Coherence phenomena in hypertextual environments

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Kohärenz ist ein Mechanismus, wodurch Textverstehen (die mentale Repräsentation) gesteuert wird. Während Kohärenz in traditionellen Texten ausführlich untersucht wurde, ist bislang relativ wenig über Kohärenzbildungsprozesse in Hypertext bekannt. Textuelle und graphische Kohärenzphänomene wie Nodes und Links, Anchors und Buttons, Frames und Farben sind entscheidend für die Effektivität des Navigierens sowie des Informationsverstehens und -reproduzierens. Wir werden zeigen, daß Navigation in hypertextuellen Umgebungen ein makropropositionaler Parsingprozeß ist (top-down wie bottom-up), der auf logisch-semantischen Verbindungen in einer top-level Architektur gründet. Aus den Schlußfolgerungen leiten wir Empfehlungen ab mit Bezug auf die funktionelle Qualität von hypertextuellen Umgebungen.

1 Introduction

One of the biggest problems in a hypertextual environment is that users are constantly traveling in a range of contexts. Every time they move from one node to another, they have to make a contextual jump. That is why it is important to provide visual equivalents as contextual cues. User friendliness is highly dependent of what users know about their actions in navigating as a process of information processing and retrieval. Users are supposed to know the rough informational structure of the document, e. g. where to get started and what primary features are relevant. As they move around in the hypertextual architecture they should know where they are, where they need to go (using halls, corridors, stairs and elevators) and how to return to a safe living room.

Several studies show that navigating in a textual network, like hypertext, is a complex cognitive activity. In comparison with linear text, reading a nonlinear hypertext requires a higher cognitive load. The user has to memorize his/her location in the network, make decisions about where to go next, and keep track of pages and their contents previously visited. As text comprehension is fully dependent of a coherent mental representation of its contents the user needs sufficient graphic and textual cues in order to establish this coherence. In hypertext the semantic and structural links between the nodes are not always explicitly represented. Therefore, hypertext users may make incoherent shifts between hypertext nodes (e. g. Rouet/Levonen 1996). As a consequence it is obvious that authors must maintain

informational coherence using the various hypertextual means, like colors, anchors, buttons, icons, frames and navigation tools. This means that hypertextual coherence will be realized not only by textual but also – and sometimes only – by visualization cues.

2 Coherence aspects of texts

When reading a conventional printed text, processing occurs at two important levels: the microstructure level (sentence) and the macrostructure level (text). These processes work together simultaneously to extract meaning from the text. During reading, the text is incorporated into the reader's representation of information. Information in a text is analyzed in terms of propositions. Information from the microstructure level is relatively quickly lost. However, some of this information is incorporated into the meaning of the text (text base), represented as propositions. Propositions serve as semantic primitives representing the information acquired. In the text base propositions are connected to each other through semantic coherence relations. Foltz (1996) indicates that in semantic coherence, constituents of text will be coherent if they share some form of semantic relatedness in the discourse.

One of the crucial differences between macrostructures and superstructures is that macrostructures necessarily characterize any kind of complex information processing, whereas superstructures are conventional hierarchical sequences based on extratextual common sense logic. If there is a superstructure available, then the user first uses his/her pre-knowledge in which other different in the structure available elements are placed hierarchically. Thus, the global structural preknowledge steers the fitting in of the lower situated elements like concrete data. Thus, coherence is the extend to which the internal components are linked with macrostructural and superstructural textual and visual elements.

According to Van Dijk (1980), macrostructures are the higher-level semantic or conceptual structures that organize the local- or microstructure of discourse, interaction and their cognitive processing. The macrostructure thus has to represent what is the major more relevant, more general information out of complex information represented at the more concrete micro level. In this case the levels are not independent but systematically related.

The macrostructure of a text becomes clearer as there are more structural elements, for instance titles, available in a text. Van Dijk (1980) indicates that such explicit text cues are indications for the global meaning of a text. The reader is then able to focus on the most important parts in the text. These can be put

together as a coherent entity, that can be remembered easily. In the theory of discourse, the term macrostructure is used to account for various notions of global meaning, such as topic or theme. Macrostructures are necessary to explain the intuitive notion of coherence. A discourse can be coherent both at the local as well as the global level.

Local coherence or microstructural coherence refers to the representation of sentence meanings and to the activation of propositions. In hypertext local coherence can be established between sentences in the nodes. The words that form a text are the raw material from which a mental representation of the meaning of that text is first constructed. In this case, language users must establish coherence as soon as possible otherwise they can not effectively move information from short-term memory to long-term memory (Rada 1991). The degree of local coherence is given by the degree of organization within the propositional network (Rickheit/ Sichelschmidt/Strohner 1995). A text can be considered as locally coherent if, in the end, the propositions are completely interrelated. For parsing and organizing a hypertext and user immediately needs local coherence cues.

On the contrary, global coherence or macrostructural coherence refers to the representation of states of affairs and to the activation of situation models. Being based on verbal information as well as on individual world knowledge, internal models of the situation conveyed by a text are comprehensive. They may even extend far beyond the information explicitly given.

Foltz (1996) emphasizes the need for textual coherence both in printed text and hypertext, and shows how users tend to stick to subjectively coherent patterns when they navigate hypertext hierarchies. He demonstrates in an experiment the need for textual cues for coherence when reading a hierarchical hypertext. In this experiment, subjects were unwilling to make long distance jumps in the systems, and their navigation patterns showed their concern of maintaining coherence in the information flow. Furthermore, the results show that reading a hypertext is not just a reading process, but also a process of problem solving. In order to understand the text, subjects developed heuristics for maintaining coherence with an unfamiliar text domain and text format. Thus, writing a coherence text is in both linear text and hypertext an important issue. In this case coherence should be interpreted not as a pure textual but an interpretative concept.

Just like Van Dijk and Kintsch (1983), who emphasize the importance of structural and propositional elements in text comprehension, Van Berkel (1997) emphasizes that in hypertextual environments without an explicit architectural structure the user is not able to navigate efficiently, which prevents him/her from building up an adequate mental representation. In that case users are often unable

to create a mental picture of the information that has been ordered in a nonlinear way. This has to do with the unclear structures for which there is no mental representation of a superstructure available. Both macro- and superstructures are determined by the way content and visual elements are organized and connected. The hypertextual architecture consists of the relations between nodes and the way links are explicitly linked. The hypertext user selects a node either locally clicking an anchor from the last unit for a hypertext link, or globally from an overview of all text nodes like an image map or table of content in order to maintain coherence.

As Foltz (1996) pointed out, hypertextual coherence is highly dependent of more or less standardized superstructures and micro- and macrostructures as well as their semantic relations (see also Van Berkel 1995). In this case we consider the set of all structural elements as the (organizational) architecture of a hypertextual environment or the website as a whole. Superstructural elements in hypertexts may be textual, but mostly they are transformed into visualizations (graphics) like lay-out, visual maps, hierarchically visualized tables of content and the repeatedly occurrence of icons and buttons inside or outside frames. Global semantic coherence or macrostructural coherence refers to the representation of states of affairs and to the activation of situation models. Being based on verbal information as well as on individual world knowledge, internal models of the situation conveyed by a text are comprehensive. They may even extend far beyond the information explicitly given. In hypertext global coherence can be established between the different nodes with information. A text is globally coherent if every entity mentioned or implied can be assigned to a node in the processing module, and if the topology of the representation corresponds to that of the represented (Rickheit et al. 1995). If hypertext searching, browsing and reading are to be feasible, the user must easily gain helpful cues about coherence at the local and global levels – cues which would not be available with text alone. So it can be argued that coherence is needed both in printed conventional text and hypertext.

The need for textual coherence both in linear text and hypertext explains why users tend to stick to subjectively coherent patterns when they navigate hypertext hierarchies. We already referred to Foltz (1996) who demonstrated the users' need for textual coherence when reading a hierarchical hypertext. In order to understand the text, subjects developed heuristics for maintaining coherence with an unfamiliar text domain and text format. Coherence should be considered as the result of a more complex processing of textual and visual elements and cues.

From an information processing perspective reading a hypertext looks like reading a printed linear text. In both propositions have to be incorporated, that means

internally presented into a text base and a situation model. However, the selection process during the reading and processing of hypertext is more prominent, because of the necessity of constantly selecting a next node after another. Thus, it is especially the selection process that distinguishes the two text forms. In other words, in hypertext the user constantly has to choose a text unit (node) in order to determine the sequence of the given information, whereas in printed linear text the user never has to choose the sequence of the text. Navigating through a hypertext has also a problem-solving dimension in the sense of Newell (1990) which implies that the user has to analyze the problem into chunks in the sense of macroprositional elements and their connectiveness.

There are several kinds of problems that follow from an inadequate structure causing misconceptions and false representations. This also prevents the user from chunking the problem which does not lead to its solution otherwise than trial and error. Sanders and Sanders (1996) mention three categories for conventional printed text which we adopt here for hypertext.

(1) Discontinuities: content elements that belong together, are not presented together, i. e. there are unclear or no links at all to content elements that macrostructurally or superstructurally belong together.

(2) Unclear hierarchy: the absence or inadequacy of image maps, hierarchally structured table of content or other structure markers and organizers.

(3) Insufficient explicitly: there are unclear or no cues at all that facilitate navigation. These cues are mostly independent of continuity and hierarchy, but user oriented, which means that an author designed them based on a more or less intuitive idea about the possible navigation problems a user may have to solve.

Continuity and hierarchy are necessary conditions for the understanding and processing of a mental representation, whereas explicitness (in a narrow sense) is a sufficient condition.

3 Coherence aspects of hypertexts

3.1 Nodes and links

For all interface elements it counts that the user friendliness is dependent of their consistency and predictability. After some experience with hypertext, users begin to construct a conceptual model or user illusion of the system as they imagine it would be. This mental model allows the user to predict the behavior of the system without having to memorize many abstract, arbitrary rules (Lynch 1997). The primary goal of interface design should be to create and support a relevant and

coherent mental model of the operations and organization of the hypertext system.

Establishing a distinctive pattern (lay-out, colors, frames, buttons) as a leitmotif throughout a hypertext document helps the user determine the location and organization of information and increases the usage and legibility (cf. Rada 1991 and Oliver 1995). Consistency can be achieved by a generic banner and navigation buttons, subtitles and text in the same size and a the continuous repetition of a frame at the left and/or right margin of the screen. Choosing the appropriate attributes and implementing them consistently is essential to maintain.

Hypertext systems can be considered to be textual database applications which provide a unique, non-sequential and flexible method of accessing information through navigation. The most essential properties of hypertext are nodes which contain information, links which connect the related nodes and navigation tools used to determine the user's path through the informational architecture. There are a number of research issues related to the design and development of hypertext systems.

According to Eyzaguirre (1996) nodes act like containers. Nodes can obtain data like text, graphics, sound and moving images. A web browser (for example Netscape), represents each node as a single page, the content, including title, graphics and headlines. As users navigate through a web site, they can load new nodes into their browser by following links. A node's location in a site determines how often it will be visited by an user. If a node is connectively almost hidden, unclear by random graphics or too much text, it may never be used. Usually, the important nodes, like introductory text, image maps and table of contents are at the very top of the hierarchy. The user can use it as a reference point that facilitates the processing which enables her/him to navigate purposefully through all information nodes. Therefore it is necessary that all pages have an anchor to the top page.

Nodes are units of information that are connected with links. Links arrange nodes in a variety of ways. A link can not independently contain any information. Links are anchored to a specific location with a node, so that the user has the ability to click on the word, icon or button that can be associated with that link. According to Musgrave (1996) links have also other characteristics, they may be explicit or implicit. An explicit link is defined as connecting an anchor node with the destination node. Implicit links are not defined but follow from various properties of information. Visual cues like text or graphical links provide paths to new and related locations. The links suggest possible relations to the current contextual node.

Rada (1991) distinguishes four different link types. A sequence or linear link shows a linearity between two text blocks X and Y, which means that text block X is sequentially followed by text block Y. Linear structures are easy to conceptualize because they are closely related to linear texts. These links may guide users to the first, previous, next and last page. Secondly an outline link goes from an outline to the beginning of a section which elaborates on that portion of the outline. Then a reference or citation link goes from a point in a text block X where an author's work is discussed to the text block Y where the author's citation is detailed. Last, an embedded or cross-reference link is in the text of a text block and takes the reader from a concept in the text block to another text block which has information related to that concept. These embedded links are most common in hypertext and may cause problems if they are not well described or explicitly represented. If not, users may make incoherent shifts between hypertext nodes.

Creating links to previous nodes reassures the user that they have not entered a brand new world because there is continuity between pages. That is why links should be bi-directional, allowing the user to move up to the previous page, the home page or a menu page as well as downward through chains of linked documents. The links to the navigation tools should be clearly labeled and consistently located.

3.2 Buttons and icons

The radical shifts in context that links can create, can easily confuse hypertext users. So they need carefully organized cues if they are to follow and understand hypertext links from one web page to another. Button bars are used to place fixed links between a series of pages to bind them into a document. In complex sites button bars can also be used to provide links to submenus, tables of content or other organizational pages.

Buttons make great navigational aids. An element of good page design is to have the same buttons throughout the whole document. This gives consistency to the document, so users know when they are in the document and when they are outside it. Buttons should always provide a text label in order to provide coherence with the graphical image. Besides, the graphical picture should be clear, in other words the reader should be able to link the image with his background knowledge. Buttons should also be consistent in the same place throughout the whole document, users feel more comfortable if a consistent look is maintained. A button can be highlighted to show the current location. Which again may create a better comprehension of the organization in the site and maintain user's coher-

ence. In other words, having buttons on each page alleviates the reader from having to keep track of the current location and short-term memory load is reduced.

Most hypertext systems also support a backtrack facility as an internal navigation tool. This means that if we are at node C from A, the backtrack facility should provide the ability to return to A. This can be achieved with a bi-directional link. The backtrack function is one of the most important navigational techniques. This technique allows the user to revisit the previous node. Unfortunately it is not always implemented consistently, which can lead to confusion on the part of the user and may cause incoherence (Musgrave 1996).

Icon bars are not inherently easier to understand than text-label buttons, and text-label buttons are often essential to clearly indicate the function of a button. Avoid labeling buttons “back”, “next” or “more”. It is best to name the actual content, for example “to page 2” and so on. “Next page” and “previous page” buttons in a document are fixed links to other associated documents. In this many users are unknown with the fact that “going back” through a series of links is not the same as “paging back” through the preceding pages. By providing the user with paging buttons and links to the local home pages and table of contents, the user is given the tools to readily investigate and understand how a web site is organized.

Buttons at the top or bottom should not prevent the user from reading the information in whatever order s/he chooses. However, they do allow the user to easily follow the sequence of pages. Place at least a few standard navigation buttons on each page to help users move around your site easily. Each page should have a button that goes to the site’s home page and also a button that goes to the site major information areas. Buttons should always appear in the same place and are always in a certain order: they go from left to right, from the lowest-level in the information hierarchy to the highest level. Internal site navigation buttons are vital when a user does not come to a site through the front door. Someone may go directly to a page on your site that is several layers deep because, for instance, a search s/he was doing recognized the page as a hit. In this case internal site navigation buttons make it easy to explore the site, no matter how a user entered.

Icons make as buttons, great navigational hints. It is very effective to have the same consistent icon throughout the work, always linked back to the top page. This kills two birds in one stone: it gives consistency to the work, so users know when they are in it and when they are outside it, and it also gives them a quick way of getting back to the top. In order to get even more consistency in the document, a small string with navigational icons can also be put at the top (or bottom) of each page. The first icon can for example go back to the top of the work, the

second can go back to the chapter, the third can go back to the section within the chapter and so on (Berners-Lee 1995).

Image maps and metaphors define the graphic concepts that introduces the user to the contents. The image map may be a single image or a set of images that represent the content and give access to it. A metaphor is a special kind of image map, that places images in a relevant, visual and predictable context, presenting them in terms of an object (place) that people use outside in daily life.

4 Conclusions and recommendations

The flexibility that hypertext supplies not only effects the reading process, but also how a user represents the hypertext structure. Furthermore, reading a hypertext is not just a reading process, but also a process of problem solving. An important issue in this case, is that a hypertext user is constantly traveling between a range of contexts. In order to make coherent relations the user has to possess a mental representation of how the information is organized. Text coherence plays a central role in building up a mental representation of the text content. In hypertext coherence should be interpreted not as a pure textual but also as an interpretative concept. Thus, an important way to improve hypertext comprehension is improving the local as well as the global coherence of information available in the hypertext. In this context it is therefore important to answer the question of how coherence can be realized in hypertextual environments and what textual and hypertextual phenomena play an important role in this process.

Processing of a hypertext occurs like a conventional text at two levels; the microstructure level and the macrostructure level. At the microstructural level, local coherence is established if in the end the propositions are completely interrelated. Global coherence, at the macrostructural level, is achieved if every entity mentioned or implied can be assigned to a node in the processing module and if the topology of the representation corresponds to that of the represented. The schematic form that organizes the global sequence of contents, the superstructure, is one of the main vehicles by which navigation can be executed efficiently. In this case the degree of coherence is the extend to which the internal components are linked with each other and the environment.

The structure of text is of essential importance of the way the reading process takes place in hypertext. After all, hypertext information is chopped into pieces and the users are restricted to see one web page at a time. Structure can in this context be defined as the way content elements are organized and how they are connected with each other. Hypertextual architecture consists mainly of the rela-

tions between nodes and the way links are organized, the hierarchical structure and the way in which relations and hierarchies are made explicitly clear. In order to build up a mental representation and maintain coherence, users need predictability, consistency and a well balanced structure with clear functional and graphic continuity between the various components and subsections of a web site. The primary goal of the interface design should be to create and support a relevant and coherent mental model of the operations and organization of the hypertext system.

The relevance and central point of a site should be reflected in every node the user sees. A collection of nodes separated and organized by content is easy to manage and leads more easy to local and global coherence. Important nodes should be placed at the top, so users can immediately see its contents and remember it as a reference point for the site's data. Links are anchored to a specific location with a node, giving the user the ability to click on the word associated with that link. For maintaining coherence these words should always be well described and predict the content of associated nodes. Readability can be improved if only the links are shown relevant to the current nodes' positions in the site. Links should be bidirectional allowing the user to move up to the homepage as well as downward to other pages. This is useful to keep the user oriented and helpful to build up a coherent mental model.

Users of hypertext need support in the form of a strong sense of structure and place. The basic organizational structures, linear, hierarchical, circular and clusters provide ways to categorize many types of data into linked nodes. It depends on the site's main goal, but mainly it is useful to use a combination of different organizational structures to present data effectively. It is also important that a site is clearly organized by creating clearly distinguishable areas. This will increase the overall legibility of the document, reduce the mental effort and help users quickly interpret the whole page. In order to create a coherent macrostructure, hypertext systems must provide the user with an easily navigable structure. Navigation tools allow users who browse hypertext documents to link to another location. Every node should provide a control or navigation panel at its beginning and end. In this case it is important not to overload the user with navigation choices. Graphic menu schemes usually offer only six to eight choices before users become visually overwhelmed.

It is useful for the comprehension of the user to achieve an optimal balance between content and visual appeal, which includes color and contrast. Because of the legibility of web sites a simple background and a dark text is recommended. If a background color or image is used, the text and link colors must be set to hues

that will show up well against the background color. Related pages can be divided into visually different information parts by giving every part a different color. This will keep the user oriented and helps him/her in building up a coherent mental representation.

A table of contents is an almost universally understood navigation tool and can provide a global macrostructure and create coherence for the user. If hypertext does not contain a table of contents, selection can only take place locally in a node itself. Hierarchical charts can provide a spatially organized overview of an entire web site, which gives the user the structural layout at one glance. Value can be added by highlighting the link of the last node visited, which provides an additional orientation cue for the user. Buttons also make great navigational aids and are used to place fixed links between a series of pages to bind them into a coherent document. Buttons should be the same throughout the document and appear in the same place and order. They should also always provide a text label in order to provide coherence with the graphical image. This gives consistency and coherence to the web site and makes it more predictable. A button can be highlighted to show the user the current location in the node. Every node should have a button with a backtrack facility, that allows the user to revisit a previous node. All of these recommendations give consistency, predictability and coherence to a site and users exactly know when they are in it and when they are outside it.

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