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Theoretical Aspects of Multimedia

Ewald M Jarz*

Abstract

This article considers multimedia from three view points. The first comes from a science theory where the definition of the term and of the environment associated with it is defined. The second point of view is concerned with the knowledge acquisition through multimedia systems and the educational and psychological aspects are considered. The third point of view gives concrete instructions for designing multimedia systems.

1. INTRODUCTION

The strong technical orientation of the multimedia evolution shows a lack of theoretical foundation. Both during the evolution and application of multimedia technology, well-founded theoretical concepts are missing[31]. Approaches for a new, yet unreflected multimedia paradigm can already be recognized in literature.

On one hand, the chance for a higher quality of information representation is seen,[22] on the other hand scenarios with dramatic social effects of the multimedia technique are made[7, 59]. The intention of this contribution is to consider multimedia from three perspectives.

The first point of view comes from a science theory. The definition of the term and of the environment associated with it is marked out. A classification of multimedia information and interaction types is given also as an overview of the problem fields of multimedia. The second perspective moves the human being as users of multimedia systems into the foreground. In this case my assumption is that information is transported by multimedia systems. The term information is nonetheless ambiguous. It stands for the process of information and it also stands for information itself as an entity. The term information system is normally used in the first sense. However, the function of information always requires a human being as interpreter of information. From this viewpoint, information is, in the final analysis, knowledge which is stored in some form in the human brain. Therefore the second point of view is concerned with the knowledge acquisition through multimedia systems. The third point of view frees itself of theoretical considerations and gives concrete instructions for designing multimedia systems.

2. WHAT IS MULTIMEDIA?

2.1 Multimedia in a broader sense

The term multimedia is defined differently by many authors[28]. Extensive consensus is that the processing of the medias must occur completely in a integrated manner on a digital electronic basis and independent from each other.

Medium in the material sense designates an 'agent' between two or more communication partners[20]. The sender of a message must use a medium in order to send the message. A medium is first an information carrier. A sender produces a message by acting on a specific medium. For example sound is a medium which is formed by a speaker to be received by a listener. Further medias are for instance light, liquids, surfaces, solid matter bodies and so on.

Within the medias, one can distinguish between concrete medias and abstract medias[46].

Concrete medias are carrier medias. For instance light could be a carrier media. Abstract medias use these carrier medias for communication like a reflecting surface. Abstract medias shape concrete medias in a way that these concrete ones contain information.

Abstract medias (e.g. graphics) can in turn be a foundation for even more abstract medias (e.g. writing), therefore also becoming a concrete medium and so on. These connections result in a hierarchy of using medias. After the structuring of different medias with a sender, receiver and medium, it becomes clear that there can be as many medias as desired, depending on the level of detail and the intended purpose.

The question, when one can speak of different medias as 'multi' media, leads to infinitely many solutions after this division. As an alternative, the distinction of the medias after the human sense organs can be used.

If 'medium' is an information carrier for communication—however information can only be activated by a subject (the human being, unlike the opinion in the information concept of Shannon)—only the perception medias are suitable as a valid multimedia definitions, since the human being is implied only in them.

A division of the medias by the human sense organs appears quite useful since the human being occupies a central position here. The stimulus arriving from the environment can only be received through the sense organs and processed for information about the modifications of the environment. Figure 1 represents the communication form between human and machine.

But this point of view is incomplete. The information, which the machine supplies to the human being, comes initially from a human being too. Consequently, Figure 1 is actually only one part of a human-machine-human-communication.

If the Information supplied by the computer is produced from itself and not from another human as a sender then it is actually a nature-machine-human-communication, because the computer processes data of the reality for the human in this way that it represents information for him (e.g. measurements, balance sheet analysis, statistical evaluations and so forth). Figure 1 is incomplete here too.

If the transmitting and receiving human is the very same person (as for example, during text processing) one can not speak of a pure

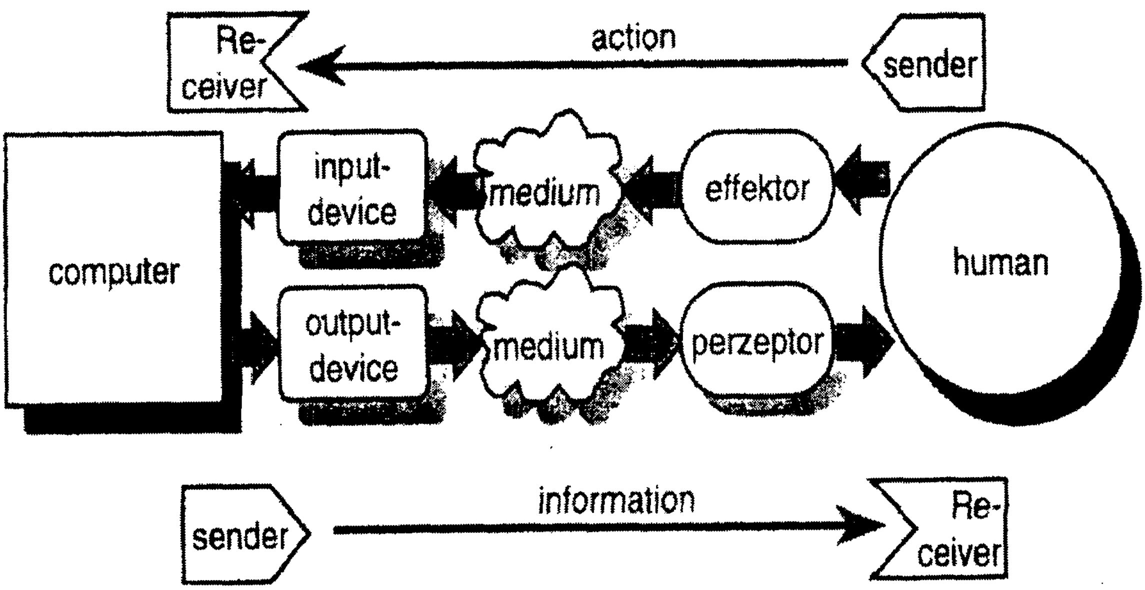

Figure 1. Human-machine-communication

human-machine-communication since this constellation is nothing other than a human-machine-human-communication, where the sender and receiver is the same person.

However, the human-machine communication form can be used for theoretical considerations. The most important feature is the action that initiates the machine to produce information. This action is either a command, that can also consist of a series of commands, or a temporal event. Due to this command, other command chains (programs) can be read back, which makes the machine send information. It is decisive that the action or the command has nothing to do with the information itself. The command only causes the representation of information. This reciprocal action is described as interaction. For example, the interaction that occurs with the computer (keyboard, mouse, data glove, body location and so on), can be called an interaction type. The representation of information (such as text, image, movie, speech, and movement in the flight simulator and so forth) can be called an information type.

Multimedia in a broader sense is therefore the completely digital, integrated and independent processing of different information types, which can be controlled interactively by the user through one or several interaction types. This definition still approves a large bandwidth of application areas.

2.2 Multimedia in a Narrower Sense

The support of perception medias by input and output devices has been improved by developments the field of virtual reality (especially the development of datagloves with tactile feedback and so on in the medicine and flight simulators for pilot training). But mainly low-cost and market-maturity systems are available for the visual and auditory perception. The restriction of multimedia in these two fields is therefore a bimedia. However 'multi' is the way of the codification of information. Text, graphics, image, movie and animation are all different codification's within the same perception media: the visual perception; only the representation of information is different. Therefore multimedia can be seen as a combination of different information representations—the information types. Multimedia in a narrower sense refers only to audiovisual information types and the standard communication equipment like keyboard, mouse and its derivatives.

2.2.1 Audiovisual Information Types

If the term information type, takes the way of transmission between sender and receiver into consideration, then the essential distinction between continuous and discreet information can be made. Continuous information is time-critical or dependent from information sections following on each other; the message is only valid and correct when time factor is included[58]. Discreet information is non-time-critical. The user can determine moment and duration of consideration. Auditory information representations are time-critical (continuous), image information is non-time-critical (discreet). But if several images follow each other (moving image), this result is time-critical again. Consequently, moving image is a separate information type.

In addition to human language, there is even further (time-critical) auditory information, for example, noise (engine noise, bird chirp and so on) or music.

The corresponding information type could be designated subsequently as a general term for language, noises and music either comprehensively as audio or there is a separate information type for human language and a further for noises and music. Since language is very important for the human being and a lot of study on the field of language input and output has been done (in particular in the field of artificial intelligence), it seems useful to see the human language as a separate type of information. Accordingly, noise and music must be taken as a further information type at least together. The word 'sound' can serve as a general term for it (The border between noice and music is not very sharp anyway, espacially with respect to different subjective, aesthatical sensation). In the case of the discreet visual information types, the alphanumeric text seems to occupy a special position since it is the visual expression of the most essential communication form between people: the language. Therefore, alphanumeric text can be seen as its own information type. If text is the discreet counterpart for language, the score can be understood as a discreet counterpart to music and/or noise (sound) and therefore a separate information type. In this case, the note values of a score are comparable with the alphabetic characters of a text. The representation form score does not appear suitable to represent the information noise (or better: all other auditory information except the human language and music) at the first sight. The existing possibility of MIDI—and synthesizer technique allows the codification of several noises as note values. Like text compared to language causes a loss in the value of information (keyword rhetoric/accentuation), the loss of information of the score compared to music and noise can be seen.

Any other discreet, visual information representation can be described as an image where one distinguishes often between graphics processing (and/or graphic data processing) and image processing[19]. This distinction refers to the different processing technology: Vector orientation in the case of graphics and point orientation at images. Despite of the already strong mixing of both processing techniques at corresponding graphic programs 'image' is described as an arranged amount of picture elements (pixels) and "graphics" as drawned, schematic chart representation of information even if with vector oriented graphic photorealistic images can be made already. The retention of the division image/graphics is reasonable if a photorealistic representation is meant by image and a schematic representation is meant by graphics even if the image was made vector oriented and the graphic point oriented. Under this aspect, a visual, discreet information is represented either as information type image in a (photo) realistic way or as information type graphics in a schematic way. The continuous counterpart for the discreet information type image is the moving image. Photorealistic moving images are in general described as movies. The term for schematic moving images is trick movie or animation. Therefore, in continuous, information, representations can be distinguished between the (photo)realistic information type movie and the schematic information type animation even if the movie is made vector oriented and the animation point oriented.

The second essential distinction in the way of information representation is—in addition to the temporal dimension—the spatial dimension. People receive audiovisual information also spatially because of the two by two arrangement of the sense organs eye and ear. Traditional visual output devices like monitor and paper support only two dimensions. Perspective representations try to simulate the third dimension.

However, real spatial visual representations are only possible with stereoscopic output devices[2]. The auditory information reception can be seen as analog. The most auditory output devices provide only a two-dimensional representation. Stereo sound systems try to simulate the third dimension but real spatial hearing experience can be produced only by sound systems beyond quadrophony which support sound sources from left/right, front/rear and above/below[64].

The third essential distinction in information representation is the inclusion of the acting human being. In the case of the information types described up to now, representation of information is independent of the actions of the user. Only the viewing moment, duration and time sequences can be determined by the user. These information types can be designated as passive. If the representation of information changes depending on the actions of the observer, one can speak of an active information type. This form can be found in multimedia applications above all at spatial visual representations.

If a body (e.g. a die) is represented, three faces are at the most simultaneously visible. If the die can now be turned by the observer, the already existing but hidden information of the remaining three faces is available for the observer. This information representation can be designated as an object. In this case, the viewpoint of the observer (perspective) is fixed and the position of the object can be modified in relation to it. This information type is to be taken as discreet, because there is no time- or order-critical continuum necessary for the modification of the position. If the position of the object during information representation does not change but the viewpoint of the observer changes, then this is a further information type. During the representation of only one object, no essential difference to the information type object–with the exception of shadows–is recognizable. Only if several objects are represented simultaneously, the change in the perspective of the observer becomes important. The information can be experienced only by a continuous change in the perspective of the observer. This information type can be designated as 'world' and is in particular used on high performance systems in architecture and in the game sector[4, 39].

The multimedia information types for audiovisual information representations can be listed as shows in Figure 2.

The (vertical) convertibility of an information type to another one of the same perception media can be seen as a criterion for the selectivity of this division. If an information type can be converted simply, this information type is not unambiguous.

The textual description of an image, for instance, is only very difficult to convert into an image and vice versa. In all cases of the classification in Figure 2–with the exception of pure numeric values of the information type text–is the convertibility within a perception media hardly attainable. The conversion between image and graphics seems to be the most possible. But the pattern recognition process necessary for it is quite complex here too and the present work to this supply only results at comparably simple examples (ref. 16; ref. 8). The (horizontal) convertibility of information types from discrete to continuous is easier between different perception medias.

Text conversion into speech (speech synthesis) is as available as speech recognition (ref. 58, p. 39ff & p. 45ff). Score conversion into music or noise is manageable through MIDI engineering (ref. 58, p. 33ff) and also tone recognition with automatic notation is available for several instruments[13]. However, continuous information types also include information which must get lost by the conversion. Language reduced to text loses the accentuation and rhetoric, sound reduced to score loses the musical expression.

The representation of information mostly occurs not only in just one information type. All

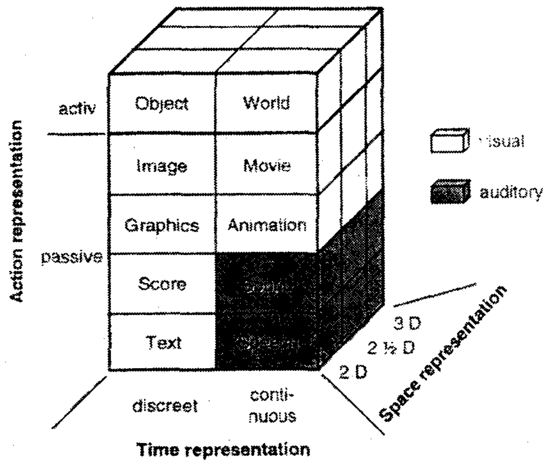

Figure 2. Classification of audiovisual information types

information representations can yet be traced back to single information types or their combinations. The classification is built up hierarchically from bottom to top. That means that every information type can include the information type lying under it and/or is built up from them. Every information type yet offers a representation of information, which contains more than the sum of the information types contained in it. In such a way, an image, for example, can also contain graphics, score and text or a movie also language and sound (e.g. a musical).

The classification of the proposed systematic of information types is selective and has the advantage that during the design of multimedia information systems it clearly shows which basic (combination-) possibilities for the representation of information exists. The structure replaces the term 'medium' in previous multimedia definitions by the term 'information type'. On this basis, a theoretical multimedia paradigm can be developed, in which statements about mutual reciprocal actions of the single information types during the audiovisual information reception of the user are possible.

2.2.2 Interaction Type

The techniques of the human-machine interface developed maturity, where the results of the research in different approaches are summarized in the first theoretical concepts[9]. Another classification is presented here, which illuminates less technical but more functional aspects, shows a stronger degree of abstraction and defaults a framework for the design of multimedia applications.

The type of donator, the type of control and the type of action possibility can determine the possibilities of data entry of the user. The type of donator can be either a pointing device, which produces spatial references, or a symbol generator which causes predefined planned reactions. The type of control can be either physical or virtual[26]. The type of action designates those variants which the user has in communication with the machine: either the selection of predefined items and/or the calling of predefined functions (static) or the varying of already available objects and/or input of new values (dynamic). Figure 3 shows the connections.

The variants in the individual fields represent the interaction possibilities. The communication with the computer first occurs via a physical interface. That can be either a symbol generator–as for instance the keyboard–or a pointing device as for example the mouse. In this way, either an action can immediately be caused (how for example pressing the escape key can cause the termination of a movie) or virtual symbol generators or pointing devices can be addressed. The most frequent case is clicking a–virtual–button with the mouse and therefore the release of specific actions.

A virtual button can also be pressed with the keyboard as for instance by hitting the return-key for confirming the request for saving a file in a dialog box. However, other symbol generators as for instance voice or gesture controllers can also call this choice. Activating a virtual pointing device such as a control dial can also occur either through physical pointing devices (setting with the mouse) or through physical symbol generators (adjustment with key combinations).

The different interaction types can cause a planned reaction. The planned reaction is identical, however, it becomes amenable to the user in different ways which are differently suitable depending on the function of the planned reaction.

In this case, two ways of experiences of the user which are caused by communication with the computer can be distinguished (ref. 35; ref. 36, p. 112ff):

First person experience: Where the user has the feeling to release an action directly. A user has for instance while activating a button on

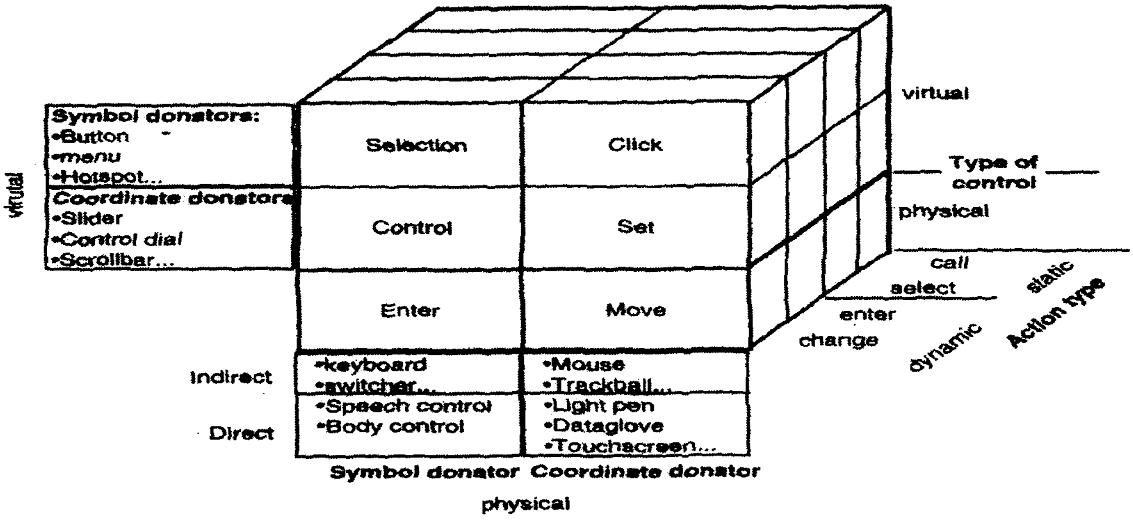

Figure 3. Interaction type

Touch-Screen the feeling to press the button directly and itself.

Second person experience: Where the user has the feeling that by his action a planned reaction is releases indirectly. While activating a button with a mouse, the user has the feeling that the button was pressed via clicking the button on the mouse.

In this way, it becomes clear that the experiences, which a user has during the use of different input devices, are different, although the result of the action is identical. This distinction allows the division into direct (possibility of the first person experience) and indirect (possibility of the second person experience) physical donators.

By interactions events arise which in turn supply the corresponding results. Table 1 shows the list from user-controlled events and its result. Activated means that the corresponding donator was released. A button is activated for example if it is pressed. At pointing devices activated means that the position, which the pointing device supplies, is marked. In such a way, pressing the mouse button on a specific place is the activation. Pointing devices can be activated and/or in motion.

If a pointing device is activated and if it is moved simultaneously then the interaction type 'adjust' or 'set' can be caused. In this case, a drag-and-drop event is also caused in some systems. An object becomes marked, taken to another place (drag) and put there (drop). This event provides a field code within which the movement occurred.

If a pointing device is not activated and only moved it causes a movement event. This event provides a movement code, which indicates position, position modification rate and direction. Not all pointing devices provide a movement code. Touchscreen and illuminated pointer cannot generate an enter-and leave event since this is in their case always an activated event. If the position indicator achieves virtual objects (e.g. a button on the screen), it causes an entry event. If it leaves the object, a leave event is caused.

If the pointing device is not moved but only activated, so the interaction type click is caused. The event down (activated) provides the position code of the click. By combination of down and up (down, up, down+up = click, double-click, triple click and so on) different functions can be called at a position. If the pointing device is neither moved nor activated, only a temporal event (timer) can occur, that provides a time difference. If a symbol generator becomes activated, it causes the interaction type 'select' or 'input'. The event down (=pressing of a key) provides the key- or symbol code, depending on the type of the symbol generator. Different functions can be caused by combination of keys (e.g. shift key + key a = A).

If the symbol generator is not activated, also in turn only a temporal event (timer) can release a function and supply a time difference as a result. With the classifications of Figure 3 and Table 1, the interaction variants of the users and their effects can be described completely. This division represents the basis for the

		Activated		Not Activated	
		Event	Result	Event	Result
Pointing Device	In motion	Control drag & drop set	Area code	move enter leave	Motion code
	Not in motion	Click DoubleClick down up	Position code	timer	Time difference
Symbol Generator		Down Wahl up Eingabe	Key code, Symbol code	timer	Time difference

Table 1: Interaction events and results

development of multimedia applications. Development- and application environments must support the interaction events and the processing of its results.

3. MULTIMEDIA THEORY

3.1 Educational Aspects

At the constuction of multimedia learning systems and mass information systems–in case of the technical-systemic point of view–the transported information is in the center of interest. In other paradigms (social, behavior oriented, psychological, didactic ones and so forth), this information is designated as knowledge. Knowledge is here the way people understood and stored information[49]. From the learn-theoretical point of view, the disciplines pedagogy, education and didactics observe the multimedia evolution in part critical.

Knowledge psychology supplies concrete action instructions from the cognitive point of view.[24] is for media science and media-psychology Multimedia the fusion of computer, television and telephone[21].

The multimedia technique is meanwhile available on low-cost personal computers and is no longer a major problem. The width of the abilities in order to make and edit all information types, which are necessary, is much more difficult. Table 2 shows a selection from occupational groups into which competence the variety of multimedia information types plays a role. For a multimedia production, additional comprehensive network-and programming techniques, dramaturgical, media didactic and learn-psychological knowledge are required. Lopuck says to this: "A jack of all trades is a master of none"[40].

Therefore, the evolution of a multimedia application is, from the beginning condemned for failing since billing is too little available for professionalization either or on the other hand forces the–authorized–question on it, whether such massive resource effort has in fact a corresponding benefit?

The answer of this question applies to benefit and this is based again on the scope. Above all, in two fields, multimedia technique is forced: in the field of the mass information medias (electronic newspaper, pay television, kiosk systems, presentations, advertising and so forth) and in the field of (virtual) learning. In the first field a benefit can easily be found, but in the field of learning systems this is much more difficult. However, both fields have many common characteristics. In both cases, the objective is to transport information (knowledge) to people and to prepare it in such a way that acquisition and application of this knowledge is supported.

In the 17th century, Comenius thought about the efficiency of the teaching/learning process. In his book *Orbis Sensualium Pictus,* which appeared in 1658 in Nuremberg, he argued that the subject should be provided via as many senses as possible. His fundamental book *Magna Didactica* influenced the design of teaching machines over centuries. Skinner developed the idea of 'programmed learning' and formulated, in 1958, seven rules which were the basis of computer-assisted teaching machines developed in the sixties and seventies. These didactic software became known as CBT (computer-based training) and were, in the beginning, not very user friendly and required a connection to a mainframe. CBT developed a new market, that was flooded with monotonous and pedagogic useless programs. Therefore, it was not amazing that the initial euphoria deviated fast to a reasonable skepticism and the approach failed to a large extent.

With the evolution of high-powered hardware at small prices, new technical possibilities seemed to balance the shortcomings. The multimedia technique already comes close to the thought of Comenius on using several medias. But regardless of the way of information representation didactic conception stuck to the behavioristic approach. Many multimedia programs are still teaching programs.

3.2 Psychological Aspects

The combination of different representation possibilities in only one system inspired the multimedia euphoria at the end of the Eighties. Especially in the case of learning systems, the expectations were particularly high. Figure 4 shows the naive expectations about the effect

Discreet Information type	Occupational group	Continuous Information type	Occupational group
Text	* Setter * Printer * Writer	Speech	* Speaker * Sound engineer
Score	* Composer * Arranger	Sound	* Sound Technician/mixer * Musician * Singer * Sound Effects
Graphics	* Layout man * Desktop publisher * Painter and draughtman * Graphics designer * Illustrator	Movie	* Animator * Modeller * Computer animator * Digital assistant
Image	* Photographer * Retoucher * Image editor		* Director * Scriptwriter/dramatic adviser * Cameraman * Actor * Illuminator * Cutter * Digital effects & assistant
Object	* Architect * Modeller * Computer illustrator	World	* Architect * Computer graphics * Real-time specialist * VR Designer

Table 2: Competence of traditional occupational groups in the case of multimedia information types

of sense modalities and learning activities on memory performance. This representation is very popular in many publications, however a source founded scientifically has not been found.

Such expectations are based on a summation hypothesis. According to that the memory performance of hearing and seeing is the sum of the two channels (20% + 30% = 50%), very according to the motto: "A lot helps a lot!" For this totalization hypothesis, two theories are stated as an argumentation: the dual coding theory of Paivio[50] and the theory of hemisphere specialization. Both theories start from the assumption that information depending on codification is processed by different cognitive systems. However, the summation hypothesis was not confirmed by empirical works but falsified in so far that even further factors like pre-knowledge, order, content and so forth play a decisive role at memory performance (see ref. 62, p.69ff).

However, the different ways of information representation advise the suspicion that they are suitable for different purposes. For this purpose, a series of experiments were undertaken, to classify them according to one or several features and to assign them to didactic functions. In this case, the information representations were designated as medias. So a number of media taxonomies have been developed with different feature categories, those were based on general pedagogic knowledge about direct and indirect and/or media mediated experience processes. Most of the ideas represented today for the use of multimedia information representations are based on origins from the postwar years.

Dale in his work about audio-visual education methods, which appeared for the first time in 1946, proposed to divide the process of knowledge acquisition according to its concrete steps[11]. As one of the first media taxonomies the media-rating table of Gagne

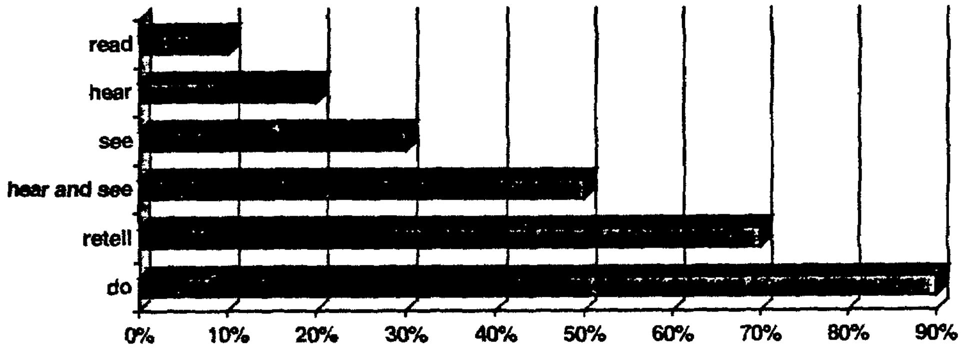

Figure 4. Naive assumptions about the effect of sense modalities and learning activities on memory performance (ref. 62, S.68)

from 1965 is known, where a selection of medias has been rated concerning their suitability for adoption of teaching functions[14]. The Gagne model is tested empirically comparably well, however, it already shows strong indefiniteness within individual information types. This is an indication that not only the information presentation is important for remembering and the thesis of "A lot helps a lot" is not tenable here too.

A lot of further media taxonomies have been developed (for example see ref. 18, p.186) however they have been proven theoretical as well as practical as unsatisfactory at all. The classifications were too general both with respect to medias and to teaching functions and learning aims in order to provide a psychologic-didactical frame theory for the use of medias (see ref. 24, p.536). They concentrated on the didactic functions but neglected the learning processes. Moreover other than didactical factors like costs, organization, time requirement and so forth have not been included in accordance with their real influence.

The Aptitude–Treatment–Interaction–approach (see ref. 24, S.537f) (ATI) attempts to include the learning processes and the personal structure of the learner. The assumption here is, that learning in general and learning effects in particular are the result of reciprocal actions between instructional measures (treatment), including the use of medias, and individual features of the individual learner (aptitudes/traits). But the ATI research only brought little findings–conceming the media aspect–which can claim certain universality (ref. 24, p. 537).

If the individual structure of the learner is decisive for the memory performance it appears only natural that each person experiences the information representations differently and therefore no universal statement can be made. With that, the way of information representation becomes secondary and the instructional method gains importance[62]. The basic setting of the application, the fixing of the user role, of the tasks and of the situation is primarily decisive. Only after these points are determined, the information presentation is important.

How can the information representation be chosen correctly for the instruction method if different persons are to be assigned to very different learning types? It would be the logical consequence of this to represent every content in all information types and to let the user choose which representation form corresponds best to him. However, this consequence is more a fear scenario for every producer and designer of a multimedia application, because in this way, neither a harmonized screen design can be maintained nor a cost framework can be kept. Only user classes can still be defined and maybe some few sections can be presented in accordance with the user classes. But the expenditure is enormous because the production of multimedia applications is very high-cost.

If there is no unambiguous generalizeable correlation between memory performance, personality structure or pre-knowledge of the learner and the information types, it can now be presumed that it is just in reverse. The individual information types themselves have very specific strengths and weaknesses. If they are combined reasonably, they can support mutually themselves either or else destroy the effect.

The strengths and weaknesses of the information types then encounter the individual strengths and weaknesses of the user ('learning type') and can, depending on the constellation (strength encounters weakness, or vice versa), cause positive or negative effects. What can the strengths of the individual information types be? Kracauer supports an idea to this with his concept of the 'aesthetically principle': the performance within a certain medium is artistic all the more satisfactory, the more it comes from the specific qualities of this medium.[34] Accordingly, it is possible that there are specific qualities for each information type, by means of them its use in every case in every application can always be decided again. In the following list are particular qualities of the information types pointed out.

3.2.1 Text

Specific quality of the information type text is the individually settable studying rate. Every reader has his own rhythm. He can read sentences again, think the formulation over and so forth. Text is a redundant language. Through this redundancy, it is possible that the contents can be understood flexibly. It is suitable as hollow studying. In multimedia applications, a longer reading of text is made more difficult by the small screen resolution. Consequently, text appertains better into printed formats, e.g. into a book in which one can become immersed. Text in multimedia applications has more decorative and symbolic character for statements or denotations in graphics.

3.2.2 Speech

Speech is continuous. Even if the spoken sentence can become repeated, no thorough studying is yet possible. Speech can introduce, give surveys, stimulate, and tell. Since the speech between people requires a dialog and the computer is (still) not capable of a natural-language dialog, it can only be used in such systems as additional information; particularly where the visual system would be superloaded by additional text reading. Speech is ideal as an explanation of animation if it is synchronized with the events on the screen. Speech as a voice melody (e.g. as a rhyme) can cause strong memory effects.

3.2.3 Score

The score has its strength at the composing or the analyzing from music and/or sound. It is the text of the melody and is suitable for those who reproduce or want to study it in widest sense for musicians. Ideal is the combination with sound if in this case the sounds played currently are emphasized or characterized visually.

3.2.4 Sound

The sound, as music or noise, is able to wake emotions. Music can stimulate moods or cause relaxation of mind and body. Sound can become the sign of recognition, the leitmotiv, or through combination with interaction types develop a 'feeling' for the corresponding actions (e.g. audible button clicking). The combination of sound with animation, movie, object and world to produce realistic effects is ideal.

3.2.5 Graphics

Strength of graphics is to represent a context, if this can not be preserved in reality or if it is too complex to recognize it. Graphics are discreet. The user himself determines viewing moment and duration. In this way, graphics are very suitable for the individual studying and analyzing of connections. The combination with text is good since both are discreet representations and if the text refers exactly to the graphics. Graphics approve more interpretations than the image and can be used better for the support of mental models.

3.2.6 Animation

The animation has its strength in representation of temporal dependences, that in reality either can not be preserved or are too complex to understand their connections. Compared to graphics the advantage is at connections where only movement explains the function. In such a way, the functional representation of a motor is for instance very suitable for an animation representation. The combination with speech and/or sound is ideal. Synchronous speech helps to understand the representations and compared to additional text there is no change of the view of the user necessary. A further strength of animation is the decoration function. Through effects combined with sound interest and attention can be woken. Animation supports like graphics the formation of mental models.

3.2.7 Image

The image represents an integrated connection. The image is very much related by its photorealistic representation to the concrete contents. Unlike text, the contents are non-flexibly interpretable. It is the question that how the image shows a thing. Image has the strength in the good situation function. Because of the reality proximity, recognition of the contents represented in the image is slightly possible. Moods can also be influenced by images. In this case, the combination of image with sound is very effective. Images are just as well suitable for the extensive considering and the recognition of details as for joining of associations.

3.2.8 Movie

The movie shows temporal dependencies in realistic form. Its strength is the authenticity as fact movie or the waking of emotions in the feature film. Through the possibilities of fixing technique, temporal and spatial distances are deliverable without linguistic communication. Ideal is the combination with speech and sound to produce either more reality or stronger emotions. The memory effect and the situation function is very high here too but also with the effect of small flexibility: so how the movie shows it, it is and not different.

3.2.9 Object

The strength of the object lies in approving of many possibilities, in trying out, in combining elements. Complex units, which can only be experienced by a person oneself, are reasonable contents. The interactivity is high here. In this way, constructivistic paradigms can be put into action. All discreet information types can be available with their respective strengths and their weaknesses as an object. The combination with sound can still increase the empirical values if actions are coded auditory.

3.2.10 World

The strength of the world lies in the spatial visualization and the orientation. Strong emotional and playful references can be built up by tridimensional representations. Impressive scenarios, which can lace the user emotionally, can be made by combination with objects and all other information types.

However, there is mostly no exclusive information representation through nonlinear techniques. Through hyperlinks, additional information can be called as text, an animation or graphics for an explanation. The effort and the combination of information types are dependent from many factors. Some are pointed out, many ones still lie in the field of the future research. The always-new combination or performance of information types always let new possibilities appear. However, a specific mix can often become a 'trademark' of a producer and information types can be used 'alien' by violation of the aesthetic principle yet achieve reasonable effects.

4. DEVELOPMENT OF MULTIMEDIA SYSTEMS

The characteristic feature of multimedia developments is its interdisciplinary nature. To meet the bandwidth of all fields a comprehensive approach is necessary. A purposeful planning can develop multimedia systems, which also place the program in the entire environment. The environment in that system should be used and the reference framework must be considered too. The conception is to be checked depending on application and is to be created again. However, heart of planning is the multimedia Storyboard. Scenes and action possibilities of the user are recorded in this document. The development of the Storyboard is a process in which a lot of creativity and media didactic knowledge is necessary. The Storyboard is then the basis for the programming and production of the individual information types (movie, sound, speech, image, text and so forth). At the beginning of the work on the storyboard users should be involved continuously and their suggestions from the accompanied evaluations on prototypes should be included. A multimedia director coordinates the harmonization of the information types with the didactic setting. Multimedia applications show many similarities with film and television. In such a way, editing guidelines are here also necessary for the preparation and above all maintenance and/or updating of the contents.

In the Storyboard educational and psychological aspects of multimedia manifest itself. Interaction types and information types are combined together in an evolutionary, creative process. In the Storyboard appear the environment, the frame story as well as the individual information representations and its triggers.

Basic principles can be used for the design of the Storyboard. These basic principles presented here are abstractions worked out by me inductively both from own experiences during the development of multimedia systems and of different sources of literature which more or less explicitly refer to these principles. However, these basic principles are in the final analysis heuristic theses. In Table 3, the basic principles described in the next two sections are summarized.

The basic design and technical principles are comparable with necessary conditions, which are important for acceptance of a multimedia application. However, they are no sufficing conditions for success of the application. In this way, a comparison can be set up with the two-factor-theory from Herzberg: the basic principles are a kind of hygiene factor, which influences only a dissatisfaction scale. If they are sufficiently fulfilled, only a small dissatisfaction results, if they are disregarded, dissatisfaction increases. Completely independent of the dissatisfaction scale is the satisfaction scale, which can be seen as motivation factor. The entire contents-related and didactical setting influences the motivation factor.

4.1 Basic Design Principles

The basic design principles (see ref. 40, p. 52) are already needed at the first Screen design. They are to be understood in such a way that there are exceptions to the basic principle which can lead consciously to specific, desired—even often very creative—effects.

4.1.1 Multiple Codification

The simultaneous responding of several input channels can increase the memory effect of information representations. Essential elements should be multiple coded. A multiple codification can be achieved.

Within the information type: Different content fields (information connections), which are represented with the same information type, are coded differently by varying of general design parameters (e.g. color or element order). So the colour of the background in an information connection for instance can be red and in another one green.

By different information types: In accordance with the dual coding theory of Paivio (see ref. 50) and the learning model of Vester[60], it is reasonable to offer the identical information contents by a combination of different codification (information types). The choice of the right combination of the information types should occur in accordance with their strengths and weaknesses.

4.1.2 Interaction Transparency

The basic principle of interaction transparency is that the user can realize at any time, both the interaction facilities which are available in a scene and their effects after the interaction. An example to this is pressing a virtual button with the mouse. If the user

Basic design principles	Basic technical principles
* Multiple codification * Interaction transparency * Metaphor consistence * Interaction consistence/functional coherence * Expectation mapping * Active orientation support * Fewer is more * Transparency * Interaction minimization	* User control * Acceptable quality of information representation * System feedback at acceptable respons time

Table 3: Overview of the basic principles of multimedia applications

announced for the user that an activatable information chunk is available here. If the user has pressed the button, he immediately sees the effect of his interaction e.g. that the button is represented inverted, which looks like 'pressed'.

4.1.3 Metaphor Consistence

The basic principle of metaphor consistence says that the stylistic devices, which are used in the application, should match the cognitive models from the everyday life environment of the users. The literary terms, which emboss the connotative importance of the metonymy and of synekdoche, are fundamental for metaphor formation. Metonymy is a turn of speech in which an associated detail is used to represent an idea or a notion. Therefore maybe the crown is a sign for a kingship.

Synektoche is a turn of speech, where a part stands for the whole and the whole stands for a part (e.g. the car for the engine or the wheel for the car[48]). Thus, if a virtual button is pressed in an application, a reasonable metaphor consistence is a sound, which simulates the clicking of a physical key. As a result, the metaphor becomes consistent.

The user has the impression to have really pressed a key. The visual codification is above all essential for metaphor consistence. The graphic symbols must be 'guessable'. However it is different from culture to culture what a correct metaphor for users is.

4.1.4 Interaction Consistence/Functional Coherence

Same functions should always be presented within an application at the same place and in the same information representation. Similarly, same information representations (e.g. a symbol) must also always make the same function available. For example, if sound elements are used for example in order to mark those fields which are 'active' ones, (where planned reactions occur), a non active place should occur in the entire application, that is not marked with a sound.

The basic principle of interaction consistence/functional coherence can also be applied to the consistence of function calls between applications. For example, users of graphic operating systems of the company Microsoft used to get a help-function by pressing the F1-key. Accordingly, in multimedia applications, which run on these operating systems, pressing the F1-key should also activate the help-function. Applications, which run on different platforms, should be considered so that user groups of every operating system of different manufacturers form an own culture and expect different functions. Thus, an application is closed in Windows- environment with the key combination 'Alt-F4' in applications of Apple operating system, this function is achieved by the key combination 'Command-Q'.

4.1.5 Expectation Mapping

The basic principle of expectation mapping says that users have a certain notion or expectation of an application. Expectation mapping is then successful if the expectations are met or outdone. The basic principle of expectation mapping results in multimedia applications achieving a higher and higher standard. What the user expects, depends on what he has already seen. In this way, the evolution spiral and the life-cycle model also are met or outdone. The basic principle of expectation mapping results in multimedia applications achieving a higher and higher standard. What the user expects, depends on what he has already seen. In this way, the evolution spiral and the life-cycle model also becomes clear here: Information types like 2 1/2 D-objects and worlds, which are to be found still rather rare, will soon raise to standard and will be in the not too distant future almost a necessity.

4.1.6 Active Orientation Support

While navigating in complex systems continuous information representations should be provided, which indicate the user at any time where he is and offer him simultaneously the possibility to jump to neighboring or preceded hierarchically elements.

4.1.7 Fewer is More

The basic principle of 'fewer is more' means the reduction of the functions to those important elements, which a user needs in a scene at the same time. Overcrowded and overloaded screens confuse more than they are useful. This basic principle is comparable with the concept of the KISS (keep it simple and short).

4.1.8 Transparency

Transparency means that a good interface design remains unnoticed. If users must invest a lot of time in order to find out the possibilities of the interface, they are distracted from the contents. Transparency means that the system works to a large extent also in a self-explanatory form and makes help functions actually unnecessary.

4.1.9 Interaction Minimization

Not more than three interactions (e.g. mouse clicks) should be required for attaining important, often required functions. (ref. 48, p. 52) Hierarchies interleaved too deep often offend against this basic principle if they allow no direct possibilities to jump from (e.g. layer 3 in part 2 to layer 4 in part 1). So five communications would be necessary in this example.

4.2 Basic Technical Principles

The following basic technical principles can be derived for the Storyboard as guidelines for the development

4.2.1 User Control

The user must be able to attain control of the system at any time. Particularly in the case of continuous information types, the user must be able to control and/or break off this linear process.

4.2.2 Acceptable Quality of Information Representations

The technical perfection of the information types has an essential role to play in the case of user acceptance. Especially continuous information types do not have that quality in standard PC systems, that people are used to from film and television. Quality depends here strongly on the expectations of the users too. In 1990, an all-digital information representation as movie on traditional PC-systems was a sensation, even with acceptance of the stamp-size format and the not very synchronous sequence. Meanwhile the expectations of the users increased, so not fluently movies are felt as not up-to-date.

4.2.3 System Feedback at Acceptable Response Times

The system must supply a feedback at acceptable response time to the user to his interactions. If the response times are surpassed, the system response for the user is no more clearly allocateable to his interaction and an interference of the interaction process occurs. The attention of the user is diverted and the train of thought is disturbed.

4.3 Cultural Influences

The development of the Storyboard is embossed by creative, personal elements. Every developer has a particular cultural background, which is embossed, both from the geographical culture area and from the social background. Supplementary influences still result from the respective specific organization cultures.

It also depends whether or not the user has the same complex cultural background as the developer. If the cultures correspond themselves to a large extent in their state of mind, their values, their norms, their rites and voice habits, problems of acceptance of a multimedia application will be minimized. If the cultural background of developer (team) and user are only low congruent, a lack of communication occurs. The possibilities of these difficulties are represented plastically in Watzlawick's concept of the trisection of confusion-disinformation- communication[61].

During the development of multimedia applications, it is important to pay attention to this cultural difference. The analysis of the user role and of the reference framework in the process of the Storyboarding is used for this purpose. The gained insights into cultural special features of the user role have effects in the following essential fields:

4.3.1 Screen Layout and Screen Design

Both elements are dependent essentially on the writing and reading habits.

4.3.2 Effect of Colours

Colours have very particular meanings in many culture areas, which must in the final analysis be synchronized semantically with the contents.

4.3.3 Effect of Language

Every culture area has a particular language with particular idiomatic expression (dialect) that identifies speakers of other culture areas as 'foreigners' and therefore the corresponding defense attitudes or total communication barriers can be cause.

4.3.4 Effect of Graphics

The composition of graphics for decorative functions is embossed essentially by the peculiarity of the cultural background. In particular setup and style of a picture let inferences to the cultural origin.

4.3.5 Recognition of Symbols

Symbols are very specific cultural. Even traffic signs differ from country to country. Symbols are deeply linked to a culture and therefore, their correct interpretation is significantly dependent on the cultural background. Symbols with different meaning can lead to forming a front very fast, because they are mostly engaged emotionally. Since many symbols (e.g. Icons), are used in multimedia applications the attention to differences at the symbol display become important.

4.3.5 Metaphor Consistence

Users have specific schemes according with their cultural area. The essential metaphors of an application must be adapted to these schemes in order to maintain the basic principle of metaphor consistence.

4.3.6 Interaction Consistence/Functional Coherence

Accustomed interaction peculiarities exist not only within a geographical but also within an operation system-specific culture area. Users, who swear on 'their' operating system, also expect accustomed functions with usual control.

Consequently, the development of an application is not simply translatable from one culture area into another one. A check should always at least occur, whether and which cultural differences exist. The effort to a larger market and therefore the export into other cultural areas is to be taken as a legitimate objective of efficiency since the development of multimedia systems is at high-cost. Under this diction a cultural adaptation is mostly renounced. However, this shortcoming is relocated through the possibilities and the effects from international mass media.

The advertisements, which have to consider cultural peculiarities, are therefore no more developed country-specific (with the exception of language), but more according to customer segments which don't differ from each other independent of the country[54]. The user becomes a cosmopolite, culture does not grow in a country but almost always becomes defaulted by a company's philosophies.

The market strategy of Coca Cola is the best example for it. However, cultural influences can not yet be negated and are to be considered in the design or adaptation stage of a good multimedia learning or mass information system.

5. FURTHER PERSPECTIVES

The development of multimedia applications requires a very broad and highly qualified knowledge. However, systems, which really guarantee a more efficient knowledge transfer process, can be developed in this way[27]. Technology is the main problem no more. The contents-related design is the challenge in order to offer support for the information transfer that must be used reasonably in a framework of action so that the personal information requirement can hold step with the increase of knowledge in the society. For this purpose, the concepts described in this paper can show the variants of the representation and interaction forms and allow its reasonable combination in a storyboard according to the basic technical and design principles.

REFERENCES

1. Ambron, S & Hooper, K. Learning with interactive multimedia: Developing and using multimedia tools in education. Microsoft Press, Redmond, WA, 1990.
2. Aukstakalnis, S & Blatner, D. Cyberspace: Die Entdeckung künstlicher Welten. Vgs, Köln, 1994.
3. Babu, GP; Mehtr, BM & Kankanhalli, MS. Color indexing for efficient image retrieval. *Multimedia Tools and Applications*, 1995, **1**(4).
4. Bauer, W & Riedel, O. VR in space—and Building-planning. *In* Virtual Reality. F Brody & RF Morawetz. Wien, Vienna, 1993. S. 34f.
5. Blattner, MM & Dannenberg, RB. Multimedia interface design. Addison-Wesley, Wokingham U.A., 1992.
6. Börner, W & Schnellhardt, G. Multimedia. te-wi Verl, München, 1992.
7. Brauner, J & Bickmann, R. Die multimediale Gesellschaft. Campus, Frankfurt am Main, 1994.
8. Cakmakov, D & Davcev, D. Information retrieval and filtering of multimedia mineral data. *Multimedia Tools and Applications,* 1995, **1**(4).
9. Card, SK; Mackinlay, JD & Robertson, G. The design space of input devices. *In* Multimedia Interface Design. MM Blattner & RB Dannenberg, Addison-Wesley, Wokingham U.A, 1992. p.224f.
10. Charwat, HJ. Lexikon der Mensch-Maschine-Kommunikation, 2. Auflage. Oldenbourg, München, Wien, 1994.
11. Dale, E. Audiovisual methods in teaching. Holt, Rinehart & Winston, New York, 1946.
12. Förster, HP & Zwernemann, M. Multimedia—Die Evolution der Sinne!. Luchterhand, Berlin, 1993.
13. Frater, H; Pauliben, D. Das gro_e Buch zu multimedia. Data Becker, Düsseldorf, 1994.
14. Gagné, RM. The conditions of learning. Holt, Rinehart & Winston, New York, 1965.
15. Gagné, RM. Instructional technology: Foundations. Erlbaum, Hillsdale, NJ, 1987.
16. Gertler, N. Multimedia Illustriert. Markt und Technik, Haar bei München, 1995.
17. Haak, G & Issing, L. Multimedia-Didaktik - state of the art. *In* Multimedia, und Computeranwendungen in der Lehre; Das Computer-Investitions-Prograrmm (CIP) in der Nutzanwendung. K Dette; D Haupt & C Polze. Mikrocomputer-Forum für Bildung und Wissenschaft 5. Springer, Heidelberg, 1992
18. Hasebrook, J. Multimedia-Psychologie: Eine neue perspektive menschlicher Komrnuni-kation. Spektrum, Heidelberg, 1995.
19. Heinrich, LJ; Lehner, F & Roithmayr, F. Informations—und Kommunikationstechnik für Betriebswirte und Wirtschafts-informatiker, 4. Auflage. Oldenbourg, Münch en, 1994. p. 216.
20. Heinrich, LJ & Roithmayr, F. Wirts-chaftsinformatik-Lexikon, 5. Auflage, München Wien, 1995. p. 341.
21. Hickethier, K & Zielsinski, S. Medien/Kultur. Schnittstellen zwischen Medien-wissenschaft, Medienpraxis und gesellschaftlicher Kommunikation. Wissenschaftsverlag Volker Spiess Berlin, Berlin,1991.
22. Hoogeveen, M. Towards a new multimedia paradigm: Is multimedia assisted instruction really effective?. *In* Educational Multimedia and Hypermedia. H Maurer. Graz, 1995. p. 351f.

23. ISO/IEC JTC1/SC29/WG12. Information technology: Coded representation of multimedia and hypermedia objects (MHEG). ISO Commitee Draft, 1993. ISO/IEC CD 13522-1.

24. Issing, LJ. Wissensvermittlung mit medien. *In* Wissenspsychologie. H Mandi & H Spada. Psychologie–Verl, München, Weinheim, 1988.

25. Issing, LJ. Instruktionsdesign für Multimedia. *In* Information und Lernen mit Multimedia. LJ Issing & P Klimsa. Psychologie–Verl., Weinheim, 1995.

26. Issing, LJ & Klimsa, P. Information und Lernen mit multimedia. Psychologie-Verl, Weinheim, 1995.

27. Jarz, EM; Kainz, GA & Walpoth, G. Multimedia-based case studies in education: Design, development, and evaluation of multimedia-based case studies.

28 Jarz, EM. Entwicklung multimedialer Systeme. Gabler, Wiebaden, 1997. p. 12ff

29. Jarz, E; Kainz, GA & Walpoth, G. The design and development of multimedia-based case studies. *In* Educational Multimedia and Hypermedia, H Maurer. Graz, 1995.

30. Jarz, E; Kainz, GA & Walpoth, G. Multimedia based case studies in education. Proceedings of the ED-Media, 1996, Boston.

31. Kerres, M. Entwicklung und einsatz computergestützter lernmedien; Aspekte des Software-Engineerings multimedialer Teachware), *In* Wirtschaftsinformatik, 32. Jahrgang, Heft 1, Februar 1990. p. 71f

32. Klimsa, P. Multimedia aus psychologischer und didaktischer Sicht. *In* Information und Lernen mit Multimedia, LJ Issing & P Klimsa Psychologie–Verl, Weinheim, 1995.

33. Klingberg, KD. ABC der Multimedia-Technologie. Multikom–Verl., Bergheim, 1993.

34. Kracauer, S. Theorie des Films: Die Errettung der äußeren Wirklichkeit. Suhrkamp, Frankfurt am Main, 1985.

35. Laurel, B. Interface as mimesis. *In* User Centered System Design: New Perspectives on Human-Computer Interaction, DA Norman & S Draper. Lawrence Erlbaum, Hillsdale, NJ, 1986.

36. Laurel, B. Computers as theatre. Addison-Wesley, New York U.A, 1993.

37. Laurel, B. New directions. *In* The art of human-computer interface design. B. Laurel, Addison-Wesley, Mountford, 1994.

38. Laurel, B. The art of human-computer interface design, 8. printing. Addison-Wesley, Mountford, 1994.

39. Loeffler, CE. Virtual polis. *In* Virtual Reality, F Brody & RF Morawetz. Wien, Vienna 1993, S. 6 f.

40. Lopuck, L. Designing multimedia. Peachpit Press, Berkeley, CA, 1996.

41. Marmolin, H. Multimedia from the perspectives of psychology. *In Multimedia: Systems, Interaction and Applications,* L Kjelldahl. Springer, Stockholm, 1992.

42. Maschke, T. Faszination der Schwarzweiß-Fotografie; 4. Auflage. Augustus, Augsburg, 1995.

43. Mathis, T. Evaluierung von multimedia-anwendungen. Diplomarbeit, Innsbruck, 1994.

44. Maurer, H. Educational multimedia and hypermedia. Proceedings of ED-Media 95—World Conference on Educational Multimedia and Hypermedia. AACE, Graz, 1995.

45. Messina, C. Was ist multimedia? Eine allgemeinverständliche Einführung. Wien, München, 1993.

46. Meyer-Wegener K. Multimedia-Datenbanken. Teubner, Stuttgart, 1991. p. 20f

47. Mikunda, C. Kino spüren. Filmland Presse, München, 1986.

48. Monaco, J. Film verstehen, 2. Auflage. rororo, Hamburg, 1980. p. 143.

49. Müller-Merbach, H. Perspektiven einer informationsorientierten betriebswirtschaftslehre. *In* C Konegen-Grenier & W Schlaffke. Praxisbezug und soziale Kompetenz, Kölner Texte & Thesen, S. 375 ff.

50. Paivio, A. Imagery and verbal processes. New York, 1971.

51. Phillips, RL. Opportunities for multimedia in education. *In* Interactive Learning Through Visualization: The Impact of Computer Graphics in Education. Heidelberg, Berlin, 1992.

52. Postman, N. Wir amüsieren uns zu Tode: Urteilsbildung im Zeitalter der

Unterhaltungsindustrie. Fischer TB, Frankfurt am Main, 1988.

53. Preece, J, *et al.* Human-computer interaction. Addison-Wesley, Loughborough, 1994.

54. Schweiger, G & Schrattenecker, G. Werbung: Eine Einführung; 3. Auflage. Fischer, Stuttgart, 1992. p. 174ff

55. Shannon, C & Weaver, W. The mathematical theories of communication. University of Illinois Press, Illinois, 1949.

56. Shneiderman, B. Designing the user interface: Strategies for effective human-computer interaction, Ed. 2. Addison-Wesley, Reading, MA, 1992.

57. Skinner, BF. Science and human behavior. Free Press, New York, 1953.

58. Steinmetz, R. Multimedia-Technologie. Heidelberg, Berlin, 1993.

59. Titze, H. Das philosophische Gesamtwerk; Band 4: Theorie der Information. Berlin, 1993. p. 15

60. Vester, F. Denken, Lernen, Vergessen, 5. Auflage. DTV, Munchen, 1980.

61. Watzlawick, P. Wie wirklich ist die Wirklichkeit? Wahn, Täuschung, Verstehen; 20. Auflage. Piper, München, 1995.

62. Weidenmann, B. Multicodierung und Multimodalität im Lernprozess. *In* Information und Lernen mit Multimedia. LJ Issing & P Klimsa. Psychologie-Verl.-Union, Weinheim, 1995.

63. Weizenbaum, J. Die Macht der Computer und die Ohnmacht der Vernunft, 8. Auflage. Suhrkamp, Frankfurt am Main, 1990. p. 268ff

64. Wenzel, EM. Three-Dimensional virtual acoustic displays. *In* Multimedia Interface Design. MM Blattner & RB Dannenberg. Addison-Wesley, Wokingham u.a, 1992.

65. Wodaski, R. Multimedia für Insider. Markt und Technik, Haar bei München, 1995.

66. Wratil, P & Schwampe, D. Multimedia für Videa und PC: Techniken und Einsatzmöglichkeiten. Markt & Technik, Haar bei München, 1992.

67. Yazdani, M & Pollard, D. Multilingual aspects of a multimedia database of learning materials. *In* Multilingual-Multimedia. M Yazdani. Cromwell Press, Wiltshire, 1993.

***Dr. Ewald Jarz**, born on 15 August 1965, educated at School for Engineering, Master of business administration at the University of Innsbruck, Ph. D. 1996. Presently Assistant Professor at the Department of Information Systems, University of Innsbruck. Special research area: Multimedia and Software Design.