María González de Cossío [UPAEP/México]

Understanding readers' movements in www documents

keywords: spatial navigation, semantic navigation, landmark, route and survey knowledge

The aim of this study is to know readers' movements in electronic space. The complete work is structured as a journey through the World Wide Web (www) environment, constituted by the description of graphic, navigation and organisational elements, readers' methods of manipulation within a web site and mental models readers develop whilst navigating in the web environment. Knowledge of navigation in physical space provides a theoretical framework to study readers' movements in web environments. The stages in acquiring spatial knowledge (landmark-route-survey) are examined and tested. Results suggest that when readers interact with web documents they recall graphic elements as landmarks. Readers develop route knowledge of well-known documents. Readers do not seem to develop survey knowledge or cognitive maps from the tests done. Finally, the author suggests that traversing web documents should be considered as semantic navigation rather than spatial navigation.

In this article the author only describes the studies conducted to discover whether readers develop route and survey knowledge in well-known www documents.

1. Physical and electronic space. The metaphor of navigation

The metaphor of navigation is used pervasively to describe readers' movements in electronic environments. In www documents, researchers have discussed whether or not to accept the metaphor. When studying the psychological aspects of the movements of users in a database, Canter, Rivers and Storrs (1985) support the metaphor and make parallels with navigating 'concrete environments' such as buildings or cities. Kahn and Lenk (2001) suggest that moving in a web document is similar to finding one's way in a building: one looks, makes assumptions, looks for consistency and learns from experience. Several studies have aimed to understand why readers get lost in electronic documents and have proposed tools to facilitate readers searching for information (Edwards & Hardman, 1989; Kim & Hirtle, 1995; McDonald & Stevenson, 1998; Otter & Johnson, 2000; Ahuja & Webster, 2001).

On the other hand, some authors reject the metaphor linking physical and information space. Stanton (1994) considers it inappropriate to translate the concepts of mathematical space into electronic space. Hypertext, says Stanton (1994), is an 'n-dimensional space', which can be traversed by moving endlessly through links. In navigating www documents there are no fixed or invariant relationships between objects and no relation between distance travelled and speed. Any user can travel on a different route and still arrive at the same destination (Wittenburg, 1997).

With a critical view, Dillon and Vaughan (1997) consider that even though people develop the same mental representations whilst navigating in physical or electronic documents the emphasis is not in physical behaviours but in the analysis of the semantics of information. Supporting the same view, Farris, Jones and Elgin (2002) suggest that people develop semantic or conceptual relationships when consulting a www document, rather than mental representations similar to the ones developed in the physical world. Some authors conclude that the understanding of navigation in a www document should not rely on transferring theories and models wholesale from the research of knowledge used in movement in physical spaces (Heffron, Dillon & Mostafa, 1996).

2. Development of spatial knowledge in physical space

People develop spatial knowledge through a sequence of stages. Siegel and White (1975) developed a model to explain how people interact with the environment and how they develop spatial knowledge from this interaction. The model has three levels:

Landmark knowledge

- *Route knowledge*
- *Survey or configuration knowledge*

2.1. Landmark knowledge

Landmark knowledge consists of recognising the reference points or outstanding features that identify a geographic location. Landmarks facilitate learning of the layout of a physical environment. When people are travelling in physical space, the location and position of landmarks specify where to make decisions, at which intersection points, which direction to take, where to turn, etc. If the landmark is relevant for spatial orientation, then it is adequate, authentic (in a pragmatic sense) and allows people to interact with the environment.

Sorrows and Hirtle (1999) summarise landmarks' characteristics in three categories which apply to physical and electronic space:

Visual

Refer to landmarks with salient features, contrasting colours, distinctive positions in the environment, different height or shape that attract the attention of the traveller. They are recalled and remembered, and used for future orientation. Landmarks can also become identifiers of a specific place. i.e. Big Ben is a particular landmark in London. It has a different height, structure and function (clock) than the surrounding buildings and has also become an identifier of London.

Cognitive

Refer to the conceptual characteristics –cultural or historical content– that landmarks can have, i.e. in Mexico City the Independence Memorial is situated in one of the most important streets, has unique visual characteristics and a strong cultural content. Even though it was created to commemorate Mexico's independence from Spain, it is still used as a cultural landmark to celebrate all types of events, those regarding success or discontent, from victories in sports to protests against government policies.

Structural

Refer to the location and positional characteristics of landmarks. When landmarks are placed at important intersections or decision points they become an important travelling cue that helps people connect them along a route. i.e. roundabouts are structural landmarks that connect paths and form a complete network of roads.

Sorrows and Hirtle (1999) suggest that landmarks that have visual, cognitive and structural values are the strongest cues. Landmark knowledge provides people with the skeletal framework on which they build the cognitive map or internal representation of space (Dillon, McKnight & Richardson, 1993).

2.2. Route knowledge

Route knowledge is acquired by sequential connections between departing points, subsequent landmarks and destination points in a journey. After identifying a set of landmarks in the environment, people connect them as routes or paths. Routes are lines of movement or travel that represent distances, orientation cues and ordering of landmarks. (Thorndyke & Goldin, 1983). Route knowledge allows people to navigate or imagine the sequence of landmarks and turns required to arrive at a destination. People gain detailed information of the environment when traversing routes.

2.3. Survey knowledge

Survey knowledge or configuration knowledge refers to an integrated understanding of the layout of space and the interrelationships of the elements contained therein (Rossano, West & Robertson, 1999). People can acquire survey knowledge by the integration of routes that form a networked configuration (Golledge, 1999) also called a cognitive map. Survey knowledge can also be acquired from maps. Maps encode global spatial relations, topographic features and location and distances of objects in the environment (Thorndyke & Hayes-Roth, 1982). People can also develop survey knowledge from descriptions (Uttal, 2000) and it is more easily gained in structured environments than in complex or chaotic ones.

Thorndyke and Hayes-Roth (1982) found that people gain different types of knowledge depending on their source of spatial information. If people learn space from a map they gain survey knowledge, whereas people who have direct experience with space learn route knowledge. Appleyard (1970) found differences depending on how people travel in the environment. People travelling by bus were unable to draw a coherent map, whereas people travelling by car drew coherent and continuous systems. Variations in the travelling mode profoundly influences the spatial knowledge people gain from physical space.

2.3.1. Cognitive maps

Cognitive maps are internal representations of spatial information, used to explain where one is at any moment, where specific objects are in the surrounding space, how to get from one place to another, or how to communicate spatial knowledge to others (Golledge, 1999). Different terms have been used for this concept, such as imaginary maps, mental maps, environmental image, spatial image, spatial schema or spatial representation (Siegel & White, 1975).

A cognitive map is not a map per se; it is a mental representation that has the same functions as the cartographic map. Cognitive maps do not have all the information there is in the environment. They are simplified versions of elements represented in relative position to each other and to a spatial reference frame (Tversky, 2000). The mapping process involves a change in scale, rotation of perspective, and abstraction and symbolisation. Cognitive maps can be fragmented, spatially distorted in distance and direction, can have exaggerations or augmentations and can present misplacements of landmarks (Appleyard, 1970; Downs & Stea, 1973). These images involve a multi-media recall of the visited place seen from different points of view, which Tversky calls 'cognitive collages'. She discusses cognitive collage from as people's recollection of journeys, verbal and written directions, facts, maps, etc. In cognitive collage the environment has proved too complex and rich to be reflected effectively in a cognitive map.

There are different ways to traverse space: reach a specific destination (having only this goal in mind), or acquire spatial knowledge (require to learn the space) for future navigation. Magliano, Cohen, Allen and Rodrigue (1995) studied whether spatial learning is constrained by goal directed activity or by stage-based processes. A goal directed activity assumes that knowledge acquired is determined by the goals of the traveller, regardless of the amount of experience provided. Stagebased processes assume that knowledge is acquired through previous presentations of landmarks and routes of an environment, so participants become aware of the space traversed.

3. Studies on cognitive maps developed from navigation

A small number of studies have mentioned the development of survey knowledge or cognitive maps. Edwards and Hardman (1989) suggest that in their study participants were attempting to create cognitive maps of the electronic document accessed when they connected screenshot cards with lines. Westerink, Majoor and Rama (2000) report that participants became aware of distance when drawing the minimaps of the infotainment application they used, because of the minimum number of steps involved. This was inferred as awareness of the topology of the information structure and as a stage of survey knowledge development. However, Hodkinson, Kiel and McColl- Kennedy (2000) said that survey knowledge is difficult to achieve and to represent in www documents, and suggest that only those highly experienced users could develop a cognitive map because of the 'limited visibility of general topographic detail' in www documents. They also mention that cognitive maps from www documents might be 'non-directional in nature and would consist of locational components such as landmarks or portals'.

Farris et al (2002) questioned how it is possible that readers navigating a www document develop spatial schemata if not all the information is present. Their study consisted of the participants' exploration of a www document for a short time, followed by their recall of the site's

structure by drawing the nodes and their connections. The authors were expecting to see the same number of levels as the site had. They concluded that users do not form accurate schemata of the structure of the web site: 'they appeared to have drawn the conceptual relationships and not the connections of the web site accessed.'

4. Studies on cognitive map representations

Some studies have reported on how to measure people's cognitive maps which are a departing point for this analysis. Thorndyke and Goldin (1983) analysed good mappers' abilities and skills and found that they showed superior visual memory, visualisation and spatial orientation task. Canter (1977) mentions that people could develop certain abilities to draw maps. He uses Pattison's (1966, quoted in Canter, 1977) requirements for map drawings which are:

- *the ability to relate directions and places on the map;*
- *the ability to miniaturise elements;*
- *the ability to project the elements from a bird's eye view;*
- *and the ability to add symbols to indicate what to find in the environment.*

These transformations imply that people need to abstract information and to represent it spatially.

Another way of evaluating representations was studied by Tversky and Lee (1998,1999). They compared verbal and graphic depictions of routes. Their results show that in both instructions, route descriptions and route maps, information was presented in similar ways. Participants used landmarks for starting and ending points, used arrows to indicate direction, double lines to indicate street paths, and intersections were drawn as perpendicular lines. Participants used verbs such as 'turn', 'take a', 'make a', and 'go'.

5. The study: are route and survey knowledge developed when interacting with www documents?

A set of readers' representations were analysed to find out if readers developed route and survey knowledge after interacting with well-known www documents. The aim is to find which characteristics are used in these drawings and how accurate and complete they are. The results will hopefully shed some light on the appropriateness of using the physical space metaphor or whether information space should be studied from another perspective.

Method

University students from Reading and Puebla were asked to carry out one of two tasks: to draw a specific route of how to get to a well-known destination within a www site, or to draw the map of a well-known www site.

Each participant had more than three years of experience in navigating web sites. Most participants were Graphic Design students, hence their ability to visualise and to encode information should be reasonably well developed. Thorndyke and Goldin (1983) would consider these participants as good mappers. Choosing design students implied that they would have the drawing skills and 'know-how' to represent the information space. Participants in both conditions, either drawing routes or maps, chose their preferred destination or www site. Participants worked on their task away from the computer, from memory on a piece of paper. Participants had no time restriction; they took between 10 and 20 minutes to do the task.

The instructions for the test were given in a written form. The route drawing students received the following text:

1. Think of a web site that you know very well.
2. Draw the route to your favourite destination.
3. Specify the URL.

The map drawing students received the following instructions:

1. Think of a web site that you know very well.

2. Draw a map of the web site: home page, 3 or 4 levels deep, links, etc. Try to draw the site structure as thoroughly as possible.

3. Specify the URL.

The analysis is divided into two parts: the first part deals with the analysis of route drawings, and the second part with the analysis of map drawings. Short discussions are included at the end of each analysis. A general discussion on the topic is presented at the end.

5.1. Analysis of route drawings

Two analyses were developed. In the first one the author used the scheme developed by Tversky and Lee (1999) and modified it with additional observations. A second analysis is the author's contribution.

According to Tversky and Lee's (1999) comparison between route descriptions and route drawings, the elements observed were: the specification of start and end points, the use of graphic elements as arrows, the use of icons (the authors use the term icons to describe elements such as rectangles or 'blobs'), the specification of turns or returning paths. Based on the data obtained from participants' drawings, the author identified additional elements which were:

- *the use of top-down, left-right or down-up sequences*
- *the specification of left or right turns*
- *additional details in the drawings such as landmarks or other elements of the layout.*

Results show that some participants produced a graphic representation and others a verbal written description of route knowledge. Table 1 shows the results of route drawings and text instructions for a total of 15 participants. The table shows the frequency which corresponds to the number of participants who included the elements specified (see figures 1-7).

Table 1: Analysis of elements used in route drawings and descriptions (Tversky & Lee, 1998, 1999)

Elements	**Frequency**	**Elements**	**Frequency**
route drawings	10	route descriptions	05
start point	10	start point	05
end point	07	end point	05
graphic elements:		verbs:	
arrows	07	put/type	03
icons	10	give click	03
		left-right	03
type of sequence:		takes to	02
top-down	07	look for	01
down-up	01	bookmark	01
left-right	04	go to	01
combined	02		
additional descriptions	10	additional descriptions	01

Figure 1 shows the division of the page (icons) suggesting the two colours of this site, the places for the menus, boxes for filling in information, etc. This drawing gives the instructions on how to send a message in hotmail.com

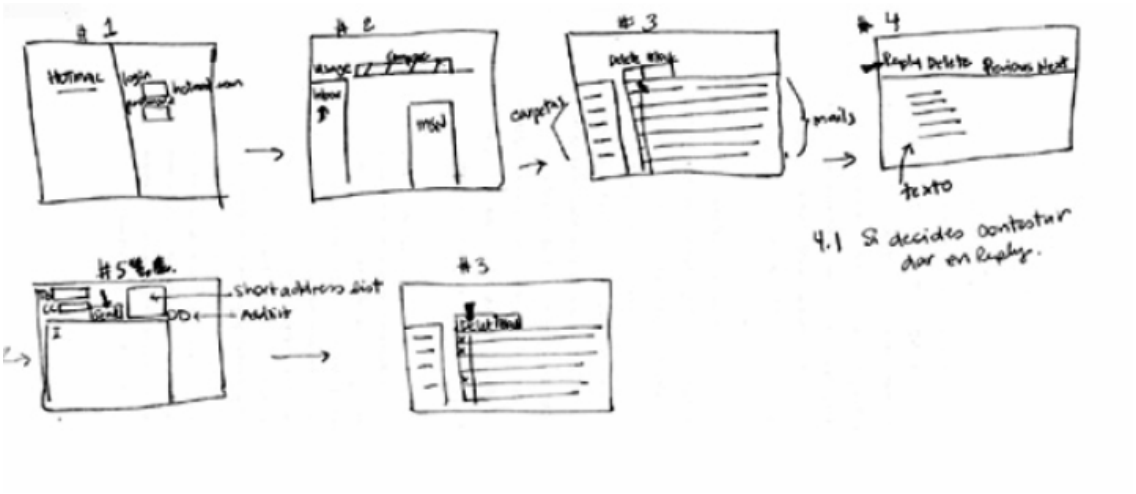


Figure 2 shows the top-down direction generally used in the route drawings.

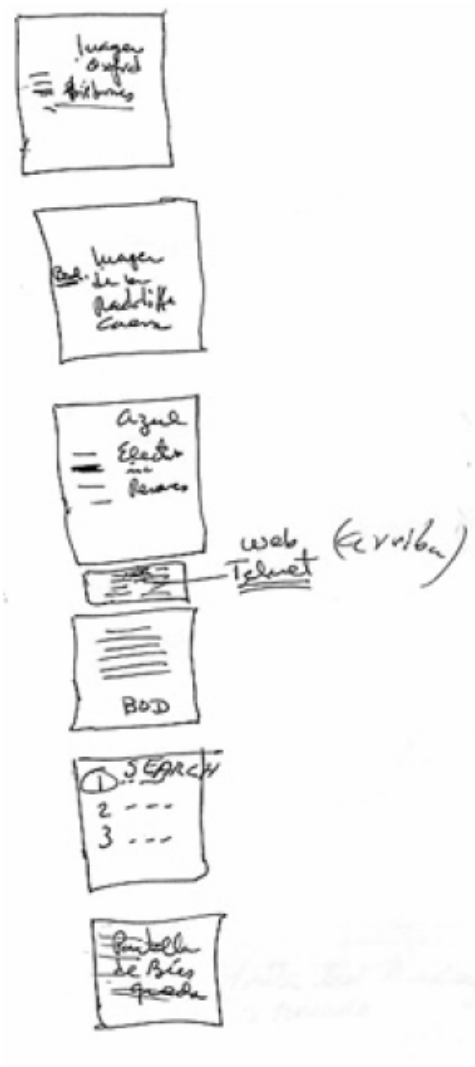


Figure 3 shows graphic detail of this route drawing which can be compared to the www document in figure 4.

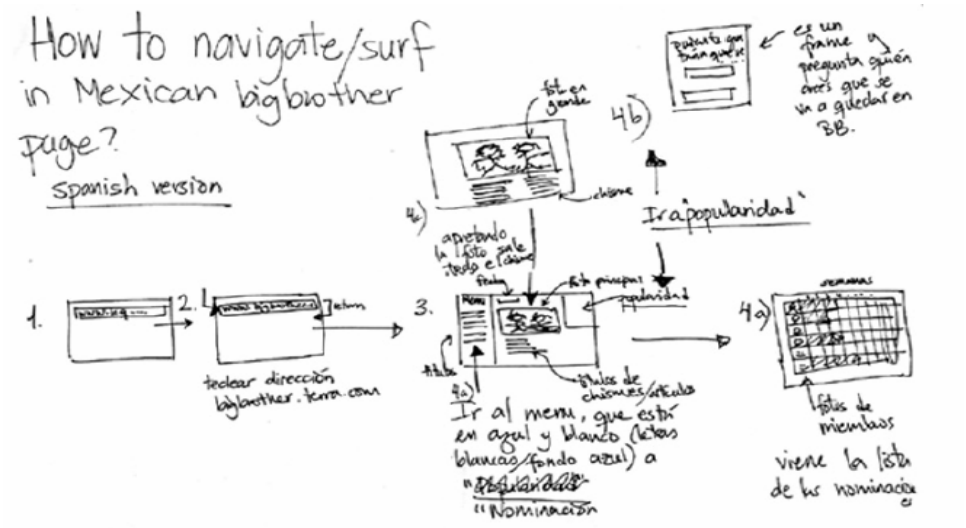


Figure 4 shows two pages of the www document www.bigbrother.com.mx depicted in figure 3.

Figure 5 shows a route drawing combining two directions: a left-right and a top-down sequence of pages. This drawing depicts how to use hotmail.com

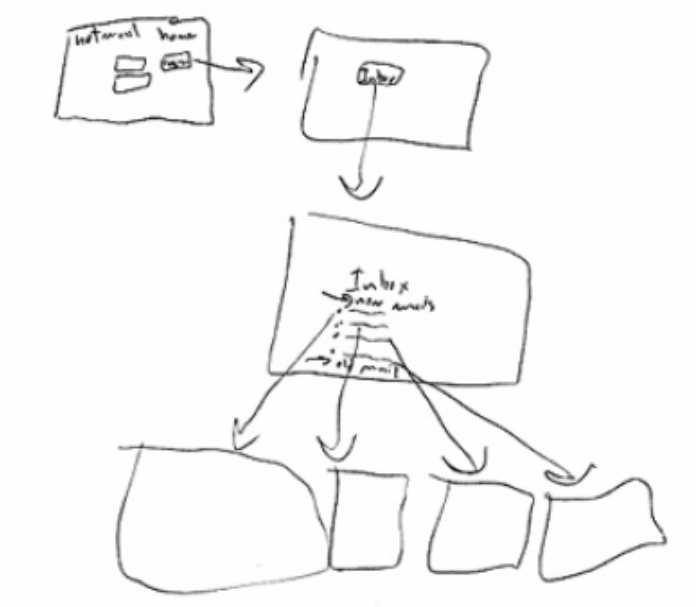
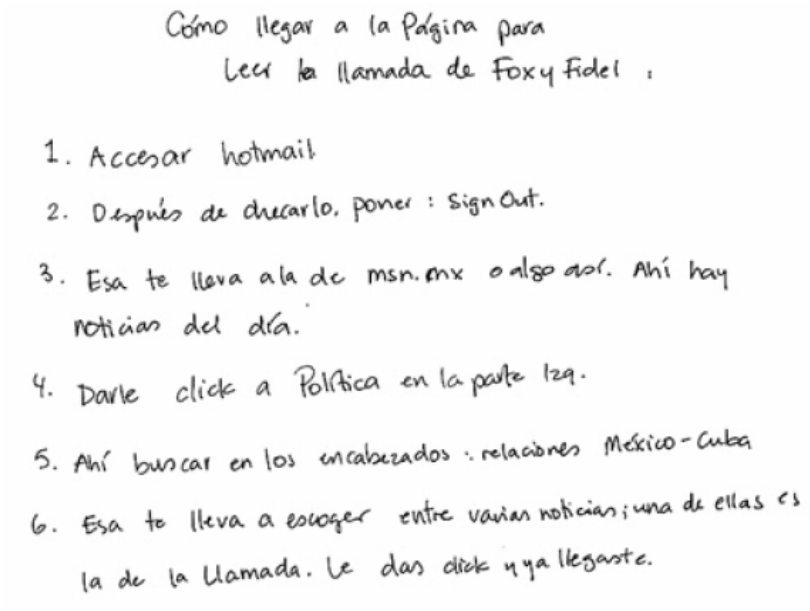


Figure 6 shows a list of instructions for how to access on-line news.


Cómo llegar a la Página para
Leer la llamada de Fox y Fidel :

1. Accesar hotmail
2. Después de checarlo, poner : Sign Out.
3. Esa te lleva a la de msn.mx o algo así. Ahí hay noticias del día.
4. Darle click a Política en la parte Izq.
5. Ahí buscar en los encabezados : relaciones México - Cuba
6. Esa te lleva a escoger entre varias noticias ; una de ellas es la de la Llamada. Le das click y ya llegaste.

Figure 7. This route drawing shows blocks of text, position of elements on the page, two types of instruction, written and graphic, use of arrows, etc.

In the second analysis, the author studied general characteristics and specification of landmarks. The author also measured the accuracy of the route descriptions and depictions by accessing each one of the sites chosen and comparing it with the participants' instructions. Results are shown in Table 2.

Table 2. General characteristics observed in route drawings and route instructions

	Frequency
Participants	15
drawing route	10
writing instructions	05
Sites chosen:	
electronic mail	06

on-line/tv/ music news	05
search machine/games	04
Characteristics:	
number of levels (mean)	3.1
Accuracy:	
correct	13
minor mistakes	02
Specific information:	
headings	14
layout/position	13
additional descriptions	12
interactive elements	07
URL indicated	07
changed names of headings	06
two types of instructions	03
intermediate steps	03
Landmarks specified:	
position of elements	13
blocks w/headings	12
blocks of text	09
divisions of page	04
pictures	03

Discussion

Participants were asked to choose a well-known site for this task. This meant that participants depicted or described a www document that they used extensively and so would be familiar with.

The depictions or graphic representations of routes were very accurate and sufficient to the site described. In Tversky and Lee's terms (1998): 'each segment contained all the essential components: start and end points, path and direction'. Participants showed the detail necessary to convey how to get to desired information in the site. They emphasised the nodes linked, and added details that gave complementary and contextual information by placing headings, boxes of text, pictures, interactive elements, etc. Participants connected pages by arrows or connecting lines.

In contrast, the routes described with written instructions were accurate, but they lack in detail. They did not have any additional contextual information that could help the readers confirm they were on the correct path.

Readers are aware of the importance of interactive elements on the page, such as the form filling boxes. Participants seem to remember the necessary landmarks and how to connect them to reach their objective. It is reasonable to infer that they have developed route knowledge of frequently visited sites.

5.2. Analysis of map drawings

Three different kinds of analyses were done from the participants' drawings of their favourite or well-known www document. These analyses were based on Pattison's (1966) proposals, the experimenter's observations, and Tversky and Lee's (1998) results. The analyses will be explained in turn with their corresponding results.

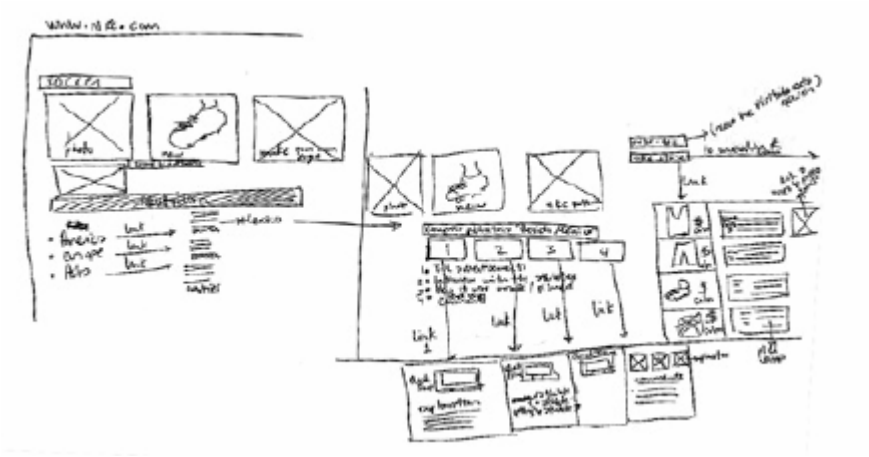
In the first analysis, the four abilities to transform spatial knowledge into map drawings proposed by Pattison (1966) were analysed: to relate directions and places, to miniaturise, to transform from eye-level to bird's eye view, and to add symbols. The results are shown in table 3. See figure 8.

Table 3. Abilities to draw maps (Pattison, 1966)

Abilities	**Frequency**
relate directions and places	14
miniaturisation	16
eye-level to bird's eye view	08
symbols:	08
headings	14
icons	05

squares	03

Figure 8 shows the site map drawing of www.nike.com. The drawing shows the ability to relate pages and directions, to miniaturise, to include symbols (in this case rectangles of pictures, links, blocks of text, layout). However, this drawing does not represent the 'bird's eye view' of a www document in a hierarchical structure.



The second analysis considered the type of drawings, the graphic elements selected, the landmarks placed on the map, and additional observations such as the change of headings' names or the indication of interactive elements. Accuracy, the relationship between elements and their hierarchies were also considered in this analysis. The results are shown in table 4.

Table 4. General characteristics of the map drawings

	Mean
levels deep	2.5
horizontal nodes	3.3
	Frequency
Sites chosen:	
electronic mail	07
on-line news	03
sports	03
education	02
other	03
Characteristics:	
tree structure	07
use of text	01
use of graphic elements	13
Accuracy:	
complete map	0
incomplete map	18
Landmarks specified:	
headings	18
connecting lines/arrows	15
layout of page	11
pictures	05
colour	01
Specific information:	
URL indicated	10
mixed levels	07
incomplete headings	18
changed names	10
interactive elements	07
additional descriptions	08
two mixed descriptions	02

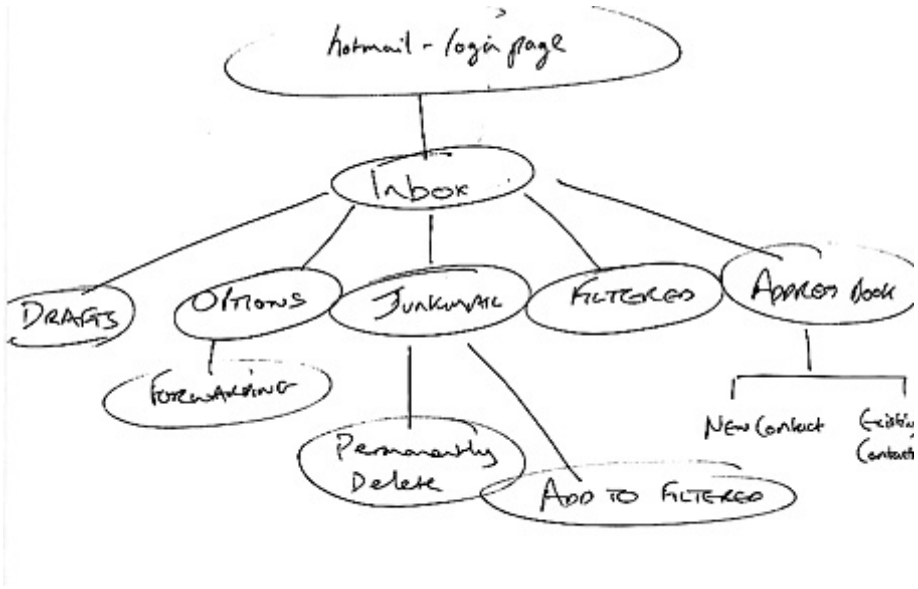
The third analysis looked at the graphic elements included in the map drawings of the site such as start and end points, arrows, icons (rectangles or 'blobs'), connecting lines (Tversky & Lee, 1998) and pictures. Other elements included were: sequences such as top-down (structures that follow vertical organisation, from top to bottom), bottom-up (vertical organisation, from bottom to top), left-right or sun-burst structures (pages that indicated connections to other pages like a centre-out drawing), and turns (pages that were connected by lines or arrows and which suggested

change of direction). The results are shown in table 5. Frequency refers to the number of participants that included the characteristics indicated. See figure 9.

Table 5. Characteristics of map drawings (Tversky & Lee, 1998)

	Frequency
start point	18
end point	08
turns	03
Graphic elements:	
headings	18
icons	15
arrows	09
connecting lines	06
pictures	03
Sequences:	
top-down	12
down-up	0
left-right	05
sun-burst	04

Figure 9 illustrates the site structure of hotmail.com using headings inside blobs connected by lines. The headings from second and third levels are mixed. It is worth noting that the page was called 'log in page' because it has interactive elements.



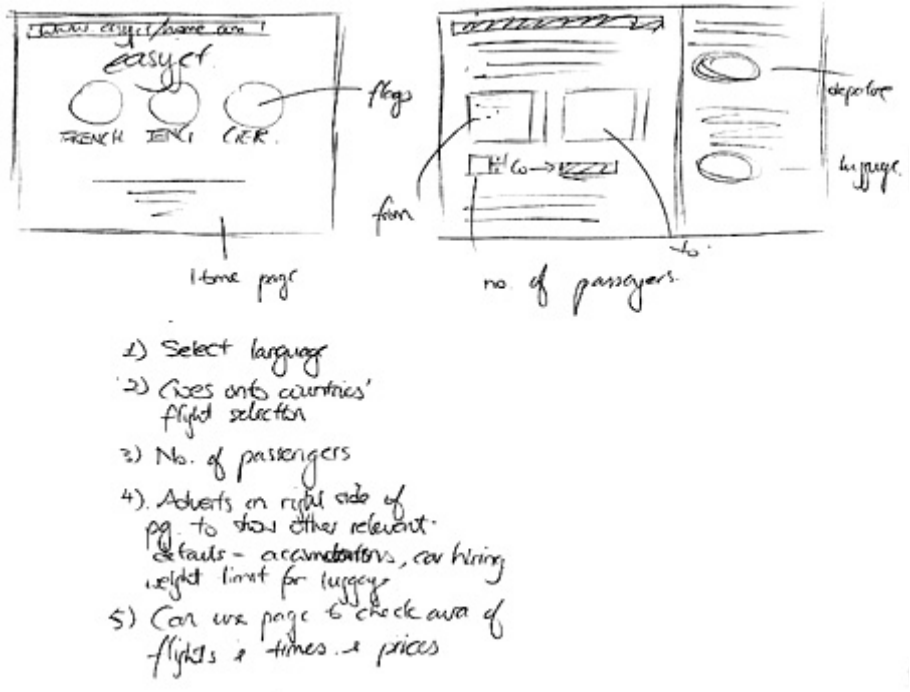
Discussion

After the various map analyses, the author discovered that the results from the map drawing group could be divided into three types:

- ***Home page as a map***

Participants drew the screen with its layout, specified the connections to some elements, identified the position of pictures, etc. Some participants seemed to know the contents of the home page, but not the depth of the www document. The topics they chose varied from sports to on-line news. See figure 10.

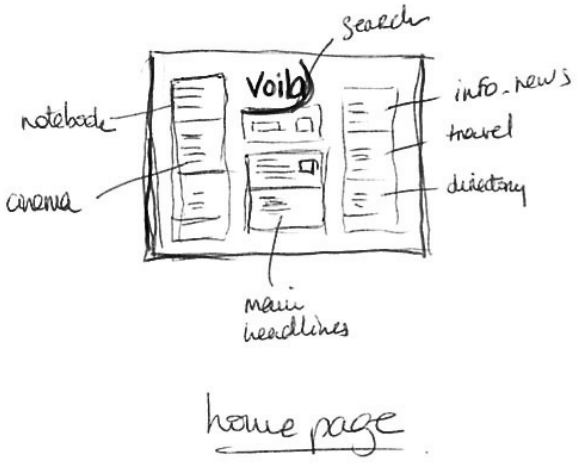
Figure 10 shows the approximate layout of the pages, but no connections that specify the structure of the site. The drawing illustrates the combination of map drawing and lists of instructions. The form filling elements are also indicated in this www page drawing



- *Tree-like map structure*

Participants drew a tree-like map structures that were incomplete and inaccurate. The headings were connected to other subheadings to form a hierarchical structure, but many of these connections were a mixture of nodes and links from different levels of the site. The drawings suggest that only traversed routes were put together, but in a confused order. The sites that participants chose to draw were electronic mail and university sites. See figure 11.

Figure 11 illustrates the home page of www.voila.fr. The drawing shows the general layout specified by the blocks of text, and the headings; but without indicating the structure of the site.



- *Home page with routes*

Participants drew home pages specifying layouts with positions of elements, pictures, interactive elements and arrows indicating a route to two or three destinations. Drawings only showed one or two nodes connected in deeper levels. Some participants mentioned that they knew how the www document functioned, i.e. on the newspaper on-line: 'select the news, go to more information of the same topic, and back again to the homepage'. These participants selected electronic mail sites and newspapers on-line. See figure 12 and 13.

Figure 12 shows the tree-like structure of www.hotmail.com. The drawing indicates four levels that mix the horizontal and vertical headings. The home page is referred to as 'login' page

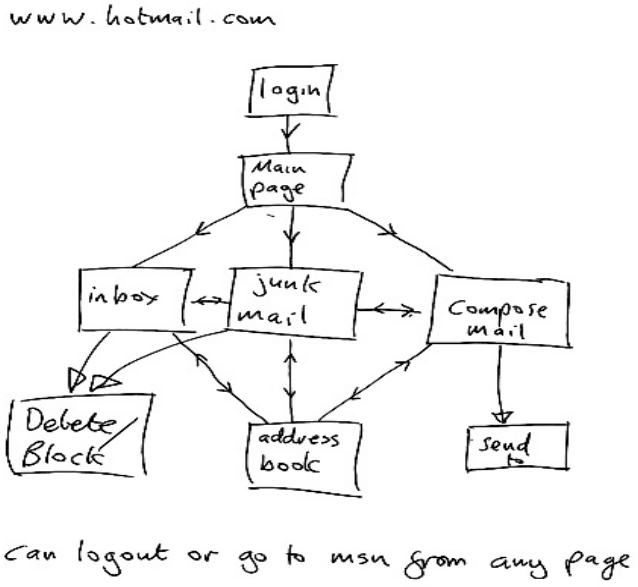
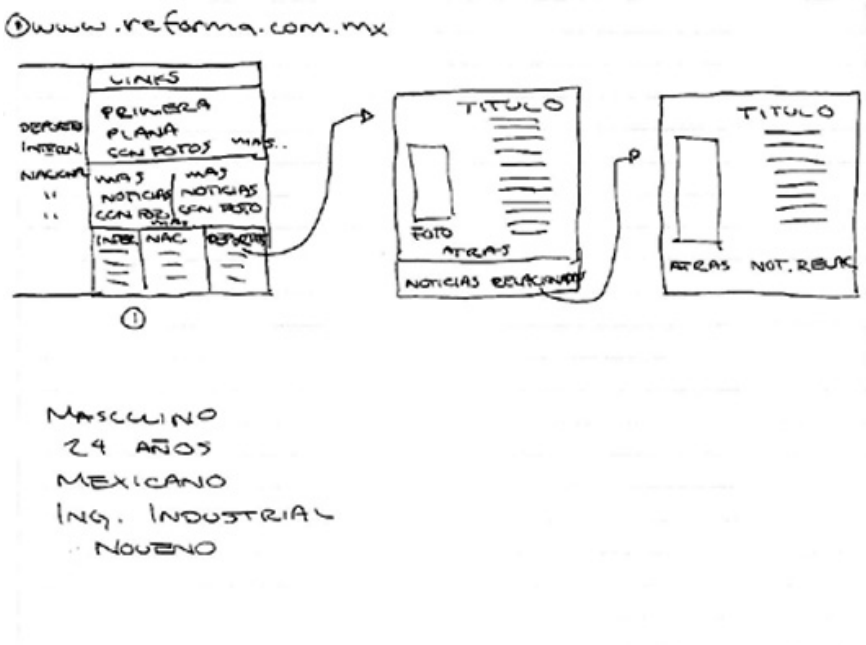


Figure 13 illustrates the home page with one route of on-line news www.reforma.com.mx. The drawing describes the layout and the route to one destination.



5.3. General discussion

Comparison between route instructions and map drawings

There was an important difference in the level of accuracy and completeness between route descriptions (drawings or written instructions) and map drawings. The former were very accurate and complete, whereas the map drawings were not accurate and showed confusion among the different use of headings of levels in the site. This could imply that route knowledge is

developed in a well-known site, whilst survey knowledge or cognitive maps are not developed in use of a wellknown site. Route instructions (either written descriptions or drawings) and map drawings show similar characteristics. Table 6 shows the comparison.

Table 6. Comparison between route instructions and map drawings of well-known sites

Characteristics	Routes	Maps
Participants	15	18
Number of levels (means)	3.1	2.5
Sites chosen:		
electronic mail	40%	39%
on-line/tv/ music news	33%	17%
search machine/games	26%	0%
sports	0%	17%
education	0%	11%
travel/culture/technology	0%	17%
Accuracy		
accurate	87%	0%
inaccurate	14%	100%
Landmarks specified:		
headings	93%	100%
layout of page	87%	61%
interactive elements	47%	39%
pictures	20%	28%
colour	7%	6%
Graphic characteristics of drawings:		
arrows/connecting lines	80%	83%
additional descriptions	80%	44%
changed names of headings	40%	56%
URL indicated	47%	56%
two types of instructions	20%	11%
blocks w/headings	80%	55%
blocks of text	60%	50%

Development of route knowledge in use of a well-known www document

Overall the results show that participants could draw routes to known destinations within a web document very accurately. This might be explained by the general way in which people learn to navigate the www environment, through direct experience, by using URLs, and following route instructions such as 'click on "services", and go to "C" in the alphabetical list'. This suggests that people acquire spatial knowledge of the www environment through route instructions or route traversing. Consequently they only know how to get from point A to point B. The results coincide with Golledge's (1999) conclusions that the 'major concern was to learn the route and the sequence of behaviours [links, in the case of www documents] needed to traverse it, rather than learning the [www] environment through which the route passes'. Thorndyke and Hayes-Roth (1982) found in studies done in physical space that through navigation people only acquire memories of traversed routes. This also seems to happen in www documents navigation as reflected in the route drawings/instructions. Appleyard (1970) found differences among the maps of the city of Guyana drawn by people who travelled in a single route (by bus) or who moved freely (by car). This result might also apply to navigating www documents where readers seem to know only routes in information space familiar to them.

Route drawings

Most of the route drawings are a depiction of what participants saw on screen or eye-view level. They provided details of layout, landmarks and arrows signalling the route to other pages, as do route drawings of routes in physical space (Tversky & Lee, 1998, 1999). Participants seemed to consider that interactive elements are an indispensable means to progress in their routes. This is evident by the fact that no one forgot to include them in their drawings. This seems to be an obvious conclusion, but it implies they are part of readers' careful consideration in understanding interactions with www documents.

Development of survey knowledge of a well-know www document

The map drawings show inaccurate and incomplete site structures even though participants were asked to draw maps of well-known sites. Moreover, there seems to be an important difference between survey knowledge development in www documents and in physical

space. Thorndyke and Goldin (1983) state that richer and more complete knowledge results from frequent visits to a physical environment. However, this does not seem to apply to www documents because the drawings did not show that participants knew the whole structure of the well-known www document and could not reproduce it.

On the other hand, studies have suggested that survey knowledge does not necessarily develop with extended experience in virtual worlds or as a progressive stage from route knowledge. In www documents, if readers are concentrating on reading specific information, choosing the correct link, filling a form, etc, reaching the goal may inhibit their acquisition of the 'site's structure knowledge'. The development of survey knowledge might be slowed down if people have to achieve a goal whilst traversing a virtual environment (Rossano & Reardon, 1999). The order of pages depends on how the reader accesses the site each time, a fact complicating even more the acquisition of survey knowledge. There seems to be a disassociation of route and survey knowledge (Rossano & Reardon, 1999) emphasised by the dynamic and changing order of accessing information in electronic documents. Stanton (1994) states that the different routes that readers can take to specific information and the different routes away from that piece of information 'make extremely difficult' the creation of a cognitive map.

The disassociation between route and survey knowledge (Rossano & Reardon, 1999) was perceived in most drawings even though participants were not asked to perform any task or fulfil any requirement. The drawings seemed to reflect that participants only knew some routes within a site, namely those of interest to them or frequently traversed.

Map drawings

Most drawings depicted a realistic representation of the www pages from an eye-level view. The screen was represented from a frontal view with information such as headings, layout, pictures, etc. Fewer drawings depicted a hierarchical tree-like structure, that is, what seemed an attempt to make abstractions or schematisations of the www document, and which might correspond to the bird's eye view of the web site. These maps did not include any additional information other than the headings and the connecting lines. Drawings of hierarchical tree-like structures perhaps reflected the interest of participants in organising information and creating web sites, as revealed by some Graphic Design students. Structural maps are basic tools for constructing www documents and are often called 'navigation trees' that help designers create the network of information. However, it seems that not all students have yet developed this ability to abstract the information and schematise it into a site structure view.

Map drawings that depicted screens did not seem to show a configurational understanding of the www document. Drawings show that only one or two screens of pages were recalled, and that the different routes away from that page are not remembered. However it might be inferred that readers rely on the information provided in the home page to navigate the whole www document and that therefore they do not need to learn the routes to information but only understand the functioning of the www document. This was shown in the on-line newspaper drawings where participants added careful descriptions of the contents.

Inaccuracy and incompleteness as well as confusion between levels of the site in map drawings, can also be explained by the fact that readers cannot perceive the whole www document at the same time. In physical space people can look at a map and acquire a general overview of the environment. In contrast, site maps are schematic representations that do not reflect the document that will appear on the screen. There is no correspondence of the site map to the documents' appearance. These facts contribute to impediments to learning the structure of a www document.

Correlation between route representations

There seems to be a correlation between route knowledge representations (instructions and drawings) of physical space (Tversky & Lee, 1998), and route knowledge representations (instructions and drawings) of www documents. Participants used the same type of verbs to describe actions (some of them adapted to www documents such as 'clicking'), and the same type of schematisations to describe starting points, landmarks, routes and ending points. In verbal and graphic language both types of route knowledge representations seem to have the same kind of elements.

Indication of cognitive collage

Participants' drawings show that they accurately remember only the first two levels of the www document. This might be an indication that participants could only draw on a cognitive collage (Tversky, 1993) in drawing a map, because only a few items were accurately placed and recalled.

The mixture of nodes and levels seems to corroborate a collage of information: images of text, pictures, elements in motion, additional windows opening (pop-up) with new text, plus the alternation of different levels of information, can provoke a multi-image experience without any stable order and structure.

The misplacement of headings in the drawings seems to correspond to that participants are guessing about the contents of the page. The headings specified seem to be those that are frequently used and therefore that have been learned. Consequently, judging by the limited number of headings recalled, it seems that readers have a vague idea of a site structure. They seem to deduce where and how to navigate, but for location and exact traversing they rely on the information they get whilst consulting the site. Siegel and White (1975) referred to this as recognition-in-context memory, a special kind of figurative memory that helps in recognising landmarks that are attached to specific meanings. Thus, the landmarks and links included in the drawings seem to be only those frequently accessed, well known or meaningful to participants in their navigation.

Site maps in www documents

People learn how to navigate in www documents in various ways, but it is rare to see a map as a source for learning the www environment.

There are www documents that provide a site map with information on the contents and direct links to each topic. Readers can access them to find their way as well as possibly acquire survey knowledge. However, the general site maps that readers are now finding in the www environment are basically tables of contents organised by headings and subheadings (Kahn & Lenk, 2001; Russell, 2002). In former www documents one could find other kinds of site maps, some of them simulating physical maps. For example, in 1999 the commercial site Walmart.com had a site map simulating a shop floor plan. In October 2002 the site introduced a 'directory list'. Other site maps used circular organisations, or used different shapes to convey the site's structure (Kahn & Lenk, 2001). The attempt to depict www space has developed into a more print-like type of representation. The site maps have changed to use hierarchical and categorical lists (Kahn & Lenk, 2001; Russell, 2002) and are sometimes called site index or index. The change from 'spatial' site maps into text organisations may be explained by the following observations:

- *The lists seem to support the idea that www documents are an issue of conceptual information spaces rather than of spatial navigation. Lists appear to be less like physical space and more a semantic network (Stanton, 1994).*
- *Site maps as tables of contents can fit into one www page (Kahn & Lenk, 2001). Spatial representations of www documents are very difficult to achieve because of the complexity of the structure (different levels and connections) structure that requires more space and detail to convey clear information.*
- *Web site software programs are providing adequate tools to create site maps in the form of tables of contents. Thus, designers do not have to struggle to construct a site map.*

6. Conclusions

Navigating in www documents seems to be a goal-oriented interaction. In this study, it was found that almost all participants knew how to draw the routes to their destinations, but they could not draw complete or accurate maps of the sites even though they chose a well-known document. This might show that route knowledge is developed but no survey knowledge is acquired in interacting with www documents because the interaction is usually goal-oriented and not navigational. It seems to be a temporal/chronological interaction more than a spatial one.

The study found that readers had not developed survey knowledge of the well-known sites depicted in their drawings by the time of drawing. A possible explanation might be that the development of survey knowledge in interaction with a www document is impaired by the temporal/ chronological sequence involved in accessing the pages by jumping back and forth in the document through the various levels of the structure. These kinds of 'movement' do not exist for navigating in the physical environment. The situation is comparable to the case of people who visit a building being taken several times up and down in a lift with no mention of the level to which they are in the end conveyed, then being asked to reconstruct the space they had traversed by drawing a map. This evidence does appear to question the suitability of transferring the navigation metaphor from the understanding of the mental process involved in moving in physical space, to the situation of understanding movement in electronic information space.

It seems that a different model should be proposed to study the readers' cognitive process and loads in interacting with the special nature of www documents.

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About the author

María González de Cossío, PhD is a lecturer and researcher at Universidad Popular Autónoma del Estado de Puebla, Mexico and the director of the Centre for Advanced Studies in Design, in Cholula, Puebla, Mexico. She is presently working on a Graphic Design History of Mexico and on consultancy projects on Information Design.

mdecosio@yahoo.com.mx

http://www.ceadmex.org