USER MULTIMEDIA PREFERENCES TO RECEIVE INFORMATION THROUGH MOBILE PHONE

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Abstract

The current study assists to define user multimedia preferences to perceive information about an object through mobile phone. We utilize literature review and quantitative analysis as methodology. Literature review advocated our understanding in general concepts of media and multimedia, its use in different disciplines, and further narrowing down the research focus on application of multimedia in delivering information to a user through a mobile phone. The multimedia combinations obtained from theoretical and empirical studies were adapted for the mobile phone applications. We have developed a pilot application based on research findings. This pilot application helps to analyze multimedia combinations that were concluded from theoretical and empirical data. Using pilot application a test is done and analyzed in order to extend our understanding of user multimedia preferences in a mobile phone.

The results of the present study indicate multimedia combinations that meet user preferences in receiving information about an object by a mobile phone. The combinations are: *text and photo (without vibration), audio and animation (with vibration), and voice and animation (with vibration)*. The combinations should be carefully applied in different situations focusing on individuals who receive information about objects, the type of the information, and the environment in which the object is located. The results of the study serve as a basis for a research in the development of information delivery mobile applications.

ACM Computing Classification System, 1998 version:

I.3.6 [Methodology and Techniques], H.4.3 [Communications Applications], H.5.1 [Multimedia Information Systems], H5.m. [Miscellaneous]

Keywords: mobile multimedia, mobile-object interaction, information delivering, vibration.

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List of Abbreviations

A & E	Art & Entertainment
ACM	Association for Computing Machinery
CD-ROM	Compact Disc Read-Only Memory
CS	Computer Science
Ebsco	Elton Bryson Stephens Company
EdITLib	Education and Information Technology Library
GIF	Graphics Interchange Format
IEEE	Institute of Electrical and Electronics Engineers
JPEG	Joint Photographic Experts Group
MC1	Text and photo (without vibration) combination
MC2	Text and photo (with vibration) combination
MC3	Text and sound/music (with vibration) combination
MC4	Text and voice (with vibration) combination
MC5	Text and additive voice (with vibration) combination
MC6	Sound/music and animation (with vibration) combination
MC7	Voice and animation (with vibration) combination
PC	Personal Computer

RFID	Radio Frequency Identification
TV	Television
UEF	University of Eastern Finland
VGA	Video Graphics Array

Chapter 1

Introduction

Utilization of multimedia and mobile devices has been growing rapidly over the last decade. Nowadays multimedia and mobile devices are common and widely deployed tools in our everyday lives (Friedland, Hürst, & Knipping, 2007; McGuigan, 2005; Sugawara, 2001). Industry and academia have embedded multimedia in mobile devices including a mobile phone ("Textually.org", 2003; "Vizrt company", 2006; Attewell, 2004). However, despite the widespread usage of multimedia in mobile phones, there is not enough research on user multimedia preferences of information received via mobile phones. Moreover, there is a question: What multimedia does a user prefer, when he or she interacts with particular object in order to gain information? For example, one can interact with goods in a shop by mobile phone, in order to get all information about them (Seishi, 2004). In other words, a mobile phone is used as a multimedia tool for simultaneous interaction and information transmission.

The aim of this study is to explore user multimedia preferences of receiving information while interacting with objects through a mobile phone. Multimedia can consists of different number of media (singular is medium) such as text, audio, and animation. The minimum number of media is two. In the current study we consider multimedia combinations with two media. The reason to select two media is based on the study of dual-coding process by Paivio, and multimedia study by Mayer. According to Paivio's theory, a human has visual and verbal information processing channels which can simultaneously proceed information in working memory (Paivio, 1986). Confirming Paivio's theory, Mayer considers efficiency to use two information processing channels to deliver information. Therefore, the usage of one medium for each channel can facilitate the information perception (Mayer & Moreno, 2005).

1.1 Research questions

To achieve the objectives of this study it is necessary to answer the following: *What are the end-user multimedia preferences to receive information while interacting with an object through a mobile phone?* This is the main research question of this thesis. Before answering it, we have to find answers to the following questions:

a) *What are medium, media and multimedia?*
b) *What dual coding process is recommended?*
c) *How do the selected disciplines study media and multimedia?*
d) *How multimedia on mobile devices is used and studied?*
e) *How does a user appreciate the media?*
f) *How does a user appreciate the multimedia in a mobile phone?*

1.2 Research methods

The research questions support us in specifying the research boundaries and assist the selection of study methodology. The main methods utilized in the study are literature review and quantitative analysis. Literature review helps to find the answers to the research questions a, b, c, and d. The answers to questions a, b, and c are given in Chapter 2. Literature review in Chapter 2 supports us in defining the main terms and multimedia combinations for further investigation. In addition to the terms defined, literature review explores how media and multimedia are studied by various disciplines. We use literature review to answer question d in Chapter 3. Further research exploits quantitative analysis methodology. Quantitative analysis helps to answer the questions e and f. The quantitative analysis evaluates two scenarios: data collected by web-based questionnaire in SciFest 2010 (Chapter 4), and Mobi application case study (Chapter 6). We apply the research findings for the case study development and analyze them in Chapter 7. The schematic representation of methodology structure is presented in Figure 1.1.

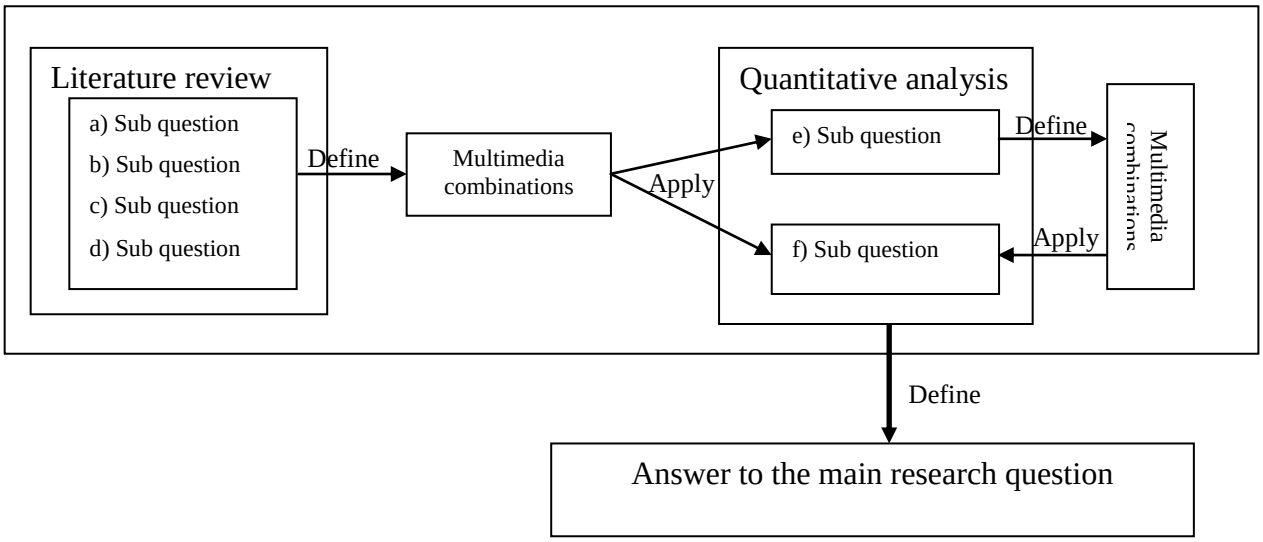


Figure 1.1: Research methods

1.3 Structure of the thesis

The entire thesis is divided into 9 chapters. Table 1.1 presents the overview of the thesis and highlights the focus of each chapter. Chapter 2 offers the main terms used in the thesis and reviews theoretical data recommendations in using multimedia combinations for the delivering information (Mayer, 2001) with further use in the case study. In addition, the literature review in Chapter 2 expands the understanding of how four selected disciplines study media and multimedia. The Chapter 3 elucidates the study of multimedia situation in the mobile industry by observing five online databases. Findings from Chapter 3 require further research of understanding a user appreciation of media. Thus, Chapter 4 presents the web-based survey with the empirical data uncovering users' opinion regarding the media appreciation, and provides four multimedia combinations for the case study. The Chapter 5 proposes adaptation of the multimedia combinations obtained in theoretical and empirical research for a mobile phone. The adapted combinations are employed in the case study (Mobi) presented in Chapter 6. The empirical data from the case study emphasizes users' appreciations of the selected multimedia combinations in mobile phone by executing Mobi application. Evaluation and analysis of data gathered in the case study is proceeded using quantitative analysis in Chapter 7. The conclusion

as regards the entire thesis is summarized in Chapter 8. Finally, Chapter 9 provides brief answers to the research questions defined at the beginning of the study.

Table 1.1: Thesis structure overview

Chapter 2:	• Defines medium, five media, and multimedia; • Introduces Mayer's theory, defines four multimedia combinations; • Overviews of media and multimedia study in four selected disciplines.
Chapter 3:	• Overview of multimedia use and study in mobile phones in four disciplines using five online repositories.
Chapter 4:	• Web-based survey analysis of user media preferences of perceiving information about three information types; • Defines four multimedia combinations.
Chapter 5:	• Mayer's theory of mobile phones towards a case study; • Defines seven adapted combinations.
Chapter 6:	• Introduction to the case study (Mobi application)
Chapter 7:	• The case study test. Evaluation and analysis.
Chapter 8:	• Summary and conclusions.
Chapter 9:	• Answers to the research questions.

Chapter 2

Literature review

In this chapter we aim to explain media and multimedia concepts. We also answer the questions related to our understanding of media and multimedia terms, its use and ways of study. The answer to *What are medium, media and multimedia?* provides the understanding of the main terms which are the foundation for our research. We review these terms in various disciplines, and thus, synthesize the appropriate definitions for the purpose of the study.

Further, we research an application of media for delivering information, and determine among others the dual coding theory and Mayer's study (Mayer, 2001). Thus, in order to answer the question *What dual coding process is recommended?* we refer to Mayer's study. Supporting the dual-coding theory, Mayer suggests the usage of two media in multimedia combination for the delivering information purpose. We embrace four multimedia combinations for gaining information from Mayer's study.

The next step in our understanding is to investigate media and multimedia usage in different disciplines. We focus on following four disciplines: computer science (CS), education, psychology, and art & entertainment (A & E). From the overview of how those four disciplines apply media and multimedia in the studies, we obtain the answer to the question *How do the selected disciplines study media and multimedia?* Findings from the literature review extend our media and multimedia understanding, and assist our further research.

2.1 Definitions of medium, media, and multimedia

Although *media* is a widely use, its meaning varies among different scopes. For example, in sociology, media often refers to *"mass media"* or *"news media"* (Newman, 2008). In fine art, media refers to a *"technique"* that painters use in their work of art (Getty, 2004). Hence, in order to build a foundation for this work we need to identify and delineate the very concept of medium, media, and multimedia.

2.1.1 Medium and media

From literature review we define that media is a plural form of *medium*. Therefore, we start our review with the definition of medium. According to McLuhan, medium (lat. medius - *"the middle")* is any new technology such as newspaper or television, which individuals use for mediating their communication (McLuhan, 1962; 1964). McLuhan's definition presents a wide and general explanation of the term. In computer glossary, medium refers to storage or transmission tool which is used for delivering and storing different types of information or data in digital form (Computer glossary, 2005). In this study, we define the following definition:

Medium is a tool for storing or transmitting information in digital form.

The five media we are going to study are: *text, image, audio, animation,* and *video***.** In some cases a single medium can exist in several forms, for example, image medium can include photo, graphics, and picture forms. Similarly audio medium can be expressed in forms of music, sound and voice. Finally, animation can exist in 2D and 3D forms.

2.1.2 Multimedia

Mayer (2001) defines *multimedia* (multi- : lat. multus – *"much, many"*; media: lat. medius - *"the middle"*) as a presentation of material using words and pictures. Mayer refers to all materials which are presented in verbal form as *"words"*, for example printed or spoken text (2001, p. 64).

Mayer refers to the static or dynamic forms such as illustrations, photos or video as *"pictures"*. Vaughan (2004) defines multimedia as all possible combinations of media which reach the end-user through computers or any other electronic or digital devices. Both definitions present an important point that multimedia includes more than one medium. Based on Vaughan (2004) and Mayer (2001) we create our definition:

> Multimedia is a combination of two or more of the five media: text, image, audio, animation, and video.

Figure 2.1 shows a representation of the defined medium, five media and multimedia which we use in the study. There are also examples of medium forms which belong to three media, namely image, audio, and animation. In the next section we describe explanations and definitions of five media type which are illustrated in Figure 2.1.

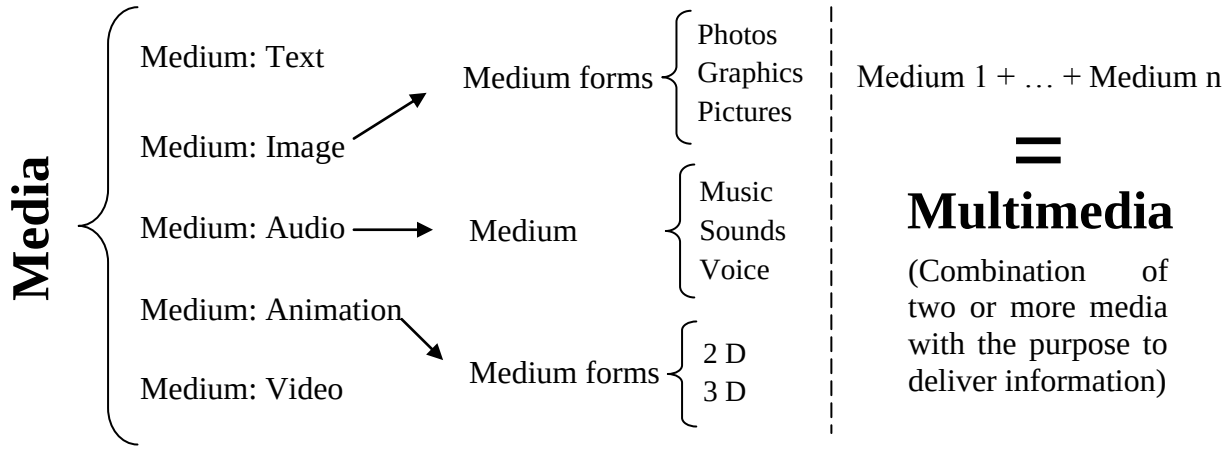


Figure 2.1: Schematic representation of the medium, five media, and multimedia

2.1.3 Media types

For our further research it is essential to specify the terms of each medium that we use in the thesis. Therefore, in this section we define five media: text, image, audio, animation, and video. Dictionaries refer to a text (lat. textus – *"written account"*, *"structure"*, and *"context"*) as any

written or printed speech (Editors of the American Heritage Dictionaries [EAHD], 2006). The definitions mainly focus on the characters used, no meanings. According to Eco (1996), text is a symbol which gives us in addition to letters and words, sequences of words or printed sentences on papers as well. In this thesis text is defined as follows:

> Text is a fix complete message presented in electronic or printed form. The message consists of a symbol or set of symbols where each symbol provides letters and words. Examples of text are articles in newspapers, stories in books etc.

The definition of image (lat. imago – "*image, likeness"*) is twofold. Some authors define *image* as something that is imagined by person or draws people imagination (Random House, 2006). On the other hand, image is a reproduction of something (Random House, 2006). In this study we define image as follows:

> Image is a photographic, graphical and pictorial reproduction of an object.

The term audio (lat. audio – *"hear"*) refers to all sound systems (School Dictionary of Foreign Words, 1983). For example, many definitions refer to audio as a sound element of television or a recording of acoustic signals (EAHD, 2005). In the current study we define audio as follows:

> Audio is the signal of sound, voice and music reproduction or playback.

The term animation (fr. animation – *"revival, liveliness"*) refers to the illusion of movement (House, 2006). There are twofold of animation definition. From one perspective animation could be interpreted as an animated images or cartoon, which is drawn on paper. From another perspective it is a sequence of digitally modeled images (EAHD, 2006). Thus, summarizing different types of animation are available, such as stop-motion, multi-sketch and many others (House, 2006). In this thesis, animation is defined as follows:

> Animation is a movie sequence of photorealistic or non-photorealistic images which are computer-generated or drawn on paper.

According to different sources, the term video (lat. video – *"to look, to see"*) is generally defined as a set of technologies for recording, processing, transferring, storing, and reproducing visual and audiovisual materials (Denikin, 2008; Wilcox & Gibson, 2005). In this study the term video is defined as follows:

> Video is a movie sequence captured by camera that transmits live motion pictures by conveying them to electronic signals with possible audio synchronization.

2.2 Multimedia: two media

We have already defined multimedia as an integration of more than one medium. The current study explores multimedia combinations of two different media. The decision to focus on two media is based on the study done by Mayer on multimedia for e-Learning. Our interest in Mayer's theory emerges from the emphasis he puts on the goal of informing in e-Learning (Mayer, 2001; Clark & Mayer, 2007; Mayer 2008). *To inform*, according to Mayer, assumes to provide relevant information, without stressing on the acquisition of new skills by the individual. Thus, the important purpose of informing is to transmit information to the user (Clark & Mayer, 2007, pp. 17-21). Mayer's study employs limiting of the number of media to two in multimedia combination for delivering information. Mayer points that multimedia design has to be compatible with the way people learn (Mayer, 2001, p. 42). Thus, Mayer grounds his theory in three principles from of cognitive theory. The principles sustaining Mayer's decision of utilizing two media are:

- *Dual-Coding* states that individual processes the information through two separate information processing channels: visual and verbal (Paivio, 1986). Dual-Coding assumes that information transferred through media and each medium belongs to particular

information processing channel. For instance, animation goes to visual channel and voice explaining some information goes to verbal channel (Mayer & Moreno, 2005).

- *Limited capacity of human brain* means that people can process limited amount of information in each channel simultaneously (Badderey, 1992; Mayer & Moreno, 2005).
- *Split attention or redundancy effect* states that information delivered through more than two media can cause a split in individual's attention and as a result, he or she would not be focused and would not perceive information (Chandler & Sweller, 1991; Mayer, 2003).

Mayer's theory is based on *active learning principle*, which implies that an individual learns by gaining experience (Mayer, 2001). The active learning principle includes three steps: *selecting*, *organizing*, and *integrating* of information (Mayer, 2001, p. 53). Figure 3 illustrates cognitive theory of multimedia learning with defined three steps of active learning principles. In this study, we focus on selection step, as we want to gain inside view into multimedia preferences while individuals select information (Figure 2.2). The selecting step implies the selection of information and transferring the information from the particular individual's receptors further to his or her memory. Due to our focus is on the selecting step only, we do not study two other steps of active learning principles. Thus, we blur the organizing and integration steps in Figure 2.2.

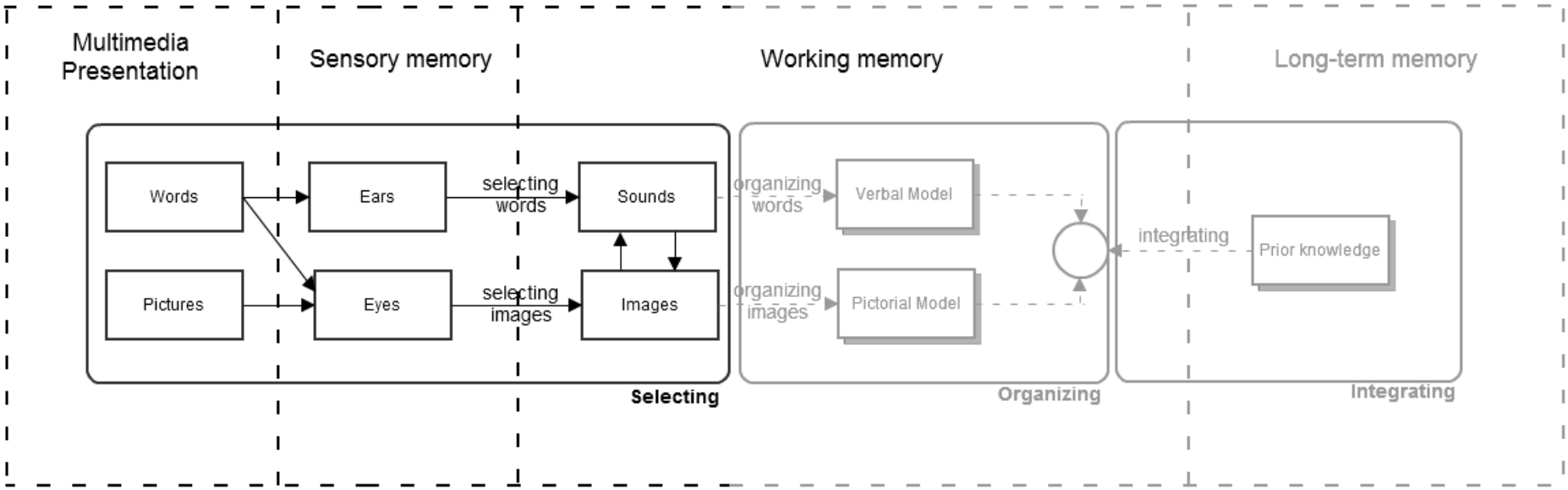


Figure 2.2: Three steps of active learning principle (Mayer, 2008)

Figure 2.2 presents two channels for processing visual (pictorial) and auditory (verbal) material (Mayer, 2001). Rounded boxes represent three steps of active learning principles. Boxes with dashed lines represent cognitive components (*Multimedia Presentation, Sensory Memory, Working Memory,* and *Long-Term Memory*), whereas arrows represent cognitive processes.

Multimedia Presentation component represents verbal medium stimulus and pictorial medium stimulus such as text, animation, photo or video, located in the outside world. The Multimedia Presentation stimulates the individual's senses: eyes and ears. Depending on the format of the medium stimulus, particular medium registers either in eyes or ears. For a short period of time all transferred information stores in the Sensory Memory. Further, some of the information is transferred to the Working Memory. Working Memory is a type of memory which keeps information in individual's mind and makes it available for further information processing. At this stage in the Working Memory, information stays unorganized in each channel and makes possible the *channel conversion*. The channel conversion is a process of converting visual image into a sound and vice versa in working memory. The channel conversion occurs the possibility of information in one channel to activate the information in the other (Mayer, 2001). For example, a person hears *the Pink Panther theme song* (Mancini, 1963), and since has seen self-titled animated cartoons, he or she submits a sample picture of pink panther - a detective. In another case a person knows nothing about this cartoon, and for him this melody is simply one among many others which do not cause any image associations. In other words, this conversion depends on differences between people and their prior knowledge.

Mayer recommends different combinations of media to transform information received by the eyes and ears into knowledge and skills in human memory (Clark & Mayer, 2007, p. 37). We derive multimedia combinations relevant for delivering information out of Mayer's work (Mayer, 1997; Mayer, 2001; Mayer, 2003; Mayer, 2005; Mayer & Moreno, 2005; Mayer, 2008; Clark & Mayer, 2007). Those combinations are:

- *Words and pictures*;
- *Narrations and dynamic pictures;*
- *Text and narration*.

It is necessary to draw our attention to the text and narration multimedia combination. Mayer suggests using this combination in case of visual medium, for instance, photo or animation deficiency. However, in theory (Clark & Mayer, 2007, pp. 138-148) it is not evident, if there is a necessity to provide identical information sentences via text and narration media or these two media must provide the same information, but using different sentences. Therefore, we came to the conclusion to investigate two variations of text and narration multimedia combination. One

refers to combination with the identical sentences represented in both media and is called *text and additive narration*. The other combination refers to information which is presented in different sentences for each medium in the combination. This combination is called *text and narration*. Thus, we obtain four Mayer's multimedia combinations:

1) Words and pictures;
2) Narrations and dynamic pictures;
3) Text and narration;
4) Text and additive narration.

Media terms which Mayer uses in his multimedia combinations are differed with definitions in current study. Therefore, we correlate the definitions of four Mayer's multimedia combinations with the media terms defined in current research. Thus, we got the adapted Mayer's combinations which are based on our definitions (Table 2.1). A detail explanation of each multimedia combination which we adapt for the study is described.

1) Words and pictures

For words Mayer refers to printed text (Mayer, 2001, p. 24) which is similar to our definition of text medium. As pictures (Mayer, 2005, p. 469) authors refer to drawing, charts, graphs, maps, or photo. According to definitions in the current study, pictures are an image medium. Thus, the adapted multimedia combination is *text and image*.

2) Narration and dynamic graphics

By narration Mayer means spoken words which are according to our definition an audio medium (Mayer, 2001, p. 26). Clark and Mayer (2007, pp. 56-94) refer dynamic graphics, to animation or video, whereas Mayer refers directly to animation (2001, pp. 27, 105, 122) definitions as a dynamic material. For us, according to three sources mentioned above, we imply dynamic graphics as an animation medium. Subsequently, there is an *audio and animation* combination for further research.

3) Text and additive narration

This combination presents identical sentences with information in text and narration media. For text, Clark and Mayer refers to on screen text (2007, pp. 127-130) which is according to our

definition is a text medium. By narration Mayer means spoken words. Correlating it with our definition, narration is an audio medium (audio medium form: voice) (Mayer, 2001, p. 26). The adapted combinations are *text and additive audio*.

4) Text and narration

Text and narration combination has the same set of media as the above mentioned multimedia combination. The only difference between combination 3 and combination 4 is that current combination (text and narration) presents different sentences in text and in narration media introducing the same information. Thus, there is a *text and audio* multimedia combination.

Table 2.1: The selected multimedia combinations

N	Mayer's combinations	Equivalent		Current thesis general combinations
		Mayer's media	Current thesis general media	
1	Words and pictures	words	text	Text and image
		pictures	image	
2	Narration and dynamic graphics	narration	audio	Audio and animation
		dynamic pictures	animation	
3	Text and additive narration	text	text	Text and additive audio
		narration	audio	
4	Text and narration	text	text	Text and audio
		narration	audio	

From Mayer's study we make references to the four multimedia combinations which we adapt based on terms defined in the current study. These combinations are:

1) Text and image,
2) Audio and animation,
3) Text and additive audio,
4) Text and audio.

We must emphasize once again our interest in Mayer's study: the purpose of e-learning is to informing and selecting information, which is the first step of active learning principle. Due to combinations mentioned above are suggested to be relevant for selecting information, we use its combinations to aid our study in further research of multimedia. Further, we would like to detect how the media defined in the study, and four multimedia combinations mentioned above are studied in different disciplines. In order to gain this understanding, the next section presents the investigation of five media and four multimedia combinations in four disciplines.

2.3 How media types and multimedia are seen across disciplines?

At this moment we have an understanding of medium, media, and multimedia with special focus on two media. Further, we want to have an inside look on how media and multimedia are studied by different disciplines related to our research. Based on a pragmatic decision our particular attention is placed on four disciplines: *computer science (CS), psychology, education, and arts & entertainment (A & E)*. The selection of CS is based on the fact that the present study belongs to the School of Computing at the University of Eastern Finland. The study was performing by Educational Technology Research Group at UEF ("EdTech Research Group", n.d.). Therefore, education discipline was selected. Psychology was selected for the current study because it influences CS and education. Our selection of A & E is based on their explicit use of different media and multimedia (Plunkett, 2006; Maraniello, 2008). The literature review for this section is basically collected from books and articles available on-line. There were no specific databases used or particular search criteria utilized. The following section contains a detailed description of each discipline.

2.3.1 Computer Science (CS)

There are two approaches to study media and multimedia in CS. First approach is *engineering*. Engineering approach includes development of technical and system resources (hardware and software platforms). Primarily it is hardware improvement (increased memory, sound cards, video cards, TV tuners, frame grabbers, converters VGA-TV and etc. (Computer glossary, 2005).

A modern multimedia PC is one of the examples of multimedia usage where stereo speaker, microphone, audio adapter and optical drive for CD-ROM are hardware and are considered as multimedia devices (Bouras & Philopoulos, 1999). Improvement of hardware platforms reflects further changes of software platforms. For example, an operating system for transferring information in digital form has to be compatible with hardware used with it (Chang, 2001).

Second approach is *processing*. Processing of media and multimedia are the key attributes in study of CS (Hassanien, Abraham, & Kacprzyk, 2008). The approach is focused on work with parameters and basic characteristics of information (delivered in digital form) or information flow process. For instance, study of data compression, where developers attempt to reduce information size without losing its information significance (Salomon & Motta, 2009).

We consider second approach (processing) to explain media in CS. In contrast to the technical approach, the processing approach examines characteristics such as ability of coding, conversion, and compression. According to the current literature review we define the list of common directions on which CS media researches focus in processing approach:

- *Lossless compression* is a process that ensures information reduction without losing its information significance (Koehler, 2005). In other words, there is a need to compress medium (for example, text or image media) which contains information, and the main purpose is to not lose the meaning of this information. The need is due to the relatively low capacity of existing technical equipment for communication (Salomon & Motta, 2009).
- *Conversion* is an integration of medium to a novel format (Little & Ghafoor, 1990). The necessity is due to either decreasing the size of medium or gaining the information in different state for different purpose. For example, converting the same medium to different formats such as from Jpeq to Gif formats and vice versa (Morishima & Harashima, 1991).
- *Data transmission* is a process of *"sending a stream of bits or bytes from one location to another using any number of technologies"* (Sumath & Surekha, 2007, p. 381). The important task in data transmission is to transmit data lossless (Halsall, 1985). An audio medium is an example of medium which uses data transmission.

- *Quality keeping* contains research directions which attempt not to lose data or information while using medium (for example, audio and animation). The examples of such directions are fidelity, coding, and noise removal (Fenrich, 2005).
- *Pattern recognition* is a process of the input data classification and identification of objects using a selection of essential features that characterize this data or the object.

According to the literature review, the researchers in CS discipline use the same approach in media and multimedia studies. The only difference is that they consider two media simultaneously in one study. Table 2.2 illustrates the focus of CS studies with research examples in relation to five media and four multimedia combinations.

Table 2.2: CS approach (processing): the focus is on work with parameters and basic characteristics of information

Medium	**CS research focus**	**Research examples**
Image	Quality keeping,	E.g., fidelity. Fidelity of image restoration by partial phase conjugation through multimode fibers (Scott, Pochi, Claire, & Byron, 1995).
	Pattern recognition	E.g., recognition. A 4GOPS 3Way-VLIW Image Recognition Processor Based on a Configurable Media-processor (Kondo, 2001).
	Quality keeping,	E.g., coding. Performance of image and video processing with general-purpose processors and media ISA extensions (Ranganathan, Adve, & Jouppi, 1999)
	Conversion	E.g., conversion. Optical and Digital Image Processing: Fundamentals and Applications (Cristobal, Schelkens, & Thienpont, 2011).
	Compression	E.g., compression. JPEG compression of digital echocardiographic images: Impact on image quality (Karson et. al., 1995).
	Quality keeping,	E.g., noise removal. Noise reduction by fuzzy image filtering (Van De Ville, Nachtegael, Van der Weken, Kerre, & Philips, 2003).

Medium	CS research focus	Research examples
Text	Pattern recognition	E.g., recognition. Text Segmentation Using Gabor Filters for Automatic Document Processing (Jain & Bhattacharjee, 1992).
	Quality keeping,	E.g., coding. Text in the Electronic Age: Texual Study and Textual Study and Text Encoding, with Examples from Medieval Texts (Sperberg-McQueen, 1991).
	Conversion	E.g., conversion. Patent: Language input architecture for converting one text form to another text form with tolerance to spelling, typographical, and conversion errors (Lee, Chen, & Han, 2004).
	Compression	E.g., compression. A text compression scheme that allows fast searching directly in the compressed file (Manber, 1997).
Audio	Pattern recognition	E.g., recognition. Classification of closed- and open-shell pistachio nuts using voice-recognition technology (Cetin, Pearson, & Tewfik, 2004).
	Quality keeping,	E.g., coding. Mpeg digital audio coding (Noll, 1997).
	Conversion	E.g., conversion. A Voice Conversion Method based on Joint Pitch and Spectral Envelope Transformation (En-Najjary, Rosec, & Chonavel, 2004).
	Compression	E.g., compression. MPEG digital audio coding (Noll, 1997).
	Quality keeping,	E.g., noise removal. Noise reduction in audio signals based on the perceptual coding approach (Czyzewski & Krolikowski, 1999).
	Data transmission	E.g., transmission. Efficiently self-synchronized audio watermarking for assured audio data transmission (Wu, Huang, Huang, & Shi, 2005).
Animation	Quality keeping,	E.g., coding. Coding of animated 3D wireframe models for internet streaming applications (Varakliotis, Ostermann, & Hardman, 2005).
	Conversion	E.g., conversion. Automatic Conversion of Natural Language to 3D Animation (Ma, 2006).
	Compression	E.g., compression. Progressive compression and surface analysis for 3D animation objects using temporal discrete shape operator (Tseng, 2007).

Medium	**CS research focus**	**Research examples**
Video	Quality keeping,	E.g., coding. Performance of image and video processing with general-purpose processors and media ISA extensions (Ranganathan, Adve, & Jouppi, 2001).
	Conversion	E.g., conversion. A monolithic video A/D converter (Peterson, 1979).
	Compression	E.g., compression. The MPEG video compression algorithm (Le Gall, 2003).
	Quality keeping	E.g., noise removal. Noise reduction for MPEG type of codec (Li, 1994).
Multimedia combination	**CS research focus**	**Research examples**
Text and image	Pattern recognition	E.g., text and photo recognition. Adaptive Linking between Text and Photos Using Common Sense Reasoning. Keynote Talk (Lieberman & Liu, 2006).
	Data transmission	E.g., text and photo transmission. An encrypto-stego technique based secure data transmission system (Sharma, Bhatia, & Gupta, 2003).
Text and audio; Text and additive audio	Pattern recognition	E.g., text and voice recognition. Synchronizing text/visual information with audio playback (Trovato, Li, & Ramaswamy, 2006).
Audio and animation	Data transmission	E.g., voice and animation transmission. Voice Puppetry (Matthew, 1999).

Summing up the above mentioned findings, we defined the focus of CS discipline towards media and multimedia study. The observed literature indicates that CS researchers focus on the modifications related to computer software and hardware in order to transmit and deliver media which are independent of the meaning that media contained.

2.3.2 Education

The study of media and multimedia in education discipline focuses on creating applications, which contribute to the understanding of subject concept. Researchers strive to have item or service to deliver information using media for a teaching aid. The current study considers the following education forms*: Distance Learning, Inside Learning, and Computer Aid Inc. (CAI).* Distance Learning refers to education in which students take academic courses by accessing information and communicating with the instructor asynchronously over a computer network (Vaughan, 2004). In this study Inside Learning refers to studying process in a class room with a teacher and students. CAI includes balanced outsourcing solutions, legacy support, application development, knowledge capture, desktop services, and managed staffing services (McLuhan, 1964).

Education is one of the main fields where multimedia is executed (Mayer, 1997). Instances of media and multimedia implementation are video encyclopedia, interactive guides, simulators, situational simulation games and many others (Shank, 2005). One example is an on-line encyclopedia, which may provide links to videos and relevant articles regarding study topics. News may include audio commentary, play background video and link to websites with additional information. Another example is on-line lessons. On-line lessons may include explanations, links to resources, simulations, illustrations, photographs, and a lot of options which, in their turn, can include different media fragments (Magued, 2007).

According to the literature review, the main approach to study media and multimedia in education is *to transfer the information* to the user who gains knowledge from training. Each of five media specify for the transferring different type of information. In case of multimedia combinations, researches' focus is similar to the focus on medium in separate. The main difference between media and multimedia focuses is that multimedia study considers two media simultaneously (Means, 1997). Thus, we elicited five different types of information which are used in the education discipline literature review for studying media and multimedia in the approach of transferring the information:

- *Present facts and assumptions.* For example, investigator tends to present facts and assumptions using image medium, where an image medium visually forms a picture of an

item. In addition, image medium form graphics allows creating charts and diagramming to demonstrate conceptual relations or summarize statistics.

- *Transfer scientific information.* Text medium assumes to transfer scientific information. Text allows transferring a lot of concrete and precise information, such as facts, concepts and statistic data.
- *Expand notion of different phenomenon, represent action.* According to reviewed studies, the usage of audio medium helps to transfer those types of information. Moreover, teaching with audio medium helps to impact training of more human and personal character which is an essential part for researchers of educational sphere.
- *Transmits and display changes over time.* Researchers focus on possibility of this type of information using animation and video media.
- *Processes simulation.* According to the literature review, the usage of animation and video media for transferring information suggests to present it as simulations of processes.

Table 2.3 provides research examples for studying five media and four multimedia combinations in education discipline. According to reviewed literature, education discipline focuses on executing media for learning by transferring meaningful study information. Multimedia in education discipline is used as a tool in study with computers-based applications or other information technologies where applications can be applied.

Table 2.3: Education approach (transfer the information): focus on creating applications, which contribute to understanding the subject concept

Medium	**Education research focus**	**Research examples**
Image	Transferring information	E.g., present facts and assumption. The Visual Understanding Environment project ("The Visual Understanding Environment", 2008).
Text	Transferring information	E.g., transferring scientific information. User Centered Design of Hypertext and Hypermedia for Education (McKnight, Dillon, & Richardson, 1996).
Audio	Transferring information	E.g., present facts and assumption, expand notions of phenomenon, and represent actions. Preparing Materials for Open, Distance and Flexible Learning: An Action Guide for Teachers and Trainers (Rowntree, 2004).
Animation	Transferring information	E.g., transmitting and displaying changes over time, and processing simulation. Animation Software with Young Bilingual Students Learning Science, Journal of Educational Computing (García, 1998).
Video	Transferring information	E.g., transmitting and displaying changes over time, and processing simulation. Effective Distance Education Planning: Lessons Learned (Willis, 1998).
Multimedia combination	**Education research focus**	**Research examples**
Text and image	Transferring information	E.g., text and image in learning words. The effectiveness of multimedia programmes in children's vocabulary learning (Acha, 2009).
Text and audio; *Text and additive audio*	Transferring information	E.g., text and audio in instructions. Audio and Text Density in Computer-Based Instruction (Koroghlanian & Sullivan, 2000).
Audio and animation	Transferring information	E.g., audio and animation in instructions. The Effect of Audio and Animation in Multimedia Instruction (Koroghlanian & Klein, 2004).

2.3.3 Psychology

The approach to apply multimedia in psychology is twofold: on the one hand psychology uses *multimedia as a tool* and on the other hand psychology studies *multimedia-user interaction*. From the one perspective, psychology observes multimedia as a tool and uses multimedia in order to process the result of psychological research (Random House, 2006). An example of the approach (multimedia as a tool) focus: text and image usage in PowerPoint presentation of the psychological research. From the other perspective, psychology studies how multimedia affects human being (multimedia-user interaction). According to the literature review, the common focus in the current approach is on study of direct multimedia-user interaction (Gillani, 1998). In multimedia-user interaction psychologists are interested in two study directions:

- *Perception and interpretation.* Psychology studies reaction of how person perceives (emotions and feelings occurred of perceiving multimedia) and interprets (purpose of multimedia creation and meaning individual empty into the multimedia) multimedia. For example, in study image medium, researcher focuses on meaning which individual inserts into that image. In case of audio medium, study deals with feelings and emotions which lead person during conversation with other people or while listening to audio files. Psychologists in animation and video media study are interested in person's reflection from animation or video.
- *Multimedia reflection.* A psychologist studies how multimedia reflects on people. The research of how people react while gaining information through text and image multimedia can be an example of this approach focus (Zhang, Wang, Zhao, Li, & Lou, 2008). For example, psychologists are not interested in text characters or other elements the text consists of. Researchers focus on objectives, on purpose of text creation and its meaning (Fenrich, 2005).

Selected research focus is on multimedia-user interaction. In other words, our focus is to use psychology while creating and applying multimedia in various fields. Therefore, we need to mention *s*tudy of cognitive psychology (Gillani, 2003). There are many studies and researchers regarding principles of perception and cognition underlying computer-based multimedia systems.

Furthermore, there is a lot of information for developing skills in order to apply media and multimedia (Doorn & Vries, 2000; Gillani, 2003; England & Finney, 1999).

The study of media and multimedia in psychology has various directions, such as educational psychology for multimedia technology (Weiner & Freedheim, 2003), psychology of advertising and media (Giles, 2003), colour logic for website design (Morton, 2001), using colour to influence decision making (Miner, 1990) and many others. The main and the most distinctive feature of the media in psychology discipline is that researchers focus on its meaning and human emotions instead of the whole object content. According to the literature review, psychologists in multimedia study focus on person's comprehension and interpretation of multimedia as well as multimedia reflection on human being. Table 2.4 illustrates summary of psychological approach focus to study media and multimedia, and presents the discipline research examples.

Table 2.4: Psychology approach (multimedia-user interaction): focuses on how multimedia affects on human being

Medium	Psychology research focus	Research examples
Image	Perception and interpretation	E.g., meaning person implies to the image. Visual intelligence: perception, image, and manipulation in visual communication (Barry, 1997).
Text	Multimedia reflection	E.g., reflection of text. Redundancy and word perception during reading (Zola, 1984).
Audio	Perception and interpretation	E.g., conversation: direction of speaker's intention: emotions, feelings.Voice and speech quality perception: assessment and evaluation (Ute, 2005).
	Multimedia reflection	E.g., narration: direction of author's intention. The Effects of Voice Changes on Orienting and Immediate Cognitive Overload in Radio Listeners (Potter, 2000).
Animation	Perception and interpretation	E.g., emotions and feelings. Practical Behavioural Animation Based on Vision and Attention (Gillies, 2001).
	Multimedia reflection	E.g., reflection. A perception experiment with time-critical graphics animation on the World-Wide Web (Hecht, Oesker, Kaiser, Civelek, & Stecker, 1999).

Medium	**Psychology research focus**	**Research examples**
Video	Perception and interpretation	E.g., emotions and feelings. Perception of emotion from dynamic point-light displays represented in dance (Dittrich, Troscianko, Lea, & Morgan, 1996).
	Multimedia reflection	E.g., reflection. Environmental perception: The effects of media, evaluative context, and observer sample (Feimer, 1984).
Multimedia combination	**Psychology research focus**	**Research examples**
Text and image	Perception and interpretation	E.g., perception of text and photo. Effects of Photographs on the Selective Reading of News Reports (Zillmann, Knobloch, & Yu, 2001).
Text and audio; *Text and additive audio*	Perception and interpretation	E.g., perception of text and voice media. Can speech perception be influenced by simultaneous presentation of print (Frost, Repp, & Katz 2004)?
Audio and animation	Perception and interpretation	E.g., perception of voice medium accompanies animation (animated face). Visual Prosody and Speech Intelligibility: Head Movement Improves Auditory Speech Perception (Munhall, Jones, Callan, Kuratate, & Vatikiotis-Bateson, 2004).
	Multimedia reflection	E.g., reflection of use voice and animation. The Effects of Pedagogical Agent Voice and Animation on Learning, Motivation and Perceived Persona (Baylor, Ryu & Shen, 2003).

The literature review indicates that psychologists focus mainly on the meaning given to each medium and the interpretation of people to this medium. The outcomes of psychology can be used by diverse disciplines such as education, entertainment, and marketing. In other words, psychology is a fundamental science which is used as a base for many disciplines.

2.3.4 Art & Entertainment (A & E)

In the current study, A & E are industries that provide entertainment and deliver art to society using such tools as television, cinema, theatre, sports, games, music and etc. In the field of Art, there is a multimedia artist, whose mind is able to blend techniques using different media that incorporates interaction with the audience (Godse & Godse, 2009). Entertainment field illustrates a wide multimedia impact. Media and multimedia is considered as a technology which makes possible to develop special effects in movies, developing multimedia games, and video games (Peterson & Kellogg, 2008; Celant & Maraniello, 2008). Example of multimedia usage in the A & E is a musical CD-ROM, which allows not only listening to composition of a composer, but also view on a screen score, mark out and listen to selected musical composition (Shlikova, 2004). Another example is recording on interactive videodiscs or presenting on-line version of fund art museums (Lehman, 2006; "Natural History Museum", 2010).

According to the literature review, one of the main approaches in A & E field is *an entertainment providing and art delivering*. In studying media and multimedia in A & E is the focus on wishes and feelings of people in order to adapt and satisfy users' requirements and attract them as customers. We emerge five major focuses available in the A & E literature review:

- *Meaning that author implies.* A & E investigators concentrate their attention upon a meaning author implies to media and multimedia, focus on the emotions and feelings of the author (Peterson & Kellogg, 2008). A & E studies image, text, audio, and animation media from the perspective of how people want to express information through text, image, music, speech, or animation. Researchers attempt to answer the question: What message does the author try to deliver?
- *Meaning that user perceives.* The focus is on the meaning which user perceives through different media and how user interprets the media. For example, researchers concern about how a user perceives a particular message through text, image or animation media. In case of video medium, researchers focus on human interpretations of video document.
- *Transferring meaning.* Researcher focuses on how to insert the concrete information to the medium or media, and to deliver medium or media with particular meaning to a user. For

example, researches study different possibilities to deliver particular message to a user through image, animation, and video.

- *Attracting attention.* One of the focuses in A & E is the attraction of people attention as spectators and consumers. Media and multimedia are observed as additional tools to attract users' attention. For example, there are special entertainment areas for children in airports or supermarkets where there is an interactive screen with the use of voice and animation multimedia combination in playing games ("Redbox Multimedias", 2010). This multimedia combination attracts children attention and keeps their interest throughout playing game while parents are waiting for a flight or go shopping (Story & French, 2004).
- *Stimulate imagination.* The focus is on the creation of mental image and association using different media for the purpose to enhance people experience and generate new ideas.

Researchers in A & E attempt to stimulate people imagination using multimedia combinations. For instance, voice and animation combination can present human-computer interface in automobile communication system (Liu & Ostermann, 2008). The interface uses human voice and animation of human being which simulates real communication and supposes to stimulate users' imagination. Table 2.5 illustrates A & E focuses on studying five media and four multimedia combinations.

The literature review indicates that psychology focuses on understanding emotions of individuals and on the meaning of media, whereas A& E uses outcomes from the psychology in stimulating people's imagination and entertain audience by using media and multimedia in games or movies, in television programs, etc.

Table 2.5: A & E approach (entertainment providing and art delivering): focus on wishes and feelings of people, focus on user performance and user satisfaction

Medium	A & E research focus	Research examples
Image	Meaning that author implies	E.g., meaning that author implies to an image. Perception and Art: Water Imagery in Nada (Thompson, 1985).
	Meaning that user perceives	E.g., meaning that user implies to an image. Art and visual perception: a psychology of the creative eye (Arnheim, 1956).
	Transferring meaning	E.g., transferring particular information through an image. A model of destination image formation (Baloglu & Ken, 1999).
Text	Meaning that author implies	E.g., meaning that author implies to a text. The Israeli souvenir: Its text and context (Shenhav-Keller, 1993).
	Meaning that user perceives	E.g., meaning that user implies to a text. Material culture and text: the art of ambiguity (Tilley, 1991).
Audio	Meaning that author implies	E.g., meaning that author implies to an audio. Radio Broadcasting: An Introduction to the Sound Medium, Hastings House (Hilliard, 1985).
	Transferring meaning	E.g., transferring particular information through an audio. Designing audio aura (Mynatt, Back, Want, Baer, & Ellis, 1998).
	Stimulating imagination	E.g., creation of mental representation using audio. Usability and Sociability of the Xbox Live Voice Channel (Hew, Gibbs, & Wadley, 2004).
Animation	Meaning that author implies	E.g., meaning that author implies to an animation. The possibility of kinetic typography expression in the Internet art museum (Uekita, Harada, & Furukata, 1999).
	Meaning that user perceives	E.g., meaning that user implies to an animation. Meaning from motion: exploring the affective properties of simple animation (Ai, 2005).
	Attracting attention	E.g., reflection of animation to a user. Promoting Socio-Cultural Values Through Storytelling Using Animation and Game-Based Edutainment Software (Zin, Nasir, & Ghazali, 2010).

Medium	A & E research focus	Research examples
Video	Meaning that user perceives	E.g., meaning user implies to a video. Semantic Modelling for Video Content-Based Retrieval Systems (Al Safadi & Getta, 2000).
	Transferring meaning	E.g., transferring particular information through a video. Infants' perception of goal-directed actions on video (Hofer, Hauf, & Aschersleben, 2007).
	Stimulating imagination	E.g., creation of mental representation using a video. The Movies As Medium (Lewis, 1970).
Multimedia combination	**A & E research focus**	**Research examples**
Text and image	Transferring information	E.g., transferring particular information through text and image. Attention Capture and Transfer in Advertising: Brand, Pictorial, and Text-Size Effects (Rik & Wedel 2004).
	Attracting attention	E.g., reflection of text and image to a user. Group storytelling for team awareness and entertainment (Schäfer, Valle, & Prinz, 2004).
	Stimulating imagination	E.g., creation of mental representation using text and image. Handbook of visual analysis (Van Leeuwen & Jewitt, 2001).
Text and audio; *Text and additive audio*	Stimulating imagination	E.g., creation of mental representation using text and audio. Synchronized soundtracks for e-books ("Synchronized soundtracks for e-books", 2011).
Audio and animation	Attracting attention	E.g., reflection of audio and animation to a user. An investigation into the effects of Text-To-Speech voice and 3D avatars on the perception of presence and flow of live help in electronic commerce (Qiu & Benbasat, 2005).
	Stimulating imagination	E.g., creation of mental representation using audio and animation. Realistic Talking Head for Human-Car-Entertainment Services (Liu & Ostermann, 2008).

2.4 Summary

In this chapter we define the terms of medium, five media (text, image, audio, animation, and video) and multimedia which we use throughout all study. Moreover, we utilize dual coding theory and Mayer's theory which supports dual coding theory by proposal of using two media in multimedia combination. There are three principles in Mayer's study which support our decision in limiting to two media: dual coding, limited capacity of human brain, and redundancy effect. Thus, we exploit four Mayer's multimedia combinations for selecting information. Those combinations are supposed to be relevant for selecting information, which is the key aspect for our selection.

In order to expand our knowledge in the field of media and multimedia, we explore four disciplines where defined media and multimedia are studied. Although, the literature review provides us with understanding of media and multimedia usage in different disciplines, we continue gaining a thorough understanding in researching multimedia in a field of mobile phones. It is required to explore the profound presentation of mobile multimedia application according to user multimedia preferences. We tend to obtain a framework among existent studies, where researchers investigate or consider user multimedia preferences for selection of information in a mobile phone. The next chapter presents a review of the existent studies in the same disciplines which were presented in this chapter, but with the focus on mobile multimedia.

Chapter 3

How multimedia on mobile devices is used and studied?

In Chapter 2 we analyze media and multimedia concept through the theoretical data. Theoretical data in Chapter 2 also assists to focus on two media in multimedia combination (Mayer, 2008). Moreover, previous chapter reveals four multimedia combinations from Mayer's study adapted for the current study. The further review describes how media and multimedia studied in four disciplines and presents several approaches of those disciplines to use media and multimedia.

Continuing our research on multimedia, the aim of this chapter is to obtain a framework of user multimedia preferences in mobile phones application in different studies. Following the aim of this chapter, we conduct the scientific search of the existent studies. To be systematic in the current literature review, our search focuses on five well-known on-line academic databases: ACM Digital library[1], ScienceDirect[2], IEEE[3], EdItLib[4], and Ebsco[5]: British Journal of Educational Technology. In order to be consistent in our research, we refer to the same disciplines as in the literature review in section 2.4: computer science (CS), education, psychology, and art & entertainment (A & E).

[1] Advancing Computing as a Science and a Profession ("ACM", 2010), ACM Digital Library of computer science literature, which contains: ACM Journals, ACM Magazines, Transactions, Proceedings, Newsletters, Publications by Affiliated Organizations, Special Interest Groups (SIGs), ACM Oral History interviews.

[2] ScienceDirect is a leading full-text scientific database offering journal articles and book chapters from more than 2,500 peer-reviewed journals and more than 11,000 books ("ScienceDirect", 2010).

[3] The IEEE Computer Society Digital Library **(**CSDL) provides online access to 27 society magazines and transactions and more than 3,300 conference publications ("IEEE", 2010).

[4] EdItLib - Education and Information Technology digital library. The Digital Library is a valuable online resource of peer-reviewed and published international journal articles and conference papers on the latest research, developments, and applications related to all aspects of Educational Technology and E-Learning ("EdItLib", 2010).

[5] Ebsco, JN "British Journal of Educational Technology" – "Articles cover the whole range of education and training, concentrating on the theory, applications and development of learning technology and communications" ("Ebsco", 2010).

It is necessary to point up one more time our interest in Mayer's theory, namely in the goal of informing in e-learning and in the active learning principles, where the step of selecting information is described. In order to keep this focus we define keywords that correspond to our interest for the use in database search system. This must systemize our search and provide required information in structured way. The next section outlines the strategy for searching, including databases searched, search filtering, time limits, and keywords generated for the review. Besides, in the current chapter there are parameters and methodology of the analysis conducting, and further analysis of the articles obtained.

3.1 Search filtering

The search period is February 2010. The publication access is occurred through electronic document search in academic databases: ACM Digital Library, ScienceDirect, IEEE, EdItLib, Ebsco: British Journal of Educational Technology. The current literature review uses advanced search tab available in every database's page in search area. Examining the search options, we define four filtering criteria for the articles selection:

- *Article database indexed criteria.* The article database indexed criteria refers to databases that we have decided to use for the study and which are common in the EdTech Research Group. Those databases are ACM, IEEE, EdTecLib, Ebsco, and ScienceDirect.
- *Search filtering criteria.* We use two search filtering options in the database search forms: *keywords* and *title*. Keywords refer to author's keywords, index items, and exact phrase mentioned in the article, whereas title refers to the article name. We input the same key phrase in the filling cells for keywords input and title input.
- *Time limits: 2005 plus criteria.* The criteria means that selected articles dated between 01.2005 and 02.2010 (the time the search was issued).
- *Keywords combination criteria.* There are two sets of keywords which we use in different databases: *basic search keywords* and *modified search keywords.* The basic search keywords set was applied in ACM, ScienceDirect, IEEE, EdItLib databases. Modified search keywords were used for the search in Ebsco: British Journal of Educational

Technology database. After using the basic search keywords, we polish and modify them in order to get modified search keywords. Table 3.1 contains all keywords used in the article search. Table 3.2 provides the search results, based on the mentioned above criteria.

Table 3.1: Search keywords

Basic search keywords	**Modified search keywords**
Mobile multimedia	Multimedia
Mobile multimedia learning	Mobile multimedia
M learning (mLearning)	Mobile learning

The total number of articles returned by the search is 200. There are 172 articles with the basic search keywords collected in ACM, ScienceDirect, IEEE, EdItLib databases, and 28 articles with additional search keywords in Ebsco: British Journal of Educational Technology. The majority of articles are collected from IEEE database (127 articles). According to Table 3.2 the second place in the rank is occupied by Ebsco (28 articles), following by ACM, EdITLib, and ScienceDirect databases. According to keywords combination criteria, the mobile multimedia keywords indicate the largest number of articles in 141 articles. There is a considerable difference with the next set of articles which is only 20 articles big. 19 articles indicate the following m learning and mLearning keywords. The search result with mobile multimedia learning contains 13 articles. The smallest number of articles belongs to mobile learning keywords.

Table 3.2: Collected articles from five databases in the period 01.2005 - 02.2010

Keywords	Basic search				Modified search	Total
	ACM	**ScienceDirect**	**IEEE**	**EdITLib**	**Ebsco**	
	1) Author's keywords 2) Title	1) Author's keywords 2) Title	1) Index terms 2) Title	1) Exact phrase or Advanced Boolean Search 2) Title	1) KW author-supplied keywords 2) Title	
Mobile multimedia	20	5	114	1	1	141
Mobile multimedia learning	2	0	8	3	-	13
M learning	3	3	0	0	-	6
mLearning	0	0	5	8	-	13
Multimedia	-	-	-	-	20	20
Mobile learning	-	-	-	-	7	7
Total	**172**				**28**	**200**
	25	8	127	12	28	

3.2 Data analysis details

Types of articles

There are two types of articles presented in the current literature review. First is an *original type* which refers to article that contains information such as media and multimedia used in the article, and discipline which studies media and multimedia in the research. Second is a *Literature Review (LR).* This type occurs only in Ebsco database. The LR article contains several short articles reviews. However, according to reviews mentioned in the article, it is not possible to define its discipline focus or media and multimedia used.

Methodology

For the analysis purpose we obtain two parameters which support our analysis. Obtaining the answers to the analysis parameters are based upon reading the found article's title and abstract. In cases the data in title and abstract do not provide answers to the analysis parameters, we search the entire article on the availability of valid answers. In order to research consistency, we analyze articles with the same parameters as in the literature review in section 2.4: the Target Discipline and Media and Multimedia Used. The details considering those parameters are described below.

- *Target Discipline* parameter refers to the discipline which studies media in the article. We define the same disciplines used in the section 2.4 literature review, which are computer science (CS), education, psychology, and art & entertainment (A & E). According to section 2.4, CS focuses on software and hardware modification with the purpose to improve quality of different media parameters in order to transmit and deliver media without focusing on its meaning. Education in section 2.4 considers approaches to employ media and multimedia in learning environment with the purpose to transfer meaningful information. Psychology includes focus on individual media and multimedia perception and interrelation of it. A & E is explained in section 2.4 as a direction which uses media and multimedia technology in order to attract people's attention, understand meaning that an author implies to the different media or meaning a user perceives through media. In addition, A & E are presented with the focus on stimulating people's imagination using different media and multimedia.
- *Media and Multimedia Used* parameter refers to five media and multimedia combinations which are defined in Chapter 2 and used throughout the article. It is necessary to point up that considerable number of articles in the current literature review consolidates different multimedia combinations and media into one term called multimedia. Thus, in our current literature review we unite different multimedia combinations in one type: multimedia. Moreover, there are articles which observe only one medium per article.

3.3 Data analysis

The current section describes the data collected from each of the selected studies. The analysis investigates the existent researches in the field of mobile multimedia in five databases, using certain constrains and samples. There are 200 articles participating in the analysis. 192 articles among 200 have ordinary type, and 8 articles have LR type. Throughout the analysis we mention LR article type in order to explain information deficiency (no information about such parameters as Target Discipline or Media and Multimedia Used occurred in some articles). The current analysis examines two data parameters: Target Discipline and Media and Multimedia Used in articles.

Target Discipline

As it is mentioned in section 3.2, there are four target disciplines defined in section 2.4: CS, education, psychology, and A & E. It is important to note that there are articles which contain two study directions, for instance, CS and education. Thus, we duplicate article to each discipline: one point to the CS and one to education. Table 3.3 illustrates the number of articles belonging to the disciplines defined previously.

Table 3.3: Topic directions observed in the literature review

Topic direction	Count (N)	Percentage (%)
CS	**139**	67,2
Education	37	17,7
Psychology	9	4,4
A & E	14	6,8
Not possible to classify (LR type)	8	3,9
Total	207	100

In addition to Table 3.3, Figure 3.1 demonstrates a pie chart with the percentage of topic directions observed in collected data. CS topic direction has the major number of articles. Then comes education with 17.7% of articles. Third largest number of articles has psychology direction, to which come ten per cent of all articles, followed by LR article type with slightly less number of articles. A & E topic direction has the smallest number of articles, which is 3.9% overall.

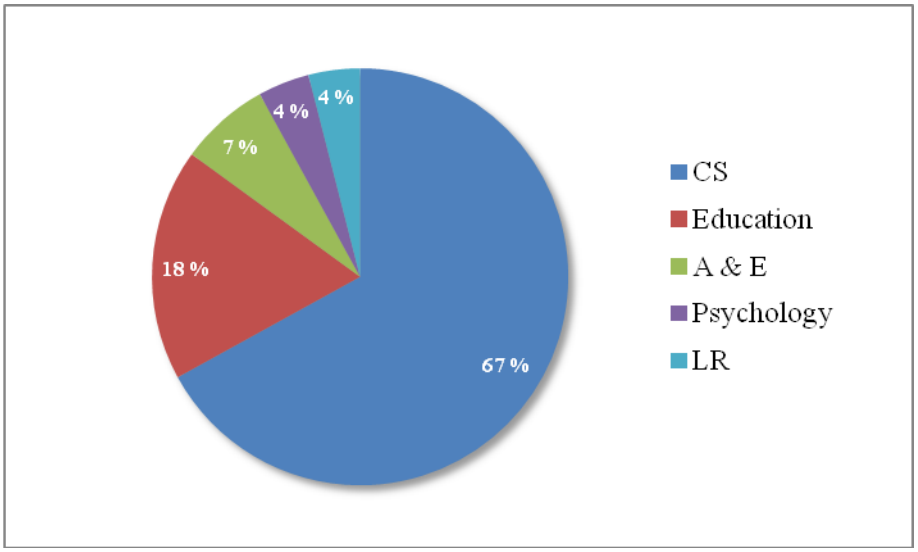


Figure 3.1: Target discipline observed in collected data

Media and Multimedia Used

Table 3.4 illustrates the division of the media and multimedia used in the literature review studies. The result demonstrates that 166 articles among 200 observe multimedia, which is considerably higher than observation of different media in separate. The literature review comprises 14 articles with video medium focus, whereas image medium acquired only in seven articles. Text and audio media occurred in three and two articles respectively. In addition, there are eight articles with LR type, and therefore, do not comprise any media and multimedia used in the article.

Table 3.4: Media and multimedia used in data samples

Media and multimedia used	Count (N)	Percentage (%)
Multimedia	**166**	83
Video	14	7
Image	7	3,5
Audio	2	1
Text	3	1,5
Not possible to classify (LR type)	8	4
Total	200	100

Figure 3.2 presents percentage representation of media and multimedia observed in the literature review. The major number of considered articles (83%) elucidates multimedia combinations, whereas only 12% of articles observe different media in separate. Moreover, 4% of the article samples belongs to indeterminate type of articles and do not consider Media and Multimedia Used parameter.

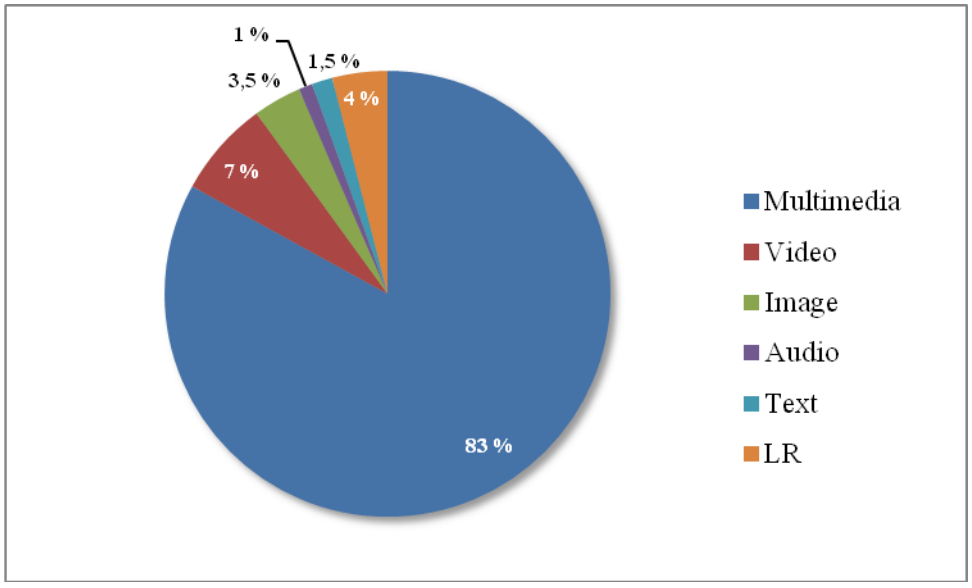


Figure 3.2: Media and multimedia studied in collected data

3.4 Data discussion

According to target discipline parameters' results, the major studies focus on CS. However, CS discipline does not study the way of delivering information in the sense of informing a user and selecting information for delivering. In addition, there is no focus on user preferences in the delivering information. Despite the fact that our keywords focus on multimedia, there are articles which include single medium in the content. We obtained the estimated result in Media and Multimedia Used parameter, where considerable number of articles observes multimedia combinations in their research. However, in the most articles it is not evident what multimedia combination researchers use in their studies. In other words, researchers use general word "*multimedia"* while refer to different multimedia combinations without distinguishing the combination. Moreover, there is a deficiency of particular suggestions regarding multimedia combinations used for delivering information.

We do not gain a clear framework or reference regarding user multimedia preferences for selecting and delivering information in mobile phones. Thus, we suggest the necessity for more research on delivering information with use of multimedia in mobile devices from the perspective of end-user preferences. In order to gain the understanding in end-user multimedia preferences we tend to gather empirical data. For the purpose to obtain a concrete opinion about user multimedia preferences, in the following chapter we revise our multimedia focus on media in separate. In other words we review media, not combinations of it. This revision supports us to answer question e. *How does a user appreciate the media?* Thus, based on user media preferences, we are able to synthesize multimedia combinations.

3.5 Summary

In Chapter 3 we focused on mobile multimedia. However, we detect that the most studies are in CS, which defers to our focus to deliver and select information through mobile phone according to user multimedia preferences. Subsequently, we do not obtain a clear framework with

experience in user multimedia preferences in mobile phone. Thus, we aim to gather empirical data and research media and multimedia from the perspective of user preferences in current chapter (question e. *How does a user appreciate the media?*).

Chapter 4

User appreciation of media

This chapter illustrates the quantitative survey analysis which assists us to collect the empirical data of user media preferences for delivering information in order to answer the question e. *How does a user appreciate the media?* The empirical data is collected from the temporary web-based survey. The survey instrument is the *Mobile and Media Usage* questionnaire. Initially, the survey questionnaire was designed to measure a user level of multimedia use in mobile and opinion about the usage of media for perceiving different information. However, in the current study we study only users' opinion regarding the usage of media for perceiving different information. The questionnaire is developed, pre-tested and further a few modifications were applied to the original questionnaire. The survey is available in appendix A. The report contains a statistical analysis of the data gathered from the temporary web-page survey available online from 14.04.2010 to 14.05.2010. During this period 114 responses were collected. The following sections contain the survey details with media sets modification as well as the analysis details and obtained data analysis.

4.1 Survey details

The questionnaire consists of three modules: *Demographics, Mobile Device Usage,* and *Media Usage*. Based on analysis purpose we reduce Mobile Device Usage module for further analysis. The first four questions (Demographics module) in the survey elicit information on the demographic characteristics of the respondents. Other questions (Media Usage module) are about

respondents' opinion and preferences to gain information through the media. Media Usage module includes three sub-modules with questions about respondents' media preferences in gaining three different types of information: *general information, historical information*, and *mathematical information.* General information refers to information, which individual perceives in everyday life, such as conversation, different life pictures, music on radio. Historical information refers to information related to historical events, narration about significant historical event, images of different wars recorded in history, and animation contains sequences of images which explain historical topic in a long time period. Mathematical information refers to information that contains explanation of mathematical theories and phenomenon, presentation of mathematical equations and theorems, images which illustrates statistics.

Pre-test

The content validity was determined by conducting a pre-test. The questionnaire was pre-tested among individuals who participated in SciFest 2010 in Joensuu ("SciFest", 2010). The pre-test participants indicated their attention towards audio and image media. Participants were intended to separate audio medium to *voice* medium form and to *sound/music* medium forms. Also, Mayer emphasizes voice medium form in multimedia combinations in his study. Subsequently, we possess sound and music medium forms which are signals of sound, and music playbacks as well as we perform voice medium form which is a signal of voice playback. During the pre-test participants suggested to specify the forms of image medium we refer to. Thus, we refer to Clark and Mayer who employ different image medium forms in their study, such as drawing, charts, graphics, maps, and photo in multimedia combinations. Due to the web-based survey focuses on three different types of information: general, historical, and mathematical, we consider image medium forms which contribute to those information types. We select *photo* and *graphics* medium forms where photo is a reproduction of objects through photos, and graphics is a reproduction of mathematical statistics through schemas or figures.

Based on the pre-test result, a modified survey presents Media Usage module with four media and three medium forms: text, photo, graphics, animation, video, voice, and sound/music, where photo and graphics are the image medium forms, and voice and sound/music are the audio medium forms. Other media mentioned in the survey contain the same definitions as we define in

section 2.2. In order to support user understanding during the survey, we provide additional explanation of media and medium forms.

4.2 Data analysis details

Despite the fact that there are 114 responses in the survey, several questions contain missing answers. Thus, there is no answer category in every frequency count table. In the final report, we present frequency counts as well as converted frequency counts to percentages which exclude no answer data. The main source used for the research analysis was sets of data collected through the questionnaire. There are two main sets of data: demographic data and media data. The web-based survey employed quantitative research techniques with descriptive type of statistics (univariate analysis).

Data type

There are two types of variables collected in web-based survey: *String (qualitative) variable* and n*umerical (quantitative) variable.* String (qualitative) variable is used to measure the values of quality attributes. Usually it refers to categories with no intrinsic ranking (SPSS User Guide, 2006). Examples of the quality attributes values are *gender* and *education*. In order to conduct the quantitative analysis the qualitative data was presented in the fixed set of variables (for example, gender: male, female). Thus, we converted qualitative data into quantitative by labeling each variable with a particular number. In the current survey, numerical (quantitative) variable are associated with scale variable that have precise numerical meaning. The examples of numerical data in the survey is age variable. Moreover, numerical variable is presented in the responses to the question where a user requires creating the preferences order list of seven different media and medium forms.

Methodology

The questionnaire was used and analyzed quantitatively. The goal of the quantitative analysis is reveal user media preferences. The application of descriptive statistics was calculated to describe

and summarize the empirical data processing, represent data in graphs, tables, etc. Example of descriptive statistics used in the current chapter is univariate analysis. *"In univariate analysis we examine variables precisely and in detail and get to know data intimately"* (Bernard, 2006, p. 458). In the current study we apply two methods of univariate analysis. They are *frequency* and *graphical* methods. Frequency distribution is a measure of how many times each value occurs in the set of observations. In order to visual our results there is a tabular representations of data. Frequency table consists of rows and several columns. Each row describes one possible value. The first column *value* shows the value which variable can posses. The *frequency* column contains the number of observations that correspond to each answer to a question from the survey. The third column *valid percent* calculates the percentage of the values excluding the missing cases. Follows the frequency table there is a graphical illustration of data using a pie or a bar chart. We present a brief introduction of demographic data in the analysis. Further, there is an analysis of user media preferences in order to gain three different types of information using descriptive analysis.

4.3 Data analysis

We received 114 completed responses to the survey in the 30 day period. As it was mentioned before, the survey has two analysed modules: Demographical module and Media Usage module. Each module is discussed separately in the following subsections: Respondents Profile and Media Data Analysis.

4.3.1 Respondents profile

The prevalent quantity of respondents' gender is male (79 individuals), compared to 35 female respondents. The considerable part of respondents belongs to age group from 20 to 25, whereas the smallest number of respondents is in the group from 35 to 39 years old. The youngest respondent registered during the survey is 17 years old, whereas the oldest is 55. The highest per cent of respondents' occupation belongs to student (71.4%) and the lowest to the self- employee (0.9%) and unemployed (0.9%). Besides, there are 26.8% of respondents who are employees.

Further, we observe educational level of the respondents. The major number of respondents is owners of Master degree or study at the Master's level. On the next place among respondents are those who either are getting Bachelor degree or who have already owned it. The least popular educational level presented in the survey is Basic school with only one response.

4.3.2 Media data analysis

The current section presents the survey analysis of Media Usage module. There are seven media and medium forms to observe: text, photo, graphics, animation, video, voice, and sound/music. The results from the Media Usage module are presented in three sub-modules divided by information type: general, historical, and mathematical. The question for each sub-module states as *"Please, rate the following media from 1 to 7 according to your preferences"*. By "*following"* we denote seven media and medium forms mentioned above. In the question we use a *"1-7"* rating scales. The respondent must enumerate every medium or medium form in a way that the most preferred has the number *"1"*, and the least preferred has the number *"7"*. There are no neutral answers such as *"I do not know"* or "*no opinion"*. This approach aids to gain relevant answer and prevent the possibility of getting missed data.

The use of media in perceiving information with general type

There are 113 respondents who provided the valid responses to this question and one individual who skips the question. Table 4.1 illustrates both frequency distribution and percentage ratio of values obtained from respondents rating activity. The generality of respondents (60.2%) considers obtaining general information through text medium is important, and thus, ranks text as the first in their priority. Individuals assess their agreement with the statement about photo importance only on a second place in the rate (32.7%). Video has a neutral position in the rate and gained fourth position in the seven rate scale. 23% and 20.4% individuals contemplate graphics and voice media penultimate in rank. 33.6% respondents vote for the animation medium as the least important for gaining general information. Likewise 27.4% vote for the audio medium.

Table 4.1: Frequency and percentage statistics: Media and medium forms preferences for the delivering general information type

Media and medium forms			Rank							Sum
			1	2	3	4	5	6	7	
Text		%	**60.2**	15.0	6.2	5.3	1.8	1.8	9.7	100.0
		N	68	17	7	6	2	2	11	113
Image	Photos	%	6.2	**32.7**	25.7	15.9	9.7	7.1	2.7	100.0
		N	7	37	29	18	11	8	3	113
	Graphics	%	8.8	12.4	17.7	10.6	17.7	**23.0**	9.7	100.0
		N	10	14	20	12	20	26	11	113
Animation		%	4.4	6.2	8.8	9.7	15.9	21.2	**33.6**	100.0
		N	5	7	10	11	18	24	38	113
Video		%	11.5	15.9	18.6	**24.8**	21.2	4.4	3.5	100.0
		N	13	18	21	28	24	5	4	113
Audio	Voice	%	9.7	9.7	11.5	18.6	16.8	**20.4**	13.3	100.0
		N	11	11	13	21	19	23	15	113
	Sound, music	%	5.3	8.0	9.7	15.0	13.3	21.2	**27.4**	100.0
		N	6	9	11	17	15	24	31	113

The use of media in perceiving information with history type

Despite the fact that there are 114 respondents who participated in the survey, there are 111 who answer to particular question, as well as one respondent among 111 who skips evaluation of animation medium. Table 4.2 illustrates both frequency distribution and percentage ratio of values obtained from respondents rating activity. Almost half of respondents (48.6%) presume it is important to obtain historical information through text medium. Thus, people rank text as the first in their priority. Photo medium is considered as important among respondents with 36.9%. However, individuals assessing their agreement with the statement about photo medium importance only as a second place in the rate. According to 29%, video has the third position in the rate. 19.8% and 26.1% individuals contemplate graphics and voice media penultimate in rank. 26.4% and 38.7% of respondents vote for the animation and audio as the least important media for gaining historical information.

Table 4.2: Frequency and percentage statistics: Media and medium forms preferences for the delivering historical information type

Media and medium forms			Rank							Sum
			1	2	3	4	5	6	7	
Text		%	**48.6**	11.7	9.9	7.2	8.1	5.4	9.0	100.0
		N	54	13	11	8	9	6	10	111
Image	Photos	%	4.5	**36.9**	18.0	16.2	17.1	5.4	1.8	100.0
		N	5	41	20	18	19	6	2	111
	Graphics	%	7.2	15.3	17.1	18.0	13.5	**19.8**	9.0	100.0
		N	8	17	19	20	15	22	10	111
Animation		%	5.5	12.7	8.2	13.6	15.5	18.2	**26.4**	100.0
		N	6	14	9	15	17	20	29	110
Video		%	26.1	12.6	**26.1**	11.7	11.7	8.1	3.6	100.0
		N	29	14	29	13	13	9	4	111
Audio	Voice	%	4.5	12.6	9.0	**27.9**	13.5	26.1	6.3	100.0
		N	5	14	10	31	15	29	7	111
	Sound. music	%	4.5	4.5	9.0	4.5	19.8	18.9	**38.7**	100.0
		N	5	5	10	5	22	21	43	111

The use of media in perceiving information with mathematics type

There are three nonresponse among 114 responses. Table 4.3 illustrates both frequency distribution and percentage ratio of values obtained from respondents' rating activity. There are 44.1% of respondents who consider text as the most important medium to gain mathematical information. According to respondents' preferences, graphics medium is indicated at the first and second places in users' priority with 35.1% of responses who rate it at the first place as well as 35.1% who rate it at the second place. Animation has a third position in the rate with 31.5% of respondents. 23.4% and 31.5% of individuals contemplate photo and video media the fifth in the rank. 23.4% of users vote for the voice medium and consider sixth place in the rate. 59.5% of respondents vote for the audio medium as the least important for perceiving mathematical information.

Table 4.3: Frequency and percentage statistics: Media and medium forms preferences for the delivering mathematical information type

Media and medium forms			Rank							Sum
			1	2	3	4	5	6	7	
Text		%	**44.1**	18.0	9.9	8.1	3.6	5.4	10.8	100.0
		N	49	20	11	9	4	6	12	111
Image	Photos	%	0.9	10.8	16.2	14.4	**23.4**	22.5	11.7	100.0
		N	1	12	18	16	26	25	13	111
	Graphics	%	**35.1**	**35.1**	11.7	4.5	7.2	3.6	2.7	100.0
		N	39	39	13	5	8	4	3	111
Animation		%	4.5	14.4	**31.5**	25.2	10.8	9.9	3.6	100.0
		N	5	16	35	28	12	11	4	111
Video		%	6.3	5.4	8.1	22.5	**31.5**	20.7	5.4	100.0
		N	7	6	9	25	35	23	6	111
Audio	Voice	%	2.7	15.3	18.0	18.9	16.2	**23.4**	5.4	100.0
		N	3	17	20	21	18	26	6	111
	Sound, music	%	5.4	1.8	4.5	5.4	7.2	16.2	**59.5**	100.0
		N	6	2	5	6	8	18	66	111

4.4 Data discussion

Table 4.4 presents the list of media popularity among respondents in three information types. Due to similar fluctuation of media selection in general and historical subjects, we consider these subjects together. In contrast to mathematical subject that answers differ with general and historical subjects in every medium in the rank. The only exception is text medium which considers as the most important medium to perceive all three information types. According to general and historical types, the most popular media and medium forms are text, video, and photo; whereas, the least popular media are audio and animation. Graphics and voice medium forms possess slightly middle position in respondents' priority. According to mathematical type, people' preferences in perceiving media and medium forms are graphics, text, and animation. Likewise, audio and video media are not in the field of respondent's priority. Voice medium form presents middle position in respondents' preferences. Additionally, there is photo medium form that locates after voice medium form.

Table 4.4: Respondents' media preferences according to the web-based survey (three information types)

Rank	Information type		
	General	**History**	**Mathematics**
1	**Text**	**Text**	Graphics
2	**Photo**	Video	**Text**
3	Video	**Photo**	**Animation**
4	Graphics	Graphics	Voice
5	Voice	Voice	**Photo**
6	Sound, music	**Animation**	Video
7	**Animation**	Sound, music	Sound, music

In section 2.3 we explain our consideration of two media in multimedia combinations. Moreover, we select four thesis multimedia combinations based on Mayer's study, which are: text and image, audio and animation, text and additive audio, and text and audio. Based on pre-test result in the current chapter, it is essential to specify the current thesis combinations for our further research. As it was mentioned in section 2.3, the image medium can be any of drawings, charts, graphs, maps, or photo (Mayer, 2005, p. 469). In our case we selected image medium form: photo. According to Mayer's study, audio medium is a narration, which according to our specified definition, is a voice medium form (Mayer, 2001, p. 26). Based on correlation the definitions of the current thesis multimedia combinations with the specific medium forms, we got the current thesis specific combinations (Table 4.5).

Table 4.5: Specified thesis combinations

N	Current thesis combinations	Equivalent		Current thesis specific combinations
		Current thesis media	**Current thesis specific medium forms**	
1	Text and image	text	text	*Text and photo*
		image	photo	
2	Audio and animation	audio	voice	*Voice and animation*
		animation	animation	
3	Text and additive audio	text	text	*Text and additive voice*
		audio	voice	
4	Text and audio	text	text	*Text and voice*
		audio	voice	

Subsequently, there is an incentive to define multimedia combinations from the survey result for further research. According to survey results, there is a text medium which is the most popular among other media. Moreover, it is interesting to combine text medium with the most and least popular media in general and historical subjects, such as photo and sounds/music. As a result we obtain *text and photo* combination as well as *text and sound/music* combination.

The next combination considered for further research is *sound/music and animation*. In general and historical information types, sound/music as well as animation are considered as least popular. However, based on findings in Mayer's study (Mayer, 2001, p. 110) the learning process is supported by relevant sounds or music and animation. Thus, because of empirical and theoretical contradictory findings it is necessary to continue research on this combination.

According to mathematical information type, major part of respondents considers graphics as the most important medium form to perceive information. However, in our further research we do not use mathematical information type: mathematical parameters and any mathematical variables. Therefore, we elucidate graphics medium in further analysis. Furthermore, respondents consider video as one of the most popular medium for perceiving information in general and historical information types. However, due to the research time limitations we do not use video medium for

further testing. Summing up the above mentioned findings from empirical data, we obtain the following multimedia combinations:

- Text and photo;
- Text and sound/music;
- Sound/music and animation.

4.5 Summary

Based on theoretical and empirical data we obtain six multimedia combinations which supposed to be relevant for delivering information. Those combinations are: text and photo, text and additive voice, text and voice, text and sound/music, sound/music and animation, and voice and animation. It is necessary to point up that questions in the survey do not focused particularly on multimedia in mobile phones, and thus, multimedia combinations obtained from this survey requires additional research. Likewise, theoretical multimedia combinations obtained from section 2.5 also do not have particular focus on use in mobile phones. Subsequently, we suggest to observe multimedia combinations listed above from the perspective to apply in mobile phones. It is required to indicate that mobile phone has its own characteristics, and we emphasize the importance raising the attention to its facilities. Hence, we propose the usage of additional human sense for the delivering information in a mobile phone. In the following chapter we suggest to use dual coding theory with the haptic channel while information perception mediating by mobile phones. In order to make our proposal transparent, we observe the multimedia combinations with three channels for delivering information.

Chapter 5

Mayer's theory for mobile phones towards a case study

In the previous chapter we obtained six multimedia combinations from theoretical and empirical data. However, the study and environment used for obtaining the combinations focus on PCs usage or conducted on internet using PCs. Thus, we propose to adapt the six multimedia combinations for the use in mobile phones. Consequently, we observe several studies focused on mobile phones and its facilities. While consider mobile phone versus PCs, it is known the haptic alerts are commonly used on mobile phones in different applications (Luk et. al., 2006). Usually, it is used for background notification providing by vibration stimulus. Authors consider that usage of haptic technologies can enhance visual and auditory interfaces. Moreover, study of mobile multimedia games by Kuts discloses many game applications employ peripherals (Kuts, 2008). Correspondingly, we propose the use of haptic technology for mobile phone application accompany to the six selected multimedia combinations in the current study.

5.1 Including vibration in Mayer's study

In Mayer's theory, there is an implication of dual-coding theory in multimedia which suggests using one medium for perceiving information in visual channel and in verbal channel. In other words, it is possible to say that individual simultaneously uses two sub-systems of *human sensory system.* Human sensory system is responsible for the perception of certain signals (so-called sensory stimuli) from the environment or internal environment and consists of five main sub-systems (Noback, Strominger, Demarest, & Ruggiero, 2005): *visual system, auditory system,*

somatosensory system, gustatory system, and olfactory system. Visual system interprets visual stimulus from an environment and analyzes them. The auditory system is a sensory system which concerned with perception of sound through aural stimulus. Somatosensory system conveys and processes conscious and unconscious sensory information from tactile stimulus. Gustatory system contains a sense of taste which combines the recognition and response to a diverse repertory of gustatory stimulus. Olfactory system perceives and recognizes the odoriferous stimulus from the environment by the olfactory receptors.

Mayer deploys dual-coding theory where there are visual system (in this research stated as visual channel) and auditory system (in the current research called as verbal channel). However, in order to use Mayer's study in mobile phones, we propose additional sub-system for perceiving information. This system is the somatosensory system (further refer to *tactile channel*). Tactile channel involves perception of patterns on skin surface which is studied by haptic technology. Haptic technology is a technology which provides tactile feedback to the user in virtual and real environments (Vashisth & Mudur, 2008). We can assume that haptic technology which is focused on somatosensory system can be an additional incentive for receiving information via mobile phone.

In our research for all combinations we use simple form of haptic technology - transfer of tactile sensations through vibration facility available in almost every modern mobile phone models. User perceives mobile phone vibration as a response to a user's action (usually by pressing particular buttons or satisfying certain application requirements). Vibration provides useful feedback, which helps a user to understand some certain action was done or application is preceding its work.

In order to create a reliable research we accept the possible contradictory results among combinations with haptic technology and without. Hence, we conclude creating one combination without vibration. For the experiment reliability we split text and photo multimedia combination into two combinations: *text and photo (without vibration)*, and *text and photo (with vibration)*.

5.2 Preparing the theory for the case study

Further, we examine the selected multimedia combinations, emphasizing cognitive theory and the science of instruction which Mayer uses in his theory. In addition to visual and verbal channels used in Mayer's study, we consider tactile channel for perceiving information in mobile phone. Based on findings mentioned in the previous chapters we derive following combinations:

1) *MC1: Text and photo (without vibration);*
2) *MC2: Text and photo (with vibration);*
3) *MC3: Text and audio (with vibration);*
4) *MC4: Text and additive voice (with vibration);*
5) *MC5: Text and voice (with vibration);*
6) *MC6: Audio and animation (with vibration);*
7) *MC7: Voice and animation (with vibration).*

We divide the combinations mentioned above into two types of multimedia combinations: *multimedia combination without vibration* and *multimedia combination with vibration*. We provide the description of each multimedia combination type considering Mayer's theory as well as haptic technology.

Multimedia combination without vibration

In current type there is one multimedia combination: MC1. Figure 5.1 shows an illustration of the combination flow according to Mayer's study. In this combination, one or two channels are set in motion (Figure 5.1). Number of channels in current combination depends on user's prior knowledge which reflects on channel conversion. The channel conversion is a process of converting visual image into a sound and vice versa.

According to Mayer's theory, text is registered in the verbal sense (eyes). Then, text medium goes from the eyes/verbal sense to working memory. From working memory, text medium may activate information from sounds. Thus, it may activate visual and verbal channels based on the referential structures that have been developed. The other output which may occur is moving

forward the organizing text into coherent structures through the visual channel, and thus, setting in motion only one channel.

Photo medium form is registered in the verbal sense (eyes). Then, the photo medium form goes from the verbal sense (eyes) to working memory. From working memory, it may activate information from sound (verbal channel). This medium can either provide one output channel by moving to organizing photo into coherent structures using visual images, or provide both channels by additionally activating auditory images in auditory channel.

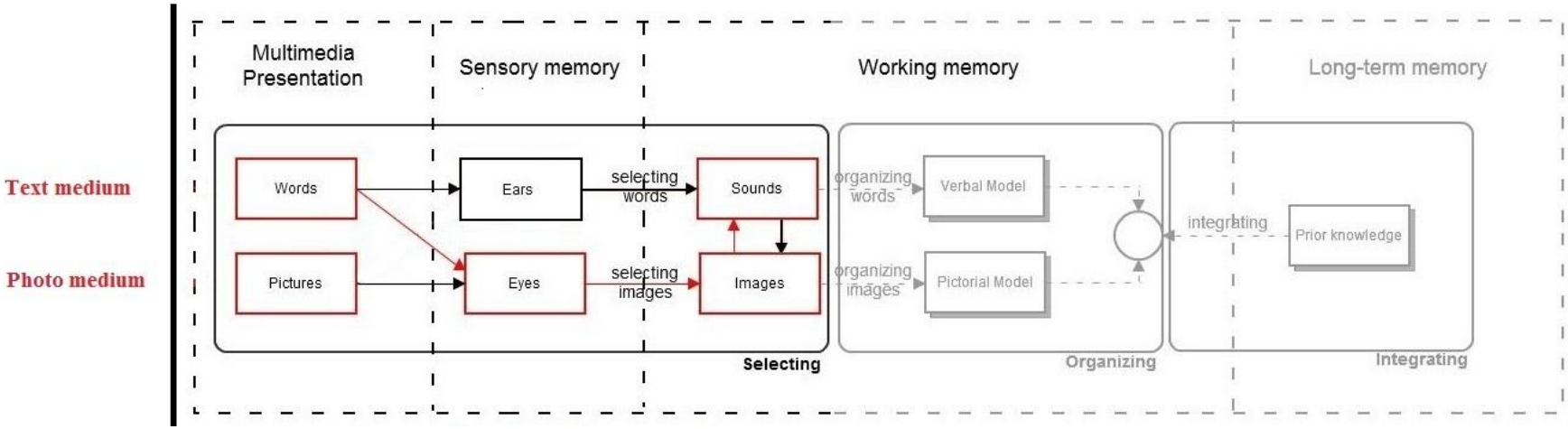


Figure 5.1: Multimedia combinations without vibration (e.g., MC1)

Multimedia combination with vibration

There are six multimedia combinations belonging to multimedia combination type with vibration: MC2, MC3, MC4, MC5, MC6, and MC7. As an example of the current multimedia combination with vibration type, we present the explanation of one combination: MC2. MC2 has the same flow as in multimedia combination without vibration type. However, there is a significant difference: in addition to previous two channels (visual and verbal channels) there is a tactile channel. Figure 5.2 illustrates the flow of multimedia combination with vibration where tactile channel is embedded into the system in order to use in mobile phone. Tactile stimulus initiator, presented in the form of vibration, sends the request to the user's skin receptors. After that, skin receptors request from the brain for processing and recognition of the stimulus. Subsequently, brain responds to the request and thus, a user reacts to the stimulus.

There is a significant difference between two types of multimedia combination with vibration and without. Multimedia combination without vibration is based on Mayer which focuses on PC application, whereas according to our supposition, the multimedia combination with vibration performs the use in mobile phone.

We consider multimedia combination that has no use of tactile channel in a mobile phone loses additional possibility (channel) of selecting and transferring information to a user. To expand the possibility of delivering information by using mobile phone facilities, we indicate the focus on three input channels: visual, verbal, and tactile.

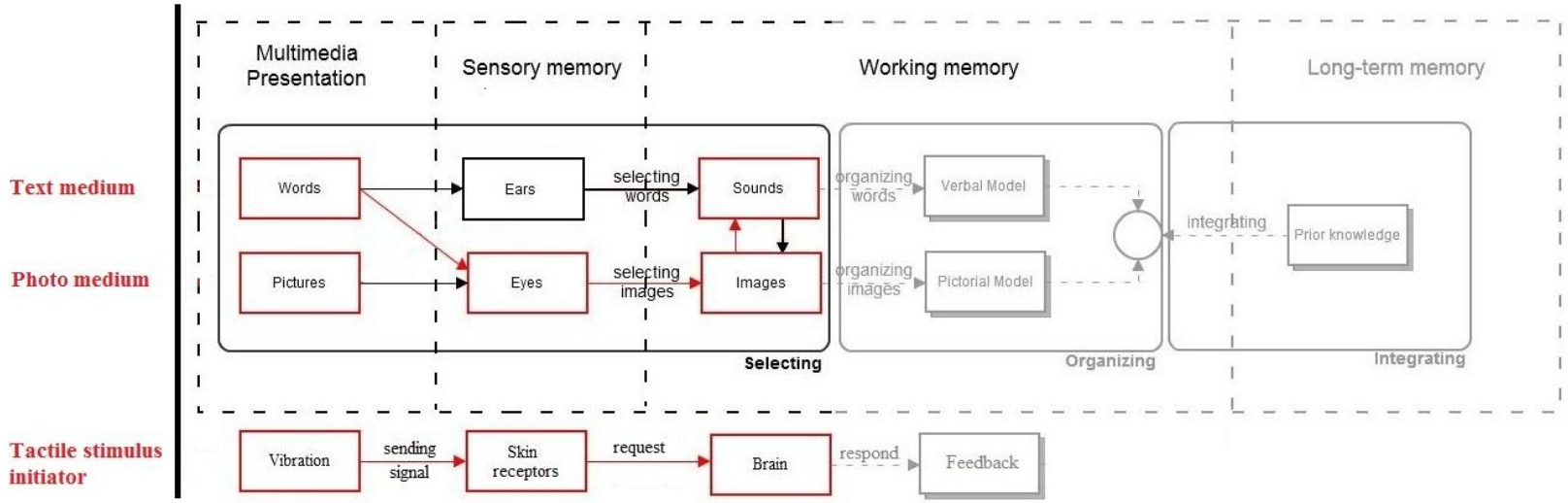


Figure 5.2: Multimedia combinations with vibration for mobile phone (e.g., MC2)

5.3 Summary

We observe six combinations obtained from Mayer's theory and web-based survey, and modify them to seven multimedia combinations adapted for the use in a mobile phone. We propose to use the haptic technology in the obtained multimedia combinations, namely vibration facility available in most mobile phone models. Thus, the obtained multimedia combinations are:

1) MC1: Text and photo (without vibration);
2) MC2: Text and photo (with vibration);
3) MC3: Text and audio (with vibration);
4) MC4: Text and voice (with vibration);
5) MC5: Text and additive voice (with vibration);
6) MC6: Audio and animation (with vibration);
7) MC7: Voice and animation (with vibration).

It is essential to investigate the adapted multimedia combinations for mobile phones in practice. Thus, we need to investigate user multimedia preferences among the above mentioned multimedia combinations using the Mobi application (Chuzhanova, 2011) in the case study. Mobi application allows us to gain the profound understanding in user multimedia preferences for delivering information. The following chapter presents the case study (Mobi application), which includes seven previously mentioned multimedia combinations with the haptic channel. Mobi application gathers users' opinion regarding the offered multimedia combinations and thus, assists us to answer the following question: *f. How does a user appreciate the multimedia in a mobile phone?* The case study and further analysis create the basis for the answer to the main research question *What are the end-user multimedia preferences to receive information while interacting with an object through a mobile phone?* The next chapter introduces Mobi application and details about its creation.

Chapter 6

The case study: Mobile-OBject Interaction (Mobi)

Many of the existing researches allow a user to employ different multimedia in mobile applications (Rasmusson, Dahlgren, Gustafsson, & Nilsson, 2004). Based on prior findings in the current research, there are small amounts of research, where user preferences towards multimedia combinations to perceive information about an object in mobile phones were studied. With the use of theoretical and empirical data in the current research, we obtained seven multimedia combinations which suppose to be relevant for delivering information. Furthermore, we proposed to embed vibration facilities of mobile phones. Nevertheless, there is a practical research necessity how those combinations are dealing with mobile phones. Thus, in this chapter we introduce *Mobile-Object Interaction* (*Mobi*) application which is able to evaluate the obtained seven multimedia combinations. The application evaluates users' mobile multimedia preferences during interaction process with objects. The concept of Mobi application and details about its creation are represented in the current chapter.

6.1 Mobi application

Mobi is an application that records user multimedia preferences of receiving information on a mobile phone while interacting with objects. MOBI uses the *Radio Frequency IDentification* (*RFID*) technology ("What is RFID?", 2005). RFID is a technology that uses wireless communication to exchange information between a reader and RFID tags. A reader is an electronic device that interprets the signal from RFID tags ("What is RFID?", 2004). An RFID

tag is a small chip in a compact package with an antenna. There are three elements required in order to use Mobi: a user, RFID enable mobile phone (a reader), and an object with RFID tags embedded. The launch of multimedia combinations can only be achieved while the interaction with the object. In the case study, the interaction of the mobile phone and an object with RFID tags. Once Mobi is running on the mobile phone, a user selects desired combinations and place mobile phone near marked area (RFID tags) on the object (Chuzhanova, 2011). Figure 6.1 illustrates the organization of Mobi.

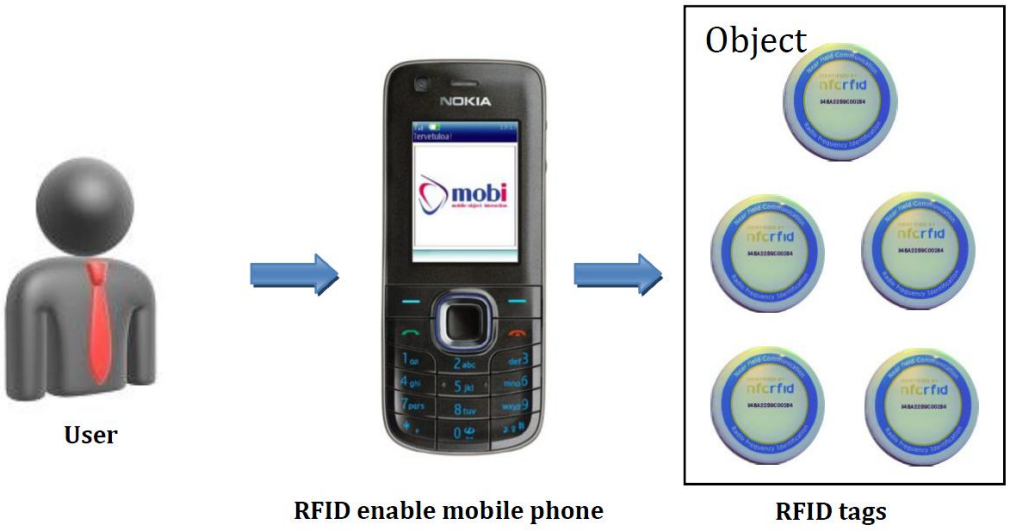


Figure 6.1: Mobi organization (Chuzhanova, 2011)

Mobi application consists of four modules (Figure 6.2). In the first *Demographic* module a user requires to provide basic demographical information about him or her. The *Multimedia* module is the core of the application. Using this module a user can interact with an object and get information through multimedia combinations. There are seven multimedia combinations which can be played in module. In the *Feedback* module a user evaluates multimedia combination from previous module. In the last *Storage* module a user saves all answers in mobile phone's memory card.

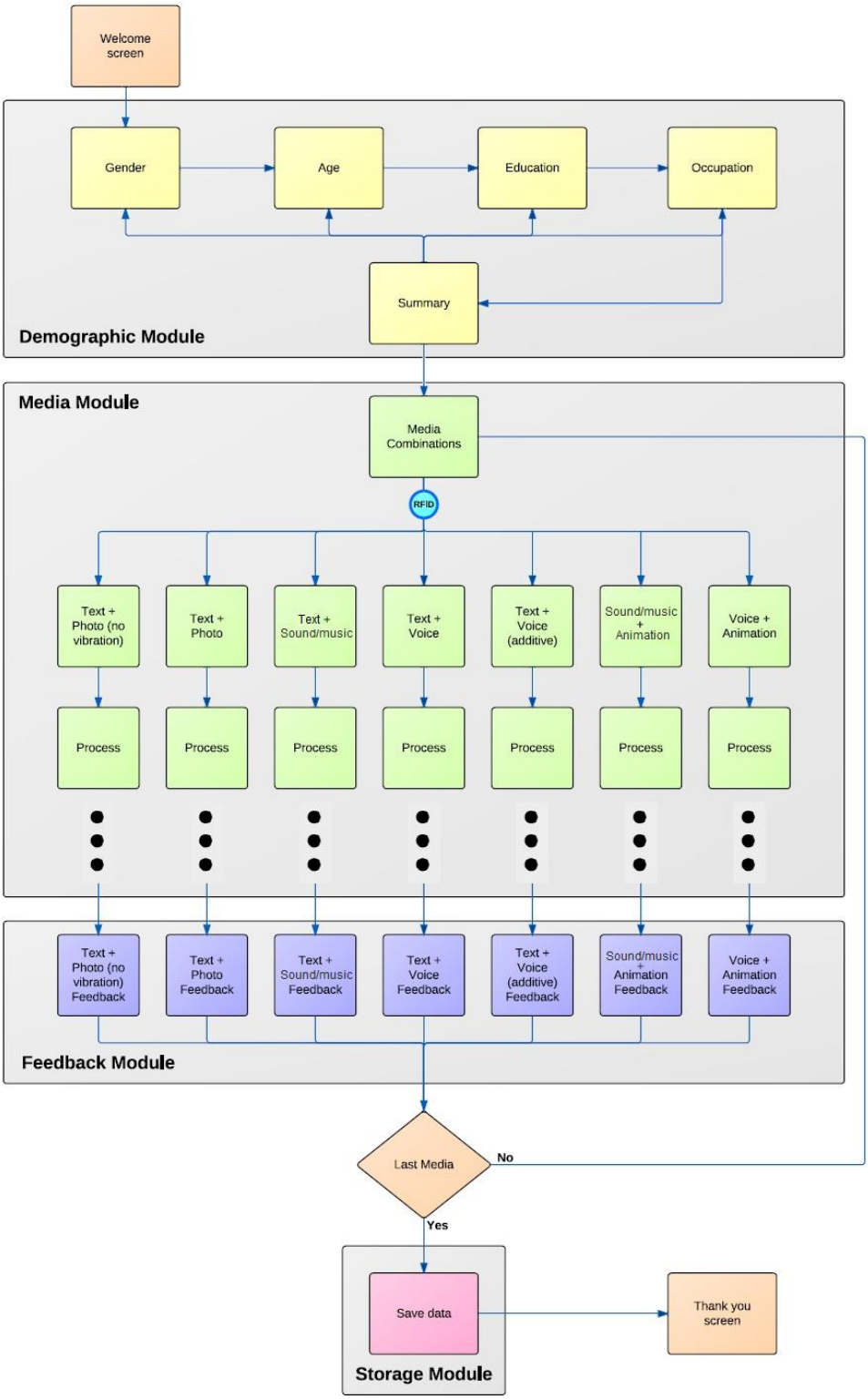


Figure 6.2: Mobi application flow (Chuzhanova, 2011)

6.2 Material used for creating multimedia combinations

The object of current study is the poster of *Kosiosusi*. Kosiosusi is a wolf monument in the Joensuu city center ("Kosiosusi palasi kaupunkiin", 2007). The objective is to deliver information about what Kosiosusi is represented using the multimedia combinations. Mobi delivers information about the wolf monument through seven multimedia combinations which we defined in section 5.3. The choice of seven multimedia combinations is based on prior theoretical and empirical findings in the study. Figure 6.3 illustrates flow of the media module where seven multimedia combinations are implemented. As it was mentioned before, after selecting the combination, a user requires to locate RFID enable mobile phone near the marked area in order to gain signal from the object. Details about the content of each multimedia combination can be found in the IT project (Chuzhanova, 2010).

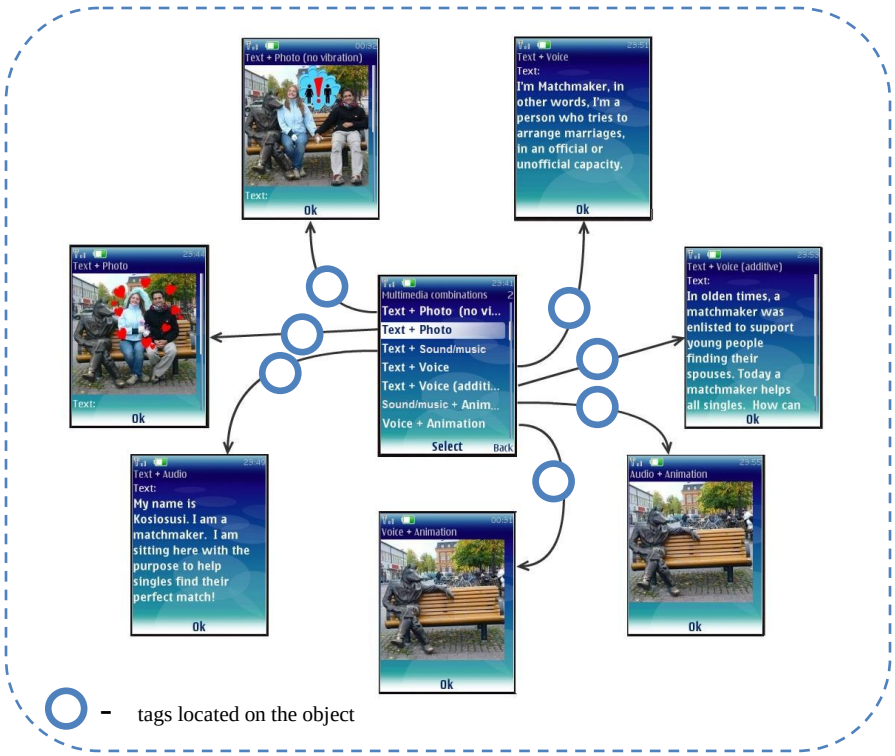


Figure 6.3: Multimedia module flow

6.3 Summary

In the current chapter we introduced the concept and creation details of Mobi mobile application. Seven multimedia combinations obtained in the research findings are implemented in Mobi solution with the use of vibration mobile facilities. It makes possible to examine previous theoretical and empirical results via practical testing to assist the answer the last question f. in the research: *How does a user appreciate the multimedia in a mobile phone?* Next chapter illustrates the evaluation and analysis of the Mobi application test.

Chapter 7

Mobi application test

Chapter 5 described our proposal about adding haptic technology to multimedia combinations obtained from theoretical and empirical data. Subsequently, we developed the case study (Mobi mobile application) described in Chapter 6 for further research of users' preferences among seven multimedia combinations to gain information about the object through a mobile phone The main purpose of the case study is to investigate the users' perception about the object information mediated by multimedia combinations in a mobile phone. The empirical data from the case study has to provide crucial information for the research. This chapter facilitates to answer the question f. *How does a user appreciate the multimedia in a mobile phone?* and, further, reveals a basis for the answer to the main research question *What are the end-user multimedia preferences to receive information while interacting with an object through a mobile phone*.

In order to answer question f, we conduct Mobi application test period from 28.10.10 to 24.11.2010. Test consists of multimedia combinations playback and conducting the survey. Details regarding the multimedia combinations playback discussed in Chapter 6, whereas the survey details presented at the next section. There are 86 responses collected during the Mobi test. The collected empirical data of the Mobi application test used quantitative analysis with descriptive statistics (univariate analysis). There are two methods used for collecting data during Mobi test. The first method is a mobile based: *the embedded questionnaire method*. This method collects the primary data type from the questionnaire embedded to Mobi application. The second method is a paper based: *the evaluation paper method*. It gathers data from the paper questionnaire filled after all multimedia combinations playback.

The following section presents survey and analysis details. The obstacles and challenges occurred before and during the test are discussed and solutions are presented. In the analysis section, the collected materials are analyzed, and the results are presented. We would like to emphasize that the goal of this section is to represent the gathering data and users' reflection to the multimedia combinations but not a deep theoretical analysis.

7.1 Survey details

The Mobi test was conducted from 28.10.10 to 24.11.2010 at two locations: shopping center and business center. First location is the *Iso Myy shopping center* which is located in Joensuu, Finland ("Iso Myy shopping center", 2006). Iso Myy contains over 70 stores. The environment is typical for shopping centers: there are additional sounds and people walking around. The test was conducted from 28.10.10 to 29.10.10 in the shopping centre hall on the first floor. Second location is the *Joensuu Science Park business centre,* student office 248 ("Joensuu Science Park", 1991). The room is organized for nine people, however only three people work there. There were no other noises during the testing. The data collection was done from 11.11.2010 to 24.11.2010.

For the current test we installed Mobi on Nokia 6212 (Classic) mobile phone and attached five RFID tags (Model: Trikker-UL CT50 by ToP Tunniste Oy) to the object: poster of wolf monument (Chuzhanova, 2010). We created the sustaining paper to support respondents to gain a brief introduction to the steps he or she requires to do.

There are two main stages: usage of Mobi application and the object, and use of paper questionnaire with additional question. Figure 7.1 illustrates the first stage, when a user is required to use a mobile phone with Mobi application installed, and the object (in our case, poster) with the information about provided in Mobi application. There are four sub-steps when a user fills basic demographical data, selects each of seven multimedia combinations. For the aim of multimedia playback a user locates the phone near special areas on the poster, and after each multimedia combination leaves user's opinion about the statement regarding the relevance of each combination.

<table>
<tr>
<td>1) Fill the 4 general questions:</td>
<td> 
</td>
<td>2) Select the media you want to use for getting info:</td>
<td> 
</td>
</tr>
<tr>
<td>3) Locate the phone to mark areas on the poster:</td>
<td>  </td>
<td>4) Evaluate the media according to your opinion:</td>
<td> 
</td>
</tr>
</table>

Figure 7.1: The first stage of Mobi test (Chuzhanova,2010)

The second stage (Figure 7.2) presents paper questions where participant requires evaluating the multimedia combinations in order of priority based on his or her preference. There are three columns presented in the paper questionnaire, where the first column provides the list of seven multimedia combinations employed in Mobi application. In the second column a user fills numbers from one to seven in front of each combination in a way that one is the most preferred combination and seven the least preferred one. The third column contains optional request to specify user's combination priority list. Thus, in front of each user's combination rank, participant can write down the reason or opinion regarding the multimedia combination.

8) Please, order the following media combinations from 1 to 7 according to your preferences, so that the **most preferred** combination has the number **1**, and the **least preferred** has the number **7**.

Name of combination	Value	Please, explain:
Text+Photo (no vibration)		
Text+Photo		
Text+Sound/music		
Text+Voice		
Text+Voice(additive)		
Sound/music +Animation		
Voice+Animation		

Note! Each value (number) can be chosen only once!

Figure 7.2: The second stage of Mobi test (Chuzhanova, 2010)

Methods for data collection

The embedded questionnaire method

The current method contains Mobi questions type which provide two sets of data collected from demographical module (scale and nominal data), and multimedia combinations module with closed questions (nominal data). Demographical module contains four open and closed questions about socio-demographics, such as age and gender. Multimedia module presents closed questions with user's multimedia feedback about combinations presented in the application. Question requires specifying user's level of agreement or disagreement on the statement: *"The (name of combination) was relevant for you to receive info of Kosiosusi"*. Instead of *"name of combination"* phrase, there is a corresponding combination to the played multimedia combination's name. There is a four-point scale, which contains four possible variants for users' answer: *strongly agree, agree, disagree,* and *strongly disagree*. We exclude any possible neutral variants (for example, *"I do not know"*) in order to prevent the likelihood of gaining an irrelevant data.

The evaluation paper method

The evaluation paper method contains: *closed* and *open questions*. Closed questions employ nominal data and ask ranking from *"1"* to *"7"* each of multimedia combinations which are used during Mobi test according to user preferences. Open questions employ string data and before filling represent an empty line in front of each combination. The aim of open question is to understand the participants' responses. Participant requires explaining the reason of selecting particular place for multimedia combination in the rank, as well as leaves his or her feedback regarding the combination.

7.2 Challenges and solution approaches encountered before and during the case study test

The mobile phone is assumed to support the information about the object provided to the individuals who move in the environment, mobile and are involved in their own affairs. Thus, the

location of the case study was selected with the focus on mobile audience such as in the shopping center. However, there were some challenges: *language*, *participation*, *volume*, and *age* which we had to cope in order to succeed with the application test. The four main challenges and their solutions are briefly described in table 7.1.

Table 7.1: Challenges and cope during the case study test

Challenge type	**Challenges and solutions**
Language	*Challenge*: The main challenge occurred due to location of the case study test: the case study test was carried out in Finland. Subsequently, there are respondents who are Finns and do not speak English. That fact leads to communication difficulties with respondents. For example, despite the fact that some people were interested in the test they refused participating in the test because interviewer was not able to describe the test purpose in the Finnish language.
	Solution: To make a user interface favorable for testers, the application has two interface language options: English and Finnish. Despite the fact most of respondents speak fluent English, they preferred using Finnish version.
Participation	*Challenge*: Considerable part of people refused to participate in the test.
	Solution: The test is voluntary, and thus, this is a normal phenomenon occurring during the test. We assess two factors supporting the attracting of individuals' attention. The first factor is providing additional material regarding the test purpose around testing area, such as images of test steps
	and description of the test purpose in three languages (Finnish, English, and Russian). The second factor is a good location. The major number of responses was collected in the shopping center hall. There was enough space in the testing area for occurring the test and a large flow of individuals in the shopping centre (local people, tourists, students) that increase probability of collecting responses.

Challenge type	Challenges and solutions
Volume	*Challenge*: Some people felt difficulties to listen the voice or audio during the test because of noises around (especially in the first testing period: shopping centre).
	Solution: We tend to provide sufficient volume level of audio medium. We set maximum volume on the mobile phone.
Age	*Challenge*: The elderly people are afraid of high-tech. There is an impression, that anything what connects to technology seems complicated for them.
	Solution: In order to explain elder participants the east steps in the survey, we focus on those who speak English and are acquainted with basic knowledge of mobile phones.

7.3 Data analysis details

The data collected for the further analysis consists of three sets: demographical data, multimedia feedback from Mobi application, and multimedia feedback from the evaluation paper. The case study deploys quantitative research techniques with descriptive statistics using univariant analysis. Further, details about data type and methodology used for data analysis are presented.

Data type

String (qualitative) variable

String variable refers to variable with no intrinsic ranking (SPSS User Guide, 2006). In the current case study string variables are presented in Mobi application in demographical data (gender, occupation, and study level) and in closed question regarding respondents' opinion about multimedia combinations. There is a string variable which a user provides in the evaluation

paper explaining his or her multimedia preference list. It is significant to point up that in the current study we do not report qualitative analysis. For the convenience of storing data for the current research, and for conducting further quantitative analysis, we summarized qualitative data by means of counts to become quantitative data. The converted qualitative data are: gender, occupation, study level, data from closed question regarding respondents' opinion about multimedia combinations. In current analysis we briefly observe qualitative data obtained in the questions where a user provides explanation about his or her opinion regarding the multimedia preferences. A qualitative data brief observation facilitates our understanding of user multimedia preferences and provides ideas for future research.

Numerical (quantitative) variable

Numerical variable refers to numbers with particular meaning. In current case study the quantitative data used in Mobi application in demographical data (question regarding participant age) and in the evaluation paper questions where participant created the multimedia preference list of seven multimedia combinations.

Data analysis methodology

We present results in two different ways. First, we present the *independent location results*. This way contains all data collected during the test. Second, we present the *location dependent results*. The approach consists of results according to test location: a shopping centre, and a student office. The reason to conduct different ways of data results representation is based on some respondents' feedback during the test. Some respondents faced difficulties with listening to multimedia combinations during Mobi test in the shopping centre (Details in section 7.2). In order to investigate respondents' answers with the focus on the test location, we separate the empirical data (multimedia combinations which contain audio medium forms) from Mobi application questionnaire into two locations: the shopping centre and the student office.

Likewise in Chapter 4, we employ quantitative analysis for the current case study analysis with descriptive statistics, which uses univariante analysis. Quantitative analysis supports our analysis and summarizes the empirical data processing, as well as descriptive statistics represents data in graphs and tables. Univariante analysis examines variables using *frequency distribution*

and *graphical* methods. Frequency distribution method measures the number of each value occurred in the set of observations. Visualization of frequency distribution is obtained by tabular representations. Follows the frequency table, a graphical method provides illustration of the Mobi test findings using pie charts or bar charts.

7.4 Data analysis

There is an analysis of respondents' multimedia preferences to gain information about the object while using quantitative analysis with descriptive statistics. There are 86 completed responses obtained during the Mobi testing in the period from 28.10.10 to 24.11.2010. Mobi test contains two analysed modules: Demographical module which presents respondents' profile, and Multimedia module where user multimedia preferences are analyzed. Each module is discussed separately.

7.4.1 Respondents profile

The vast majority of respondents are male (65.1%) compared to 34.9% of female participants. According to the test results, we possess a big diversity of respondents' age. The youngest respondent is 13 years old, whereas the oldest is 68. The majority responses collected in the age group 23-26, which is 41.9%. Considerable number of respondents' occupation is a student (70.9%). The second place among respondents' occupation belongs to employees with 22.1%. Conversely, there are few of respondents who are self-employee, unemployed, or retired. Almost third part of respondents is master students or has owned a master degree. Fourth of respondents study at Vocational school or have already graduated. 17.7% of the respondents either study or have already finished Bachelor degree at university. The number of respondents who is getting PhD or has graduated from PhD is quite small, at 8.2% overall. There are 7% of respondents who are studying or finished only basic school.

7.4.2 Multimedia combinations analysis

Mobi application questionnaire

After each multimedia combination playback in Mobi application, there is a multimedia combination module which provides questions corresponding to each multimedia combination. There are 86 responses to the Mobi question type without nonresponse data. The data obtained in Mobi application questionnaire is analyzed in two approaches: the total results independent of location are presented, and the specific results by location of the test: a shopping center (65 responses) and a student office (21 responses).

Location independent results

Figures 7.3 – 7.9 describe the total results of Mobi questions independent of location about the relevance of seven multimedia combinations. Figure 7.3 represents superiority of positive answers with 83.7 % in the statement that MC1 is relevant to gain information. Figure 7.4 reveals a considerable rise in the positive responses about the statement about MC1 relevance. One third of respondents (70.9%) provided their agreement that MC3 is relevant to receive information (Figure 7.5). Figure 7.6, likewise Figure 7.7, performs similar proportions of respondents' answers corresponding to MC4 and text and MC5. Both results have declared agreements above the relevance to perceive information of two previously mentioned multimedia combinations. However, MC4 and MC5 contain the highest percent of disagreement of combinations relevance in compare to other combinations in the case study. Figure 7.8 illustrates the majority opinions that state users' agreement with the statement about relevance of MC6 to receive information. Similarly to previously mentioned combination, MC7 possesses a strong agreement of the relevance to gain information through this multimedia combination (Figure 7.9)

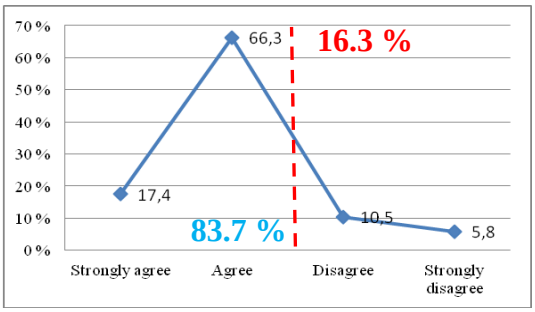


Figure 7.3: MC1 relevant to receiving information

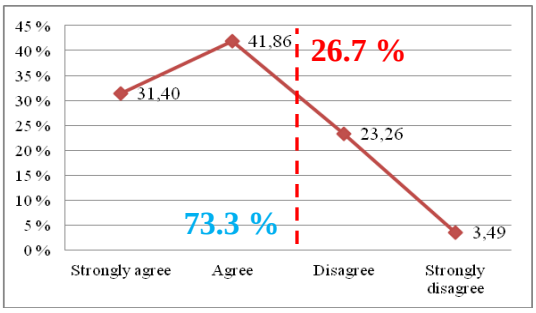


Figure 7.4: MC2 relevant to receiving information

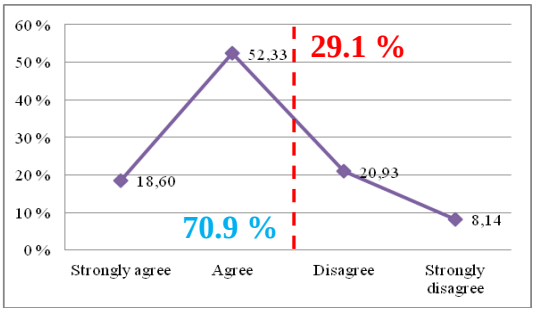


Figure 7.5: MC3 relevant to receiving information

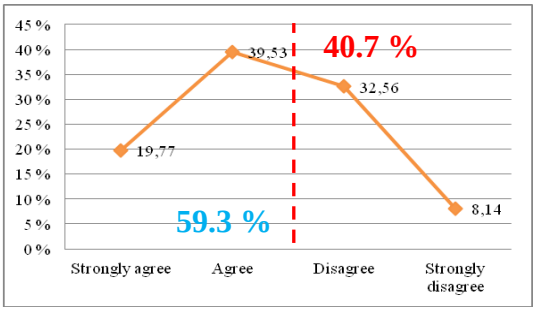


Figure 7.6: MC4 relevant to receiving information

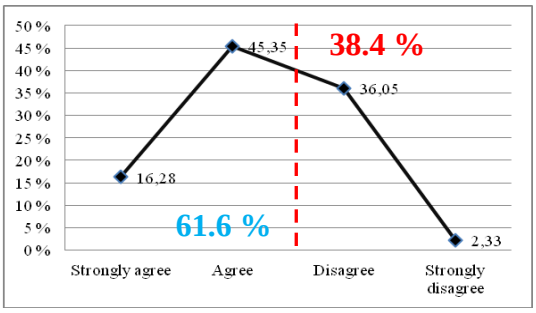


Figure 7.7: MC5 relevant to receiving information

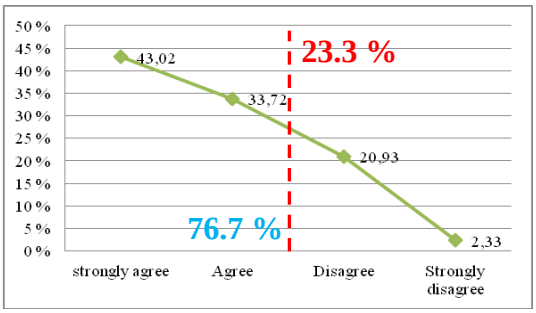


Figure 7.8: MC6 relevant to receiving information

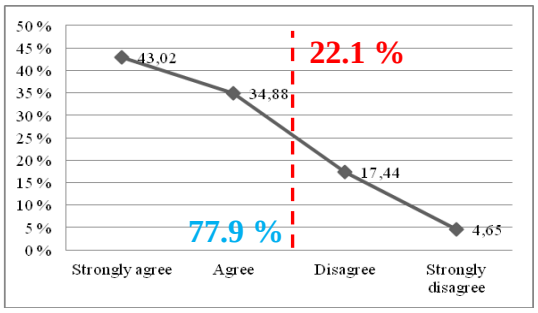


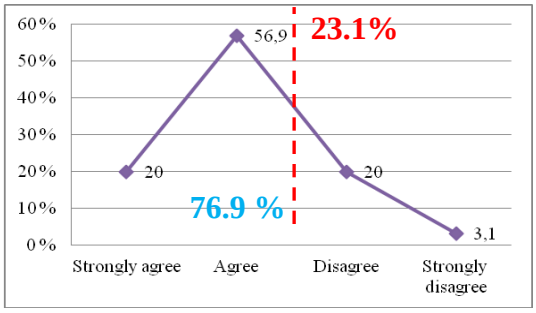
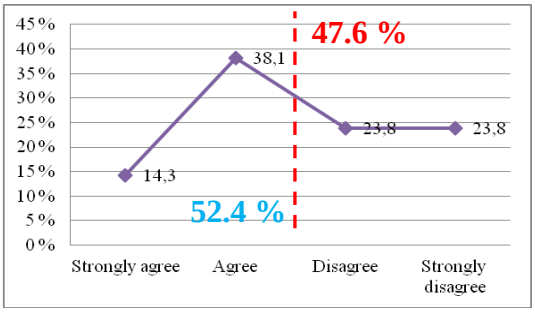
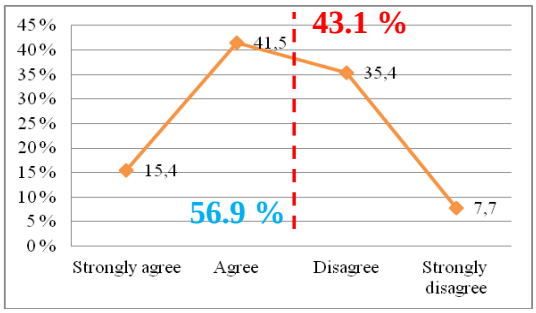
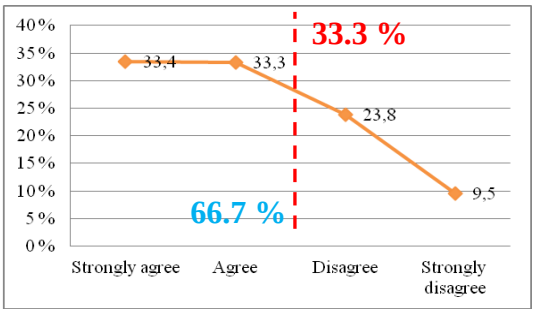
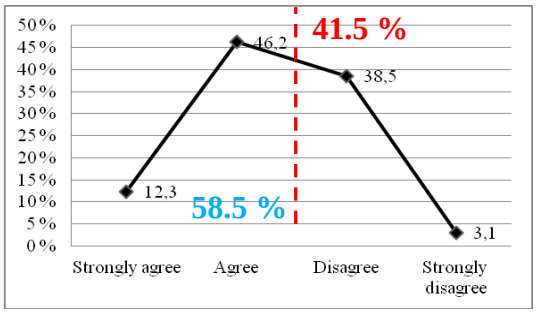
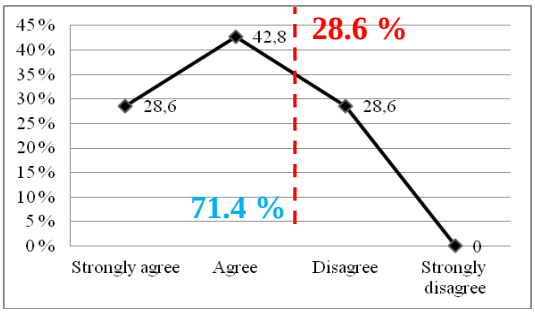
Figure 7.9: MC7 relevant to receiving information

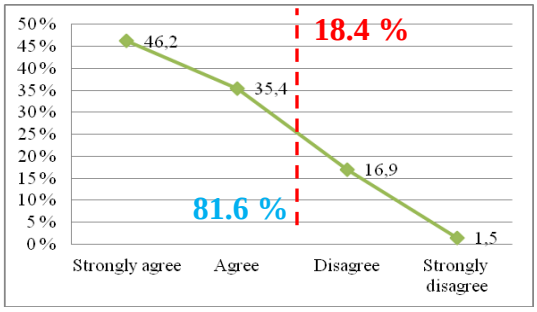
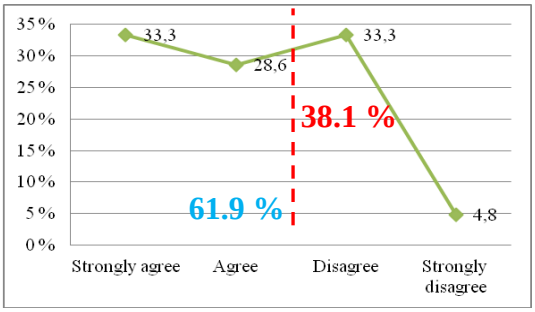
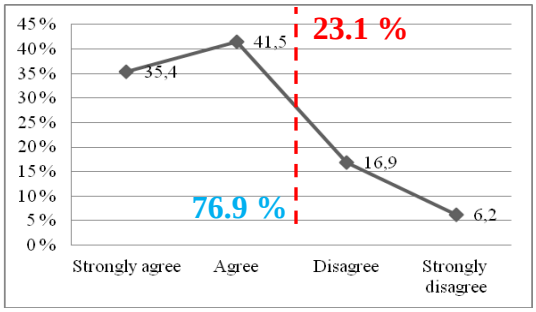
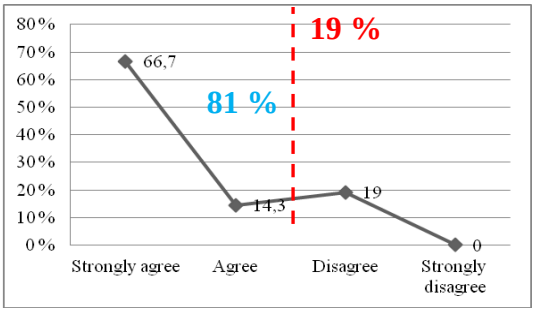
Summing up all the results obtained by Mobi application, respondents point their agreement towards the relevance of all others multimedia combination presented in Mobi application. The highest percentage of responses declares an agreement about relevance of MC1, MC6, and MC7 combinations to gain information about the object.

Location dependent results (shopping center and student office)

There are 65 respondents are interrogated in a shopping centre and 21 in Science Park student office. Table 7.2 illustrates Mobi application questionnaire results of conducted in two different environments with the emphasis on multimedia combinations which contain audio medium forms. According to table 7.2 those individuals, who responded in the shopping centre, defined combinations with sound/music medium forms (MC3, MC6) as the most relevant to perceive information in contrast to combinations with voice medium form (MC4, MC5, and MC7). Contradictory to these findings, individuals who responded to the questionnaire in the student office declared relevance of combinations with voice medium form higher than combinations with sound/music. The highest percent of users' agreement about relevance to perceive information in the shopping centre belongs to MC6, in contrast to MC7 which is considered the most relevant combination among all combinations containing audio medium form in the student office. MC4 combination possessed the highest percent of disagreement about the relevance to perceiving information in the shopping centre. Likewise, MC3 obtained the biggest number of disagreement in the student office.

Table 7.2: Mobi application questionnaire results about multimedia combinations relevance to receiving information in two different environments

MC	Location	
	IsoMyy shopping centre	**Science Park student office**
MC3		
MC4		
MC5		

MC	IsoMyy shopping centre	Science Park student office
MC6		
MC7		

Evaluation paper questionnaire

At the end of direct Mobi application use, there is an evaluation paper questionnaire requesting to enumerate (from *"1"* to *"7"*) each multimedia combination according to user preferences to gain information about the object. In addition, questionnaire asks to specify user's decision. There are 85 responses to the current question with one nonresponse. Further in this section, we present results of ranking the multimedia combinations in the total results independent of location and in the specific results by location: a shopping center and a student office.

Location independent results

Table 7.3 shows that a large majority of respondents evaluate MC6 as the most preferred to percieve information about the object. According to users' preferences, MC7 considered the first and the second places in the rank as the main places. However, the first place prevails over the second one. The most of the respondents appraise MC2 at the third place in the rank. The respondents' evaluation of MC1 shows relatively similar responses in each level of the rank with

a considerable rise at the fourth rank place. Table 7.3 presents instability opinion of MC3 where the major number of the responses reaches the peak at the fifth rating place. There is a fluctuation in respondents' opinion in ranking MC4 with the privale number of responses towards the six place in the rank for current multimedia combination. MC5 is considered as the least popular multimedia combination to gain information about the object with the last place in the rank.

Table 7.3: Total results independent of location. User multimedia preferences from evaluation paper questionnaire

	Rank						
Multimedia combination	**1**	**2**	**3**	**4**	**5**	**6**	**7**
MC1: Text and photo (without vibration)	10.59	12.94	11.76	**22.35**	11.76	14.12	16.47
MC2: Text and photo (with vibration)	14.12	15.29	**27.06**	9.41	14.12	12.94	7.06
MC3: Text and sound/music (with vibration)	4.71	9.41	18.82	14.12	**31.76**	14.12	7.06
MC4: Text and voice (with vibration)	4.71	10.59	10.59	21.18	11.76	**27.06**	14.12
MC5: Text and additive voice (with vibration)	3.53	4.71	14.12	16.47	22.35	9.41	**29.41**
MC6: Sound/music and animation (with vibration)	**38.82**	18.82	8.24	5.88	4.71	10.59	12.94
MC7: Voice and animation (with vibration)	23.53	**28.24**	9.41	11.76	3.53	10.59	12.94

Location dependent results (shopping centre and student office)

There are 64 responses collected in the shopping center and 21 gathered in the student office. Table 7.4 illustrates participants' preferences list in percentage where participants evaluate five multimedia combinations containing audio medium forms (MC3, MC4, MC5, MC6, and MC7) in two different environments. The preference list obtained from two different environments indicating the similar results corresponding to multimedia rank places in the shopping centre and the student office. However, there is a different rank place for MC7 where in the shopping center it possessed the second place in the rank, and in the student office it obtained the first place in the priority list. Moreover, it is noticeable that in the shopping centre responses, the percentage of placing particular rank to combinations with sound/music medium forms (MC3 and MC6) is higher than for the same combinations in the student office environment.

Table 7.4: Specific results by location. User multimedia preferences from evaluation paper questionnaire

Multimedia combination	Location	Rank						
		1	**2**	**3**	**4**	**5**	**6**	**7**
MC3: Text and sound/music (with vibration)	Shopping centre	1.7	7.9	24.8	15.6	**32.5**	12.5	5
	Student office	14.3	14.3	0	9.5	**28.6**	19.0	14.3
MC4: Text and voice (with vibration)	Shopping centre	3.4	9.4	9.4	23.3	11	**27.9**	15.6
	Student office	9.5	14.3	14.3	14.3	14.3	**23.8**	9.5
MC5: Text and additive voice (with vibration)	Shopping centre	3.3	3.3	12.5	15.6	23.3	11	**31**
	Student office	4.8	9.6	19.0	19.0	19.0	4.8	**23.8**
MC6: Sound/music and animation (with vibration)	Shopping centre	**43.3**	21.7	4.8	4.8	3.5	7.9	14
	Student office	**24**	9.5	19.0	9.5	9.5	19.0	9.5
MC7: Voice and animation (with vibration)	Shopping centre	21.7	**32.6**	9.4	12.4	3.4	9.5	11
	Student office	**28.6**	14.3	9.5	9.5	4.8	14.3	19.0

The next part of the questionnaire consists of open questions about the reason of respondents' decision to select particular rank to seven multimedia combinations presented in the test. There is a qualitative data obtained in the paper question. As it was mentioned in section 7.2.2, we are not reporting a qualitative analysis in the current study; however we skimmed through the qualitative data in order to specify users' preferences corresponding to each multimedia combination. Most of respondents admitted the interesting approach of interaction with the object and the idea to gain information about the object through a mobile phone:

"Interesting approach, I like a new way of interacting with objects".

We have got different feedbacks regarding the combinations. Some users draw attention to the multimedia design, others to the mobile vibration facility. Majority of the respondents note their interest in content of MC6, and pointed at clear content with no need in any other multimedia combination:

"Very interesting, fun, and useful",

"It was nice to follow how the animation and sound attracted my attention".

However, some users indicated the lack of information about the object in MC6:

"Nice animation, but not enough information obtained",

"Not enough information when there is no voice or text".

Some users noted their dissatisfaction with voice medium form in different multimedia combinations:

"Do not like voice in general".

In addition, many users were concerned about additional noises in the environment that complicated the process of obtaining the information through combinations with voice medium form included:

"One can't hear the speech in the city noise, doesn't work with the hearing-impaired",

"Voice cannot be heard unless you put the cell phone next to your ear".

"I find an inherent danger of multifocal cacophony here. Imaging, busload of tourists is playing the same audio concurrently from their devices. Museums become like orchestra concerts. Care should be taken when to use audio. When personal audio plays personal it is an excellent tool, but should be configurable via the mobile tool".

Some of the respondents consider vibration supports the understanding of application work:

"With vibration it is more clear and comfortable".

In contrast to other users who pointed no need in vibration:

"Vibration is not important",

"Do not notice there was no vibration in one of combination",

"The vibration was perhaps too much, and it was distracting".

7.5 Summary and data discussion

The case study examines seven multimedia combinations, three of combinations are from the Mayer's study (MC4, MC5, and MC7), two are from the current research empirical data (MC3, and MC6), and two other are mutual combinations (MC1, and MC2), which occurred in both previously mentioned sources. Summary of users' preferences according to the case study are presented in Table 7.5.

Table 7.5: Summary of user multimedia preferences according to the case study

Rank	Multimedia combination	Relevance %		Combination source
		Agreement	Disagreement	
1	MC6: Sound/music and animation (with vibration)	76.7	23.3	Empirical study
2	MC7: Voice and animation (with vibration)	77.9	21.1	Mayer's study
3	MC2: Text and photo (with vibration)	73.3	26.7	Mayer's study and empirical study
4	MC1: Text and photo (without vibration)	**83.7**	16.3	Mayer's study and empirical study
5	MC3: Text and sound/music (with vibration)	70.9	29.1	Empirical study
6	MC4: Text and voice (with vibration)	59.3	**40.7**	Mayer's study
7	MC5: Text and additive voice (with vibration)	61.6	38.4	Mayer's study

Most of the respondents designate their agreement about relevance of each multimedia combination to receive information about the object. According to the user multimedia priority list, there are two most preferred multimedia combinations: MC6 which possesses first place, whereas MC7 - the second. Surprisingly, according to percentage correlation among seven multimedia combinations, the biggest percent of agreement of combination relevance belongs to MC1 of 83.7%. Despite the fact that MC1 has the biggest percent of agreement responses, in the feedback paper, this combination was possessed fourth in the rank. Empirical study's combination: MC3 uncovered the last three combinations in the user priority list with the fifth place. The highest percent of disagreement belongs to MC4 and MC5 multimedia combinations. It is supported by users' decision to appoint the sixth and the seventh places in the rank.

Table 7.6 illustrates summary of user multimedia preferences with the focus on combinations with audio medium forms (MC3, MC4, MC5, MC6, and MC7), and on a different environment where case study took place, namely the shopping center and the student office. The evaluation of relevance to perceiving information through five multimedia combinations, and ranking of its combinations are presented (Table 7.6). We registered the difference in the answers about multimedia combinations with audio medium forms among respondents who held the test in the shopping center and those who conducted the test in the Science Park student office. The most respondents from the shopping center agreed that MC6 is a relevant combination to perceive information. In contrast, most of respondents who had test in the office, defined MC7 as relevant to perceive information.

Table 7.6: Summary of user multimedia preferences towards combinations containing audio medium forms in two different environments

Multimedia combination containing audio medium forms	Environment					
	IsoMyy shopping centre			Science Park student office		
	Rank	Relevance		Relevance		Rank
		Agreement	Disagreement	Agreement	Disagreement	
MC6: Sound/music and animation (with vibration)	1	**81.6**	18.4	61.9	38.1	1
MC7: Voice and animation (with vibration)	2	76.9	23.1	**81**	19	1
MC3: Text and sound/music (with vibration)	5	76.9	32.1	52.4	**47.6**	5
MC4: Text and voice (with vibration)	6	56.9	**43.1**	66.7	33.3	6
MC5: Text and additive voice (with vibration)	7	58.5	41.5	71.4	28.6	7

Chapter 8

Summary, discussion, and conclusion

Recently, multimedia employs in many disciplines and it is used different devices, such as PCs and mobile phones. The one direction of using multimedia is to transfer and deliver information about objects. It was of our interest, what are the end-user multimedia preferences for delivering information in mobile phones. We started our research from the understanding of medium and its derivatives: media and multimedia. We noticed that there are many definitions of medium, media, and multimedia. Each of them was discussed in terms of a particular discipline differently. To avoid being lost in the variety of definitions and to create a foundation for our research, we identified the definitions, which would be used throughout the research. Thus, we have found that medium (plural media) is a tool for storing information in digital form and it can include such media as text, audio, image, animation, and video. We also defined multimedia which is a combination of more than two media.

During the research of different definitions of medium, media, and multimedia, our attention was on Mayer's study where the multimedia research is focused on using two media in multimedia combination. Based on his study we considered narrowing down our research focus to application of multimedia with two different media for the purpose of delivering information (Mayer, 2001). Our attention to Mayer's theory is the acceptance of dual coding theory and his explanation of one E-learning purpose: to inform, which is our study focus. Out of Mayer's study and its adaptation to the current study four multimedia combinations were defined: text and image, audio and animation, text and additive audio, and text and audio. Primarily Mayer's multimedia combinations are oriented for PCs usage and thus, require further research towards use of its combinations in mobile phone.

We were concerned in how defined media and media combinations are used and studied presently. We have already determined that the media is widely used in various disciplines, and each discipline approaches to the study of media from different directions. To research in the current study we selected four disciplines: computer science (CS), education, psychology, art and entertainment (A & E). Subsequently, we retrieved that CS studies media and multimedia with the focus on its' processing the modifications relative to computer software and hardware. Education focuses on executing media for learning purpose. Psychologists focus mainly on the meaning which is given to each medium, and the interpretation of people to this medium. A & E uses outcomes from the psychology in stimulating people's imagination and entertain audience. At the same time, we have not found a lot of information about those researchers who study multimedia directly in terms of user preferences to perceive information through a mobile phone, since most of the studies were concentrated on reviewing media and multimedia related to PCs. These outcomes require continues us to research deeply the media and multimedia in a mobile phone. In order to follow our focus to use multimedia for delivering information and to be relevant for selecting information, we review different databases and concentrate upon databases with learning purposes (defined e-learning purpose to inform).

We provided 200 organized articles from the literature review using constrain and limitation with the focus on the same four disciplines as in the earlier research of disciplines' study focus. Those disciplines are: CS, psychology, education, and A & E. We attempted to obtain frameworks or different approaches among the existent studies in order to gain the understanding of user multimedia preferences to perceive information about an object through mobile phone. The research findings have not provided us with the necessary approaches or frameworks. The results indicated the CS discipline as the most frequent discipline where the media and multimedia are studied. Contradictory to our research focus, CS does not study the ways of delivering information in the sense of informing a user and selecting information for delivering. Moreover, the findings indicated that a lot of researches generalize multimedia and refer to multimedia as a generalization of the various media, without specifying on the combination and quantity of media to multimedia. Due to the lack of approaches or framework regarding the multimedia combinations, we came to conclusion of gaining the empirical data about user preferences for delivering information corresponding to media and multimedia.

Thus, we developed survey and arranged the pre-test. The pre-test results stimulated the changes in the created media set. According to pre-test suggestions and theoretical basis, we split image medium to photo and graphic medium forms. We also spit audio medium into voice and sound/music medium forms. Thus, the observed media and multimedia forms are: text, photo, graphics, voice, sound/music, animation, and video. The previously mentioned media and medium forms are used for delivering three information types covered in the survey: general, historical, and mathematical.

The results stated the different preferences on media and medium forms depending on information types. We focus our attention on general and historical information types. According to findings obtained in the survey, text medium and photo medium were considered as the most preferred among presented information types. Due to research purpose video medium and graphic medium form were elucidated in our further analysis.

We synthesized text and photo multimedia combination as text and photo media have been considered the most preferred among others. We also obtained combination with the most preferred medium (text) and the least preferred medium forms (sound/music). The last combination is sound/music and animation, which was established due to theoretical and empirical contradiction findings. According to empirical data, sound/music and animation are the least preferred whereas theory considers relevance of current combination use. Consequently, we obtained three combinations: text and photo, text and sound/music, and sound/music and animation.

In addition to empirical combinations there are four theoretical combinations (text and photo, voice and animation, text and additive voice, and text and voice) deployed in Mayer's study in section 2.3 which also have to be specified according the survey pre-test findings. Based on pre-test findings we obtained the following theoretical combinations: text and photo, text and additive voice, text and voice, and voice and animation.

It is worth to point up that empirical data analyzed in the survey do not relate particularly to a mobile multimedia. Questions in the survey examine media and medium forms in relation to the certain information types (general, historical, and mathematic) and do not specify the use of media and multimedia in mobile devices. Moreover, the questionnaire is web-based, and thus there is a probability that users perceive questions in correspondence to computer or internet. In

addition to empirical combinations there are four theoretical combinations which are supposed to be used on PCs, and thus, are also required to be studied in a mobile phone.

Before moving directly to the combinations test in a mobile phone, we emphasized the mobile phone peripherals. We propose the use of mobile peripherals to enhance delivering of the information. Based on mobile facilities we propose the use of haptic channel for delivering the information. In current study the haptic channel is presented in the form of vibration mobile facility. On the basis of Mayer's theory with two channels to perceive information, we described how the process of information perception goes while additional tactile channel is used. The number of channels varies from two to three in the selected combinations. This number depends on users' previous knowledge and media or medium type used in particular multimedia combination. As a result of adaptation the multimedia combinations from empirical and theoretical findings, we received seven combinations including a combination without vibration facility. The combination without vibration allows us to compare the difference in users' responses regarding vibration facility. The list of received seven multimedia combinations is presented as follows:

1) MC1: Text and photo (without vibration);
2) MC2: Text and photo (with vibration);
3) MC3: Text and sound/music (with vibration);
4) MC4: Text and voice (with vibration);
5) MC5: Text and additive voice (with vibration);
6) MC6: Sound/music and animation (with vibration);
7) MC7: Voice and animation (with vibration).

For the further testing of combinations in a mobile phone, we conducted the case study (Mobi application) which implemented seven defined combinations. Mobi test presented two methods for data collection: Mobi embedded questionnaire and paper questionnaire. Mobi embedded questionnaire indicated each combination relevance according to users' opinion. Paper questionnaire indicated the list of user multimedia preferences among presented combinations.

It is necessary to emphasize that Mobi embedded questionnaire conducted immediately after each multimedia combination playback, whereas paper questionnaire was filled after particular

mobile object interaction and considered as a feedback for all multimedia combinations presented in Mobi application. The contradictory findings in Mobi embedded questionnaire and paper questionnaire were mentioned in section 7.5. The first combination obtained in the respondents' priority list (Mobi embedded questionnaire) is MC6. However, according to users' agreement of combination relevance to perceive information (paper questionnaire), MC6 got only the third place inferior to MC1, and MC7. In turn, the highest percent of participants agreement of the relevance to perceive information obtained by MC1. Moreover, in the middle of our research the web-based survey indicated users' major preference of text medium as well as photo medium form. It was a surprise to see that, despite the different combinations and mobile peripheral presented in this study, users still prefer the basic and widely used combination - MC1. We assume that this combination is indicated as the most reliable and containing a complete information. The qualitative data presented in the work apparently supports the previously mentioned findings about vibration use in the multimedia combinations. The qualitative data elucidates that some respondents state their opinion about vibration as not important or they do not notice the difference.

Nevertheless, there is an interesting notice during the case study test. Those respondents who selected the combination without vibration in the middle of the test (participant selected few combinations with vibration facility before), experienced disconcertion and were unclear about appeared multimedia (a tactile stimulus was expecting from a mobile phone). Moreover, those individuals reported a positive feedback upon vibration facility and evaluated vibration as a good addition to the multimedia combination. Therefore, it is essential to continue the research of mobile peripherals and conditions of users' vibration appreciation.

We have uncovered surprising findings in users' multimedia preferences. MC4 as well as MC5 were considered as the least preferred combinations in the rank and contained the highest percent of disagreement about combinations' relevance to gain the information. According to empirical data, there are two least preferred combinations, which however, are supposed to be relevant for the delivering information in Mayer's study. The possible explanation can be like that: those combinations assume to be relevant with the visual data deficiency. Because the case study test contains combinations with visual data, there is a probability that users considered

combinations with visual data and associate text and voice combination as the least attractive for perceiving information compared to visual ones.

It is necessary to recall the focus of our work which is the selection and transferring the information about an object in mobile phone without stressing on the acquisition of new skills. Moreover, our focus does not assume storing the information in the user's long-term memory. Examining Mayer's study, we rely on active learning principles, particularly on the first step - selecting the information. We have not considered the second and third steps - organizing and integration. However, in the feedback response (paper questionnaire) we can assume that the process of organizing and integrating steps has occurred. Since the paper questionnaire was conducted after the particular test, there is a possibility that users recall memory in order to revise each combination and evaluate it. We assume that users provide more relevant information for our study when responds to Mobi embedded questionnaire immediately after playing a combination. Nevertheless, more research is needed in order to make any reclamation.

Special mention must be made about the places where the case study test was conducted: a shopping centre and a student office in Science Park. We emphasize that our participants' target group are individuals who move around in the environment and engaged in their own affairs. Therefore, the primary test took place in a crowded shopping centre, where participants are shopping centre visitors. During the testing process, some of respondents discovered difficulty in listening to combinations that included audio media forms. Therefore, we decided to carry out an additional testing in Science Park student office, where there are no additional sounds. The respondents are mostly students and workers from different companies' located in the Science Park building. Our attention was attached by the comparison of combinations that contain audio medium forms: voice, and sound/music. We found that individuals in the shopping centre preferred combinations with sound/music (MC3, and MC6), while people in the student office determined combinations with voice (MC4, MC5, and MC7) as more relevant. These results allowed us to conclude that the environment affects the multimedia preferences of individuals.

Recommendations and future work

The current work contains necessary foundation for the future research. According to the research findings, users are mostly interested in perceiving information in a mobile phone about the object

through the combinations: MC1, MC6, and MC7. However, the multimedia preferences for delivering information could vary depending on different aspects. Therefore, it is essential to direct the attention to the individuals who perceive information about an object, to the type of information about an object that you would like to deliver, and to the environment where an object is located. For instance, individuals who are busy with their affairs consider MC6 is more preferable by in a noise environment, in compare to MC7, which is more preferred in a quite environment.

Nevertheless, there are issues that can be further investigated. There is still an open question regarding the data collected from the case study: *"What was the reason of getting such diverse results in the Mobi embedded questionnaire and paper questionnaire?"* Thus, we consider a deeper analysis of the collected study has to be done. Moreover, the existence of qualitative data from the case study allows the implementation of a deeper analysis, possibly including psychological methods for determining the relevant of responses. Another open question we would like to emphasize for further research is: *"What is the reason of users' preferences towards sound/music and animation and voice and animation combinations? Is this the reason because users are in the noise environment and do not want to spend time on reading?"*

There is a possibility of further exploration of sound/music and animation combination. Some respondents in qualitative data indicated the lack of information in sound/music and animation combination; however, it is one of the most preferred combinations. Thus, it is importance to continue investigation, whether sound/music and animation are sufficient to transfer the information with particular meaning, or there is a probability that the user implies his or her meaning into it. It is also required to conduct a deeper study of vibration facilities, including multimedia combinations in a mobile phone.

Mayer in his study mentions individual prior knowledge that can effect on a user learning. However, we assume that users did not have any knowledge about the object during the case study test. Therefore, there is a possibility for further research how prior knowledge can effect on user multimedia preferences. Consequently, the thesis has touched upon many subtopics among mobile multimedia for delivering information, which offers interesting challenges for future research.

Chapter 9

Answers to the research questions

All research findings presented in the current study was possible to achieve with the assistance of the research questions defined at the beginning of the research. The main research question stated as: "What are the end-user multimedia preferences for receiving information while interacting with an object through a mobile phone?" In order to answer the main research question, the five research sub-questions were defined. The answers to each of the research question are briefly performed in the chapter.

Question a: What are medium, media and multimedia?

At the beginning of Chapter 2 we reviewed different sources in order to introduce basic understanding of terms required for the current study, and obtain definitions used throughout the study. Table 9.1 presents definitions of medium, media, multimedia, and five media types obtained in the current study.

Table 9.1: Thesis definitions

Medium is a tool for storing or transmitting information in digital form; these *"tools"* are: text, image, audio, animation, and video, i.e. a total of five media. *Media* is a plural form of medium (lat. medius - *"the middle"*).
Multimedia as a combination of two or more of the five media: text, image, audio, animation, and video.
Text is a fix complete message presented in electronic or printed form. The message consists of a symbol or set of symbols where each symbol provides letters and words.
Image is a graphical reproduction of an object. Examples of image are photos, graphics and pictures.

Audio is a signal of sound, voice and music reproduction.
Animation is a movie sequence of photorealistic or non-photorealistic images which are computer-generated or drawn on paper.
Video is a movie sequence capturing by camera that transmits live motion pictures by conveying to electronic signals with possible synchronization with audio.

Question b: What dual coding process is recommended?

To answer the question b, section 2.3 presents the literature review where Mayer's explanation is studied and which uses dual coding theory and suggests to limit multimedia combination to two media in combination. To supports his theory, Mayer refers to the three principles: dual coding, limited capacity of human brain, and redundancy effect.

In Mayer's theory we focus on active learning processing, namely on its first step selecting relevant information for delivering information purposes. Based on three Mayer's principals and our focus on selecting information, we derive four combinations, which are considered being fruitful for delivering information. Subsequently, we deployed four multimedia combinations in Mayer's theory which suppose to be relevant for delivering information. Based on terms defined in this study, we adapt Mayer's combinations and obtained the following combinations: text and photo, text and voice, text and additive voice, and voice and animation. After terms adaptation in Mayer's study to the terms defined in our study we obtained the following combination:

- Text and image;
- Audio and animation;
- Text and additive audio;
- Text and audio.

Question c: How do the selected disciplines study media and multimedia?

To research how different disciplines study media and multimedia, we examined four disciplines: CS, education, psychology, and A & E. The literature review from Chapter 2 provided us with disciplines' focus and samples related to each discipline approach to study defined media and four multimedia combinations in four selected disciplines. The defined focuses are presented in Table 9.2.

Table 9.2: Discipline's approach to study media and multimedia

CS	CS focuses on the modifications relative to computer software and hardware in order to transmit and deliver media which is independent of the meaning that media contained.
Education	Education focuses on executing media for learning purpose by transferring meaningful for study information. Multimedia in educational discipline is used as a tool in study with computers based applications or other information technologies where applications can be applied.
Psychologists	Psychology focuses mainly on the meaning given to each medium and the interpretation of people to this medium. The outcomes of psychology can be used by diverse disciplines such as education, entertainment, and marketing. In other words, psychology is a fundamental science which is used as a base for many disciplines.
A & E	A & E uses outcomes from the psychology in stimulating people's imagination and entertain audience by using media and multimedia in games or movies, in television programs, and etc.

Question d: How multimedia on mobile devices is used and studied?

In order to answer the question d, we used the literature review in Chapter 3. With the literature review we systematically researched existent studies in order to obtain framework or other existent references regarding media and multimedia usage in a mobile phones with the focus on user preferences. Five on-line repositories were used; the observing articles publication period is 01.2005 – 02.2010; the keywords (mobile multimedia, mobile multimedia learning, m learning, mLearning, multimedia, mobile multimedia, and mobile learning) for title and abstract search

input were indicated. We analyzed all articles towards the media and multimedia used in an article, and disciplines to which an article is focused.

The literature review results state that considerable number of articles belong to CS direction which focus on media and multimedia processing, not on research of delivering information to the user according to user preferences to gain information through media and multimedia. Moreover, the literature review indicated on not careful use of multimedia term, where in many articles writers do not imply a particular explanation of multimedia, or do not provide a concrete multimedia combination by using unifying term multimedia. From the obtained data we did not gain a clear framework or reference regarding user multimedia preferences for selecting and delivering information in a mobile phone.

Question e: How does a user appreciate the media?

The web-based survey from Chapter 4 supports the understanding of user appreciation of media. The conducted survey was focused on three types of information which could be delivered through seven media and medium forms presented in the survey. The information types are general, historical, and mathematical. We have taken an interest in general and historical types. According to general and historical types, the most popular media and medium forms are text, video, and photo; whereas, the least popular media are audio and animation. Graphics and voice medium forms possess slightly middle position in respondents' priority. The results of respondents' media preferences according to the web based survey are presented in Table 4.4 in section 4.4.

Question f: How does a user appreciate the multimedia in a mobile phone?

Despite the fact that theoretical study does not emphasize a big attention to audio and animation multimedia combination (MC6), users contributed their preferences to this combination for perceiving information about the object using a mobile phone. Moreover, the most preferred combination obtained from the case study findings is MC6.

Following, there is a preference of using voice and animation combination with vibration (MC7) in a mobile phone. Users indicated their interest and possibility to hear information details

accompanied to animation through the voice explanations. However, there was a concern about difficulties to use this combination in noisy environment.

One of the most preferred multimedia combinations in users' priority are text and photo combinations with and without vibration (MC1, and MC2). Participants designated as an advantage to use of text and photo pointing up the text and photo as the most reliable multimedia combination, especially in a noisy environment. Other users stressed to the opportunity of MC1 and MC2 that allow users absorbing information about the object at users' own pace. Preference towards haptice technology (vibration facility) in MC1 and MC2 was not noticeable. The combinations MC1 and MC2 were placed in the sixth and seventh in the rank. Though, MC2 gains higher rate in the priority list than MC1. Text and audio combination (MC3) did not gain a lot of users' attention, and thus, places in the neutral middle place.

We have uncovered some surprising findings in users' multimedia preferences. There are two least preferred combinations in empirical findings: text and voice with vibration (MC4), and text and additive voice with vibration (MC5). MC4 and MC5 were obtained from Mayer's study and were supposed to be relevant for delivering information.

The main research question: What are the end-user multimedia preferences for receiving information while interacting with an object through a mobile phone?

Based on the research findings, we define three multimedia combinations which end-users mostly preferred for receiving information while interacting with an object through a mobile phone. Those combinations are text and photo, sound/music and animation, and voice and animation. It is worth to mention that the end-user multimedia preferences can vary due to aspects such as users target group, the type of information being receiving about the object, and the environment where an object is located.

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Appendix A

Questionnaire: "The Mobile and Media Usage" (Modules analyzed in the study are presented)

"My name is Tatyana Chuzhanova and I'm completing my Master Degree at the University of Eastern Finland, School of Computing. The questionnaire I'm presenting to You will be useful for my Master's Thesis. All Your answers significantly important for doing research in understanding people preferences in mobile devices and media in general. Your participation is voluntarily and Your answers will be treated confidentially. It is important that You answer all the questions as honestly as possible. Completing this questionnaire means, that You have consented to use the information provided for research purposes. ***Thank You*** for your attention and time!"

This questionnaire is a part of Master's Thesis of the student Chuzhanova Tatyana,
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Module 1: Demographics

1) Indicate your gender, please:

2) Are you currently university student?

- Yes
- No

3) Please, choose in the following list the course year:

- Bachelor: 1 year
- Bachelor: 2 year
- Bachelor: 3 year
- Bachelor: 4 year
- Master degree
- PhD student

4) Please, select your current occupation status:

- Student
- Employees
- Self- employee
- Unemployed

Module 3: Media Usage

a) USAGE of media in GENERAL information

Receiving general information through the following media is important:

	Strongly agree	Agree	Disagree	Strongly disagree	I do not know
Text (written information to read)	1	2	3	4	5
Photos (real life images to look at)	1	2	3	4	5
Graphics (schemas, cartoons or any image to explain something)	1	2	3	4	5
Animation (an explanation made by computer animation can be 2D or 3D)	1	2	3	4	5
Video (a sequence of life images)	1	2	3	4	5
Voice (listen the voice of someone else explaining)	1	2	3	4	5
Sound/music (any type of sounds like birds singing, and music)	1	2	3	4	5
Other					

b) USAGE of media in HISTORICAL information

Receiving historical information through the following media is important:

HISTORY	Strongly agree	Agree	Disagree	Strongly disagree	I do not know
Text (written information to read history topic)	1	2	3	4	5
Photos (real life images related to the history topic)	1	2	3	4	5
Graphics (schemas, cartoons or any image to explain something related to history topic)	1	2	3	4	5
Animation (an explanation made by computer animation can be 2D or 3D related to history)	1	2	3	4	5
Video (a sequence of life images related to history topic)	1	2	3	4	5
Voice (listen the voice of someone else explaining a historical event)	1	2	3	4	5
Sound/music (any type of sounds like birds singing, and music in order to explain a historical topic)	1	2	3	4	5
Other					

c) USAGE of media in MATEMATIC information

Receiving mathematic information through the following media is important:

MATHEMATICS	Strongly agree	Agree	Disagree	Strongly disagree	I do not know
Text (written information to read mathematical topics)	1	2	3	4	5
Photos (real life images to look at mathematical topics)	1	2	3	4	5
Graphics (schemas, cartoons or any image to explain something mathematical topics)	1	2	3	4	5
Animation (an explanation made by computer animation can be 2D or 3D of mathematical topics)	1	2	3	4	5
Video (a sequence of life images of mathematical topics)	1	2	3	4	5
Voice (listen the voice of someone else explaining mathematical topics)	1	2	3	4	5
Sound/music (any type of sounds like birds singing, and music of mathematical topics)	1	2	3	4	5
Other					