Chapter 9

The Conceptual Structure of Information Space

Paul P. Maglio and Teenie Matlock

Abstract

In this chapter we examine how people think about the information space of the World Wide Web. We provide empirical evidence collected in interviews with beginning and experienced web users to show that much of people's conceptual experience of the web is metaphorical and understood through the process of conceptual integration. We argue that designers of tools for navigation and collaboration in information space should consider how people experience web space, including the natural tendency to metaphorically construe information space in terms of physical space.

9.1 Introduction

Navigation is a basic part of human experience. Walking across a parking lot, driving to work, and searching for an item in a store or library all involve navigation: moving from one point to another in physical space. Empirical research has shown that while navigating, people rely on different types of knowledge: landmark knowledge, route knowledge, and survey knowledge [1, 2]. It has also been argued that people incorporate knowledge based on certain organizational principles [3, 4] and awareness of certain elements, such as paths, landmarks, districts, nodes, and edges. Navigation in electronic worlds has been compared to navigation in the physical world (e.g. [5, 6]), but navigation in information spaces is not as well understood as navigation in physical space. Although recent research shows interesting results, much emphasis lies in how people perceive the environment, instead of how people conceive of the environment [7].

In this chapter, we argue that people rely on experience in physical space to structure experience in virtual information spaces such as the World Wide Web (WWW). Specifically, we are interested in people's *natural* conception of information spaces. We report the findings of a web-use study conducted in 1996 in which we analysed how people talk about the web to get at their natural conception of information space. We found that both experienced and

inexperienced web users naturally talk about the web in consistent ways. For instance, people see themselves as metaphorically moving toward information, rather than information as moving toward them. We also found some differences between experienced and inexperienced web users in the way they talked about web activities. In the end, we argue that (a) the particular language people use is based on conceptual metaphor and is motivated by basic image schemata, which emerge from natural embodied experience (e.g. [8, 9]); and (b) web users' experience is structured by conceptual integration [10–13].

Before presenting our data and argument in detail, we first discuss some prior research concerning the way people think about the web, along with some background on metaphor and thought.

9.1.1 How People Remember the Web

Based on data collected from people asked to recall specific web searches, Maglio and Barrett [14] argued that web navigation is conceived in terms of a cognitive map similar to a cognitive map of physical space, that is, in terms of landmarks and routes (e.g. [15]). In this study, experienced users searched the web for answers to specific questions. To identify key cognitive aspects of their activities, users were first asked about their plans, and their behaviour was tracked while they searched. Then a day later they were asked to recall the steps they had taken in each of their searches the previous day, and finally to retrace their steps. Participants were not warned on the first day that recall would be required on the second day. This method enabled Maglio and Barrett both to chart behaviour to uncover search tactics (using the behavioural traces) and to extract some of the structure of their internal representations (using the recall data).

The data showed that participants recalled only a few of the sites they visited. Specifically, they remembered key nodes that led to the target information. These nodes were called *anchor points* by analogy to the notion of anchor points in the cognitive map literature [16]. An anchor was defined as a node along a search path from which there is an unbroken sequence of links on successive pages that lead to the goal node (i.e. no URLs need to be typed in or explicitly recalled). Once traversed, anchor points are recognized as lying along the path to the goal – even if the same path is not followed to the goal in every case. For the participants in the study, searching on the second day often meant finding anchors encountered on the first day, rather than finding paths found on the first day.

A second observation that emerged from the behavioural data is that individuals relied on personal routines when trying to find information. For instance, some participants routinely used a particular search engine, such as AltaVista, whereas others routinely used a particular hierarchical catalogue, such as Yahoo! It is not merely that these searchers preferred to use one approach over another, but that they conceptualised their search tasks in terms of their favourite routines. It often did not matter what was actually done on the first day, the searchers remembered searching as if their personal routines had been

followed. On the analogy to cognitive maps of physical space, personal routines correspond to the familiar routes that an individual uses to get from one landmark (or anchor point) to another.

If people mentally structure web use in this way, tools for web navigation ought to present the web in this way. Because individuals tend to use the same search patterns over and over, and because they recall their searches in terms of their standard patterns – almost regardless of what they actually did – Maglio and Barrett [17] built a personal web agent to identify repeated search patterns and to suggest similar patterns for new searches. Because people focus on key nodes or anchor points when recalling their searches, and because these structure memory for the searches, Maglio and Barrett [17] also built a web agent to identify the key nodes in finding a piece of information, and to maintain personal trails in terms of these.

9.1.2 How People Talk About the Web

The key to designing information navigation tools lies in discovering how people naturally conceive of information spaces. Technically, the web is part of a network of geographically distributed machines connected via wires. The information accessible by users of this physical network is organised in a conceptual network of hyperlinks among documents. Despite this actual structure, people's conceptual structure of the web is rather different.

Matlock and Maglio [18] found that web users often refer to the web as a multidimensional (most commonly two-dimensional) landscape. Obtaining information in this landscape is expressed as traversing interconnected paths toward locations that contain information objects, such as user homepages and commercial catalogue sites. Users say things such as, "I went to his homepage", and "I came back to where I saw that picture". Some of these information objects are talked about as two-dimensional and others, as three-dimensional; for instance, people say "in Yahoo!" which suggests a three-dimensional container, and "at AltaVista" which suggests a point on a two-dimensional plane.

In a follow-up study, Matlock and Maglio [19] asked experienced and inexperienced web users to judge the sensibility of sentences containing metaphorical language (specifically regarding motion) about obtaining information on the web. Using a scale of one to seven, participants rated the sensibility of sentences containing verbs of motion. For instance, "John went to a new web site today"; "Do you want to climb up to the UCSC home page?"; and "I waited for the information to come to me". Sentences in which the web user was viewed as an agent, actively moving along a horizontal path, were rated as significantly more sensible than those in which the web user moved up or down, and as significantly more sensible than those in which the web user was passive. These results suggest that both experienced and inexperienced participants have clear and consistent ideas about how motion does and does not occur on the web.

Though there are many ways in which people might talk about the web (see [20]), the fact that they naturally talk about it using particular metaphors is no

accident. As Lakoff and Johnson [21], Gibbs [22] and others have argued, such language is motivated by metaphorical thought.

9.1.3 Metaphor and Thought

Prior to the seminal work of Lakoff and Johnson [21], metaphor was generally seen as nothing more than a literary device. Lakoff and Johnson radically changed this misconception, offering compelling arguments to show that metaphor is an integral part of thought and action:

> Metaphor is typically viewed as a characteristic of language alone, a matter of words rather than thought or action ... that metaphor is pervasive in everyday life, not just in language, but in thought and action. Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature ([21], p. 3).

Subsequent work in cognitive linguistics and psychology has continued to offer theoretical and empirical evidence to show that metaphor is ubiquitous and serves many functions relative to conceptual experience [9, 23, 24]. One of the functions of metaphor is that it helps people think about relatively abstract conceptual domains in terms of relatively concrete domains [22]. For instance, spatial concepts are often helpful when reasoning about time [25]. On the standard view of metaphor, a relatively concrete source domain maps on to a relatively abstract target domain. Consider the often-cited metaphor THEORIES ARE BUILDINGS. In this metaphor, elements of the conceptual structure of BUILDINGS (source domain) map onto THEORIES (target domain). Linguistic evidence to support the existence of this metaphor includes statements such as: "You need empirical evidence to buttress your arguments", "The foundation of the theory is shaky", "His entire theory was toppled by the claim that Basque is a language isolate", or "Construct a different argument to support your theory". It makes sense that this mapping progresses from BUILDINGS to THEORIES because buildings are common in everyday experience. In western culture, buildings serve an important function: namely, people live and work in buildings. In addition, buildings offer protection from adverse effects of nature, and so on. Theories, by contrast, are important in the academic or philosophical world, but not commonplace to most people.

Another example of a metaphor is the MIND IS A CONTAINER. In this case, the concrete conceptual domain of CONTAINER maps on to the more abstract conceptual domain of the MIND. Hence, we understand the mind as a storehouse. Ideas can enter the storehouse, can be processed there, stored in a specific location, or even misplaced. Linguistic evidence for this metaphor includes expressions such as "The thought suddenly came into my head", "It's in the back of my mind", or "She lost her senses". This metaphor underlies many psychological theories (see [22] for a discussion).

As pointed out by Coulson [26], the standard approach to metaphor arose in part to account for simple examples of analogical thinking, such as TIME IS SPACE. As such, the approach is parsimonious but cannot account for complex mappings requiring some degree of sensitivity [27]. Moreover, the standard

approach falls short with respect to productivity: why do only certain elements of the source domain map onto the target domain? Consider THEORIES ARE BUILDINGS. As noted, foundation and support map onto the target domain, but doors and windows do not. Recent approaches have attempted to solve this problem by suggesting that there are a variety of types of metaphors, including primitive and compound (e.g. [28]).

Although more recent approaches to metaphor diverge from the standard model with respect to issues of mapping complexity, there is agreement that metaphor plays a central role in structuring how people think. But metaphor is only part of the story. Image schemata, basic pre-conceptual structures that arise from embodied experience. Formed early in development [31], image schemata structure both metaphorical and non-metaphorical thought [8, 9, 29, 30].

Image Schemata

Daily life includes active physical motion toward objects or destinations (concrete or abstract): going to the door to let the cat out, walking or driving to work, and reaching out to grab a pencil or pick up the telephone. Life also includes abstract motion toward goals (abstract destinations): working to get a promotion, writing a dissertation to obtain a degree, and saving money for a trip. Each of these actions involves the image schema TRAJECTORY (also referred to as SOURCE-PATH-GOAL), comprised of a starting point, an end point, and a path between the two. Another image schema is CONTAINER, which arises out of bodily experience: swallowing things, entering and remaining in buildings, and so on. As we will see, these image schemata figure prominently in how people view obtaining information in the world and on the web.

In what follows, we explore the nature of people's metaphorical conception of the web. A specific goal of the study is to examine the presence and frequency of language reflecting underlying image schemata. We believe these elements structure much of conceptual structure of web users. Furthermore, as Lund and Waterworth [32] have claimed, an important step in the design process is identifying image schemata to provide a more experientially based environment for the user (see also [33]). In the current study, we investigate how users with varying levels of expertise talk about the web. We first describe a study that elicited verbatim reports from both experienced and inexperienced web. We next discuss reasons people use the metaphors they do, and finally, some implications of our results for the design of tools for navigating and collaborating in information spaces.

9.2 Study: Users Describe Web Experience

The purpose of this study was to further explore how people think about the web in natural settings. We looked specifically at how people conceive of the actions taken while using the web; for instance, to what extent users see themselves

actively moving through space and to what extent they focus on the physical environment. We also wanted to observe differences between beginning and experienced users.

We hypothesised that beginners would talk about their experiences using the web in terms of the physical actions they performed more than experienced users would because beginners are likely to have only a partial understanding of the web domain. Along the same lines, we hypothesised that experienced users would generate more metaphorically consistent utterances than beginners would.

We analysed the data both quantitatively and qualitatively. In the quantitative analysis, we counted utterances of various types to compare beginning and experienced web users. In our qualitative analysis, we followed a method similar to that of Raubal et al. [34], who analysed the image schematic structure of talk about wayfinding in airports.

9.2.1 Method

Twenty-four undergraduates at the University of California at Santa Cruz took part, including 13 males and 11 females. All were native English speakers except five fluent bilinguals.

Participants first completed a questionnaire about their prior experience using computers and the web. They were asked about length of time using the web (e.g. one month or less) and hours per week used. Participants were then seated in front of a computer that was running the Netscape Navigator browser, which displayed the homepage for the University of California, Santa Cruz. They were then instructed to click on whatever icons or hyperlinks appeared interesting and to continue doing so for 5 minutes. The experimenter was extremely careful to avoid language that would bias the participant to think of the web metaphorically, such as, "Go to that page".

After each participant had spent sufficient time getting used to the task and experiencing the environment, he or she was instructed to look at a new domain: Yahoo!, a well-known catalogue in which information is organised hierarchically. The participant was again instructed to use the mouse to gain access to information that seemed interesting and to continue to do so for 5 minutes.

A tape-recorded interview followed the web session. To begin, the experimenter prompted the participant: "Tell me what you just did using as much detail as possible". If a response was not immediately forthcoming, the experimenter began, "Tell me what you did first", and so on.

9.2.2 Results

Participants were separated into two groups according to self-reported web experience: 12 beginners reported under 6 months of web use, and 12 experienced users reported over 6 months of web use.

Coding

In coding the data, we distinguished among seven kinds of verb phrases (verbs and conventional verb-preposition expressions) that correspond to seven kinds of web actions (see Table 9.1). For instance, the sorts of phrases coded included verbs such as "clicked" and verb-preposition combinations such as "went to". These were chosen based on discourse about the web that we had collected previously [18]. Only utterances that referred to what the participant did while using the web were assigned to one or more of the categories shown in the table. For example, statements such as "I'm on a tight budget", or "Using the web is pretty fun" were not included in our analysis.

In analysing utterances, we wanted to be careful not to confuse language referring to the information space of the web with language referring to the user interface of the web. Thus, in looking at verb phrases, we distinguished among three general types of action: (a) *outside actions,* which reflect the user's experience with things external to the web (such as typing on the keyboard, using the mouse, and clicking on browser icons); (b) *inside actions,* which reflect the user's experience conceptually within the web (such as going to a web page, and following a link); and (c) *miscellaneous actions*, which cannot be definitely classified as either outside or inside. Expressions such as "I *typed* something", "I *clicked on* the grapes icon", or "I *pressed* buttons" were coded as outside actions.

Expressions referring to inside actions were split into three types: TRAJECTORY, CONTAINER, and information actions. Motion of the user along a path in web space highlights the TRAJECTORY schema, such as "I *went into* this thing called Yahoo", "I couldn't *get back to* where I was", or "It *brought me to* the anthropology page". Transfer of information along a path from computer to user also highlights the TRAJECTORY schema, as in "It told me" and "It said". Sometimes a web site is talked about in terms of a container, instantiating the CONTAINER schema, as in "Yahoo! *contained* some cool stuff, or "Yahoo! *had* what I wanted". At other times, the web is described as a general information resource similar to a library or a phone book, as suggested by expressions such as "I *looked up* Chewbacca".

Table 9.1 Verb coding scheme

Category	Examples
Outside	click, press, type, scroll
Inside	go, follow, have, look up
TRAJECTORY	go, come, bring, follow
User Agent	go, follow
Web Agent	bring, come up, bring, show
CONTAINER	have, contain
Information Action	look for, lookup, search
Miscellaneous	look, see

The TRAJECTORY category was divided into utterances with user is the agent and those with web is the agent. Agency refers to who or what initiates and undertakes action. In some cases, the user is agent, as in "I *went* ...", whereas in others, the web is agent, as in "It *took me to* ...".

The miscellaneous category was used for verbs that could not be obviously classified into either of the other categories. This group mainly contained expressions beginning with "I *saw* ..." or "I *looked at* ..." because it is unclear whether these describe visual perception of the screen (an outside action) or visual perception of objects in web space (inside action).

Finally, note that we also could have examined use of prepositions to help code for TRAJECTORY and CONTAINER. For instance, *through* and *to* imply TRAJECTORY, and *in* suggests CONTAINER. For the present study, we looked specifically at verb phrases. A more thorough analysis would certainly include prepositions (for example, "I can't remember if I found information *in* Yahoo! or *inside* AltaVista") and nouns ("I took a direct *route* from the UCSC site to my homepage") as well (see [34]).

Qualitative Results

We first conducted a qualitative analysis of the data. To get a feel for the data and our coding scheme, consider the following utterance, which is fairly typical of beginning web users (participant 4):

> ... I clicked on uh grapes ... and it brought me to um ... this place where they had choices and then I clicked on bookstore ...

Note the presence of two outside actions ("I *clicked* on ..."), an instance of TRAJECTORY in which the web is agent ("it *brought me to* ..."), and an instance of CONTAINER ("place where they *had* choices"). In this utterance, the user clicks on an icon on the screen, is taken to a new location, and then she clicks again.

Now consider an utterance produced by an experienced web user (participant 14):

> ... I went to net search because that seemed like a good wholesome opportunity for going somewhere else ... I probably typed something and it told me I couldn't do it, so I dunno, I just went and clicked around a whole bunch ...

Here we see three instances of outside actions ("typed", "clicked", and "do"), two instances of TRAJECTORY with the user as agent ("went", "going") and one instance of TRAJECTORY with web as agent ("told"). (The verb "seem" and the second instance of "went" were not coded because they do not refer to actions taken while using the web. The use of "went" simply means "proceeded to"). In this case, the user's report blends different types of actions: metaphorically going somewhere, typing something, receiving information, and clicking.

These sorts of responses are representative of what experienced and beginning web users do: they both mix outside actions with actions inside the web's information domain. Nonetheless, we observed some interesting differences. For

the beginner, the web can function as a kind of conveyance that moves the user ("brought me to"), but for the expert, the web is a kind of roadway on which the user moves ("I went"). In addition, for the beginner, the web passively contains information ("had choices"), but for the expert, the web actively provides information ("it told me").

Consider the report of another beginner (participant 2):

> ... I went into the um Brian's tattoo something or other, but when I clicked into it, it said that like it was gonna show tattoos of his body and like front, side, whatever ... it had objects to click on, and I clicked on em and there was no pictures ...

In this report, we see one instance of TRAJECTORY in which the user is agent ("went into"), and two in which the web is agent ("it said", "was gonna show"). We also see two outside actions ("click"), and one CONTAINER ("had"). As in both previous cases, outside actions are mixed with inside actions. Like the first beginner, this one refers to a web site as a container. Unlike the first beginner, however, this one also refers to the web as a kind of roadway along which people can travel ("went") rather than as a kind of conveyance ("brought me to"). For this beginner, as for the expert, the web actively provides information ("it said").

The utterance from participant 2 illustrates something our coding scheme does not recognise: the novel use of "click" in the verb phrase "click into". Whereas the verb "click" refers to an outside action, the preposition "into" specifies an inside location. Usually the verb "click" is followed by the preposition "on", and the construction refers to an icon or hyperlink visible on the screen. In this case, however, "click into" refers both to something visible on the screen and also to something contained in the information space of the web. We will return to this point in the discussion of conceptual blends.

Finally, consider a second expert's response (participant 23):

> ... I couldn't get through. I returned to the first page I started on and selected travel.

In this case, we note two instances of TRAJECTORY in which the user is agent ("get through", "returned") and one outside action ("selected"). The path is blocked ("couldn't get through"), and previous steps were retraced ("returned").

In summarising our qualitative results, we can see that both beginners and experts use the same sort of language overall. In reporting on their experience using the web, most participants mixed language about actions they did outside web space with they did inside web space, especially actions reflecting the schemata TRAJECTORY and CONTAINER. In talking about the web, people also described the web as moving the user, or described the user as moving on the web. Their verbatim reports also suggest that the web can simply contain information, or it can actively convey or provide users with information. In any event, people seem to prefer to talk about their experience in using the web in more familiar terms, such as physical motion, physical actions, and physical containers.

Quantitative Results

The total number of verbs in each category was computed for beginners and for experts, as shown in Table 9.2.

Because we collected frequency data, χ^2 was used to compare beginners and experts along each of the seven action categories. As shown in Table 9.3, significant differences were obtained for TRAJECTORY versus outside actions, for user agent versus web agent, and for CONTAINER versus all other verbs. Thus, experts used the TRAJECTORY verb phrases rather than outside action verbs more often than beginners. Within the TRAJECTORY category, experts reported themselves as agent (i.e. actively moving through information space) instead of web as agent (i.e. information moving through web to user) more often than beginners did. By contrast, verbs phrases of the CONTAINER type were reported more by beginners than experts.

Overall, all web users reported a similar experience while using the web. Both beginners and experts talked about their experiences as if they had been moving from place to place though in fact they had not gone anywhere. The data also revealed noticeable differences between experts and beginners. Beginners more often mixed in their experiences using the keyboard, mouse, and other elements of the physical (non-web) domain (e.g. "I clicked on ..." or "I typed in ..."),

Table 9.2 Verb coding scheme

	Beginners (n = 12)	Experts (n = 12)
Outside	54	26
TRAJECTORY	56	87
User Agent	37	79
Web Agent	19	8
CONTAINER	22	11
Info Action	30	42
Miscellaneous	24	20
Total	186	186

Table 9.3 Percentage of verbs in each category for each group. The χ^2 statistic compares the difference between groups

	Beginners	Experts	χ^2
TRAJECTORY vs outside	51%	77%	16.49**
User agent vs web agent	66%	91%	13.60**
CONTAINER vs all others	12%	6%	4.02*
Info actions vs all others	16%	23%	2.48
Miscellaneous vs all others	13%	11%	0.41

*$p < 0.05$; **$p < 0.005$.

whereas experienced users did not. In addition, beginners were more likely to refer to the web as a container than were experienced web users.

9.3 Discussion

All web users in our study consistently used metaphorical language when talking about the WWW. In particular, they used verb phrases referring to physical motion to describe their experience using the web. However, there were differences between the language of beginning and experienced web users. In what follows, we discuss reasons why people use metaphorical language when talking about the web, and discuss implications for the design of tools for navigation and collaboration in information spaces.

9.3.1 Agency and Web Use

Our data suggest that web users – even those who had never used the web – view web activity as traversal along paths. In particular, participants most often see themselves as the agent, initiating and actively moving along these paths (even for beginners; see Table 9.3). According to the data, less often is the user viewed as the passive recipient of information or as a passenger being transported in some sort of web vehicle. This suggests that the semantic property of agency is primarily viewed as something inherent in the web user, rather than something inherent in the web.

One reason the user might view obtaining information on the web as actively moving through space toward objects is because of the ease of information access. The most common way of moving from one web page to another is by clicking on hyperlinks or using the browser's back button [35, 36]. Much less often do web users type in full addresses to obtain information. Simply clicking on links and instantly seeing new information creates a sense of fluidity and hence, the illusion of motion. One way to test this hypothesis may be to systematically vary the delay between clicking on a link and the subsequent presentation of information. Results from such a test, especially if conducted with novice web users, will tell whether longer delays result in fewer utterances in which the user is the agent.

It seems natural to talk about information access metaphorically in physical terms. After all, obtaining information in a library, in a reference book, or by telephone involves directed action. Thus, the reason why users talk about the web in terms of physical space most likely lies in human embodied experience [8, 30, 37]. The way people experience the web or other information spaces is shaped by human activities in the real world. A large part of human experience involves physical activities, such as standing up, walking toward a location, reaching out, and grasping what is desired. From these recurrent patterns of activity, people develop image schemata, as discussed previously. Thus, it is reasonable to assume that because directed motion toward goals is part of our embodied

experience, it naturally structures how we think about and interact in information spaces, such as the web.

9.3.2 Conceptual Blends in Information Space

We now return to our finding that novice web users mix talk about the outside domain with talk about the inside domain more than experienced users did (see Table 9.3). Recall the utterances of participants 2 and 4. These and all inexperienced web users often mixed inside and outside actions, seemingly unaware of the fact that they were switching between them. Sometimes this sort of blending happened at the sentence level, as in "I clicked on [outside] grapes ... and it brought me to [inside]...". At other times, it occurred at the phrase level, as in "I clicked into it", in which the participant created a novel verb–particle construction. These results indicate that in using the web, people naturally integrate two or more domains to create something more than simply the combination of its parts.

Such conceptual integration (also known as "blending") is not unique to web activity or even to language use, as Gilles Fauconnier and others have demonstrated [10–13]. In this framework, there are not just two domains, as in standard metaphor theory [21], but multiple domains. Through a complex interplay of mapping, or projection, from one domain to another, an emergent structure arises. This structure is to some extent independent of the meanings afforded by the domains on their own. A blend emerges from two or more input spaces, a generic space, and a blended space. The best way to show how the mapping works is through an example of how people create novel meaning by blending domains. The example comes from Coulson [38]: rwo college students are up late at night studying for an exam. One student grabs a piece of paper, crumbles it up, and throws it towards a wastepaper basket. The other student grabs the crumpled piece of paper and also throws it toward the basket. The actions of the students develop into a game in which the paper is a "ball" and the trashcan is a "basket". The students' understanding of this activity as "trashcan basketball" arises through integrating knowledge about different domains. In this blend, trash disposal is one input space and the conventional game of basketball is the other input space. The blended space combines elements from both the input domains. Importantly, though it involves the incorporation of elements from both domains, the emergent structure in blended space differs in many respects from the two input domains.

An example closer to home may be seen in Fauconnier's [10] discussion of the computer *desktop* metaphor. He argues that conceptual integration can account for the complexity of this familiar metaphor. According to Fauconnier, the desktop metaphor is constructed on the basis of two separate conceptual inputs: (a) traditional computer commands, such as saving a file, and listing a directory; and (b) work in an office, including a desk, files, folders, and trashcan. To create the desktop metaphor, a cross-mapping occurs whereby computer files are mapped to paper files, directories are mapped to folders, and so on. General

knowledge – such as image schematic notions of CONTAINER and TRAJECTORY – mediate the mapping. Structure is selectively projected from the inputs, yielding a coherent, well-integrated, emergent structure specific to the blend. What emerges from these mappings is a "world" in which a trashcan can sit on the desktop, in which double clicking opens files or applications, and in which objects are routinely dragged from one location to another. The integration is completely novel, but at the same time it is meaningful to the desktop interface user. Note that if the mapping from the office domain to the computer domain were simple (i.e. creating no new structure), the computer desktop could be no better than a real desktop: such an interface could only selectively mirror the world.

We believe conceptual integration provides a nice account of how web users think about the web. It provides a plausible explanation for how novice users can understand and use the web. For example, a person who has never seen the web can sit down at a computer, browse for awhile, have the feeling of shifting between inside actions and outside actions (e.g. "click into"): Conceptual integration also provides some insight into how experts talk about the web less in terms of outside actions than novice web users: Experts seem to rely on the input from the abstract web domain to a greater extent than they rely on input from the physical browser domain.

Conceptual blend theory also integrates web users' conceptual information much more effectively than would a standard metaphorical approach, which would be limited to a single source domain and a single target domain (e.g. [21]). Of course, a traditional metaphorical account can explain the obvious metaphors: (a) WEB SPACE IS PHYSICAL SPACE, which reflects to how users view the web as a place; and (b) OBTAINING INFORMATION IS MOVING THROUGH SPACE, which reflects how users view themselves as moving along paths to information objects. However, it fails to say anything about how web users naturally blend inside and outside actions, or about how this tendency interacts with metaphorical thought.

Finally, as Rohrer [39] argues, blending can also explain how people can understand and incorporate other, higher level metaphors of cyberspace, including the popular *information super highway*. There are two parts to understanding this metaphor. People understand it as highway upon which movement occurs, much in the same way the beginners and experts in our study understood the web, and as a road through time that allows travel into the future. Rohrer provides nice examples from headlines and news reports to show the dual, blended nature of this metaphor, for instance, "Prime Minister rides the info-highway", "Congress suffers wreck on info highway", and "AT&T stalled on the info-highway". In each case, there is the notion of movement through physical space blended with the notion of "movement" into the future.

9.3.3 Designing Information Interfaces

If metaphorical language in fact reflects metaphorical thought, and people naturally think of the web as a kind of physical space in which they actively move along paths, what might be the consequences for the design of information navigation and collaboration tools?

Shum [40] points out many potential uses for the concepts of physical space in the structuring and presentation of information, such as Euclidean distance in two or three dimensions, direction, orientation, and depth. Nevertheless, Shum also notes that the key to adapting spatial metaphors to information presentation lies in understanding user tasks. Thus, adding a notion of distance to the information interface solely because physical space has distance would probably not be useful in all cases. For instance, distance in information space might reasonably be used to convey semantic relatedness (e.g. [41]) or expected download delay (see also [42, 43]).

Our data show that even novice web users conceive of themselves as actively moving on the web under their own control. Thus, we believe that the power of spatial metaphors for information presentation is not merely the result of people's *ability to use spatial metaphors*. Rather, its power lies in the fact that people *naturally use spatial metaphors* – that they cannot help but use them. It follows that interface designers should not construct virtual worlds that are merely consistent with ordinary experience and that merely use spatial attributes in task-relevant ways. Rather, the most useful information interfaces will target people's natural spatial understanding of information use and at the same time allow people flexibility to create an appropriate metaphorical understanding of the domain (see [44]).

Navigation in Information Spaces

Dieberger's [45] city metaphor for information navigation seems to be a good approach to information space design. In particular, Dieberger carefully balances spatially real interface elements with *magic features* that break the spatial metaphor. In a sense, magic features provide the user with known boundaries that can be used in guiding the conceptual blending process. For instance, because magic windows provide shortcuts between distal points in the information city, semantic-relatedness need not be determined solely by spatial proximity. Nevertheless, both sorts of connections can be understood spatially as TRAJECTORY, which provides a consistent basis for the mappings.

We also see much promise in Waterworth's experiential approach to information landscape design [33]. This approach offers an alternative to the traditional human–computer interface (HCI) approach, which is based on an objectivist cognitivism (e.g. mental models). One advantage of the experiential approach is that users are offered a more meaningful interface, one that affords metaphorical thought and action. An excellent example of such a design may be seen in Lund and Waterworth's SchemaSpace [32], which is grounded

embodiment and which is structured – at least to some extent – in a way that reflects image schematic structure. For excellent discussion and compelling arguments against the traditional HCI approach and for details on the experiential approach, see Waterworth's chapter in this book (Ch. 8).

The key point is that people should not have to adapt to information space; rather, they should play an active role in determining how the space is used through their activities and practice [7]. As we have seen, people's conceptual experience of information space is largely structured metaphorically and based on embodied experience in physical space. We believe that web browsers or other tools for navigation in information space should be designed based on how people conceptualise and experience the environment.

Social Interaction in Information Spaces

Tools for collaboration in information space can likewise be informed by understanding how people conceptualise interaction in information spaces. Research on how people interact will likely reveal that people conceptualise virtual interactions with others much as they conceptualiase actual interactions. Nevertheless, differences between the two will undoubtedly arise, providing opportunities for creating interfaces that are both different from and possibly more effective than physical interaction.

For instance, consider Babble, a computer-mediated communication system meant to facilitate long-term, ongoing conversations [46]. One design goal of Babble was to enable those involved in a conversation to be made aware of many social cues, such as users' presence and actions with respect to a particular conversation. In addition to a text window that displays conversational content, Babble uses a very elegant graphical representation called a *social proxy*, which depicts a conversation as a large circle, individuals as small coloured dots within the circle, and chatting as movement of the dots toward the circle's centre. In this way, the Babble interface relies on a spatial metaphor in which an area of the screen represents a conversation, icons within the area represent individuals engaged in the conversation, and motion of the icons represents conversational action. This metaphor abstracts away many details of actual conversations, such as facial expressions and intonation, yet retains significant spatial relationships, such as proximity. In addition, unlike verbal conversations or other computer-mediated chat systems, Babble adds timestamps to each conversational action and can store the text of conversations indefinitely. This enables Babble users to retrieve previous interactions and to reconstruct all previous conversational contexts. Thus, the Babble interface is in some ways similar to and in other ways more effective than actual conversation.

Though our empirical data do not specifically concern social interactions in information space, it is reasonable to expect similar results. From our perspective, then, using space to depict conversations follows the principle that people conceptualise information activities in physical terms. Moreover, movement of the dots in Babble follows the TRAJECTORY schema, just as a

chat action follows a TRAJECTORY. Being inside the circle instantiates CONTAINER, just as being in a conversation suggests containment.

In any event, Babble provides an environment in which users can create and participate in conversations. This communication system was not set up as part of a larger information space. But why not? Consider that the web is a fundamentally social structure – it enables users to publish and to read what others have published. Although web users interact through published documents, these interactions are asynchronous and lack the richness of ordinary communication. The web misses the people behind the documents. Users are invisible to each other because social affordances are not built into the web.

The WebPlaces system was constructed to enable social interaction on the web [47, 48]. The idea was to make interpersonal awareness and interaction an integral part of web activity by creating virtual places through which users can communicate. In this system, a *place* does not necessarily map to a location in web space, but might be automatically constructed based on the interests and activities of web users. To make users aware of one another, WebPlaces adapted Babble's social proxy: a circle represents the group or community of users, and small coloured dots represent individual users (see [48]). Motion of a dot toward the centre of the circle represents a group interaction (e.g. chat), motion of a dot toward another dot represents a user-user action (e.g. whisper), and motion of a dot around the circle represents an individual user action (e.g., browsing). In this way, Babble's social proxy was extended to maintain social awareness in a user community rather than in a conversation. Actions were included that are not specifically related to the ongoing conversation, but that are nonetheless relevant to the users who are gathered together. In coding various types of actions by these iconic motions, WebPlaces' proxy indicates both the state and activity of the users in a place. A glance at the social proxy tells a user how busy the place is, who is there, and what activity there is. Thus, by combining affordances of information space with affordances for interpersonal interaction, WebPlaces blends information activities with social activities, and in the process, WebPlaces creates a novel user interface that relies on TRAJECTORY and CONTAINER to structure user experience.

9.4 Conclusion

The way that people think about the WWW has implications for the way that they navigate it. The key to designing effective information navigation tools lies in discovering how people naturally conceive of information spaces, including the extent to which such spaces are thought of in terms of physical space. Likewise, to facilitate efficient collaboration in information space, it is critical that software be designed to reflect people's natural conceptualisation of the space. To discover how people think about the web, one type of information space, we studied how people talk about using it. In doing so, we found that people consistently refer to the experience in terms of user-directed motion

through physical space toward information objects. That particular metaphorical language is used is no accident, even though there are many different ways to talk about the web. Such language is motivated by metaphorical thought, which is structured by the same basic image schemata that people rely on to mentally structure everyday life. Thus, the power of spatial metaphors for information presentation is not merely the result of people's ability to learn to use spatial metaphors. Rather, its power lies in people's tendency to naturally use spatial metaphors – they cannot help but use them. It follows that efficient interface design should go much deeper than constructing virtual worlds that merely include a few task-specific spatial attributes. The most useful information interfaces will target people's natural spatial understanding of information use, and at the same time allow people flexibility to create appropriate metaphorical and blended understanding of the domain. Because of the striking consistency in conceptualisation of information space across web users, collaboration would be well afforded by a user interface that makes explicit appropriate aspects of users' apparent common ground. The trick lies in discovering the conceptual differences between real space and information space, and then in using those differences to afford rich and effective interactions in information space.

Acknowledgements

Thanks to Rob Barrett, Seana Coulson, Gilles Fauconnier, Ray Gibbs, and Mark Turner for thoughtful discussions, to Chris Dryer for advice on statistical analyses, and to David Benyon, Alan Munro, Barbara Tversky, and John Waterworth for many helpful comments on a draft of this paper.

References

1. Thorndyke, P.W. and Hayes-Roth, B. Differences in spatial knowledge acquired from maps and navigation. *Cognitive Psychology*, 1982.
2. Tversky, B. Spatial perspective in descriptions. In *Language and Space. Language, Speech, and Communication*, P. Bloom, M. A. Peterson, L. Nadel, and M. F. Garrett, editors. Cambridge, MA: MIT Press, 1996.
3. Lynch, D. *Image of the City*. Cambridge, MA: MIT Press, 1960.
4. Passini , R. *Wayfinding in Architecture*. New York: Van Nostrand Reinhold, 1984.
5. Darken, R. and Sibert, J.L. Wayfinding strategies and behaviors in large virtual worlds. *Human Factors in Computing Systems: Proceedings of the chi '96 Conference*. New York: ACM, 1996.
6. Hirtle, S. Spatial knowledge and navigation in real and virtual environments. Position paper for the *CHI '97 Workshop on Navigation in Electronic Worlds*, 1997.
7. Benyon, D. Beyond navigation as metaphor. In *Exploring Navigation: Towards a Framework for Design and Evaluation of Navigation in Electronic Spaces*, N. Dahlback, editor. SICS Technical Report 98–01, 1998, pp. 31–43.
8. Johnson, M. *The Body in the Mind: The Bodily Basis of Meaning Imagination and Reason*. Chicago, IL: University of Chicago Press, 1987.
9. Lakoff, G. *Women, Fire, and Dangerous Things: What Categories Reveal about the Mind*. Chicago, IL: University of Chicago Press, 1987.
10. Fauconnier, G. *Mappings in Thought and Language*. Cambridge: Cambridge University Press, 1997.

11. Fauconnier, G. and Turner, M. Conceptual projection and middle spaces. Technical Report 9401, University of California, San Diego, Department of Cognitive Science, 1994.
12. Fauconnier, G. and Turner, M. Blending as a central process in grammar. In *Conceptual Structure, Discourse, and Language*, A. Goldberg, editor. Cambridge: Cambridge University Press, 1996.
13. Fauconnier, G. and Turner, M. Conceptual integration networks. *Cognitive Science* **22:** 133–187, 1998.
14. Maglio, P.P. and Barrett, R. On the trail of information searchers. *Proceedings of the Nineteenth Annual Conference of the Cognitive Science Society*. Mahwah, NJ: LEA, 1997.
15. Anderson, J.R. *Cognitive Psychology and its Implications*. San Francisco, CA: Freeman, 1980.
16. Coulclelis, H., Golledge, G., Gale, N. and Tobler, W. Exploring the anchor-point hypothesis of spatial cognition. *Journal of Environmental Psychology* **7:** 99–122, 1987.
17. Maglio, P.P. and Barrett, R. How to build modeling agents to support web searchers. *Proceedings of the Sixth International Conference on User Modeling*. New York: Springer, 1997.
18. Matlock, T. and Maglio, P.P. Apparent motion on the World Wide Web. *Proceedings of the Eighteenth Annual Conference of the Cognitive Science Society*. Mahwah, NJ: LEA, 1996.
19. Matlock, T. and Maglio, P.P. Untangling talk about the World-Wide Web. University of California, Santa Cruz, Psychology Department, 1997.
20. Benyon, D. and Höök, K. Navigation in information spaces: Supporting the individual. *Human Computer Interaction: INTERACT '97*. London: Chapman and Hall, 1997.
21. Lakoff, G. and Johnson, M. *Metaphors We Live By*. Chicago, IL: University of Chicago Press, 1980.
22. Gibbs, R.W. *The Poetics of Mind*. Cambridge: Cambridge University Press, 1994.
23. Sweetser, E. *From Etymology to Pragmatics: Metaphorical and Cultural Aspects of Semantic Structure.* Cambridge: Cambridge University Press, 1990.
24. Turner, M. *Death is the Mother of Beauty: Mind, Metaphor, Criticism*. Chicago, IL: University of Chicago Press, 1987.
25. Gentner, D. and Imai, M. Is the future always ahead? Evidence for system-mappings in understanding space–time metaphors. *Proceedings of the Fourteenth Annual Meeting of the Cognitive Science Society*. Hillsdale, NJ: LEA, 1992.
26. Coulson, S. The Menendez brothers virus. In *Conceptual Structure, Discourse, and Language*, A. Goldberg, editor. Cambridge: Cambridge University Press, 1996.
27. Turner, M. and Fauconnier, G. Conceptual integration and formal expression. *Metaphor and Symbolic Activity* **10:** 183–204, 1995.
28. Grady, J., Taub, S. and Morgan, P. Primitive and compound metaphors. In *Conceptual Structure, Discourse, and Language*, A. Goldberg, editor. Cambridge: Cambridge University Press, 1996.
29. Gibbs, R.W. and Colston, H.L. The cognitive psychological reality of image schemas and their transformations. *Cognitive Linguistics* **6:** 347–378, 1995.
30. Johnson, M. Philosophical implications of cognitive semantics. *Cognitive Linguistics* **3:** 345–366, 1992.
31. Mandler, J.M. How to build a baby: II. Conceptual primitives. *Psychological Review* **99:** 587–604, 1992.
32. Lund, A. and Waterworth, J.A. Experiential design: reflecting embodiment at the interface. *Proceedings of Computation for Metaphors, Analogy and Agents: An International Workshop*, University of Aizu, Japan, 1998.
33. Waterworth, J.A. Personal spaces: 3D spatial worlds for information exploration, organisation and communication. In *The Internet in 3D*, R. Earnshaw and J. Vince, editors. New York: Academic Press, 1997.
34. Raubal, M., Egenhofer, M.J., Pfoser, D. and Tryfona, N. Structuring space with image schemata: wayfinding in airports as a case study. In *Spatial Information Theory: A Theoretical Basis for GIS (COSIT '97)*, S.C. Hirtle and A.U. Frank, editors. Berlin: Springer, 1997.
35. Catledge, L. and Pitkow, J. Characterizing browsing in the World Wide Web. *Proceedings of the Third International World Wide Web Conference*, 1995.
36. Tauscher, L. and Greenberg, S. Revisitation patterns in World Wide Web navigation. *Proceedings of the Conference on Human Factors in Computing Systems (CHI '97).* New York: ACM, 1997.
37. Lakoff, G. and Johnson, M. *Philosophy in the Flesh.* Chicago, IL: University of Chicago Press, 1998.
38. Coulson, S. Semantic leaps: the role of frame-shifting and conceptual blending in meaning construction. PhD dissertation. University of California, San Diego, 1996.

39. Rohrer, T. Conceptual blending on the information highway: How metaphorical inferences work. *Discourse and Perspective in Cognitive Linguistics*. Amsterdam: John Benjamins, 1997.
40. Shum, S.B. Real and virtual spaces: mapping from spatial cognition to hypertext. *Hypermedia* **2:** 133–158, 1990.
41. Chalmers, M. and Chitson, P. Bead: explorations in information visualization. *Proceedings of the Fifteenth Annual ACM SIGIR Conference on Research and Development in Information Retrieval*. New York: ACM, 1992.
42. Barrett, R., Maglio, P.P. and Kellem, D.C. How to personalize the web. *Proceedings of Human Factors in Computing Systems, CHI '97*. New York: ACM, 1997.
43. Campbell, C.S. and Maglio, P.P. Facilitating navigation in information spaces: road signs on the World Wide Web. *International Journal of Human–Computer Studies* (in press).
44. Kuhn, W. Metaphors create theories for users. In *Spatial Information Theory: A Theoretical Basis for GIS (COSIT '93)*, A.U. Frank and I. Campari, editors. Berlin: Springer, 1993.
45. Dieberger, A. A city metaphor to support navigation in complex information spaces. In *Spatial Information Theory: A Theoretical Basis for GIS (COSIT '97)*, S.C. Hirtle and A.U. Frank, editors. Berlin: Springer-Verlag, 1997.
46. Erickson, T., Smith, D.N., Kellogg, W.A., Laff, M., Richards, J.T. and Bradner, E. A sociotechnical approach to design: social proxies, persistent conversations, and the design of Babble. *Proceedings of Human Factors in Computing Systems, CHI '99*. New York: ACM, 1999.
47. Maglio, P.P. and Barrett, R. Adaptive communities and web places. In *Proceedings of Second Workshop on Adaptive Hypertext and Hypermedia (Hypertext '98)*, P. Brusilovsky and P. De Bra, chairs. Pittsburgh, PA, 1998.
48. Maglio, P.P. and Barrett, R. WebPlaces: adding people to the web. IBM Almaden Research Center, 1998.