in mind. The target could be just to enjoy the information of one's interest, or to find a specific target within the structure. We expected the former target patterns during the browsing task, the latter during the information search task.

In the experiment, similar distinctions are reflected in an objective measure for the browsing behaviour of the subjects: the balance between the visited landmarks and the visited minimaps. In figure 4.2.3 two types of patterns become clear: periods in which the percentage of minimaps visited is more or less equal to that of visited landmarks, and periods in which the percentage of the minimaps is considerably higher, such as in the first periods of browsing and during the information search task. We intend to interpret the balanced situation as a reflection of content exploration: if you use the CD-i as it was intended (content viewing), you are likely to visit roughly equal percentages of landmarks and minimaps. Notice that we expected this to happen during browsing, not during the info search task.

The unbalanced situation with higher percentages of accessed minimaps than of landmarks, on the other hand, can be interpreted as a result of a more hectic exploration strategy with a specific target in mind: one is not interested in the content (of the landmarks) itself, but rather in unravelling the structure (minimaps consisting of landmark labels). As we can see this behaviour is found in the information search task, where the subject indeed was requested to find a specific target (landmark). The imbalance is also found in the first two periods of browsing, and we presume that in these periods subjects have a specific goal as well: building up an

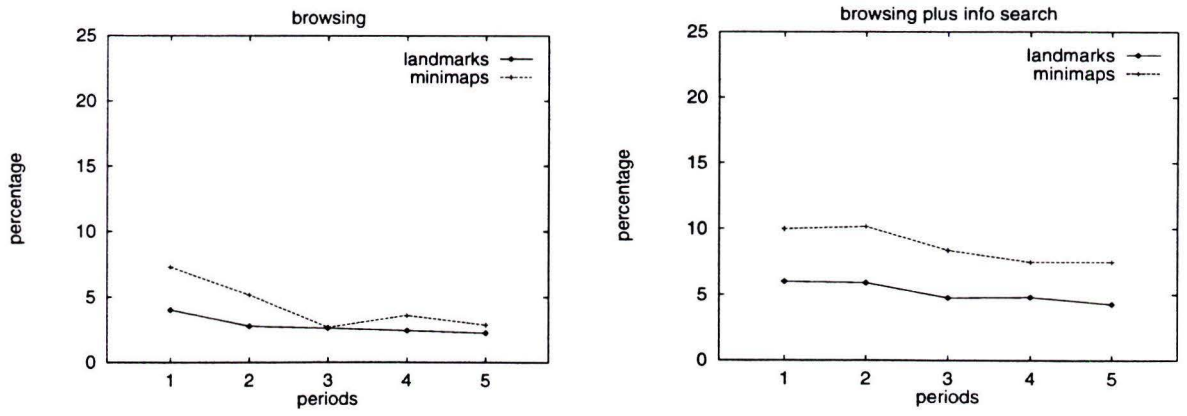


Figure 4.2.3 The balance between landmarks and minimaps during browsing only (a; left) and during browsing plus information search (b; right).

image of the type of information structure. This agrees well with our previous finding (from the data on the shifts of the levels with most browsing activity over the time periods) that subjects spend the first 2 - 3 periods looking for structure in the information using a depth search. In conclusion, it is only after some 20 minutes that the subjects start to use the CD-i title in the relaxed way it was intended.

The collected data did not lend itself to a straightforward analysis of the way in which the forms of sub-parts of the info structure (deep, shallow) influence the penetration. However, we did make some qualitative observations on this matter, which are reported in section 5.2.

4.3 Information search task: description & results

Task description
After each browsing period the subject was given an information search task (see appendix B). First the subject was asked to find specific information. Before the actual search process started, the subject was asked to estimate the distance between the starting point and the place where he expected that the information could be found. This estimation task will be discussed in detail in the next section (4.4). Then the subject started to search for the wanted information. If he didn't succeed within a pre-defined time period (3 minutes), he received a hint on where to look for it. If that didn't help (2 extra minutes), eventually the experiment leader would help him to reach the specified information. After the destination was reached the subject was asked again to estimate the distance between starting point and destination (again, for details see section 4.4). Then the whole procedure was repeated for a second time, with the exception that now no help was offered if the subject could not find the information and that the search was stopped after a time limit of 3 minutes was exceeded.

Hypothesis and parameters
There are many factors that can make it more or less difficult to find specific information. Here the focus was be on the role of the structuring of the information. It may be plausible that information located on a level far from the root of the hierarchy, will be more difficult to find than information that is located nearby that root. Furthermore, the distance between two locations may be identical in terms of steps, but it may be easier to go from one location to the other if both locations are situated far from the root, than in the case that they are near the root of the information structure: in the first condition it is likely that the information of the two locations is more specific and more closely related to each other than it is for the second condition. Other factors that can play a role are the navigation means that are offered and the knowledge of the information structure that probably grows over time.

Information search tasks were developed to test the assumptions here above. The tasks met the following specifications:

- The starting position (after the browsing period) is called location X; this could not be controlled by us.
- The first search task brought the subject from location X to location A (XA-task).
- The information from the second search task could be found on location B (AB-task).
- The path from A to B always consisted of 3 steps: 1 step backwards and 2 steps forwards in the information tree structure; this was done to be able to focus on the location in the information structure, without extra parameters like actual path length.
- There was 1 search task with A located on level 3, there were 2 search tasks with A on level 4 and 2 search tasks with A on level 6.

- The search task of the first period was identical for all subjects, A was located on level 3; this search task was meant to give the subject an easy start.
- The search tasks for the second to the fifth period were also identical for all subjects, except for their order: for half of the subjects A was successively on levels 4, 6, 4 and 6 (target destinations B on levels 5, 7, 5, and 7), for the other half A was on levels 6, 4, 6 and 4 (target destinations on levels 7, 5, 7, and 5). The two groups of subjects will further be referred to as group-5757 and group-7575.

The first task (from X to A) was meant to bring the subject in a well defined starting position. This was the reason that a subject was assisted in case he had difficulties to get there. The second task (from A to B) was using a well defined path (length and pattern) but was situated on different levels in the information structure. If in this case a subject had difficulties to find the information that was asked for no support was given, to avoid too much induced knowledge about the information structure. The formulation of the tasks and exact positions of destinations A's and B's are given in appendix C.

Data collection
For each information search task the following facts were registered:

- whether the task was completed successfully or not (if the subject received extra information the task was considered to be not successful),
- the number of steps (level changes) that was used to fulfil the task,
- the minimum number of steps that was necessary to fulfil the task;
  for the AB-tasks this number was always 3.

The path that the subject traversed while searching for information was annotated on a map of the information structure. For each time period a new map was used, which made it possible to note down every step that was taken, including the double paths that were taken. This made it possible to count the navigation means that the subject had used. The following categories were discriminated:

- forwards (by selecting an item),
- backwards with the '<<' button (fast backwards) from the tool bar or from a menu,
- backwards with the '<-]' button (back to main menu) from the tool bar or menu,
- backwards but not retraceable how this was established, and
- backwards established by the system.

Data analysis
The XA-tasks could not be controlled by us and therefore were not taken into account in this analysis. From the AB-tasks especially the tasks with A on levels 4 and 6 are of interest to us because we included two balanced groups in our design using those levels of the information structure.

The effectiveness of the search efforts is rather poor. The AB-task in period 1 (meant to be a warming up with a target at level 4) had a success-rate of 88%, but for periods 2 to 5 resp. only 6, 18, 29 and 41% of the AB-tasks (in each time period half of the targets at level 5, and half at level 7) was successfully completed by the subjects.
Apparently, the task at level 4 is much simpler, although no significant difference was found between level 5 and level 7 tasks. For these more difficult tasks, the subjects gradually improve the effectiveness of their search efforts. So they gained knowledge about the information structure and learned to apply this knowledge for searching goals. The low effectiveness, even in

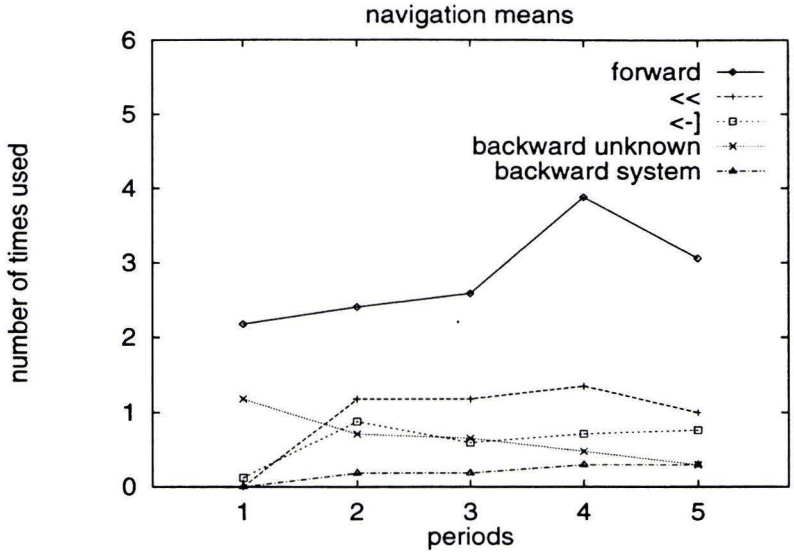


Figure 4.3.1 Mean number of times per subjects that navigation means were used to execute an information search task.

period 5 not even half of the subjects could complete the task successfully, must be due to a lack of knowledge about parts of the information structure. The destination targets of the information search tasks were located on levels of the information structure that were only partly explored. The insight in the information structure that most of the subjects had developed possibly did not include these parts of the information structure yet.

Figure 4.3.1 shows the navigation means that were used to search for the target information. The increase in steps forward seems to indicate that during the progress of the experiment the subjects became more persistent to find the target destination. The usage of navigation means to go backward in the information structure, didn't change over time. Perhaps people develop a way to use the available navigation means and are cautious to try out other ways.
The data indicate that with the given information structure, navigation means and search mechanisms it is difficult to find specific information. During the course of the experiment there is no improvement in the usage of navigation means. However, the gradual increase in the number of steps forward that subjects take to search for a destination is interpreted as an increasing persistency and perhaps even an increasing believe in their ability to find information.

4.4 Estimation of distances: description & results

Task description
Before and after an information search task, the subject was asked to estimate the distance between the starting point and the place where he expected to find, respectively had found, the wanted information. A distance bar running from 'dichtbij' to 'ver weg' ('close by' to 'far away') was used to point out the estimated distance (see appendix B).
The subject then was asked to motivate his estimation.

Hypothesis and parameters
A subject will always have some idea about the distance from his current position to another location. This may be a well defined estimation in case he has a good knowledge of the information structure or very vague guess in case he has no clue on where to search. It is not clear in

what dimension his estimation takes shape: it can be the number of steps to go, the amount of time that will be needed, the diversity of information content or maybe other dimensions as well. Also the position in the information structure may be of influence to the semantic coherence of information. Locations that are situated near the root of the hierarchy probably contain more diverse information and may give a feeling of large distance. Locations that are located further from the root will contain more specific information that is likely to be more related. In that case the distance between the locations may seem to be closer to each other. It may well be that this kind of mechanisms influence the perception of distance in which case a subject will adjust his first estimation after completion of the search task.

The information search task was designed in such a way that the distance between the locations A and B was always the same in terms of steps (see the description of the information search task in section 4.3). The parameter that is controlled here is the level in the information structure on which the events take place. Another, less controlled, parameter is the subjects' knowledge of the information structure that grows over the time periods.

Data collection

The data was quantified by calculating the fragment of the maximum distance that was used on the distance bar (so, if the subject had marked his estimation at the middle of the bar, the distance was 0.5, where 'dichtbij' = 0.0 and 'ver weg' = 1.0). The motivation(s) for the estimation that was made were classified in one of the following categories, according to the navigation model we adopted (see sections 2 and 4.2):

- mentioning landmarks (like, 'I'll have to go to *Japan* first'),
- route based motivation (like, 'I'll have to retrace 1 step'),
- using indications about the information structure (minimap and survey based, like 'This is more specific info'), and
- don't know (missing values).

Data analysis

Here we were only interested in the AB tasks with B on levels 5 or 7. So, the data from the XA-tasks and from the AB-tasks from period 1 are not used for this analysis.

The average a priori estimation of the distance between destinations A and B is 0.53. For the successfully executed tasks the a priori estimation is 0.50 and after execution 0.44. There is no significant influence of the time periods. The subjects do not learn to make better estimations. Neither did the 2 groups 5757 and 7575 give different results, which means that there is no influence of the level on which the target information was situated.

There was no significant difference between the types of motivation that were used by the subjects to discuss their distance estimation. On average subjects used more landmark- and survey-type motivations (resp. 28 and 26%) than motivations with route indications (7%). Again, the two groups (5757 and 7575) do not show significant differences. This implies that the level of the target information is not found to influence the landmark/route/survey motivations.

We also wanted to interpret the data according to the model that Majoor and Paulissen (1995) used to categorize a database of remarks about the user interface of CD-i discs. They discern three layers in the interaction between user and system:

- syntax (about perceptive issues including the way in which the interaction is effectuated),
- semantics (about cognitive aspects like understanding the purpose and meaning of components of the interface),

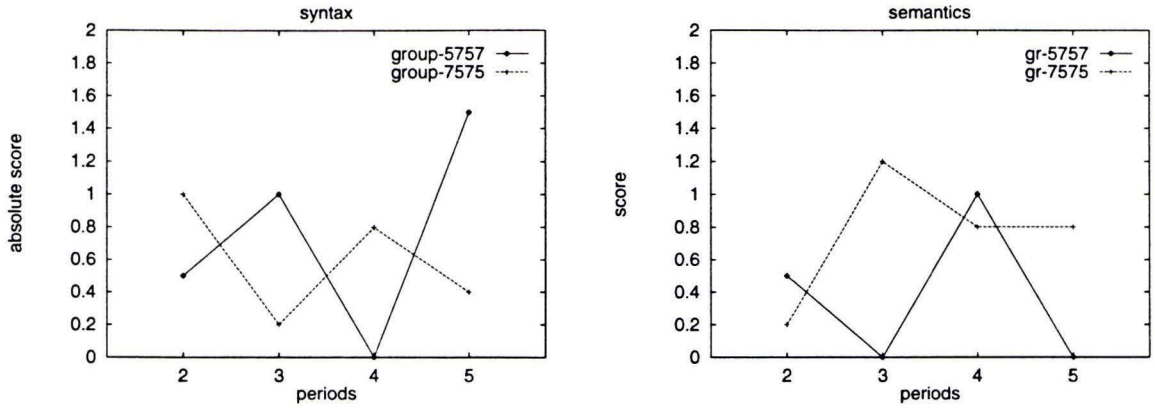


Figure 4.4.1 The average number syntax-type (a; left) and semantics-type (b; right) motivations used per subject, subdivided into subject groups who received a different order of the level on which the target information was situated.

- involvement (concerning high level issues like emotion, satisfaction, the expectations a user has from a CD-i disc and the pleasure he gets from the interaction).

The concepts of landmarks and routes have a local character: they explicitly show up in the interaction dialogues. Thus they can be attributed to the syntax layer. The more global concept of survey and minimap knowledge demands more of the cognitive abilities and is ascribed here to the layer of semantics.

The two types of motivations, syntax- and semantics-based, are about equally often used (38 and 41% resp.). Now a significant interaction ($p<.05$) between groups, motivations and periods becomes visible (see figure 4.4.1). As each motivation has its maxima in periods in which one and the same target level is involved, irrespective of the subject group, this indicates that there is an influence of the location in the information structure on how people experience their environment. Syntax-type motivations occur more often at the deeper levels of the information structure where the coherence between the information items is relatively high. This seems to impose a feeling of being in a small, local area. Semantics-based motivations occur more often at levels closer to the root of the hierarchy. Here the coherence between topics is much lower. Subjects might experience this as being in a large area (global).

4.5 Drawing task: description & results

Task description
Each time period of browsing & information search tasks was concluded with a drawing task. The subject was asked to draw a representation of his image of the contents of the disc thus far. Sometimes it took a lot of persuasion to make subjects do this, but finally they all managed to draw boats, overviews, structures or whatever they thought suitable to represent the things they had seen.

Hypothesis and parameters
The drawings will depend upon what the subject has seen until then. The most recent browsing period may be the source of (additions to) the drawing, but also all preceding time periods may contribute to what the subject puts on paper. The type of elements that are drawn can evolve

over the time periods. According to the navigation model people first learn to think in terms of landmarks and will later make use of routes and the more global oriented minimaps. It should be possible to find this mechanism back in the drawings. The representations that are used can give insight in the way that a subject builds up an image of the information structure. This image can stay close to the metaphors that are used, but it can also be some sort of abstraction or take other forms as well.

The only parameter that was used here is the factor time, as the internal representation of the information structure will evolve over time. The development over time will be expressed here as development over time periods.

Data collection

To quantify the data, the various items of the drawings were labelled with entities from the navigation model (see sections 2, 4.2 and 4.4):

- Titles (labels) of stories, or words that very much resembled that titles, were labelled as landmarks.
- Arrows pointing at or from landmarks, or the suggestion of arrows e.g. by grouping of landmarks, were labelled as routes. This definition restricts the meaning of 'route' to a single step (level change), whereas a path is a concatenation of one or more routes (steps). A route was considered to be at the same level as a landmark if the (suggested) arrow was pointing *from* that landmark.
- Landmarks with at least two outgoing routes were labelled as minimaps.

Data analysis

Following the above definition of a route, we find that each landmark at level N>1 can be seen as a route at level N-1, except four routes (arrows) that do not have a landmark drawn behind it. But this exception turns out to occur only seldom. Therefore, it suffices to discus the results for landmarks and minimaps. We find that after 5 time periods 13% of the total amount of landmarks and 12% of the total amount of minimaps is drawn.

If we look at the amount of landmarks drawn per level of the information structure, we see that about as many landmarks are drawn as there are seen during the browsing periods (see figure 4.5.1a). The peaks that were caused by the execution of the information search tasks are

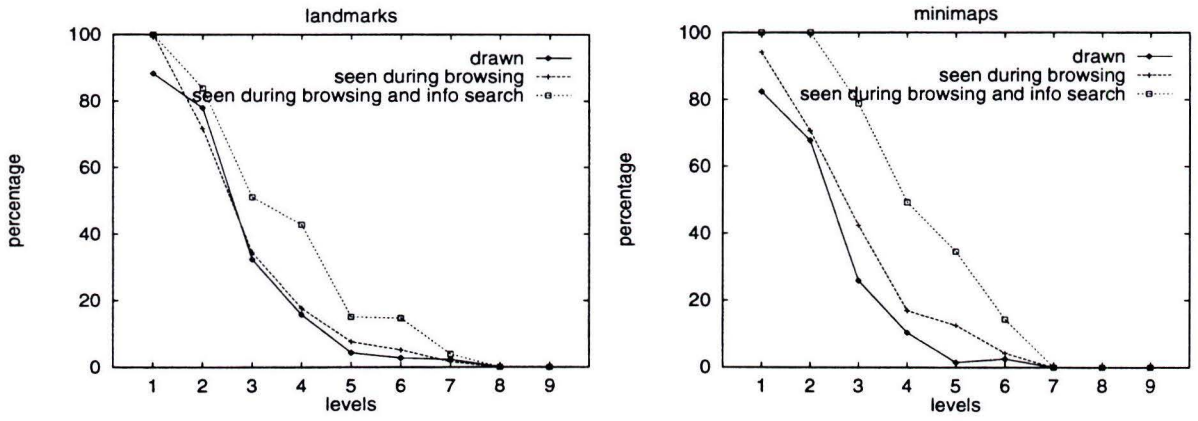


Figure 4.5.1 The percentage, per level of the information structure, of landmarks (a; left) and minimaps (b; right) drawn during the drawing task, seen during browsing only and seen during browsing plus information search task after 5 time periods.

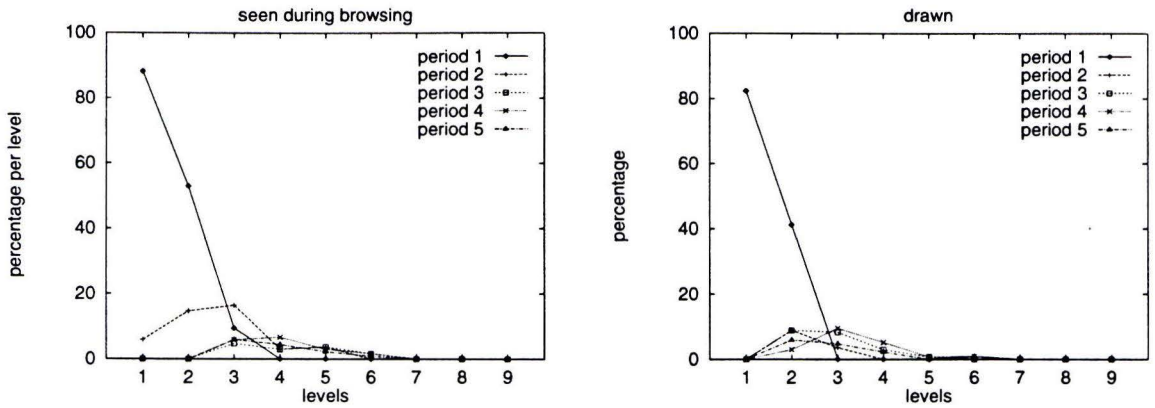


Figure 4.5.2 Percentage, per level of the information structure, of minimaps seen during browsing (a; left) and minimaps drawn (b; right) per time period.

not found back in the data of the drawings. Plausible explanations for this behaviour are that information seen during the information search task is less frequently visited than information seen during browsing. Furthermore, it might be the case that subjects didn't like to reconstruct knowledge that was induced directly by us. Subjects might aim at building a global image of the information structure and didn't incorporate the more detailed information that resulted from our information search task.
There is a significant interaction between the percentage of landmarks seen per level and landmarks seen per time period ($p<.01$). The curves for the time periods 1 to 5 have maxima on levels 1, 2, 3, 4 and 2 respectively.

The minimaps show another course than the landmarks (see figure 4.5.1b). Here the amount of drawn minimaps is even lower than the amount of minimaps seen during browsing.
There is a significant interaction between the percentage of minimaps seen per level and minimaps seen per time period ($p<.01$). The curves for the time periods 1 to 5 have maxima on levels 1, 2, 2, 3 and 2 respectively. If we compare the number of minimaps seen per time period and the number of minimaps drawn per time period it becomes evident that the minimaps that are seen during the early periods, are drawn in a later stage of the experiment (see figure 4.5.2). This relates closely to the navigation model that states that in the early stages of the development of a mental model of an information structure the emphasis is on the usage of landmarks and routes. The knowledge about minimaps will be incorporated in a later stage.

We can also look at the balance between landmarks and minimaps seen during browsing and between landmarks and minimaps drawn during the drawing task (see figure 4.5.3). In time periods 1 and 2 more minimaps are browsed than landmarks. We interpreted this as subjects looking for the global structure of the information structure (see section 4.2). Figure 4.5.3b shows that during the first two periods a higher percentage of landmarks is drawn than of minimaps; the period dependencies are found to be significantly different ($p<0.01$). This indicates that first the emphasis is on the processing of the information items that are seen, while later the more global information structure is added. In section 4.2 we concluded that it took the subjects about two periods to feel confident about the environment that they were exploring, and that this gave them the rest to pay more attention to the contents of the information items. We can now add that after this exploring phase they started to arrange the information that they had seen into a global structure.

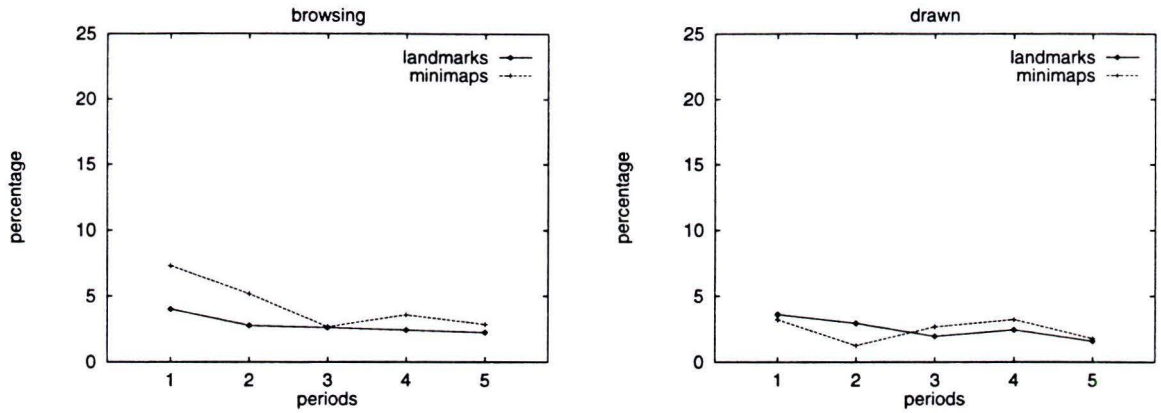


Figure 4.5.3 Balance between landmarks and minimaps seen during browsing (a; left, also reproduced as figure 4.2.3a) and drawn (b; right).

4.6 Image search task: description & results

Task description
The image search task was derived from the game that is part of the disc. On the basis of a picture questions were asked. Three alternative answers were given from which one must be selected. The subject was explicitly told to search until the picture occurred on the screen, even if he knew the answer beforehand.

Hypothesis and parameters
Given a certain level of knowledge of the information structure, there are a number of factors that can make it more or less difficult to find specific information (in this case a specific picture). The time that elapses before the information becomes available can be an important factor. The fact that the wanted information has or has not been seen before will play a role. If multiple-choice alternatives are given, it might be more effective if they are formulated in the same words that label the landmarks (of which one is correct) than if this is not the case.

We developed 4 image search tasks to test the assumptions here above:

1. The image was the very first image of a story;
   the multiple-choice alternatives were identical to the words labelling landmarks and therefore can be considered to be hints given to the subjects.

2. The image would appear later on in a story;
   the multiple-choice alternatives were identical to the words labelling landmarks and therefore can be considered to be hints given to the subjects.

3. The image would appear later on in a story and was already seen before;
   the multiple-choice alternatives differed from the words labelling stories, so the subjects didn't get any hints from us.

4. The image would appear later on in a story and was definitely not seen before;
   the multiple-choice alternatives differed from the words labelling stories, so the subjects didn't get any hints from us.

The tasks were presented in the same order as above, with the assumption that this would be an ascending order of difficulty.

Data collection
The processing of the image search data was identical to that of the information search task. For each task the following facts were registered:

- whether the task was completed successfully or not,
- the number of steps that was used to fulfil the task, and
- the minimum number of steps that was necessary to fulfil the task.

The paths taken by the subjects were annotated on a map, one map for each time period, the notes included the paths that were taken twice. As in section 4.3, this made it possible to count the navigation means used. So, for quantification purposes the following categories were used:

- forwards (by selecting an item),
- backwards with the 'fast backwards' button from the tool bar or from a menu,
- backwards with the 'back to main menu' button from the tool bar or from a menu,
- backwards but not retraceable how this was established, and
- backwards established by the system.

Data analysis
The amount of success for these tasks is high, except for the last task (no hint, image not seen before); we registered resp. 94, 71, 88 and 35% successfully performed tasks. Tasks 1 and 2 (image displayed immediately and image occurring later, both with hints), do not differ significantly ($p>.05$). However the difference between tasks 3 and 4 (image seen before and image not seen before, both without hints), is significant ($p<.05$).

Another measure for the performance of the subjects is the number of steps that they needed on top of the minimum number of steps necessary to reach the wanted image (3.2, 2.7, 4.1 and 5.6 extra steps for tasks 1 to 4 respectively). This shows that the subjects could solve the tasks where hints were given with less steps than the tasks without hints. When they can only rely on their own knowledge about the information on the disc they try more options. The difference between tasks 1 and 2 is not significant ($p>.05$), but the difference between tasks 3 and 4 is ($p<.01$).

Both succes rates and number of extra steps needed show that it does not matter whether the image searched for is in the beginning or later in a story. Apparently, subjects who have a clue on where to look are not really impatient to wait to see story content of a landmark unveiled, even if the wanted image does not occur immediately. The knowledge that they are looking at one of the possible solutions give them enough confidence to keep watching a story until the wanted image occurs (or not).
Both measures also show that the difference between whether the subjects have seen an image before or not is highly important. So, subjects do remember what they have seen and moreover where, and they are able to use this knowledge.

Although the data on navigation means are categorized in the same way as in section 4.3, it is now harder to interpret averages etc., because in the image search tasks the minimum path needed is not constant over subjects nor over tasks. Therefore, this issue is not discussed any further.

4.7 Interview: description & results

Task description
We asked the subjects to comment on some general issues of the CD-i title as well as posed a number of specific questions in the field of navigation. The subjects could elaborate on these issues as much as they wanted.

Hypothesis and parameters
The interview had several purposes. Firstly we were interested in spontaneous comments about strong and weak points of the disc, in particular the ones that concern navigation aspects. The subjects were stimulated to mention more than one point. The second reason was to get answers on a set of 10 specific questions in the field of navigation and information structure. The final reason is a very practical one. During the tasks the subjects often wanted to give comments on content related matters. Although this could be a valuable source of information, it also was a source of things running out of hand (particularly time). In these cases the experiment leader could refer to the interview coming up, where the subjects would be able to ventilate their comments. This secured the progress of the total experiment. A comprised version (only as far as the lay-out is concerned) of the interview forms can be found in appendix D. Here a brief translation of the 10 navigation questions is given:

1. How did you like this disc?
2. How long would you keep playing with this disc (number of hours)?
3. Which room would you use most: the corridor, the control room or the study?
4. How would you use the study: to wander around or to search for items?
5. There were two big maps: one for the whole world and one for the inter-Asia trade; which one was according to you the closest by to the study and why?
6. Can you find interesting information back easily?
7. And if you didn't use the disc for a couple of weeks?
8. How did you explore the possible options on a screen?
9. How did you like this?
10. There were two menu's to find information: 'kies selectie' and the study; which was according to you the closest by to the corridor and why?

Data collection
The comments on the general issues in the CD-i title were noted down in short. Because of their qualitative nature they will be discussed in section 5.
The answers on questions 1 to 10 are summarized in a number of categories. The questions make use of categories that are characteristic for each single question. For questions 1, 5, 6, 7, and 10 also the interaction layers 'syntax, semantics and involvement' as used by Majoor and Paulissen (1995), were adopted to categorize the *motivations* that were given (see also section 4.4). Sometimes it was not possible to use these motivation categories e.g. because the reply of a subject existed only of a 'yes' or a 'no'. In that case the answer was interpreted as missing data.

Data analysis
The table in appendix E shows per question the frequency of usage of the various categories.
Because the questions are formulated in a way that often induces very short (one-word) answers, it is difficult to get a good insight in the issues that play a role in the knowledge and impressions of the subjects.

From the data a few observations about this particular CD-i disc can be made.

- Only some 30% of the subjects anticipated to be entertained by this disk for a further period of more that 4 hrs.; some 25% expect less than 1 hour.
- Most subjects (82%) would use the study most often. Apparently the information on the disc is more attractive than the game. 71% of the subjects would use the study to browse the information instead of searching for specific items. This is not surprising because of the exploration-oriented user interface of the disc (options only become visible if the cursor hits the corresponding active region). This also may cause the fact that 71% of the subjects didn't use any system to search for the options in a menu screen. Subjects where either enthusiastic about this adventure type user interface (65%) or they didn't like it at all (35%) and would have preferred a more organized overview of the available information.
- The majority of the subjects (95%) regarded the large map of the whole world to be closer to the study than the map of the far east, although being in the study both maps could be accessed with only one button-press. This high difference can be explained by the fact that the large map is directly visible in the study. Selection of the map results in enlargement of the map, while the study remains visible outside the borders of the map. Furthermore the map of the far east is hidden in a book. Selection of the book starts up a presentation that finally results in the map projected on an opened book. So beside difference in visibility of the maps there is also a difference in elapsed time before the maps are available for interaction.

  A large part of the subjects (65%) regarded 'Kies selectie' to be closer to the corridor than the study, although being in the corridor both 'Kies selectie' and the study can be selected by only one button-press. The explanations look similar to those for the difference between the maps. Selection of 'Kies selectie' results in the appearance of a menu, that is transparently projected on top of the corridor. The hotspot for 'Kies selectie', a question mark with numbers, is more suggestive than the hotspot for the study, a door that could also be just a part of the scenery. And finally, selection of the study starts up an animation of opening the door of the study, resulting in a close-up of the desktop in the study. So also here the factor time plays a role.

  Concluding from these two cases at least one of the following user interface aspects influence the feeling of distance between items, certainly to a greater extent than the number of steps (button presses or level changes) does: the explicit presence of the hotspot leading to the following item, the visibility of the environment where the subject just came from and the time that elapses during the transition between the two items.

An attempt was made to find a correlation between the syntax- and semantics-based motivations for the answers (on questions 1, 5, 6 and 10) and data that might give an indication of the acquired knowledge about the information structure. Therefore these answers were correlated with the amount of landmarks and minimaps that were seen. Only the answers on question 5 correlated with this data: Subjects who gave a syntax-based answer, saw on average 16% of the landmarks during browsing and 28% during browsing plus information search task, and for the minimaps these percentages are 26% and 47%, respectively. For the group of subjects with semantics-based answers these numbers are 12% and 23% for the landmarks and 17% and 39% for the minimaps, that is lower on all respects.

Thus, subjects that have browsed a lot tend to formulate their answers in syntax-type statements. Perhaps they have gathered enough knowledge about the terminology that is used to name things by their names. The training may give them the knowledge to express their thoughts in terms of steps in the information structure. Subjects that have browsed less, have seen and heard less often the labels and names of information items and they still need global

terms to formulate their answers. Here the mental model that a subjects has build of the information structure must be translated into language. This extra transition may handicap the transfer of the actual knowledge of the information structure. The drawing and composition tasks probably are better tools to measure that knowledge.

4.8 Composition task: description & results

Task description
The subject was given material that represented all information that was available in the CD-i title. The stories were represented by their labels and there were photographs of the menu screens. The material was attached to post-it notes, that could be pasted on a large piece of paper to reconstruct the structure of the disc. A pencil could be used to draw connections between the components that were used. The subject was free to choose whatever material he wanted to use: only labels, only photographs, a mixture of both, anything that he thought suitable for the task. It was emphasized that we were particularly interested in the connections between elements.

Hypothesis and parameters
This task was, like the drawing task, designed to get an impression of the image that a subject had build up about the structure of the information on the disc. However, more than the drawing task, this task was aimed at revealing the subjects' comprehension of the structure itself. There was no room here to use metaphors and by giving the basic elements it was not necessary to retrieve this information from memory. Thus the whole emphasis could be on the relations between elements.

Data collection
To quantify the data, the various items of the composition were labelled with entities from the navigation model (see sections 2, 4.2, 4.4 and 4.5):

- The following items were labelled as landmarks: a label, a label + a matching menu, a label + an arrow + a matching menu.
- An arrow pointing to a landmark (on level N>1) was labelled as a route (on level N-1).
- Landmarks with at least two outgoing routes were labelled as minimaps.

Data analysis
As in section 4.5, it was found that the data for routes was almost identical to that for landmarks with one level difference. Therefore, we will restrict the discussions to landmarks and minimaps. On average the subjects reproduced 26% of all landmarks and 20% of the minimaps in their compositions.

Figure 4.8.1 shows the percentage of landmarks that was used in the composition per level of the information structure, together with the landmark data from the browsing periods and the drawing tasks after 5 periods.
Significantly more landmarks are reproduced (pasted) in the composition task than in the drawings ($p<.01$). This is not an unexpected result. In the composition task all landmarks were made available and their usage could be based on recognition or on logical reasoning, whereas during the drawing tasks the subjects could only rely on memorized knowledge.
There were pasted as many landmarks as were seen during the browsing and information search task ($p=.974$) and surprisingly the curve of the pasted landmarks sometimes even exceeds the curve of the landmarks that are seen. This can be explained by the fact that the

photo's of the menus (minimaps) sometimes show the amount of information items that is available in that menu screen. This might stimulate the subjects to look for more landmarks that fit in that place than they would have done without that extra information. The extra amount of landmarks can also originate from landmarks whose labels were seen in the menus but who were not visited. These landmarks were not considered accessed by us but their names could have been memorized or perhaps only recognized anyway.
We think it might only be an coincidence that the curves of landmarks pasted and landmarks seen are looking so strikingly the same. Probably part of the landmarks that are used in the composition only were seen as a label popping up and never were not registered by us as a landmark that was seen. The conclusion that all landmarks that were seen also were reproduced in the composition probably is incorrect.

The minimaps behave significantly differently from the landmarks ($p<.01$). The number of minimaps that are used in the compositions is much lower than the number of minimaps seen during browsing and information search task. The curve of the minimaps pasted in the reconstruction task resembles much more the curve of the minimaps drawn during the drawing tasks (see figure 4.8.1). And indeed, the explanations suggested for the relatively high amount of pasted landmarks do only hold to a much smaller extent for the minimaps. To correctly paste a minimaps that was *not* actually visited, it is necessary that the subject has seen maximally one option of a menu screen (otherwise the minimap would be considered accessed), but nevertheless is stimulated by the picture of the menu to look for at least 2 landmarks that fit that place. This is much less likely to happen than the equivalent in the landmark case. Thus we conclude that subjects need actual knowledge about the information structure to place a minimap at the correct place in their composition. As stimulated recognition plays a much smaller role, the subjects must depend on their memory to a greater extent, which is also the case in the drawing tasks. This might explain why for minimaps, it are the pasted and drawn curves that are most alike.

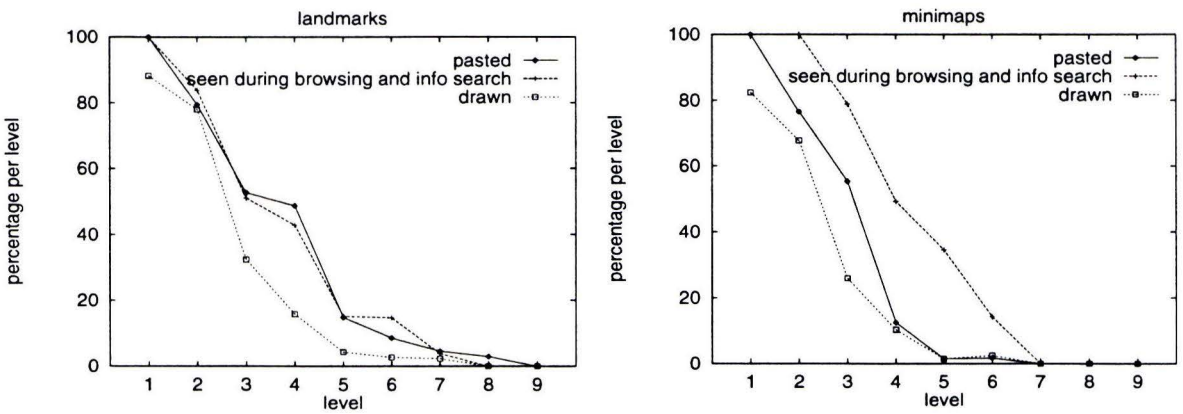


Figure 4.8.1 The percentage, per level of the information structure, of the landmarks (a; left) and minimaps (b; right) pasted, seen during browsing plus information search task and drawn after 5 periods.

5 Additional observations

Beside the material that is presented in the previous chapter, other, more qualitative, data was obtained as well. Although this data is not validated by statistical methods, there may be some interesting observations, that can contribute to practical solutions for navigation problems. This includes comments on general issues of this CD-i as given in the interview (see section 4.7). Also our own observations are included as well as detailed motivations accompanying the answers to the interview questions (section 4.7).

5.1 Feed forward mechanisms for hotspots

Most subjects spontaneously gave comments about the feed forward mechanism that was used for the hotspots (they were not visible until the cursor was on the corresponding active region) and they often suggested alternatives that might be used. They discussed 4 alternative feed forward mechanisms:

1. Hotspots are not visible as such, but a label pops up if the cursor enters the active region of the hotspot (this mechanism was used in several menus in 'De Vliegende Hollander').
   - This is considered to be adventurous, exciting and surprising; you don't know beforehand what you will get.
   - There is no overview of the choices that can be made in a menu screen; sometimes you discover a hotspot that you didn't see before.
   - It gives a neat image or menu screen, no disruptions.
   - If there are only a few hotspots, they can be hard to find.
   - It gives little information if you look for a specific item.
   - The labels can be shown in a separate window, but then they are not always recognized as belonging to the activated hotspot.
   - It gives no information about the information structure.

2. All hotspots in a menu screen are visible simultaneously by their labels.
   - This gives a good overview of the choices that can be made in a menu screen.
   - It can give a very chaotic image or menu screen.
   - It might give a little guidance if you look for a specific item.
   - It gives maximum information about the local information structure.

3. The hotspots are recognizable as such, and a label pops up if the cursor enters the active region of a hotspot.
   - This gives a good overview of the available hotspots in a menu screen.
   - There still is the element of surprise what a hotspot actually can offer.
   - It gives little information if you look for a specific item.
   - It gives no information about the information structure

4. The information can also be accessed by means of an index.
   - No frustration that you cannot find a specific item, it is there or it is not, but then you know so.
   - Not adventurous at all.
   - Should be used along with the general information structure.
   - It gives no information about the local information structure.

5.2 Exploration of the tree structure

The information that could be found in the study is organized in a tree structure that contains branches with 1 to 7 layers of items. In the study there are 12 branches to select from, 10 of these contain no more than 3 layers of information (see appendix A). These branches will further be referred to as the shallow structures, the other branches will be called the deeper structures. With this terminology it is possible to describe some observations.

1. The shallow structures are generally selected in an earlier stage of the exploration of the disc.
   - The shallow structures have more concrete representations, like navigation objects or a book with a well described subject (the objects all represent a 1-layer structure).
   - The deeper structures have a more abstract representation like books about general topics.
   - The book titled VOC. (regarded to be the main topic of the disc) suggests more than the 2-layer structure that is behind it, most users were rather disappointed by this.

2. The deeper structures often were a complete surprise to the users.
   - Because there are many shallow structures, users didn't expect deeper structures at all.

5.3 Interpretation of the maps

There are two maps available, the large map in the study and the map of the far east in the book 'Interazië handel'. The interpretation and the usage of these maps could be rather confusing. The main observations here are:

1. The large map in the study is considered to be an information source about cities and places.
   - All places are expected to be directly available on the map; the subjects were surprised to find more places in sub menus.
   - The subjects find the presence of a second map, the map of the far east, very illogical, especially because the area that is covered by the second map is also visible on the large map.
   - The subjects did not expect at all to find background information, e.g. about the 'Hottentotten', via the map.
   - Very few subjects interpreted the large map as the source of information about events that the ships could meet along their route to Asia, as it is intended to be.

2. Most subjects regarded the large map of the whole world to be closer to the study than the map of the far east (also presented in section 4.7).
   - Although being in the study both maps could be accessed with only one button-press.
   - The large map is directly visible in the study, selection of the map results in enlargement of the map, while the study remains visible outside the borders of the map.
   - The map of the far east is hidden in a book, selection of the book starts up a presentation that finally results in the map projected on an opened book.

5.4 Interpretation of 'Kies selectie'

'Kies selectie' could be used to get a selection of stories about a certain topic. The menu screen of 'Kies selectie' looks like an index with labelled boxes that are neatly arranged in two rows beside each other. The lay-out of 'Kies selectie' probably induces a number of assumptions.

1. Some of the subjects thought that 'Kies selectie' was the main menu of the disc.
   - Especially subjects that hadn't used 'Kies selectie' extensively thought, even at the end of the experiment, that 'Kies selectie' was the main source of information.
   - Subjects thought that the information in the study is a subset of the information in 'Kies selectie'.
   - The selection of information in 'Kies selectie' seems to be much more efficient and to the point than in the study, because the information is not hidden in metaphors or submenus, there are clear labels showing the information that is available.

2. Many subjects regarded 'Kies selectie' to be closer to the corridor than to the study (also presented in section 4.7).
   - Being in the corridor both 'Kies selectie' and the study can be selected by only one button-press.
   - Selection of 'Kies selectie' results in the appearance of a menu, that is transparently projected on top of the corridor.
   - The hotspot for 'Kies selectie', a question mark with numbers, is more suggestive than the hotspot for the study, a door that could also be just a part of the scenery.
   - Selection of the study starts up an animation of opening the door of the study, resulting in a close-up of the desktop in the study.

5.5 Usage of the navigation tool bar

When a story is interrupted the navigation tool bar appears. The tool bar offers a fixed set of buttons that facilitate the functions 'back to study', 'return to previous menu', 'continue', 'go to next menu' and 'select narrative or music only'. The buttons are only labelled with an icon. There were no text labels or a help function to clarify the functions of the tool bar. This can lead to confusing situations.

1. Sometimes there was confusion about the usage of the tool bar itself.
   - The tool bar appears if a story is interrupted, while the cursor remains at the same position; if a button is pressed without the cursor being on one of the hotspots of the tool bar, the tool bar disappears while the story simply continues, a next button press brings the tool bar back again; subjects were rather puzzled if this happened to them.
   - One of the subjects thought that the tool bar was some sort of decoration (maybe because it has the looks of the desk in the study).
   - Only one subject mentioned the fact that the tool bar looked like the desk from the study on top of which the interrupted story was positioned.

2. The functions of the navigation tool bar were not always understood.
   - Especially the 'go to next menu' option is hardly understood; this is due to the fact that if there is no next menu, the usage of this button results in going back to the previous menu; after a few attempts some subjects stopped using this button.
   - For the 1-layer structures the 'back to study', 'return to previous menu' and 'go to next menu' buttons all have the same result; subjects are soon discouraged to attempt to find out what the functions of the buttons might be; they express their disappointment that it seems to be impossible to skip stories and to go ahead.
   - The 'select narrative or music only' option was hardly explored; even if the function was activated is mostly took some time before the subject discovered that the narrative had disappeared.

5.6 Usage of the help facilities

On most screens there is a help option available that offers a user context-dependent information. The information concerns the procedures that must be followed like 'click here and something will happen'. Sometimes the help option was consulted over and over again as if the subject could not believe that this was all information that he could get, as he expected information about what was to be found there.

6 Conclusions and recommendations

We used a number of methods to gain insight in the processes that take place during the exploration of an unknown information structure. The various methods had their specific merits to learn more about these processes.
The analysis of the data was placed as much as possible in the context the navigation model that we adopted (Edwards and Hardman, 1989, see section 2). Also a description of interaction layers (Majoor and Paulissen, 1995, see also section 4.4) proved to be useful for the interpretation of the results.
The conclusions that we present here are arranged according to the processes that were monitored during this experiment.

Exploration strategy
From the browsing data it was possible to monitor the strategy that subjects applied while they explored the information on the CD-i disc. A change in browsing pattern after some 20-30 minutes shows that the subjects needed this amount of time to feel at ease about the information structure and start to pay more attention to the information contents of the disc.
The browsing data also shows that after more than one hour only a small portion (25%) of the information was explored while the interest of the subjects was diminishing already. Probably most of the subjects wouldn't have explored the disc to its full extent even if they would have had the chance to do so. This assumption is supported by the fact that only a small part (some 30%) of the subjects anticipated to use the disc for a considerable amount of time.
Although it was laborious to do so, the browsing data was the most simple to obtain. However a build-in logging routine in CD-i discs can fully automate the acquisition of this data.

Cognitive representation of the information structure
The image search task shows that the knowledge that was gained in roughly 1 hour about the information structure wasn't sufficient yet to search successfully for specific information. The results from the composition task reveal that large parts of the information structure that were explored could be reconstructed correctly. The data from the drawing task fully support the assumptions that are made in the navigation model, viz. that local knowledge is established prior to the knowledge about the more global components of the structure. This change from local to global occurs after some 20-30 minutes and thus it seems to be related to the change in browsing pattern discussed above.
How different features of the structure itself influence the perception of distance in that structure can be learned from the motivations that were given for the distance estimations. A relatively high coherence between information items, such as found at deep levels, gives users the feeling of being in a small area. A small coherence (as usual between the items on low levels) suggest being in a large area.
From the interview we learned that also the visibility of hotspots, the presence of parts of previous environments and the time delay between subsequent items contribute to the feeling of distance between information items on the disc, probably more than the actual number of steps (button presses) between them.

Use of navigation tools
Analysis of the navigation means that were used during the information search task, reveals that there is no noticeable development over time in the usage of the various available navigation buttons. Adding this data to the observation that people stop using buttons that gave unexpected results only can lead to the conclusion that navigation means must be self-explaining,

consistent and suitable for the situation. Damage that is done by violating these rules is not restored easily.
From the interviews and our own observations we learn that the user interface from this disc was experienced to be adventurous, but also that most people would like to have a opportunity for more direct access to the information e.g. by means of an index.

7 References

Canter, D., Rivers, R. and Storrs, G., 1985, *Characterizing user navigation through complex datastructures*, Behaviour and information technology, 93-102.

Dillon, A., McKnight, C. and Richardson, J., 1990, *Navigation in Hypertext: A Critical Review of the Concept*, in: Diaper, D. et al. (eds.), Human-Computer Interaction - INTERACT '90, Elsevier Science Publishers B.V., North-Holland, 587-592.

Edwards, D.E. and Hardman L., 1989, *'Lost in Hyperspace': Cognitive Mapping in a Hypertext Environment*, in: McAleese, R. (ed.), Hypertext: theory into practice, Oxford: Intellect, 105-125.

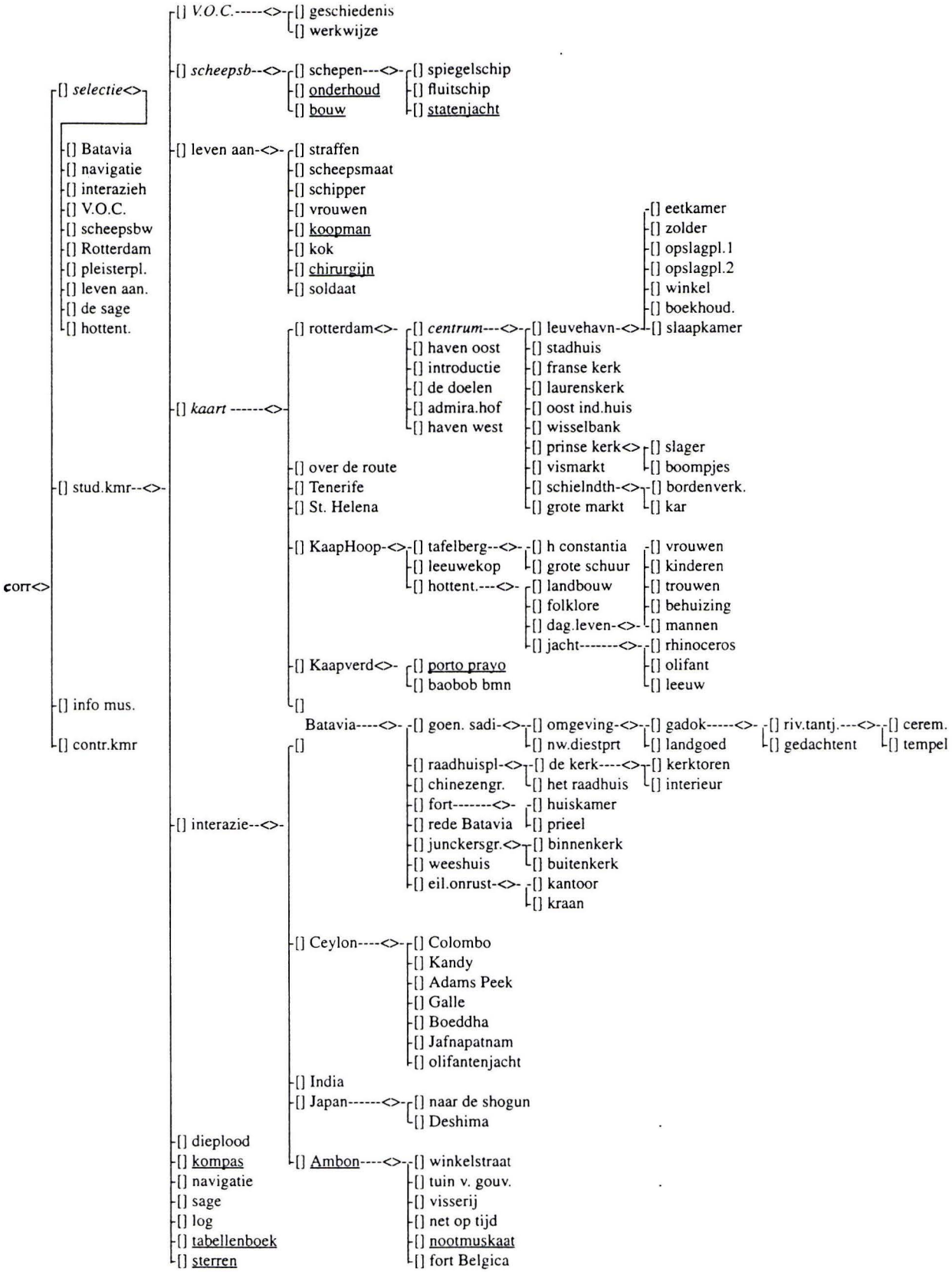
Majoor, G.M.M. and Westerink, J.H.D.M., 1994, *Navigation aspects in CD-i; an exploration*, IPO report no. 973.

Majoor, G.M.M. and Paulissen H., 1995, *User interfaces for CD-i; an inventory of problem areas*, IPO report 1080.

Van Dyke Parunak, H., 1989, *Hypermedia Topologies and User Navigation*, Hypertext '89 Proceedings, 43-50.

Westerink, J.H.D.M. and van den Reek, K., 1994, *Event logging of cursor-control patterns in CD-i: Literature overview and user experiments*, IPO report no. 948.

Appendix A: Tree structure of 'De Vliegende Hollander'



Appendix B: Assignments: protocol

Here follows the protocol of the assignments that were given after each period of browsing. The comments in italics were substituted with the relevant information like the number of the time period, the actual information search tasks or the hints that would be given if the subject could not find the target destination. The time indications between brackets indicate the maximum time that a subject was allowed to search before (additional) help was given.

opdracht *(label of time period)*:

↵: Waar kom je terecht als je 1 stap teruggaat (recursief, niet uitvoeren)

.....

- Hoeveel stappen is het terug naar de corridor?.....

A: *(Here the subject was asked a question about destination A)*

- Hoe ver denk je dat deze informatie afligt van je huidige positie.
- Probeer dat eens aan te geven op de volgende schaal.

dichtbij ver weg

|----------|----------|----------|----------|----------|

- Waarom denk je dat. .....
- Ga er maar eens heen. (3 min.)

(Here a hint was given to help the subject to find the right destination) (2 min.)

- Hoe ver vond je het nu achteraf.

dichtbij ver weg

|----------|----------|----------|----------|----------|

B: *(Here the subject was asked a question about destination B)*

- Hoe ver denk je dat deze informatie afligt van je huidige positie.
- Probeer dat eens aan te geven op de volgende schaal.

dichtbij ver weg

|----------|----------|----------|----------|----------|

- Waarom denk je dat. .....
- Ga er maar eens heen. (3min.)
- Hoe ver vond je het nu achteraf.

dichtbij ver weg

|----------|----------|----------|----------|----------|

✎: Hoe denk je dat de titel in elkaar zit; wat denk je dat er allemaal opstaat.

- Kun je dit in een tekening weergeven.
- Hoe ben je hierachter gekomen. .....

Appendix C: Assignments: information search tasks

The following information search tasks were presented verbally to each subject. In the formulation of the questions the exact words from the CD-i were used to describe the target destination (these are written in italics). In the questions for the B destination it was avoided as much as possible to use context information. The numbers between brackets indicate the level of the target destination in the information structure.

A(3) : Hoe was het *leven aan boord*?
Hint : Zoek in de studeerkamer een boek op over het leven aan boord.
B(4) : Kun je iets vinden over de *geschiedenis* van de V.O.C.?

A(4) : Ga eens naar *Rotterdam*?
Hint : Zoek op de kaart in de studeerkamer eens Rotterdam op.
B(5) : Wat kun je vinden over *Porto Prayo*?

A(4) : Hoe was de situatie in *Japan*?
Hint : Zoek eens in de studeerkamerin het boek over de interaziehandel Japan op.
B(5) : Wat wordt er verteld over *Boeddha*?

A(6) : Kun je iets vinden over het *dagelijks leven* van de Zuid Afrikaanse volksstam de hottentotten?
Hint : De hottentotten leven bij Kaap de Goede Hoop, dat je via de kaart in de studeerkamer kunt bereiken.
B(7) : Wat was de betekenis van de *rhinoceros* in die tijd. ?

A(6) : Waar ligt de *Prinse Kerk* in Rotterdam?
Hint : Zoek eens via de kaart in de studeerkamer in het centrum van Rotterdam de Prinse Kerk op.
B(7) : Hoe ging indertijd de *(haven)boekhouding* eraan toe?

Appendix D: Interview

leukste onderdeel van CD-i titel:

- wat vond je het leukste aan deze titel:
- waarom vond je dat zo
- druk dit eens uit in een rapportcijfer (1 t/m 10)

minst leuke onderdeel van CD-i titel:

- wat vond je het minst leuke aan deze titel:
- waarom vond je dat zo
- druk dit eens uit in een rapportcijfer (1 t/m 10)

andere opvallende onderdelen van CD-i titel:

- waren er nog andere opvallende delen aan deze titel:
- waarom vond je dat zo
- druk dit eens uit in een rapportcijfer (1 t/m 10)

nog andere opvallende onderdelen van CD-i titel:

- waren er nog andere opvallende delen aan deze titel:
- waarom vond je dat zo
- druk dit eens uit in een rapportcijfer (1 t/m 10)

verdere vragen:

1. Wat vond je van de titel.
2. Hoe lang denk je dat je met deze titel bezig zou blijven (aantal uren).
3. Welke ruimte zou je het meest gebruiken: de hal (voor de presentaties), de controlekamer of de studeerkamer.
4. Hoe zou je de studeerkamer vooral gebruiken: om zomaar wat rond te neuzen of om dingen op te zoeken.
5. Er waren twee grote kaarten; eentje voor de hele wereld en eentje voor de interaziëhandel. Welke was volgens jou het dichts bij de studeerkamer, en waarom?
6. Denk je dat je informatie die je interessant vond makkelijk weer terug kunt vinden.
7. En als je de titel een paar weken niet gebruikt hebt.
8. Hoe onderzocht je wat er op een bepaald scherm voor mogelijkheden waren.
9. Hoe vind je deze manier van mogelijkheden onderzoeken.
10. Je kon via twee menu's informatie krijgen: via 'kies selectie' en via de studeerkamer. Welke was volgens jou het dichtst bij de hal, en waarom?

Appendix E: Frequencies of categorized answers

The table below gives the frequencies of the categorized answers on the following questions of the interview (here only the translation of the questions is given):

1. How did you like this disc.
2. How long would you keep playing with this disc (number of hours).
3. Which room would you use most: the corridor, the control room or the study.
4. How would you use the study: to wander around or to search for items.
5. There were two big maps: one for the whole world and one for the inter-Asia trade. Which one was according to you the closest by to the study and why.
6. Can you find interesting information back easily.
7. And if you didn't use the disc for a couple of weeks.
8. How did you explore the possible options on a screen.
9. How did you like this.
10. There were two menu's to find information: 'kies selectie' and the study. Which was according to you the closest by to the corridor and why.

1:	positive: 13	moderate: 2	negative: 0	missing: 2
2:	< 1 hour: 4	< 2 hour: 5	< 4 hour: 3	> 4 hour: 5
3:	corridor: 0	study: 14	control room: 3	missing: 0
4:	searching: 3	browsing: 12	both: 2	missing: 0
5:	whole world: 16	inter-Asia: 0	equally close: 1	missing: 0
6:	yes: 12	no: 2	reserved: 3	missing: 0
7:	yes: 7	no: 3	reserved: 7	missing: 0
8:	systematically: 4	without system: 12		missing: 1
9:	appreciation: 11	disapproval: 6		missing: 0
10:	'kies selectie': 11	study: 1	equally close: 2	missing: 3

The answers and motivations from question 1, 5, 6, 7, and 10 are also categorized according to the interaction layers 'syntax, semantics and involvement' (Majoor and Paulissen 1995).

1:	syntax: 0	semantics: 1	involvement: 12	missing: 4
5:	syntax: 9	semantics: 8	involvement: 0	missing: 0
6:	syntax: 4	semantics: 5	involvement: 1	missing: 7
7:	syntax: 2	semantics: 5	involvement: 2	missing: 8
10:	syntax: 4	semantics: 10	involvement: 0	missing: 3