Developing Multimedia Principles from Design Features

F. Nemetz
P. Johnson

Department of Computer Science
Queen Mary and Westfield College
University of London

Mile End Road, London, E1 4NS, UK
Tel: +44 (0)171 975 5224
Fax: +44 (0)181 980 6533
{fabio, pete}@dcs.qmw.ac.uk
URL: www.dcs.qmw.ac.uk

Abstract

The rapid growth of multimedia technology has made it possible to deliver high quality audio, graphics, video and animation to the user. However, this growth in technology has not been met by a growth in design knowledge. While it is possible to have multimedia it is not at all obvious that we know how to design high-quality multimedia systems that are fully usable to the degree we should expect. To improve the situation much work is under way to develop guidelines, style guides and principles for multimedia design. In this paper, we consider what areas might be in need for investigation in order to derive design principles. Examples of these areas are given and a research agenda for developing principles for multimedia systems is offered.

Keywords

Multimedia system design, principles for multimedia design, multimedia features

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1 INTRODUCTION

Multimedia is a technological achievement that currently lacks a theoretical basis for reasoning about its utility and effects on usability. Using the most advanced technology will not necessarily improve the usability of current designs. Relying upon naive assumptions, beliefs and intuitions alone will not be enough to bring about a widespread improvement in the quality and usability of interactive systems through the use of multimedia. Although multimedia technology can increase the options open to the user-interface designer (Alty, 1997), it has not yet been met by a growth in design criteria and knowledge.

A common view of multimedia is that it is simply the use of more than one medium to present information to users. We adopt a wider definition, encompassing both input and output media and focusing on human-computer interaction rather than on the technological aspects. In this way, we consider interactions with animations, gesture recognition, speech input, speech synthesis, haptic input and output, hypermedia and virtual reality as pertaining to multimedia. As Marmolin (1992) states:

'A user centred definition would characterise multimedia systems as systems enabling the usage of multiple sensory modalities and multiple channels of the same or different modality (for example both ears, both hands etc.), and as systems enabling one user to perform several tasks at the same time. That is, multimedia is viewed as a multisensory, multichannel, and multitasking approach to system design. In addition multimedia systems put the user in control, i.e. could be described as a user centred approach' (Marmolin, 1992).

Traditional approaches to design for usability from Human-Computer Interaction do not yet directly deal with the unique characteristics of multimedia systems: 'while general usability criteria such as learnability, flexibility and robustness apply equally to single media and multimedia systems, they have little to say regarding the specific benefits and drawbacks of concurrent media input and output' (Bearne et al., 1994).

The use of multiple media, when well exploited by designers, potentially makes multimedia interfaces more exciting, more natural, more enjoyable and pleasant to use than traditional mainly text-based interfaces (Petersen, 1996). This occurs because multimedia provides us with richer forms of representing information in human-computer interactions. However, it does not necessarily follow that merely by increasing the richness of the media we will increase the utility and usability of computers and the information. While in some cases the addition of more media will allow us to express concepts and information more fully, with greater clarity,

and with greater accuracy than before, in other cases it will introduce ambiguity, confusion and contradiction.

Our research aims to define a set of principles to address the complexities of multimedia design and evaluation, in order to make multimedia systems useful and usable, rather than 'gimmicky' and ephemeral. The principles that will emerge from this research are expected to support designers in making decisions about the various media so as to maximise the effectiveness and efficiency of the user-computer interactions. This will enable designers to build more usable multimedia systems, moving from a craft style design approach to a more systematic principled-based approach.

In the following section, we present some of the design issues we are focusing our research upon, and for which we hope to be developing the principles. We include some examples to illustrate them. Finally, we discuss the basic steps involved in the continuation of this research.

2 TOWARDS MULTIMEDIA PRINCIPLES

The term *principle* is being used in different ways in the literature. Shneiderman (1997) differentiates between three kinds of guidance for designers: *high-level theories and models*, which offer a framework or language to discuss issues that are application independent, *middle-level principles*, which are useful in creating and comparing design alternatives, and *specific and practical guidelines*, which provide reminders of rules uncovered by designers. For instance, one of his middle-level principles is 'Use the Eight Golden Rules of Interface Design' which includes eight design recommendations (e.g. enable frequent users to use shortcuts). This agrees with his statement that 'the separation between basic principles and more informal guidelines is not a sharp line'. Yet, Preece et al. (1994) consider principles to be a special case of guidelines. For them, there are two kinds of guidelines: *high-level guiding principles* and *low-level detailed rules*. They consider principles as guidelines that offer high-level advice that can be applied widely (e.g. know the user population). On the other hand, *principles* and *rules* are considered to be synonyms by Baecker et al. (1995): 'collections of statements that advise the designer on how to proceed (e.g. know the user)', while guidelines are defined as 'collections of tests that can be applied to an interface to determine if it is satisfactory (e.g. provide an average response time of less than one second)'.

We consider a principle to be some established fact that has a theoretical and empirical basis for its acceptance, that can be applied to a prescribed problem area in a well-defined manner and for which there is some indication of what the result of following the principle (or not) will be. At this stage in our research we are able

to point to areas where we believe we ought to be developing a more principled understanding of interacting with multimedia and what might be the features that an underlying set of principles for multimedia design have to address. The areas presented here resulted from a literature survey, the main source being Alty (1993).

They seem to help to understand and explain the complexities of multimedia systems, and are serving as the basis for us to pursue the search for the aforementioned principles. Some of the features are particular to multimedia, while others are more general to wider areas of HCI.

2.1 Naturalness and Realness

Multimedia systems try to take advantage of human senses to facilitate human-computer communication, and human-human communication. Considering that we live in a world of multimedia events (Rudnicky, 1992), 'many people believe that multimedia communication is natural and corresponds more closely with how the brain has developed' (Alty, 1997), and, therefore, multimedia exercises the whole mind (Marmolin, 1992). In this viewpoint, the human brain is seen as having evolved in a multisensory environment, where simultaneous input on different channels was essential for survival. Thus, 'the processing of the human brain has been fine-tuned to allow simultaneous sampling and comparison between different channels' (Alty, 1997). Multimedia systems have the potential to make more appropriate and efficient use of human perceptual and cognitive capabilities, by making the interaction more natural. In this sense, a better understanding of how our perception and cognition are affected by a particular medium and by their combination is needed.

A related feature to naturalness is realness, or the degree of correspondence to the real thing. Naturalness and realness are similar but not the same. Naturalness here is concerned with the mapping between the stimuli and the senses, taking recognition of the fact that people normally gain information about the world from multiple senses (e.g. hearing an explosion would cause people to look for a cloud of smoke). On the other hand, realness is concerned with how close the representation of the explosion corresponds to the actual explosion.

Two consequences for systems that possess these features appear to be that they show properties of believability (the closer to the reality, the more believable) and fidelity (degree of detail and faithfulness). Hence, in figure 1 the representation of the document has a high degree of realness (i.e. it closely corresponds to the appearance of the actual document) and naturalness (i.e. it is perceived through our visual object recognition system).

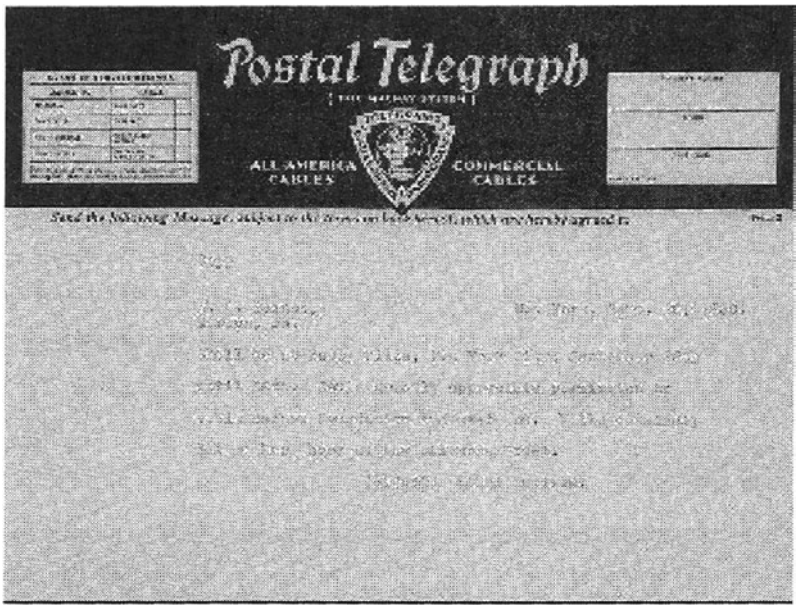

Figure 1: A smaller version of a document shown in (Corbis, 1995).

2.2 Media Allocation

How, and on what basis, is a particular medium selected for the presentation of a particular piece of information? Each medium has both constraining and enabling features (Arens et al., 1993), affords different interactions, offers different communicative intentions and has its own rules and conventions.

But is it enough to have a knowledge of each medium in order to make an adequate selection? Some argue that it also depends on the user's knowledge and experience of a domain and task: if the domain and task are new to the user, a concrete representation that allows exploration seems to be best; if the user has a lot of experience in the domain and task, more abstract representation may be adequate (adapted from Marmolin, 1992). Alty (1993) adds that the usefulness of different media in presentation situations is closely related to the complexity of the idea being conveyed. Nevertheless, he also states that the capabilities of the perceiver play an important role on the media allocation problem.

There is an important difference between abstract and concrete concepts. Abstract and complex concepts are more easily and completely represented by words than by pictures. In contrast, more concrete concepts, if represented by pictures and sounds, can improve the speed of understanding and comprehension over that of text representation. Moreover, the choice of medium also has to consider what information is intended to be conveyed and what is the intended effect of the information.

It is not easy to define a complete set of criteria to solve the media allocation problem. One aspect that should be investigated in detail is the relation between media and tasks. In other words, the main problem is to establish which media best transmit the information needed by the users to carry out their tasks.

Summarising, it seems that multiple factors play a role in the media allocation decision (Arens et al., 1993):

- Characteristics of the media
- Characteristics of the information
- Goals and characteristics of the user
- Goals of the producer.

Based on these factors, it is necessary to determine the enabling and constraining features of each medium, given the goals and characteristics of the user, the intended effect of the information and the characteristics of the information itself. Then, it will be possible to determine the media to be used.

In a CD-ROM produced for orthopaedists (Evolucao, 1996), there were several possible ways to show the manoeuvres employed to make a diagnosis about a given joint problem. In books, they are usually presented by pictures or by abstract sketches. In the particular CD-ROM, video (figure 2) with audio and text explanations were used to show the dynamics and clarify the important aspects of the particular manoeuvres in a way that the media could match to the nature of the information, the goals and skills of the users and the purpose of training.

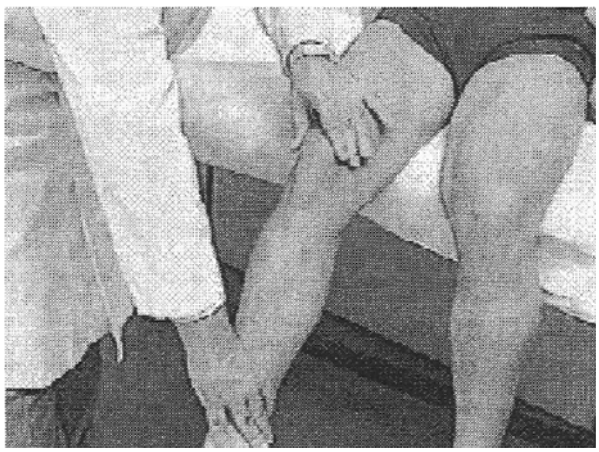

Figure 2: A video frame from the CD-ROM 'Semiology of the Knee' (Evolucao, 1996).

2.3 Redundancy

Often considered useful in complex and cognitively laden tasks, redundancy is considered a significant phenomenon in multimedia systems (Vetere, 1997). It is

well known that using both visual and audio channels simultaneously to explain a complex diagram can be better than using only one channel; it is also true that 'human beings use the redundancy offered by multiple channels to improve their understanding of situations' (Alty, 1991). Redundancy is related to naturalness, when we consider the multiple sensory input channels a person uses. However, redundancy relates to the information content of stimuli rather than their forms.

In multimedia systems, redundancy is achieved through the integration and synchronisation of different media. It can produce 'real-world' like conditions, and reduce the overload on working memory (e.g. video and audio, animated graphics and text overlay (or sound commentary)). Comprehension is directly affected by redundancy, since there is more chance of the information provided being understood. For instance, if there is confusion and misunderstanding as a result of a misperception of information in one medium, then this can be supplemented by providing the same material in another medium, at the same time (or proximal in time).

Understanding how to use redundancy effectively is still a challenge for multimedia systems designers. If combined in a congruent (harmonic, synchronised) way, the use of multiple media are far more effective than the using a single medium (Hoogeven, 1997). However, if combined in a non-congruent way, they are less effective (in this case, disruption, ambiguity and confusion occur). Multiple-resource theorists have argued (Anderson, 1995) that human beings have multiple resources and that how much two tasks interfere with each other depends on whether they make demands for the same resources. Paivio (1986) in his dual-coding theory states that we have two separate but interdependent information processing systems: a verbal system (specialised for dealing with linguistic information) and a visual system (specialised for processing non-verbal objects). In experiments with multimedia learning, Mayer (1997) showed that, if the verbal end visual modes are coordinated (e.g. words with pictures, animation with narration), it is possible to produce significant improvements in understanding and learning. It helps learners to select visual and verbal information and to build one-to-one connections between actions in the visual representation and in the verbal representation.

Vetere (1997) states that presently there is insufficient knowledge to help designers manipulate these redundancies to improve interactions. No methodology or criteria on how to apply redundancy in multimedia systems have been developed so far, let alone a theory of redundancy and its effects on usability.

To exemplify the use of redundancy, in figure 3 a document is presented in two ways: as a photographic reproduction and as a textual transcription. Even though the photograph can be zoomed in, the transcription is easier to read and to search

for. This is an example of redundancy, where two representations of the same information are presented in different formats.

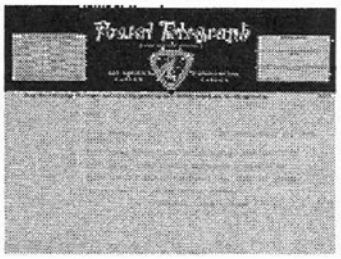

Figure 3: A document and its transcription (Corbis, 1995).

2.4 Significant Contribution of the Media

The opposite of redundancy is information richness. However, this can lead to information overload. Just adding a new medium will not guarantee an improvement in the user's ability to recognise and understand how to interact with a given system or the meaning of a particular piece of information; it can even exceed human attentional capabilities for handling multiple sources of information (Bearne et al., 1994, Barnard & May, 1995). Hence, additional media should be used only if they make a significant and relevant contribution in the transmission of a message. Otherwise, it can distract the user, making her loose attention to what is required.

It is important to observe that this kind of problem also occurs in everyday general communications. Our understanding of multimedia can greatly benefit from many communication theories. Grice's theory of implicature (Levinson, 1983), for instance, is concerned with the efficient and effective use of language in conversation. One of its maxims, the *maxim of quantity*, is related to the fact that, when making a contribution to a conversation, this contribution must carry all and only the necessary information, not more and not less than what is required. Another maxim, the *maxim of relevance*, states that one should make his/her contributions relevant.

In a hypermedia application - a literature multimedia encyclopaedia (Nemetz et al., 1996) - we can find an example of this feature. Figure 4 shows a passage of a book that illustrates a particular characteristic of an author. This passage is presented in text and, optionally, in audio. The audio is actually composed by two channels: the first contains the reading of the passage by a narrator, and the second contains an audio-effect that resembles the sound of wind. This effect provides an

atmosphere to the narration, associating its contents with the name of the book: *Time and Wind.* In this case, the audio-effect makes a fundamental contribution, because it is actually reinforcing this association, enhancing its semantics and making it more pleasant, but at the same time it does not seem to hinder comprehension.

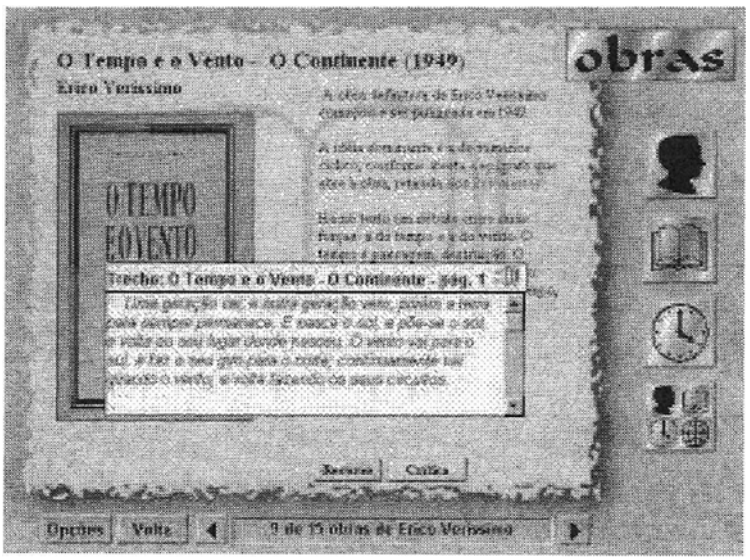

Figure 4: A passage from a book (Nemetz et al., 1996).

2.5 Exploration

One of the main advantages of multimedia systems seems to be the increased level of interactivity* they provide. This happens not only due to the use of our senses in a fuller and more orchestrated manner, but also because of a greater flexibility and freedom to explore the information. Ideally, neither the author nor the designer should decide how the information should be processed (Marmolin, 1992); the user should be in control, exploring the interface and choosing the best media for the task.

Exploration is a desirable property of general HCI in that it allows users to discover the workings, content and functional use of a system (Carroll, 1990). Multimedia can be used to facilitate greater exploration in all these areas, but the media have to be designed to support exploration. The ability to support the user in exploration itself has to be designed; it does not just happen.

* Level of interactivity, in this context, is the degree to which a computer system is responsive to the user's (explorative) behaviour (Hoogeveen, 1997)

A high level of interactivity improves sensory stimulation, and thus facilitates human information processing (Hoogeveen, 1997). Alty (1993) adds that, for ill-defined goals (or goals not well understood), it is better to allow users to exploit the interface and choose the best media for the task. And Bearne et al. (1994) suggest, in their usability guidelines for multimedia systems, that users must be given control over the appearance and the disappearance of each piece of information. The feeling of engagement produced by the freedom of exploration is an important issue to take into consideration when designing a multimedia system.

One possible explanation for this phenomenon is that we explore our environments in an active way; we are not passive receivers of information (Marmolin, 1992). Quoting Gibson (cited by Marmolin (1992)), 'we do not hear, we listen; we do not see, we look around'. This is consistent with the principle in active learning that users learn best when they are actively involved and creating. The system should explicitly afford exploration, inviting the user to explore it, providing appropriate feedback to each action, and offering an easy way to reverse any action, thus providing a safe environment for exploration.

An example of the exploration feature is the slide show facility (figure 5) provided in (Corbis, 1995). With this tool, the user can prepare customised guided tours of paintings based on his own criteria. Although there are several guided tours available, giving this possibility to the user, allows him to explore the system in a more active way according to his goals, rather than being just a passive viewer. The only problem is that, in this particular case, the user is not able to add annotations or audio to the presentations, which would give him a better way to actively explore the contents of the system.

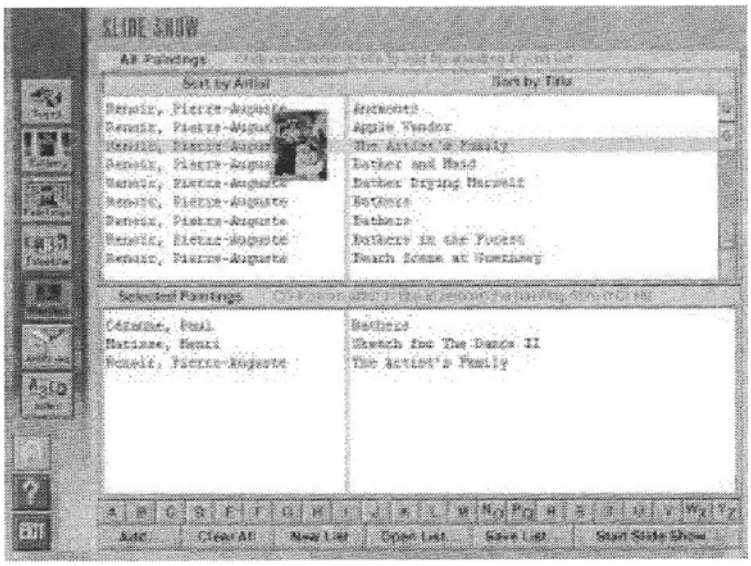

Figure 5: Building a slide show with paintings (Corbis, 1995).

2.6 Quality of Information Representation

It has been argued (Hoogeveen, 1997) that the quality of the representation of multimedia information (e.g. graphic representation x photographic representation) can affect the way people interact with multimedia systems. Each medium has its own rules and conventions and will make its own special demands and requirements upon technology to enable that medium to be used optimally. Although literacy is required in every medium, most software designers are not well skilled in film or video presentation languages (Alty, 1991). People are used to high-quality productions (such as in films or television) and could expect to see something of the same standard in a computer display.

With today's technology, current multimedia representations often have poor quality if compared with their analogue counterparts. For instance, a digital video in a small window cannot compete with the quality provided by an ordinary television. Even though for some kinds of applications this quality is enough (e.g. video-conferencing), for others it can be a restrictive factor (e.g. remote diagnosis by a dermatologist). Therefore, we still do not have a full realisation of the potential of multimedia, although the adequate quality depends ultimately on the task the user is performing.

4 DISCUSSION AND CONCLUSION

The features presented in this paper reflect many of the main aspects of multimedia systems. At the present stage, they can be considered as design problems that would require principles to guide their solution. It is important to note that, although some of the features can be general, i.e. not specifically addressed to

multimedia systems (e.g. redundancy, quality of information representation, exploration), they do represent pertinent aspects of multimedia systems design. It should also be noted that the desired principles may not be equally applicable to all classes of multimedia systems and domains.

The features presented here are a step above guidelines. The problem to be addressed is to formulate principles in such a way that:

- Each principle must embrace at least one feature, and the set of principles should embrace all the features.
- The principles have to be somehow generically applicable, but at the same time detailed enough to be tested.

In order to advance the research, first we need to refine these features into a set of principles, so that they can be expressed in a more complete and systematic manner, including examples, appropriate theoretical and empirical evidence, and to make predictions about their effects on usability.

The next step is to assess and refine the principles on different classes of multimedia systems, domains and tasks. In doing this, we will assess their (i) *predictiveness and reliability* through experimental testing, and (ii) *applicability and usability* through use in design context. In this way we will be assessing if they apply to multimedia design problems, if they can predict usability issues and be applied to those issues, and if the principles themselves are usable by designers and evaluators to develop and evaluate the usability of systems using multimedia.

In the end, we should be able to propose evaluation and design methods or techniques that are principle-based. A method of evaluation would include criteria, data, analysis and interpretation to produce redesign recommendations. In order to support design creation, an environment could be developed, which would include exemplars, guidelines and constraints derived from the principles.

In this paper, we showed that we need a principle-based approach for the design and evaluation of multimedia systems. We proposed a tentative set of six features that were elaborated with evidences from the literature. The features are:

- naturalness and realness
- media allocation
- redundancy
- significant contribution of the media
- exploration
- quality of information representation.

This is an on-going research topic. In order to achieve our goals, these features need to be further refined, tested and used in real-world situations before they can emerge as principles for multimedia design.

Our research aims to develop basic principles for the design and evaluation of multimedia systems. We believe that these principles will provide a consistent basis for user-interface designers to make better decisions and, hence, to build more usable and useful multimedia systems.

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7 BIOGRAPHY

Fabio Nemetz holds BSc and MSc in Computer Science. Currently, he is a PhD student of Computer Science at Queen Mary and Westfield College, University of London, funded by CAPES/Brazil. His interests are HCI and design and evaluation of multimedia systems.

Peter Johnson is Professor of Human Computer Interaction at QMW and Head of the Department of Computer Science. He holds BSc and PhD in Psychology. His past research has developed the theory and methods of Task Knowledge Structures and of user interface design in ADEPT. His present research is concerned with developing principles of Human Computer Interaction to support design and evaluation. He teaches undergraduate and masters courses in graphical user interface design, user interaction modelling and interactive system design.