Behaviour & Information Technology, Vol. 26, No. 3, May–June 2007, 209–220

Taylor & Francis
Taylor & Francis Group

An approach for designing composite metaphors for user interfaces

Y. C. HSU*† and E. BOLING**‡

†National Tsing-Hua University, Taiwan, R.O.C.
‡Indiana University, Bloomington, IN, USA

A composite-metaphor interface is a computer interface consisting of a combination of two or more metaphors. As computer systems have become more sophisticated, researchers have proposed the use of multiple metaphors to design computer systems because they would better match the characteristics of complex target systems; however, due to the difficulty of designing interface metaphors and limited research in this area, there are few guidelines or accepted standards for generating and implementing composite metaphors for interface design. In this paper, the authors propose an approach for designing composite metaphors. We first present the metaphor design strategies as we interviewed eight game designers, then summarise the design considerations from the metaphor literatures. Finally, we propose the design approach for selecting and combining metaphors in designing composite-metaphor interfaces.

Keywords: Composite metaphors; Game designers; Hypermedia systems; Interview; Metaphorical interfaces; Structural cues

1. Introduction

The concept of metaphor has been studied and applied in a wide range of fields for a long time. Beginning with Xerox Star's desktop metaphor, metaphors have been increasingly applied in the area of human–computer interaction (HCI). Considering the flourishing growth of the Internet and diverse styles of information presentation in hypertext systems, metaphors have been designed to provide navigational aids to reduce the problem of 'getting lost'. As computer systems become more sophisticated, the use of multiple metaphors (composite metaphor) in designing interfaces has been proposed by researchers. This is based on the view that different metaphors may supplement each other to better match the complex target domain and provide greater breadth to cover interface properties (Neale and Carroll 1997).

However, there is no accepted standard for designing composite-metaphor interfaces, due to the vague definition of composite metaphors and limited literatures available in this area. The focus of this paper is to present a design approach for creating the composite-metaphor interfaces by using metaphorical cues to represent the system structure. Two empirical studies (Hsu and Schwen 2003, Hsu 2005) have applied this approach to design composite-metaphor interfaces to examine the effects of single versus composite metaphors. The methods and results of these studies will be briefly presented later.

This paper includes four major sections. It begins by presenting two studies applying the approach, followed by a discussion of the definition of metaphors and composite metaphors in section two. Next, in section three we review the design issues of composite metaphors. The section includes two subsections. First, we present the views of eight game designers on design using composite metaphor. Then we discuss the issues to consider in creating composite-metaphor interfaces. Finally, in section four we propose the design approach, which is the main focus of this paper.

1.1 *Context of the design approach – studies of single versus composite metaphors*

Hsu *et al.* (Hsu and Schwen 2003, Hsu 2005) compare the effects of structural cues derived from integral (single)

*Corresponding author. Email: ychsu@mx.nthu.edu.tw; **eboling@indiana.edu

Behaviour & Information Technology
ISSN 0144-929X print/ISSN 1362-3001 online © 2007 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/01449290500402528

versus composite metaphors in designing hypertext systems. The first study compared integral versus composite-metaphor interfaces, specifically their effects on facilitating users' information–search behaviours in a hypermedia system. The second study further examined their long-term effects on novice and expert users. In these studies, three interfaces served as the independent variables, with the first interface containing minimal metaphorical elements, the second (integral-metaphor interface) containing some metaphorical elements from a single metaphor, and the third (composite-metaphor interface) containing more metaphorical elements from two metaphors. The subjects' tasks were to locate the information required to answer questions in the hypertext system.

The findings in the first study led to several conclusions. The better performances of the composite-metaphor group suggest that composite metaphors help subjects to engage in a deeper thinking process by mapping different metaphors. But this also requires subjects to spend more mental effort in performing information–search tasks and thus leads to longer information-search time than the integral-metaphor interface. In the second study, a metaphor-rich interface facilitates experts' searching better than it does novices' searching as long as the interface uses metaphors that correspond to the experts' mental models. Regarding the effects of metaphor over time, the improved effects of using metaphor-rich cues (composite metaphors) in interface design increase with practise, but decrease after a period of time.

From subjects' answers in an open-ended questionnaire in the second study, it is known that the design of these three interfaces successfully convey the intended meaning. That is, subjects using the first interface perceived it less as a metaphorical interface. Those using the second and third interfaces perceived them as integral- and composite-metaphor interfaces, respectively. This may suggest that using metaphorical cues to represent the system structure is an effective way of designing a composite-metaphor interface.

2. Composite metaphor in interface design

2.1 *Metaphor*

Metaphor is traditionally a concept that belongs to the fields of linguistics and philosophy. In 1980, Lakoff and Johnson (1980: 5) presented new ways of thinking about metaphor regarding everyday experience. They consider the essence of metaphor to be 'understanding and experiencing one kind of thing in terms of another'. They demonstrate that people's conceptual systems are metaphorical and people's everyday actions are a matter of metaphor. In HCI, a metaphor is 'present when terminology or concepts from a familiar noncomputer domain are used to depict computer functions and objects in a user interface (Smilowitz 1995). According to Carroll and Thomas (1982), when a computer user learns a new computer program, he calls upon his prior knowledge (analogies or metaphors) as the basis on which to form a new mental model. Designers can take advantage of users' existing mental models to present ways of conceptualising computer functions and to design interfaces for computing systems. Using metaphor is a way to control the complexity of user interfaces by designing the actions, procedures and concepts of new interfaces based on users' familiar actions, procedures, and concepts from previously learned interfaces (Carroll *et al.* 1988). Metaphors used in this way are called *interface metaphors*.

Because humans learn new concepts or knowledge in terms of what they already know, almost all the computer interfaces in the world contain various types of metaphors taken from other domains. Cates (2002: 395) notes that 'few things on a computer screen are what they appear to be, particularly in a GUI ... It seems unlikely that we can–or should–avoid metaphors in technology-based learning products'. Marcus (2002) also claims that metaphors are fundamental underpinnings for human communication. Although the desktop metaphor is criticised as culturally biased or inefficient, Marcus argues that metaphor won't disappear any time soon, but will be expanded in use to design agents that facilitate both our regular and irregular computing tasks.

2.2 *The needs of composite metaphors in interface design*

While metaphor is useful for helping people to reason about new knowledge, mismatches between the base and target domains may occur, which lead to incorrect inferences. Mismatches happen in situations in which the attributes and relationships of a single metaphor cannot be perfectly correlated with the attributes and relationships of the target domain. Marcus (1994) notes that a single metaphor has limited attributes and that can't fully represent complex communication. Even the familiar GUI desktop metaphor has several submetaphors to help explain computer functions.

This is especially true when the target domain is so complex that no individual model can fully explain anticipated behaviour. In this case, the use of several metaphors to design interfaces may be a solution. Researchers (Staggers and Norcio 1993, Smilowitz 1995, Hsu and Schwen 2003) have proposed the use of composite metaphors to design systems because composite metaphors allow for more complete representation of the various objects, relationships and operations of the target system. Neale and Carroll (1997: 446) suggest using 'composite metaphors for greater breadth to cover literal and magical properties of user interfaces'. Benking and Judge (1994) also claim that three or more complementary metaphors may be used together in order to adequately represent some complex systems. Booth's (1989: 73) argument provides a basis for the use of multiple metaphors. He notes that

people 'appear to have blocks of knowledge relating to different domains and use parts of these knowledge blocks when they believe that it is appropriate'. Because computer users draw knowledge from different source domains in learning a new system, the provision of multiple metaphors may better facilitate the users to learn different parts of the system.

2.3 *Definition of composite metaphor*

There are several terms related to the concept of multiple metaphors: integral/composite metaphors, underlying (primary)/auxiliary (secondary) metaphors, complementary metaphors and mixed metaphors. An integral-metaphor interface is one in which a single metaphor is used, while a composite (mixed) metaphor interface is one in which two or more metaphors are used to design the interface for a target system. These distinct metaphors can be used to map to different functions of the new system, which provides more complete coverage and mapping.

Cates (2002: 388) discusses the design of graphical user interface (GUI) metaphors and divides metaphor into two classes: the underlying metaphors and the auxiliary metaphors. He reviews several articles and concludes that designers should select a main metaphor as the basis of understanding and add subsequent metaphors that are consonant with the first metaphor. In this situation the underlying metaphor 'serves as the basis for users' understanding of the interface' and establishes the context for the auxiliary metaphor to fit. The complementary relationship of the auxiliary metaphor to the underlying metaphor is what Alty *et al.* (2000) call 'between-metaphor consistency'. The contrast between the underlying and auxiliary metaphors encourages users to reconstruct the operation of the interface. In the case when the contrast between the two metaphors is so big that users feel it difficult to reinterpret the operations and reject the comparison, Cates call the interaction between the two metaphors 'confounding'. To design complementary metaphors, Cates suggests selecting a broader underlying metaphor that enables designers to choose a wider collection of subsequent metaphors. For example, if we choose an entertainment centre as the underlying metaphor, we can choose a videotape player or a book as the auxiliary metaphor. The authors of this paper adopt Cates's view of mixing multiple metaphors by selecting a metaphor as the primary one and adding subsequent metaphors that complement the first one. Interfaces created in this way are called 'composite-metaphor interfaces'.

Another term often mentioned when people talk about metaphor is 'analogy'. We take 'analogy' as a synonym for 'metaphor' because metaphor is an implicit analogy – it shows similarities in an implicit way, rather than directly pointing out that one thing is like another thing (Presmeg 1997).

2.4 *Related studies of composite metaphors*

In terms of the theoretical basis for composite metaphors, Rumelhart and Norman (1981) conducted a study on teaching new users to learn a text editor. They observed that students made errors because of their inadequate conceptualisation of the various parts of the computer system. This resulted from the insufficient mental models students brought to the situation; they limited the kinds of analogies they might have employed. The authors note that no single metaphor can fully explain a complex piece of subject matter. Thus, they postulate an effective solution to eliminate student errors – the provision of a more appropriate analogical framework, with different conceptual models to help students in their reasoning. They claim that as people grow more experienced in a domain, they become better at choosing appropriate models for a specific situation. In teaching this subject matter, it is effective to present a set of models, each with its own built-in context dependencies, as alternative conceptualisations of the target domain.

Collins and Gentner (1983, 1987) found that analogies allow people to create multiple mental models for use in reasoning about a complex system. They used analogies to map the set of transition rules from a known domain (the base) into the new domain (the target), thereby constructing a mental model that can generate inferences in the target domain. To test this hypothesis, they observed how subjects reason about evaporation and did an analysis of their protocols. The qualitative data suggest that subjects formed three different levels of interrelated mental models while reasoning about the target domain. These findings support the view that people learn the target domain by partitioning it into different component models, each mapped to a different base domain.

Multiple metaphors have also been employed in the field of artificial intelligence. Burstein (1983) presented a model for students to learn a programming language. This involved the use of a box analogy, an algebra analogy and a human processor analogy. In the example, the author used analogies in such a way that each analogy covered several levels of description, but served different functions. The use of multiple analogy models has been found to be helpful in facilitating students who are learning the new domain in this case.

Spiro *et al.* (1989: 502) describe the danger of using single analogies for learning and instruction. They suggest that misconceptions are often caused by the reductive effect of analogies. 'When analogies are used to "start simple", the knowledge ultimately acquired often stays simple. Well-intended analogies often result in oversimplified knowledge.' They present eight situations in which the use of an analogy induces misconceptions or mismatches. One common characteristic of these eight situations is that users

tend to depend too much on the properties of an analogous source domain to understand the target domain. To solve this problem, they propose the use of integrated multiple analogies to represent complex concepts. They claim that by introducing new analogies that emend the missing or misleading aspects of the earlier analogy, the strength of the original analogy is retained, but its weakness is discarded.

Smilowitz (1995) conducted a series of studies to examine the effects of integral and composite metaphors by mixing a library metaphor and a travel metaphor to create the composite-metaphor interfaces in her study. The findings suggest that a composite metaphor is no less effective than an integral metaphor, and the former one was certainly more flexible in allowing more coverage of the target domain.

Hsu (Hsu and Schwen 2003, Hsu 2005) conducted two studies on the effects of composite metaphors by mixing structural cues from two metaphors to create the composite-metaphor interfaces. The results indicate that composite metaphors may help subjects to develop more sophisticated representations of the target structure. The detailed methods and results have been introduced in an earlier section.

2.5 *Needs for design methods of composite metaphor*

In section 2.2 the authors point out the important roles of metaphors, especially composite metaphors, in interface design. Nevertheless, there is very little guidance for designers on how to select, implement and evaluate interface metaphors (Alty *et al*. 2000). Regarding the design of composite metaphors, Akoumianakis *et al*. (2000: 388) note that several researchers explore metaphor's effect for interface design from different perspectives. However, 'very little is known as to how different metaphors can be embedded into computer-based interactive software'. Akoumianakis *et al*. work is among the few papers that propose a method for building multiple-metaphor environments. However, in their method, different metaphors are alternative to each other (alternative conceptualisations of the target system) and act in a programming-intensive manner. That is, a metaphor that characterises the overall environment is called up each time (judged by the system) to fit the specific user's task. In this environment, multiple metaphors are not mixed in an interface.

The above statements indicate that the design guidelines derived from research findings on interface metaphors lag far behind the present demand for them from the practitioner field. Due to the lack of clarity regarding elements and methods of design that embody the composite-metaphor interfaces, the authors of this paper propose an approach focusing on deriving structural cues from multiple metaphors in order to design interfaces of hypertext systems. In the next section, we present designers' views and address issues from literatures regarding mixing multiple metaphors.

3. Design issues of composite metaphors

3.1 *Interview with designers on the design of composite metaphors*

In order to understand how interface designers handle the design issues involved in using composite metaphors, eight game designers solicited from four major game companies in Taiwan were interviewed about using metaphorical concepts in game design. Although the interview data were collected after the two metaphor studies, many of the designers' suggestions are found to be consistent with the literatures as well as the design considerations proposed in this paper. The designers' strategies signify the key design points of composite metaphors and provide insight into issues to consider in metaphor design.

The authors chose to interview designers from the game industry because metaphor is used frequently in designing complex game environments. So, game designers may provide deep insight into metaphor design. The eight designers were selected, based on type of expertise as well as years of design experience. Six of the designers are project managers who are experienced with interface design, and the other designers currently work as interface designers. The average length of their work experience is seven years.

The interviews lasted, on average, 40 minutes. All the interviews were audiotaped and transcribed verbatim, including comments about aspects of the interview such as tone of voice and the researcher's feedback during the interview. These were semi-structured interviews consisting of the following two main questions:

> What are your strategies for designing an interface with composite metaphors?
>
> When designing a product, do you ever observe any problems or conflicts caused by mixing multiple metaphors derived from different base domains? Which design methods do you apply to eliminate the potential problems?

The interviewer first explained the context of the study and presented the two questions, which generated deeper discussion and subsequent questions. The same definition of composite metaphors (see section 2.3) and examples were also provided to all interviewees to ensure that they understood the meaning. The constant-comparison method was chosen to analyse the data where the thematic categories were sorted and compared. The following sections are the summaries of the interviews, divided by four major themes that emerged during the analysis process.

3.1.1 Use of central theme. Hudson (2000: 14) provides metaphorical guidelines and notes that 'metaphors operate on systems of relationships, not on individual concepts. Make sure that the system of relationships is reflected in your user interface, and do not use concepts out of context.' His words point out the importance of a metaphor's intact structure. Mixing multiple metaphors may break the internal structure and cause user confusion because users do not see the boundary between different metaphors and are unable to make a correct inference. However, this problem can be eliminated by careful design, as pointed out by several designers during the interviews. Three designers mention the 'congruence' or 'consistency' of an interface. Designer C said that 'we can make the metaphorical elements congruent by providing a central theme or style of an interface. When mixing several metaphors, we tried to make the metaphorical elements consistent with the central theme and use the theme to manifest the interrelationships between these elements.'

3.1.2 Selection of metaphors. During the interviews, the designers talked about several criteria for selecting metaphors, which can be summarised as a metaphor's familiarity to users, the number of metaphors, similarity between metaphors, function versus perfect mapping, and metaphor's visual representation.

Designer D believed that the main criterion for selecting metaphors is their familiarity to users. In a good design with appropriate metaphors, users should be able to intuitively operate the metaphorical objects without too much learning. He said that 'as long as the metaphors were familiar to users and were not conflicting with each other, there should be no problem for us to combine them together in the same environment'. In terms of the number of metaphors in an interface, designers B and G both suggested that we should limit the number of different metaphors mapped from distinct base domains in order to avoid user confusion. A good strategy to combine several metaphors is to select a primary metaphor that characterises the environment and add two to three additional metaphors. The metaphors should not be too similar or alternative to each other so that users can easily distinguish among them; for example, do not mix Chinese magic with western magic because they refer to the same thing. This opinion is similar to that of Carroll and Thomas (1982) and will be further discussed in another section.

Designer F thought that objects with good functions were more important than those with perfect metaphorical mapping. 'In selecting metaphors, you face a trade-off between function and mapping. You need to decide whether to choose metaphors which easily represent the interface functions or choose ones which map perfectly to the base domain. In the case that both are not available at the same time, choose the one with good representation of interface functions'. Regarding the last criterion, designer E suggested that we ought to consider if a metaphor can easily be represented visually. His view is consistent with Hudson's (2000) in that he suggests selecting metaphors that can provide concrete images.

3.1.3 Strategies of mixing multiple metaphors. Several designers provide strategies to mix multiple metaphors in the same environment. Designer C said that 'different metaphorical elements should be modified visually to fit into the context (the central theme). When it is needed, designers can provide background description to inform users how different metaphorical elements merge with each others'. Similar to the view of Cates (2002), designers B and D both suggest selecting a major metaphor to characterise the overall context and then embedding subsequent metaphors (secondary metaphors) that are complementary to the primary metaphor. In this way we can retain the internal structure of the primary metaphor, which retains the interrelationships among the different elements. When combining multiple metaphors, we select and modify elements from the secondary metaphors to fit with the primary metaphor. If two or more alternative metaphors were mixed equally to represent the overall environment, users would get puzzled. In addition to the content or function consonance, designers E and H emphasised the importance of visual consistency between different metaphor elements. They thought that users would regard them as the same thing if these different elements could be designed to fit into the same visual style.

3.1.4 Conflicts between different metaphors. Regarding the possible conflicts caused by mixing different metaphors, designer A mentioned that 'we should consider the trade-off between perfect mapping and congruence between metaphors. Conflict can be avoided by selecting metaphors that are congruent with each other in terms of the functions and visual element they represent'. Designer H thought that visual discrepancies caused by mixing metaphors would be more apparent than those in other aspects. In this case, designers should generate methods to make these visual elements consistent; for example, designing these elements to fit the interface style.

In a game environment, conflicts are sometimes created on purpose. Designer A indicated that 'we create contradiction between metaphorical elements with intent to produce special effects. In a game environment you will see many exceptional cases that will bring about users' curiosity, for example a motorcycle placed in the middle of ancient times. While it may be problematic sometimes for the users to understand the meaning, it's the feature of a game.' Designers B and F have similar views. They stated 'the purpose for playing a game is to get fun and be entertained. Occasionally, we deliberately violate the

consistency principle by mixing contradictive things together so that users will continuously check what happening and keep interest on it.' When they were asked about the possible bewilderment of users that might be caused by mixing unrelated concepts, the designers said that 'unlike the software in a regular working environment, games are more similar to mass media such as movies or novels. The users would imagine fantastic plots happened in a game and appreciate the discrepancy among elements.'

3.1.5 Conclusions of interviews. Eight game designers shared their views about the use of central theme, possible conflicts between different metaphors and methods for selecting as well as combining metaphors. The conclusion of the interviews indicates that in a game environment, a design using multiple metaphors from different knowledge domains is inevitable. The guidelines derived from the interviews explicitly indicate the strategies adopted by these experienced designers. Since a game and hypertext system have some points in common (e.g. a space where users can browse inside to perform some tasks), the metaphor-design strategies can also be applied to create a hypertext system.

3.2 *Issues to consider for designing composite-metaphor interfaces*

Several researchers have discussed the considerations of metaphor design in the past 20 years. One kind of composite metaphor consists of complementary metaphors to represent functions of an interface, with each metaphor representing a function at a single level. Carroll *et al*. (1988) give an example of this kind of composite metaphor – the integrated office system, which includes electronic mail, spreadsheets, text editing and decision support, each with a different metaphor to represent it in the system. Since the generation of a composite-metaphor interface involves both the selection and the combination of multiple metaphors, design considerations and problems concerning these two phases are discussed below.

3.2.1 Selection of metaphor. When selecting metaphors to design interfaces for computer systems, the designer needs to consider several issues, including: the type of information and structure of the system; users' tasks; methods of task completion; appearance of the interface; description level of the metaphors; users' expert levels and prior knowledge; and consistency between metaphors.

- The *type and structure of information* of the target system influence how designers select metaphors. Designers need to consider the information content and structure of the target system when choosing appropriate metaphors.
- Carroll *et al*. (1988: 78) explain three aspects to consider in designing a metaphor: the *tasks, methods and appearance levels*. The task level describes users' goals and what they can do; an example is the information search in the studies that will be reviewed in this paper. The method level describes how tasks are accomplished. The appearance level is the 'look and feel of the task situation vis-à-vis the physical implementation of the domain'. It includes aspects of the hardware and the presentation of screen objects.
- In terms of *description level of the target system*, Booth (1989: 77) claims that 'the level of description of a metaphor is concerned with the type of information that a metaphor might be expected to communicate'. He takes an example from Moran's (1981) 'Command Language Grammar' and says that a metaphor can be aimed at the task level, the semantic level, the syntactic level, or the physical level. This characteristic increases not only the possibilities for metaphors, but also the difficulty in designing a metaphorical interface.
- When choosing metaphors, the designer should consider *users' prior knowledge* in their familiar domains as a basis for designing tools for learning new things. Stagger and Norcio (1993) claim that when designing multiple models for users to learn new knowledge, designers need to consider the expert level of the users and the tasks to be completed. As users gain expertise in the target area, their ability to manipulate multiple models increases. Since metaphors work by mapping previously acquired knowledge of users (the base domain) to the target domain that they are going to learn, some attributes (objects, relations, actions, effects) of the base domain must match the attributes of the target domain. The selection of metaphors should be based on a user's familiar knowledge.
- Cates (2002: 388) suggests selecting one metaphor as the *underlying metaphor* and choosing *auxiliary metaphors* that complement the underlying metaphor.

In addition to consideration of the above criteria in selecting interface metaphors, designers also face some design problems described by Cooper (1996): 1) there are not enough metaphors; 2) the metaphors do not scale well; and 3) the ability of users to recognise them is questionable. As the number of metaphors in an interface design increases, the more constraints there are regarding the criteria of metaphor selection. Carroll and Thomas (1982) suggest that when using two or more metaphors to design a system, one should not choose objects or procedures that are exclusively contrary to each other, so as to avoid interference and confusion. In another article, Carroll and Mack (1999) argue that good metaphors also should not

provide completely transparent and comprehensive mapping, so that they may better enable users to learn.

3.2.2 Combination of metaphors. Once multiple metaphors are selected, designers need to identify an optimal way of combining the metaphors. One method was suggested by Cates (2002: 388), who proposes the POPIT model for designing metaphorical interfaces, and notes that the 'properties, operations, phrases, images, types, and sounds associated with the underlying metaphor may provide the imaginal and semantic links to related metaphors that might serve as auxiliary metaphors'. In designing a composite-metaphor interface, designers first identify the properties, operations, phrases, images, types and sounds of the underlying metaphor to map to the key feature and functions of the interface, and then select auxiliary metaphors that map to different parts not covered by the underlying metaphor.

The method for combining metaphors has not been well-discussed by designers or researchers, so there are not many guidelines regarding how to bring together several metaphors to create an interface. In addition, designers face some problems in combining multiple metaphors. First, it is hard to draw the boundaries between different metaphors. Booth (1989: 78) raises this question for designers: 'how [can we] signpost the boundaries of metaphors within a system so that users know when a metaphor is no longer relevant and when another metaphor is appropriate [?]' Second, although practitioners have suggested using composite metaphors for interface design, operationalising composite metaphors to create interfaces is very difficult to carry out. Most previous studies used separate analogies to teach new knowledge, or they used separate metaphorical interfaces to help users learn new computer systems. Methods for combining different metaphors in a system have not been well-explored by those researchers. One known method was that proposed by Cates (2002) regarding the selection of underlying and *auxiliary* metaphors.

Smilowitz (1995) was a pioneering researcher who in her experimental studies tried to mix two metaphors in an interface. She mixed two metaphors within the navigation area of a hypertext system by designing navigational icons represented in two metaphors. Due to the challenging nature of this case, there were design deficiencies in her approach to combining multiple metaphors.

In comparing the designer's view about metaphor design with that summarised from the literatures discussed above, some similarities are found. Both the designers and researchers suggest selecting a primary metaphor (central theme) as the context and adding subsequent metaphors that are consistent with or complement the first one. They both emphasise the importance of user's prior knowledge and ease of representation (appearance level) in selecting appropriate metaphors. In addition, they regard good representation of functions as a more important issue than comprehensive or perfect mapping. They suggest using composite metaphors to overcome the problems of mismatch between the base and target domains. Differences are found as well in the comparison. In selecting metaphors, researchers emphasise, in addition to the appearance level, the importance of a user's task and goal as well as the information type a metaphor means to communicate. They address more contextual considerations in selecting metaphors, but offer less practical methods in combining multiple metaphors, which can be supplemented by the designers' strategies.

In light of the design difficulties of composite metaphors, the application of structural cues taken from multiple metaphors may be a solution for integrating two or more metaphors when designing an interface. This design approach will be presented in the next section.

4. The design approach for creating composite-metaphor interfaces

Because the method of using metaphor in computer interface design is still vague to many designers and because there is limited research available in this area, interface design in this area is more laborious due to the problem concerning the operational definition of metaphorical interfaces. Stanney *et al.* (2003) propose six stages of metaphorical-design generation: (1) identify system functionality; (2) generate metaphoric concepts; (3) identify metaphor/interface matches; (4) identify metaphor/interface mismatches; (5) determine how to manage metaphor/interface mismatches; and (6) identify weaning strategies to employ when a metaphor loses its utility.

Part of the approach proposed in this paper was for the purpose of research, not design. The approach is somewhat similar to that of Stanney *et al.* (2003), but is divided into two stages due to the nature of the studies. In addition, a main difference between these two approaches is that the later one (Stanney's approach) appears to have step-by-step (linear) sequences, while in the former approach many of the design steps (i.e. metaphor/metaphor matches and mismatches, metaphor/interface matches and mismatches) need to be considered simultaneously because the steps are interrelated to each other in designing for the composite-metaphor interfaces. Although the design process is divided into two stages, the considerations in different stages need to be carefully planned together.

Below are the stages by which composite-metaphor interfaces in these studies were created.

4.1 *Selection of metaphors*

We considered the placed constraints on the variety of possible metaphors that could be used to design the interfaces based on

the particular circumstances of the project. The issues taken into account are summarised below:

- subjects' prior knowledge concerning the metaphors (user's prior knowledge)
- characteristics of hypermedia systems versus the attributes of metaphors (mapping between the base and the target domain)
- potential mismatches between the metaphors and the hypermedia system (mismatch between the base and the target domain)
- overall structures of metaphors in covering hypermedia systems (structure mapping between the base and the target domain)
- appropriateness of metaphors for information searching (task level)
- ease of representation
- manifestations/appearances of metaphors
- existing metaphors used in other software
- methods of combining multiple metaphors (combining underlying and auxiliary metaphors).

Since the user's task is an information search, some related characteristics proposed by Lin (1989) were also taken into consideration. These include:

- style of presentation of information
- size of information units
- degree of user control over the ordering of information
- routes of traversing
- visibility of linkages among units
- implied internal structure of information units
- style of access to specific information.

One criterion in selecting multiple metaphors is that the chosen metaphors must be independent of each other. In other words, one metaphor cannot be subordinate to the primary metaphor. According to Cates (1994: 98), the secondary metaphor 'stimulates images and semantic expressions related to those stimulated by the primary metaphors which they are intended to accompany'. If one metaphor is subordinate to the other, then they can be seen as the same metaphor family. In addition, Carroll and Thomas (1982: 113) note that 'when it is necessary to use more than one metaphor for a system, choose metaphors drawn from a single real-world task domain (e.g. similar enough), but do not choose objects or procedures which are exclusive alternatives from within that domain (i.e. not too similar)'. The same principle can also be derived from the interviews with the game designers, who suggested selecting a major metaphor to characterise the context and adding complementary elements from subsequent metaphors.

After several unsuccessful attempts (using different combinations of multiple metaphors such as timeline, map, journey, path, container, building ...), book and folder metaphors were ultimately selected, based on the above guidelines and the consideration of possible ways to combine metaphors.

The reason that the researchers selected book and folder metaphors is that since each could map to different aspects of the hypermedia system, they are complementary (see table 1). Spiro *et al.* (1989) propose the employment of multiple analogies in learning and instruction, and identify ways that analogies may induce misconceptions. Based on their framework, the researchers analysed the strengths and weaknesses of book and folder metaphors (see table 2) and used them in the design of three interfaces.

4.2 *Combination of two metaphors and the creation of three interfaces (use of structural cues)*

A method was proposed to create the metaphorical interfaces based on design guidelines derived from the literature as well as the revision of design methods used by other researchers. In this strategy, the metaphors work as the source for the structural cues to be combined in creating a metaphorical interface. Metaphors were used as the basis for deriving navigational cues, but those cues were not treated illustratively. In other words, the cues provided onscreen are related structurally to the metaphors (e.g. table of contents), but do not necessarily represent elements of the metaphors in a pictorial way. The metaphors provided a logic for the designs, which guided the choice of structural cues that distinguish the three interfaces by the varying degrees to which those structural cues appear. This approach leads to a more precise operational definition of composite metaphors and manipulation of the variables. Below is a review of structural cues and the method for combining the metaphorical structure cues.

4.2.1 Structural cue. The flexible structure of hypertext systems is an advantage, but it also causes some problems. Hammond and Allinson (1989) point out the 'getting lost' problem with hypertext and think that the problem could be explained as disorientation in navigating a hypertext system. One way to solve navigation problems in hypermedia is to provide structural cues that can inform users of the information available, its location and its organisation. Structural cues in hypertext refer to the use of contextual cues to inform users of the structure of the hyperspace. Examples of these cues are table of contents, keywords and alphabetical index or indexing by subject, page numbers, sections, hierarchical content lists and typographical cues. In addition to the use of text to represent hypertext structure, an alternative way is the use of graphical

Table 1. Analysis of metaphor functions and structural cues.

	Elements related to content or to the hypermedia structure	Metaphor functions related to hypermedia characteristics
Book metaphor	• Books have structure. Each book page can be used to place an information unit (e.g. a web page) • A book has a cover, a table of contents, chapters, sections and pages • Turn page/page number • Open/close a book	• Linkages among units are visible • A book structure resembles the internal structure of an information unit in a hypertext system • A book has a particular style of information presentation and access to specific information • Book pages must be accessed sequentially by page turning or by reading the table of contents (Lin 1989: 48)
Folder metaphor	• Each folder can be used to place an information unit • Folder tabs with labels enable users to easily identify the content of a folder • Flexible ordering of information (Lin 1989: 46)	• Folder tabs allow random access to specific information units (Lin 1989: 46) • Information units in different levels can be directly accessed

Table 2. Analysis of book and folder metaphors based on Spiro *et al*. (1989) discussion of analogy misconceptions.

Book metaphor (elements that require supplementation by a second metaphor)	Characteristics of the folder metaphor that supplement the book metaphor
Missing properties	
A hypermedia system in a network structure has the characteristic of flexible information access, while a book has a linear sequence that does not share this characteristic.	The folder metaphor allows for flexible information access. Users can flip folder tabs to immediately access information stored in a different folder. Folder tabs work like hyperlinks that enable users to access different pieces of information.
A hypermedia system allows users to go directly to information on other pages by clicking hyperlinks, while in a book only the table of contents and index possess this characteristic.	
Misleading properties	
Information in a book is presented from left page to right page (double side), but in a hypermedia system the information is extended from the top to the bottom of the page.	Information is contained in a folder unit. Each folder unit corresponds to a node in a hypermedia system.
Misleading language	
In using a book metaphor to design a hypermedia system, we use the phrase 'turn to previous or next page' to go to a different page. But the physical effect in a hypermedia system does not match the effect of turning the pages of a real book. The use of the term is thus misleading.	No supplementary characteristics here.

representation. In this case, graphical metaphors are often applied to visually represent the system structure.

The above examples indicate that structural cues are closely related to the concept of metaphor. Due to the navigation problems that a novice user may experience, Rouet and Levonen (1996: 18) argue that novice users need analogies with conventional structures. Therefore, familiar concepts (metaphor) are often used to represent the hypertext structure for users to easily navigate the hyperspace.

Results of past studies prove that structural cues facilitate navigation and increase readability in hypertext. Their effects have been proved in Dee-Lucas's study (Dee-Lucas and Larkin 1995, Dee-Lucas 1996), in which the results indicate that the provision of structured overview in hypertext enhances its usability. The use of structural cues in hypertext helps users to select units more efficiently and aids them in determining desired information to meet learning goals. In addition, Nilsson and Mayer (2002) conducted two experiments to examine the effects of maps and graphical organisers on users' navigation. The findings of the second experiment indicate that subjects using the interface with structural cues performed more efficiently in information searching. The results support the cognitive load theory and show that reducing subjects' effort for comprehending the system structure would improve their navigational behaviours.

Due to the problems designers or researchers may experience when combining multiple metaphors to create an interface, creating a metaphorical interface by combining structural cues that are derived from two or more

metaphors may be a design solution. A detailed discussion of the method will be presented in the following section.

4.2.2 Combination of metaphorical structure cues. After each metaphor was selected, all of its objects and functions were analysed using the POPIT model, as shown in table 3. The design problems that Smilowitz (1995) faced in combining multiple metaphors have been discussed. In addition, Lakoff and Johnson (1980: 96) claim that 'metaphors do not imply a complete mapping of every concrete detail of one object or situation onto another; rather they emphasise certain features and suppress others'. It is also impossible to manipulate metaphorical elements in an interface from complete absence to presence.

Because of the context of the design, three interfaces were created. They can be used to demonstrate different degrees of metaphor use.

First interface (with minimal cues): the first interface contains a minimal degree of metaphorical concepts (see figure 1). In addition, for the sake of comparison and data collection the three interfaces needed to have similar structures and styles of information presentation. Since all computer interfaces contain some metaphors taken from other domains, it is impossible to totally rule out metaphorical elements. In the original hypertext system, each article was organised hierarchically, with its title listed in previous levels as a hyperlink. This made the title lists look more like the table of contents of a book. For this reason, this interface still contains a small number of metaphorical elements, partially due to the nature of the information content.

Second interface (with medial cues): the same structural components and elements can be found in all three interfaces: (1) four levels in the system; (2) a main page as the first level with hyperlinks linking to the second and third levels; (3) articles in the second, the third and the fourth levels with or without hyperlinks linking to the next level; and (4) titles and body text for each article. Based on the analysis, terms, images, structures and operations were taken from a book metaphor to add to the design of the second interface. This caused the second interface (see figure 2) to contain more structural cues from a book metaphor. All the information was presented in book format; for example, the text of each article was presented on double-sided pages, as in a real book. Users can click on the 'dog ear' (turned-up page corner) to turn to the previous or next page. In addition, the title of each article was labelled with chapter, section and subsection number to resemble the title of a book.

Third interface (with maximal cues): in order to compare the effects of the second interface, in which the structural cues were taken from only one metaphor, with the third interface, in which the structural cues were taken from multiple metaphors, the third interface was created with the book as the primary metaphor and the folder as the secondary metaphor (see figure 3). To create the third interface, extra structural cues, including the images, structures and operations of a folder metaphor, were added to the second interface. Whereas information presentation in a book metaphor is linear, the folder metaphor conveys the hypermedia attribute of flexible information access. The book metaphor worked as the main metaphor and was broader in its scope, while the folder metaphor was added to the design to supplement the book metaphor. Booth (1989) describes the dimensions of a metaphor in terms of its scope and level of description. The scope describes the number of concepts that a metaphor addresses, and the level of description deals with the information types that a metaphor communicates. Similarly, Hammond and Allinson (1987) describe four levels of information that a metaphor may convey: (1) task information; (2) semantic information; (3) lexical information; and (4) physical information. Using those concepts to examine the design in these studies, the book metaphor has a larger scope and conveys four information levels: the hypertext structure, the layout, the

Table 3. POPIT Model (Cates 2002).

	Book (Cates 2002)	Folder
Properties	Book cover, pages, table of contents, chapters, sections, title	Tabs on the top of each folder, several folders can be put together, labels or keywords on the tabs
Operations	Open a book, turn page forward and backward	Folder tabs can be thumbed through, it allows random access, flexible ordering of folders
Phases	Turn pages, open, close, begin reading, fold the corner of the page down, highlight	Select the folder, open the folder, select section by way of thumb tabs
Images	Book cover, layout of books	Same size and shape for each folder, tab in different location on the top, tabs have different colours
Types	Reference works, recreational books	Information storage

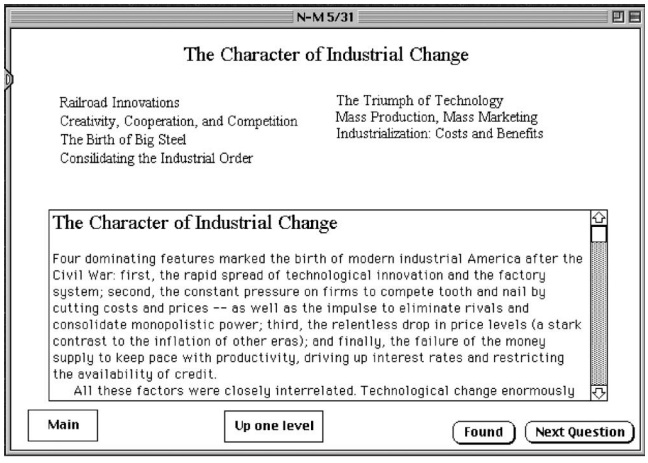

Figure 1. Screen shot of the third level for interface A (Hsu and Schwen 2003).

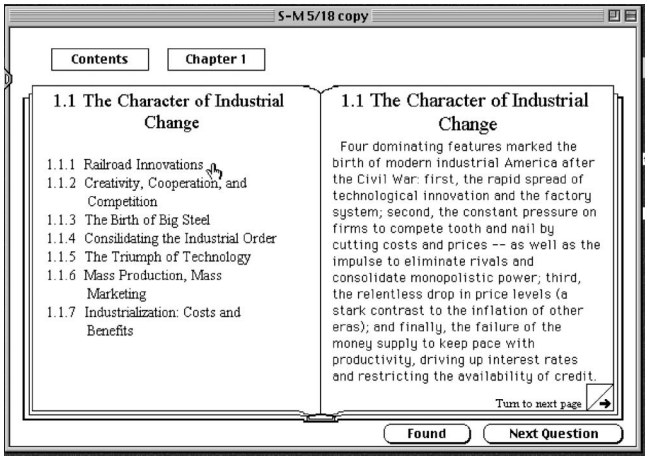

Figure 2. Screen-shot of the third level for interface B (Hsu and Schwen 2003).

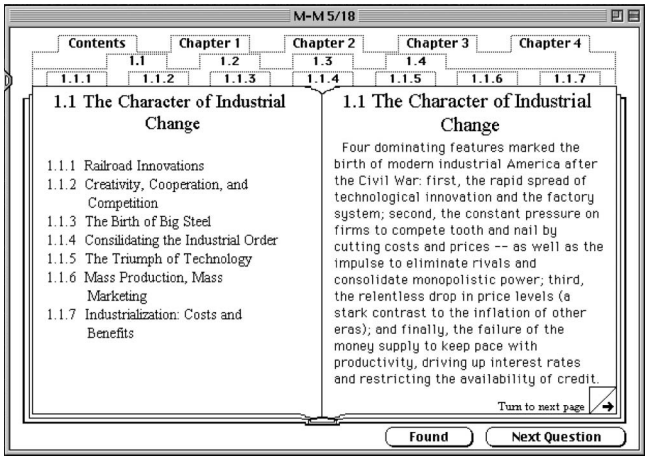

Figure 3. Screen shot of the third level for interface C (Hsu and Schwen 2003).

terms and the operations; the scope and information levels of the folder metaphor are more restricted. The main function of the folder metaphor is to provide a flexible means of information access so that users can randomly access articles in different levels.

The structural cues taken from the book and folder metaphors include a contents list, section titles and numbers, a double-page layout, book-turning corners, folder labels with section numbers, physical layouts of book and folder metaphors, and so on. Those elements consist of textual and graphical structural cues, which were combined to create the metaphorical interfaces.

Metaphors do not apply equally in the three interface designs, and usually only the most salient points are drawn from a metaphor. The book and folder metaphors are not alternate choices; instead, they complement each other (in a nonexhaustive way). This is consistent with Benking and Judge's (1994) view of using three or more complementary metaphors to explain complex systems. Due to the consideration of ease of manipulation in the experimental studies, only two metaphors were chosen for the design of the interfaces. At each step in creating the interfaces, not only more possibilities, but also more constraints were added to the design. The selection and combination of the structural cues were completed with much deliberation about the many design possibilities and trade-offs.

5. Conclusion

In this paper the authors proposed a design approach for creating composite-metaphor interfaces for two studies. The study results indicate that subjects do perceive these metaphorical interfaces differently, which can be reflected in their performance. As long as the metaphors are consistent with the computer users' mental models, the use of composite metaphors will facilitate users to develop a more comprehensive understanding of the system. As users' expertise increases, designers can introduce more detailed aspects of the original metaphor with different levels of sophistication (Carroll and Thomas 1982).

Although some scholars (Laurel 1993, Norman 1998) claim that metaphors will eventually impede the development of computer user's mental models, other scholars (Neale and Carroll 1997, Cates 2002) point out that it is impossible to design a system without any concept or element of a metaphor. 'Without metaphors it is not possible from a realistic standpoint to fully represent any system with an abstract model devoid of metaphors' (Neale and Carroll 1997: 448). As Marcus (2002) notes that metaphor won't disappear any time soon, the issue of mixing several metaphors in designing a system becomes more important, as evidenced in the design trends of new applications such as online games.

It is the hope of the authors that the method presented in this paper can provide designers or researchers with insights for creating metaphorical interfaces. There are many complex design issues involved in the creation of metaphorical interfaces. Further effort is needed to explore other possible methodology to design effective interfaces with composite metaphors.

References

Akoumianakis, D., Savidis, A. and Stephanidis, C., 2000, Encapsulating intelligent interactive behaviour in unified user interface artefacts. *Interacting with Computers*, **12,** pp. 383–403.

Alty, J.L., Knott, R.P., Anderson, B. and Smyth, M., 2000, A framework for engineering metaphor at the user interface. *Interacting with Computers*, **13,** pp. 301–322.

Benking, H. and Judge, A., 1994, Design considerations for spatial metaphors. Available online at: www.uia.org/uiadocs/spatialm.htm (accessed 15 August, 1998).

Booth, P.A., 1989, *An Introduction to Human–Computer Interaction*, pp. 65–101 (Hillsdale: Lawrence Erlbaum Associates).

Boyer, P.S., Clark, C.E., Kett, J.F., Salisbury, N. and Woloch, N., 1993, The enduring vision: A history of the American people (Lexington, MA: D.C. Heath and Company), CD-ROM.

Burstein, M.H., 1983, Concept formation by incremental analogical reasoning and debugging. *Proceedings of the International Machine Learning Workshop* (Monticello, IL: University of Illinois), pp. 19–25.

Carroll, J.M. and Thomas, J.C., 1982, Metaphor and the cognitive representation of computing systems. *IEEE Transactions on Systems, Man, and Cybernetics, SMC*, **12,** pp. 107–116.

Carroll, J.M. and Mack, R.L., 1999, Metaphor, computing systems, and active learning. *International Journal of Human–Computer Studies*, **51,** pp. 385–403.

Carroll, J.M., Mack, R.L. and Kellogg, W.A., 1988, Interface metaphors and user interface design. In *Handbook of Human-Computer Interaction*, M. Helander (Ed.), pp. 67–85 (North-Holland: Elsevier Science Publishers).

Cates, W.M., 1994, Designing hypermedia is hell: Metaphor's role in instructional design. In *Proceedings of Selected Research and Development Presentations at the 1994 Annual Convention of the Association for Educational Communications and Technology*, February 16–20, Nashville, TN, pp. 95–108.

Cates, W.M., 2002, Systematic selection and implementation of graphical user interface metaphors. *Computers & Education*, **38,** pp. 385–397.

Collins, A. and Gentner, D., 1983, Multiple models of evaporation processes. In *Proceedings of the Fifth Annual Conference of the Cognitive Science Society*, July 31–August 2, San Diego, CA, pp. 16–20.

Collins, A. and Gentner, D., 1987, How people construct mental models. In *Cultural Models in Language and Thought*, D. Holland and N. Quinn (Eds) pp. 243–268 (New York: Cambridge University Press).

Cooper, A., 1996, The myth of metaphor. Available online at: www.copper.com/articles/vbpj_myth_of_metaphor.html (accessed 20 September 1999).

Dee-Lucas, D., 1996, Effects of overview structure on study strategies and text representations for instructional hypertext. In *Hypertext and Cognition*, J.F. Rouet, J.J. Levonen, D. Andrew and R.J. Spiro (Eds), pp. 73–107 (Mahwah, NJ: Lawrence Erlbaum).

Dee-Lucas, D. and Larkin, J.H., 1995, Learning from electronic texts: effects of interactive overviews for information access. *Cognition & Instruction*, **13,** pp. 431–468.

Hsu, Y.C., 2005, The long-term effects of integral versus composite metaphors on experts' and novices' search behaviors. *Interacting with Computers*, **17,** pp. 367–394.

Hsu, Y.C. and Schwen, T., 2003, The effects of structural cues from multiple metaphors on computer users' information search performance. *International Journal of Human Computer Studies*, **58,** pp. 39–55.

Hudson, W., 2000, Why metaphor is a double-edged sword. *Interactions*, **7**, pp. 11–15.

Hulley, A.J., 1990, Navigation, browsing, and understanding in an anatomical 'hypermedia' environment. *Current Psychology: Research & Reviews*, **9,** pp. 162–180.

Lakoff, G. and Johnson, M., 1980, *Metaphors We Live By*, pp. 5–96 (Chicago: University of Chicago Press).

Laurel, B., 1993, *Computers as Theatre,* (Reading, MA: Addison-Wesley).

Lin, L.Y., 1989, Learning to use hypertext systems with metaphors: an interface design perspective. Unpublished doctoral dissertation (University of Illinois at Urbana-Champaign).

Marcus, A., 1994, Metaphor mayhem: Mismanaging expectation and surprise. *Interactions*, **1,** pp. 41–43.

Marcus, A., 2002, Metaphors and user interfaces in the 21st century. *Interactions*, **9,** pp. 7–10.

Moran, T.P., 1981, The command language grammar: a representation for the user interface of interactive computer systems. *International Journal of Man-Machine Studies*, **15,** pp. 3–50.

Neale, D.C. and Carroll, J.M., 1997, The role of metaphors in user interface design. In *Handbook of Human-Computer Interaction*, M. Helander, T.K. Landauer and P. Prabhu (Eds), pp. 441–462 (North-Holland: Elsevier Science Publishers).

Nilsson, R.M. and Mayer, R.E., 2002, The effects of graphic organizers giving cues to the structure of a hypertext document on users' navigation strategies and performance. *International Journal of Human Computer Studies*, **57,** pp. 1–26.

Norman, D., 1998, *The Invisible Computer*, pp. 135–162 (Cambridge: MIT Press).

Presmeg, N., 1997, Reasoning with metaphors and metonymies in mathematical learning. In *Mathematical reasoning: Analogies, metaphors and images*, L. English (Ed.), pp. 267–279 (Mahwah, NJ: Lawrence Erlbaum).

Rouet, J.F. and Levonen, J.J., 1996, Studying and learning with hypertext: empirical studies and their implication. In *Hypertext and Cognition*, J.F. Rouet *et al.* (Eds), pp. 9–23 (Mahwah, NJ: Lawrence Erlbaum).

Rumelhart, D.E. and Norman, D.A., 1981, Analogical processes in learning. In *Cognitive Skills and Their Acquisition*, J.R. Anderson (Ed.), pp. 335–361 (Hillsdale, NJ: Lawrence Erlbaum Associates).

Smilowitz, E.D., 1995, Metaphors in user interface design: an empirical investigation. Unpublished doctoral dissertation (New Mexico State University).

Spiro, R.J., Feltovich, P.J., Coulson, R.L. and Anderson, D., 1989, Multiple analogies for complex concepts: antidotes for analogy-induced misconception in advanced knowledge acquisition. In *Similarity and Analogical Reasoning*, S. Vosniadou and A. Ortony (Eds), pp. 498–531 (Cambridge, NY: Cambridge University Press).

Staggers, N. and Norcio, A.F., 1993, Mental models: concepts for human–computer interaction research. *International Journal of Man-Machine Studies*, **38,** pp. 587–605.

Stanney, K.M., Chen, J.L., Wedell, B. and Breaux, R., 2003, Identification of metaphors for virtual environment training systems. *Ergonomics*, **46,** pp. 197–219.