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Effect of experienced emotion on technology use intention

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HELSINKI UNIVERSITY OF TECHNOLOGY **ABSTRACT OF MASTER'S THESIS**

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Technology products aim to give users quality experiences, which promote technology acceptance. This can be modelled with for example cognition-based Technology acceptance model (TAM). Lately it has been recognized that emotions have a role in technology use, and affective-holistic measures of Cognitive absorption (CA) and Perceived affective quality (PAQ) have been modelled. The task was to solve whether these concepts are relevant, so the holistic-affective factors could be researched with TAM.

In this thesis, emotional indices are measured psychophysiologically and subjectively. 42 university-educated young adults in three groups tested different digital newspaper interfaces. Subjective data was analysed with Exploratory factor analysis (EFA). Results supported the importance of holistic-affective concepts, though the original model was not reproduced. Psychophysiological data fulfilled theoretical assumption of chronic stimuli raising subjects' Skin conductance (SC), but it was not possible to establish a connection between subjective and objective results.

Keywords: user acceptance, emotion, affect, use experience, Technology acceptance model, TAM, Cognitive absorption, CA, Perceived affective quality, PAQ, psychophysiology

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Tekijä, työn nimi

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Tunnekokemuksen vaikutus teknologian käyttöaikeeseen

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Uusilla teknologiatuotteilla pyritään tuottamaan käyttäjille laadukkaita kokemuksia, jonka perusteella teknologia omaksutaan. Teknologiaomaksunta voidaan mallintaa esimerkiksi kognitiolähtöisen Teknologianomaksuntamallin (TAM) avulla. Viime aikoina on todettu, että tunteillakin on rooli teknologiakäytössä, ja tätä selittämään on mallinnettu holistinen ja affektiivinen mittaustekijä, Kognitiivinen absorptio (CA) ja Havaittu affektiivinen laatu (PAQ). Tutkimustehtävänä oli selvittää, ovatko nämä konseptit relevantteja, jolloin holistis-affektiivisia tekijöitä voisi tutkia TAM:in yhteydessä.

Työssä on psykofysiologisesti ja subjektiivisesti mitattu emotionaalisia indikaattoreita. 42 yliopistokoulututettua nuorta aikuista testasi kolmessa koehenkilöryhmässä erilaisia digitaalisen sanomalehden käyttörajapintoja. Subjektiivinen data analysoitiin eksploratiivisella faktorianalyysilla (EFA). Tulokset tukivat holistis-affektiivisten konseptien tärkeyttä, vaikkei analyysi tuottanutkaan alkuperäistä mallia. Psykofysiologinen data toteutti teoreettisen oletuksen, ja pitkäkestoisen ärsykkeen seurauksena ihon sähkönjohtavuus (SC) kasvoi, mutta yhteyttä subjektiivisten ja objektiivisten tulosten välille ei voinut muodostaa.

Avainsanat: käyttäjän omaksuminen, tunne, käyttökokemus, teknologianomaksuntamalli, TAM, kognitiivinen uppoutuminen, CA, havaittu affektiivinen laatu, PAQ, psykofysiologia

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This is dedicated to my voluntary audience.

Abbreviations

AQ	arousal quality, part of arousal dimension in core affect
BI	behavioural intention (to use), concept in TAM
CA	cognitive absorption, technology acceptance concept
CFA	confirmatory factor analysis, statistical method family
CO	control, part of CA
CU	curiosity, part of CA
EDA	electrodermal activity, psychophysiological measurement method
EFA	exploratory factor analysis, statistical method family
EMG	electromyography, psychophysiological measurement method
FI	focused immersion, part of CA
GLS	generalized least squares, statistical method
HCI	human-computer interaction
HE	heightened enjoyment, part of CA
HR	heart rate, psychophysiological measurement method
ML	maximum likelihood, statistical method
PAF	principal axis factoring, statistical method
PAQ	perceived affective quality, technology acceptance concept
PEOU	perceived ease of use, concept in TAM
PIIT	personal innovativeness in the domain of information technology
PLS	partial least squares, statistical method
PQ	pleasant quality, part of pleasant dimension in core affect
PrC	principal components analysis, statistical method
PU	perceived usefulness, concept in TAM
SC	skin conductance, psychophysiological measurement
SCL	skin conductance level (tonic EDA)
SCR	skin conductance response (phasic EDA)
SCT	social cognitive theory, a technology acceptance model
SEM	structural equation modelling, statistical method family
SQ	sleepy quality, part of arousal dimension in core affect
TAM	Technology Acceptance Model, developed by Fred Davis
TD	temporal dissociation, part of CA
TPB	theory of planned behaviour, a technology acceptance model
TRA	theory of reasoned action, a technology acceptance model
ULS	unweighed least squares, statistical method
UQ	unpleasant quality, part of pleasant dimension in core affect
UTAUT	unified theory of acceptance and use of technology, a technology acceptance model

CONTENTS

1 Introduction

1.1 Research interest

Digitalization of information has brought along the separation of storage and representation of media content. The consequences of this to media have been thought to be profound, and for instance the changes caused to a journal-publishing process by Internet have been under research (Varian 1997). In the information provider level, the developments in technology have led to a "convergence", gradual similarization of media industries, and to expectations of consumers to quickly adopt new "converged" technological products (Stipp 1999; Wirtz 1999).

The term "convergence" can mean either market consolidation and integration, or technical convergence. The technological convergence has been seen for instance as "a dynamic approach or partial integration of different communication and information based market applications… it brings out integrated multimedia products and services that render possible the satisfaction of additional and multiple consumer preferences" (Wirtz 1999). It has most often been forecasted that the traditional media will converge with computer, and be enhanced by computer functions (Stipp 1999).

As a result of convergence and technological advancements the number of media has increased, both in selection of different media types and selection among a certain media type like cable, digital, and mobile television. In the press, it is stated that the consumers are often eagerly waiting for new possibilities to use media their way, but the solutions offered are not up to scratch technologically, or do not fill the needs of the consumers (Tomkins 2005). Still, the consumer time is the crucial resource for which all media compete: the number of hours in a day does not increase, neither necessarily does the number of hours available for free time or dedicated time for media use (van den Broek & Breedveld 2004).

Among affecting factors and actors for overall acceptance of technologies are not only the technology and its developers, but also economic factors and actors in micro-, meso- and macro-levels; politics, regulators and legislators; and socio-cultural factors and actors like privacy issues, consumer rights, general attitude and labour positions (Bouwman & de Jong 1996). Predicting the near and far future needs of the public is expensive for companies trying to manage their expectations of sales figures. Often the problem is that user requirements are difficult to predict, as people cannot tell what they want from systems that do not yet exist (Brouwer-Janse 1996). Therefore it is important to develop a methodology with which to find elements affecting the public's choices and likings, instead of asking straight what it is that the public wants. In this study, factors and methods concerning the "public reasons" for acceptance are not considered: the study concentrates on the end-user and the factors predicting the final choice from the user's point of view, thus, "individual reasons" for acceptance.

Indeed, the interest in modeling consumer action has risen in importance with the presentation of new technologies. The reasons for people accepting or rejecting different technologies have been a focus of interest for a long while: scientific research for predicting and facilitating user acceptance of technologies has flourished ever since it was widely noted that in organizations, end-users were often unwilling to use computer application systems that would generate significant performance gains (cf. Davis, Bagozzi, & Warshaw 1989). Tools with their roots in many disciplines are being used in prediction of the public's future interest, which can be directed both to new services and to new technologies. While it is unclear whether both of these can be researched with same modeling theories (Carlsson, Carlsson, Hyvönen, Puhakainen, & Walden 2006), this study concentrates in measures that predict technology acceptance.

There is an abundance of theories modelling technology acceptance, and none of these have gained the monopoly for instance in guiding management action (Agarwal 2000). In this study, the theoretical focus is on individual user acceptance, instead of scrutinizing users as a group. Some comparative research finds that many acceptance theories perform unreliably, and while they suggest combinations of the models to replace the simpler theories (Venkatesh, Morris, Davis, & Davis 2003), these suggestions are still in infancy. Therefore, a relatively established and proven theory, Technology acceptance model (TAM) is studied in the thesis. TAM is a model consisting of two cognitive concepts that affect the intention to use a technology. It is intuitive and simple, but often its constructs and additional concepts show inconsistent relationships (Sun & Zhang 2005). However, TAM is stated to explain user acceptance slightly better than its peers (Venkatesh et al. 2003). Therefore it is believed to be the most appropriate starting point for studying technology acceptance modelling.

A recent change in paradigm of individual technology acceptance is that of holistic viewpoints gaining attention. It is possible to explain technology experiences and use decisions with other constructs than cognition-based only. In this study, the focus is in affective concepts. Basic psychological studies show that affect or emotion occurs before cognition and intervenes with it (Russell 2003). Therefore, concepts including affective variables have been suggested to be important determinants in technology acceptance, and to be added to TAM. Holistic concept used in this study is Cognitive absorption (CA) (Agarwal & Karahanna 2000), and a pure affective construct is Perceived affective quality

(PAQ) (Zhang & Li 2004). These concepts are fairly new, and there is as yet neither much contradicting nor corroborating research of these constructs.

The author's aim in this study is therefore to explore the viability of affective dimensions of technology acceptance, and map the model's possibilities in developing media technologies and predicting their adoption success. The author hypothesizes that emotions and affects, as conceptualized by the concepts of Cognitive absorption and Perceived affective quality, have a remarkable influence on the technology acceptance.

Original aim of the thesis was to concentrate in strategic and comparative viewpoints to the used hybrid technologies. This analysis would have received its experimental data from the user experience results. Due to the limited nature of experiment, discussed more profoundly in results-section, the focus of the thesis changed. Also the literary research showed, that there isn't yet agreed knowledge on use experience of hybrid technologies (combinations of computer and printed media), let alone of printed media. The following conceptual and methodological approach of the thesis is therefore useful in opening up the developing concept of user experience, its emotional dimensions and the expedients of researching it.

1.2 Research background

In the University of Technology Media Laboratory, there is an interest to model the user experience of media technologies. There was some previous research on the experiences and the emotions they evoke, using for instance the objective methods of psychophysiology and different subjective methods of filling questionnaires (M. Heikkilä 2005; Närhi 2006). There seemed, however, to be little connecting research between the media experiences and the subsequent media use decisions, as stated by Saarelma and Oittinen (2004), and using the modelling theories was thought to fill this gap.

The thesis has been accomplished as part of a DigiTVandPrint-project financed by Finnish Funding Agency for Technology and Innovation (Teknologian kehittämiskeskus, TEKES). The goal of the project, involving Finnish companies from different areas of media production, is to make strategic analysis and a pilot study of digital content for high definition television, focusing on visually rich newspaper content (VTT 2005). This framework provided the technology case with which to explore technology acceptance.

1.3 Structure of the thesis

This thesis can be divided in two parts. The introduction discusses the study context and the interest of the thesis. The first part continues with the chapters from two to four, which are based on literature study. In chapters two and three, the basic concepts of experience and emotion are explained according to the literature review. The chapters further explain some of the factors affecting the origin of enjoyment and positive attitude towards a technology created by the experience the user has via interaction with a media.

In chapter four, Technology acceptance model (TAM) is covered along with its suggested holistic-affective additions of Cognitive absorption (CA) and Perceived affective quality (PAQ). Theoretical viewpoints of the weaknesses of the TAM are presented, but the focus is on the factors affecting the user choices. The models are suggested to be under continuing change.

The second part consists of the chapters' five to nine, which describe the experiments conducted in order to test the viability of technology acceptance model and especially the additions of psychological pleasantness. In the beginning of the chapter, a research question is presented, which is to be explored experimentally. Test technologies have been chosen along the lines of the background project of DigiTVandPrint, and the chapter five describes the variables of the test and its apparatus. Chapter six handles the results of experiment along with some criticism towards the set-up and other avoidable error sources. In chapter seven, statistical analysis process of the subjective results is presented, and the reasons for the chosen methodology are discussed. Chapter eight contains lighter analysis of physiological measures. Chapter nine concludes the results, chapter ten is discussion about the success of the research and future challenges, and chapter eleven is the final conclusion drawing together the accomplishments of this thesis.

2 User media experience

2.1 Definitions of experience

Experience as a term is conceptualized in different ways. The viewpoint used in this thesis is to understand experience as "the observing, encountering, or undergoing of things generally as they occur in the course of time" (Webster's encyclopaedic unabridged dictionary of the English language 1994). In a common sense conceptualization, "experience determines knowledge, forms of expression or culture" (O'Sullivan et al. 1996). Earlier, experience was taken as a source of meaning, so that the experiences of people and groups build their culture. But "without cultural --- systems which predate the individual, and which form the resources out of which an individuality can be constructed for/by each person, there would not be anything to experience *with* --- As a result of this, attention has been focused on experience as an object of study in itself rather than as an explanatory term." (O'Sullivan et al. 1996) Different paradigms produce different conceptualizations of this object, some of which are discussed below.

Wright, McCarthy, and Meekison (2003) pragmatic-philosophically divide experience into four aspects that intertwine, these being:

- compositional thread: structure of an experience telling what experience is about, what has happened;
- sensual thread: sensory engagement with a situation;
- emotional thread; and
- spatio-temporal thread: actions and events unfolding in particular time and place.

From perceptual psychology viewpoint, an experience is born from perception caused by perceptual stimuli (Goldstein 1989; ref. Reeves & Nass 2000). On this viewpoint, the most important research question in computer technology development is, what perceptual stimuli computers produce that affect the user's experience (Reeves & Nass 2000). Vision and hearing have inspired most extensive research, some of the study objects being colour, brightness, movement, objects, and their size (Reeves & Nass 2000; cf. Närhi 2006; Saarinen 2006).

Experiences are not ready-made; they must be constructed through the reflexive and recursive process of sense-making (Wright et al. 2003). Sense-making happens in processes that are not linearly related in cause and effect (Wright et al. 2003). The results can be defined at three different levels, and they are described in Table 1.

Table 1. Experience categorized (Forlizzi & Ford 2000)

experience	meaning a continuous stream that flows through human's mind, being something that user experiences all the time and even totally subconsciously
an experience	something extraordinary and satisfactory, a fulfilment of experience that can change the user and the context in some way, and, from the companies' point of view, can be sold
experience as a story	as a way to organise and remember experiences and as a way to enable humans to communicate their experiences to other people

Albeit the term "experience" has been regarded to mean an individual's unique experience and reaction in and to a particular interaction, there is also some new research concerning co-experience, where the user experience is created in social interaction (Battarbee 2003).

2.2 Computer technology as user experience

2.2.1 General

Technological artefacts are the stimulus for technology user experience (cf. McCarthy & Wright 2004). The quality of a subjective experience is a fundamental part of human psychology (cf. Moneta & Csikszentmihalyi 1996), and the experiential or emotional quality of products is increasingly a differential advantage to products that are otherwise similar (Desmet 2003). In technology development, then, increasingly often the goal is to provide individuals with quality experiences with the aid of a technological product (cf. Alben 1996).

From perceptual psychology view, it is the simpler constructs in human-computer interaction that create experiences. With computers, vision and hearing have been the fundamental forms of output. Computing is about sight and sound, because these senses dominate human perception (Goldstein 1989; ref. Reeves & Nass 2000). The sense of touch has also primitive significance (Reeves & Nass 2000), a trait that may have been a cause for the survival of paper. As an example of a more complex viewpoint, motivation, personality and subjective experience are integrated into a unified framework in the theory of flow (cf. Moneta & Csikszentmihalyi 1996). For instance, Internet is a multi-activity medium often used to explore user experiences, and its use behaviour has been described with phrases typical to flow: “time going very fast”, “an absorbed interest” (Chen, Wigand, & Nilan 1999).

2.2.2 Different approaches to understanding technology user experience

User experience is becoming central to the understanding of the usability of technology, putting experience-centred development to the foreground (McCarthy & Wright 2004). User experience approaches can be divided the following way (McCarthy & Wright 2004):

- Human-computer interaction design (HCI);
- emotional approaches; and
- activity theory: this is a socially oriented tool, focusing on a unit of activity including context; it is not examined closer in this thesis.

HCI approach is the traditional cognitive framework for user experience, presenting the interaction as the knowledge transmission between humans and computers (McCarthy & Wright 2004). Cognition refers to the individual's acquisition and application of knowledge; by this process people assimilate and organize information about events and relationships, so that they 'know' about the world (O'Sullivan et al. 1996). According to HCI approach, humans are goal-oriented, trying to achieve their goal by performing planned cognitive tasks (McCarthy & Wright 2004).

HCI user experience quality criteria described by Alben (1996) have been criticized too one-dimensional (Forlizzi & Ford 2000). Traditionally, HCI did not understand emotions as fundamental components of human beings, but expected users forget their emotional selves in order to work efficiently (Brave & Nass 2002). Lately this view has been discarded, as wide range of emotions plays a critical role in computer-related activities (Brave & Nass 2002). For instance the "fun of use" is not rational, but affective experience that may be a decisive factor in technology choice (Desmet 2003). Constructs such as the level of individual's enjoyment while interacting with a technology, are significant predictors to further technology use intention (cf. Saadé & Bahli 2005).

Instead of trying to model complex human behaviours, the heuristics can be turned around to shape the actual experience of the user: humans do not care about information or data, but what it means to them (Sengers 2003). Interest towards emotions has arisen, giving birth to new generation of affective user technology acceptance research (cf. Kankainen 2002). Cognitive scientists are conducting empirical research on the relationship between emotion and cognition (Kankainen 2002), and emotional responses triggered by products are an area of growing interest (Desmet 2003). Affective approaches are used in tandem with cognitive ones, and rather present additions to the viewpoints presented in traditional HCI research.

Designing pleasurable user experiences often requires interdisciplinary approach, i.e. technological design intertwined with philosophical and cultural analysis (Sengers 2003). In order to use experience as a designing information source, improve the quality of experience of using a technology, and possibly to develop better measures for experienced quality, a new framework consisting of the dimensions of experience presented in Table 1 has been suggested as a tool for designers (Forlizzi & Ford 2000). HCI is shifting from creating task and work-oriented experiences to other kinds of experiences, and this creates a need to designers to understand how to embody new qualities of experience (Forlizzi & Ford 2000).

2.3 Researching media user experience

Four primary goals of media messages are to attract attention, to be remembered, to entertain, and to persuade (Ravaja 2004). For instance, the content or assumed purpose of an image causes the user to focus in different parts of it in order to extract different information from the image (cf. Saarinen 2006). This poses challenges to media technology experience studies (cf. Ravaja 2004). In media technology use affective factors are omnipresent by the nature of media content, as the specific content of the media affects the experience. For instance the expectations for the media content can cause implications in user requirements to the technology. Famous conceptualization of this is the media richness theory (Webster & Trevino 1995). This theory suggests that the content of a communicated message drives media choice, so that communication is expected to be more effective when medium matches the message content, although the motivation of content driving media choice has been found to be less important for new media (Webster & Trevino 1995).

Additionally, the boundaries between computer, television and film are not substantial anymore, and computer is a media among others (Reeves & Nass 2000). More complicated media interfaces for humans and computers are being developed (cf. for instance Lombard, Reich, Grabe, Bracken, & Ditton 2000). Still, not necessarily do more and richer perceptions make for better experiences: greater intensity of an experience does not equal quality (Reeves & Nass 2000). Therefore, to enhance the quality of experience, the research is focusing on studying “influences on experience and qualities of experience” (Forlizzi & Ford 2000) instead of formulating designing criteria for development process (Alben 1996). Observation of user experience can be a tool that gives information in technology design. Experience is growingly an object of scientific study, and user experience caused by interaction with some technology even more so. There is a paradigm change towards studying the importance of affect in user experience.

3 Emotion

3.1 Definitions of emotion

3.1.1 Introduction

Emotions enable functions: they reorient readiness to act, and prompting of plans (Oatley, Keltner, & Jenkins 2006). Emotions direct and focus attention to objects that are important to needs and goals, and emotion-relevant thoughts dominate conscious processing (Clore & Gasper 2000; ref. Brave & Nass 2002). They have a motivational function, and ability to give some action a sense of urgency and priority over mental process and action (Kankainen 2002). Cognitive style, performance, judgment, and decision making are also affected by emotions (Brave & Nass 2002).

Emotion as a term is colloquially used to describe many kinds of experiences. One division has been made between emotion, mood and sentiment (Brave & Nass 2002). Emotion, unlike mood, is directed towards an object, and is intentional, implying and involving relationships with particular objects (Frijda 1994; ref. Brave & Nass 2002), whereas mood is more diffuse, global and general. Emotions bias action, preparing the body and the mind for an appropriate and immediate response, but moods serve as background affective filter. Sentiments, on the other hand, are assigned properties of an object, judgements arising for instance from earlier experiences, generalization, assumptions, or social learning (Frijda 1994; ref. Brave & Nass 2002). If emotions last only seconds, moods last for hours or even days, but sentiments can persist indefinitely (Brave & Nass 2002).

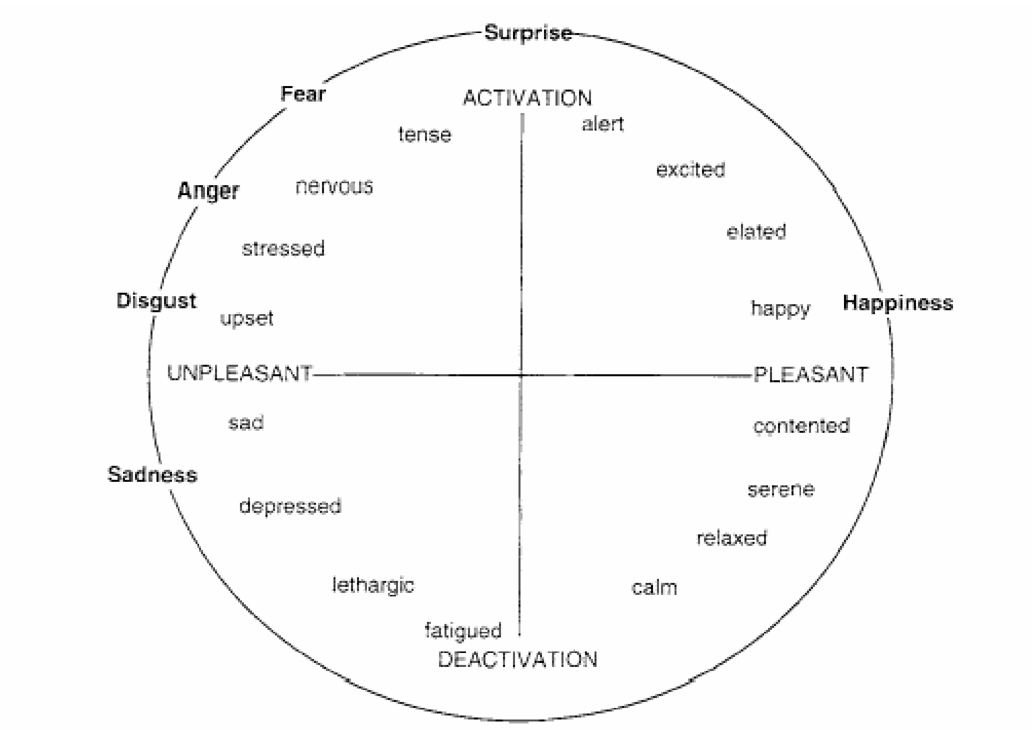

Figure 1. Schematic map of core affect (Russell & Feldman Barrett 1999).

Since the end of the nineteenth century, there has been agreement on two main dimensions of emotion (Bradley 2000). Most often the factorizing of self-reported emotions yields two broad dimensions of pleasure/pleasantness/valence, and activation/arousal (Russell & Feldman Barrett 1999). Pleasantness "summarizes how well one is doing", and arousal "refers to a sense of mobilization and energy". Of these two, pleasantness has in some research been found to be the primary category for organizing the world (Bradley 2000). The dimensions are presented in Figure 1 along with some descriptive adjectives.

3.1.2 Emotional episodes and core affect

Russell and Feldman Barrett (1999) divide the concept of emotion into two by distinguishing prototypical emotional episodes from core affect. The previous term refers to "what most people consider the clearest case of emotion", a complex set of interrelated sub-events concerned with a specific object (Russell & Feldman Barrett 1999). This concludes emotion as "a reaction to events deemed relevant to needs, goals and concerns of an individual" (Brave & Nass 2002).

Prototypical episode, a "full-blown emotion", necessarily includes all of the following attributes, though most often the non-prototypical cases are more common, in which some of the elements are missing (Russell & Feldman Barrett 1999):

- core affect;
- overt behaviour of the right sort in relation of the object (flight with fear etc.);
- attention toward, appraisal of, and attributions to that object;
- the experience of oneself as having a specific emotion; and
- all the neural, chemical, and other bodily events underlying these psychological happenings.

Emotional episodes, being broken down into their fundamental parts, consist of core affects. Core affect refers to "the most elementary consciously accessible affective feelings --- that need not be directed at anything" (Russell & Feldman Barrett 1999). A core affect is caused, but it's flowing and varies in intensity. It can also occur outside prototypical emotional episode. This describes core affects as being the physiological, affective, behavioural, and cognitive components of emotion, which reminds the concept of mood of Brave and Nass (2002). It is these core affects that are products of the pleasant and arousal dimensions, all possible combinations of which can occur as core affects (Russell & Feldman Barrett 1999).

3.1.3 Perceived affective quality

Most of the emotions that the designers of the human-computer interaction are concerned with, are secondary emotions that require somewhat extensive cognitive processing (Brave & Nass 2002). The concept of core affect, while clearing the idea of emotion somewhat, still leaves many questions concerning the nature of emotion (Russell 2003). Emotion could be described as action, reflex, instinct, brain mode, feeling, attitude, sensation, cognitive structure or feeling. Therefore Russell (2003) suggested another primitive to the concept of emotion: perception of affective quality.

Perception is initial consciousness of sensory activity; a process implying awareness and interpretation of surrounding stimuli or events. It means the active selection and making sense of the world, and provides a foundation for information that supports and directs subsequent monitoring (O'Sullivan, Hartley, Saunders, Montgomery, & Fiske 1996). Perception of affective quality is then the sense-making of the pleasant and arousing qualities in a stimulus. It is a process that may or may not cause a change in the core affect (Russell 2003). This is close to the concept of sentiment of Brave and Nass (2002) presented above, which states sentiments to be "judgements" and "assigned properties of an object". Interestingly, core affect can change without any reference to any external stimulus, and an affective quality can be perceived without a change to the core affect (Russell 2003).

3.2 Behavioural and subjective measures of emotion

Emotional indices that can be measured and quantified in the laboratory, can be divided in three systems, following which there are three types of measures (Cozby 2006):

- behavioural;
- subjective; and
- physiological.

Behavioural measures are reports of observations of overt behaviours; these are used extensively in animal studies (Bradley 2000). Human behavioural measures include for instance expressive language, vocalization and performance measures, and observable facial expressions (Bradley 2000). Behavioural, observational measures are difficult to apply to constructs representing internal feelings (Davis 1986; ref. Webster & Martocchio 1992); it is stated that behaviours do not necessarily reflect the feelings only, but also other forces in the environment (Ajzen & Fishbein 1977). This is presumably due to that the link between emotion and overt action has loosened in humans, so controlling and other mental abilities reduce the evident overt behaviour, unless the emotion is intense

(Bradley 2000). Behavioural measures may also suffer from experimenter bias, where the grader biases the ratings in favour of the wanted results (Insko 2003).

Subjective measures are reports from subjects themselves regarding their awareness of emotional reactions (Bradley 2000). Measures include for instance verbal descriptions, ratings scales, and participant reporting of physiological responses that occurred (Bradley 2000). There are different methods utilizing adjective check-lists, experience sampling, or offering statements with which participants can agree or disagree (Oatley et al. 2006). Self-report, however, can suffer for instance from cultural norms and individual differences discouraging emotional disclosure (Bradley 2000).

3.3 Physiological measures of emotion

3.3.1 Introduction

Core affect may be simple at the subjective level, but complex at the biological level: the subjective experience is not a separate event from neurophysiologic experiences (Russell 2003). Physiological measures are then reports of bodily events of subjects that occur in social and physical environments (Cacioppo, Tassinary, & Berntson 2000). These include responses for instance from cardiovascular, electrodermal, somatic, reflex, or neurochemical systems (Bradley 2000). Physiological measures can provide complementary or even contradictory information to that received from self-report, and it is more objective than self-report (Ravaja 2004). To the contrary of subjective self-report, physiological measures can be performed continuously during message viewing (Ravaja 2004).

In previous Master’s thesis’ completed in the Helsinki University of Technology Media Lab, several experiments using psychophysiological methods have been conducted. In these studies the physiological systems are discussed (M. Heikkilä 2005; Närhi 2006), and repeating this discussion is not necessary. This study therefore follows the guidelines of Cacioppo et al. (2000), according to whom it is more important to concentrate on factors like the quality of the experimental design, psychometric properties of the measures, and the appropriateness of the data analysis and interpretation.

The science of measuring psychological reactions with physiological indices, psychophysiology, has not yet received wide acceptance in the human factors research community, however: the information received from psychophysiological measures is often not original, but can be acquired using other, less costly and easier measures (Kramer & Weber 2000). Emotional response, measurable in psychophysiological methods, is context-dependent, so that the response is not the same for a given emotional state (Bradley 2000), and the possibilities of psychophysiology to address problems in human factors of human-machine systems may be unclear even to its practitioners (Kramer & Weber 2000). For these reasons, some aspects of physiological measures are explained further.

3.3.2 On different possibilities to measure affective reactions

Lately researchers have used psychophysiological measures, along with behavioural and self-report measures, as an index whether two systems differ (Kramer & Weber 2000). The information of differing response compared to the base system is not sufficient; also the nature of the difference is interesting as knowing it enables modifications in correct targets (Kramer & Weber 2000). As there are several measures for physical responses to affective stimuli, the measurement method must be chosen to answer the research question (Jennings & Stine 2000). Three of the most often used in communication and media studies (Ravaja 2004) are presented below. These are (Bradley 2000):

- Heart rate (HR), which consistently indicates the level of activation caused by unpleasantness;
- Electromyography (EMG), which measures muscle displays: of different areas of measure, facial activity is quite sensitive to pleasure; and
- Electrodermal activity (EDA) or Skin conductance (SC), which consistently indicates the level of activation caused by arousal and attention.

All these measures have their problems. Traits causing contextual effects are individual differences for instance in physiological reactivity (Bradley 2000). Measure-wise, in pleasant or neutral conditions, heart rate increases less than with arousing negative stimuli (Bradley 2000; cf. M. Heikkilä 2005). HR is also a function of motor preparation: i.e. it is affected by the physical activity of the participant (Bradley 2000). EMG on its part may not reflect spontaneous or voluntary movement (Bradley 2000). It is an example of physiological affective responses being affected by social context: facial expressions increase in the presence of other people, or even under the belief somebody is observing (Bradley 2000). This emotional contagion suggests that emotional reactions in laboratory may be affected by experimental setting (Bradley 2000).

Disadvantage of using EDA is that it is multiply caused, i.e. the elicited Skin conductance response (SCR) is not specific to single type of event and situation (Dawson, Schell, & Filion 2000). This is not surprising: mapping between physiological measures and psychological constructs is rarely one-to-one, but rather from psychophysiological one-to-many physiological (Kramer & Weber 2000). As the other side of the coin, EDA can be used to measure a wide variety of issues: this is due to its relative ease of measurement and quantification, and with its sensitivity to psychological states and processes (Dawson et al. 2000). Due to reasons posited below, EDA was considered the most adequate measure for this study, wherefore it is represented with more precision.

3.3.3 Electrodermal activity

Electrodermal activity (EDA) is one of the most widely used response systems in the history of psychophysiology (Dawson et al. 2000). As an indicator of EDA, Skin conductance (SC) is measured by passing a small electrical current across the skin through a pair of electrodes placed on its surface, usually on the palm of the hand (Bradley 2000). Individual sweat glands function as resistors in parallel, so that a conductance of a parallel circuit is the sum of all the conductances in parallel (Dawson et al. 2000). In terms of the two dimensions of core affect, the amount of sweat glands' activity increases along with rated arousal, regardless of valence/pleasure (Bradley 2000).

Skin conductance can be divided in two parts. The tonic level, Skin conductance level (SCL) is the absolute level of conductance at a given moment in the absence of a measurable basic response (Dawson et al. 2000). This is the long term average that varies between different subjects and within the same subject in different psychological states (Hopkins & Fletcher 1994; ref. Ravaja 2004). Superimposed on the tonic level are the phasic increases in conductance, which is Skin conductance response (SCR) (Dawson et al. 2000). SCR:s are small fraction of SCL, and they are either spontaneous and non-specific in the absence of an identifiable stimulus, or specific and event-related in connection with presentation of a novel, unexpected, significant, or aversive stimulus (Dawson et al. 2000). Particularly, tonic EDA (SCL) is useful for investigating general states of arousal and alertness, and phasic EDA (SCR) is useful for studying attention and stimulus significance, as well as individual differences (Dawson et al. 2000).

There are three types of paradigms where EDA is often used (Dawson et al. 2000):

- presentation of discrete stimuli;
- measurement of individual differences in EDA; and
- presentation of chronic stimuli.

The experimental part of the study, as represented below, belongs to the last paradigm: it involves the presentation of a continuous, chronic stimulus or situation such as that involved in performing an ongoing task. For chronic stimuli, it has been found (Lacey et al. 1963; ref. Dawson et al. 2000) that SCL increases in task situation, the typical increase being about 1 microsiemens above resting level during anticipation, and then increasing another 1 or 2 microsiemens during performance of the task (Dawson et al. 2000). This is due to that chronic stimuli are modulating increases in tonic arousal; as a result, SCL and frequency of SCR are most useful EDA-measures in the chronic stimuli paradigm, because they can be measured on an ongoing basis over relatively long periods of time (Dawson et al. 2000).

4 User technology acceptance

4.1 Predicting user acceptance of technologies

4.1.1 Introduction

Technology being accepted means it being institutionalized as part of regular behaviour, so that the routinization, confirmation and even value-added, fused use of a technology is different from mere surface-level trying of a technology (Agarwal 2000). Behaviour, like technology use and subsequent acceptance, is best predicted by intention towards behaviour (Ajzen & Fishbein 1977). For technological systems still under development, intention to perform behaviour of using them can therefore be used as a measure to predict actual future behaviour (Mathieson 1991).

Intention is among other things affected by attitude towards behaviour (Ajzen & Fishbein 1977), and people form intentions to perform behaviours toward which they have positive affect (Davis et al. 1989). A positive evaluation of an information system is then a necessary but not always a sufficient condition for its use (Fishbein & Ajzen 1975; ref. Mathieson 1991). In other words, the qualities of a technology in themselves are not the only reasons for which it may be used. Formulating these reasons and combining their relationships in a model is a challenge, which different technology acceptance models try to resolve.

4.1.2 Modelling technology acceptance

Not surprisingly, the user-centred focus on acceptance of technology can be theorized in several ways. For instance, Human-centred design process aims to produce usable and acceptable products, concentrating on designing process in the developer organization; Innovation diffusion theory studies the likelihood and rate of an innovation to be adopted by different user categories and populations, concentrating on post-design process within some user groups; and the Technology hype cycle describes the progress of new technologies subject to hype, disappointments and unrealistic expectations (Kaasinen 2005).

Instead of studying individuals as part of some group that expresses its own dynamics, yet another approach is to study user characteristics, environment and perceived product attributes (Kaasinen 2005). Major theoretical paradigms conceptualizing information technology acceptance this way base mostly on social psychology, while drawing from several reference disciplines (Agarwal 2000). Some of the theories are Theory of reasoned action (TRA), Theory of planned behaviour (TPB), Social cognitive theory (SCT), and Technology acceptance model (TAM) (Agarwal 2000).

Recently the research interest has been on comparing different theories empirically (Agarwal 2000) and to add new dimensions to old ones (Legris, Ingham, & Collerette 2003). According to some studies, current individual user acceptance models have limited explanatory powers (Venkatesh et al. 2003). One reason for this may be that originally, many theories emerged from the needs of organizations trying to evaluate new computer technologies (Davis 1989).

Reflecting the need to enhance the models, there is a change happening in the technology acceptance research paradigm. In accordance with the emphasis towards user experience as a guideline to technology design, several studies have established that user actions and decisions are not cognition based only. For instance in an early research by Iqbaria, Schiffman and Wieckowski (1994) the roles of both usefulness and perceived fun in technology acceptance were studied. They suggested that even though usefulness is more influential factor in technology acceptance, fun is valuable as a means to make individuals adaptable and satisfied with the quality of the system. There have also been suggestions, that usability can be divided in two parts: traditional ergonomic quality, and hedonic quality, which comprises dimensions with no obvious relation to the task at hand (Hassenzahl, Platz, Burmester, & Lehner 2000). Hedonic quality may then be an important aspect for its own sake, examples being beauty and originality. Also affects evoked by the technology have a central meaning in how a technology is perceived by its potential users and, eventually, whether the technology is accepted (Zhang & Li 2004).

4.2 Technology acceptance model and its kin

4.2.1 Technology acceptance model

Technology acceptance model (TAM) was introduced as an adaptation of the general model of Theory of reasoned action (TRA) for more specific modelling of user acceptance of information systems (Davis et al. 1989). The basic TAM has its roots in the belief that users make their decisions based on instrumental considerations (Agarwal & Karahanna 2000). TAM can be tested with short user trials of the suggested technology; one hour is suggested to be enough (Davis et al. 1989). Furthermore, TAM has been trialled in testing technology mock-ups to assess a viability of a product concept, and it can be used in technology development projects and processes (Davis & Venkatesh 2004).

TAM (Figure 2) has two general constructs, which are believed to work for every context and for every specific technology (Agarwal 2000). These constructs are the user's Perceived usefulness (PU) and Perceived ease of use (PEOU) of the technology. PU is the degree to which a person believes that using a particular system would enhance his or her job performance, and PEOU is the degree to which a person believes that using a particular system will be free from effort (Davis 1989). The perceived usefulness and ease of use are postulated a priori to the context, which makes them general determinants of user acceptance (Davis et al. 1989).

PU and PEOU affect the user's measurable Behavioural intention to use (BI), which determines the user's actual usage of (computer) technology. BI measures the strength of intention to perform behaviour, which then leads to actual technology use. The purpose of TAM is to trace the impact of external factors on internal beliefs, attitudes, and intentions, which affect BI. (Davis et al. 1989)

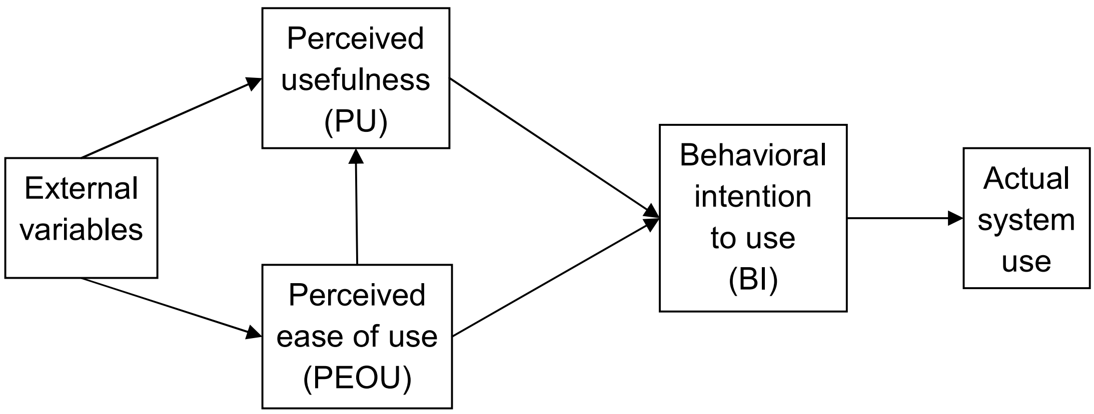

Figure 2. Technology Acceptance Model (Davis & Venkatesh 2004)

During the years TAM has been tested, extended and compared with other models (Sun & Zhang 2005). The three factors of TAM have been during the years proven to be reliable concepts, correlating well with the final outcome of actual system use (Davis & Venkatesh 2004). Especially PU has been confirmed as possibly the most important factor influencing user technology acceptance (Sun & Zhang 2005). In its earliest form, PU as a major determinant was theorized to be affected by the PEOU and external variables, and PEOU as a minor determinant to be affected only by external variables. These external variables would affect the BI only indirectly (Davis et al. 1989). The relationships between and the nature of the concepts in the model have received many suggestions after experimental theory testing however, and some of these are discussed below.

4.2.2 Developing TAM: TAM2

The original TAM-model has been extended with the introduction of TAM2, developed partly by its original author. These extensions were the result of studies that had showed other constructs than PU and PEOU effect technology acceptance. As a result, three interrelated social forces affecting the perceived usefulness were added in TAM2: subjective norm, image, and voluntariness. Additionally, TAM2 has three additional cognitive instrumental processes of job relevance, output quality, and result demonstrability, that concern work motivation and determining usefulness compared on what people need to do in their job. (Venkatesh & Davis 2000)

The subjective norm was already an important concept on the Theory of reasoned action (TRA) model that the TAM was built on, but it was left out as it was thought to have minor direct effect on BI and to be too difficult to measure (Davis et al. 1989). Subjective norm affects the user's intention of use so that users having a view, that people they consider important think they should use the technology, are more prone to use it (Fishbein & Ajzen 1975; ref. Davis et al. 1989). The image is the degree to which use of an innovation is perceived to enhance one's status in the social system (Tornatzky & Klein 1982; ref. Moore & Benbasat 1991), and it has been presented for instance in the theory of innovation diffusion (Rogers 1983; ref. Moore & Benbasat 1991). Voluntariness is the extent to which potential adopters perceive the adoption decision to be non-mandatory, which affects the importance of subjective norm in technology acceptance (Agarwal & Prasad 1997; ref. Venkatesh & Davis 2000). TAM2 therefore combines cognitive and social constructs as determinants in technology acceptance.

4.2.3 Developing TAM: UTAUT

TAM2 does not seem to gain much popularity, and after wide research in which several individual technology acceptance research approaches were used and results compared, Venkatesh et al. (2003) suggested a new view for user acceptance combining constructs such as innovation diffusion theory, TAM, and TRA. This model, Unified Theory of Acceptance and Use of Technology (UTAUT) has four determinants for intention and final usage, along with four moderators. The determinants of the model along with their descriptions are (Venkatesh et al. 2003).

- performance expectancy: the degree to which the individual believes that using the system will help him or her to attain gains in job performance; it is the strongest predictor of intention, replacing PU;
- effort expectancy: the degree of ease associated with the use of the system, replacing PEOU;
- social influence: the degree to which an individual perceives that important others believe he or she should use the new system, replacing the social norm as in TAM2;
- facilitating conditions: the degree to which an individual believes that an organization and technical infrastructure exists to support the use of the system. There is no counterpart of this construct in TAM or TAM2, but it rather combines concepts from for instance theory of innovation diffusion.

To these determinants, four influences have been theorized to be affecting, viz. those of gender, age, experience and voluntariness of use. A few constructs, appearing in different models also used as a source for UTAUT, are reconstructed, viz. those of self-efficacy and anxiety, which according to Venkatesh et al. (2003) are fully mediated by perceived ease of use.

According to its developers, UTAUT is a model that synthesizes what is known and provides a foundation to guide future research (Venkatesh et al. 2003). UTAUT-model has not solved all questions posed to TAM however: it still does not consider the alternatives for the measured technological solution if the user rejects the new technology, even though these are often available to comparison (Järveläinen 2004). There may also be a need for different theories for different types of technologies and services, as for instance mobile technologies and organizational technologies have different characteristics (Carlsson et al. 2006). UTAUT fails to measure individual characteristics apart from age, gender, and experience, but psychological traits like willingness to use technologies are relatively important factors in technology acceptance (Rosen 2004). Also the problem of not measuring attitudes that influence performance expectancy and intention to use still exists (Carlsson et al. 2006).

Research also suggests that the model is not fully functional: influence of social factors and facilitating conditions may be discovered partly through other factors and together with them, this being a slight contradiction to the UTAUT model that separates Social Influence as its own concept (Carlsson et al. 2006). Indeed, in 2005, there existed no other study than the original one confirming UTAUT's validity (Jones, Cranston, Behrens, & Jamieson 2005). This has encouraged the decision to use the more robust theory of TAM as the basis for those conceptual additions that TAM2 and UTAUT also lack (Agarwal & Karahanna 2000; Zhang & Li 2004).

4.3 Considerations on technology acceptance

4.3.1 Beliefs and attitude

According to Agarwal (2000), all conceptualizations of IT acceptance have three themes in common:

- beliefs are critical antecedents to acceptance outcomes;
- user attitude i.e. affective belief toward the use of IT is important; and
- aspects of the individual user and both social and environmental context in which the technology is to be used, must be considered.

Of these, beliefs and attitude are often encapsulated as a single construct, even if there is no clear understanding on the precise role of attitude construct in the technology acceptance (Agarwal 2000).

The concept of beliefs and attitude has been grasped in either trying to extract the beliefs from the users for each context and technology separately, or by trying to find some general beliefs (Agarwal 2000). TAM uses the latter approach: its main constructs are two general unweighed beliefs, usefulness and ease of use, that as the most significant determinants affect attitude and subsequently the intention to use (Davis 1989). Other beliefs not included in TAM, but found to affect technology acceptance in certain situations, include relative advantage; compatibility with the existing values and past experiences; or result demonstrability (Agarwal 2000). For all the importance of beliefs and attitude, the set of these needed to predict technology acceptance is unclear, however: there is not a single set of beliefs and their causalities that can be said to affect technology acceptance in all situations (Agarwal 2000).

4.3.2 Individual differences

There are two pathways through which individual differences affect technology acceptance: either indirectly via beliefs, or directly (Agarwal 2000). Researched individual differences affecting technology acceptance include cognitive style, demographic/situational variables, and personality (Zmud 1970; ref. Agarwal 2000).

There is some argumentation that in some situations, these may cause differences in technology acceptance (Sun & Zhang 2005).

Cultural background of the individual can affect the psychological measurements as a moderating factor and hamper the generalizability (Cozby 2006). It has not yet received much attention in technology acceptance research, however (Sun & Zhang 2006). Intellectual capability of the user has also its effect on technology acceptance, and it has been suggested that ease of use may not have as strong an effect among users with above-average competence on the subject (Hu, Chau, Liu Sheng, & Tam 1999). Another individual trait closely associated with intellectual capability is absorptive capacity, the ability to facilitate the absorption of new knowledge, recognize its value, assimilate and apply it (Cohen & Levinthal 1990; ref. Sun & Zhang 2005). This would help the user to learn the technology's properties faster and subsequently perceive it easier to use.

There has also been some research that has validated the TAM with demographic moderators; results assigned that gender, IT competency and age do not bias the model (Lai & Li 2005). Including some moderators to the model does, however, enhance the model's explanatory power to some degree (Chin et al. 2003; ref. Sun & Zhang 2006). Inclusion of moderators may therefore enhance explanatory power, but it lowers the model's elegance, and simplicity has always been an asset of TAM (Sun & Zhang 2005).

4.3.3 Context

TAM has been applied mostly in the area of office software usage (Legris et al. 2003), where it explains about 40 % of system use (Venkatesh 1999; ref. Venkatesh & Davis 2000). Management and information services have been another often-studied area (Lai & Li 2005). TAM serves as the theoretical basis for many researches, though to some extent it still needs contextual validation: this is due to the fact that most studies have had students or business organization users as research subjects (Hu et al. 1999).

A division can be made between work-oriented or entertainment-oriented technologies, in which especially the usability factor may affect the use intention to different degree. In a flexible technology like newspaper reading interface, many possible future contexts and therefore situation of use may also be unfamiliar to potential adopters. In laboratory test setup, future use context is even more difficult to pin down. Promisingly, TAM has had higher explanatory powers in laboratory experiments than in field tests. This may be due to that in field tests, several factors are at work, which causes the model to be too simple; i.e. in a complex context there is a need for additional factors to capture the complexity. In a less complex context, the influence of context then diminishes compared to other factors. (Sun & Zhang 2005)

Laboratory studies have demonstrated better explanatory power for technology acceptance than field tests, probably because in order to grasp the technology acceptance situation in real world, the models would need additional factors (Sun & Zhang 2005). For instance social systems are a complex context that includes normative influences that cause pressure to the individual choices. Yet another account on generalizability of the study results, and therefore the model, is that the measurements are based on self-reported use rather than observing actual usage (Legris et al. 2003).

Technological moderators of context include complexity or the degree of individualism in using the technology, i.e. the degree to which the technology is used in company of other people (Sun & Zhang 2005). There may be factors that are implementation-specific, such as received user training or support (Adams, Nelson, & Todd 1992). Some may be technology-dependent: for instance for Internet and especially e-commerce, trust is an important factor (Gefen et al. 2003; ref. Kaasinen 2005). Most TAM tests are applied with the implicit assumption that there would be no difference between single or multiple-choice situations, i.e. no specific comparison behaviour is needed (Mathieson 1991). This may be the reason for some inconclusive results for the model: there is empirical evidence of people having positive attitude towards a technology, but still the technology is used rarely or not at all (Eikebrokk & Sørebø 1998).

Also mandatory use vs. voluntary use, own attitude vs. social norm of using a technology have effects in technology acceptance (Agarwal 2000). These suggestions have been easier to apply and be included in later technology acceptance models: as described above, both TAM2 and UTAUT have taken the considerations of normative influences into account.

Another dimension of context is that of situational influences. These are complex combinations of constructs mentioned earlier, making it problematic to construct a distinct concept at all (Agarwal 2000): no conceptualization of situational context, i.e. the situations in which the technology will be used, is explicitly included in TAM. Currently, this is causing concern among researchers: if a context-free judgment is not possible, the participants may induce their own context which damages controlling the measures (Hassenzahl et al. 2000).

TAM is an example of a model that has proved powerful even without the concept of context included (Sun & Zhang 2006). However, the often-used office-context ties the used technology to a certain task, the nature of which can then affect acceptance factors (Sun & Zhang 2005). Resulting problem is that in work-related technologies, even if the task is not implicitly named, people can easily compare their tasks with the functionalities in order to assess the usefulness of a technology. Davis and Venkatesh (2004) even themselves posit that “people form perceived usefulness judgments by comparing what a software product is capable of doing, with what they need to get done”. Therefore they are able to find a common context for the use of the technology.

4.3.4 Process approach

The influence of some factors on Behavioural intention (BI) varies at different stages of the information system adoption process. For instance it is unclear, whether all the antecedents for technology acceptance are as important during all the phases of the technology acceptance process: there is some proof that social influences are important in early adoption decisions, and attitudes are important in later stages when users have had the opportunity to develop them (Agarwal 2000). This would call for a more dynamic, process-oriented approach to technology acceptance.

One possibility is to study the acceptance in different stages of its implementation, as the systems, the users, and the environment change (Mathieson 1991). For instance the achieved skill of users influences the relationships between different concepts of technology acceptance (Taylor & Todd 1995). Some longitudinal research with TAM has been conducted, in order to construct more dynamic model; this includes the phases of adoption from pre-implementation user reactions, post-implementation user reactions and actual usage behaviour (Davis & Venkatesh 2004). There have been suggestions to give more attention to adaptation, reinvention and learning as a reason for technology acceptance outcomes, as this may help the developers to find out unpredicted ways to use a technology (Agarwal 2000).

4.3.5 New framework

As suggested earlier, there are additional recognized factors and moderators affecting the acceptance of a technology, many rising from other disciplines like social sciences. Methodological proposition to gain richer understanding of less studied factors has been to inspect technology acceptance with qualitative methods instead of positivist, quantitative methods. Contextual and process elements of technology acceptance could be then investigated by interviewing and grounded theory analysis (Sun & Zhang 2005).

Instead of trying to create a grand unified theory of technology acceptance, it has also been suggested that several models can be used in order to gain information on the subject on wider scale. As TAM provides general information on technology acceptance, other models such as Theory of planned behaviour (TPB) could be used during development and post-implementation evaluation. Therefore, TAM as an easily implementable instrument could be used primarily to find dissatisfied users and the nature of their complaints. After the problematic area has been diagnosed, TPB might provide more specific information on important user groups, system's performance, and to identify barriers to use. (Mathieson 1991)

4.4 Cognitive absorption

4.4.1 Cognitive absorption: deep involvement with software

Critics positing that the number of factors in TAM is too small have quite recently been replied by stating that many of the predictors of user acceptance mediate via TAM constructs (Davis & Venkatesh 2004). TAM and many other models of technology acceptance have focused on instrumental beliefs, believing them to be in the core as drivers of individual usage intentions (Agarwal & Karahanna 2000). Designed for organizational use, TAM expects technology use is based on sensible choices and cognition. Some suggested factors, however, represent the change of viewpoint for technology acceptance, and their clearer inclusion to the model is therefore arguable.

Individual's interaction with technologies has become increasingly engaging experience with the development of rich graphical interfaces (Agarwal & Karahanna 2000). It is possible to explain technological experiences with constructs such as cognitive enjoyment (Webster & Ho 1997). There has been some research studying the concept of "fun", which has showed to effect the user satisfaction even in work context (Iqbaria et al. 1994).

Combining these results together with others like the theory of flow discussed shortly in Chapter 2.2.1, Agarwal and Karahanna (2000) have proposed a construct called Cognitive absorption (CA), which they defined to be "a state of deep involvement with software". This concept serves as an antecedent to beliefs about an information technology, and is an intrinsic motivation related variable related to motivation.

CA is theorized to affect both belief constructs, Perceived ease of use (PEOU) and Perceived usefulness (PU) in TAM. PEOU is affected by all five dimensions in CA, which are (Agarwal & Karahanna 2000):

- Temporal dissociation (TD), which causes the individual to perceive to have ample time to use the technology;
- Focused immersion (FI), which suggests that all of the attentional resources of an individual are focused on the particular task;

- Heightened enjoyment (HE), which causes the activity to be perceived as less taxing;
- Control (CO) perceived as in being in charge over software, which should reduce the perceived difficulty in task performance; and
- Curiosity (CU), which suggests that the interaction invokes excitement about available possibilities. This serves to reduce the perceived cognitive burden associated with the interaction. Curiosity may be caused by the used technology's relative complexity: too simple technologies can be boring (Csikszentmihalyi 1975; ref. Hassenzahl et al. 2000). Therefore overt simplicity does not necessarily account for increased perceived ease of use.

PU is affected by Heightened enjoyment of CA. This has been theorized to be due to that HE raises cognitive dissonance (Agarwal & Karahanna 2000). Cognitive dissonance is "a state of disharmony, inconsistency or conflict between the organized attitudes, beliefs and values within an individual's cognitive system", suggesting that people are motivated to restore a balance by reducing anxiety, for instance, with the help of contradictory experiences to the situation in question (O'Sullivan et al. 1996). Cognitive dissonance is solved by justifying the behaviour of enjoying the technology by rationalizing the enjoyment and attributing instrumental value to the technology, e.g. perceiving the technology as useful (Agarwal & Karahanna 2000).

4.4.2 Traits effecting Cognitive absorption

Originally, Agarwal & Karahanna (2000) theorized two determinants to affect the experience of cognitive absorption. One is the willingness of an individual to try out any new information technology, Personal innovativeness in the domain of information Technology (PIIT). Agarwal & Prasad (1998) conceptualized PIIT as "an individual trait reflecting the willingness to try out any new technology", thus influencing cognitive absorption so that the "individuals who have an innate propensity to be more innovative with computers are likely to be more predisposed to experience episodes of cognitive absorption".

Another trait suggested by Agarwal and Karahanna (2000) is the cognitive playfulness, defined as "the degree of cognitive spontaneity in microcomputer interactions" (Webster & Martocchio 1992). This is thought to be an antecedent of the state of flow, and to explain some variance in cognitive absorption. According to Agarwal & Karahanna (2000), there may well be other traits that affect cognitive absorption, for instance a personality trait of absorption, i.e. the individuals who are more disposed to absorption will more readily enter into, for instance, a state of focused immersion.

PIIT has been used as an antecedent, a moderator or a consequent to several concepts in the area of technology adoption, none of which relationships has been shown to be fully satisfying; lately, Rosen (2004) has suggested PIIT to be added to the UTAUT-model, as an influence of both BI and actual use behaviour. To test the theorized moderators of CA, PIIT was included in this study, even though its place in the model was not undisputed.

4.5 Perceived affective quality

4.5.1 Qualities of a technology

Affect or emotion occurs before cognition and intervenes with it, influencing the quality and type of cognitive processing (Russell 2003). There may possibly be effects by something intrinsic to the used technology. That is, the perception is not necessarily depending on before-hand attitude, i.e. beliefs and attitudes (Agarwal 2000), but also on the technology's on-use-effect to the user. On internet design, some research is already done: certain manipulable web site design factors have been suggested to cause certain affections (Kim et al. 2003; ref. Zhang & Li 2005). For different types of information technology, there might be specific or universal affective features, identifying of which would be an interesting task (Zhang & Li 2005).

Perceived affective quality, as explained earlier in Chapter 3.1.3, is the ability of an object or stimulus to cause changes in one's affect (Russell 2003). Therefore in technology, the perceived affective quality is "an individual's perception of the ability of a stimulus such as IT to change his or her core affect" (Zhang & Li 2004). Perceived affective quality is directly related to the characteristics of IT and users' immediate impression on it prior to any in depth appraisal or evaluation of interacting with IT (Zhang et al. 2006).

4.5.2 Concept of Perceived affective quality

The ultimate goal to finding affective features is to be able to manipulate affective qualities in a technology, and find out which affective features result in high perceived affective quality. According to research, effect of perceived affective quality is long-lasting, and the impact of the affective quality on the intention to use the technology gets stronger with time. A construct named Perceived affective quality (PAQ) has therefore been suggested to model a connection between a person's affect and the affect-eliciting quality of an information technology. (Zhang & Li 2004)

The measurement instrument of PAQ consists of a series of adjectives, developed by Russell and Pratt (1980; ref. Zhang & Li 2004). These adjectives are adapted for the two dimensions of core affect, arousal and pleasantness, as presented in Chapter 3.1.1 Figure 1, so that both extremities of arousal and pleasant dimension are covered (Zhang & Li 2004). Here, pleasant dimension measures the pleasantness of the technology, and the arousal indicates how interesting the technology is (Zhang et al. 2006).

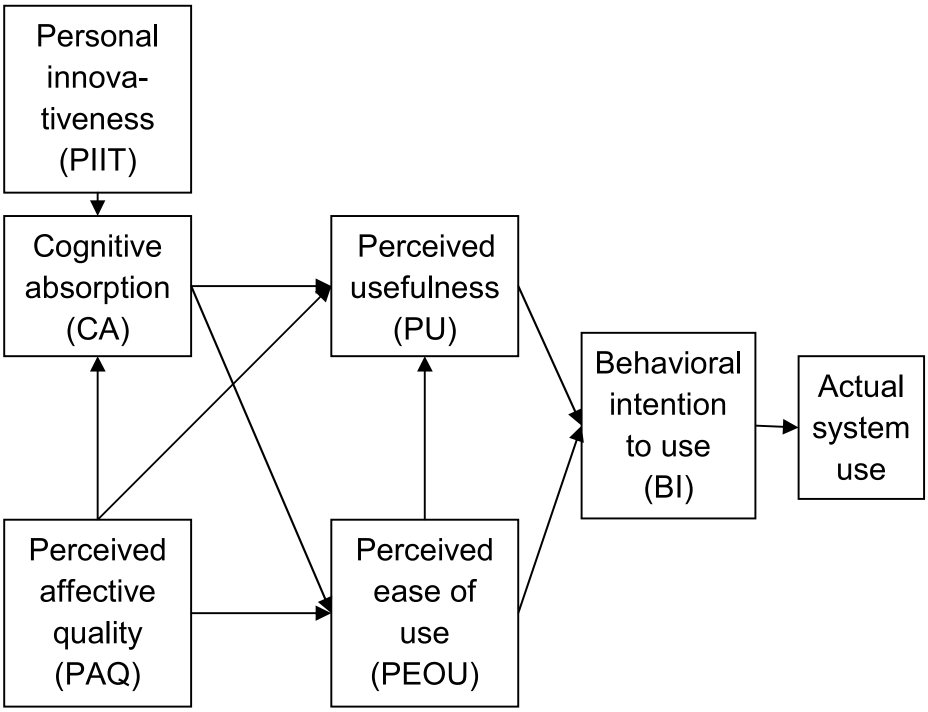

Figure 3. TAM-CA-PAQ-model (Zhang et al. 2006; cf. Agarwal & Karahanna 2000)

In its earliest form, PAQ affected all the constructs of TAM, viz. PU, PEOU and BI (Zhang & Li 2004). Adding the concept of PAQ into the combination model of TAM and CA (Figure 3) has been theorized to affect the three constructs of PU, CA, and PEOU (Zhang et al. 2006). Due to the freshness of the concept, there is again differing and scarce empirical evidence of the relationships within the constructs. Also the original measuring instrument has been developed for environments, which has caused problems since the launching of the concept (Zhang & Li 2004).

4.6 Conclusion

Of individual technology acceptance models, experiments have shown TAM to be primus inter pares (Venkatesh et al. 2003). During the years, TAM has been criticized to the extent that the model has been renewed, first by introducing TAM2 and last by introducing UTAUT, which combines several technology acceptance models of which TAM is considered superior. Even though UTAUT could be a more concise model than any single model before it, it is not yet perfect. UTAUT-model grasps many of the concepts of individual technology acceptance discussed earlier, but TAM, as an already well-established model, is the basis in most researches conceptualizing new factors affecting technology acceptance. With its wide-spread use and confirmation, it has means to remain so - at least until UTAUT gains wider recognition. As a result, the robust theory of TAM was the test model of choice for this study, despite its criticized lack of finesse. When possible, measures have been taken to avoid some of the fallacies in the model.

Theories having their roots in other disciplines seem to have interesting overlap with socio-psychological line of research, which TAM represents. The holistic and affective aspects like cognitive absorption, computer playfulness, or aesthetics are often treated as additions to these models (Zhang & Li 2004). The concepts represent the current change of paradigm in individual technology acceptance theories. Cognitive absorption is one recent addition to technology acceptance factors. Especially its dimension of Heightened Enjoyment seems to be of importance in use intention (Agarwal & Karahanna 2003), which is a renowned factor affecting actual technology use. Another additional construct is that of Perceived affective quality, which attempts to grasp the affects caused by the technology. There exists also confirming research on these constructs to support the view that instrumental considerations are not enough as explanations for technology acceptance (Igbaria et al. 1994; Yi & Hwang 2003; Saadé & Bahli 2005).

5 Method

5.1 Hypothesis

For the experimental part, the author’s research interest is to study the importance of affective factors in technology acceptance. By using Technology acceptance model (TAM) as a theoretical basis, the interest reduces into the task of finding out whether the holistic and affective concepts of CA and PAQ produce meaningful additions to TAM. The conceptualization of this is presented in the Figure 3, as presented in Chapter 4.5.2, which combines the models of PAQ and CA with TAM.

As discussed in Chapter 3.2, the subjective self-report measure, in most acceptance models applied as a Likert-scaled questionnaire, is not only method to research psychological events such as emotion. Instead, several behavioural, subjective, and physiological measures can be used in order to gain thorough understanding of a psychological situation and human affective responses to that (Bradley 2000).

Of the three measuring methods, applying behavioural measures is demanding (cf. Chapter 3.2), especially without prior experience. Behavioural measures are also redundant to the extent that observable changes in behaviour cause changes in associated physiological measures, and physiological measures record even changes that are behaviourally unobservable (Bradley 2000). For these reasons, this study relied on the use of self-report and physiological methods.

Self-report method in this study consists of the translated modelling questions of TAM, CA and PAQ (Appendix 1), along with some questions mapping simple moderators such as age and gender (Appendix 2). Choosing the physiological method requires more review. In ideal situation several psychophysiological measures are used to complete one another to give relevant information on responses (Dawson et al. 2000). Another procedure is to conduct an experiment to see if a method acts as a measure for a certain psychological concept (Jennings & Stine 2000), and this approach is applied in this study.

Of the physiological measures shortly presented in Chapter 3.3.2, EDA is highly correlated with self-reported emotional arousal (Lang et al. 1993; ref. Ravaja 2004). Half of the questions in PAQ are dedicated arousal dimension of affect, and measure of skin conductance was therefore chosen to be compared with arousal results received from self-report. Another possibility would have been to compare results of heart rate with the dimension of pleasantness in PAQ. However, as the focus was in technology acceptance and in order to subjects to have as natural an experience as possible, the experiment was to be very loose with unrestricted physical activity. This would have hindered receiving reliable results from HR, which indicates also physical activity (Bradley 2000). On the other hand, the appliances recording EMG activity need to be attached to the face (Ravaja 2004); this would have destroyed the naturalness of the test situation.

EDA is in this study treated as a supporting measure in order to gain information on the importance of emotion in technology acceptance. Indeed, in psychophysiological paradigm, the stimulus of a new technology is most probably too complex and the emotions evoked by it are difficult to be pinpointed (Ravaja 2004). Expertise is needed to receive adequate results with psychophysiological methods even in strictly controlled environments with simple stimuli (Kramer & Weber 2000). This research is therefore content to find even vague relationship between self-report and physiological measures when researching emotions emerging in using a new technology. If this is not possible, recognizing the problems in psychophysiological method applying is in itself advantageous, and would suffice as a result.

5.2 Experimental overview

5.2.1 Tested technologies

To test technology acceptance models, the study prepared two different television screens to be used in look-alike newspaper reading. In order to make comparisons of these digital technologies to the current way of reading a newspaper, there was one reference group reading an ordinary printed paper.

The DigiTVandPrint-project had earlier researched the delivery of newspaper content to digital television (VTT 2005), so the “living-room” television was chosen as a new technology with which to test the technology acceptance model’s explanation power. This kind of multimedia information system, having television as its user interface, has been often under research (cf. for instance Irven, Nilson, Judd, Patterson, & Shibata 1988; Carey 1997; Södergård et al. 1999).

For the purposes of finding the pros and cons of the suggested technology in comparison with other possible technology, an earlier study within the Helsinki University of Technology Media Lab (Suni 2005) was taken as a reference. This study concerned reading an electronic newspaper in the print paper’s traditional setting; the content was texts projected to a table. In this thesis, an embedded screen (“kitchen-table television”) was chosen to serve as a reference technology for the living-room television. This resembles a technology already commercially available: flat television embedded in refrigerator (Fila 2004), and could also simulate the experience of reading from paper-like screens.

5.2.2 Preceding preparations

Before the test, in total nine pilot experiments were conducted with eight different participants in order to correct flaws in the experimental design. The greatest change concerned that of the test time. As explained earlier, even a short, one-hour introduction to a system is sufficient for TAM to predict the future use of the system in question (Davis et al. 1989). In order to come close to this suggested time, first pilot experiments lasted 45 minutes, but this was considered much too long by some participants. Therefore a more modest time of 35 minutes was chosen as the duration of the final test.

The content in all three tests was the same, and the timing of the tests was evenly scrambled to different times of day to spread the alertness of the participants evenly. The manipulated variable in all three measurements was to be the technology tested. Other variables were not manipulated, because concentrating on one variable at a time was thought to ease the pressure on reliability in a test set-up and instructions: in a complex concept of media experience there were thought to be too many changing variables the tester was unable to isolate.

5.3 Test participants

5.3.1 General

The pool of participants consisted of 42 subjects, divided in three groups, totalling 14 participants per group, seven of which were men and seven women. Subjects took part in the experiment with no reward, and most people who were originally asked to join the experiment agreed, thus diminishing self-selection bias, i.e. leading to that not only those who are interested in the subject respond (cf. Hu et al. 1999). Before the experiment, the participants were asked to fill in a short questionnaire inquiring about their background. The following information was asked for:

- gender;
- age;
- profession; and
- education.

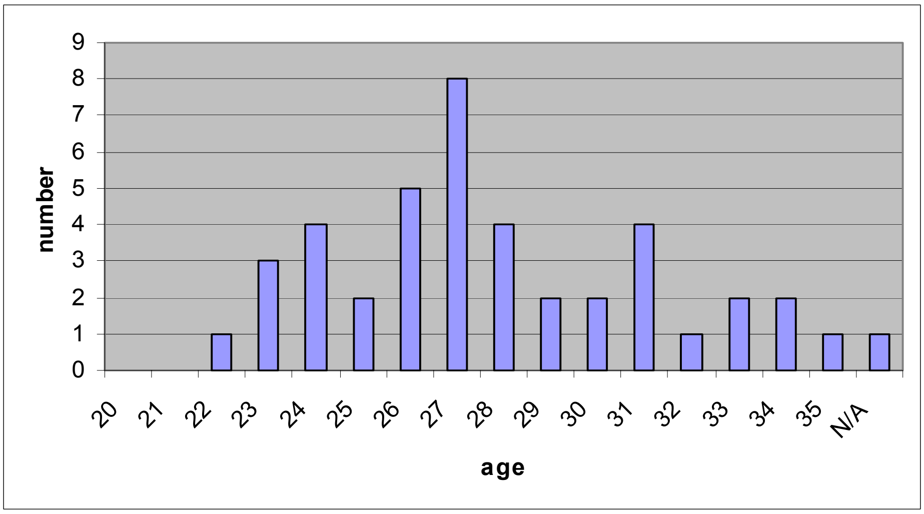

Figure 4. Age distribution of test participants

Of the respondents 55 % (23 of 42) had a master's degree or higher, and the age distribution was limited to 20−35-year-olds. Age distribution ($\bar{x}$ = 27.8, *stdev* = 3.4) of the participants is presented in Figure 4 above. More focused considerations of demography were outside of the scope of the thesis, but attributes like income and residence size are characteristics that indicate segments that have different media preferences (Kim 2002).

Ten questions concerning following certain media were also posed; viz. those of importance, and daily importance of

- television;
- television news;
- newspaper;
- Internet; and
- online-news.

The respondents judged their preferences with 7-point Likert scale. These questions were earlier pilot-experimented with 42 students from the University of Technology Media Laboratory. The results from the importance of different media to participants are presented in Figure 5.

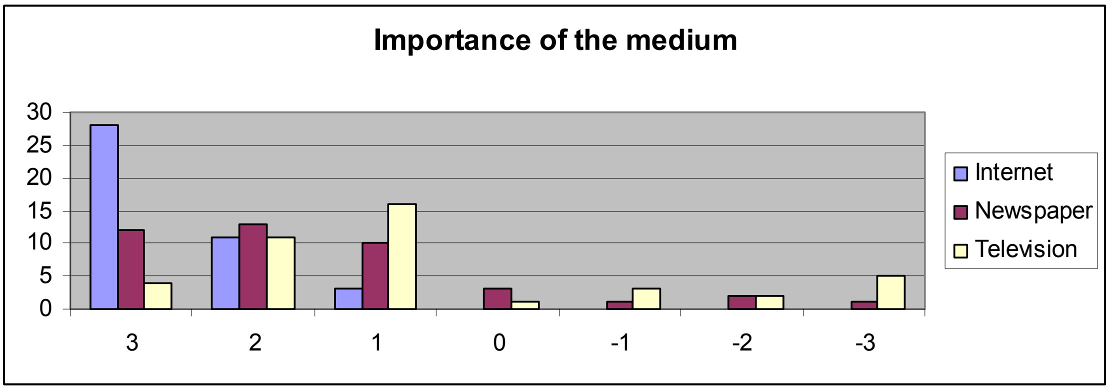

Figure 5. Importance of different media

The most important medium to the participants was the Internet ($\bar{x}$ = 2.60; *stdev* = 0.63, *median* = 3). Newspaper comes second ($\bar{x}$ = 1.52; *stdev* = 1.49, *md* = 2) and television was the third ($\bar{x}$ = 0.67; *stdev* = 1.80, *md* = 1).

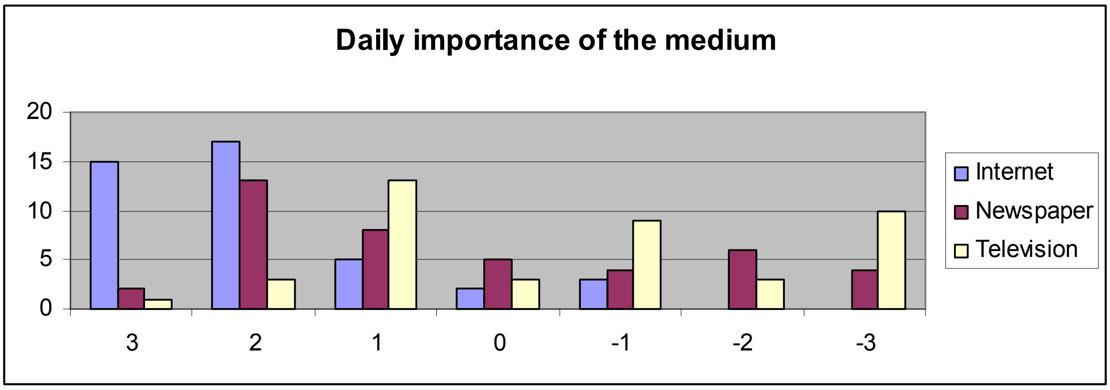

Figure 6. Daily importance of media

The daily importance of all media was presented in Figure 6. The results showed that the attached importance falls with every medium. Internet was still most important media ($\bar{x}$ = 1.93; *stdev* = 1.16, *md* = 2). Newspaper ($\bar{x}$ = 0.29; *stdev* = 1.84, *md* = 1) and television ($\bar{x}$ = -0.55; *stdev* = 1.80, *md* = -1) were still less important. With wide deviation, Internet seemed the most important medium for the subjects.

5.3.2 Age group

In this study, it was only young adults whom were presented with different technological choices. Limiting the age group is not unproblematic: for instance Funk (2004; ref. Kaasinen 2005) notes that "focusing too early on only limited user groups may miss possible early adopters" of a technology. However the interest of newspapers, the background project participants, is in trying to find a technology that might be adopted by a certain user group. It is these young adults, who have proven to be the most challenging group of readers, not embracing the newspaper as their daily ritual as the previous generations did (Lyytikäinen 2003).

On the other hand the technology acceptance models, enhanced with emotional factors, are not trying to forecast who will accept the technology, but rather theorize the factors affecting the acceptance. Therefore, the limitation of age group was thought to enhance the reliability of results to test the recent technology acceptance model, and at the same time be of special interest to newspapers. It is not impossible that some other age group would have had different media habits or shown different kind of interest in the technologies tested, but it was decided to concentrate on one age group instead of trying to properly cover a wider selection of possible users. The small size of groups taken into account, this limitation was definitely appropriate.

5.3.3 Educational background

Often in researches conducted in universities, participants are undergraduate students, perhaps even of the same discipline as the scientists (cf. Webster & Martocchio 1992; Taylor & Todd 1995; Webster & Ho 1997; Agarwal & Karahanna 2000; Zhang & Li 2004; Lai & Li 2005; Zhang et al. 2006). This approach has been criticized as “the science of the sophomore”, by stating that students are inappropriate participants whenever the study involves assessing a psychological state (Sears 1986). In order to avoid the most obvious issues of life experience, a group of volunteers from companies, from the personnel of the laboratory, and from universities, also other than Helsinki University of Technology, was collected.

As it happened, 33 % (14 of 42) of the participants considered themselves to be primarily students, both undergraduate and postgraduate. The full-time workers were all in somewhat homogenous status stages in organizations, 60 % of the participants (25 of 42) announcing being employees. Also a remarkable part of the test participants had studied natural sciences at university level in one form or another: for instance 40 % (17 of 42) had a degree in Masters of Science in Technology. Due to this homogeneity of backgrounds, the ambiguities of the wording and flaws in the pre-questionnaire’s demographical part were not thought to be grave; the perceivable homogeneity was thought to further enhance the reliability of results, if not their generalizability. Should a further research be conducted, the background of the participants should be more precisely defined.

5.4 Content and its format

5.4.1 General

The content in the tests was provided by a major Finnish daily newspaper taking part in the DigiTVandPrint-project. It consisted of a newspaper of 22nd of February 2006, thus approximately two months old at the time of the tests, which took part in April. The original content of the paper had been originally processed with Java to a look-alike-paper by Finnish software company. This look-alike-paper had been customized to wide-screen television presentation instead of a computer screen, and to it, some MPEG4-video clips had been added to bring extra functionality.

The video clips could be viewed in Apple QuickTime-plug-in that opened to the right, when a caption link was pressed. This format of presenting videos along with text had been studied earlier in the Media Laboratory. Here, the result had been the size of the video window not having statistical significance on reading speed and comprehension (Haataja 2002), so the inability to change the window size was not considered a flaw. (On other viewpoints on the readability of texts and video from television screen, cf. Haataja (2002); on the caused mental workload, cf. Närhi (2006).)

The user interface for the content was the web browser Mozilla Firefox 1.5 in its full screen mode. There was available another user interface: a non-commercial Media Centre of the Windows Media Centre type, which could have been used with a remote control in the television setup. This interface was very slow however, and the content would have been browsed with an internal browser of the Media Centre interface, thus making it very similar to using the plain browser. For consistency between the television and table TV, Firefox and the mouse were therefore chosen as the user interface.

5.4.2 Problems of the layout

Additional video clips did not have any connection to the written content. The content of the video clips was in several occasions meaningless, for instance, a video containing street noise and passing people. As with the layout of the content, it seemed that also this interface had to overcome the usual problems of trying to develop a new medium format. According to Poynter Institute, that examines newspaper readers' online reading habits, three most basic problems in online print are the following (Veseling 2006):

- lack of good navigation;
- lack of hierarchy in storytelling; and
- poor use of photos.

The test version of the look-a-like-paper had limited possibilities for navigation, and both the photos and the videos were of poor visual quality compared to the high resolution of screen. The author warned participants about this and asked participants to concentrate on the whole, but from some responses it became clear, that these flaws had been annoying.

5.4.3 Missing functionalities in the laboratory test

A trait not available in the laboratory test but a promising functionality overall, was the possibility to make television programs appear in a separate window during the reading. This was thought to be one of the advantages of the technology in real life (VTT 2005). In laboratory tests, however, the content of real time programs would have been different for every weekday and time of day, i.e. for every participant, and the contents of the old newspaper and the news and other programs in the television broadcast would have differed much. This suggested the need to show the same recorded television shows for all the participants, but as the publishing day of the paper was not known beforehand, there was no material available.

The effort to make the situation time context -independent would have been undermined by the choice of the television program: by choosing to show morning or evening programs the reading time would have been tied to a certain time of the day. It would have been needed to record several channels in order for the participants to be able to choose their favourite one. In case the program had been more interesting than the reading material, the readers' focus might have deviated from reading the newspaper to watching the television show. While the newspaper was old and not the familiar, local paper of the test participants, this was taken to be a serious threat. All in all, the possibility to view television during the reading was considered to cause too many complexities to handle, and was therefore abandoned.

5.5 Apparatus

5.5.1 Hardware

A lap-top computer provided the data for different screens. The laptop providing content for digital newspaper in the two new technology groups was a Hewlett-Packard Pavilion dv5009. This laptop sent two signals, audio and video signal, to either a 32' 1366x768 LCD for television set-up (16:9 widescreen format), or a 23' 1920x1600 LCD for the table set-up (16:10 widescreen format). In television set-up, internal loudspeakers provided the audio needed in watching the video content, and in table set-up, there were two external loudspeakers providing the audio.

5.5.2 TV setup

For the living-room set-up, the test participants were sitting on a sofa approximately 160 centimetres from the television. The lighting of the room was by fluorescent tube. The television was used with an optical cordless mouse that could be moved on the lap, on the surface of the sofa, or on a small round living-room table next to the sofa, which is not shown in the Figure 7 below.

During the tests, the lighting of the room was automatically put out, if no movement was detected for a certain time. This caused annoyance to the participants: some exclaimed when the lights turned off. Luckily the put-out happened at least superficially randomly. The sound insulation in the room was not optimal either, as there was only one closed door leading to the corridor at the end of which was the laboratory coffee room. Certain test intervals were also noisier than others due to the routines of personnel in the laboratory.

Figure 7. Living-room set-up (courtesy of Ville Rantanen)

5.5.3 Table TV setup

For the table TV set-up, there was a wide desk in which a hole was cut and a wide-screen LCD was embedded. The screen was covered with a special glass, in order to avoid its scratching, breaking or reflecting light. Half of the test room was lit with fluorescent tubes, not immediately above the screen. There was also some sunlight getting into the test room, and a smallish office lamp to the right, which the participant could move according to his/her wishes. The browser was used with an optical cordless mouse, which was placed on the table next to the screen.

The distance between the edge of the desk and the screen was roughly 10 centimetres, as no indicator for a more specific measure was found in the studied literature. The optimal distance would probably be dependant on the personal preferences in reading positions, and also by the height of the person in question. It was possible to adjust both the height and the back rest of the chair used in the test, and this was thought to be enough of an adjustment available. There was also plenty of room to lean on the table, even if leaning on the screen was not recommended, as the glass was not unbreakable.

The test set-up is viewed in Figure 8 below.

Figure 8. Table set-up (courtesy of Joni Jääskeläinen)

For navigating in the newspaper, a mouse was used. The resolution used for the signal was 1240x1080 pixels, which was not the natural aspect ratio of the screen; this ratio was, however, well balanced and did not make the newspaper and its details appear too small. The images and videos in the look-alike-paper were unfortunately seen to be of poor quality - simply put, the high-resolution screen was too good for the look-alike paper.

The table set-up room was remarkably better sound insulated than the television set-up room, with two walls and closed doors leading to the coffee room of the Media Lab. On the other hand, the tester was notably closer to the participants behind the standing screen, and therefore the noises of the tester may have caused interruptions of thought for the participant.

5.5.4 Newspaper setup

The reading experience of an ordinary newspaper was measured for a paper that was from the same day as the look-a-like-paper. There were two exemplars of the print papers from local libraries, both of which were in good condition. The set-up took place in the same desk that the table-TV-test, as this room was quieter and the tester was more conveniently posited behind screen. Lighting and the position of the measurement appliances were similar to the previously presented set-up. One exception was the fact that the newspaper was read on top of the glass covering the screen, and some participants leaned on the glass under the paper during their reading, thus causing creaking.

There had been some discussion that two different ways of reading a paper could be measured, viz. those of reading the paper on a table leaning over the paper, and in a sofa leaning back. The limitation of the psychophysiological appliances caused this idea to be buried: as the measurement sensor had to be fastened in the hand of the participant, reading a newspaper in the sofa leaning backwards and using both hands was not possible. As the other possibility of reading the newspaper lying on the sofa table was thought to be similar to the experience of reading the paper from a bigger table, only the table-reading context was used.

The newspaper test setup was simple and the physical conditions did not show any special problems before or after the analysis.

5.6 Experiment course

The test began with the participant filling a pre-questionnaire. After this, the participant was asked to sit on the sofa or the chair, where psychophysiological appliances were put into their fingers. The variable of skin conductance was measured from the participants' non-dominant hand, which was for most of the participants the left one. All left-handed participants asked to have the appliances in the left hand as they were familiar in using the mouse with right hand. The appliances were put to the hand this early in order to give them more time to get used to the apparel.

The tester explained what there was to do with the technology in question, i.e. that the subject could read the newspaper freely and that there would be no questions concerning the content. The tester went then behind screen, and measured the base level of skin conductance for five minutes. Base level measurement is needed as a reference point, as natural skin conductance and its stability vary between individuals (Dawson et al. 2000). After this, the participant was told to begin reading. During the test, notes were written about the activities of the participant: the number and the content of the videos started were written down, as were background noises and the heard reactions of the participants. The tester sat behind a screen making notes, and announced from there when the test time was up.

After 35 minutes, the participants were asked to stop reading, and another base level was measured. This second base level was measured in order to neutralize the effect of pre-test excitement. When the last five minutes had passed, the participants were asked to fill the post-questionnaire, and the tester went away from the room.

6 Results

6.1 Behavioural measures

As stated Chapter 3.2, there are three types of psychological scientific measures: behavioural, subjective, and physiological (Cozby 2006). In this study, all three measures were used. Self-report measures were taken with two series of questions, pre-questionnaire and post-questionnaire, and physiological measures consisted of skin conductance measurements. The collection of this data is described below.

Behavioural measures were taken as notes during the experiment, and they were used mainly to remind the author of extraordinary happenings during the trials in order to explain how the test situation might have affected the self-reporting. The number of the videos watched fully and partially, and the number of how many different videos the participants watched, were calculated and analysed in preliminary phases of the analysis. These did not show any correlation with technology acceptance factors, however. As mentioned, the content of the videos differed from the newspaper article content, and the subjects knew this. The video viewing reflects perhaps curiosity of the participant towards the video technology properties, and to some extent the degree of the participant being dulled towards the end of experiment. Finding the exact reasons are outside of the scope of this research, not least because the behavioural measure was not applied with full care.

6.2 Subjective measures

There were two series of questionnaires in digital form, accomplished by Microsoft InfoPath 2003, to be filled by the participants. The laptop including the questionnaires was Acer Aspire 5672WLMi for 41 test cases and Hewlett-Packard nx6110 for one test case. The forms were XML-based, and after their filling, the information was readable in Microsoft Excel. The pre-questionnaire, created by the author, served as background information (Appendix 2) and the post-questionnaire (Appendix 1) included the technology acceptance modelling questions.

The questions in both questionnaires were scrambled pseudo-randomly to avoid the order effect: this means the phenomenon of the order of presentation affecting the dependent variable in the form of participant fatigue, practice or felt contrast (Cozby 2006). This was done despite the statement of Davis and Venkatesh (1996) that the questions may predict and explain user acceptance of information technology best when assembled in groups.

In the pre-questionnaire the demographic questions came first and always at the same order, followed by the scrambled questions collecting information on media use; in the post-questionnaire there were two groups of questions and the questions were scrambled within the group. All in all, there were seven different versions of the first questionnaire, and six different versions of the second questionnaire. With forty-two subjects, this secured no pair of respondents answered to a similar combination of questionnaires.

After experimenting, the participants were presented another form to fill. This form consisted of two parts. First the participants judged the used technology with a given adjective, 20 in total, by a 7-point Likert scale. The series of adjectives modelled the properties of Perceived affective quality as presented by Zhang et al. (2006). After the adjectives, participants answered 32 questions concerning the technology and impressions the respondents had got during their 35 minutes of exposure to it. This series of questions were applied from the Technology acceptance model with the added Cognitive absorption factor.

6.3 Physiological measures

The laptops including the software to collect the psychophysiological data were the same that were used to fill the questionnaires. BioGraph Infiniti 2.5 software by Thought Technology Ltd. received the measurement information from its hardware unit ProComp Infinity. The hardware measuring unit consisted of a coder and two sensors. The coder was located behind the user (television set-up), or in left-front side (table-television and newspaper set-up). To it, a cable attaching the sensor was connected. The coder sampled the sensor signal, digitized, coded and sent the information to the software via a light cable connected to a USB-port in the laptop (Thought Technology n.d.) behind the screen where the tester was located.

In the test, one channel was used for measuring plain skin conductance values in micro-siemens units, in frequency of 256 samples per second with time stamps. As suggested in the literature (Dawson et al. 2000), the skin conductance was measured from two fingers of the same non-dominant hand. The sensor included two electrodes, which were fastened to fingertips. The electrodes and the fingertips were cleaned with disinfectant before the fastening, as was done by M. Heikkilä (2005). This policy, however, was later found to be undesirable, as explained by Dawson et al. (2000), and it was thought to affect the results received from the measures.

6.4 Uncertainties in the measurements

6.4.1 Testing time

It has been reported that an average time a Finnish young adult uses for reading a newspaper per day is over 30 minutes (Intermediatutkimus 2002; ref. Moilanen 2004); more precisely, for 20 to 24 year olds 35 minutes, for 25 to 29 year olds 31 minutes, and for 30 to 34 year olds 42 minutes. The final test time of 35 minutes was therefore slightly above the reported average reading time of the test group consisting mainly of 25 to 29 year olds.

Daily newspaper reading does not necessarily happen on one occasion, but is split within the day. However the participants were thought to need some extra time to get used to the interface and to pause their reading for looking at the videos. As it was proven, 35 minutes was still too long a time for some participants, who reported being forced to repeat reading the newspaper from the beginning because the measurement time was not due.

6.4.2 Problems with the pre-questionnaire

The possible conclusions drawn from the results of the pre-questionnaire are limited. For instance choices in the profession and education were unclear for many respondents. It would have been better to ask a specifying question of how important the printed paper is as a news source. This was asked about other media. There is no clear consensus on whether an important medium can be considered to be an important source for specific content: for instance Hawkins et al. (2001) consider this inappropriate; on the other hand according to the research reported by Kytömäki and Ruohomaa (2001), important media are often also important news media.

These flaws would be serious, if the number of people studied was larger. As a study of this size most often serves as a pilot experiment for one using more test participants, these failures are to be noted and avoided in following research that may be able to include a greater number of test participants. In this thesis, the groups of age, profession, and education were within limits homogeneous. Also the focus of the thesis shifted to the Technology acceptance model study, where this information was not strictly necessary and therefore it was not used.

6.4.3 Problems during the measurements: Random error

There were extra variables causing confusion in the analysis. The results may be due to both the independent, deliberately manipulated variable, and the extraneous variable (Solso & MacLin 2002). The noticed sources of uncertainties during the measurements could be divided into three categories, along the description of Nunnally and Bernstein (1994) of errors affecting measurement reliability:

- constant error: repeating external factors and mistakes of the set-up;
- systematic bias: internal factors of participants; and
- random error: external factors that differed from measurement to measurement.

Random error complicates the relationships in the experiment in vain (Nunnally & Bernstein 1994). In this study, random uncertainty factors were either accidental, for instance caused by the tester’s mistakes, or due to the fact that the test environment was used by other people when the tests were not going on. For example, once the tester realized that another computer in the test room was keeping such a noise, that it was impossible to hear whether the participant watched any video clips or not. Another time, the tester noticed that somebody had removed the lamp from the test table. During television technology measurement, the screen suddenly changed its aspect ratio from wide to letterbox.

Random errors can never be completely eliminated, but the objective is to minimize them (Nunnally & Bernstein 1994). There were not too many unavoidable errors in this research, either. Most random errors in this test could have been avoided either by the tester being more careful, or the test set-up being untouched during the measurement period.

6.4.4 Problems during the measurements: Constant error

Constant error is the systematic error that affects all measures equally (Nunnally & Bernstein 1994). In this study, constant error of the setup was mainly noises from outside of the test rooms, and changing lightness. Instead of having only the technology as a manipulated variable, the test room was changed also. This happened because of practical reasons: different test set-ups required their own rooms. Strictly speaking, the study was then not a single-factor experiment but factorial (Solso & MacLin 2002), which was not understood in time.

Initial assumption had been that both rooms were appropriately isolated and otherwise identical, but the table set-up room was isolated from the coffee room next to it with two doors. Yet the slamming of the corridor doors and some noise from outside was audible during the silent moments of the test. The television set-up room was much worse with only one unisolated door.

The problem of the lightness was also more visible in the television set-up room. In the room, the lighting is automated. This meant that during the tests the lighting went on and off, if the participant was not moving "enough" for the sensors. A few times, the lightning in the whole room went gradually off; then the tester had to put the lights on again, which caused noise.

6.4.5 Problems during the measurements: Bias

Bias is the systematic error that affects measures differently (Nunnally & Bernstein 1994). Here, internal factors of participants were not controlled though they were affected by the time of the day and thus their alertness varied. Also the content and the read newspaper as such may well have evoked reactions in participants. As discussed in Chapter 4.3.1, the attitudes and beliefs of the users towards a technology have not been successfully modelled yet. Many of the suggested additions to TAM include concepts affecting individuals' predispositions, so this is rather a theoretical problem instead of practical.

What is harder to analyse, is how much the constant error of noise and lightning affected the participants because of their internal differences causing bias. Some people get the feeling of deep attention and engagement more easily than others (Tellegen & Atkinson 1974; ref. Agarwal & Karahanna 2000). It is impossible to say, how many and whom of the participants were severely distracted by the external noise or annoyed by the lights going off. Overhearing discussions in the television set-up room and reacting to them might have also been possible.

6.4.6 Discussion on errors

Repeating experiments with a better design is suggested to eliminate the influence of extraneous variables (Solso & MacLin 2002). In this study, repeating the measurements was not possible due to schedule reasons. Therefore, a consideration on whether the errors were grave was conducted.

Random errors were caused by accidents, so better design would remove the resulting uncertainties. The accidents caused by the participants can be reduced by making the situation as fool-proof as possible. The accidents caused by mistakes on the tester's part can be diminished with better preliminary preparation, and the accidents caused by test environment's characteristics can be avoided by redesigning the environment.

Random errors did not cause severe uncertainty to the objective post-questionnaire responses, as they had mostly nothing to do with the technology in question. In other two measures the situation was different. In objective psychophysiological measures, shocks caused by accidents such as the tester coughing, have caused reactional changes in skin conductance, and the ability to isolate the effects of these accidents from the proper signal was dubious. The behavioural measures were not prompt enough for EDA measures: these require discrimination of intervals of 100 ms or less for complex events, while the latency of the measure overall is around 1-3 seconds (Dawson et al. 2000).

Constant uncertainty factors, continuing background noise and the changing lightning, which differed in different rooms, were severe errors in the experiment design and could be diminished with better set-up preparation. As the confounding effects were exposed only during the experiment, psychophysiological results were thought to be seriously polluted and to be vague material for conclusions.

Subjective responses on the perceived quality of these technologies are uncertain on the dimensions of immersion at least due to repeating distractions, especially the more constant background noise. Due to this, no deep analysis on the “likeability” of or comparison between different technologies was done; it was suspected, that the existing differences of the responses for different technologies were to some extent caused by differing experimental circumstances. In modelling technology acceptance this does not present a problem: theoretically, immersion is a dimension of Cognitive absorption (Agarwal & Karahanna 2003), and will affect responses to other concept variables accordingly. This was expected to be worthy guiding material to further technology development.

6.5 Conclusion

The objective, psychophysiological measures suffered from disturbances in test situation and was doomed unreliable before further analysis. The delicacy of the psychophysiological measures was known beforehand; in enormously better-controlled settings and handling of the data, there still exists artefacts hampering the analysis (Kramer & Weber 2000). As stated in Chapter 5.1, the gain from this measure became to be of the experimental design improvement kind. Analysis of the results is therefore very basic.

The subjective measures did not suffer from similar problems. In real-life situations, disturbances and suboptimal circumstances occur often, and on cognitive level people are able to treat them accordingly: different psychological events may cause similar physiological events (Cacioppo et al. 2000). As the effect of extraneous variables differed between different technologies, comparisons between the technologies were not considered to be reliable. This suggested the responses from the control group of newspaper readers might have no further use. Also the incompleteness of the pre-questionnaire was not considered very grave, but its usefulness seemed to diminish along with the inability to do comparisons between different media types. As a result, the post-questionnaire responses of the new technology participants were the final subjective measure analyzed.

7 Subjective measure analysis

7.1 Methodology

7.1.1 Factor analysis

For psychological constructs, factorial analysis is a method family able to determine both internal structure of a construct, and cross structures between constructs (Nunnally & Bernstein 1994). Different factorial analysis methods have developed in generations, the first generation consisting of principal components analysis, factor analysis, or multiple regression models (Chin & Newsted 1999). Factor analysis explores latent variables, that are not directly measurable, but cause variation in measured variables; the variables that vary similarly are bundled into factors (Nummenmaa 2004). In this study, BI is the measured variable, whose items had significant correlation inside the construct. The other concepts are latent variables.

Of second generation methods, Structural Equation Modelling (SEM) has gained popularity during last decades. SEM-techniques offer generalizations and extensions of older procedures, and as a result they often require developed software such as LISREL or AMOS. Partial least squares method (PLS), an approach of SEM, is a tool often used in later TAM and related studies (cf. Davis & Venkatesh 2004, Saadé & Bahli 2004, Iqbaria et al. 1994). The approach of PLS is to form a predictive model from the data; it can suggest where relationships might or might not exist (Chin & Newsted 1999). PLS approach and first-generation factorial techniques are also complementary (Chin & Newsted 1999). Due to the complexity of conducting SEM and PLS, factor analysis was used in this study. In this case, the theory (emotion does affect technology acceptance) was known and the situation was a theory testing kind, so the simpler approach was suitable.

There are two types of factor analysis: Exploratory factor analysis (EFA) and Confirmatory factor analysis (CFA). Some researches in the studied technology acceptance literature conduct CFA (cf. Lai & Li 2005). CFA is mainly used to find out whether the data fits the given theory (Nummenmaa 2004). This may cause a “confirmation bias”, i.e. a prejudice in favour of the model being evaluated, instead of being open to distinct models that may provide alternative meaningful explanations of the data (MacCallum & Austin 2000). To diminish confirmation bias, alternative models should be examined (MacCallum & Austin 2000).

In the context of this study, finding that the resulting data does not replicate the expected model combination does not mean that the holistic and emotional aspects of technology acceptance are insignificant. Therefore, EFA as a method of testing models (Nunnally & Bernstein 1994) rather than CFA was conducted in hope to find factors that might support the importance of holistic-emotional additions to the TAM, even if the study would not reproduce the expected model. The method of conducting EFA is followed below as recommended by T. Heikkilä (1998). Before continuing the analysis however, the challenges caused by the sample size must be discussed.

7.1.2 Sample size considerations

Statistical analysis practitioners are often concerned of the question of appropriate sample size. Most statistical methods have restrictions limiting their accuracy unless the data fulfils certain requirements. Often only a sample big enough can fulfil these. Generally, the sample size is suggested to be as big as possible and often $N = 100$ is considered a “sufficiently large” sample (Hoyle & Kenny 1999).

N affects for instance statistical power, i.e. the ability to detect and reject a poor model (Chin 1998), by causing standard error (Hoyle & Kenny 1999). Also if *N* is small, factor groupings of items in studied models suffer from sampling error (Nunnally & Bernstein 1994). Sampling error in statistical results arises for instance from the lack of exact correspondence between a sample and a population (MacCallum & Tucker 1991). In other words, if the sample size is too small, it is difficult to formulate a reliable model from the data, and on the other hand the sample fails to reliably represent the chosen population.

The sample size discussion in factor analysis includes three variables, *N*, *p*, and *r*. Here $N = 27$, *p* is the number of variables being analysed ($p = 50$), and *r* is the number of factors. In this study, it was expected to find factors between the minimum of 5 first- and second-order factors (PU, PEOU, CA, PIIT and PAQ) or the maximum of 10 first-order factors (PU, PEOU, CO, CU, FI, TD, HE, PIIT, PAQpleasant=PQ+UQ, PAQarousal=AQ+SQ). The significant ratios of these are (Nummenmaa 2004; MacCallum, Widaman, Zhang & Hong 1999)

- *N:p* –ratio;
- *p:r* –ratio, defining overdetermination (the degree to which each factor is represented by a sufficient number of variables); and
- *N:r* –ratio.

Suggestions for appropriate ratios fluctuate, and in different studies different recommendations are presented (cf. Hoyle & Kenny 1999; MacCallum et al. 1999; Marsh & Hau 1999; Nummenmaa 2004). There is no explicit recommendation however (MacCallum et al. 1999), but appropriate sample size *N* depends on the used analysis method and its complexity (Chin 1998). Also smaller ratios of *p:r* have proved to produce good results, with small *N* not necessarily causing error as long as certain requirements are met (cf. MacCallum et al. 1999; Hoyle & Kenny 1999).

The problems caused by small sample size can be tackled in three ways: by finding a way to increase the sample size; by using a statistical approach appropriate for small samples; or by reorienting research questions to be answerable with small samples (Hoyle 1999). If the resources are limited, sample size cannot be increased; on the other hand, choosing research questions based on assumptions of some method is not good practice (Hoyle 1999). Therefore, statistical strategy and methods must be chosen accordingly.

To achieve good reliability of the model, normality of data is often implicitly required in factor analysis methods (Nummenmaa 2004). This is difficult to acquire with too small *N*. Here, the distribution of the questionnaire sample was explored with Shapiro-Wilk-test, which is suitable for small sample size, below 50 items (Nummenmaa 2004), and the data was not normally distributed (Appendix 3; $\Delta W = 0.88$, $\Delta p = 0.045$). This example of the small sample restriction requires the chosen factor analysis method to be suitable for nonnormal data.

To achieve good population representativeness, on certain conditions small-sample studies can produce good factor results. One condition is that the communalities of the variables for the factor solution must be high (MacCallum et al. 1999). Communality measures that part of a variable's variance, which the factor is able to explain; it reveals the variables, which do not fit into the model described by the factors (Nummenmaa 2004). Communality has its values between [0,1], and values below 0.4 are usually considered low, those above 0.6 high (MacCallum et al. 1999). As another condition, high overdetermination of factors diminishes the impacts of sample size on the quality of results, if the communalities are on the lower side (MacCallum et al. 1999). For high communalities, moderate overdetermination (three to seven indicators per factor) is enough, and the battery of variables can even be reduced to extract the items that show evidence of being most reliable and valid indicators (MacCallum et al. 1999). If the resulting factor solution communalities and overdetermination *p:r* fulfil these requirements, it can be established that the sample has represented the population sufficiently.

7.1.3 Reliability assessment

Technology acceptance model together with its suggested holistic-affective additions is used as a tool to find the importance of emotional attributes to technology acceptance. To establish the technical goodness of a research instrument, two kinds of considerations on the measurement device need to be done: its reliability and validity (Cozby 2006). Reliability measures the consistency of an experiment, and represents the replicability of the research (Solso & MacLin 2002); in other words, whether the test gives the same result every time it is used for the same subject (Cozby 2006).

To compare the measure's reliability over time in different situations, it should be retested with many individuals; if the measure is reliable, the scores should be similar and the correlation coefficients should be high and positive (Cozby 2006). When doing retests is not possible, assessing a measure's internal consistency is possible with different internal consistency indicators (Cozby 2006). Cronbach's alpha is a criticized (Metsämuuronen 2002) but also often-used measure for reliability (cf. Adams et al. 1992, Iqbaria et al. 1994). Alpha confidence interval calculation is needed in order to estimate the reliability of the measure; 0.6 is often the lowest acceptable value, but having the confidence interval to fall below this is more than probable in small samples (Metsämuuronen 2002).

7.1.4 Validity assessment

Reliability is a necessary but not sufficient condition to validity (Nunnally & Bernstein 1994). Validity means the factual accuracy of an observation made with the measure, in other words, the degree to which the result, i.e. values and/or conclusions, are true (Solso & MacLin 2002). Strictly said, it is the use of the test that is validated, as tests are often valid for one use and not another (Nunnally & Bernstein 1994). Validity of a research must be ensured beforehand; in order to receive unambiguous results, the experiment and the measures must be designed well (T. Heikkilä 1998). If there is no systematic error and the research is truly measuring the things expected, the validity is good (T. Heikkilä 1998).

There are different ways to classify validities (cf. for instance Nunnally & Bernstein 1994): in this study, the classification of Cozby (2006) is used. This considers three types of validity (Cozby 2006):

- internal validity, that describes causal relationships existing in the data obtained by the measure and the ability to extract them;
- external validity, that describes the ability of the measure to be generalized and the results be replicated in different settings than the originating one; and
- construct validity.

Construct validity researches the relationship between scores on the measure and some criterion (Cozby 2006); i.e. the fit of the data to the theorized model can be assessed by construct validity. It can be further divided into four indicators (Cozby 2006):

- predictive validity, that needs to be tested for research that tries to predict some future behaviour;
- concurrent validity, for research that examines whether different groups concurrently lead different behaviours in the same situation;
- convergent validity; and
- discriminant validity.

In technology acceptance modelling, the last two validities are most often considered (cf. Adams et al. 1992, Iqbaria et al. 1994, Agarwal & Karahanna 2000, Zhang & Li 2004). Discriminant validity is demonstrated when "the measure is not related to variables with which it should not be related" (Cozby 2006). Often used method is the one of ensuring that the constructs diverge from other related constructs (Ghiselli et al. 1981; ref. Webster & Martocchio 1992). Other important validity is convergent validity, which is "the extent to which scores on the measure in question are related to scores on other measures of the same construct or similar constructs" (Cozby 2006). In practice, measure items should load significantly higher on their own construct than in the others of the model (Nunnally & Bernstein 1994). Convergent validity is, therefore, to be assessed by comparing the loadings of variables to their resulted factors, and discriminant validity by comparing the loadings of variables to other factors.

7.2 Factor analysis

7.2.1 Preparation of the material

The purpose of the statistical analysis was to explore, whether emotional aspects do have a role in behavioural intention to use the tried technology. To this purpose, subjective measures were analysed. The analysis of the subjective data (50 items) was conducted with SPSS 14.0.1 software.

Factor analysis consists of six phases (Nummenmaa 2004):

1. Preparation of the material;
2. Design of the analysis;
3. Factor extraction;

4. Factor rotation, which in this case is done with Varimax;
5. Solution interpretation;
6. Solution review.

As primary analysis, frequency distributions and a summary for key figures of responses were produced and scrutinized to get an overall view of the material. These were done to the whole material, to all separate test groups, and to two trial technologies as one group. Due to problems with software, one questionnaire was lost during the testing, and in six other respondents' questionnaire version, one question (PEOU2) was missing. The number of analyzable questionnaires was thus 41. The missing values were not substituted with mean values, as the sample size was small and missing values of PEOU2 represented a high percentage (6/41 = 15 %) of the responses, so instead the items were listwise excluded.

Correlation coefficients were calculated using non-parametric (i.e. meant for ordinal data) Kendall Tau-b (T. Heikkilä 1998). These have values between [-1, 1], and they express dependency between two variables (T. Heikkilä 1998). Correlation coefficient matrix supported varying correlating relationship between behavioural intention and other variables. Sum correlation coefficients of presumed concepts are presented in Table 2.

Table 2. Sum correlation coefficients of theorized concepts

	AQ	BI	CO	CU	FI	HE	PEOU	PIIT	PQ	PU	SQ	TD	UQ
AQ	**0.14**												
BI	0.26	**0.86**											
CO	0.11	0.32	**0.24**										
CU	0.22	0.37	0.27	**0.51**									
FI	0.04	0.27	0.20	0.16	**0.51**								
HE	0.26	0.41	0.26	0.36	0.30	**0.59**							
PEOU	0.01	0.28	0.04	-0.01	0.16	0.22	**0.46**						
PIIT	-0.07	0.01	0.08	-0.09	0.05	0.00	0.21	**0.55**					
PQ	0.21	0.52	0.20	0.30	0.15	0.51	0.22	0.04	**0.52**				
PU	0.06	0.24	0.12	0.20	0.20	0.25	0.27	0.16	0.25	**0.59**			
SQ	-0.09	-0.19	-0.15	-0.07	-0.05	-0.13	-0.06	-0.04	-0.12	0.01	**0.18**		
TD	0.13	0.42	0.14	0.26	0.35	0.43	0.18	0.08	0.25	0.22	-0.01	**0.65**	
UQ	-0.18	-0.61	-0.33	-0.22	-0.27	-0.55	-0.38	-0.19	-0.50	-0.30	0.19	-0.35	**0.60**

Only the concept of behavioural intention has statistically sufficient (over 0.7) correlation with itself, but most theorized concepts exhibit the highest correlation with themselves (CU, FI, HE, PEOU, PIIT, PU, and TD). Concepts of pleasant dimension (PQ, UQ) have comparatively high self-correlations, but they correlate similarly with the concept of BI.

The concepts of arousal dimension (AQ, SQ) and control CO do not correlate well with themselves or any other concept.

On item level, the correlation coefficients of the arousal dimension caused further anxiety. These, as well as sum correlation coefficient, did not show presumed linear dependencies between Sleepy (SQ) and Active Quality (AQ). As explained earlier, these concepts should have reverse correlation, as they are extremities of the same dimension (Zhang & Li 2004; Russell 2003). Pleasant dimension, on its part, did show reversible correlation (-0.5) between Pleasant (PQ) and Unpleasant (UQ) quality.

Correlation coefficients were also calculated with different combinations of test groups. The responses from the newspaper test group did have different correlation coefficient characteristics than the responses from new technology trials. As newspaper in fact was the benchmarked technology, the questions measuring new technology use were often inappropriate and caused confusion among respondents. As a result, only responses from new technology testers were used in later analysis.

7.2.2 Factor extraction

After the preliminary scrutiny described in previous chapter, extraction of the factors was conducted. Extraction defines the factors and their connections, loadings, to the variables in the model (Nummenmaa 2004). In general, several extraction methods should be experimented and then the one that produces the most sensible solution should be chosen (Nummenmaa 2004): indeed, different methods often lead to the same solution (Nunnally & Bernstein 1994).

Extraction methods available in SPSS include Principal Components Analysis (PrC), Principal Axis Factoring (PAF), Maximum Likelihood (ML), Generalized Least Squares (GLS), and Unweighted Least Squares (ULS). PrC is strictly not a factor analysis method (Nummenmaa 2004), and in this study, PrC was used to give preliminary insight on what the resulting factors might look like. Of other extraction methods, ULS is suitable for highly nonnormal data (Nunnally & Bernstein 1994). It was therefore the chosen extraction method.

7.2.3 Iteration of the factor solution

Finding a good factor solution requires optimization. When iterating the best factor solution for a dataset, the following viewpoints need to be considered (Nummenmaa 2004):

- factors should be able to explain common variation;
- there should be as few factors as possible;
- loadings should be extremities, i.e. as high and low as possible; and
- factors must have a sensible interpretation.

For the acceptability of items included in a factor, loading of 0.7 is recommended generally (e.g. Agarwal & Karahanna 2000; Zhang et al. 2006), but also the value of 0.5 can be used in new application studies when other items in the same construct have high reliability scores (Barclay, Higgins, & Thompson 1995, Chin 1998; ref. Zhang et al. 2006). During the primary analysis with different factor numbers, it became clear that the concepts of AQ, SQ, and CO, that had shown poor correlation with themselves, were unable to load sufficiently to any factor, so these items were removed from the data.

First analysis of the data with Kaiser-Guttman rule (factors' eigenvalues over one, Nunnally & Bernstein 1994) produced twelve factors. Further solution of five factors (converged in 15 iterations) was chosen as the basis from which to continue analysis. Explanation power is 76 %, and it is presented in Table 3 below. The solution was accepted, even though it produced a factor of two variables (cf. Nunnally & Bernstein 1994): diminishing the number of factors did not change the situation.

Table 3. Basic factor solution.

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
UQunpleasant	-0.875	-0.210	-0.118	-0.044	-0.097
PQpleasing	0.868	0.341	0.044	0.032	-0.006
PQnice	0.862	-0.055	0.120	-0.144	-0.182
HE2	0.841	0.372	0.106	0.059	0.173
PQpleasant	0.807	0.359	0.067	0.078	0.058
UQuncomfortable	-0.806	-0.264	-0.121	-0.098	-0.070
HE3	0.778	0.367	0.277	-0.093	-0.076
PQbeautiful	0.714	-0.247	0.458	0.109	-0.129
UQdispleasing	-0.712	-0.389	-0.191	-0.123	-0.186
HE1	0.711	0.518	-0.029	-0.202	0.110
UQdissatisfying	-0.694	-0.212	-0.373	-0.144	-0.337
PEOU4	0.605	-0.133	0.177	-0.086	0.520
PQpretty	0.598	-0.114	0.210	0.190	0.028
PEOU3	0.557	-0.036	0.117	0.446	0.393
HE4	-0.552	-0.157	-0.074	0.282	0.042
CU3	0.358	0.098	0.310	-0.353	-0.185
TD1	0.303	0.854	0.141	0.061	0.073

TD3	0.251	0.844	0.083	-0.052	0.061
FI5	0.168	0.824	0.095	0.054	0.076
FI1	0.109	0.729	0.277	0.270	0.199
FI2	0.351	0.709	0.332	0.093	0.199
FI3	-0.205	0.701	0.424	-0.040	-0.349
UQrepulsive	-0.381	-0.614	0.065	-0.074	-0.319
TD2	0.492	0.556	0.064	-0.244	-0.034
FI4	0.019	-0.386	0.083	-0.318	0.054
PU4	0.216	0.137	0.853	0.193	0.188
PU3	0.324	-0.064	0.782	-0.192	0.401
PU1	0.400	0.351	0.717	0.165	0.101
PU2	0.072	0.338	0.626	0.248	-0.046
CU1	0.340	0.280	0.551	-0.319	-0.542
CU2	0.400	0.231	0.401	-0.357	-0.398
PIIT4	0.244	0.179	0.145	0.772	0.027
PIIT3	-0.010	0.033	-0.068	0.764	0.045
PIIT1	0.081	0.117	0.345	0.702	-0.199
PIIT2	0.202	-0.018	-0.142	-0.594	-0.489
PEOU1	0.061	0.330	0.101	0.166	0.806
PEOU2	0.200	0.364	0.169	-0.275	0.802

Analysing this solution, the factor solution seems to consist of first factor of Pleasant quality, Unpleasant quality and Heightened enjoyment; second factor of Focused immersion and Temporal Dissociation; third factor of Perceived usability; fourth factor of PIIT, and fifth factor of Perceived ease of use, thus suggesting that the items were able to measure consistently their expected concepts. Concept of Curiosity did not converge into an own factor, and loaded insufficiently.

The next step was to conduct another factor analysis with new dataset, where items with loadings below 0.7 are removed; the rule of 0.5 was not yet applied, as there are several loadings under this lower bound. Removable items are UQdissatisfying, PEOU4, PQpretty, PEOU3, HE4, CU3, UQrepulsive, TD2, FI4, PU2, CU1, CU2, and PIIT2. Of these, PIIT2, FI4, and HE4 were reverse questions which have caused problems in previous studies (Agarwal & Karahanna 2000; Zhang et al. 2006). Next solution of five factors produced similar results to the previously presented solution; in the results factor loading were overall high, so that the rule of accepting items over 0.5 to the factor solution was used, and therefore all remaining items were included in the factor solution. The final factorization (converged in 7 iterations) is presented in Table 4.

Table 4. Final factor solution, communalities and variance

	Factor					extraction communalities
	1	2	3	4	5	
PQpleasing	0.916	0.224	0.058	0.055	0.088	0.903
UQunpleasant	-0.880	-0.147	-0.171	-0.085	-0.072	0.839
HE2	0.871	0.259	0.126	0.254	0.107	0.918
PQpleasant	0.842	0.269	0.123	0.086	0.085	0.812
UQuncomfortable	-0.826	-0.151	-0.123	-0.124	-0.175	0.766
PQnice	0.815	-0.099	0.173	-0.139	-0.056	0.727
HE3	0.801	0.295	0.283	0.03	-0.002	0.809
HE1	0.773	0.414	0.012	0.183	-0.19	0.838
UQdispleasing	-0.752	-0.276	-0.164	-0.265	-0.213	0.784
PQbeautiful	0.622	-0.187	0.591	-0.183	0.107	0.816
TD1	0.351	0.821	0.034	0.216	0.102	0.856
FI5	0.256	0.801	0.013	0.174	0.043	0.74
TD3	0.341	0.792	-0.027	0.204	-0.025	0.786
FI3	-0.095	0.769	0.199	-0.213	0.027	0.686
FI1	0.167	0.704	0.183	0.268	0.288	0.712
FI2	0.365	0.688	0.263	0.321	0.142	0.799
PU4	0.145	0.261	0.886	0.121	0.171	0.919
PU3	0.271	-0.018	0.77	0.375	-0.105	0.818
PU1	0.367	0.438	0.734	0.059	0.142	0.889
PEOU2	0.203	0.225	0.155	0.919	-0.208	0.999
PEOU1	0.042	0.217	0.126	0.800	0.176	0.736
PIIT3	0.003	-0.03	-0.149	0.091	0.815	0.695
PIIT4	0.187	0.163	0.099	0.027	0.775	0.672
PIIT1	0.046	0.136	0.278	-0.133	0.753	0.682
% of variance	45.393	13.563	10.179	8.374	6.737	

When comparing the factor solution with the original TAM-CA-PAQ-model, the concepts the questions were supposed to measure have emerged as their own factors in the cases of PEOU, PU and PIIT. The items of PQ/UQ and HE, and FI and TD, on the other hand, have merged into two constructs that can be called Enjoyment-PAQ, and Immersion-CA. The final factor solution is expressed in Table 5 with the original questions clarifying the resulted concepts:

Table 5. Final factors expressed in questions

Factor 1. **Enjoyment-PAQ**	PQpleasing
	Uqunpleasant
	HE2 Using this technology provided me with a lot of enjoyment.
	PQpleasant
	UQuncomfortable
	PQnice
	HE3 Using this technology bored me.
	HE1 I had fun interacting with this technology.
	UQdispleasing
	PQbeautiful
Factor 2. **Immersion-CA**	TD1 Time appeared to go by very quickly when I was using this technology.
	FI5 While using this technology, my attention did not get diverted very easily.
	TD3 Time flew when I was using this technology.
	FI3 While using this technology, I was immersed on the task I was performing.
	FI1 While using this technology, I was able to block out most other distractions.
	FI2 While using this technology, I was absorbed in what I was doing.
Factor 3. **Perceived usability**	PU4 Using this technology would improve my performance in studies or at work.
	PU3 I find this technology would be useful in my studies/work.
	PU1 Using this technology would enhance my effectiveness in studies or at work.
Factor 4. **Perceived ease of use**	PEOU2 I found it easy to get this technology to do what I wanted it to do.
	PEOU1 Learning to operate this technology was easy for me.
Factor 5. **Personal innovativeness in the domain of information technology**	PIIT3 Among my peers, I am usually the first to try out new technologies.
	PIIT4 I like to experiment with new technologies.
	PIIT1 If I heard about a new technology, I would look for ways to experiment with it.

7.2.4 Affect of emotion to technology acceptance

Enjoyment of technology use and a pleasant perception of it do not necessarily cause the intention to use the technology in the future, as correlation does suggest a causal relation (T. Heikkilä 1998). Causality can be established, if the variables covariate; the reason exists before the result; there is no third exterior factor being the common reason to both variables; and there exists a theory supporting the causality (T. Heikkilä 1998; Cozby 2006). Usually path analysis is conducted, and causalities between concepts of TAM, CA and PAQ are routinely analyzed (cf. Agarwal & Karahanna 2000; Zhang & Li 2004; Zhang et al. 2006).

TAM may be a robust measure and the concepts well-established, but the relationships within the model are not robust according to preceding studies, and produce controversial results (Sun & Zhang 2006). Such examples (Legris et al. 2003; cf. Saadé and Bahli 2005) cause suspicion towards the modelling of technology acceptance; the concepts show signs of importance, but their exact place in the model and relationship to use intention and subsequently actual use seem unclear. As discussed in Chapter 3.4, this is arguably due to that in different phases of technology acceptance, and with different user and technology characteristics, different concepts influence the use intention with different weight.

In this study the focus was to establish the viability of the holistic constructs and especially the role of emotions in the technology acceptance, and more complicated relationship analysis was kept simple. New correlation coefficients for factor solution and their measurable variable and BI were calculated, and the result is presented below in Table 6.

Table 6. Final correlation coefficients

	BI	Enjoyment-PAQ	Immersion-CA	PU	PEOU	PIIT
BI	0.86					
Enjoyment-PAQ	0.65	0.61				
Immersion-CA	0.38	0.32	0.60			
PU	0.27	0.33	0.28	0.70		
PEOU	0.29	0.22	0.34	0.27	0.71	
PIIT	0.0048	0.10	0.18	0.18	0.12	0.58

Correlation coefficients are, in new construct cases (Enjoyment-PAQ, Immersion-CA, PIIT), too low (< 0.7) for the result to be statistically significant. All constructs of original TAM (BI, PEOU, PU) correlate with each other statistically significantly. PIIT is the only construct that correlates next to nothing with BI, which emphasizes the ambiguousness of the placement of the concept in technology acceptance, discussed in Chapter 4.4.2.

7.2.5 Failed constructs

Measures in PAQ of arousal dimension, Sleepy and Active quality, failed early in the analysis. These measures consisting of adjectives are suspected to have flawed because of their semantically unsatisfying translation in Finnish. This reflects the wider problem of verbal measurement instruments: they are difficult to apply between cultures, as for many emotion words, a one-to-one translation is not possible (Desmet 2003).

Concept of Curiosity (CU) did not succeed either. The reason for this may be the simplicity of the technological structure, which was apparent, and did not encourage imagination. In previous research studied, this concept has not shown signs of unreliability, nor has it been considered to be especially important or insignificant (Saadé & Bahli 2005; Zhang et al. 2006).

Concept of Control (CO) seemed to have problems as a whole, as it did not converge into any single factor. This reflects the results received by Zhang et al. (2006), who declared the Control dimension to have a low loading on CA, although the loading was significant; the inability to form a coherent factor from CO or to have it attached with some other construct may be due that the sample was too small to detect its importance. The author assumes the reason for the hardships of concept of CO is the background most of the test subjects had in engineering; this would make many subjects extraordinary confident in the use and control of the technology (cf. Hu et al. 1999). Control concept would therefore be judged differently to the average user, and the concepts would not influence the intentions of use similarly.

Two of four questions measuring PEOU loaded on same construct, and two failed to converge. This is not unusual: PEOU has not been as consistent determinant of BI as PU (Venkatesh & Davis 2000). Its reliability as a moderating factor of PU is not clear either: in some studies this concept has shown to have negative role (Adams et al. 1992), unimportant role in the model (Saadé & Bahli 2005), and in some, it has failed to affect perceived usefulness (Hu et al. 1999). Experience, therefore, may be a moderator for the relationship between PEOU and PU (Sun & Zhang 2005). Another research has suggested that enjoying using the technology diminishes the effect of ease of use on perceived usefulness (Yi & Hwang 2003).

7.2.6 Sample size revisited

Considering the population representativeness of the sample, as discussed in Chapter 7.1.2, it can be seen from Table 6, that the communalities of the final factor solution have high values, above 0.6. This means unique factor loadings are low and the resulting solution has consistent factors (MacCallum et al. 1999). In the final factor solution, $p{:}r$ is 24:5 = 4.8:1. Due to the removal of items, the overdetermination is moderate, between the recommended 5:1 and 3:1.

Both the resulting communalities and overdetermination indicate good recovery of population factors. This suggests the sample size was adequate and factor solution corresponds to population factors. Therefore, the conclusions made based on the data should be generalizable to the test population, i.e. young, technically-oriented, university-educated people.

7.2.7 Model reliability and validity

To establish the reliability of the factor solution, Cronbach alpha –levels were calculated. For BI, (α = 0.976); for Enjoyment-PAQ (α = 0.960), Immersion-CA (α = 0.921), PU (α = 0.810), PEOU (α = 0.880), and PIIT (α = 0.782). The result is therefore reliable, all values being above the recommended 0.7. To establish the validity of the factor solution, coefficients in Table 6 support modest discriminant validity for the resulting model, as the factor item loadings to other factors are consistently but not significantly lower than the loading to the converged factor. Loadings of factors in Table 6 also support modest convergent validity for the resulting model, as notably only the loadings of established concepts of TAM are above the recommended value of 0.7.

Overall, establishing adequate reliability is a question of analysing the data and results with all appropriate statistical methods. In establishing reliability, the statistical power of the resulting factor solution should also be assessed (Chin 1998). Also fit indices are left uncalculated. However, exploiting for instance a covariance-based SEM in a small sample can result in poor model achieving adequate model fit (Chin & Newsted 1999). Complex models have problems related to fit indices, and final model derived via post hoc modifications should not be trusted (Chin & Newsted 1999). As this factor solution was a result of modifications, no goodness-of-fit-indices were calculated. Indeed, as a whole it has been argued that these are not necessary good indicators of a good model (Chin 1998): a good fit means a model is plausible, not correct (MacCallum & Austin 2000).

7.3 Conclusions

7.3.1 Importance of emotion

In the resulting factor solution, the items of original TAM loaded on separate factors as expected. New concepts of CA and PAQ overlapped somewhat with each other, forming factors of Enjoyment-PAQ (HE, PQ, UQ) and Immersion-CA (FI, TD). Of the new factors Enjoyment-PAQ has a sensible interpretation of "perceived pleasantness of the technology". The factor Immersion-CA also produces a sensible interpretation of "plunging into the technology".

The validity of the factor solution was not significant, so the result model is not suggested to replace the TAM-CA-PAQ-combination serving as the theoretical background for the measurements. Due to the nature of factor analysis, there is no single "true" model to be achieved (MacCallum & Austin 2000), but depending on for instance the rotation method, different models can be formulated, that have as good a fit (Chin 1998; Nummenmaa 2004). Therefore, the solution along with the factor explanations is not necessary a failure to reproduce the correct model, but can be treated as a simpler alternative to TAM-CA-PAQ-model.

Failures of variables to load to "correct" constructs can be due to chance. The small sample size causes single responses to have strong influence on the results; this is mirrored in the non-normality of responses. Few deviating responses can then affect the loading of a variable remarkably. It may also be that the factor solution resulted only because of the sample size: the smaller the sample, the simpler the resulting model (MacCallum & Austin 2000). Therefore, the ability to produce the original model might have been at stake from the beginning.

Apart from the optimal factor composition, holistic-emotional factors of Enjoyment-PAQ and Immersion-CA along cognitive factors of PEOU and PU correlated strongly with the Behavioural intention to use a technology. This is in accordance with the presented theoretical paradigm suggesting that cognitive, instrumental purposes are not the only reasons guiding technology use. Factor interpretations support the meaningfulness of holistic concepts which should be studied in further studies with larger sample and Confirmatory factor analysis.

7.3.2 Comparing the factors to original model

The sensibility of the factors Enjoyment-PAQ (HE, PQ, UQ) and Immersion-CA (FI, TD) causes a reason to be wary of the constructs of CA and PAQ overlapping also in more extensive research. The theoretical construct of PAQ is built with well-tested dimensions of arousal and pleasantness, and even though the measures failed, the construct's theoretical internal reliability should be high, as it is materializing a basic psychological concept (Russell 2003; Zhang & Li 2004); it is the instrument reliability that is questionable, as the questionnaire used is applied from qualifying other objects than technologies (Zhang & Li 2004). In order to analyse the complex concept of CA, on the other hand, more advanced methods and wider participant pool would have been needed, so nothing definite can be said of the appropriateness of this theoretical construct as a whole based on this study. All in all, the overlapping of these constructs and their other problems, as discussed in other studies (Saadé & Bahli 2005; Zhang et al. 2006), gives ground to believe the concepts need further revision as to their placement and relationships in technology acceptance and use intention.

Considering the resulting model, the analysis is acknowledged to be incomplete. After the correlation coefficients had demonstrated some significance of emotional factors in technology acceptance, the clearer relationship of factors could have been analysed. Nothing can be said on the connections between different concepts in the combined model based on this study. This was not considered necessary, as the purpose of the study was not to form a model, but to acquire knowledge of the viability of affective and holistic constructs in technology acceptance.

On the subject of separate failed variables of otherwise well constructs, the results are not strong enough to propose their elimination from the measure to increase reliability (Cozby 2006). If, in a wider research, yet the same variables show inconsistencies with the model, the elimination may show to be appropriate. As to further research, the following suggestions are made:

- adjectives in the dimensions of PAQ need new translation, with the nature of semantic differentials in mind;
- concepts of CA and PAQ need additional comparative studies in order to remove overlapping and possibly unnecessary dimensions.

As a reminder from the theoretical part, it is clear that “conclusions may be limited to the particular sample, variables, and time frame” (MacCallum & Austin 2000). Also the presented concepts do by no means represent the only factors affecting technology use intention; for instance questions of context could have been raised in this study too. With the inclusion of moderators, the explanatory power of the model increases; therefore with participant group more heterogeneous than in this study, more background information should be collected (Sun & Zhang 2005). This holds especially if the model is to be applied in field tests (Sun & Zhang 2005).

8 Physiological measure analysis

8.1 Comparing physiological and subjective data

Secondary purpose of the research was to find whether the subjective and objective measures have substantial correlation for the latter to be used in technology acceptance research along with subjective measure. To this purpose, results of subjective and objective analysis were to be compared. The analysis of the objective data was conducted with Microsoft Excel and Statistix software.

One mapping between a physiological reaction and a concept was thought to be found in a relationship between SCL and arousal dimension of PAQ, because the tonic changes i.e. Skin conductivity level (SCL) are able to express connections between subjective and objective measures of arousal emotions (Dawson et al. 2000).

The question of isolating SCL from SC would have, however, required better knowledge of stimuli and their timing causing fluctuations i.e. Skin conductance response (SCR). Calculating the SCR, a decision must be made of a necessary minimum amplitude change in SC for it to be perceived as SCR (Dawson et al. 2000). This would have been optimal to do automatically by computer scoring program during the measures, and not afterwards, as computer can detect responses too small for hand (Dawson et al. 2000). As the amplitude of SCR is around ten times smaller than that of SCL (Dawson et al. 2000), SCL was therefore approximated with the whole measured SC.

In total there were three measures of SC,

- *beginning_base* that was the measure of the first five minutes of attendance before activity;
- *measure* that was the actual measure of activity; and
- *end_base* that was the measure of last five minutes of attendance after activity.

In order to make comparisons between the Technology Acceptance Model and EDA, the 256-times-in-second-sampled *measure* needed to be shrunk to a few key values. This was done by calculating mean values for SC of five-minute periods. This was already the duration of *beginning_base* and *end_base* measurements, and as a result of averaging *measure* was divided into seven periods, $mean_n$. This resembles the averaging as conducted by Lovibond (1992). Calculating logarithms of SCL is recommended to avoid data skewness (Dawson et al. 2000) so this was also conducted.

One problem SC as a comparable measure has is that individual extraneous differences cause the skin conductance to vary remarkably between different subjects (Dawson et al. 2000). There are several means to correct the variance with different transformations, presented by Boucsein (1992; ref. Dawson et al. 2000). For instance Lovibond (1992) subtracts baseline levels from period mean levels, and M. Heikkilä (2005) calculates the change between base level and measures. In this study, calculating change approach is used, and the ΔSC is therefore calculated per individual (Appendix 4):

$$\Delta SC_n = \frac{\log(mean_n + 1)}{\log(beginning\_base + 1)}$$

As explained in Chapter 7.2, the arousal dimension in subjective measurement instrument did not perform satisfactorily, so mapping objective and subjective results reliably was not possible. Despite discarding the original purpose of measuring physiological data, some other aspects could be extracted from it.

8.2 Chronic stimuli consequences in Skin conductance

In order to examine EDA results, individual ΔSC_n values were averaged for different technologies and for all technologies. This process yields Figure 9, which includes also the regression trendline of all technologies, along with its equation and the coefficient of determination ($R^2 = 0.94$). The graph gives support to the theoretical expectation of the SCL rising towards the end of an experiment including long-lasting, chronic stimuli (Lacey et al 1963; ref. Dawson et al. 2000). This rise was seen also in *beginning_base* and *end_base* value differences among individual subjects: *end_base*-values were consistently higher than *beginning_base*-values. This prevented calculating ΔSC_n with the mean of *beginning_base* and *end_base*.

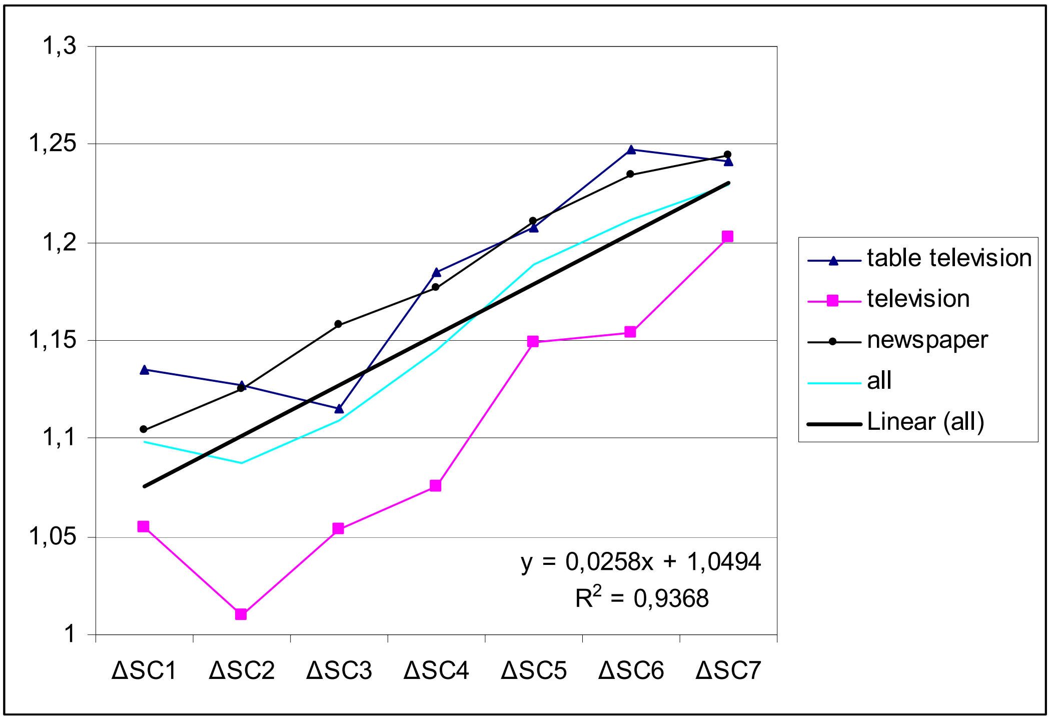

Figure 9. ΔSC-values per technology and for all data.

The differences of results between technologies were not statistically significant: with pairwise conducted two-sample t-tests, only in two instances of 24 comparisons, *p* was around 0.5, which would allow discarding the equality hypothesis (Appendix 5). This discouraged analysing the differences between technologies further (cf. Kramer & Weber 2000).

In Chapter 6.5 the potential unreliability of objective measure due to errors presented in Chapter 6.4 is discussed. Therefore the result of objective measures not showing statistically significant differences between different technologies is not necessarily reliable. In better testing conditions and with bigger sample some differences might have been found.

9 Discussion

9.1 Research evaluation

9.1.1 Results overview

Pilot studies are suggested to be conducted in order to evaluate the psychometric properties of measures (Marsh & Hau 1999). This study can be assessed as a pilot study of research-making in the field of hybrid media technology acceptance. In studied literature, there was also no example of previous research on prototypical media technology being used as a case in technology acceptance model.

The results of this study supported the expected relationship between affective factors and technology acceptance. Rewarding results can therefore be expected from media technology cases researched with used technology acceptance models. On the other hand, the inability to prove a connection between Skin conductance measure and arousal dimension of PAQ cannot be assigned to the connection's non-existence, as neither of the measures worked properly. This research question did not therefore receive a satisfying answer.

9.1.2 Instrument evaluation

The subjective modelling questions of TAM worked reliably and produced independent factors, as can be expected from an established measure. Some concepts of CA (CU and

CO) did not perform quite as well, which is natural to a much more recent instrument. The ability of PAQ pleasant dimension to perform satisfactorily is apparently due to the primality of the dimension in organizing affective experiences, which makes it easier to formulate one's (un)pleasant experience in linguistic form (Russell 2003). The adjectives of PAQ planned to measure the arousal dimension did not produce satisfactory results. This is due to the fact that the instrument is not yet reliable, as the concept is only a few years old (Zhang & Li 2004) and much more recent than other tested models.

Psychophysiological measures suffered from inconsistencies in experimental situation and the suboptimal experimental set-up. If both research process and extracted information were planned more carefully, the outcome would better as to the reliability of the data. Still, the ability to use the data for the purposes of comparing results from arousal dimension PAQ is not as indisputable, as the subjective measure is perhaps too complex (Ravaja 2004).

9.1.3 Methodological

As presented in the preceding chapters, there were two methodological challenges in the study: the other was the amount of experimental mistakes and difficulties, and the other was the small sample size and the homogeneity of subject background. The previous caused the results and conclusions to be unreliable, and therefore only approximate conclusions are made on viability of affective factors in technology acceptance. To avoid similar mistakes in the future, methodological analysis on different types of measurement errors was conducted and suggestions were made to enhance the used experimental environment and research processes.

The problem of sample size also caused complications to analysis process. Most statistical methods used in other studies are not recommended to be used in research with restricted sample size, so compensating methods had to be found. This required more time to be used to study statistical methodologies, and as a result, more thorough discussion on the reasons for choosing the methods used.

9.2 Future research challenges

9.2.1 Instrumental

An interesting future research question is the need for improvement of TAM-CA-PAQ in order to satisfactorily solve the relationships of the new affective factors as measuring instruments. Many quantitative validating researches are done with the assistance of committed companies, or by using Internet both as the target technology and the interface of filling the questionnaires. This research path would be easy to follow.

Verifying and enhancing the model requires statistical knowledge and corresponding complex analysis tools suitable for quantitative study, however. The need of several hundred samples for satisfactory confirmatory factor analysis gives some perspective for this requirement. In trying to find a connection and overlap between PAQ and CA, the purpose might be achieved in a simpler experiment, which is therefore suggested.

Aside from enhancing the current model, the main practical focus is the reworking on the chosen adjectives of PAQ suitable for use when assessing the quality of a technology in Finnish. The problems of the original instrument and the translation of it were best avoided, would the measure be generated from within Finnish culture. At the time of this being written, such measure unfortunately seems to be unavailable.

9.2.2 Methodological

It is possible to use the TAM-CA-PAQ-model in research with smaller subject groups either in laboratories, or in field tests which require new equipment to be purchased specially for the test participants. This approach might be more suitable to develop TAM and the affective concepts with cultural differences in mind, i.e. to localize the model. Honing the model may take time, but localization is worth while, as the models are becoming more aware of the context of use and the user's qualities, in which the culture along with language affects significantly.

Structural equation modelling (SEM), of which factor analysis is a special case as discussed in Chapter 7.1.1, is a developing statistical analysis tool. There are suggestions that some SEM methods could incorporate interactions and other nonlinear effects among latent variables into models (MacCallum & Austin 2000). This would widen the possibilities of technology acceptance models to better represent the process of acceptance.

9.2.3 Pragmatical

To acquire information of an affective response to a technology is obviously not sufficient; as important is the question what to do after the information has been acquired. There are five important research questions in HCI and emotion (Brave and Nass 2002):

- with which emotion should HCI researchers be most concerned;
- when and how should interfaces attempt to directly address users' emotions and basic needs (vs. application-specific goals);
- how accurate must emotion recognition be to be useful as an interface technique;
- when and how should users be informed that their affective states are being monitored and adapted to; and
- how does emotion play out in computer-mediated communication.

These questions extend the fields of affective technology acceptance research very wide, but finding their answers would definitely be both interesting and useful.

10 Conclusion

The primary aim of this research was to study importance of emotional factors in technology acceptance by literature research and using the methods of measuring Technology acceptance model along with its holistic-affective conceptual additions of Cognitive absorption and Perceived affective quality. The significance of the additional concept was established, and encourage further research in the same area of hybrid media technologies.

The resulted factor solution confirms the view that affective impressions influence the Behavioural intention to use trialled technology in the future. The reliability and validity of the solution were assessed, and alpha values were statistically sufficient to support the factor solution's reliability. Discriminant and convergent reliability coefficients, on the other hand, gave only modest support to the factor result. The difference between resulting solution and the original factor models was concluded to be due to the size of subject sample, which, even though being representative of the research population (university-educated technically-oriented young adults), was not sufficient to support a complex model.

Secondary aim was to map the possibilities of objective affective measures in technology acceptance research. This was done by using the physiological method of measuring Electrodermal activity, or Skin conductance. Hypothesis was that the subjective measure of PAQ and its arousal dimension would have correlation with objective measure of SC.

The experimental set-up was not fully satisfactory, and most uncertainties affected the objective measure of SC, which by its nature is vulnerable to errors. However it is also probable, that the phenomenon measured is too complex to be satisfactorily gathered with psychophysiological methods. The hypothesis of relationship did not receive sufficient support but theoretically, such a connection exists: therefore the difficulties of the research process were concluded to be the reason for the inability to find parallels between subjective and objective methods.

It is a valuable piece of knowledge that perceived enjoyment and pleasantness correlate with intention to use a technology, at least for this population group. The author accounts the results support the holistic theories proposing affective constructs' viability in technology acceptance models. This creates an interest to conduct further research using these tools within the field of media technology and studying new hybrid media interfaces.

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11 Appendices

Appendix 1.

AQintense kiihkeä
AQarousing herättävä
AQactive aktiivinen
AQalive eloisa
AQforceful voimakas

SQinactive joutilas
SQdrowsy unelias
SQidle toimeton
SQlazy laiska
SQslow hidas

PQpleasant miellyttävä
PQnice kiva
PQpleasing mukava
PQpretty sievä
PQbeautiful kaunis

UQdissatisfying epätyydyttävä
UQdispleasing ärsyttävä
UQrepulsive kuvottava
UQuncomfortable epämukava
UQunpleasant epämiellyttävä

TD1 Aika tuntui kuluvan hyvin nopeasti, kun käytin tätä teknologiaa.
TD2 Joskus menetin ajantajun, kun käytin tätä teknologiaa.
TD3 Aika lensi kun käytin tätä teknologiaa.

FI1 Kun käytin tätä teknologiaa, pystyin häivyttämään useimmat häiriötekijät.
FI2 Kun käytin tätä teknologiaa, olin uppoutunut siihen mitä teen.
FI3 Kun käytin tätä teknologiaa, olin syventynyt tehtävääni.
FI4 Kun käytin tätä teknologiaa, muut asiat veivät huomioni helposti.
FI5 Kun käytin tätä teknologiaa, muut asiat eivät vieneet huomiotani kovin helposti.

HE1 Minulla oli hauskaa, kun olin vuorovaikutuksessa tämän teknologian kanssa.

HE2 Tämän teknologian käyttäminen toi minulle paljon nautintoa.
HE3 Nautin tämän teknologian käyttämisestä.
HE4 Tämän teknologian käyttäminen kyllästytti minua.

CO1 Tunsin hallitsevani tilanteen, kun käytin tätä teknologiaa.
CO2 Tunsin, etten hallitse minun ja tämän teknologian välistä vuorovaikutusta.
CO3 Tämä teknologia antoi minulle mahdollisuuden hallita minun ja tietokoneen vuorovaikutusta.

CU1 Tämän teknologian käyttäminen herätti uteliaisuuteni.
CU2 Tämän teknologian kanssa vuorovaikutussuhteessa oleminen sai minut uteliaaksi.
CU3 Tämän teknologian käyttäminen herätti mielikuvitukseni.

PEOU1 Minun oli helppo oppia käyttämään tätä teknologiaa.
PEOU2 Minun oli helppo saada tämä teknologia toimimaan tahtomallani tavalla.
PEOU3 Minun oli helppoa tulla taitavaksi tämän teknologian käyttäjäksi.
PEOU4 Minun oli helppo käyttää tätä teknologiaa.

PU1 Tämän teknologian käyttäminen voisi parantaa opiskelu- tai työtehokkuuttani.
PU2 Tämän teknologian käyttäminen voisi parantaa tuottavuuttani.
PU3 Tämä teknologia voisi olla minulle hyödyllinen opinnoissani/työssäni.
PU4 Tämän teknologian käyttäminen voisi parantaa opinto- tai työsuorituksiani.

PIIT1 Jos kuulisin uudenlaisesta teknologiasta, etsisin tapoja kokeilla sitä.
PIIT2 Yleensä epäröin kokeilla uudenlaista teknologiaa.
PIIT3 Vertaisteni joukossa olen yleensä ensimmäinen, joka kokeilee uudenlaista teknologiaa.
PIIT4 Pidän uudenlaisen teknologian kokeilemisesta.

BI1 Aion käyttää tätä teknologiaa tulevaisuudessa, jos se on laajasti saatavilla.
BI2 Aion jatkaa tämän teknologian käyttämistä tulevaisuudessa, jos se on laajasti saatavilla.
BI3 Oletan, että tämän teknologian käyttöni jatkuu tulevaisuudessa, jos se on laajasti saatavilla.

Appendix 2.

ikä

sukupuoli: nainen, mies

viimeisin loppuun suoritettu koulutus: peruskoulu, ylioppilas, toisen asteen tutkinto, ammattitutkinto, alempi korkeakoulututkinto, diplomi-insinööri, muu korkeakoulututkinto, ylempi korkeakoulututkinto

pääasiallinen työtehtävä: opiskelija, alempi toimihenkilö, ylempi toimihenkilö, johtavassa asemassa, muu

TV1 Television seuraaminen on minulle tärkeää.
TV2 Television seuraaminen päivittäin on minulle tärkeää.

TVU1 Televisiouutisten seuraaminen on minulle tärkeää.
TVU2 Televisiouutisten seuraaminen päivittäin on minulle tärkeää.

IN1 Internetin käyttö on minulle tärkeää.
IN2 Internetin käyttö päivittäin on minulle tärkeää.

INU1 Uutisten lukeminen Internetissä on minulle tärkeää.
INU2 Uutisten lukeminen Internetissä päivittäin on minulle tärkeää.

SL1 Sanomalehtien lukeminen on minulle tärkeää.
SL2 Sanomalehtien lukeminen päivittäin on minulle tärkeää.

Appendix 3.

	Shapiro-Wilk	
	Statistic	Sig.
AQactive	0.860	0.006
AQalive	0.851	0.004
AQarousing	0.921	0.092
AQforceful	0.912	0.061
AQintense	0.852	0.005
BI1	0.872	0.010
BI2	0.894	0.026
BI3	0.934	0.167
CO1	0.885	0.018
CO2	0.799	0.001
CO3	0.931	0.145
CU1	0.936	0.186
CU2	0.928	0.127
CU3	0.884	0.018
FI1	0.873	0.011
FI2	0.878	0.014
FI3	0.880	0.014
FI4	0.907	0.048
FI5	0.903	0.041
HE1	0.926	0.117
HE2	0.902	0.039
HE3	0.923	0.101
HE4	0.876	0.013
PEOU1	0.832	0.002
PEOU2	0.869	0.009
PEOU3	0.882	0.016
PEOU4	0.804	0.001
PIIT1	0.815	0.001
PIIT2	0.823	0.001
PIIT3	0.868	0.009
PIIT4	0.843	0.003
PQbeautiful	0.946	0.289
PQnice	0.891	0.024
PQpleasant	0.880	0.015
PQpleasing	0.894	0.027
PQpretty	0.915	0.069

PU1	0.870	0.009
PU2	0.865	0.008
PU3	0.881	0.015
PU4	0.880	0.015
SQdrowsy	0.875	0.012
SQidle	0.944	0.261
SQinactive	0.867	0.008
SQlazy	0.844	0.003
SQslow	0.885	0.018
TD1	0.909	0.052
TD2	0.915	0.069
TD3	0.910	0.055
UQdispleasing	0.901	0.036
UQdissatisfying	0.903	0.041
UQrepulsive	0.657	0.000
UQuncomfortable	0.902	0.038
UQunpleasant	0.879	0.014

df = 21

Appendix 4.

ΔSC_1	ΔSC_2	ΔSC_3	ΔSC_4	ΔSC_5	ΔSC_6	ΔSC_7
1.018	1.007	1.036	1.075	1.084	1.146	1.110
0.702	0.782	0.801	1.071	1.057	1.389	1.197
1.047	0.992	0.972	0.953	0.945	0.946	0.927
1.320	1.473	0.817	1.135	1.427	1.359	1.544
1.008	0.995	0.937	1.036	1.033	1.032	0.992
1.043	1.068	1.115	1.124	1.127	1.114	1.092
0.732	0.535	0.912	1.478	1.722	2.216	2.049
0.793	0.880	0.925	1.116	1.195	1.267	1.330
0.789	0.726	0.926	0.995	0.940	1.079	1.150
1.984	1.829	1.177	1.462	1.677	1.409	1.222
1.012	1.019	0.977	1.074	1.133	1.112	1.172
0.677	0.923	1.117	1.261	1.313	1.377	1.363
1.133	1.192	1.188	1.109	1.072	1.203	1.164
0.868	0.266	0.366	0.492	0.391	0.582	0.913
0.813	0.382	0.459	0.698	0.568	0.392	0.656
0.553	0.452	0.608	0.621	0.741	1.034	1.202
0.868	0.874	0.933	1.013	1.004	1.028	1.063
1.180	1.002	1.021	1.099	0.968	1.008	0.934
0.834	1.037	1.025	1.012	1.234	1.287	1.380
0.822	0.669	0.596	0.740	1.176	1.280	1.136
0.680	-0.141	0.444	0.792	0.932	1.038	1.366
1.244	1.110	1.073	0.930	1.209	1.098	1.134
0.894	0.867	1.026	1.036	1.044	1.028	1.074
0.457	0.619	0.438	0.946	1.588	0.901	1.255
1.090	1.071	1.188	1.131	1.090	1.122	1.081
1.094	1.119	1.087	1.036	1.023	0.981	0.971
1.330	1.623	2.013	1.356	2.254	1.929	2.872
0.466	0.450	0.554	0.568	0.847	1.199	1.132
0.852	0.826	0.897	0.910	0.898	0.952	1.032
2.303	3.401	3.907	3.842	3.229	3.149	3.182
-0.355	-2.305	-2.611	-2.461	-0.823	0.277	0.219
1.184	1.219	1.241	1.213	1.161	1.163	1.158
0.533	0.569	0.531	0.478	0.780	0.903	0.464
0.852	1.206	1.242	1.463	1.463	1.633	1.628
1.640	1.940	2.370	2.566	2.269	2.697	3.130

1.044	1.420	1.637	1.589	1.737	1.951	2.064
1.059	1.150	1.286	1.393	1.440	1.466	1.459
0.880	1.076	1.257	1.272	1.269	1.277	1.270
1.051	1.113	1.170	1.099	1.221	1.276	1.377
1.107	0.953	0.920	1.177	1.263	0.776	0.767
0.909	0.996	1.017	0.980	1.044	1.088	1.035
0.999	1.057	1.071	1.079	1.110	1.016	1.090

Appendix 5.

pair		df	t	p
1 & 3	ΔSC_1	26	0.38	0.7055
	ΔSC_2		0.02	0.9836
	ΔSC_3		-0.39	0.6982
	ΔSC_4		0.07	0.9465
	ΔSC_5		-0.03	0.9796
	ΔSC_6		0.11	0.9134
	ΔSC_7		-0.03	0.9785
	last 5 min		-0.19	0.8476
1 & 2	ΔSC_1	26	1.69	0.1032
	ΔSC_2		1.97	0.0592
	ΔSC_3		1.15	0.2615
	ΔSC_4		2.09	0.0461
	ΔSC_5		0.89	0.379
	ΔSC_6		1.22	0.2317
	ΔSC_7		0.49	0.6273
	last 5 min		0.45	0.6562
1 & 3	ΔSC_1	26	-0.66	0.5129
	ΔSC_2		-1.15	0.2597
	ΔSC_3		-0.94	0.3547
	ΔSC_4		-0.93	0.3608
	ΔSC_5		-0.61	0.5456
	ΔSC_6		-0.74	0.4632
	ΔSC_7		-0.34	0.7357
	last 5 min		-0.56	0.5778