Empirical research on the Effect of Dynamic Media for Information Presentation

Guttormsen Schär, S., Krueger, H.

Institute of Hygiene and Applied Physiology, Swiss Federal Institute of Technology, Zürich

Abstract

Key words
Dynamic information presentation, information types, empirical research

This paper addresses particularly the employment of *dynamic* media and the fit between media and information. Media selection should follow a thorough analysis of the information. Different media, single or in combinations, do not in general support information acquisition. We define dynamic presentation media by video, animation, simulation, or voice. Based on a literature review of the relative few empirical studies addressing this issue, we designed two experiments for the investigation of how to represent dynamic information.

2 Theory

1. Which psychological paradigms apply to dynamic media?
2. Which educational conditions apply to dynamic media?
3. How effective are dynamic media in comparison to other media?

The first question addresses research and development with dynamic media, employing a preferred psychological paradigm or cognitive models. The second question applies to research and development based on pedagogical conditions. The first two questions offer a frame for the third question, which refers to results from research incorporating these questions.

Some general guidelines for the instructional role and conditions for dynamic media are offered by Park & Hopkins [2].

2.1 Psychological paradigms for dynamic media

Currently objectivistic and constructivistic learning *philosophies* contrast each other as the extremes of a continuum: The objectivistic philosophy is based on that people acquire information by being told and that knowledge is objective and existing independent of the person. The constructivistic philosophy builds on that people learn by doing, i.e. by constructing the knowledge by „situating" cognitive experiences in authentic activities. Media designers have different preferences when it comes to learning philosophy, which will influence the basic structure of the design. The trend today goes towards a constructivistic philosophy [5]. This approach advocates designs incorporating dynamic media that enables user initiated interaction and individually structured information flow. In contrast, the objectivistic philosophy advocates structured presentation for information content regarded as unquestionable truths.

Also two other distinct *paradigms* of learning theory has guided research on the role of dynamic media; A behaviouristic paradigm which places primary emphasis on principles of associative and perceptual learning, and on the other hand a cognitive paradigm addressing mental structures and processes for explaining the effect of verbal and visual representations. The behaviouristic paradigm assumes that learning requires only association by contiguity and that most associations are mediated by perceptual and/or verbal responses. The behavioristic paradigm does not appear to have been extended beyond the 1970's when it was exchanged with the cognitive paradigm. The cognitive paradigm explain learning by mental concept as perception, memory, information processing. Paivio's dual coding theory represents this tradition. Paivio argues that human cognition is specialised for dealing with language and with non-verbal objects and events.

We suggest that multimedia designers should achieve a basic of knowledge of learning philosophies and paradigms, and also be aware of that design suggestions emerging from a certain learning philosophy or paradigm are not absolute but to a great extent also dependent various educational conditions. The next section addresses the impact of information content in more detail.

2.2 Educational conditions for dynamic media

> *"...only when the 'amodal' specification of content has been produced should media selection and design proceed, followed by means taken to directing the users attention to extract required information from a given presentation and focus on the correct level of detail".* (Sutcliffe, 1999).

We need descriptions of information which are objective, i.e. independent of situation and content. Such information types must also be reliable, enabling different people to be able to identify the same information class given a certain information unit. Ideally, a systematic classification system for different information contents should be developed and combined with empirically supported suggestions for media allocation. This need is currently recognised among researchers in this field, but relevant results are only slowly emerging. Some standard task analysis methods are available which can support the media-information allocation (e.g. Johnson, 1992 in [6]). Below, we give some suggestions for relevant information types in this context.

The Component Display Theory (CDT) uses only four categories in describing information [7]. A description of the categories is given in Table 1. A more differentiated classification of information applies a hierarchical model [8], as shown in Table 2.

Table 1: Merrill's information types

Facts	The definition of a special object, an event or a symbol.
Concepts	Groups of objects, events or symbols, which within the group have the equal function or belong to the same category.
Principles	Refer to cause / effect relationships or correlation between two or more concepts, synonymous to a rule. A principle explains the co-function of several concepts.
Processes	Sequential actions by which a goal can be reached. A sequence of actions can result in branching of new possible actions.

Table 2: Sutcliffe's information types

Physical	Static	States
		Descriptions
		Relationship
		Spatial
	Dynamic	Discrete acti
		Cont. action
		Events
		Procedure
		Causal
Conceptual	Static	States
		Descriptions
		Relationship
		Values
	Dynamic	Discrete acti
		Cont. action
		Procedure
		Causal

We have investigated the impact of two-dimensional classifications of information in earlier studies: i.e. well- and ill-defined [9], complexity (high and low) [10], and saliency (high and low) [11]. Although these concepts apply to almost all kinds of information, we believe that multimedia research should use multi-dimensional rather than two-dimensional information characterisations. In the research with two-dimensional concepts we found two problems for the derivation of guidelines. First, two-dimensional concepts describe extremes of a continuum, leaving too much room for speculation about exactly where given information can be positioned. Influencing factors can be content specific, based on individual experience, context etc. Second, it is difficult to explain all kinds of information in an intelligible way with the two-dimensional concepts mentioned above; "Ill-and well-defined" and "saliency" are defined by rules that are not intuitive, and "complexity" is not applicable as a general description because it must be operational defined from case to case.

The complex interaction between media and information content is well conveyed in the following statement:

> "*Animations cannot necessarily compensate for knowledge deficiency if the learning content or the animation itself is too complex. If a concept is too simple, any single medium can convey it*

successfully. If a concept is too difficult, the presentation will fail whatever media is used." (ChanLin 1999, p 2)

The above statement also has a clear message about the influence of the design of the presentation. It is essential that information presentations must reflect the learning goal in an appropriate way. This issue is however seldom addressed in research directly, hence, few empirical studies can be consulted. One problem with complex but appealing animations is that they may result in information overflow for users, particularly those who have little experienced with the presented topic.

2.3 Research on the effect of dynamic media

The efficiency of dynamic media depends on a number of factors of which the fit to the information content, the individual characteristics of the learner, and design aspects are particularly relevant. Based on an in depth studies of 25 experiments, Park & Hopkins comes to the conclusion that dynamic media are best applied when fit to the domain knowledge [2]. They found that 14 of 25 examined experiments showed a positive effect of dynamic media, while in 11 of the studies no clear effect was found. None of the studies revealed a clear disadvantage of the dynamic media. A significant factor for the disparate findings lies in the researcher's conceptual approaches to learning and strategic applications of the unique findings for the dynamic media tested. It is interesting to notice that the majority of research before 1970 found that dynamic media are more effective than static media, and that many experiments over the last two decades and up to today do not find such an effect [2]. It is plausible to expect that this effect is due to a change of theoretical paradigm guiding the studies. This reminds us that media selection, experimental design, and the resulting findings will be influenced by the prevalent educational paradigm. The studies we have reviewed are not clear in showing a positive effect of dynamic media. The findings can be differentiated interpreted by looking at the effects of learning tasks, individual experience and presentation design.

Relevance of information type

Many studies find a positive effect of combinations between complex, dynamic and spatially information and dynamic media [12], [13]. A meta study of 25 experiments investigating the effect of dynamic media concluded that animations are effective to illustrate complex structural, functional, and procedural relationships among objects and events [14]. In Large (1994) a benefit was found for animation representation of a procedural texts compared with descriptive texts. That study was, however, methodological weak in that there was a better link between the text and the animation for the procedural content as for the descriptive text. A follow up study was therefore performed in which the same procedural and descriptive texts were used, but with a better link to the animation for the descriptive text (n= 122 students) [13]. The media examined were text, text + picture, text + picture + animation, and text + picture + animation + captions (i.e. cueing the attention by closing showing links between the text and the animation). The learning effect was tested by written recall, multiple choice questions and problem solving. This study supported the results from the former in that the animated versions are superior to the other media in supporting procedural problem solving performance.

Another study compared the effect of text, animation and animation + text for the learning of Newton's law of motion (n=111 students) [15]. Their assumption for the study was that animations are most suited to represent spatially oriented information. They did, however, not find any effect of media at all. The animation they presented was very simple in nature, which should enable the students to focus on the essential information. The learning effect was measured by rule using and problem solving ability. Rieber explains this by the fact that the presentations with animations resulted in less time spent on studying the tasks. In a new experiment where animations were made less complex and divided in sections with direct reference to the theme instructions, the presentations with animations in comparison to presentations with pictures resulted in significant better performance [16].

Recent empirical research is however not consistent in finding a positive effect of dynamic media. In a series of experiments the effects of static and dynamic presentation forms were examined [17]. In one of the experiments the effect of text, voice, graphics and animation was examined in relation to the complexity of the learning task (i.e. number of elements to learn). The results revealed that presentations with still graphics resulted in best performance when the complexity was low. The learning performance was poorest in the high complexity condition for text, voice and animation. ChanLin applied a distinction between descriptive and procedural contents and the subjects prior knowledge [18]. The study derived descriptive or procedural learning content from basic genetic concepts and the technique of synthesising human growth hormone. Descriptive learning content was defined as describing an object, a definition or a rule; the procedural content referred to a series of executable actions, or concepts that contained to-be-remembered steps presented in a specific time sequence. The material was presented as either text, still graphics + text or animations + text. This study revealed an interaction between learning content and individual experience for the effect of the presentations. For descriptive learning content people with high prior knowledge learned more with animations than with text, this was not significant for the low prior knowledge group. Also for procedural knowledge the high prior knowledge group performed best, anyway animations did not have any superior effect, rather picture + text was better than the text condition. Hence, animated presentations may not guarantee successful learning for all groups of students.

Relevance of learner characteristics

Some authors find that the effect of dynamic presentations depends on the learners spatial ability [19], [20]. They suggest that students with low spatial ability benefit more from dynamic presentations than students with high spatial ability. The importance of spatial aptitude is also claimed by Blake [21]. He found that the effect of media (full motion, simple animation with arrows, still-pictures) depended on the spatial aptitude. The results shows, however, that the spatial ability only were relevant for still presentation, i.e. high spatial aptitude subjects scored better. For full motion presentations there were no difference between the subjects in their learning ability. A newer study did not find support for this, mainly finding no effect of spatial ability at all [22]. Further analysis of ChanLins' results rather suggest the opposite, i.e. that students with low spatial abilities benefit more from static representations with pictures. The study investigated the effect of animation, graphics and text in relationship with spatial ability for descriptive and procedural learning effects. In this study 357 students were asked to solve physics problems. The study did not reveal any unique effects of the animated presentation form. For procedural knowledge animated and graphical presentations resulted in equal learning performance. There were no effect of presentation form for descriptive knowledge.

Relevance of design characteristics

Research indicates that the effect of dynamic media or motion is related to the amount of information being presented [21]. Blake holds that the degree of detail included in the visual dynamic presentation determines whether the observer can focus on the relevant parts of the information.

> "*Irrelevant cues could interfere with learning if the additional time needed to scan before fixating on the relevant cues resulted in insufficient exposure time to the critical cues or the increased complexity prevented the identification of the critical ones*" [21], p. 976.

Experiment 1: n = 27, mixed design		**Experiment 2: n = 36, between group**	
Media: Picture + Voice Picture + Text Animation Animation + Voice Animation + Flow contr.	*Dependent measures:* Subjective preference Visual knowledge Active knowledge Inductive knowledge	*Media*: Picture + Text Picture + Voice Animation + Voice	*Dependent measu* Process Passive / Active Visual / Verbal
Results			
• Results independent of task • Animation + voice mostly preferred • AV = PV for inductive knowledge • Presentation no effect for visual and active knowledge		• Main effect of media: (AV = PV) > PT • Process knowledge: no effect of media • Structure knowledge: (AV = PV) > PT • Visual, Active knowledge: (AV = PV) > • Verbal, Active knowledge: No effect of	

3.1 Discussion and conclusion

Conclusive for these studies is that complex dynamic presentation of dynamic content do not necessarily have a superior effect on knowledge acquisition, but notably also not detrimental effects. Combined presentations are better than single presentations, but care should be taken regarding the selected combination. Presentations combining text and pictures have a negative effect on knowledge acquisition compared to animation or pictures combined with voice. Media designers should consider the available resource when designing presentations. A good picture is better than a bad animation. Hence, unless required resources for visual dynamic design is available, and unless high quality dynamic presentations are preferred in order to impress, the combination using picture and voice should be preferred. With the words of Freeman...,

> "*The effectiveness of motion...has undoubtedly been over estimated in comparison with slides, stereographs, still pictures, and demonstration. They are not as effective as many people claim them to be...However, motion pictures have an distinctive part to play"*.. Freeman (1924), in [2]

we notice that the enthusiastic but not always appropriate attitude towards new media is a persistent disposition.

References

1. Guttormsen Schär, S. and H. Krueger, *Using New Learning Technologies with Multimedia.* IEEE MultiMedia Magazine, 2000. **July-September 2000**.

2. Park, O.-C. and R. Hopkins, *Instructional conditions for using visual displays: a review*. Instructionsl Science, 1993. **21**: p. 427-449.
3. Langley, P. and H.A. Simon, *The central role of learning in cognitio*n, in *Cognitive skills and their acquisition*, J.R. Anderson, Editor. 1981, Lawrence Erlbaum Associates: Hillsdale, NJ.
4. Döring, K.W., *Lehren in der Weiterausbildung. Ein Dozentenleitfade*n. 1995, Weinheim: Deutscher Studien Verlag.
5. Herrington, J. and P. Standen. *Moving from an Instructivist to a Constructivist, Multimedia Learning Environment. in Ed-Media'99*. 1999. Seattle, USA: Association for the Advancement of Computing in Education (AACE).
6. Sutcliffe, A.G., *Task related information analysis*. International Journal of Human Computer Studies, 1997. **47**: p. 223-255.
7. Merrill, M.D., *Component Display Theor*y, in *Instructional-design theoried and models. An overview of their current status*, C.M. Reigeluth, Editor. 1983, Lawrence Erlbaum: Hillsdale. p. 61-95.
8. Sutcliffe, A. *Designing Multimedia Presentation*s. 1999. Munich, Germany.
9. Guttormsen, S., *The influence of the user-inteface on solving well- and ill-defined problems*. International Journal of Human-Computer Studies, 1996. **44**: p. 1-18.
10. Guttormsen Schär, S., *The 'History' as a cognitive tool for navigation in a hypertext syste*m, in *Design of Computer Systems: Social and Ergonomic Consideration*s, M.J. Smith, G. Salvendy, and R.J. Koubek, Editors. 1997, Elsevier: California, USA. p. 743-746.
11. Guttormsen Schär, S., *Implicit and Explicit learning of Computerised tasks. The role of the computer user-interface and task saliency.. 1998, University of Zürich: Zürich.*
12. Large, J.A., et al., *Multimedia and Comprehension: A cognitive study*. Journal of the American Society for Information Science, 1994. **45**: p. 515-528.
13. Large, A., et al., *Effects of Animation in Enhancing Descriptive and Procedural Texts in multimedia Learning Environment*. Journal of the American Society for Information Science, 1996. **47**(6): p. 437-448.
14. Park, O. and S.S. Gittelman, *Selective use of animation and feedback in computer-based instruction*. Educational Technology Research and Development, 1992. **40**(4): p. 27 - 38.
15. Rieber, L.P. and M.J. Hannafin, *Effects of Textual and Animated Orienting Activities and Practice on Learning from Computer-Based instruction*. Computers in Schools, 1988. **5**(1/2): p. 77-89.
16. Rieber, L.P., *Animation in computer-based instruction*. Educational technology Research and Development, 1990. **38**: p. 77-86.
17. Buck, S., *Entwicklung von Grundlagen für kognitionspsychologiisch orientierte Richtlinien zur Gestaltung von Multimedia-Produkten*. 1993, Universit-t GH Paderborn: Paderborn. p. 232.
18. ChanLin, L., *Visual Treatment for Different Prior Knowledge*. International Journal of Instructional Media, 1999. **26**(2): p. 213-219.
19. Hays, T.A., *Spatial abilities and the effects of computer animation on short-term and long-term memory in learning from multimedia systems*. Journal of Educational Computing Research, 1996. **14**(2): p. 139-155.
20. Hegarthy, M. and V.K. Sims, *Individual differences in mental animation during mechanical reasoning*. Memory and Cognition, 1994. **22***:* p. 411-430.
21. Blake, T., *Motion in Instructional Media: Some Subject-Display Mode interactions*. Perceptual and Motor Skills, 1977. **44**: p. 975-985.
22. ChanLin, L.-J. *Considerations of Spatial Ability in Learning from Animatio*n. in *Ed-Medi*a. 2001. Tampere, Finnland: AACE.
23. Guttormsen Schär, S., et al., *Presentation of process oriented learning content with multimedia: A comparison of dynamic and static media types*. (in preparation).

Author(s)

Guttormsen Schär, Sissel, Dr.
Institute of Hygiene and Applied Physiology,

Swiss Federal Institute of Technology
Clausiusstrasse 25,
CH-8092 Zürich
guttormsen@iha.bepr.ethz.ch

Krueger, Helmut, Prof. Dr, Dr.
Institute of Hygiene and Applied Physiology,
Swiss Federal Institute of Technology
Clausiusstrasse 25,
CH-8092 Zürich
krueger@iha.bepr.ethz.ch