REFLECTIONS ON THE DESIGN OF INTERFACE METAPHORS

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ABSTRACT: This paper introduces a model of metaphor at the human-computer interface that is grounded in the psycho-linguistic literature. It demonstrates the utility of this model in a number of case studies of the design and evaluation of systems that use metaphor as a strategy in interface design. In doing so it draws on experiences of the design of such systems in order to propose practical set of steps that can be undertaken using this model as a 'Tool for Thinking' about metaphor.

THE PERVASIVENESS OF METAPHOR

The recent emphasis on the use of graphical user interfaces, with their reliance on analogies from the real world, has fuelled a similar interest in the use of metaphor as a strategy for system design (cf Hammond & Allinson 1987, Carroll et al 1988). Understanding a computer system of any complexity can be characterised as layers of different metaphors ranging from silicon gates and electrons, through those that deal with files and disk pointers, to those that are used by the user at the interface (Hutchins 1989). Thus, metaphors are pervasive throughout our understanding of computer systems.

Apart from classifications or taxonomies of metaphors (Hutchins 1989), and discourses as to the merits of each (Kay 1990), little work, with the exception of Carroll et al (1988), has offered interface designers with any tools for thinking about the generation, selection and refinement of appropriate metaphors in any given situation. This paper introduces a model and a set of practices that can be seen as 'Tools for Thinking' about metaphor, and which can be used by practitioners as a structured design framework.

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THE PSYCHOLINGUISTIC CONCEPTION OF METAPHOR

Recent authors have suggested that the psycholinguistic conception of metaphor (Richards 1936, Lakoff & Johnson 1980), can be usefully applied in the context of human-computer interaction (Anderson et al 1994). Under this conception, metaphor is seen as the active interaction between two entities: the topic, that is the entity to be explained; and the vehicle, the familiar entity used in a novel context in order to get across some important points about the topic (see Figure 1). In the human computer interface, the topic corresponds to the system functionality that needs to be understood by the user, and the vehicle is the real world concept or entity in whose terms it is explained.

In this paper, italicised type is used to refer to interface representation of real world vehicles that are used as part of a metaphor. Thus the paper will refer to the Macintosh™ *desk-top*, complete with its *folders, files* and *wastebasket*, each of which utilises elements of real world folders, files and wastebaskets.

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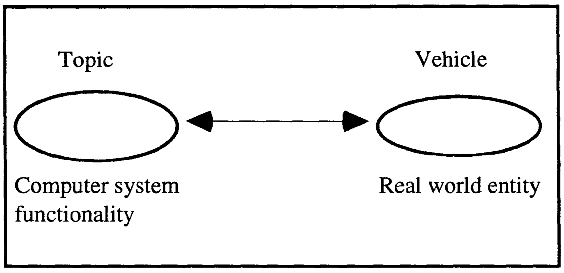

Figure 1. The psycho-linguistic conception of metaphor

A THINKING TOOL

The interaction between features of a system's functionality and features of its vehicle, will largely determine effectiveness of the resulting interface (Hammond & Allinson 1987). A set-based model of this interaction leads to the following definitions (Figure 2):

- S, the set of features of the system functionality
- V, the set of features of the vehicle.

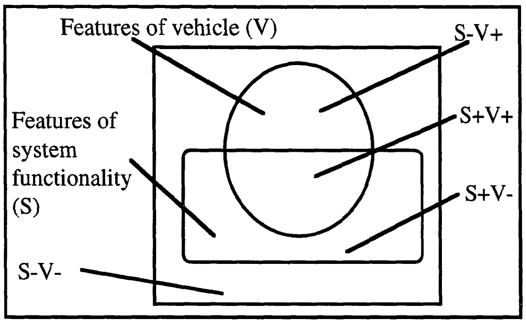

Figure 2. Metaphor at the Human Computer Interface

Further, Figure 2 suggests that four categories of features can be identified in the interaction between the two sets. These categories are described below;

- ***S+V+ features*** Features that lie in the intersection between the two sets. This category consists of those features of the vehicle which map completely on to the system.
- ***S+V- features*** System features that do not map onto features of the vehicle.
- ***S-V+ features*** Features of the vehicle that do not map onto the system. These features are characterised as the 'Conceptual Baggage' that the vehicle brings with it to the interface (Anderson et al 1994).
- ***S-V- features*** Features that are not part of the vehicle nor of the functionality of the system. This category includes features that could be expected to be provided by the system, but in fact are not.

REFLECTIONS ON DESIGN

The remainder of this paper describes the experiences gained during the design, implementation and evaluation of a series of prototype metaphor-based interfaces developed as part of the RACE funded MITS Project (Metaphors for Integrated Telecommunications Services: R2094). In this activity, the designers were able to 'reflect on action' (Schon 1983) about the processes involved, the techniques available for the development of such interfaces and the utility of the model described above.

The first prototype, DOORS compared the utility and appropriateness of three equivalent interface metaphors which supported identical system functionality. The metaphors of *Office doors*, *dogs* and *traffic lights* were compared in terms of their actual and perceived ability to convey accurately the availability state of an intended recipient of an audio-visual connection. The results of this study have been reported in a previous paper, (Anderson et al 1994). The second prototype, ROME (MITS, D6 1994), assessed the utility of a real time virtual conferencing system based on a *room* metaphor. The final prototype interfaces explored the relevance of spatial, activity-based and interactional metaphors in interface design (Condon & Keuneke 1994). Three interfaces were designed which corresponded to these classifications: MILAN, a room based metaphor (spatial class), Little People, an animistic metaphor (activity-based class) and Link Journal, a publishing metaphor (interactional class). The detailed results and underpinning rationale are reported by Condon & Keuneke (1994).

Clarification of System Functionality

During system development, designers may adopt a variety of metaphors to improve understanding and to clarify relationships between the application software and the underlying system. The choice of appropriate interface metaphors is a different goal. Thus, suitable metaphors for guiding the systems design process may not necessarily act as suitable metaphors for the interface.

Experience during the development of the prototype systems has shown that it is easy to lose sight of the system functionality and be seduced into designing the system as a mimic of that vehicle (MITS, D7 1994). The metaphor shifts from acting as a technique for thinking about a problem, to being seen as a solution to that problem. It is important, therefore, to keep the intended system functionality as the firm focus of design so that the design process should be 'metaphor informed' rather than 'metaphor led'. This stance clarifies the point that the power of metaphor is not in the mimicking of real world entities, but in the selective referencing of particular aspects of those entities in order to explain interface artifacts.

Thus, three key design issues should guide the process. Firstly, the underlying system functionality should be the sole arbiter of the choice of interface metaphors. Secondly, metaphors should be considered as tools for thought, not solutions in themselves. Finally, designers should not implement potential interface metaphors too early in the design process.

STEPS IN THE DESIGN PROCESS

Step 1: Definition of System Functionality. The first step in the design process is to define the functionality of the system itself using an existing system design methodology. While these methodologies differ in detail, they all produce a structured design model or plan that specifies the proposed system, including a complete specification of the proposed functional requirements of the system (the set S in Figure 2). It thus can be used to explore the mappings between the system and potential vehicles

Step 2: Generation and Description of Potential Vehicles. A number of techniques can be used at this step in the design process in order to generate a candidate set of vehicles that have the potential for use in the final interface:

Design metaphors: The metaphors used by system designers to communicate the proposed functionality of the system may be re-usable in the presentation of the system to the user. However, interface designers must bear in mind that their conception of a particular metaphor may be radically different from an end-user's conception of the same metaphor.

Extension: Metaphors used by currently available software that provides similar functionality, or indeed standard interface metaphors such as windows, buttons and menus, can all be extended to new systems. These techniques can ensure consistency between software running on the same platform, and allows skills learnt using one system to be transferred to another.

Brainstorming: Brainstorming can be of great use in the generation of vehicles for novel systems. Inevitably such methods draw on elements of the previous two techniques and so perhaps suffer from the problems outlined above.

Market feedback: Market feedback from customers can be a useful resource. When customers try to describe the functionality of a proposed system they often employ metaphors from their everyday lives.

Work-place studies: Systems should blend in to the current environment, empowering the user, and supporting everyday tools, skills and knowledge. Fieldwork is needed to identify and describe this world and ethnographic techniques are beginning to be recognised as useful in this process (Hughes et al 1994). Such fieldwork techniques are being used in the MITS project in order to generate possibilities for workplace tools.

Once a number of potential vehicles have been identified, techniques influenced by semiotics (Peirce 1932), linguistics (Lakoff & Johnson 1980), ethnography (Quinn 1982) and cognitive anthropology (Frake 1962) can be used to access the user's 'mental model' of the vehicle in question. In the DOORS system for example, an extensive use of frame elicitation techniques (Frake 1962) enabled the exploration of office personnel's conceptions of the office door as a means of displaying social cues for communication (Anderson 1994). Such frames took the form of sentences such as:

"As I walked towards ___________'s door, I saw that it was __________, so I _______________".

Note that such frames can be used to elicit the different door states that are expected, as well as accepted behaviour for a given door state. In addition, by manipulating the status of the person who owns the door (by fixing the first phrase to 'boss' for example), it is possible to analyse the effect of status on accepted behaviour. Finally, such frames allow the informants to supply answers expressed in their own language and which make sense to them. Thus potential vehicles are described from the point of view of the end users rather than system designers. This step of the process allows the designer to define set V of Figure 2 for a number of potential vehicle-system pairings.

Step 3: Analyse Vehicle-System Pairings The third step analyses particular vehicle-system pairings, enabling the designer to assess the effectiveness of mappings between the system and vehicle, and also the potential conceptual baggage involved in any one pairing.

Category	Feature
S+V+	Knocking on a door to attract the owner's attention.
S+V-	A user can't be seen by the owner when knocking on an open door.
S-V+	Doors in the same corridor can indicate a related group of individuals
S-V-	A phone number is not needed in order to make a connection

Table 1. Examples of Categorised Features of the Doors vehicle-system pairing

This analysis is carried out by allocating features of the sets S and V to each of the four categories illustrated in Figure 2. Table 1 provides an example of the results of this process in the case of the DOORS system. The results of this categorisation process can be visualised using the set intersection model described above and illustrated in Figure 2. In the case of the three candidate vehicles (*Office doors*, *dogs* and *traffic lights*) selected for prototyping during the development of DOORS for example (see Figure 3) it can be seen that the greatest mapping between system and vehicle is found for the *Office door* vehicle and progressively less for the other two vehicles. However the degree of expected conceptual baggage is higher for the *Office door* than for the other two, since the office door is rich in relevant features that are not utilised by the DOORS system.

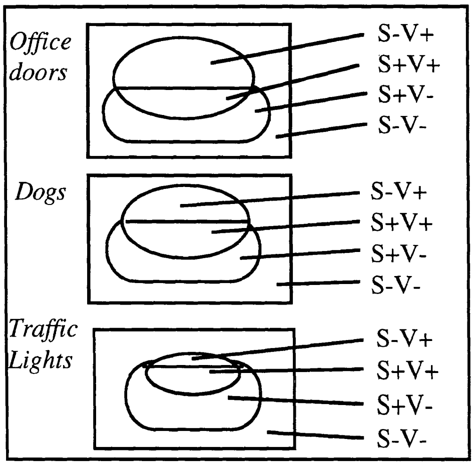

Figure 3. Visualisation of vehicle-system pairings

It might be expected therefore that whilst the *Office door* interface is more intuitive, it may suffer more from the effects of conceptual baggage (i.e. users make incorrect inferences about the system based on their knowledge of the vehicle) than the other two. As is reported elsewhere, (Anderson et al 1994) this indeed was found to be the case.

On completion of step 3, an interface practitioner will have completed an analysis of a number of potential vehicle-system pairings and will be in a position to actually evaluate these pairings using representative user groups following the implementation of prototypes.

Step 4: Implementation: Issues of Representation, Realism and Consistency Reflection on the implementation process and the consequent evaluation of the prototype interfaces in use revealed a number of issues.

Recognition: An interface metaphor must be able to portray the object that carries the information to the user, and the user must recognise this vehicle. For example, users of the Traffic Lights interface reported initial difficulty concerning the recognition of the vehicle. Only through exploration of the system did the users discover the rationale behind the choice of vehicle. Once understood, the users quickly took advantage of the system functionality. Interestingly, the act of exploration appeared to have a positive effect on the overall utility of this vehicle, a result which supports those reported in Carroll et al, (1988).

Realism: The problem of recognition could be overcome by generating realistic computer based representations of real world entities, thus facilitating recognition of the vehicle. In this situation, the user's existing model of the real world artefact would be directly applied to the computer based representation. While intuitively appealing, this approach does appear to have a number of shortcomings because any novel functionality offered by the technology is not directly apparent to the user, and because the real world model can inappropriately shape the user's expectations of the functionality associated with the system. For example, a subject reported difficulty in setting up a video link which adopted a realistic television metaphor in the MILAN interface, and subjects were confused about the degree of privacy associated with a *briefcase* in the ROME interface, (MITS, D7 1994). High fidelity representations, therefore, appear to compound the effect of conceptual baggage associated with the metaphor. Thus, decisions concerning the degree of representation of a vehicle that are based solely on system requirements and constraints, should be made in the understanding that they may have unforeseen implications on the user's expectation of system performance.

Maintenance of Consistency: Menu items should reflect the attributes normally associated with that metaphor, the choice of command language and terminology should reinforce the utility of a chosen metaphor, and designers must acknowledge user experience with particular interface styles. Thus metaphors should reflect the look and feel of generic interface objects, as discussed in step 2.

Step 5: Making Choices about Metaphor - Techniques for Evaluation Drawing upon Hammond & Allinson (1987), an evaluation technique has been devised which can be administered in the working environment and is sensitive to the nature of the metaphor's relationship with the system functionality. Using the vehicle-system relationship categorisation described earlier, a framework for the design of a questionnaire was developed. To enable a meaningful comparison, each candidate metaphor must support identical system functionality and subjects must undertake a standard task, (Anderson et al 1994).

The questionnaire contained three sections, the first and third requiring subjects to answer short open-ended questions concerning the interface metaphor. The second section consisted of 12 statements attributing features to the system, split into four conditions, each one corresponding to one of the categories illustrated in Figure 2. Subjects were instructed to indicate their agreement or disagreement with the statements, together with a rating of their confidence in their answer (0-100%) (examples for the DOORS system are provided in Table 1). In the case of the S-V- condition the statements presented to the subjects were consistent across all of the vehicle-system pairings. The inclusion of a confidence rating associated with each statement provided a distinction between the subject's perceived and actual understanding of the system functionality. Actual understanding was measured in terms of the number of correct answers to the questionnaire statements, whilst perceived understanding was reflected in the associated confidence level. Supportive evidence for the understanding of the metaphor was provided by the answers from the first and third sections of the questionnaire. Video recordings were also made of the interaction, together with the subject's verbal protocol.

The techniques outlined above enable a system designer to make an informed choice among a candidate set of interface metaphors in terms of usability and utility in conveying the system functionality.

Step 6: Feedback on Design.
The use of these techniques provided direct feedback into the re-design of the prototype interfaces.

The DOORS system demonstrated that the effect of conceptual baggage on system usability is as important as a sufficient mapping between vehicle and system, and provided an empirical basis for making quantitative comparisons between the candidate metaphors of Doors, Dogs and Traffic Lights, (Anderson et al 1994). It also highlighted some interface problems. Many users expected the system based on the office door to provide additional door-like functionality such as the ability to *lock a door* (preventing all communication access except messaging); the automatic *closing of a door* once a connection is made; the idea of grouping the *doors* of members of a group into *corridors*, and the need for information on the physical location of each office.

The ROME system enabled designers to examine the problems users appeared to have with the *briefcase* by targeting the category-based questions at this particular interface metaphor (MITS, D7, 1994). It was found that users' vehicle-related expectation of functionality was higher than was actually supported by the system, causing them to make incorrect inferences about the system.

In the final case the techniques provided designers with feedback on the utility of three different classes of interface metaphors. They also demonstrated that each class of interface metaphor can lead to users developing different and distinct mental models of the system, and provided empirical support for the conception of interfaces as 'layers of signification'. (Condon & Keuneke 1994).

DISCUSSION

This paper has presented a model of metaphor at the human computer interface that is based on both the psycho-linguistic and cognitive science perspectives. It could have a significant impact on the design of metaphor based interfaces, because it can characterise vehicle-system pairings prior to implementation, and can provide a framework from which to evaluate these pairings. The model has acted as a tool for thinking about the strategy of metaphor in user-centred system design, and has resulted in the development of a design process complete with practical tools that can be used by system designers. Current MITS activity is focusing on the further refinement and assessment of the approach.

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