

Is a hypertext a book or a space? The impact of different introductory metaphors on hypertext construction

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Abstract

This study examines the impact of different metaphors on the process of hypertext construction. Two groups of 20 college students with no experience in hypertext construction received introductory explanations on the text format “hypertext” based on either a book or a space metaphor. Then they had to construct hypertexts by linking prepared nodes on the topic of the “Internet”. The different metaphors had significant effects on the constructed hypertexts, the construction process, and knowledge acquisition. The book metaphor encouraged a more linear way of viewing hypertexts that conflicted with the complexity of the contents to be processed. The space metaphor permitted a correspondence between complex semantic structures and complex hypertext structures. Hence, the space metaphor seems to be more appropriate for explaining the text format hypertext to students.

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1. Introduction

The construction of hypertexts in the form of Internet pages has become increasingly popular in recent years. Software development has made it technically easy for anybody to produce their own hypertexts. Furthermore, some projects on the construction of hypertexts have been carried out in schools and universities. These projects are based on the assumption that hypertext construction may foster an active, cooperative, and constructive learning process about the subject matter (e.g., Bromme & Stahl, 2002; Talamo & Fasulo, 2002; Wolf, 2002). Writing hypertexts can be conceptualized as a design act. It is not easy to maintain the balance between thinking about the

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content to be processed and thinking about surface features of the hypertext (Dillon, 2002). Accordingly, one problem that arises in such projects is, that too much attention is paid to the design of hypertexts. This has the consequence that students have only a superficial comprehension of the subject matter presented by their hypertexts (Bereiter, 2002).

To promote knowledge acquisition through constructing hypertexts, it seems necessary to encourage reflection on the contents while creating the hypertext design. This assumption is analogue to ideas from research on writing traditional text: In their “knowledge-transforming model,” Bereiter and Scardamalia (1987) claimed that writing promotes knowledge acquisition only when authors formulate their text within a continuous interaction between their content-related knowledge on the topic addressed in the text and their rhetorical knowledge on the design of the text and its structure. Such problem-oriented procedures (see, also Hayes, 1996; Hayes & Flower, 1980, 1986; Kellogg, 1994) require authors to reflect on and extend their own knowledge (Horton, 1982).

This research on learning by writing provides a helpful heuristic with which to examine conditions and processes of learning by constructing hypertexts. Constructing hypertexts places special constraints on the design of the documents through features of the text format: the nodes, the links, and the multilinear structures. Conscious consideration of these constraints might initiate a learning process comparable with “knowledge-transforming.” This process might support knowledge acquisition in the following way (see Bromme & Stahl, 1999, 2002; Stahl, 2001):

1. Constructing node texts requires an author to discriminate between main concepts so that they can be presented as separately comprehensible text units. As a result, their construction can contribute to a comprehension of the concepts and of conceptual differences within the subject matter.
2. Thinking about necessary links requires a processing of semantic relations between the concepts explained in single nodes. A thoughtful application of links can thus contribute to the comprehension of semantic relations.
3. When planning the total structure, an author has to comprehend the content structure of the subject matter. Because of their multilinearity, hypertexts can be read in different ways. Thus an author has to anticipate possible audience perspectives in order to create flexible ways of reading the hypertexts. Considering multiple perspectives can contribute to a deeper comprehension of semantic structures within the subject matter and to a more flexible use of the new knowledge (e.g., Jacobson & Spiro, 1995).

Of course, the processes described above represent an ideal case. What we have to do is to find instructions that help learners to deal with the features of hypertexts in a way that encourages these learning processes. For traditional text formats, stable patterns of presentations have emerged over the centuries that serve as guides for both writers and readers (see Landow, 1994; McKnight, Richardson, & Dillon, 1990; Ong, 1982). Newspapers, books, articles, and so forth follow conventions of style and layout (Dillon, 2002). Such knowledge about texts is important for both text comprehension (e.g., Kintsch & Yarbrough, 1982) and text production (e.g., Bereiter & Scardamalia, 1987; Kellogg, 1994; Torrance, 1996). However, such conventions are only just beginning to emerge for digital genres like hypertexts (Dillon & Gushrowski, 2000; Foltz, 1996; Hammwöhner, 1993; Hannemann & Thüring, 1993; Jonassen & Grabinger, 1990; Marchionini, 1990; Rouet & Levonen, 1996).

If hypertext construction is to be used as a method for knowledge acquisition in schools and universities, it is necessary to find instructions that explain the features of hypertexts in a way that will initiate the anticipated learning processes. One possible way of doing this is to use metaphors.

2. Metaphorical models of hypertexts

A common practice in the design of computer software is to communicate the structure of software by metaphors. Metaphors assist in linking new information to existing knowledge (Indurkha, 1992; Petrie & Oshlag, 1993). They structure the perception and the handling of the environment they refer to (Jih & Reeves, 1992; Kim & Hirtle, 1995; McAleese, 1990). The reason why they are helpful for teaching is that they shape a complex semantic into one concept. They are vague, and therefore give rise to inferences about the issues they refer to. A prominent example is the desktop metaphor widely used to communicate the idea of graphically oriented user interfaces. The use of metaphors to explain hypertexts is also widespread (Gall & Hannafin, 1994; Hammond, 1993; Hofman, 1991; McAleese, 1989; Nielsen, 1993). The most common ones used are the book metaphor and the space metaphor (McKnight, Dillon, & Richardson, 1991).

A *book metaphor* compares hypertexts with traditional books. Its advantage is the comparison of hypertexts, as a new text format, with the prototype of text formats – a book – that is familiar to every user. Because linking new knowledge to existing knowledge is an important learning function of metaphors, this may help learners who are constructing their first hypertexts. Its disadvantage is that users may associate the book metaphor too strongly with the idea of increasing linearity and reducing complexity (Edwards & Hardman, 1989; Gerdes, 1997; Tergan, 1997). This disadvantage can be seen in studies on navigation in hypertexts. Gray (1990, 1995), for example, showed that inexperienced users often applied linear mental models to hypertexts, and this, in turn, led to problems of navigation and information processing because they triggered the wrong expectations. Leventhal, Teasley, Instone, Rohlman, and Farhat (1993) offered their participants different functions for navigation and information search. They reported that users particularly selected those functions corresponding to the use of a book, although others would have been more useful. Tergan (1997) and Hasebrook (1995) reported that inexperienced users often work with hypertexts in the same way they do with linear texts by, for example, “paging” through the nodes. All these findings suggest that a book metaphor may well be disadvantageous when trying to communicate the potential complexity of multilinear hypertexts.

A *space metaphor* compares hypertexts with virtual information nets in which users can move about and seek information (Allinson & Hammond, 1989; Baird & Percival, 1989; Gall & Hannafin, 1994; Kim & Hirtle, 1995; Smith & Wilson, 1993). Concepts like “navigation” are typical for spatial associations. By using a space metaphor, it should be possible to link new information with fundamental sensory experiences in our environment (in the sense of Lakoff, 1990; Lakoff & Johnson, 1980). Cunningham, Duffy, and Knuth (1993) as well as Turner and Dipinto (1992) reported that students who worked on hypertexts for any length of time developed spatial metaphors to talk about their hypertexts. Moreover, Edwards and Hardman (1989) argued that users acquire spatial cognitive maps of their hypertext structure. Levin, Stuve, and Jacobson (1999) carried out a study on mental representations among Internet users with different degrees of expertise. They found that increasing expertise led to multiple representations of the Internet, and that most of these representations could be conceived as spatial metaphors.

However, the use of this metaphor is also controversial. Landow (1990), for example, noted that it creates the impression of a space-time relation that does not exist in hypertexts. He argued that every distance corresponds to just one mouse click; that is, there is no distance as such. In

contrast, Kommers (1990) argued that distance could be defined as the number of nodes between a starting node and a target node. However, McKnight et al. (1991) and Dillon, McKnight, and Richardson (1993) compared the development of cognitive maps of the real world with that of hypertexts and concluded that the basic cognitive processes of moving in imagined geometric space could not be applied to navigation in hypertexts. Nonetheless, even if fundamental spatial experiences cannot be applied fully to navigation in hypertexts, this space metaphor could be more suitable than a book metaphor in that it is appropriate for conveying the complexity (i.e., the multilinear structure) of this text format.

In sum, the use of metaphors has been the subject of many discussions and studies on navigation within hypertexts. However, it cannot be taken for granted that metaphors have any impact at all on the processes of hypertext *construction*. Indeed, up to now, no empirical evidence is available on the influence of these metaphors.

3. Study goals

This study examined how two different introductions to hypertexts in the form of a book metaphor and a space metaphor would impact on the processes of hypertext construction, the hypertext product, and on learning in college students producing hypertexts. There were two research questions:

1. Do different metaphorical explanations have any impact at all on the subsequent construction of hypertexts? Nearly all students at schools and universities have at least some idea about the Internet and hypertexts. Perhaps these general ideas cannot be influenced further by short metaphorical introductions. Hence, we examined whether such metaphorical explanations sway students' ideas on what is a hypertext.
2. If effects can be found, which metaphor is better suited to give an idea of the multilinear structure of hypertexts that could facilitate knowledge-transforming processes? We assume that an understanding of the potential complexity of hypertexts is a necessary step toward initiating knowledge-transforming processes as described above. If one metaphor proves to be more suitable for this, it could be used as an introduction to hypertexts in school and university projects.

To examine these questions, we asked psychology students who were unfamiliar with constructing hypertexts to link 16 prepared nodes about the topic "Internet" to a hypertext. The themes of the nodes included the history of the Internet, its technology, and Internet services. Half of the students were introduced to hypertexts with a book metaphor; the other half, with a space metaphor. The construction phases were videotaped, and the students were asked during their work to report what they were just thinking about.

We focused on the process of *setting* links. Students were not asked to write the nodes themselves, but to construct hypertexts by linking prepared nodes. Node writing was not included for methodological reasons: It would increase the variance in the constructed hypertexts and in the construction processes. This might make it hard to detect the effects we were interested in.

We assumed that both metaphorical introductions should have different effects on the design of the hypertexts, the construction processes, and knowledge acquisition on the topic Internet. In detail, we tested the following hypotheses:

3.1. Hypothesis 1: Number of links

Students who read the introduction with a space metaphor should set significantly more links in their hypertexts than students receiving the book metaphor.

Rationale. The space metaphor compares hypertexts with a virtual information network. This should promote the idea of highly interlinked contents and result in a lot of links between nodes. The book metaphor, in contrast, is expected to support an idea of skimming through pages and a more linear way of reading. This should result in a small number of links.

3.2. Hypothesis 2: Structure of hypertexts

Students in the space metaphor group should construct significantly more hypertexts with a network-like structure. Students in the book metaphor group should construct significantly more hypertexts with a linear structure.

Rationale. The use of a space metaphor might result in a hypertext structure with highly interconnected nodes. A book metaphor might result in linear hypertexts; that is, each node connected to *one* following node by a link.

3.3. Hypothesis 3: Pauses during the construction processes

The total time used for pauses should be significantly higher in the book metaphor group than in the space metaphor group.

Rationale. We define pauses as time periods lasting a minimum of 5 s during which no operations on the computer screen can be observed. Research on text production views pauses as indicators of cognitive processes in writing (see Eigler, 1997; Flower & Hayes, 1981). We think that pauses during hypertext construction likewise indicate time periods of cognitive processes like comprehension of contents and reflections on how to structure the hypertext. We assume that the book metaphor supports the idea of a reading order. Thus, this group will try to reduce the semantic complexity between the nodes in order to find such a reading order. Because of the incongruity between the complex contents and the idea of reduction, a large amount of time will be necessary to reflect on how to structure the hypertexts. The space metaphor group will express the semantic complexity between the nodes by setting a large number of links. Because of the congruence between the complexity of content and the idea of an interconnected hypertext, this does not require so much reflection on the hypertext structure.

3.4. Hypothesis 4: Verbal statements on the rationale for link setting

Students in the book metaphor group should verbalize more reflections on how to “linearize” their hypertexts, whereas students in the space metaphor group should verbalize more reflections on the idea of a complex network.

Rationale. We assume that decisions about how to structure the hypertexts are influenced by the particular metaphor. Thus verbal statements will reflect the metaphorical explanation.

3.5. Hypothesis 5: Statements on the hypertext structure

Students in the book metaphor group should make more verbal statements on the structure of their hypertexts than students in the space metaphor group.

Rationale. This is analogue to Hypothesis 3. The book metaphor group will have problems in structuring their hypertexts appropriately. Thus, they will produce more statements about trying to reduce the semantically complex contents of the nodes to an appropriate reading order. It should be noted that this hypothesis refers to the amount of explicit considerations on the overall structure of the hypertext to be constructed, whereas Hypothesis 4 examines how students interpret the metaphorical ideas.

3.6. Hypothesis 6: Knowledge acquisition

Students in the space metaphor group should gain more knowledge about semantic relations and more transfer knowledge than students in the book metaphor group.

Rationale. We assume that the space metaphor group will set more links. That is, they will express more semantic relations between the contents of the nodes by means of links. This will result in a deeper knowledge about the semantic relations and structures of the topic Internet. The book metaphor group will try to reduce complexity. Thus, they will not gain as much knowledge about different relations and structures between these nodes.

4. Method

4.1. Participants

Forty psychology students (20 per group) participated in the experiment. The book metaphor group contained 17 women and 3 men with a mean age of 20.05 years ($SD = 1.19$). The space metaphor group contained 15 women and 5 men with a mean age of 20.35 years ($SD = 1.14$). Participation was voluntary and rewarded with €15. A criterion for participation was no prior in-depth knowledge of the topic Internet and no experiences with the construction of hypertexts. This was controlled with a pretest. At the time of data collection, it was not obligatory for students at this university to have a personal email and Internet account. This made it possible to find enough students who were interested in the topic but knew hardly anything about it.

4.2. Material

4.2.1. Instruments

Students worked with a Power-Macintosh G3 connected to a 21-in. monitor. They used the software “AOLpress 2.0.” for hypertext construction. The computer was connected to a video-recorder with an external microphone so that both the participants’ operations on the screen and their statements could be recorded on the same videotape. Paper and pens were provided for taking notes.

4.2.2. Introduction to hypertexts

Two introductions to explain hypertexts were written, comparing them metaphorically to either books (book metaphor) or virtual information spaces (space metaphor). In the introduction based on a book metaphor, hypertexts were compared with books, nodes were described as pages, and links were presented as the possibility of paging through the book. In the introduction based on a space metaphor, hypertexts were presented as virtual information landscapes, nodes as individual information locations, and links as pathways between these locations. Both introductions started with a general explanation of hypertexts, followed by more detailed explications of nodes, links, and the overall structure. The texts for the first nodes in both introductions are presented in Fig. 1.

What are hypertexts? The following paragraph will give you a short explanation of what “hypertexts” are. Perhaps, you’ve already had a chance to look around in the Internet. If so, you will have noticed that, even though it is a new medium, the Internet also presents information as written texts. Despite the fact that, at times, pictures or even short films are inserted, texts still predominate. Most are short texts that are easy to read in one go. Almost all text documents to be found in the Internet are hypertexts. Therefore, the first feature of a hypertext is that it is an <i>electronic</i> text document. Hypertexts are a form of presenting texts that are constructed and stored electronically. Hypertexts can only be produced on the computer and are meant to be read on the screen. When dealing with larger documents, hypertexts are best compared with electronic books. Hypertexts are electronic text documents or electronic books Hypertexts can therefore be described through the idea of an electronic book filled with many stored pages. The two essential components of such a book are the nodes and the links.
What are hypertexts? The following paragraph will give you a short explanation of what “hypertexts” are. Perhaps, you’ve already had a chance to look around in the Internet. If so, you will have noticed that its texts differ from normal texts: It is possible to jump from specific marked points to other reference points within them. In this way, the information forms a net in which you can follow the contents in several directions. Nearly all text documents in the Internet offer this option because they are hypertexts. Therefore, the first feature of hypertexts is that they are electronic information nets. They can only be produced on the computer and are meant to be read on the screen. When dealing with larger documents, hypertexts are best compared with information spaces. Since one can, figuratively speaking, conceive these nets as landscapes or as spaces in which one can move around mentally, they are also called information spaces. Hypertexts are information nets or spaces Hypertexts can therefore be described through the idea of a virtual information space filled with network-like interlinked information units. The two essential components of these information nets are the nodes and the links.

Fig. 1. Text excerpts from the two metaphor introductions. Top: book metaphor, bottom: space metaphor.

Each introduction contained approximately 1300 words and was presented in the form of short hypertexts with four nodes. Both were broadly identical in their formal aspects, for example, central concepts were explained at identical positions within the texts. All aspects unrelated to the metaphors were explained identically.

4.2.3. Exercise with the HTML editor

Each participant was given the opportunity to practice linking six nodes under supervision. The main topic of these nodes was “mammals.” Twelve different links were set during the exercise. Each student practiced setting links until she or he had mastered the necessary commands. These exercises were identical for both groups.

4.2.4. Nodes on the topic Internet

Students had to construct a hypertext by linking 16 prepared nodes. Each node explained a concept in the domain of the Internet in about 100 words. The texts dealt with historical developments, technical basics, and Internet services. They were semantically complex so as to offer many potential links to other nodes. The nodes had been tested for comprehensibility and semantic complexity in previous studies (Stahl, 2001). They were presented on the computer in the form of HTML files and as printouts on 16 file cards. Fig. 2 presents an example of a node text.

4.2.5. Knowledge tests

The test on knowledge acquisition about the topic Internet was developed in prior studies (Stahl, 2001). It is made up of five subtests on the contents of single nodes (content knowledge), relations between nodes (relations knowledge), and transfer knowledge. The first subtest presents

NCP

Network Control Protocol. This protocol was used for the distribution of data packages in the ARPANET. To ensure a reliable data transfer, it confirmed the reception of every data package. In addition, the NCP controlled whether the data packages arrived without any errors by calculating a sum of the digits of the package contents and returning this to the sender. NCP was used by special computers comparable with “routers.” For the correct routing of data packages toward the target computer, the best connection—according to the present capacity of the different routes—was calculated every 0.7 s.

Fig. 2. Example of a node text. NCP is a technical protocol previously used in computer networks.

10 multiple-choice questions on the contents of single nodes. The second contains 10 multiple-choice questions on relations between the contents of different nodes. The third consists of four items presenting a logical relation (i.e., “is a”). From a number of given concepts (explained in the different nodes), students have to select five pairs to which this kind of relation would apply. Transfer knowledge is assessed with two additional subtests: The fourth subtest contains 10 items presenting incomplete analogies between concepts. They have to be completed by selecting the missing concept from a given list. Finding these analogies can be viewed as a test for transfer knowledge, because acquired knowledge has to be restructured in order to deal successfully with the task (Jonassen, 1993). The final subtest contains two questions on the Internet that have to be answered in the form of short essays. Writing essays on given problems is a common way of assessing transfer knowledge (see, also, Jacobson & Spiro, 1995). Fig. 3 presents examples of subtest items.

4.3. Procedure

Data were collected in single sessions, each lasting about 3 hours. Students began the session by completing the first subtest in the knowledge test in order to control for their prior knowledge of the Internet. They were also asked to define what a hypertext is. Then, they read the metaphorical introduction and completed the link-setting exercise. Afterwards, they had 15 min to read the 16 nodes and gain an overview of their contents. During the next 60 min, each participant constructed a personal hypertext by linking the nodes together. All 16 nodes had to be included. The session ended with the knowledge test.

Students’ decision processes during hypertext construction were assessed through “direct” retrospection (see, also, Kellogg, 1988, 1994). While constructing their hypertexts, they were asked every 2 min (measured from the end of the previous answer) to report what they had just been thinking about.

5. Results

5.1. Pretests

Results from the subtest on prior knowledge of the Internet were nearly identical in both groups. From a possible maximum of 10 points, both groups scored an average of 0.1 points ($SD = 0.3$). No student was able to give a clear definition of hypertexts.

We concluded that students had no prior knowledge on the topic of the Internet and that all students had no clear concept of hypertexts before reading the metaphorical explanations.

5.1.1. Hypothesis 1: Number of links

Students who read the introduction with a space metaphor should set significantly more links in their hypertexts than students receiving the book metaphor.

This hypothesis was examined by calculating the average number of links set by the students in both groups. Those in the space metaphor group set a mean of 2.60 links per node ($SD = 0.79$) compared with a mean of 1.46 links per node ($SD = 0.62$) in the book metaphor group. In line

Item from Subtest 1 (content knowledge): 7) “NCP” stands for: q A protocol serving as a basis for the World Wide Web (WWW) q A service enabling synchronous communication between several users q A protocol that used to be necessary for the allocation of data packets q A service enabling the use of someone else's computer resources q A protocol to copy programs from someone else's computers on ones own q Don't know	Item from Subtest 2 (relations knowledge): Which kind of relation exists between the two concepts? 10) TCP - NCP q TCP and NCP ensure data transport and data safety within the Internet q TCP is a predecessor of NCP q TCP is a successor of NCP q TCP and NCP used to ensure data transport and data safety within the ARPANET q TCP and NCP have been replaced by IP q Don't know
Item from Subtest 3 (relations knowledge): 1) Some of the following concepts can be paired, connected by the relation: “is a.” Please find 5 pairs of concepts and their generic terms. Some concepts can be used several times; others do not have to be included! ARPANET - e-mail – FTP – Gopher – Internet – IP – IRC – NCP – packet-oriented network – protocol	
Item from Subtest 4 (transfer knowledge): Please complete the following analogy: 2) ARPANET : Internet = Gopher : ? q WWW q NSFNET q Telnet q Internet-Program q IRC q Don't know	Item from Subtest 5 (transfer knowledge): The following question was embedded in a cover story: Please explain the technology of the Internet: “Given what you can do with the Internet, it seems to be quite interesting. But, from a technical point of view: How does it work?”

Fig. 3. Examples of items from the five subtests assessing knowledge about contents of individual nodes (content knowledge), relations between nodes (relations knowledge), and transfer knowledge.

with Hypothesis 1, the space metaphor group set significantly more links than the book metaphor group, $t(38) = -5.09$, $p < .0001$.

5.1.2. Hypothesis 2: Structure of hypertexts

Students in the space metaphor group should construct significantly more hypertexts with a network-like structure. Students in the book metaphor group should construct significantly more hypertexts with a linear structure.

Table 1

Number of Hypertext structures categorized as linear, network-like, and other

Structure	Book metaphor	Space metaphor
Linear	5	0
Network-like	4	16
Others	11	4

Two independent raters assessed the structures of the hypertexts. Interrater agreement was 90%. For each hypertext, raters had to decide whether the structure was linear (each node connected to *one* following node), network-like (each node connected to several nodes by a large number of links) or other (including structures like hierarchical hypertexts or star-shaped structures with one central node connected with a large number of peripheral nodes that have no further connections). Table 1 shows the results. A chi-square test revealed significant differences between groups, $\chi^2(2, 40) = 15.47$, $p < .001$. Linear structures were found only in the book metaphor group. Twenty-five percent of these hypertexts showed linear structures. Eighty percent of the structures in the space metaphor group were network-like, compared with 20% in the book metaphor group. This confirmed Hypothesis 2.

5.1.3. Hypothesis 3: Pauses during the construction processes

The total time used for pauses should be significantly higher in the book metaphor group than in the space metaphor group.

To analyze the total time of pauses, all time periods of 5 s or more during which no operations on the screen were observable were summed for each participant. The book metaphor group produced a mean of 43.33 min ($SD = 4.10$) compared with a mean of 35.44 ($SD = 5.27$) in the space metaphor group. This difference was significant, $t(38) = 5.09$, $p < .0001$, confirming Hypothesis 3.

5.1.4. Hypothesis 4: Verbal statements on the rationale for link setting

Students in the book metaphor group should verbalize more reflections on how to linearize their hypertexts, whereas students in the space metaphor group should verbalize more reflections on the idea of a complex network.

We used a content analysis to examine which rationale for link settings was invoked by the two metaphors. Each participant was assigned to one of the following categories:

1. *Linearization idea (idea of a book metaphor)*. This category was used when students' statements referred to a reading order; when they spoke about paging or about books; when they worried about setting too many links per node; or when their goal seemed to be to link each node only once.
2. *Network idea (idea of a space metaphor)*. This category was used when students reported that their goal was to place as many links as possible or to make sure that each node included many links; or when they spoke specifically about a network or a landscape.
3. *No definite preference*. Students were assigned to this category when they did not make any structural statements at all or when their statements referred to both categories.

We found significant differences between the two groups, $\chi^2(2, 40) = 28.27$, $p < .001$. In the *book metaphor group*, 16 students (80%) could be categorized as tracking the linearization idea. Only one student engaged in reflections that could be characterized as network-like. In the *space metaphor group*, however, 14 students (70%) could be categorized as tracking the network idea. No student made statements reflecting ideas about linearizing the hypertext.

Therefore, in line with Hypothesis 4, students' statements were clearly influenced by which structural metaphor they had been given.

5.1.5. Hypothesis 5: Statements on the hypertext structure

Students in the book metaphor group should make more verbal statements on the structure of their hypertexts than students in the space metaphor group.

All student statements were classified according to the following six categories:

- *Content-related reflections.* This category included statements about the contents to be processed. It covered statements about the contents of single nodes as well as semantic relations and semantic structures between the node contents.
- *Search processes.* This included all statements about the search for links between nodes, for instance, when students were scanning nodes for potential relations to other nodes or when they searched for a location in a node to place a link.
- *Reflections on the structure of the hypertext.* This included all statements on the structure of the hypertext, for example, reflections on a starting node or the overall structure of the hypertext they were producing. We assumed that we would find significant differences between the two groups within this category.
- *Composing activities.* All statements not relating to reflections on content but to technical aspects of the software fell into this category.
- *General statements on one's own approach.* This included statements in which students reflected in a general way on their strategy or the task of constructing the hypertext.
- *Other statements.* This category included all statements that did not relate to the construction of hypertexts.

Two raters classified students' statements to the category system. Interrater agreement was 97%. Table 2 provides an overview of the distribution of statements across the categories. Longer statements referring to several categories were decomposed, and each part was categorized separately.

Table 2
Mean number of statements in the different categories

Category	Book metaphor	Space metaphor
Content-related	8.10 (4.48)	7.70 (5.31)
Search processes	7.95 (4.14)	9.00 (3.55)
Structure of hypertext	9.90 (5.17)	5.20 (3.11)
Composing activities	2.15 (1.73)	3.20 (2.17)
Own approach	3.15 (2.43)	4.50 (2.42)
Other statements	0.90 (0.97)	2.00 (2.13)

Note. Standard deviations (SD) in parentheses.

A MANOVA across the six categories showed a significant difference between groups, $F(6, 33) = 3.47$, $p < .01$ (Hotelling–Lawley Trace). Subsequent ANOVAs showed significant differences for the category “reflections on the structure of the hypertext,” $F(1, 38) = 12.15$, $p < .01$. Compared with the space metaphor group, students in the book metaphor group made approximately twice as many statements on the structure of the hypertext. Therefore, Hypothesis 5 could be confirmed.

However, we assumed that one reason for these differences was that the book metaphor group had problems in finding an appropriate structure for their hypertexts. Therefore, we additionally examined how often the two groups explicitly mentioned problems of transforming the complex semantic structure of the contents into a hypertext structure, that is, of finding an appropriate structure for their hypertext.

The *book metaphor group* expressed significantly more problems in finding an appropriate structure for their hypertexts (Mann–Whitney U test = -2.48 , $p < .05$). In the book metaphor group, 15 students (75%) expressed such problems ($M = 2.45$; $SD = 3.35$). In the space metaphor group, in contrast, only 9 participants (45%) expressed problems in structuring ($M = 0.65$; $SD = 0.81$).

Differences between the two groups were also found in terms of the quality of the expressed problems. Students in the space metaphor group mainly feared that their hypertexts might become too complex. Students in the book metaphor group, in contrast, mainly expressed fundamental problems in implementing the structural ideas suggested by their metaphor. We conclude that one main reason for the book metaphor group’s increased reflections on structure was the difficulty in matching the complexity of the contents with the idea of the book metaphor.

5.1.6. Hypothesis 6: Knowledge acquisition

Students in the space metaphor group should gain more knowledge about semantic relations and more transfer knowledge than students in the book metaphor group.

Table 3 gives an overview of scores on the knowledge tests about contents of single nodes, relations between nodes, and transfer knowledge. We found no differences in total scores on the knowledge test, $t(38) = -0.13$, $p > .05$. From a maximum of 66 points, members of the book metaphor group scored an average of 26.50 ($SD = 12.45$); the space metaphor group, 26.95 ($SD = 8.61$). We also found no significant differences in subtests. Therefore, Hypothesis 6 could not be confirmed.

Table 3
Mean knowledge test scores split for the two metaphors

Knowledge about	Book metaphor	Space metaphor
Contents	5.20 (2.53)	5.55 (2.16)
Relations	12.50 (5.67)	13.35 (3.48)
Transfer	8.80 (5.41)	8.05 (4.50)
Total score	26.50 (12.45)	26.95 (8.61)

Note. Standard deviations (SD) in parentheses.

6. Discussion

This study compares the effects of two different metaphors (book metaphor and space metaphor) on hypertext construction by college students. Students have to link prepared nodes about the topic Internet to hypertexts. The study investigates whether the different metaphorical explanations have any influence at all on the subsequent construction of these hypertexts, and which metaphor is more suitable for imparting an idea on the multilinear structure of hypertexts that may facilitate knowledge-transforming processes. The metaphorical explanations are written in a way that gives no clear instruction on the number of links to be set or the overall structure of the hypertexts. However, we assumed that both metaphors would inspire different ideas about these issues.

6.1. Do different metaphorical explanations have any impact at all on the subsequent construction of hypertexts?

We can conclude that our subjects' understanding of how to construct a hypertext is clearly influenced by the two metaphors. The book metaphor encourages the idea of sequencing and reducing the complexity of the contents to be processed. The space metaphor encourages the idea of interconnected information networks. These different ideas of hypertexts influence the processes as well as the products of hypertext construction.

The structure of the students' hypertexts reveals these differences in the number of set links and the overall structure of the hypertexts. The space metaphor group sets significantly more links than the book metaphor group. Furthermore, students in the space metaphor group primarily construct hypertexts with a network-like structure (80%). Students in the book metaphor group construct significantly fewer hypertexts with a network-like structure (20%), but significantly more with a linear structure (25%).

We also find significantly more time spent on pauses in the book metaphor group, that is, time periods of cognitive processes like comprehension of the contents and reflections on how to structure the hypertexts. A qualitative analysis of the verbal statements shows that students' in the book metaphor group mostly reflect on how to linearize their hypertexts. In contrast, those in the space metaphor group talk primarily about how to express all the semantic relations they find via links.

Thus we have clear evidence that the idea of hypertexts can be manipulated by metaphors. Relatively short texts (about 1300 words) are sufficient to generate mental models of what a hypertext is, and these have an influence on the whole process of hypertext construction. If it is possible to manipulate the idea of hypertexts so easily, it seems worthwhile to carefully consider how to introduce hypertexts in school or university projects on hypertext construction.

6.2. Which metaphor is more appropriate to communicate an idea of the multilinear structure of hypertexts that could facilitate knowledge-transforming processes?

According to the knowledge-transforming model, writing promotes knowledge acquisition only when authors formulate their text within a continuous interaction between their content-related

knowledge on the topic addressed in the text and their rhetorical knowledge on the design of the text and its structure. Likewise, it can be assumed that hypertext construction will foster learning processes only when students have an appropriate idea of the text format hypertext. Use of a metaphor to introduce hypertexts should ensure an understanding of the potential complexity of hypertexts. This is particularly important if the content to be processed is semantically complex (ill-structured domains, see, e.g., Jacobson & Spiro, 1995).

Our results indicate that the space metaphor is more appropriate than the book metaphor, because it facilitates congruence between the potential complexity of hypertext structures and content structures. One reason for the greater number of statements about their hypertext structure in the book metaphor group is their problem in reconciling the idea of reducing complexity (as encouraged by the book metaphor) with the semantic complexity of the nodes. Students in this group do not just report significantly more problems with hypertext construction. Their problems also take a different quality: Some of them seem to find it nearly impossible to structure their contents in agreement with their association of what a hypertext structure should look like. Thus, the book metaphor seems to be less suitable for creating the required congruence between the structures of complex learning contents and the structure of the hypertexts. Because this metaphor encourages students to reduce the complexity of the content relations, it may contribute to the possibility that the variety of semantic relations in complex content domains is not recognized within a students' learning process.

Furthermore, the hypertexts in the book metaphor group are heterogeneous; that is, the hypertext structures differ far more than those in the space metaphor group. The book metaphor seems to elicit different associations on how to structure a hypertext. Those students who construct linear hypertexts probably have in mind the idea of paging through a book. The group that creates hierarchical or star-shaped hypertexts, in contrast, may be focusing on the idea of chapters and subchapters in books, or on the idea of a central document containing references to a variety of additional information like a glossary. The small number of students who construct network-like hypertexts might be focusing on the idea of an encyclopedia with many references between the different topics.

If writing hypertexts is practiced within instructional settings (e.g., in schools or universities), such a high degree of freedom may be a disadvantage – particularly when working in groups. If students differ implicitly in their ideas on hypertexts, problems in the collaborative construction of hypertexts may arise.

Nonetheless, it has to be emphasized that the other metaphor also has problematic effects on the process of hypertext construction: The space metaphor may increase the risk of focusing insufficiently on the structure of hypertexts and their contents. It is more likely that the space metaphor rather than the book metaphor will result in adopting a strategy of setting links wherever possible. Students who use such a strategy do not have to think about structure at all. This conclusion is corroborated by the significantly lower number of reflections on the overall structure of the hypertexts in the space metaphor group.

This kind of strategy may be the main reason for the results in the knowledge tests. We expected scores to be higher in the space metaphor group. We assumed that students in this group would express more semantic relations between the contents of the nodes by means of links, and thus should learn more about semantic relations and the structure of the contents. But the results show no differences between the groups. If some students in the space metaphor group search the

nodes for keywords and set every possible link they find, then they will not have to think about the semantic relations at all. Therefore, we can conclude that neither metaphor is inherently better suited to foster a deeper consideration of the contents.

Nonetheless, the space metaphor seems to be more suitable than the book metaphor for fostering the interaction between the structures of the content and the hypertext required by the knowledge-transforming approach: It permits a correspondence between complex semantic structures and the text format. However, it should be complemented by further instructions that may foster a more conscious processing of the semantic structures.

7. Conclusion

In their review of hypermedia, Dillon and Gabbard (1998) argued that their successful use as a learning tool depends on various variables such as learning style, the task, and abilities in the learner. The results of the present study indicate that a further variable needs to be taken more seriously: the conceptual understanding of hypertexts as a text format. Our results are in line with conclusions from research on learning by reading hypertexts. As pointed out in the introduction, inexperienced readers develop metaphorical ideas about the text format hypertext and have problems when their expectations are inappropriate for navigating in the hypertexts they are working with. Up to now, the impact of such metaphorical ideas has been either posited theoretically or reported only in explorative studies – often as a secondary finding. Our study demonstrates that this effect can also be confirmed empirically. Future research on hypertexts should take into account that the way in which learners work with hypertexts depends on the ideas they have on what a hypertext is.

Concerning the construction of hypertexts, the metaphorical introductions influence the entire construction process. The comparison of a book metaphor with a space metaphor reveals that the latter seems to be more useful for preparing learners to deal with the complexity of content structures and hypertext structures. Nonetheless, performance on the knowledge test shows that a metaphorical introduction does not ensure deeper learning processes. We need to find further instructions to encourage such an interaction on a higher level of structural relations. This is one of the issues we shall be addressing in future research.

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