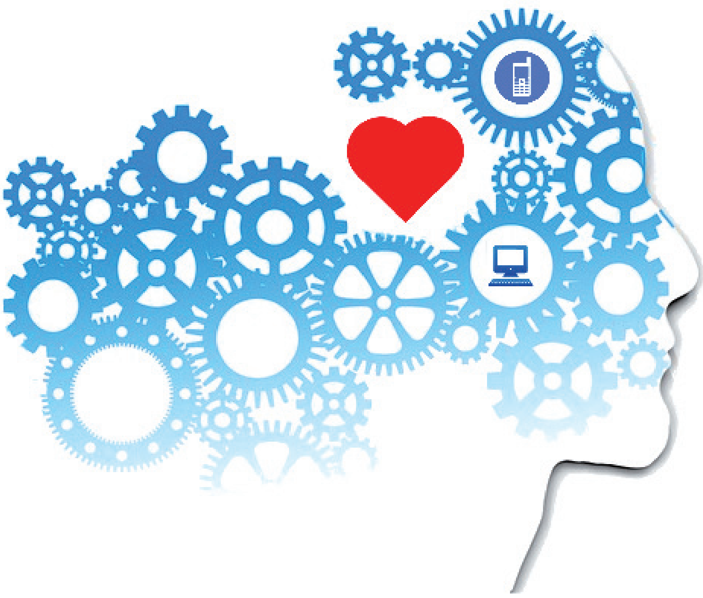
JYVÄSKYLÄ STUDIES IN COMPUTING
213

Jussi P. P. Jokinen

User Psychology of Emotional User Experience



JYVÄSKYLÄN YLIOPISTO

JYVÄSKYLÄ STUDIES IN COMPUTING 213

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Esitetään Jyväskylän yliopiston informaatioteknologian tiedekunnan suostumuksella
julkisesti tarkastettavaksi yliopiston Agora-rakennuksen auditoriossa 2
kesäkuun 6. päivänä 2015 kello 12.

Academic dissertation to be publicly discussed, by permission of
the Faculty of Information Technology of the University of Jyväskylä,
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UNIVERSITY OF JYVÄSKYLÄ

JYVÄSKYLÄ 2015

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Publishing Unit, University Library of Jyväskylä

URN:ISBN:978-951-39-6225-8
ISBN 978-951-39-6225-8 (PDF)

ISBN 978-951-39-6224-1 (nid.)
ISSN 1456-5390

Jyväskylä University Printing House, Jyväskylä 2015

"For all men begin, as we said, by wondering that things are as they are, as they do about self-moving marionettes, or about the solstices or the incommensurability of the diagonal of a square with the side; for it seems wonderful to all who have not yet seen the reason, that there is a thing which cannot be measured even by the smallest unit."

(Aristotle, *Metaphysics*, 983a15)

ABSTRACT

Jokinen, Jussi P. P.
User psychology of emotional user experience
Jyväskylä: University of Jyväskylä, 2015, 89 p. (+ included articles)
(Jyväskylä Studies in Computing
ISSN 1456-5390; 213)
ISBN 978-951-39-6224-1 (nid.)
ISBN 978-951-39-6225-8 (PDF)

Researchers of human-technology interaction have started to emphasise the importance of technology users' experiences: experience is an important aspect of daily life, and thus it should be taken into account in human-technology interaction research and in design of new technologies. However, scientific study of conscious experience is difficult, and the field of user experience research is afflicted by incompatible definitions, assumptions, and guidelines for investigating users' experiences and designing for them. This problem is emphasised by the lack of foundational framework, which would allow for comparing the metascientific and methodological assumptions behind different accounts of user experience. Here, such an account is presented in the form of foundational analysis of human-technology interaction. The resulting methodological framework is used to review theories of user experience with a conclusion that while the topics investigated under the umbrella of user experience seem to be the correct ones, their operationalisation lacks proper psychological basis.

As a result of the foundational analysis of user experience, one of the core concepts related to conscious experience, emotion, is introduced, and different psychological accounts for it are reviewed using the methodological framework. Appraisal theory of emotion is shown to provide methodologically the best option for studying emotional user experience. A review of empirical studies, included as the articles of this thesis, supports this conclusion. Emotional user experience is discussed in terms of (1) a competence-frustration model, (2) individual coping differences in human-technology interaction, (3) mental contents of emotional experience, and (4) the non-conscious cognitive processes associated with the appraisal process. These elaborations can be used to investigate what users experience emotionally when they interact with technology, and explain these experiences. Such investigations should provide valid knowledge structures for designers, who aim to create technologies with certain experience goals.

Keywords: user experience, emotion, appraisal, mental content

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ACKNOWLEDGEMENTS

As I started my studies on emotion in human-technology interaction over four years ago, I wasn't that familiar with the topic, nor with the field of human-technology interaction in general. What I've learned during my doctoral studies, and what I hopefully can teach to others, has not been achieved by myself alone, but with the help of multiple people: colleagues in academia, industrial partners, family members, study participants, and interviewees.

Pertti Saariluoma has shaped my learning process the most. He took me as a student, I like to think because he believed in my ability to learn the field in which I did not have that much experience. I hope I have proven myself. I have benefited from your ideas that combine deep philosophical thought and practical interest in actual matters. We may have certain metaphysical differences of opinion (which I do enjoy discussing in an academic manner), but on the level that matters the most, I believe you have taught me how to think correctly (not that I would always do so). My other supervisor, Tuomo Kujala has served in an enormously encouraging manner, both by listening to my problems and being a living proof that what we are doing can be done, and it can be done well.

My closest day-to-day collaborators have been Johanna Silvennoinen and Piia Perälä. Johanna, I enjoy our so far fruitful collaboration and (at times disorganised) discussions. You have already designed more fascinating topics of study than we would have time to explore, but I think this is the fate for anyone creative, artistic and intelligent. Piia, should you choose to continue on the scientific path, as I believe you should, you will come into great expectations. You are great at designing and carrying out experiments, and your handiwork is behind almost all of my publications.

I have been lucky to work in a Tekes-funded Fimecc project UXUS (User experience and usability in complex systems) for the whole time I've been doing my dissertation. Having a network of academic and industrial collaborators to ask whether what you are doing makes any sense or is relevant to anyone is important. Especially I'd like to thank the project leader Maaria Nuutinen, Eija Kaasinen, and Virpi Roto, whose always implicit (and at relevant times explicit) belief in my work encouraged me. This dissertation would not be about emotional user experience without UXUS. I just hope I have been able to give to the project as much as I have benefited from it.

While you are supposed to work on your dissertation when you are at work, I don't think there are that many doctoral students who have not taken their work to their homes. Scientific problems follow you anywhere and do not ask whether you have time for them. I am grateful that my wife Jenni understands this, and she always tries to be interested in my problems, although it's not her field of interest. You listen to me and support me, and thanks to you I can't fall too deeply into the abyss of endless thought.

Helsinki 8.5.2015
Jussi Jokinen

FIGURES

TABLES

CONTENTS

LIST OF INCLUDED ARTICLES[1]

I. Saariluoma, P., & Jokinen, J. P. P. (2014). Emotional dimensions of user experience: a user psychological analysis. *International Journal of Human–Computer Interaction, 30*(4), 303–320.

II. Saariluoma, P., & Jokinen, J. P. P. (2015). Appraisal and mental contents in human-technology interaction. *International Journal of Technology and Human Interaction, 11*(2), 1–32.

III. Jokinen, J. P.P., Silvennoinen, J., Perälä, P., & Saariluoma, P. (unpublished manuscript). The effect of brand experience and interaction events on contents of visual experience in web page appraisal.

IV. Jokinen, J. P. P. (2015). Emotional user experience: Traits, events, and states. *International Journal of Human Computer Studies, 76*, 67–77.

V. Jokinen J. P. P., Silvennoinen, J., Perälä, P., & Saariluoma, P. (2015). Quick affective judgments: Validation of a method for primed product comparisons. In *Proceedings of the 2015 conference on Human factors in computing systems - CHI '15* (pp. 2221–2230). New York: ACM.

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1 In the articles I and II, Pertti Saariluoma and me have collaborated closely. Usually Pertti supplies the greater theoretical ideas, and I make the data collection (with help of Piia Perälä, of course) and analysis. The final articles were written and reviewed in a close collaboration. In articles III and V, all four of us worked in close collaboration, I as the principal author, responsible for the main line of thought as well as for the data analysis and the structure of the text.

1 INTRODUCTION

1.1 User experience and user psychology

Technology is practically an inseparable part of our life, and our experiences in this world are thoroughly technological. Often, technology is only an implicit part of our daily actions: our focus is on the actual task, and only at times we stop to explicitly and consciously represent an experience with a technological artefact. A software problem during a work day provokes a verbal response, or new smartphone interface is so fluent that we want to tell about this experience to friends and colleagues. However, even when we are not consciously representing the technological artefacts with which we interact, we face the world with a technological attitude and make sense of the world in technological terms. In our planning we account how technology can help us to meet our goals. Where there are people interacting with the world, there is mental activity and experiences, which concern technological artefacts. Scientific elaboration of this activity is the key to understanding and explaining technologically organised mental and social life. The problem, however, is that the study of how people experience, even defining what experience is, is notably difficult. This makes the scientific study of experience in human-technology interaction arduous, but also prompts researchers to seek better understanding of how experience can be understood.

Making sense of experience in human-technology interaction is an ongoing task, and during the past twenty years, this problem has received increasing amount of interest. First explicit references to the importance of experience come from the early 1990s (Norman, Miller, & Henderson, 1995; Norman, 2004, p. 10), and since the turn of the century, the focus of human-technology interaction research has broadened from work settings and groups of people working with computer applications to more comprehensive contexts and purposes of technology use. Acknowledgement has been given to the fact that not all technology use is necessarily purposeful in the sense that people use technology to attain clearly defined goals, such as daily work-related tasks. This transition has been called the 'third wave of human-computer interaction[2]' (Bødker, 2006) to underline the need to account the diverse aspects human mental life, such as cognition, emotion, culture, and social life, when investigating how people use and experience technological artefacts. The proliferation of terms such as *user experience* (Hassenzahl & Tractinsky, 2006; Kuniavsky, 2003; Norman, 2013), *product experience* (Desmet & Hekkert, 2007), and *consumer experience* (Schmitt, 1999) demonstrates how experience has become a significant issue in human-technology interaction research and design.

The interest in how people experience technology, and how designers of technology should consider experience, has been accompanied by various theories aiming at defining experience in human-technology interaction, and methods for studying the phenomenon. Reviews of user experience theories (Hassenzahl & Tractinsky, 2006) and methods (Bargas-Avila & Hornbæk, 2011; Vermeeren, Law, & Roto, 2010) are clear on the fact that there are various disagreeing perspectives and methodologically incompatible positions in the field. This observation is not only related to the scientific study of experience in human-technology interaction: there are also disagreeing positions between designers on what user experience is (Law, van Schaik, & Roto, 2014). Of course, different perspectives into what experience is and how one should design for experience are not necessarily a problem, and indeed scientific and technological progress depends on discussions concerning incompatible foundational assumptions and operational procedures (Saariluoma, 1997). However, the proposition here is that it is time to establish more foundationally stable framework for studying experience in human-technology interaction. This would help the dissemination of competing theoretical perspectives – something which is lacking in user experience research (Kuutti, 2010) – and it would also clarify the role of experience in the design of new technologies.

Experience-driven design has received treatment from many perspectives and on many levels of theoretical detail. As an example of a very general principle, Jordan (2000) advocates design based on a 'holistic', all-encompassing understanding of the relationship between the user and the product. Norman (2004) distinguishes between three levels of design, biological, behavioural, and cultural, and presents a slightly more detailed picture than Jordan's holistic approach. On even more detailed level, guidelines for experience design have been drawn from specific theoretical frameworks, such as appraisal theory of emotion (Demir, Desmet, & Hekkert, 2009) or cognitive-affective computational models (Xu, Zhou, & Jiao, 2010). The basis for each of the these different frameworks for experience-driven design is in the scientific analysis of human-technology interaction: each is based on a scientific theory and empirical evidence. The importance of utilising a scientific framework in design is clear: sci-

[2] Human-computer interaction is the established name of the field, which nowadays studies not only computers, but all kinds of interactive technological artefacts. I prefer to use the term human-technology interaction here, because it emphasises that technological experiences are not limited to computers.

ence provides explanatory frameworks, which guide in formulation of design principles (Saariluoma, 2005).

Explanation is one of the ultimate goals of scientific inquiry (Hempel, 1965; G. von Wright, 1971; Woodward, 2003), and scientific explanations are also necessary in design. While basic scientific research and applied design may appear to be distant from each other, they both ultimately involve the same human capacity to think and solve problems (Langley, Simon, Bradshaw, & Zytkow, 1987; Newell & Simon, 1972; Saariluoma, 2005; Simon, 1969). Regardless of whether the problem is related to science or design, domain-specific knowledge is required in solving the problem. When designers devise technological solutions, they must have reasons for their decisions – they need to explain why a particular design is an answer to a particular design problem (Saariluoma, 2005). Whether the design occurs in solitude or in a collaboration, there is the need to explain, to justify design solutions either to oneself or to the other team participants (Okada & Simon, 1997).

As exemplified in the case of user experience, the current state of the scientific knowledge concerning human-technology interaction is fragmented (Saariluoma & Oulasvirta, 2010). Scientific progress in general benefits from different perspectives and frameworks (Saariluoma, 1997), but the current fragmentary state of user experience research provides little grounds for unified theories capable of explanations. Saariluoma and Oulasvirta (2010) have proposed a discipline of *user psychology* to tackle the problem of unifying theoretical, conceptual, and empirical knowledge concerning human-technology interaction in such a manner that allows for explanations (see also Moran, 1981). Central in user psychology is its problem solving epistemology: the advancement in user psychological research happens not by arriving closer at the 'truth' of human-technology interaction, but via increased problem solving ability (Laudan, 1977; Saariluoma & Oulasvirta, 2010). Thus, the task of grounding user experience research on scientifically solid basis is clearly user psychological.

Perhaps one of the main reasons for the difficulties for user psychologically coherent theory of user experience is the difficult nature of conscious experience. Consciousness is one of the most debated concepts in philosophy, psychology, and cognitive science – it has been since the question concerning human existence was established in the history of thought (see Revonsuo, 2010 for a review). The study of user experience implies the study of consciousness, and therefore it is understandable how user psychology of user experience is theoretically difficult. An easier way is to explicate important components or dimensions of user experience, and investigate how these components can be theorised. At the moment, the number of such dimensions is large (Bargas-Avila & Hornbæk, 2011), and it is possible that user experience can never be understood in terms of a finite number of dimensions (Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009). However, the problem is not necessarily in defining user experience in its totality. A more problem solving oriented way is to determine, which dimensions of user experience can be conceptualised in user psychological terms, and focus on investigating them in order to create scientifically valid explanatory framework to be used in design.

What are, then, the most user psychologically relevant dimensions of user experience? In a review of user experience measurement instruments, Bargas-Avila and Hornbæk (2011) provide a list of eight dimensions: emotion, enjoyment, aesthetics, hedonic quality, engagement, motivation, enhancement, and frustration. Each of the dimensions has received explicit treatment in studies of user experience, but are they actually distinct categories of human experience? For example, are enjoyment and frustration distinct categories, separate from emotion? Following the categorisation of human mental life by Kant (1792), there are three distinct faculties: cognition, emotion, and motivation. From the list of user experience dimensions above, 'emotion', 'enjoyment', 'enhancement', and 'frustration' would be related to the emotion category, while 'engagement' and 'motivation' would be more associated with Kant's motivation category. Further, psychology of emotion has also adapted the notion of aesthetics as part of its investigations (e.g., Scherer, 2005). Thus, it seems that from the different categories of human mental life, emotion seems to be most related to user experience.

As explored below in detail, associating user experience with the faculty of emotion does not exclude it from the other faculties. As already evident in the list of user experience dimensions (Bargas-Avila & Hornbæk, 2011), motivation has been named as an important aspect of user experience. However, as will become clear below, it is necessary to define emotion and cognition inseparably, and thus it will be necessary to define user experience in a way which simultaneously refers to all three faculties of human mental life. Here, the investigation starts with emotion, and the conclusion that emotion must be one of the core user experience dimensions can be justified from the perspective of psychology of emotion: although there are foundational disagreements concerning the details of the emotion process, few dispute the belief that emotion is inseparably related conscious experience (Izard, 2007; Lambie & Marcel, 2002; Moors, Ellsworth, Scherer, & Frijda, 2013; Russell, 2009; Scherer, 1995; Thagard & Aubie, 2008). Without a theory of emotion, there is no theory of user experience. Therefore, in order to establish a user psychological framework for studying user experience, one of the main dimensions of user experience, emotion, needs to be investigated. This implies analysing the emotional aspects of human-technology interaction with modern psychological theories, concepts, and methods (Saariluoma & Oulasvirta, 2010). In other words, what is necessary, is *user psychology of emotional user experience*.

1.2 Approach of the study & the structure of the work

The question concerning emotional user experience is problematic largely due to the want of explicit definitions of emotion and experience. Scientific inquiry into these concepts faces the challenge of being already well-known to all of us through our own experience. Each of us knows, albeit tacitly, what emotion and experience are. The problem in constructing scientific theories about such concepts as emotion and experience is that our tacit assumptions concerning them are easily embedded into the theoretical accounts. Because observable phenomena look different to observers with different conceptual foundations (Kuhn, 1962), it is possible that pre-scientific conceptual assumptions guide and limit scientific inquiry. Often these assumptions are tacit, and it is difficult not to embed them in theory building and experiment design, which makes the pre-scientific assumptions to 'hide' in the observed results (Saariluoma, 1997). Therefore, the first task of user psychology of emotional user experience is to create a framework for explicating the assumptions one might have concerning emotion and experience. This serves as the basis for the first question of this thesis.

Q1. What are the conceptual foundations of human-technology interaction research?

This question will be asked and analysed in the third chapter of this thesis using foundational analysis, a tool for uncovering tacit metascientific assumptions in empirical scientific research (Saariluoma, 1997). Two foundational assumptions, one relating to intentionality of human beings, and one relating to causal explanations of human behaviour and thought, are explicated, and a methodological framework based on different foundational choices concerning these assumptions is presented. This allows the investigation of the following question of this thesis.

Q2. What is emotion and how can it be studied in the context of human-technology interaction?

With the help of foundational analysis and the methodological framework given as an answer to Q1, different psychological accounts of emotion are investigated in the third chapter of this thesis. Theories of basic emotion, core affect, and appraisal are reviewed and their relevance to the study of emotional user experience evaluated. The result of this investigation is a proposition to utilise appraisal theory – and notice some important points of the other theories – in constructing a model for emotional user experience, which will be presented as an answer to the third question of this thesis.

Q3. What is emotional user experience?

The challenge for user psychology of emotional user experience is to provide a model, which can be used to explain how emotional experiences occur in human-technology interaction. This would allow the justification of experience-centred design solutions, that is, why certain designs invoke certain emotional experiences. Of course, such model will not be simple, and it may be impossible to construct an all-encompassing explanation of emotion. Thus, the goal is to outline a general model and focus on some more specific features of it. The resulting proposition will be appraisal-based model of emotional user experience. More detailed investigations will consider the individual differences in emotional responses and in the cognitive process of how these emotional responses to technology use occur.

Finally, in order to justify the usefulness of the proposed model of emotional user experience in design, it is necessary to define the actual process of design and investigate how a scientific model of emotional user experience could help a designer to devise better technologies. The investigation in this dissertation starts therefore with a review of what is design, which necessitates a quick review of such fundamental questions as what is technology and what is thinking.

2 TECHNOLOGY AND THOUGHT

2.1 What is technology?

Technology has always been a major question for philosophers to consider, and not surprisingly, there are still many contesting definitions and perspectives. The classical definition for technology is, that it is man-made, that is, *artificial* (Simon, 1969). The foundational upshot of this definition is that it makes 'technological' ontologically different from 'natural', a distinction utilised prominently by Aristotle (*DA*, *EN*, *Met.*, *Phys.*)[3]. Whereas nature has its own inner cause, the cause of technology is human skill, which is employed to meet human end. In this sense, the root of technology is in *techne*, which means human skill or art (*EN*, VI). The art of a medical doctor is curing people, and the art of a scientist is discovery and knowledge creation. In order to attain goals associated with their skills, people often require tools, machines, instruments, and materials. A scalpel, for example, is a tool that helps doctors in their goals by enhancing their art of curing people. A scientist investigates celestial bodies in an observatory, because the magnifying properties of its telescope extend the ability of the scientist to make observations, which lead to discoveries. Thus, *technology* is the human arrangement of tools, machines, instruments, and materials, which serve people in attaining goals.

The classical characterisation of technology often leads to a juxtaposition between science, applied science, and technology (Feibleman, 1983). Put in simple terms, if the task of a 'basic scientist' is to develop theories and the task of an 'applied scientist' is to discover applications to these theories, a 'technologist' starts from practical problems and utilises the discoveries made by the applied scientist to invent artefacts, which help in solving the practical problems. However, although it is useful to consider the essence of technology in a relation to practical problems, the classification into pure science, applied science, and

3 Here, citations to Aristotle are done using the Latin abbreviation of the titles, with Bekker numbers when relevant. *DA* = *De Anima*, *EN* = *Nicomachean ethics*, *Met.* = *Metaphysics*, and *Phys.* = *Physics*.

technology does not necessarily offer insights for investigating technology. Consider, for example, the development of the *t*-test by William Gossett (Salsburg, 2002) or Pasteur's discovery of germs (Stokes, 1997). Gossett developed his test for practical purpose of analysing yeast batches at the Guinness brewery, but *t*-test played also a major role in development of basic inferential statistics, and is an immensely useful and popular tool in applied statistics in various scientific fields. Pasteur started from a practical problem of preserving beer (among other substances), but while doing so improved immensely the understanding on the nature of disease. These intellectual accomplishments do not benefit from the distinction between pure science, applied science, and technology.

The Aristotelian conception of technology can be explored further by following the thinking of Heidegger (1927), for whom the analysis of the world starts from human experience and understanding. What connects all meaningful things together is that people take them *as being* something. Thus, what makes a ship a ship, even if its parts are being constantly replaced so that in the end there is no single original part left, is a human being who takes the ship as a ship. The key to defining technology is in the kind of attitude that this 'taking something as something' involves. Heidegger analyses this as a person's 'in-order-to' attitude towards objects of the environment. This means that physical objects are not technology by themselves: they become technology in the experience of a person, who needs them in order to do something. For example, a hammer becomes technology when someone is mentally and physically oriented towards it with an attitude that the hammer is useful for hammering something down. It is in the experiential constitution of the world that a physical object becomes technology, and because people experience the world differently and have various goals, the purpose of an object cannot be derived from the object itself, but it must be defined in the context of the user's experience.

What is common in both Aristotelian and Heideggerian conception of technology is the centrality of human purpose. Herbert Simon (1969), in his investigation of the artificial, furthers the relevance of purpose in the definition of technology. He defines an artefact as an interface between its inner and outer environment. The inner environment refers to the physical configuration of the artefact, and the outer environment gives the surroundings in which the artefact and its user exist. A hand watch has a certain physical configuration: it consists of springs, cogs, hands for minutes and hours, and so on. Conversely, a sundial consists of a rod and a dial. Both inner environments – that of a hand watch and that of a sun dial – are capable of fulfilling a human purpose, which in this case is the need to know what time it is. In some environments, such as in cloudy areas or polar areas during the winter, the inner environment of a sundial is not purposeful for telling the time, while in sunny areas it is. For cloudy areas, a hand watch would be more purposeful, as long as its requirements, such as need for energy, are met. Although modern watches have practically replaced sundials, one can still find sundials at parks and backyards. This

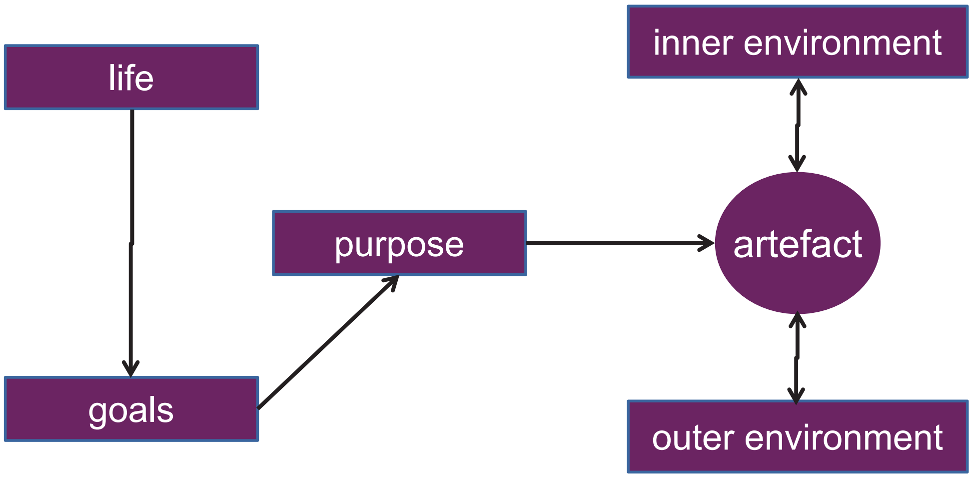

FIGURE 1 Framework for an artefact.

tells us that perhaps they serve other goals, such as aesthetical, in addition to or in a replacement of their original, practical function.

It is the task of the *designer* of an artefact to device such an inner environment, which fulfils the intended purpose in certain outer environment. In order to complete this task, the designer needs knowledge about inner and outer environments, as well as the purposes that people give to artefacts. The purposes are derived from goals, and human goals are related to life, as shown in Figure 1. Thus, the task of the designer is to devise artefacts using knowledge about human life and about the environments in which people live, in addition to the engineering skills needed to accomplish the necessary inner configuration of the artefact. The important result of the definition of artificial from either Aristotle, Heidegger, or Simon, is that technology cannot be defined without a reference to human life. In other words, it does not make sense to design technologies for anything else than human life, and thus the analysis of any design process should start from life. This notion has been developed under the concept of *life-based design* (Leikas, 2009; Saariluoma & Leikas, 2010).

2.2 Design as problem solving

To investigate the design of technology, Simon (1969) proposed a new field of study, which he named *sciences of the artificial*. The goal of this field is to analyse design process from the perspective of various fields and practises, such as organisation research, psychology, and cognitive modelling. Simon (1969) defines *design* as intelligent thinking, in which courses of action are devised in order to change existing situations into preferred one.[4] It is notable that this definition is closely in line with Simon's theories concerning human problem solving (Newell & Simon, 1972): design is conscious problem solving activity. Many later definitions of design are in coherence with this perspective. A recent textbook on innovation and design, for example, defines design as the conscious decision-making process in which information is transformed into an outcome (von Stamm, 2008, p. 17).

Design does, of course, involve other aspects than problem solving: design has many practical phases, and idea generation is only the starting point of new product development (P. D. Bennett, 1988, p. 338). Thus, the definition of design as problem solving activity needs to be understood here in very broad terms. Further, the understanding of design as problem solving does not mean that design is a solitary practice. On the contrary, design is usually collaborative problem solving activity (Hayes, Wheelwright, & Clark, 1988, p. 313), and the explication of tacit knowledge and the justification of own ideas to the other members of the community are obviously critical in design processes (Von Kroch, Ichijo, & Nonaka, 2000). However, these challenges can also be understood in terms of problem solving so that collaborative design can be explicated in terms of human problem solving as clearly as designing alone (Okada & Simon, 1997).

Human problem solving can be explored with concepts of information processing, task environment, and problem space (Newell & Simon, 1972; Newell, 1990). First, *a problem* consists of states and permissible transformations between the states (also called operations), so that if these transformations are executed in the correct order, an initial problem state can be transformed to the goal state. *Problem solving* is the search for the correct operations: to solve a problem, a processing system (such as the human cognitive faculty) needs to extract information concerning the problem, and apply a set of operations on this knowledge and the task environment. The problem solving system has an internal representation of the situation, called the *problem space*. The outcome of the solution is dependent on having all critical features of the situation properly represented (Simon, 1978). Firstly, this implies that the problem solving system needs all relevant information concerning the situation. Sometimes all information required for solving the problem is included in the statement of the problem, such as in certain puzzles and laboratory tasks used for studying human problem solving (Simon, 1978). Usually, however, arriving at the solution requires large amounts of information, which can either be drawn from the long-term memory of the problem solving system or from external sources. Design, for example, is complex domain-specific problem solving activity, which necessitates the use of information from both long-term and external sources (Jonassen, 2000).

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4 "Designer devises" has, of course, a problem of falling into *petitio principii*, because in order to define what 'devising' is, one needs to define what 'designing' is. However, the point is to conceptualise design in terms of thinking, which can then be defined without utilising 'design' or 'devise'.

Especially when the problem is large and its solution requires a lot of information, it is important that the problem solving agent is able to represent the information in a coherent structure (Saariluoma, 1997). Such a coherent, domain-specific body of knowledge is called an ontology. More specifically, *an ontology* refers to a theory about the sorts of objects, properties of the objects, and relations the between objects, that are possible in a specified domain of knowledge (Chandrasekaran, Josephson, & Benjamins, 1999). *Formal ontologies* are content-specific agreements for sharing and using knowledge concerning a domain (Gruber, 1995). A human-technology interaction ontology, for example, would list relevant objects (e.g., the user, the artefact, and the environment), what properties these objects have, and what their relationships are. Therefore, a good ontology is necessary in complex problem solving situations, because the coherence of the problem space and thus the capacity of the problem solver to solve the problem depends on it. Further, collaborative problem solving necessitates a common, formal ontology for requesting and sharing problems, hypotheses, and solutions (Okada & Simon, 1997) In the context of problem solving activity, the role of user psychological research is to provide coherent interaction ontologies for researchers and designers (Saariluoma & Oulasvirta, 2010). A well-constructed ontology of emotional user experience would, for example, provide suggestions to a designer about the kinds of design solutions, which would result in the desired experience.

How does one use an ontology? In order to understand how a problem solver uses information, it is important to make a distinction between practical action and the theoretical model which describes this action. In his analysis of scientific logic, Kaplan (1964) proposes that while *logic in use* refers to how a scientist actually proceeds in the process of discovery, it is not possible to theorise this logic with perfect accuracy. Instead, it is possible to make hypotheses concerning logic in use. This hypothetical model of scientific thinking is called *reconstructed logic* (Kaplan, 1964). For example, it is possible to make a hypothesis, related to reconstructed logic, concerning how an ontology is applied in design thinking, which is an example of logic in use. It is important to keep in mind that reconstructed logic is not the same as logic in use. For example, intuition is logic in use, and it is perhaps not even possible to describe intuition with reconstructed logic (Kaplan, 1964). However, it is still possible to investigate the role of intuition in scientific or design thinking (Saariluoma, 1997, 2005), and a general description of how design proceeds from problems to solutions utilising interaction ontologies helps in building useful ontologies.

2.3 Design, explanation, and justification

As described above, on the level of abstract problem solving system, the problem space is navigated by applying operators on the different states of the problem (Simon, 1978). The problem solver can, for example, compare the current situation with the desired one, and choose an operator which changes the cur-

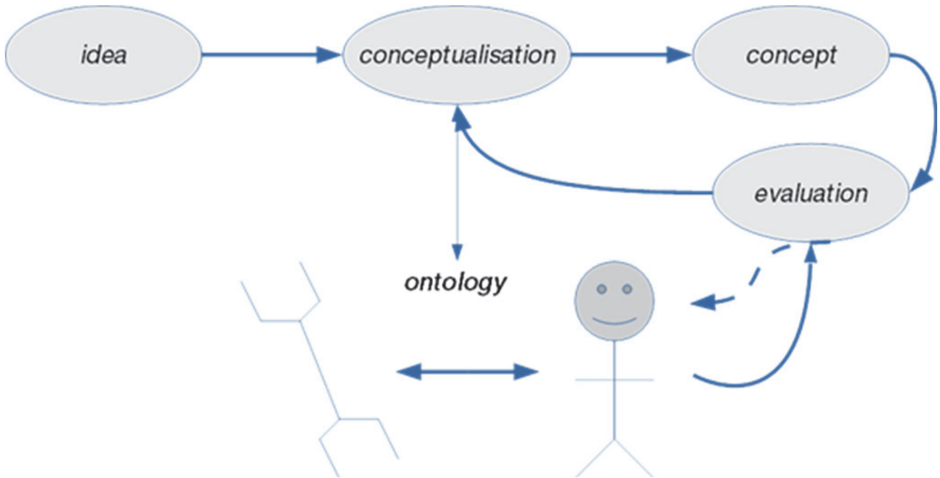

FIGURE 2 Conceptualisation process.

rent situation towards the desired one. In simple tasks, the number of operators may be low, and the choice between them easy. However, with complex problems, such as encountered in scientific research or human-technology interaction design, the number of operators is large and the route from the initial problem state to the solution is not necessarily clear. Moreover, often the necessary operators do not exist at the start of the problem solving process: they need to be created. *Operationalisation* refers to the shift from formal to operable concepts: is the act of creating a concrete operation from an abstract representation. In empirical sciences, operationalisation is defined as the design of concrete operations, such as measurement instruments, from abstract theoretical concepts (Saariluoma, 1997).

Figure 2 depicts how a design problem is solved in a *conceptualisation* process, in which the designer utilises a relevant interaction ontology to arrive at a *concept*, which is given as a solution to a design problem. The process of conceptualisation is dependent on successful operationalisations from the interaction ontology, similarly as successful application of an operation in general problem solving process is dependent on good problem space. In other words, a designer with a coherent and informative representation concerning the design problem is more likely to arrive at a good concept, which serves as a good solution to the design problem. For example, perhaps the goal is to create an interface for remotely operated port crane so that the operator's feeling of control is supported (Koskinen, Karvonen, & Tokkonen, 2013). Any design solution that answers to this problem, and therefore increases the operator's feeling of control, is a concretisation of the theoretical concept of feeling of control and therefore an operationalisation. A solution for assisting the operator to look at the correct screen at all times, for example, is an operationalisation, which requires an ontology explaining why the solution helps the operator to have feeling of control.

Design concepts, similar to research methods, require justification in order to be accepted as valid solutions for given problems. In Simon's (1969) terms of what artificial is, this means that a valid design is such an inner environment, which makes the artefact satisfy its desired purpose in a certain outer environment. Thus, a concept for a sundial is not a valid solution for the problem of knowing what time it is, if the outer environment is often cloudy (it can still be a solution for the problem that a park needs decoration). Aside from such obvious examples, the justification of a concept is often difficult and may be left to the designer's intuition. The problem of intuition-based justification, however, is that intuition does not necessarily conform to the facts about the reality in which the artefacts are used. If a design for a bridge does not take into account the laws of physics, the bridge is likely to collapse. If a design of a nuclear power plant control system does not take into account how the user associates certain indicators with certain functions, safety-critical processes may be compromised (Perrow, 1984). If a user experience designer does not know that frustration is related to goal-incongruent obstacles (Saariluoma & Jokinen, 2014), designing for non-frustrating interfaces will be difficult.

Often, the validity of a design is evaluated using prototypes, and in addition to supporting next iterations of the conceptualisation process, prototype evaluations may provide information for developing design ontologies further. However, it is also possible to justify design solutions without prototyping and user testing by basing the design on ontologies, which are validated using scientific knowledge. A bridge designer would not build an actual bridge to try out an idea and see if the bridge collapses. Instead, he uses engineering knowledge and physics to design a bridge is guaranteed not to collapse[5]. Similarly, a user experience designer should not wait for the user to get frustrated, but instead design interfaces, which take into account the possibility of users getting frustrated and the knowledge concerning the reasons for it. In fact, the process of conceptualisation for best designs incorporates validation into the process itself in a design strategy, which can be called *explanatory design* (Saariluoma, 2005). In explanatory design, scientific knowledge is used to define problems, and solutions result from applying relevant interaction ontologies.

User psychology provides concepts and relations to an interaction ontology, which the designer then utilises in conceptualisation, as depicted in Figure 2. A good interaction ontology, which draws from user psychological knowledge, will conform to the underlying structure of user psychological understanding of human experience (Saariluoma & Oulasvirta, 2010). In other words, while many user experience ontologies can coexist, the more truthful and thus useful ontol-

5 Obviously, reality is not the same as a collection of facts and laws 'governing' it, and thus a bridge which is constructed according to certain principles of engineering and physics can still collapse. An interesting example of this is Tacoma Narrows Bridge, which collapsed due to aeroelastic flutter, a phenomenon which was not accounted for in the ontology of the bridge building of the time. The collapse provided information about this phenomenon for developing a better ontology for bridge engineering, which exemplifies how concept prototypes can be evaluated in real-life to improve ontologies. Sadly, this is often the default habit in interaction design.

ogy will be the one that has more coherence with the scientific, user psychological theory of user experience. The usefulness of a solution to a design problem is, of course, contingent, in that the success of a concept cannot be fully established before the final product or service is in practical use. However, the probability that the concept is good depends on the good ontology used to conceptualise it: a good ontology should contain scientifically defined concepts, valid and reliable empirical methods, and empirically proven laws governing the relationships of the concepts.

An early example of a systematic utilisation of interaction ontologies in design comes from the 1970s Japanese car industry. *Kansei engineering* is a consumer-oriented design method, in which the design targets are connected with desired user feelings, and these connections are then used to drive the design process (Nagamachi, 1995, 2002). The word *kansei* was introduced in the 19th century by a Japanese philosopher Amane Nishi, who used it to denote sensibility (Lévy, 2013). This can, of course, be compared to Kant's (1787) *sensibility* (Sinnlichkeit), which is the form of understanding that structures perception in space and time. Kansei is therefore the human capacity to sense and fit the external world into meaningful structures (Nagamachi, 1995). Kansei engineering aims at revealing the meaning-structures of products, and thus provides the design process of those products an ontology concerning how the users experience them. Kansei engineering is related to Osgoodian (1952) psycholinguistics, in which affective meaning-structures are explored with factor analysis of semantic differential questionnaires[6] (see also Osgood, May, & Miron, 1975). Such explorations of questionnaires concerning, for example, styles and values can be used to construct a database, which functions as an expert system that helps a designer to find designs that satisfy the targeted user needs (Nagamachi, 2002).

If an inefficient ontology is used in the conceptualisation or the designer is otherwise unskilled in using ontologies, the product will probably involve usability and user experience problems. According to Norman (2013), such problems are prevalent in today's technological world, and the reason for constant failures in design is indeed the designer's lack of understanding of the principles of human-technology interaction. In other words, either the designer lacks proper interaction ontology for creating concepts with good usability and user experience, or then the designer is unable to utilise the ontology even if it is available. These problems are especially pertinent in experience-centred design, as any ontology of experience in human-technology interaction faces the problem of defining what a conscious experience actually is (Vermeeren et al., 2010).

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6 A semantic differential questionnaire contains opposite word pairs (e.g., *beautiful* – *ugly*), and the respondent uses such pairs to appraise objects on an interval scale. The object may be, for example, a drinking glass, and the participant appraises it with a questionnaire containing 20 adjective pairs. The responses are factor analysed into a number of meaning-structures, such as *Beauty* and *Practicality*, and the dependency of these factors on different designs can then be explored (Saariluoma, Jokinen, Kuuva, & Leikas, 2011)

The difficulty of defining conscious experience can be approached with the help of Dennett (1988), who has identified four properties of conscious experience[7]:

1. Ineffable: it is not possible to exactly say, what someone is currently experiencing.
2. Intrinsic: the quality of experience is atomic and unanalysable, and hence there is nothing tangible to get hold on to describe is exhaustively.
3. Private: comparing experiences between subjects in a systematic way seems to be impossible, because how something appears to me may be altogether different from how the same thing appears to someone else.
4. Directly or immediately apprehensible in consciousness: experience is a subjective property of an experiencing subject, and thus it cannot be removed by surgery and placed on a petri dish for objective analysis.

These descriptions relating to the quality of conscious experience clarify the problem of designing for experience. It is clear that there are good and bad experiences and that the design of a technological artefact influences the quality of experience, but it is not at all clear how this influence works. For example, an experience-centred designer is probably aware that, at least in certain contexts, the user expects fun, pleasurable, and enjoyable experiences (Monk, Hassenzahl, Blythe, & Reed, 2002). However, it is difficult to show exactly how one designs for fun and enjoyment, because this would require an ontology which clearly links design solutions to the pleasurable experiences of fun and enjoyment. If experience is indeed partly ineffable, intrinsic, private, and only apprehensible to the experiencing subject, it may be impossible to create a general interaction ontology, which validly and reliably shows how certain designs cause certain experiences.

Based on the above it is understandable that user experience is hard to define, and therefore it is difficult to design for good experiences. Possibly due to the difficulty of the concept, there exist many attempts at trying to model user experience.[8] Further, reviews of models and measurement instruments of user experience reveal that current science of user experience lacks a common framework for comparing the assumptions behind the different models and methods (Bargas-Avila & Hornbæk, 2011; Hornbæk & Law, 2007; Hornbæk, 2006). Hence, in order to construct user psychology of user experience, a framework needed for analysing the assumptions behind different answers to the question ‘what is user experience’. The explication of the hidden assumptions in user experience research would help researchers to discuss and com-

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7 More specifically, Dennett (1988) associates these characteristics with *qualia*, which refers to the quality of conscious experience.

8 Web site http://www.slideshare.net/Hienadz.Drahun/50-visual-definitions-of-user-experience lists more than 200 articulations of user experience, collected by Hienadz.Drahun. I thank Johanna Silvennoinen for pointing out this site.

pare their theories, and designers to understand different user experience ontologies.

Although the incommensurability of experience may start us with wonder. Although we start our inquiries about the world with wonder, it is the goal of a scientist to understand reasons, that is, the causes of phenomena, so that we no longer wonder about their effects (Aristotle, *Met*., 983a15). We must seek to understand the causes of why someone loves or hates particular technology, so that we don't need to wonder whether a particular design will cause love or hate in users. This task should not come to nought despite the incommensurability of experience. A geometrician can elaborate why a diagonal is not commensurable to a side using a geometrical proof, and likewise, a user experience researcher should elaborate why incommensurability of experience is not a problem for designing products for good experience. The geometrical proof is evident to someone who has understood is, and so should a scientific account of experience be evident to those who study it and understand it. For this purpose, it is necessary to ask, what are the fundamental presuppositions behind the scientific account of experience.

3 FOUNDATIONAL ANALYSIS OF HUMAN-TECHNOLOGY INTERACTION

3.1 Metascience and methodology

Foundational analysis is a metascientific method, which by analysing the intuitive assumptions in scientific argumentation and experimentation seeks to improve the validity of scientific research (Saariluoma, 1997). Foundational analysis focuses on scientific concepts and operationalisations of research processes, and aims to uncover tacit assumptions behind those concepts, and how these assumptions are constructed into experiments and how they thus hide in the results of those experiments. In other words, utilising the previously introduced concepts of Kaplan (1964), scientific research is *logic in use*, and foundational analysis aims at *reconstructing* this logic so that a meta-scientist can analyse that logic and its assumptions. Reconstructed logic can never perfectly correspond to the actual logic, which is used in scientific conduct, but it helps to understand this conduct and may offer ideas on how to improve it. At the heart of this reconstruction is methodological analysis, which is also one of the core components of foundational analysis.

Methodology can have various meanings, but in metascientific context it refers to the description, explanation, and justification of scientific methods (Kaplan, 1964). Sometimes methodology is taken to mean the epistemological analysis of science, involving such topics as justification of induction, analysis of causality, or reflection of causality; but this analysis is here called *metascience*. Metascience incorporates the analysis of tacit assumptions in scientific concepts, the methodological analysis of how these concepts are constructed into experimental settings, and the analysis of scientific argumentation in general (including appeals to induction, causality, and determinism). Scientific argumentation is, of course, always at least tacitly present in operationalisation of experiments. The connection between metascience and methodology is thus that while metascience focuses on the analysis of scientific thinking in general, methodology focuses in analysing justifications of empirical operationalisations and the presuppositions behind them.

How does a methodological position affect the operationalisation of empirical investigation? Analysing the metascience and especially the methodology of social sciences, Johnson, Dandeker, and Ashworth (1984) divide social theories among two dimensions: ontological and epistemological. The ontological dimension concerns the philosophical debate regarding the existence of ideas, and the choices in this dimension are between idealism and materialism. The epistemological dimensions concern the existence of universals, and the choice is between realism and nominalism. Answers to these questions create four methodological positions, which serve as ideal types for describing different theoretical formulations and empirical studies. This model is used here as a preliminary ground for a revised model, which better suits the methodological analysis of human-technology interaction and user experience. Two 'yes or no' questions, one ontological and one epistemological are posed, and the four possible combinations of answers are analysed as abstract ideal types, which researchers of human-technology interaction can adapt for practical use.

3.2 Intentionality

The first question, relating to the fundamental ontological question of ideas, concens intentionality. *Intentionality*, first presented by Brentano (1874) in its modern sense, is the ability of the mind to be about something, to represent something. Intentionality is therefore a feature of a mental state: when a mental state is about something, directed at something, or represents something, it is called intentional (Fodor, 1985a; Jaworski, 2011). Intentional mental states are hence relations between a person and the object which is being represented. In Kant's (1787) analysis of human thought, mental representations presuppose thinking, because otherwise mental representations would be nothing to the subject who represents them. However, before thinking occurs, cognition relates to objects through *intuition*. Intuition is afforded by *sensibility*, which is the ability of the mind to receive impressions about objects. Further, the ability of the mind to think these objects is called *understanding*. Without sensibility no object would be given to the perceiver, and without understanding no object would be thought. Thus, sensibility gives thought its content, without which it would be void; without concepts given by understanding, impressions about objects would be blind.

Mental representations are related to the concept of *mental content*: an intentional mental state has a connection to its content because representations have semantic properties (Saariluoma, 1997). In Kantian terms, content is given to the thinking being via understanding. Among capacity and format, information content is of particular importance in explaining human behaviour and thought (Allport, 1977; Fodor, 1985a; McClelland, 1955; Saariluoma, 1997, 2005). An intentional mental state, that is, a mental state which is about something, has always a particular content. For example, if a person is thirsty, they may have a desire for water, which is the content of their mental representation about what they desire. This content is obviously not the same thing as the potable liquid consisting of (mainly) H_2O molecules: when people represent things, they do not represent them as they can be described objectively, but instead attach subjective meanings to the representations.

The same object in the environment can be represented by multiple people and with various contents, depending on how the object relates to the goals of the subject. A representation of a hammer, for example, will have different content depending on whether someone is in need of hammering a nail or not. For a person needing a hammer, its representational content relates the hammer to the person's desires in a certain way, but perhaps the hammer is just an obstacle because it is in front of another, more useful tool, in which case the hammer has a very different relation to the goals of the person. The person's intentional relationship with the world affects the contents of the representations concerning the world.[9] The structure of a representation can be explicated in terms of content-specific rules, which state what makes sense in the representation (Saariluoma, 1997). The presupposition is that each element of representation must make sense from the perspective of the intentions of the subject.

Intentionality and mental content are crucial aspects in what is known as *folk-psychology,* or *common-sense psychological explanation* (Jaworski, 2011; Waskan, 2006). People explain their own actions and actions of other people by referring to beliefs and desires, which are mental states with a content. Why did my friend go to the grocery shop? Because she is hungry, and hence desires food, and because she believes that the shop sells food. Folk explanation involves interpretation, which means that the world is represented using symbolic expressions, that is, expressions with meaning (Newell & Simon, 1976). Without such explanations, individual and social life would be very difficult, as we would not be able to explain and make sense of the actions of others. Shared symbolic system makes it possible to interpret others and communicate these interpretations, as well as own beliefs and desires, to others. Folk explanation of human action involving desires and beliefs is, of course, not necessarily the correct scientific account of human thinking and behaviour, a fact which serves as the basis for the methodological debate about the relevance of intentionality as a scientific concept.

Human intentionality has been criticised as a pseudo-scientific folk assumption, which misleads the scientists of human mental life from constructing valid models of human behaviour and thinking (Churchland, 1986). It is, of course, evident, that there must a level of explanation, which does not invoke the concept mental representation. For example, findings concerning the recall of facts cannot be explained solely in terms of intentional mental states, and

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9 Here it is important to note that 'intentionality', as referring to the capacity of mind to represent things and have information contents, is not the same thing as 'intending to do something purposeful'. Of course, these two concepts are related in the Heideggerian (1927) sense: the in-order-to relationships we take towards the world of course define how we experience its objects.

suggest that there is a level of processing, which does not deal in terms of meaningful symbols, but in terms of non-symbolic associative processing (Anderson et al., 2004). This does not necessarily mean that the symbolic level of explanation is irrelevant, and there are indeed models of thought and behaviour which combine both sub-symbolic associative processing and symbolic rules (Anderson, 2000; Anderson et al., 2004). However, the most intense critics of intentionality maintain that as it is clearly not possible to explain *all* human thought and behaviour using intentional concepts, one should let go of them and focus on notions, which explain what intentional concepts do not (Churchland, 1986). More precisely, such explanations should be based on a *connectionist network*, which is a unified system of interconnected elements (Fodor & Pylyshyn, 1988).

Stated in the context of human-technology interaction, the question of intentionality is whether people's beliefs and desires can be investigated and used to explain technology users' thought and behaviour. For example, two articles by Dekker and co-authors argue that such important concepts of human technology interaction as *situation awareness* and *trust in automation* are folk concepts, and using them in explanations leads to circular reasoning (Dekker & Hollnagel, 2004; Dekker & Woods, 2002). The authors posit that researchers use their intuitive understanding of feeling of trust, for example, and hence leave the concept underspecified and immune to falsification (Dekker & Hollnagel, 2004). They further claim that the solution is to focus on the performance of the joint human-machine system and disregard the non-observable mental states of the users (Dekker & Hollnagel, 2004). This, of course, is an argument from a non-intentional methodological position, a claim that at least certain intentional mental states are not useful in the scientific discussions concerning human-technology interaction.

Conversely, defenders of the intentional position criticise the anti-intentional claims above, and point out that there is nothing wrong in using folk concepts and assuming human intentionality as long as one can measure these constructs reliably and demonstrate how they are connected to other observable phenomena, such as task performance (Parasuraman, Sheridan, & Wickens, 2008). What needs to be understood, of course, is that experiencing situational awareness, for example, does not equate to actually being aware of the situation (Parasuraman et al., 2008). However, this does not mean that it would be enough to only measure how aware the user is objectively (e.g., the responsiveness to new events), and disregard the subjective experience of awareness. One of the major questions concerning user experience is indeed the connection between the observable events of an interaction and a user's subjective experience (Hornbæk & Law, 2007). One of the main contributions that the foundational analytic project carried out here aims to make is the clarification of these kinds of disputes in human-technology interaction research. The aim is not, of course, to arrive at a final methodological truth concerning whether users should be assumed to have mental representations, but the understanding that any empirical study of human-technology interaction necessarily makes an assumption –

negative or positive, in a varying degree – about intentionality. Explicating such methodological assumptions helps scientists to discuss their conflicting positions.

3.3 Causality

The stance towards intentionality of human thought answers the ontological methodological question. The other, epistemological, question, concerns the role of *causality* in investigations and explanations of human behaviour and thought. When we try to explain observed phenomena, the concept of causality seems to be something that comes naturally to us. Generalisations of these everyday explanations serve as the foundation for causal laws. For example, observing a warm body under the sun leads the observer to hypothesise that the light of the sun warms the body (Kant, 1792). In essence, *cause* is in the heart of explanation: subjective statements concerning the reasons of experienced states of affairs are valid insofar as they are instances of explanatory principles governing the experienced. The causal hypothesis that the sun causes the body to become warm can be tested by moving the object to shade or trying different objects. In this manner, although we are not able to observe causes as such, but only the observable phenomena of the world, our intellectual faculty can try to determine the causes behind the observable phenomena (Kant, 1787).

The discussion about causes has always been part of western philosophical canon, but recently, more explicit formulations have started to emerge in general and in connection to human action and thinking (Pearl, 2000; Wolff, 2007; Woodward, 2003). As with intentionality, a detailed analysis of causality is not possible here. It is, however, important to be aware when the notion of causality is invoked in studies of human-technology interaction and user experience. There are many different philosophical accounts of what causality is, such as the four causes famously listed by Aristotle (*Met.*). Here, the treatment focuses on the so called manipulability theories of causation, which suggest that causal relations are exploitable for manipulation and control, a position which is proper for an experimental of quasi-experimental scientific field such as psychology (Cook & Campbell, 1979).

One of the earlier manipulability accounts of causality comes from von Wright (1971, p. 74), who states that "to think of a relation between events as causal is to think of it under the aspect of (possible) action" (see also Taylor, 1964). This means that if there is a cause and an effect, then an action that brings out the cause will also bring out the effect. Thus, if an action brings out the cause so that, other things being equal, if and only if the action is conducted, the observer can observe the effect, then the causal link between the cause and the effect can be established. The same can be stated as the following rule for a necessary and sufficient condition for direct causality (Woodward, 2003, p. 59). To posit causality between $\boldsymbol{X}$ and $\boldsymbol{Y}$ is to state, that there exists an intervention $\boldsymbol{I}$, which changes the value or the probability distribution of $\boldsymbol{X}$, so that if, and only if, ***I*** is executed, the value or the probability distribution of ***Y*** changes. Notable here is that the definition does not assume that X and Y can be directly measured and represented as exact values, but allows for the possibility of repeated measurements and the establishment of probability distributions. This definition of causality can thus be used as a methodological tool: in order to study phenomena, one needs to design an experiment with interventions, and repeatedly measure how changing the probability distribution of an independent variable causes a change in the probability distribution of the dependent variable. This is the classic experimental paradigm in cognitive psychology (Eysenck & Keane, 2005).

In human-technology interaction research, causality has an obvious importance. The term *interaction* assumes a connection between people and technological artefacts, and this connection is often either implicitly or explicitly assumed to be causal. Further, assuming that user psychological research can provide information for design, at least a commonsensical causal explanation is required: when a designer uses an ontological rule concerning how people interact with technology, one must assume that the design choices *cause* better usability or user experience. These reasons warrant further investigation of how causality is defined, and how it is operationalised into design of empirical studies as well as technology itself.

3.4 Four methodological positions of human-technology interaction

The two methodological choices, one ontological and relating to the intentionality of human being, and the other epistemological and relating to causality, can be used to present four methodological positions. The positions, displayed in Figure 3, are presented in general psychological framework, but below they are discussed in the context of human-technology interaction. As mentioned above, the positions should be considered as abstracts or ideals (T. Johnson et al., 1984): one should not expect to be able to fit studies of human-technology interaction precisely into one of the methodological positions. Rather, the framework can be utilised to analyse the underlying assumptions behind such studies. This means that one study can draw from multiple methodological positions, and does not need to conform perfectly to any of them. However, as will become clear in examples below, non-explicated methodological positions may lead to problematic assumptions, and a study occupying multiple positions without an explicit treatment of its underlying assumptions has a risk of having contradictory assumptions, which may lead to ambiguous argumentation and non-falsifiable assertions.

		Causal explanations: No	Causal explanations: Yes
Intentionality	No	behaviourism (*empiricism*)	neuroscience (*physicalism*)
	Yes	subjectivism (*phenomenology*)	cognitivism (*functionalism*)

FIGURE 3 Methodological framework.

3.4.1 Behaviourism

The first methodological position does not consider either intentionality or causality as useful tools for research on human mental life, and is called here *behaviourism*. In behaviouristic tradition, focus is placed on objectively measurable events (Skinner, 1969; Watson, 1913). Any references to such introspectionist terms as 'sensation' or 'consciousness' are meaningless, unless these concepts are defined in physicalistic terms and operationalised as objectively measurable simple instances (Bergmann & Spence, 1944). Therefore, the methodological position of behaviourism maintains that a scientist should not make references to mental states, but rather describe objectively observable events of the physical world (Watson, 1913). This associates behaviourism with the philosophical tradition of *empiricism*, advocated by such thinkers as John Locke and David Hume. The task of a behaviourist is to investigate the associations between observed events in the environment and the subsequent behaviour. A completely worked out psychological system can, given environmental stimuli, perfectly predict the response without utilising introspective methods, that is, without explaining behaviour with people's mental states (Watson, 1913). This refutation of the relevance of introspectionist concepts puts behaviourism into the 'no intentionality' row of the methodological framework outlined in Figure 3.

Behaviourism can also be – with certain caveats – situated into the 'no causality' column of the methodological scheme. Following the interventionist definition of causality above, behaviourism would allow for manipulations of stimuli to observe changes in responses, which would, on a quick glance, allow a behaviourist to assume causality and design experiments to test causal hypotheses. However, a closer investigation shows that the behaviourist formulation for causality is not in line with the manipulability theory of causation. According to Skinner (1969), for example, scientific laws are not obeyed by nature, but rather they govern how people deal effectively with nature, how they make predictions about the environment in which they work. This is an empiricist, Baconian, or Machian notion of causality, where 'cause' is taken to mean 'observed correlation' (Leigland, 2012; Marr, 1985).

Conversely, the definition of causality, presented above as the manipulability account of causality, does not refer to just correlations. Rather, there should exist an actual mechanism, which explains the observed correlation. This is because the controlled manipulation, which precedes the determination of a causal mechanism, aims at separating spurious correlations from actual causal relationships (Woodward, 2003). Thus, a researcher subscribing to the manipulability view assumes that correct experimental manipulations can determine the actual causal sequence, a kind of 'causal history', of phenomena. The idea of intervention is in manipulating the causal sequence to cause changes in the observed correlation, and in order to make meaningful manipulations, one must postulate a causal mechanism. In the context of psychology, an assumption of this kind of causality makes the purpose of science not to observe associations, but to understand *what it is that occurs in human thinking* that explains why certain stimuli are associated with certain behaviours. This kind of a methodological position necessitates mental concepts, which behaviourism does not accept as part of scientific conduct. In simple terms, behaviourists are interested in behaviour, not thinking.

As we have learned in the cognitive psychological experiments of the past century, thinking is indispensable for the kind of behaviour in which human action finds its home. Therefore, researchers very seldom explicitly associate themselves with behaviourism anymore. However, the behaviouristic methodology is still popular in human-technology interaction – if not in name, in practice. Although studies of human information processing, for example, are not metascientifically behaviourist in that they do acknowledge that the human mind processes information and we can research these processes, methodologically they can often be placed in the upper left corner of the methodological scheme. Fitt's law, which states that the time it takes to point a cursor to a target correlates with the size of the target and the distance of the target from the cursor, serves as an example of Baconian correlation, where the mechanism of the stated relationship is not explicated to allow an intervention. Thus, the necessary assumptions for causality are not met in Fitt's law, if it is stated as just an associative formula. This is not a problem per se, because such correlative laws can be extremely useful in design. However, if the concept of cause is utilised in a study which does not actually subscribe to a causal methodology, one may run into problems.

An example of an implicitly empiricist (or behaviouristic) methodology, utilising the concept of causality, is a study that evaluates the accuracy measures of pointing devices (MacKenzie, Kauppinen, & Silfverberg, 2001). The authors discuss their correlative results as causal, but their definition of causality – left implicit – is Baconian. Such differences between correlative and causal relationships might be difficult to note, but the authors clearly do not explicate a causal mechanism for the observed associations between pointing devices and user performance. This is not a problem for the results of the study, but although the authors discuss about causality, they do not actually offer a causal mechanism, which would inform interventions for further studies. This is the usefulness of a methodological position which accepts causality: studies do not only provide associative rules, but they also inform future investigations of the phenomena by suggesting mechanisms for the association. Targeting these mechanisms with clever experimentation has been an immensely powerful methodological procedure for uncovering the inner workings of human mental life (Eysenck & Keane, 2005)

An example of a study in which the authors *have* made clear the distinction between association and correlation concerns ageing effects on mouse-aiming abilities (Cheong, Shehab, & Ling, 2013). The authors state that while age does have a negative correlative relationship with psychomotor ability, age should not be understood as the actual *cause* of decreased psychomotor ability, but as a *surrogate* for the actual causes. Ageing is indeed correlated with decrease in motor performance, but it does not causally explain this phenomenon because it does not present an intervention (other than age, which is impossible to manipulate in a laboratory environment). What the age is a surrogate of, and what actually explain decrease in motor performance as we get older, are the changes in our cognitive capacities, such as visuomotor abilities and memory. Therefore, an assertion between age and pointing device efficiency is behaviouristic as long as it does not explicate the causal connection between the pointing device use and the observed performance efficiency.

The examples above highlight how the methodological scheme outlined here works. An empirical study is rarely 'radical' in a methodological sense, but rather navigates somewhere between the absolute positions. For example, there can be multiple levels of causal explanation for the same phenomenon (Woodward, 2003), and similarly the amount of mental processes needed to explain the observed associations and causal mechanisms may vary. Fitts' law gives an associative law between pointer movement and task difficulty, but does not provide an explanatory model for this association, and thus excludes counterfactual considerations. It does not, for example, explain why the elderly have difficulty in mouse-aiming. The explanation for this requires a causal model that connects pointer movement and task difficulty together using a model of human cognitive abilities. Aging changes human cognitive abilities, and this explains the change in mouse-pointing skills. It is possible to develop the model by explaining within a biological framework why aging causes change in relevant cognitive abilities. Further, these biological mechanisms could eventually be explained using laws of physics, which highlights how causal explanation can be offered in many levels. However, explaining human-technology interaction using only laws of physics would, of course, make no sense. Once again, the deciding factor is in the capacity of the given set of concepts, facts, and laws to provide solutions to problems (Laudan, 1977; Saariluoma, 2005; Saariluoma & Oulasvirta, 2010).

3.4.2 Cognitivism

The behaviourist denial of the legitimacy of thinking as a useful psychological concept faced accumulating problems in the 1940s and 1950s. For example, in what is perhaps the first 'boxes and arrows' depiction of human thinking, Broadbent (1958) analysed attention as non-conscious perception of a stimulus, as well as conscious semantic analysis, which occurs in the human cognitive system. According to the now outdated model, attention can be focused only on one object at a time, and shifts in attention cannot be explained only in terms of the external stimuli, but need to be explained in terms of what occurs in thinking. This line of argumentation culminated in the middle of 1960s in a paradigmatic shift called 'the cognitive revolution' (Cummins, 1988; Neisser, 1967). The philosophical foundations of *cognitivism* are in the computer-metaphor of human thought: a computer carries operations based on inputs it receives, and gives outputs based on these operations, and similarly, human thinking proceeds in cognitive processes, which involves perceptual stimuli as inputs and motor responses as outputs (Newell & Simon, 1972; Turing, 1936, 1950). During the process, new sensory information is analysed in a relation to the actor's goals and existing knowledge, and resulting motor outputs are thus not only a function of the stimuli, but also of thinking.

The 'mind as computer' metaphor associates cognitivism with the philosophical position of *functionalism*, which asserts that what makes something a mental state is not dependent on its internal constitution but on its functional role in the system in which it belongs (Jaworski, 2011). This means that regardless of the physical substrate of thinking – a brain or a computer – mental states are identified by their causal links to sensory inputs, other mental states, and motor outputs. In other words, well-designed computer software should be able to reproduce thinking. The early attempts utilised problem solving rules or production systems (Newell, Shaw, & Simon, 1958; Newell & Simon, 1972), and based on these formulations the work has lately shifted towards studies of *cognitive architectures* (Newell, 1990), which aim to implement cognitive psychological knowledge about human thinking on a computer software level called a *cognitive model*. In human-computer interaction cognitive modelling has proceeded from relatively simple collection of rules (Card, Moran, & Newell, 1983) to complex architectures, which can to a degree replicate human cognitive processing in environments relevant for human-technology interaction, for example in car driving (Salvucci, 2006).

Saariluoma (1997) argues that production systems subscribe, at least implicitly, to the behaviourist tradition by operationalising human thought using associations between patterns and actions. However, here the cognitive architectures, based on the idea of production systems, is presented as a cognitivistic metascientific choice. This illustrates that the methodological scheme presented here does not consist of exclusive dichotomies, but ways of thinking about problems. Therefore, the cognitivist stance can be positioned as the opposite of behaviourist in the methodological scheme, but this does not mean that the notion of association is abolished – it means that it is supplemented by the notion of causal mechanisms and mental representation, which the radical behaviourism eschews. As mental states are identified by their causal links to sensory inputs, a cognitivist assumes both intentionality in the form of mental states, and causality in the form of a causal mechanism, which links inputs, mental states, and outputs together.

Thus, a cognitive architecture can be behaviouristic on some level and cognitivistic on another. For example, research shows that when people have to navigate in an environment using maps, they take longer and make more mistakes if the map is not aligned with the environment (Gugerty & Brooks, 2004; Hintzman, O'Dell, & Arndt, 1981). A behaviourist could allow for this, as long as it is just an observed association between observable stimuli (the environment, the map, and their misalignment), and observable behaviour (longer navigation times and navigation errors). One could augment an existing cognitive architecture, such as ACT-R, by implementing a strictly associative rule into the architecture. In practice, one would program what is called an 'imaginary-action' function, which states that "if the task is mental orientation, and the discrepancy is x degrees, then wait for y seconds, where y is determined by x multiplied by a predefined parameter. This is an associative rule without causal assumptions. However, a cognitivist posits that this association is causal, and thus allows the study of the inner workings of this mechanism. In the ACT-R example, one assumes therefore that further investigation will rid the simple imaginary-action function and replace it with more extensive account of the mental processes that occur when people represent space.

The benefit of the methodological position of cognitivism on causality is that mental processes can be investigated causally, that is, it is possible to define an experimental intervention which can be used to study the details of this process. It has been shown, for example, that the misalignment between a map and the environment is linearly related to decision times, except if the decision concerns an object right behind the subject (Hintzman et al., 1981). This suggests that there are multiple mental strategies, which people use to orient themselves in an environment (Gugerty & Brooks, 2004; Hintzman et al., 1981). Clever experimental manipulation (which assume causality) can reveal more about these strategies, but also because people able to discuss about their mental states (assuming intentionality), it is possible to study these strategies by asking people to think aloud when navigating in environments (Gugerty, de Boom, Jenkins, & Morley, 2000). These findings can then be used to augment the cognitive architecture, which simulates how people represent and process space. In this way, the cognitivist methodology is capable of producing explanations, which have immense benefit to technology design. Knowledge on how people orient themselves using maps can be, for example, used to design mobile maps, which help the user to apply the mental transformation required to correct the discrepancy between the map and the environment (Jokinen & Saariluoma, 2015).

Another good example of the transition from the behaviouristic to the cognitivistic point of view is a study of keyboard layouts by Norman and Fisher (1982). The authors investigated if alphabetising a computer keyboard would make its adoption faster than the seemingly random 'Qwerty'-keyboard. The study compared the typing speed of alphabetised and completely randomised keyboards. The experimental setup did not methodologically assume intentionality or causality, and can thus be considered fully in behaviouristic terms. However, the authors then proceeded to explain their findings – that the alphabetised keyboard does not offer notable improvement – using the cognitive concept of *mental load*. Finding a key in the alphabetised keyboard requires a memory search concerning the position of the letter in the alphabet, and then visual search of this position from the keyboard, and hence the alphabetised keyboard is not faster than a randomised. Therefore, while methodologically the study by can be considered behaviouristic, while discussing the findings the authors assume that there are such things as mental representations, and posit a causal explanation of keyboard use in the cognitivistic framework (Norman & Fisher, 1982). This explanation could be used to design an experiment, which in the cognitivistic framework studies the cognitive process of using different kinds of keyboard layouts with various interventions.

3.4.3 Neuroscience

Supported by advancements in neuroimaging in the 20^{th} century, the study of how human nervous system works was established as its own field, *neuroscience*. Neuroscience involves various disciplines on its own, such as behavioural neuroscience or cognitive neuroscience, and thus the methodological map of neuroscience is not uniform (Bear, Connors, & Paradiso, 2007). However, following the idea of ideal types, here neuroscientific methodological position is defined from the philosophical perspective of *physicalism*. In its most radical, conception, called *eliminativist materialism*, physicalism maintains that folk psychological terms give a misleading description of human mind, and hence they should be replaced with a physicalistic account of human mind as revealed by neuroscientific observations (Churchland, 1986). Intentionality is 'eliminated', reduced into physical patterns observable in the nervous system.

Neuroscience takes the physicalist 'no intentionality' stance towards the science of human mind, but allows for causal explanations. Therefore, studies of brain lesions to the occipital cortex, for example, can be used to infer how human brain processes visual information in a scheme which implies causal mechanisms between the brain structure and observable human behaviour (Eysenck & Keane, 2005). In this sense, neuroscience and behaviourism share commonalities, but are also different methodological positions. For the behaviourist Skinner (1953), for example, although neurobiological conditions sustain the interaction between the animal and the environment and, therefore, information about the 'inside mechanism' of an animal may be clarifying, behaviour is the function of external variables, not the inner workings of the brain.

Defending radical physicalist position is philosophically difficult (the same can, of course, be said about all 'far corners' of the methodological framework), and is indeed rarely encountered in human-technology interaction research. However, cross-methodological positions can be found, such as *neuroergonomics*, which adopts the neuroscientific methodological position to the context of human-technology interaction, but accepts also cognitivistic concepts and explanations. Neuroergonomists study technology use by investigating the neural basis of mental functions, that is, they 'study the brain at work' (A. Johnson & Proctor, 2013; Parasuraman, 2007). Thus, the ideal type definition following the strictly physicalistic interpretation of human mind does not describe neuroergonomics well. Rather, neuroergonomics can be understood better in terms of *cognitive neuroscience*, which adopts a cross-methodological position and studies the human brain utilising the concepts of cognitive psychology (M. Bennett & Hacker, 2003). The idea behind the project of cognitive neuroscience is that while neuroscience provides a good methodological ground for conducting empirical research, its results are conceptually empty without the support of such concepts of cognitive psychology as 'memory' or 'attention'. These concepts cannot be observed directly with neuroscientific methodology: doing so would be what is called a *mereological fallacy* (M. Bennett & Hacker, 2003). However, a cognitive neuroscientist can posit correlations between cognitive processes and neuronal changes. These are tested experimentally by utilising both cognitivist and neuroscientific methodologies, which exemplifies how methodological positions can at best complement, not exclude, each other.

The neuroscientific methodology has been applied in neuroergonomics for example in the study of mental workload. EEG measurements or pupil size readings, for example, can be used to make inferences about the degree of resources that a user has invested to a task (Beatty, 1982; Kahneman, 1973; Parasuraman, 2007). Using these methods allows the researcher to make inferences about the connection between interface design and mental workload, which should provide useful information for the design of interfaces that minimise mental workload. An interesting example is a study, in which the authors investigated whether a break during a long drive helps the driver to recover from cognitive fatigue, measured as saccade peak velocities (Di Stasi et al., 2012). Although a break during a long drive may be a refreshing experience, the study revealed that it did not actually benefit the driver in terms of fatigue. This contrasts the neuroscientific measurement of fatigue with the subjective experience of fatigue, and showcases how different methodologies can produce different and even contradictory results. In order to investigate this issue further, the fourth position, highlighting the importance of subjective experience in human-technology interaction, is examined.

3.4.4 Subjectivism

Heidegger's (1927) phenomenological programme, introduced in the second chapter above, starts from the fundamental claim that before it is possible to investigate things that exist, one should focus on the question of existence: what does it mean for something to exist? Heidegger gives his answer in the form of what he calls the *existential ontology*, which is the analysis of how our experience of the world influences other ontologies that are constructed to classify and make sense of the objects and the phenomena of the world. All other ontologies, scientific and otherwise, thus depend on how we fundamentally experience the world, and hence scientific analysis becomes contorted if it does not start with clarifying the meaning of existence. This necessitates *phenomenology*, which is the study of the structures of experience (Heidegger, 1927; Husserl, 1913). Phenomenology can thus be used to clarify the contrast between experience and experiment, which for example helps in discussing the contradictory findings about fatigue and breaks in long driving (Di Stasi et al., 2012). An experimental result cannot be falsified or validated by experience, but it is in our experience in which we decide whether the results are meaningful and can be considered relevant. An experiment cannot show that experience is meaningless, but it can provide empirical results, which shape how we experience the world.

The methodological position, which follows the phenomenological line of thought, is here called *subjectivism* to emphasise the need to focus on the experience of the subject, instead of focusing on the objective results obtained in experiments. Subjectivism obviously assumes that people are intentional creatures, that is, that they have mental representations and that these representations have information contents. In these terms, experience can be defined as the conscious part of mental representation (Saariluoma, 2003). Further, because subjective experience seems to be ineffable, intrinsic, private, and directly accessible by consciousness (Dennett, 1988), causal attributions are problematic, at least in the manipulative sense in which causality is defined above. Although it is clearly possible to externally affect what people think, it seems implausible that one could to do this so that only a particular mental aspect, and no others, are manipulated (and thus the 'all other things being equal' part of the intervention is not fulfilled). Further, because it is not possible to completely observe what occurs as the result of this manipulation, it seems that subjectivism eschews methodological causality. In subjectivist methodology, it is still possible to investigate and explain human behaviour and thought by referring to people's mental contents, but these explanations are not causal.

An extreme subjectivist position can be called *constructivism*, which focuses on the fact that experiences are not passive recordings of the environment, but involve active interpretation, which constructs these experiences (Jaworski, 2011). In the most radical sense, constructivism adheres to an epistemology of *relativistic holism*, which states that because cognition saturates perception, all that can be known is comprehensively determined by one's existing epistemological framework (Fodor, 1985b). This means that a person's social class or culture, for example, determines how the person experiences the world. The problem with a radical constructivist methodological position is that it does not account for the fixed structure of human mind: while the mind is malleable, there exists at least some rigidity in the human thought (Fodor, 1985b). The content of mental representation is saturated by one's culture, but the process in which mental representations are formed, can be studied using cognitive psychology, which aims to generalise knowledge on mental processes. For example, cognitive psychological research into learning has created a bulk of knowledge concerning the causal mental processes associated with acquiring new knowledge, recalling what has been acquired, and adapting existing strategies for novel problems (Anderson, Reder, & Simon, 1998; Anderson, 2007). Thus, it is important to investigate both the rigid, causally definable structure of human cognition, as well as its culturally saturated content.

Saariluoma (1997, p. 114) provides an example of the difference between content-based explanation and causal explanation using a sentence ‘If Christmas is coming and I have money, I go and buy presents for the children’. The cognitive mechanism leading to the firing of certain productions and eventually to the representation of this thought provides a causal explanation of the thought. However, ‘the Christmas’ refers to something which has not yet occurred, so the reason for the selection of certain productions is a future occurrence. This latter, content-based explanation, has a different logic from the former, production-based explanation: the firing of the production is causal, but the content-specific pattern is not. Of course, the thought that ‘Christmas is coming’ does exist before the thought that ‘I go to buy presents’ and is the cause of the latter, but this relationship is not causal on the level of the content of those representations.

The discussion of mental causation and mental content can be further explored with an *epiphenomenalist* position, which asserts that while mental properties do exist, they are caused by physical properties (Jaworski, 2011). Private mental states do not have explanatory power, because they do not have a causal connection ‘back’ to the physical properties of the mind: they are *epiphenomena*, by-products, of the physical mind. An epiphenomenalist methodological position, assuming intentionality and causality, and taking an extreme stance towards the latter, operationalises intentionality in terms of causal mental processes. Content-based explanation, involving at least some flavour of phenomenology and aiming to explain people’s behaviour with content, is in this sense methodologically incompatible with epiphenomenalism, which maintains that phenomenological concepts such as experience do not have explanatory power unless they are subsumed into the causal cognitive process (Jaworski, 2011).[10]

It is clear that subjectivism is an influential methodological position in user experience research. From the start, research of user experience has emphasised the importance of the subjective experience (Hassenzahl, 2001), although it seems that experienced user experience researchers avoid overly subjectivist conceptualisations (Law, Roto, Vermeeren, Kort, & Hassenzahl, 2008). The degree to which user experience research should abide to subjectivist, cognitivist, and neuroergonomic positions is an interesting question, but this discussion is hindered by the fact that the methodological foundations of user experience research are rarely laid out clearly (Kuutti, 2010). Thus, as stated above, the goal of the methodological investigation here is to provide tools for the explicit evaluation of the methodological foundations of the model of emotional user experience, which is the topic of this dissertation.

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10 An interesting position in this vein is what Dennett (1991, p. 85) calls *heterophenomenology*: “[I]f we were to find real goings-on in people’s brain that had enough of the ‘defining’ properties of the items that populate their heterophenomenological worlds, we could reasonably propose that we had discovered what they were really talking about …”.

It is important to emphasise once more that the methodological framework presented here does not necessarily indicate that different methodological positions are in conflict. Following Laudan's (1977) notion of problem solving epistemology, it is helpful to think that different methodologies are suitable for solving different research problems, and thus the relevance of a methodology is related to the problems that one needs to answer. Often a problem presents itself in such a way that two or more methodological positions can be utilised concurrently, but in this case extra care must be placed on not confusing concepts with methodological interpretations. The model of emotional user experience proposed below as the result of this dissertation draws from different methodologies, and the explication of this is the main reason for the methodological exposition carried out here. However, before exploring the model for emotional user experience, the methodological framework can be used to explore different definitions of user experience. As the goal of this dissertation is not a systematic methodological analysis of user experience but the development of a new model for it, what follows is only a brief analysis.

3.5 A brief foundational analysis of user experience

First usages of the term 'user experience' can be found in the early 1990s (Norman, 2013, p. 10), but the proliferation of user experience research did not start until the turn of the decade (Hassenzahl & Tractinsky, 2006; Kuniavsky, 2003). In order to make sense of user experience, and in order to apply the concept consistently and efficiently in human-technology interaction research, its theoretical assumptions should be analysed using the methodological framework proposed above. While user experience is a widely discussed and research topic today, criticism concerning its theoretical foundations have been expressed (Kuutti, 2010). There are user experience scholars with sober foundational basis in their analysis, but it seems that the majority of user experience research is still without proper foundational basis. One of the problems may be that the concept of user experience integrates (or at least brings together) people from a number of very different fields, such as marketing, psychology, arts, and engineering.

The loose theoretical and methodological foundations of user experience result in, for example, difficulties in creating standard operationalisations of what user experience actually is (Bargas-Avila & Hornbæk, 2011). The ISO-standardised definition for user experience is "a person's perceptions and responses that result from the use or anticipated use of a product, system or service" (ISO 9241-210). Another relatively standard definition is given in the *User experience white paper*, a collaboration of various UX researchers and designers:

> The noun 'user experience' refers to an encounter with a system that has a beginning and an end. It refers to an overall designation of how people have experienced (verb) a period of encountering a system. This view emphasizes the outcome and memories of an experience rather than its dynamic nature. It does not specifically emphasize its

> individual nature because 'a user experience' can refer to either an individual or a group of people encountering a system together. (Roto, Law, Vermeeren, & Hoonhout, 2011)

These definitions serve as useful generics, with which most scholars and practitioners can probably agree. However, the theoretical assumptions behind these definitions are not clearly defined, which means that while agreeing upon the definitions, researchers and practitioners may well have disagreeing notions about the foundations. The ISO definition uses the terms 'perception', 'response', and 'anticipation', and states that experience results from these factors. Perception and response can be used in various methodological positions, but the way 'anticipation' is used in the definition seems to implicate the methodological assumption of intentionality. The ISO definition allows user experience to occur without any actual interaction, as it states that user experience can result from the use *or* anticipated use. This probably means, that the mental representation about the interaction is already enough to result in user experience, an assumption that positions the ISO definition of user experience into the lower row ('yes intentionality') of the methodological scheme. *User experience white paper* seems to make similar assumption when emphasising remembering an experience.

Generally it seems that research of user experience assumes that people have mental states, and that experience is the conscious part of these mental states. Further, there seems to be an implicit – and sometimes explicit – lean towards the phenomenological account of user experience, which is not surprising considering the centrality of the concept of subjective experience in the phenomenological thought. The emphasis on the subjective experience is often stated as the main difference between usability, with which user experience is often contrasted. Early texts about user experience focused on 'going beyond' task-related issues of human-technology interaction by emphasising that experience is fundamental in human life, and thus human-technology interaction cannot be fully understood in terms of usability engineering (e.g., Alben, 1996; Hassenzahl, Beu, & Burmester, 2001). Put in different terms, the *pragmatic* aspect of human-technology interaction was contrasted with a *hedonic* aspect: user experience goes beyond the instrumental, and is about emotion and experience of human-technology interaction (Hassenzahl & Tractinsky, 2006).[11] While these arguments are acceptable, they are problematic insofar as the definition of experience, and the methodological assumptions, are often left out from the description of user experience (Kuutti, 2010). For example, when Hassenzahl (2004) notes that the top-down and bottom-up processes, which produce aesthetic experiences when people interact with technology, are often left non-explicated in experimental studies of user experience, he does not tell us how this explication should be done.

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11 This does not, of course, mean that there is no correlation between usability and user experience. The grounding study on this correlation provided evidence for the notion that 'what is beautiful is usable' (Tractinsky, Katz, & Ikar, 2000). However, more recent work has started to indicate that the association between beauty and usability is more complex than previously believed (Hassenzahl & Monk, 2010).

Indeed, discussions of user experience often point out that it should not be defined as something measurable. This view is often associated with the concept of *holism*, which means that the organisation of the whole must guide the analysis of the parts. In the context of user experience, holism emphasises the situational, temporal, and emotional aspects of human-technology interaction, and that these aspects cannot be reduced to component parts and operationalised into measures without losing something essential from the phenomenon (Hassenzahl & Tractinsky, 2006; P. Wright, Wallace, & McCarthy, 2008). In the most radical phenomenological form, this argument juxtaposes laboratory experiments and subjective experience, and states that such aspects of experience as emotion are socially constructed, and thus need to be investigated in their full complexity without reduction into experimentally testable models (e.g., Boehner, DePaula, Dourish, & Sengers, 2007).

The notion of experience as irreducible, holistic, can be investigated with the help of Baumgarten (1750), who made a distinction between an *intensive* and an *extensive clarification*. The former refers to detailed attention to individual parts of cognition; logic represents this kind of analysis. However, according to Baumgarten, logical knowledge is not always possible, and sometimes extensive clarification is required. This means bringing new and various parts of cognition together. For Baumgarten, *aesthetics* is the science for extensive analysis of cognition. Critics of reductive operationalisation of user experience can be understood with the distinction between intensive and extensive clarification of cognition. Those who argue that operationalisation of user experience is fundamentally impossible, support the extensive clarification of experience. Of course, already Baumgarten (1750, §7–9) noted, that while we must start from unorganised understanding, the direction must be towards more clarity, by making distinctive concepts, progressing with the help of the existing, clear rules. This does not, of course, necessitate a tyranny of logical analysis on aesthetic faculties – merely that the use of logical analysis will be a helpful guide in making sense of the aesthetical aspect of human experience.

The extreme subjectivist attitude is problematic for the study of experience, as it methodologically does not allow for causal explanations or testable hypotheses. Thus, a proponent of such a position is unable to make generalisations, at least from one design case to another, because in this position one has no metascientific way to generalise from the subjective experience of a particular user of a particular technological artefact to other users and artefacts (P. Wright et al., 2008). Ultimately, this hinders greatly the building of a consistent user experience ontology, which would guide the design of technologies with good user experience. For this reason, at least more experienced user experience researchers seem to be wary of the extreme subjectivist position (Law et al., 2014), and many user experience researchers advocate the use of psychological ontologies for user experience research. The work of Marc Hassenzahl is among the most notable, but even though he argues for the use of psychological constructs and theories for the basis of user experience research and design (e.g., Harbich & Hassenzahl, 2011; Hassenzahl, 2004), his work lacks the explicit methodological basis for comparing different theoretical frameworks, which can be used to answer his call.

For this reason the first of the three questions stated at the beginning of this thesis concerned the conceptual foundations of human-technology interaction research. Hopefully, the investigation of different methodological choices that a user psychologist can make has convinced the reader of the necessity of such a methodological framework. Now that the foundations of human-technology interaction have been laid out, it is possible to examine the second question of this thesis: What is emotion and how can it be studied in the context of human-technology interaction. Certainly, this question will be investigated in the methodological framework presented here. The hope of this investigation is not only clarification, but also extension of the scientific study of emotion in human-technology interaction.

4 MODEL OF EMOTIONAL USER EXPERIENCE

4.1 Theories of emotion

What is emotion? The question has inspired philosophical theorisation since the ancient times, but the scientific treatment of emotion had to wait until much later. Of the three mental faculties by Kant (1792), the one relating to human cognition received most treatment in the 20th century psychology, while studies relating to emotion and the will were left to less detailed and thorough analysis (Baddeley, 2007). This does not, however, mean that the research on emotion was stagnant during the 20th century. On the contrary, this is when the foundations for all of current major psychological theories of emotion were laid (Arnold, 1960; Ekman & Friesen, 1971; Russell, 1980). However, the prime of emotion research with detailed models and rich empirical data had to wait until decades later (Izard, 2007; Russell, 2009; Scherer, 2009).

Emotion research is currently flourishing, but there are still foundational disagreements on the topic. The main one concerns the connection between conscious experience of emotion and the natural, bodily basis of emotion (Barrett, 2006b; Izard, 2007; Scherer, 2005). In other words, the disagreement is related to the old problem of mind-body dualism, that is, the degree to which we can associate phenomena with the body and with the mind. While the question is very philosophical, its implications to the study of emotion are critical and relate to such ontological and epistemological questions as “Are there universal emotions?” and “What does a self-report tell about emotions?”. Here, these questions are treated with three major theories of emotion: basic emotions, core affect, and appraisal theory. While all have their merits and benefits for understanding emotional user experience, and each can increase the problem-solving capability of a designer who designs for emotions, it will be argued below that appraisal theory is the most suitable as a framework of emotional user experience.

4.1.1 Basic emotions

In his considerations of the genetic determination of behaviour, Darwin (1872) posited that due to the evolutionary process, certain human facial expressions of emotion are universal. However, the study of this hypothesis was not easy due to the difficulties in distinguishing between universal and cultural expressions of emotion. In order to solve this problem, Paul Ekman and Wallace Friesen (1971) conducted a study with two Oceanic Neolithic cultures, both which had been extremely isolated from any western influence. The participants of the study were told simple stories concerning different emotional states, and were asked to point from three pictures of facial expressions the one, which they associated with the emotional story. The emotions described in the stories were happiness, anger, sadness, disgust, surprise, and fear, and the participants were able to point to the intended facial expression better than chance, giving support to the Darwin's hypothesis that expression of emotion is universal.

Theories that posit psychobiological universality of emotion patterning are called *discrete emotion theories* or *basic emotion theories* (Ekman, 1992a, 1992b; Izard, 2007). Their main argument is that there exists a set of discrete emotions: each discrete emotion has a distinct pattern of bodily change, evident as a universal signal, a physiological response, and antecedent events (Ekman, 1992a). By emphasising the word 'basic', the proponents of these theories refer to two claims: firstly, that there is a fixed number of 'basic emotions', which differ from each other, and secondly, that these emotions are 'basic' because each of them has adaptive value for human life (Ekman, 1999). What actually counts as basic emotions varies between researchers, as is evident in Table 1, but the consensus within basic emotion theorists is that the number of these emotions is relatively limited. Some commonly listed basic emotions are, for example, happiness, surprise, sadness, fear, disgust, and anger (Ekman, 1999; Ekman et al., 1987). There are two experimental strategies to study the connection of the ex-

TABLE 1 Lists of basic emotions.

Ekman & Friesen, 1971	Ekman, 1993	Izard, 1977	Izard, 2007
	interest[a]	interest	interest
happiness[b]	enjoyment[b]	joy[b]	joy/happiness[b]
anger	anger	anger	anger
sadness	sadness		sadness
disgust	disgust	disgust	disgust
fear	fear	fear	fear
	contempt[a]	contempt	
	surprise[a]	surprise	
		guilt	
		distress	
		shame	

[a]Ekman (1993) lists these as tentative additions, as their evidence is less certain.
[b]Happiness, enjoyment, and joy are listed interchangeably.

perience of basic emotions and their physiological patterning. In the first, the participants are presented facial or vocal expressions of emotions and asked to name the emotion they are observing; in the second, emotional states are elicited in the participants and their facial expressions observed.

Theories of basic emotion are appealing, as they give a scientific legitimisation to many common-sense emotions. We all know what anger feels like, and the knowledge that anger is a universal emotion, accompanied by the familiar observable physiological patterns (lowered brow, tightened lid, lips pressed together) sounds agreeable – after all, we are accustomed to interpreting the feelings of others from their facial expressions. However, basic emotion theories have been criticised on foundational, method-related, and meta-analytic grounds. On the method-related side, the main criticism is focused on the habit of maximising the effect of expression detection (Barrett, 2006a). For example, presenting the participants facial expressions as acted-out poses, which tend to overemphasise the assumed physiological emotion pattern, carries the problem of ecological fallacy, namely, that the poses do not in fact correspond to the real physiological responses to the chosen emotions but reflect the cultural interpretation of the emotion (Elfenbein & Ambady, 2002). Further, giving the participant a preselected set of emotion words from which to choose the one associated with given facial expression may mean that the chosen emotion words do not necessarily correlate strongly with the facial expressions (Russell, 1994).

The meta-analytic criticism is focused on the general trend of relatively small and inconsistent correlations between emotion words and expression recognition or production. Although cross-cultural emotional expression recognition happens clearly at better-than chance levels, there is a large variance at the recognition levels: recognition accuracy increases if the posers of the expressions are from the same culture as the participants (Elfenbein & Ambady, 2002). Further criticism has been targeted at the natural-kind assumption of basic emotion, that is, different emotions are distinguished from each other on their natural properties (Barrett, 2006a; Griffiths, 1997). Assuming that emotions are natural-kinds the difference between fear and anger, for example, should be demonstrated via a reference to distinct facial expressions and changes in the autonomous nervous system as well as voluntary expression. However, meta-analyses have found little coherence in studies of correlations between emotions and physiological responses, such as facial muscles (EMG) or localised brain activation (fMRI) (Barrett, 2006a; Cacioppo, Berntson, Larsen, Poehlmann, & Ito, 2000). Therefore, while it is evident that there is a connection between physiological patterns and emotions, there is not reliable enough empirical evidence to support the assumption that there is a set of basic emotions, which are universal, and clearly distinguished from each other based on their physiological patterning (Barrett, 2006a; cf. Izard, 2007).

Despite the criticism on theories of basic emotions, one can still consider them in the context of emotional user experience. Firstly, although the meta-analyses reviewed here demonstrate inconsistencies between studies of physiological correlates of emotions, there is a strong body of evidence supporting the assumption that emotion is grounded on localised neural activity (Damasio et al., 2000). Therefore, it is possible that more detailed analyses will show more consistent associations between distinct emotions and their neural correlates (Izard, 2007). It may be that the current methods for studying the physiological localisation of emotion are not detailed enough for coherent results. Perhaps even more importantly, although the lists of basic emotions vary, and the assumption of the universality of those emotions is somewhat questionable, it seems that participants from various cultures are able to make sense of certain basic emotion words fairly consistently (Elfenbein & Ambady, 2002). This has an important method-related implication: regardless of the validity of the natural-kinds assumption, one can expect fairly consistent interpretations of basic emotion words. In other words, what studies of basic emotions have shown to be universal, is the ability to name emotions, and reliably associate these names with emotional episodes. This involves, of course, a folk psychological assumption that how people mentally represent and classify emotions can serve as a useful scientific tool (Scarantino, 2012).

Therefore, self-reports of emotion, which are important in emotional user experience research, can benefit from basic emotion theories. For example, the competence-frustration model of emotional user experience by Saariluoma and Jokinen (2014), described in detail below, assumes that basic emotion words are useful because they make sense to people. Regardless of whether basic emotions are natural in that they have consistent physiological patterns, self-reports of emotion using basic emotion words feels natural and meaningful to users because they are informative descriptions of the subjectively experienced emotional states (Saariluoma & Jokinen, 2014). However, theory of basic emotions is not by itself enough for the basis for the model of emotional user experience, as it does not explicate in detail the process in which emotional mental representations arise. The explication of this process is necessary in order to understand emotional user experience.

In the methodological framework described in the second chapter, theories of basic emotion can be situated to the neuroscientific position, because they maintain that emotion has a physiological patterning. Although studies of basic emotion require people interpreting facial expressions, this does not necessarily move basic emotion theories towards the subjectivist methodological position. The subjectivist position is relevant for theories of basic emotion only in the sense that asking participants across different cultures provides evidence that in fact the subjective experience is not very relevant, because regardless cultural background, people have the same expression patterns, detection rules, and prototypical antecedent narratives for emotions. Thus, the subjective experience is not causally connected back to the physiological patterning, but lies above the actual causal emotion process as an epiphenomenon.

Theories of basic emotions assume that emotion words are scientific, because they do not stem from the folk interpretation of emotion, but from the universal physiological patterns of emotion. However, as reviewed above, this position is not necessarily justified. If the natural-kind assumption is not true, or even if it is only partially true, emotion researchers are faced with the question concerning the relationship between the physiological or basis of the emotion process and the conscious experience of emotion. The common distinction made here is between emotion and feeling: whereas *emotion* refers to the whole process or event, *feeling* or *affect* refers to its consciously represented part. However, while the distinction between the total process of emotion and the conscious experience of emotion is acknowledged between different theories of emotion (e.g., Damasio et al., 2000; Russell & Barrett, 1999; Scherer, 2009), the details of the relationship between emotion and feeling differ between theories. Below, the two remaining theories of emotion chosen to be examined here are presented and analysed especially within the methodological framework of causality and intentionality, that is, how the physiological process and the mental process are related to each other. In other words, the theories are analysed on their ability to show how mental representations have emotional contents, how these can be studied, and how human action can be explained with emotional mental contents.

4.1.2 Core affect

Studies investigating the structure of consciously represented emotions with statistical techniques were popular in the 1950s. A classic example is Osgood's (1952) proposition of analysing meaning structures with factor analysis (see also Osgood et al., 1975). In another classic text, Nowlis and Nowlis (1956) observed behavioural and mood changes of drug use, and reported plans for using factor analysis of emotional questionnaire items as soon as a computer capable of these calculations was obtained[12]. Based on the idea of finding latent structures from questionnaires about emotions, Russell (1980, experiment 2) asked participants to sort given emotion words into groups by their similarity. Analysing the latent structures, which would explain the variation in the results of the grouping, Russell was able to show how the participants represented emotions among a two dimensions, *valence* (pleasantness) and *arousal* (activation). The resulting *circumplex model of affect*, depicted in Figure 4 (adapted from Yik, Russell, & Steiger, 2011), illustrates how these two dimensions can be used to relate emotions with each other. Sadness and pleasure, for example, differ from each other on their valence, whereas the difference between sleepiness and excitement is more accounted by arousal.

Based on the circumplex model, Russell and Barrett (1999) investigated the relationship between the physiological emotion process and the affective experience. They proposed a fundamental element of emotion called *core affect*, which is defined as the simplest possible part of the emotion process still accessible to consciousness (Russell & Barrett, 1999). Core affect is a blend of hedonic and arousal component values, and can be identified as a single point in the circumplex valence-arousal model (Russell, 2003). It is important to notice that

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12 Obviously, such factor analyses pose no challenge for today's computers, but in the 1950s, computers capable of this feat were rare and expensive.

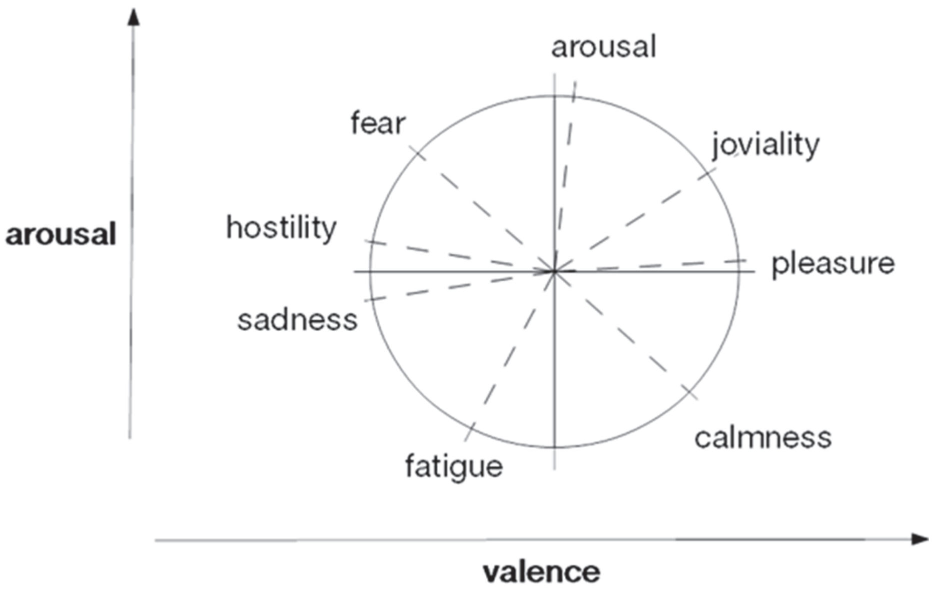

FIGURE 4 Circumplex of core affect.

the elementary or primitive nature of core affect means, that it is *just* a point on the circumplex – it is not one of the emotion words which can be located on the circumplex. Therefore, being in love, for example, can be located on the pleasant side ("feeling good") of the horizontal axis of the circumplex, but love is not a core affect itself. Part of being in love is feeling good, and this is the core affect, but love entails other components than this (evident for example in the fact that love is usually being directed at someone). Therefore, core affect is not intentional, that is, it is not a mental representation in itself (but it can be accessed by consciousness). This, in turn, raises the critical question: what is the relationship between core affect and the emotional content of mental representation?

Everyone has a core affect all times, but it is not necessarily consciously attended at all times. Instead, core affect becomes conscious if it is either intense, that is, it is located on the extremes of the circumplex, or if there is a sudden change in core affect (Russell, 2003). A change in core affect comes about by complex causal mechanism, and while this mechanism is not elaborated in core affect theory, it is assumed to occur non-consciously (Russell, 2003, 2009). Therefore, core affect itself is natural kind, that is, the valence-arousal circumplex is assumed to be universal and perfectly realisable as distinct physiological patterning. The ability of a stimulus to cause changes in core affect is called its affective quality, and the conscious representation of this is called *perceived affective quality*. Something dangerous, such as an encounter with a wild bear in a forest, would have the affective quality of causing negative and arousing core affect, and this would be perceived as the feeling of being afraid. In this scenario the conscious representation of fear would be linked to the encounter with the bear, and this gives the content of the representation.

Methodologically, core affect theory can be described as a kind of opposite of basic emotion theory. Basic emotion theory states that basic emotions are natural, and the conscious experience related to them is epiphenomenal. Conversely, although core affect itself is natural, the conscious experience of emotion is dependent on how the subject interprets core affect. In other words, emotions emerge from the subjective conceptual analysis of core affect: conceptual knowledge is used to categorise the momentary state of core affect (Barrett, 2006a). Basic emotion words are, while not natural kinds, *efficient* concepts for communicating different states of core affect (Barrett, 2006a). This position has attracted criticism concerning the apparent constructivism of the core affect theory (Scherer, 2009; Zachar, 2006). The problem is that the act of conceptualising the core affect into feelings is not explicated theoretically. In other words, core affect theory stipulates that emotions are constructed in an emotionally arousing situation, but the details of the actual process are left vague and amorphous (Ellsworth, 2013).

Regardless of the metascientific and methodological status of core affect, the circumplex structure of valence and arousal has been observed robustly in various studies. This is true also in studies of emotion in human-technology interaction. Saariluoma and Jokinen (2014), for example, observed a consistent circumplex model across three studies of emotional user experience, with an especially strong valence dimension and less clear arousal dimension[13]. Robustness does not mean that the current circumplex interpretation is the final word on the classification of emotion (Zachar, 2006), but it does provide a useful tool at understanding how, for example, users experience interaction events emotionally. However, although the valence-arousal circumplex offers an intuitive an seemingly clear and easy-to-use tool for the study human-technology interaction (e.g., Bradley & Lang, 1994), its users need to carefully consider the methodological assumptions of core affect. For example, when Zhang (2013) proposes core affect as the explanatory framework for affective responses in the information technology context, she omits the methodological considerations related to such a proposal. She then proceeds to discuss how the appraisal theory (introduced below) can be used as part of the proposed framework, but does not account for the fundamental metascientific and methodological differences between core affect and appraisal theory (Barrett, 2006a; Scherer, 2009).

One of the most important outcomes of the debate over the natural-kindness of human emotions is that the arguments from both sides are useful in assessing the use of self-reporting as the main source of data in studying emotional user experience. Regardless of the theory of emotion we choose to utilise, the current state of emotion research is that self-reports are the primary source of information. While psychophysiological measures of emotion exist, and

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13 Russell (1991) notes that valence is stronger dimension than arousal, and therefore while one should expect to always observe the activation of the valence dimension, it is more difficult to elicit a clear arousal dimension.

while each emotion theory posits at least some kind of natural substrate of emotional experience, currently the most plausible way of gaining insight about the emotional states of people is by asking them to report how they feel. Even if a study on emotion operates methodologically from the naturalistic position, for example by measuring heartbeat or brain activation, the interpretation of the results still occurs frim a phenomenological position. In other words, the phenomenological theory of emotion informs the interpretation of the physicalist measurements concerning emotion (Kihlstrom, 2010).

4.1.3 Appraisal process of emotion

The methodological analysis of basic emotion theory and core affect theory illustrates how these two accounts of emotion differ fundamentally from each other. However, what should be apparent now, is that while they both refer to the physiological *and* the experiential side of emotion, neither seems to relate to the cognitivist corner of the methodological framework. In other words, they do not propose a causal mental model for the emotion process. The foundational differences between these two theories are clear, but perhaps a third position, utilising the corner between the physicalist and the phenomenological methodological positions could mediate between them. This idea leads to a question concerning the role that cognition plays in emotion.

The origin of many major ideas of western thought are credited to Aristotle, and this is true also for the cognitive theory of emotion (Power & Dalgleish, 1997). Thus, before introducing the actual, modern appraisal theory of emotion, the following is a derivation of appraisal theory from the principles laid out by Aristotle. While Aristotle did not treat emotion as a separate topic, there are references to emotions throughout his work. Perhaps the best, albeit short, treatment comes from *De Anima*, in which Aristotle (*DA*, 403a) notes, that affect can be studied either as matter or as form. For example, anger is physically evident as 'boiling blood', which is the *matter* of anger; a natural scientist, positioning herself in the physicalist methodology, would therefore measure the temperature of blood to study anger. Conversely, anger has a *form*, which is 'desire for revenge'; natural scientist has no way of making sense of the form of anger, and hence a philosopher (or a cognitive scientist, if there are no philosophers around), is needed in order to give an account of anger from a methodological position that assumes intentionality. Both explanations, "He is angry because his blood is hot" and "He is angry as he desires for revenge" are acceptable explanations of why he is angry, but they stem from different methodologies. A meticulous student of emotion would definitely want to explore both sides of the same phenomenon.

The conceptualisation of matter and form as metaphysically distinct but interdependent substances is called *hylomorphism* (*hyle* for matter, and *morphe* for form; Jaworski, 2011). A wax candle, for example, cannot be defined solely in terms of its *matter*, wax. What is also needed is its *form* as a candle. Even after the candle has burned, its matter, wax, remains, but now it can no longer be called a wax candle: matter persists, but it realises the form (Aristotle, *Met.*

1038b6, 1042b10). Matter and form are two of the four causes described by Aristotle. The other two are efficient cause and final cause. Efficient cause refers to the primary source of change and rest. Our wax candle, for example, would not exist if a candle-maker had not manufactured it, that is, had he not changed the form of the wax so that it became candle. Thus, the candle-maker is the efficient cause of our candle. However, even this is not actually the *reason* for the candle's existence: the candle was built because it provides light; this is its final cause. All four causes are necessary for explaining why our candle exists: it consists of wax, it has the form of a candle, it was made by the candle-maker, and it was made for the purpose of providing light. If one of these causes is missing, there is no candle.

In order to explain mental life, references to all four causes are required: there needs to be a material, a formal, an efficient, and a final explanation. Hylomorphic account of emotion can thus proceed, for example, as follows. A person is angry, because there are *physiological patterns* associated with anger; a person is angry, because anger is a *subjective* response to an event, which for the person goal-relevant and unfair; a person is angry, because generally, such an emotional response to goal-relevant and unfair events is *beneficial to the organism*. Here, the physiological pattern is the material cause of anger, an appraisal profile of the emotion is its formal cause, feeling angry is the efficient cause, and an evolutionary explanation of anger is the final cause. It is evident that all four causes of emotion need to be explicated, and according to the hylomorphic principle (Aristotle, *Met*.), these four should be sufficient for explaining emotion in its totality.

From the perspective of emotional user experience, especially interesting in the above explanation of emotion are the formal and efficient causes. The formal cause implies that in order to make sense of emotion, one needs to explicate a structure, in which different circumstances of an event are related to each other in certain ways. In case of anger, injustice is not enough: the event also needs to be novel (prolonged injustice would better be associated with grudge). Further, the formal structure of an emotion such as anger cannot be understood without reference to subjective meaning. The same novel event can be interpreted, that is, appraised, as fair or unfair depending on the significance that the event has to the experiencing subject. Therefore, while the formal cause of an emotion lists and structures the necessary antecedents of the emotion, the emotion does not make sense without subjective interpretation, which gives the emotion its efficient cause.

The above discussion is conducted in terms of Aristotelian exposition on the four causes. However, it was not until much later that the modern psychological theory of emotion as a cognitive process was proposed by Magda Arnold (1960; see also Lazarus, 1966)[14]. Arnold's treatment raised the concept of *appraisal* into the focus of psychology of emotion: she defined emotion as "a felt tendency toward anything appraised as good, and away from anything ap-

14 One should also note the early cognitive theory of emotion proposed by Carl Stumpf as early as in 1899 (Reisenzein & Schönpflug, 1992).

praised as bad" (Arnold, 1970, p. 176). Appraisal is thus the process in which the personal significance of an event is evaluated, prompting the subject to have a tendency of attraction or aversion towards anything in the environment (Arnold, 1960, 1970). This emphasis on the personal significance can be highlighted by what Frijda (1988) calls *the law of situated meaning*: emotions are responses to the subjective meaning structures of given situations. What this means is that people appraise situations according to the subjective significance of the occurring events, and this process is the process of emotion. For example, an event that satisfies the goals of individual results in a positive emotion through the process of appraisal; harming, threatening, or goal-incongruent events result in negative emotions. Thus, as different people may associate the same event with different meanings, the emotional response to the same event may vary between people. The input for the appraisal process is therefore not only an event, but the event *with* its subjective meaning (Frijda, 1988).

Appraisal theory defines emotion as a process, not a state (Folkman & Lazarus, 1985; Moors et al., 2013). This process consists of *components*, which interact recursively during the appraisal and result in changes in cognitive, physiological, motivational, motor expression, and subjective feeling responses (Scherer, 2005, 2009). While the subjective feeling component implies that emotion can be represented consciously, it should be noted that most of the appraisal process occurs unconsciously (Scherer, 2009). In this unconscious process, the components are interlinked so that a change in one affects all the others. This creates a recursive feedback system, which manifests as constant changes in all components. The antecedent of the appraisal process is always an event, and the result is the multilevel process. An event does not necessarily result in an observable response, but it always results in a process which readies a response to an event (Scherer, 2009).

The component process model of appraisal is provides rich predictions concerning various observable changes in human physiology and metal states (Scherer, 2009). The major components of emotion are cognitive, neurophysiological, motivational, motor expression, and subjective feeling. In the component process model (Scherer, 2009), the appraisal process, triggered by an event, proceeds in four sequential 'checks', which evaluate the *relevance* of the event, its *implication*, the subject's *coping* ability, and the event's normative *significance*. Each check involves all components, which interact with each other during the sequence. The cognitive component has a special role in integrating the different components in order to produce coherent emotion response to an event; this integration occurs as *central representation* of the emotion, and its conscious part is feeling (Scherer, 2004, 2009). Central representation monitors and regulates the appraisal process, and makes it possible for individuals to communicate their feelings to each other (Scherer, 2009). Part of the central representation is unconscious, and it is responsible for spreading coherence to the other components of appraisal in order for the organism to have a relatively coherent emotional state.[15] However, part of the central representation is conscious, and allows for verbal categorisation of feeling and communication of emotional experience. While appraisal theory does not propose a fixed set of biologically basic emotions, there clearly are certain emotion words which are used often, perhaps because they are effective means of communicating certain experiences. These emotions are called *modal emotions* (Scherer, 2005). This helps the experiencing subject to represent emotional experiences of meaningful episodes.

While all six appraisal components are relevant in human-technology interaction research, they have differing methodological implications. For example, the neurophysiological component is studied within the neuroscientific methodology, and the subjective feeling component within the subjectivist methodology. Further, understanding the whole appraisal process and how the central representation within the cognitive component is able to causally affect physiological and experiential aspects of emotion (and vice versa), it is necessary to work within the cognitivistic methodology. Compared to the other two theories of emotion reviewed above, it therefore seems that appraisal theory provides the most ‘methodologically complete’ definition of emotion. This is a promising notion for a researcher, who wants to utilise appraisal theory in constructing the theory of emotional user experience, but one needs to be wary of the different methodological choices that the investigation of different appraisal components involves. Obviously, as conscious experience is of particular importance in user experience research, the feeling component must always be at least somewhat present. Further, as appraisal theory gives special focus on the cognitive component, which centrally represents the emotion process, researchers of user experience should be methodologically prepared to study the cognitive aspects of human-technology interaction.

The event that starts the appraisal process can be internal, such as when remembering something embarrassing, or external, such as when encountering a software error. There are three distinct sources for appraisal: perceptual stimuli, associative processing, and reasoning (Smith & Kirby, 2001). The detection of perceptual stimuli is direct, and the appraisal process quick, requiring no complex mental processing. For example, if a person encounters a snake on a path, she will recoil from the snake immediately and start feeling anxious. Associative processing is fast and automatic, and is based on spreading activation, which means that the activation of certain declarative long-term memories triggers the activation of others (Anderson, 2000). Due to the nature of associative processing, the appraisal process from this source takes more time than from the perceptual stimuli. In the snake example, perhaps the person remembers that the kids left their toy snake on the path, and anxiousness changes to relief. The third source of information is reasoning, which is slower than associative processing, and occurs under conscious control. It is involved in constructing

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15 It should be noted that from the perspective of appraisal theory, emotion is not a state, but a constant process. However, for coherent subjective experience, it makes sense for the organism to be able to experience emotions as discrete chunks (Scherer, 2009).

meanings with linguistic properties. In our example, the person now starts to feel frustration at the kids who always leave their toys lying around, but perhaps she will eventually reason that 'kids will be kids', and leave the whole episode with a humorous note. All three information sources are important when investigating emotion in human-technology interaction, but it is important to make the distinction between them in studies of emotional user experience.

The dynamic component process model of appraisal is detailed, but not necessarily always the easiest and most useful way of describing the appraisal process. It is often easier to start by reducing the four 'checks' above into two phenomenological main phases, primary and secondary (Folkman & Lazarus, 1985; Lazarus, 2001; Scherer, 2009). *Primary appraisal* is the evaluation of an event regarding the subject's personal goals and values. It establishes the subjective significance of an event, that is, how relevant the event is to the goals of the subject, how pleasant or unpleasant the event is. *Secondary appraisal* refers to the evaluation of the subject's coping ability. It establishes the subject's ability to control the event, and cope with the results of the event. Both phases of appraisal are relevant in human-technology interaction. Emotional responses to artefact use depend both on how congruent the interaction events are with the user's goals and values, and how well the user is able to control the interaction events and her reactions to those events.

Appraisal theory agrees with constructivist theories such as core affect theory in that appraisals are affected by culture, past experiences, and goals, so that different people may have different emotional response to the same event, or that the same person may have different emotional experience to the same event at different times (Ellsworth, 2013). In fact, from the perspective of appraisal, there is nothing inherently wrong in the circumplex-model of emotion categorisation[16], but in addition to valence and arousal, appraisal theory suggests that there are other necessary categories, such as situational control and certainty (Smith & Ellsworth, 1985). However, whereas core affect theorists state that the valence and arousal components are the basic building blocks of an emotional experience (Russell & Barrett, 1999; Russell, 2003, 2009), appraisal theorists do not (Ellsworth, 2013; Scherer, 2009; Smith & Ellsworth, 1985). Further, as critiqued above, core affect theory does not explicate the details of the emotion process. Whereas core affect theory does not connect actual observable events with emotional experience in a detailed manner, this exposition is at the very heart of appraisal theory, which aims to explain emotion in its totality, including the feeling component, in a relation to an event. It does this by showing how the meaning of the event to the subject translates into subjective feeling via a the component process of appraisal, which involves multiple levels and phases, the most integral of which is defined as a cognitive process (Ellsworth, 2013; Moors et al., 2013; Scherer, 2009).

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[16] This refers solely to the categorisation of emotion, not to the natural-kind assumption of core affect. The neurophysiological component of appraisal does not conform to the core affect theory.

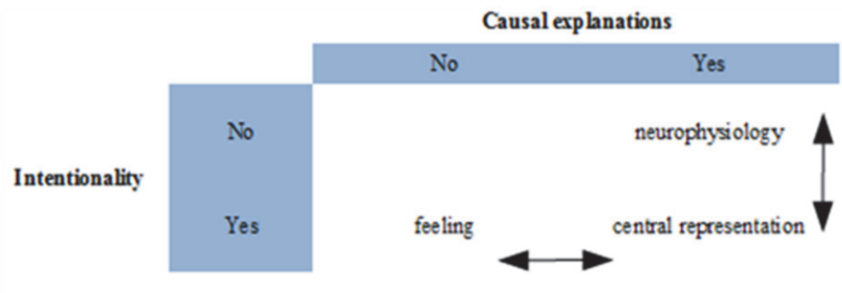

FIGURE 5 Methodological position of appraisal theory.

The methodological advantage of appraisal theory is thus in its capacity to marshal neuroscientific, cognitivist, and phenomenological positions to the study of emotion. The emotion process has a physiological response patterning, which can be studied using neuroscientific methodology. However, the emotion process is not reducible to physiological patterns. Instead, a central part of appraisal is the conscious representation of the emotion – feeling (Scherer, 2009). This conscious representation is only 'tip of the iceberg' of the whole cognitive emotion process, which integrates the physiological patterning and the feeling component, among all the other appraisal components, and regulates the emotion process. Physiological patterns are in interaction with the cognitive central representation, and as part of the system, its conscious part (feeling) is thus also in interaction with the physiological component. Thus, our subjective interpretation of the physiological emotion response moderates the physiological emotion response: the causal relationship moves to both directions. According to appraisal theory, feeling is therefore not epiphenomenal to the physiological emotion process. The methodological position of appraisal theory is depicted in Figure 5, which illustrates how the different methodologies work together to create an encompassing psychological theory of emotion.

The logic connecting the feeling component and the cognitive component of appraisal is revealed with the concept of mental content. As posited above in the previous chapter, actions of people can be explained by referring to the information contents of their mental representations (McClelland, 1955; Saariluoma, 1997, 2005). The concept of mental content provides therefore a key methodological element in studying emotional user experience. Enquiries into the affective information that people represent about technology interaction provide data concerning the subjective emotional experience. In terms of appraisal theory, *affective mental contents*, that is, information that an individual has concerning her feelings, provide evidence about the feeling component of the emotion process. While mental content is one key element in studying emotional user experience, it is not sufficient alone: other components such as the cognitive and the physiological should also be taken into account. Fortunately, psychology of mental contents offers a theoretical perspective into the cognitive principles governing the formation of mental contents (Saariluoma, 1997, 2001), and therefore provides a connection between the feeling and the cognitive components of appraisal. Indeed, without the cognitive psychological explanation of the formation of mental contents one would be methodologically positioned into the phenomenological corner without the possibility of causal explanation of human emotion.

In the analysis of the formation of mental contents it is important to note that mental representations do not have a one one-to-one correspondence with what is represented. The situation is thus different from the neural representation of perception, where the brain areas responsible for different sensory modalities have a one-to-one mapping to the brain, such as between the retina and the primary visual cortex, or a body region and the primary somatosensory cortex (Eysenck & Keane, 2005). Contrary to this, mental representations entail content elements which cannot be reduced back to perceptual stimuli: it is possible to imagine something which is not seen, and closing one's eyes does not prevent the formation of mental representations (Saariluoma, Karlsson, Lyytinen, Teräs, & Geisler, 2004). Because mental representations are not reducible to perception but involve other mental processes, the formation of mental representations is called *apperception*, which in demotic terms means 'seeing something as something' (Husserl, 1936; Kant, 1787; Saariluoma, 2003). In the domain of emotions, apperception is 'feeling something as something'.

Appraisal theory seems an intriguing theoretical framework for user psychology of emotional user experience. It is therefore not surprising, that it has been tentatively introduced in user experience research. Thüring and Mahlke (2007) studied users' emotional responses to technological artefacts, and referred to these as 'cognitive appraisals'. However, the theoretical framework and thus the methodological foundations of the study were not coherent, as the data for the study was collected both from the practical implications of core affect theory (in form of self-assessment manikins which draw from the valence/arousal –structure of core affect) and appraisal theory (in form of the Geneva appraisal questionnaire). Further, it seems that neither theory was actually utilised in the study to *explain* the observed emotional responses. While the name of appraisal theory was invoked, and one of the questionnaires of the study was derived using appraisal theory, the study did not seem to gain additional insights from appraisal theory in user psychological sense, for example in the form of using the theory to inform the interpretation of the results.

In another user experience study utilising appraisal theory (Demir et al., 2009), the authors present appraisal theory as a candidate for informing designers on how to evoke or prevent particular emotions. In the study, participants were interviewed about emotional episodes with products. The responses were analysed using content analysis, and the classification was based on the appraisal components provided by appraisal theory. The study demonstrated how appraisal theory can be used to inform analysis of emotional experience in human-product interaction. However, the study did not describe in detail the process of emotional user experience, that is, how emotions actually occur in human-technology interaction and what factors (subjective, product-related, and environmental) influence the emotional responses. It seems therefore, that currently appraisal theory has not been utilised in the study of emotional user experience to its full extent. The methodological considerations of appraisal theory illustrate its potential power as grounds for building a model, which can describe and explain emotional responses in human-technology interaction. The next subchapter presents such a model as a response to the third and final question of this thesis.

4.2 Appraisal theory and emotional user experience

Appraisal is the apperceptive process in which conscious feelings, and thus the affective contents of mental representations are formed. The definition of appraisal as the evaluation of subjective significance of an event supports this connection between the philosophical and methodological concept of mental content and the cognitive psychological concept of appraisal. Thus, appraisal serves the role of a middle range theory (Merton, 1957) between the philosophical notion of intentionality, and the general working hypothesis that people have different subjective emotional responses to different events. As such, a theoretical answer to the third question of this dissertation (What is emotional user experience?) can be provided in three parts, one empirical (there are feelings), one psychological (feelings result from a cognitive process), and one philosophical (people have mental representations): *Emotional user experience is a subjective feeling, represented as an affective information content of the subject's mental representation, which is a part of a cognitive emotion process that occurs as a response to a technological interaction event.* Now that emotional user experience has been defined in terms of appraisal process of emotion, the next task is to investigate the model of emotional user experience that this definition implies.

4.2.1 Competence and frustration in primary appraisal

As appraisal theory emphasises, the emotion process starts with an event. Primary appraisal evaluates the goal- and value-congruency of the event, and establishes how relevant the event is to the goals of the subject and how pleasant or unpleasant the event is. In human-technology interaction, an event can be considered anything that happens during the use of technology, be it objectively observable occurrence in the task environment, or a change in the mental state of the user. Generally, successful events elicit pleasant emotions due to their congruency with the user's goals. On the contrary, negative emotions arise from goal-incongruent events. For example, frustration is related to obstructions in the interaction, as these are incongruent to the user's goals. Saariluoma and Jokinen (2014) investigated pleasant and unpleasant emotional responses to technology use with their *competence-frustration model* of emotional user experience. In simple terms, feeling *competence* (or techno-competence) results from successful task completion, whereas feeling *frustration* (or techno-frustration) results from goal-incongruent obstructions.

Competence is often defined as knowledge and skills required for successful task performance: a competent person is someone who performs well. However, the competence component of emotional user experience refers to the *experience* of being competent in action, that is, successfully applying the skills required to perform well (Saariluoma & Jokinen, 2014; see also Sandberg, 2000). Feeling of competence is thus related to effectiveness and efficiency during technology use, which can be measured, for example, as the number of errors, accuracy, task completion time, learning, or effort (Hornbæk, 2006). Many of these measures refer directly or indirectly to objective use events, and thus they are not the same as competence as an emotional user experience component. However, there is a clear correlation between objective measures of performance and subjective assessments (Hornbæk & Law, 2007): better task performance is related to increased feeling of competence (see also Jokinen, 2015; Saariluoma & Jokinen, 2015). Nevertheless, it is important to remember that feeling competent and actually being competent in performing tasks do not necessarily have a one-to-one relationship.

Feeling of competence is related to *self-efficacy*, which refers to an individual's appraisal of her own operational capability (Bandura, 1977, 1982). Both self-efficacy and competence are related to the individual's self-perceived capacities, but competence and self-efficacy are not the same thing. The former is an individual's belief in her ability to perform well in a particular domain, while the latter is the emotional associate of successful employment of this ability (Saariluoma & Jokinen, 2014). Goal-congruent use events are given a positive appraisal, and if the user perceives that this use event was due to her skills and knowledge, the resulting emotional user experience is competence. This is related to the distinction between achieving task performance with *effort* and achieving it with *ability*. In a demonstrative experiment (Schunk, 1983), children were given positive feedback on their math learning, either by referring to their effort ("You've been working hard.") or to their ability ("You're good at this."). The group that got ability-based feedback scored higher in their math test than the 'effort-group', demonstrating how self-efficacy is more about the individual's abilities or skills, not her performance per se. Further, the experiment demonstrates a connection between emotion, motivation, and performance.

This notion is also related to the fact that those with more skill are able to assess their skills more accurately (Gravill, Compeau, & Marcolin, 2006; Kruger & Dunning, 1999). If this notion extends to emotional user experience (currently this is a hypothesis that should receive empirical treatment), it means that the self-report of feeling of competence does not necessarily accurately reflect the actual skills and abilities of the user. Instead, this accuracy is dependent on the abilities of the user: self-reports of users with more skill are more representative of their actual performance than those of less skilled users. The studies leading to the characterisation of techno-competence by Saariluoma and Jokinen (2014) considered novel and complex interactions, which makes understandable the focus on the need to apply skills in order to be successful in work tasks. However, techno-competence has also been shown to work as a psychological construct for assessing emotional user experience of normal computer use, such as image manipulation and web browsing (Jokinen, 2015). Following the ability-based definition of techno-competence, it is probable that all technology interactions require at least some ability.

Primary appraisal in human-technology interaction can also result in an emotional response with a negative valence, as for example in case of anxiety or frustration. Techno-frustration results from goal-incongruent events or obstructions (Saariluoma & Jokinen, 2014). Due to the subjective nature of appraisal, the frustration response to the same obstructive event may vary, depending on the importance that the obstructed goal had to the user. Regardless, techno-frustration presupposes a subjective goal, and an event, which the user appraises as obstructing her from reaching the goal. Experiencing techno-frustration involves conscious acknowledgment that the obstructive event is the source of the frustration (Scherer, 2009). Frustration is accompanied by at least small amounts of aggression towards the frustrating agent, and therefore techno-frustration can lead to aggressive behaviour towards the attributed source of frustration (Berkowitz, 1989), as demonstrated in human–computer-interaction research (Lazar, Jones, & Shneiderman, 2006).

The competence-frustration model of emotional user experience provided by Saariluoma and Jokinen (2014) utilised various questionnaire items in the three experiments reported by the authors. These questionnaire items are reported in Table 2, which also reports the final questionnaire as it was adopted in use for the next studies utilising the model (Jokinen, 2015; Saariluoma and Jokinen, 2015). The competence-frustration questionnaire is intended to be filled straight after participants have stopped conducting tasks, and prompts them to recall what they felt during the interaction. The scales have indicated good construct validities in the studies that have utilised them.

While Saariluoma and Jokinen (2014) provided a measurement model for emotional user experience, and discussed how competence and frustration

TABLE 2 Questionnaire items for the competence-frustration model.

Competence: “during the tasks, I felt …”	Frustration “during the tasks, I felt …”
determined	**annoyed**
excellence	**anxious**
efficacious	**confused**
successful	desperate
proud	**frustrated**
vigilant	that I had to struggle

Note. All items used by Saariluoma and Jokinen (2014) are listed, but the final items included in the model reported in this thesis and used by Jokinen (2015) and Saariluoma and Jokinen (2015) are in boldface. The original Finnish questionnaire was in the form “Kun tein tehtäviä, tunsin itseni määrätietoiseksi”, for example.

could be related to task events, they did not provide observation-based statistical associations between task events and self-reports of emotional user experience. This was augmented by Jokinen (2015) and Saariluoma and Jokinen (2015), who demonstrated strong correlations between task performance and both factors of emotional user experience. The study by Jokinen (2015) involved participants conducting tasks on ordinary desktop computer software, such as text document editing and image manipulation. In the statistical model, the standardised coefficient between task performance and competence was .63, and between task performance and frustration –.59. As Jokinen (2015) notes, these associations are higher than usually encountered when correlating task performance and subjective measurements, which may highlight the effectiveness of competence-frustration model in assessing emotional user experience. In Saariluoma and Jokinen (2015), the absolute standardised coefficients between objective task performance and emotional user experience factors were between .29 and .58 (.49 on average).

The competence-frustration model is bi-polar, which means that these two emotional user experience responses differ from each other by their valence, one of the basic and very salient content-dimensions of emotional experience (Frijda, 1988; Russell, 1980; Saariluoma & Jokinen, 2014; Smith & Ellsworth, 1985). However, competence and frustration do not necessarily have a negative correlation, as demonstrated by Saariluoma and Jokinen (2014). Thus, it is possible that there is a frustrating interaction event, but the user is still able to utilise her skills and carry on with the interaction. In this case, the user may experience both techno-competence (e.g., "I could do this because I'm skilful") and techno-frustration (e.g., "This is an annoying user interface."). Saariluoma and Jokinen (2014) hypothesised that the correlation between these two factors of emotional user experience is moderated by such factors as feeling of control. Research on this possibility is currently ongoing, and the results cannot be yet reported here.

Although here the choice for the theoretical background of emotional user experience is appraisal theory, the competence-frustration model of emotional user proposed by Saariluoma and Jokinen (2014) is based on a combination of basic emotion theory and core affect theory. However, as discussed above in the sections dissecting these two theories, this is not necessarily a problem. The original purpose of the authors was to utilise theory of basic emotions to extract a collection of basic emotion words, which technology users could easily relate to and use to give self-reports of their emotional states. However, the authors also used emotion words not listed in theories of basic emotions, and overall did not conform very strongly to the methodology of basic emotion theories. The authors, for example, noted that physiological data is relevant in emotion research, but encouraged utilising subjective data to inform these readings. They did not follow the natural-kinds assumption of basic emotion theories in discussing how physiological measurements would limit the subjective interpretation of the emotion. For Saariluoma and Jokinen (2014), subjective experience was not only epiphenomenal to the physiological emotion process.

Saariluoma and Jokinen (2014) also utilised core affect theory in describing the strong difference in valence they observed between competence and frustration. Their emotion circumplexes, constructed similarly to Russell's (1980), were useful in characterising how the more basic emotion words are related to each other when people interact with novel and challenging technologies, and how these relations are used to create the psychological constructs of competence and frustration. The authors did not discuss the foundational differences between basic emotion theory and core affect theory, however. Instead, they focused on the methodological consideration of mental content and on the problematics of extracting reliable and valid self-reports of emotional experience in human-technology interaction. This line of research was continued by the authors with an extension towards appraisal theory in a new study, which focused on the rules governing appraisal, that is, the formation of affective mental contents in the appraisal process (Saariluoma & Jokinen, 2015).

In the study by Saariluoma and Jokinen (2015), participants either only looked at screenshots of online shops, or conducted tasks on those shops, after which they reported their experiences using the competence-frustration model of emotional user experience. The results demonstrate that the logic of emotional experience was different depending on whether the participants were in actual interaction with the stimuli. Interestingly, the two groups of participants did not have different grand means for the measures of competence: even the participants who did not actually do anything (and thus no skill was required from them) reported feeling of competence. On the surface, this seems a strange result, because Saariluoma and Jokinen (2014) defined competence in terms of the experience of being successful in task completion due to one's own abilities. Therefore, if a user only watches screenshots without having to accomplish tasks, he should not feel competence. The same is valid for frustration: no tasks, no obstructions, no frustration. To solve this dilemma, the authors demonstrated that feelings of competence and frustration for the group that did not conduct tasks correlated with *pre-test self-confidence* that the participants were asked to report at the start of the experiment (Saariluoma & Jokinen, 2015). For the group that conducted tasks, this correlation did not hold, but rather for them, competence and frustration was associated with task performance.

The observation by Saariluoma and Jokinen can be extended by a similar one made by Jokinen (2015). He observed that the correlation between task performance and emotional user experience is dependent on the self-reported pre-test self-confidence of the participant. Participants with less than average self-confidence start out with less than average feeling of competence, but if they are successful in conducting the experimental tasks, their 'gain' for competence is greater than for those who started the experiment with more self-confidence. Self-confidence therefore moderates negatively the relationship between task performance and feeling of competence. This is evidence for appraisal process, as appraisal theory posits that the same objectively observable events may have different emotion responses depending on the experiencing subject. The observations made by Saariluoma and Jokinen (2015) demonstrate a certain top-down mechanism of appraisal process, in which the goals of the user affect the logic of emotional responses. Further, the results by Jokinen (2015) demonstrate that individual traits and mood also affect this logic, probably in a non-conscious manner.

The results reported by Jokinen (2015) and Saariluoma and Jokinen (2015) also exhibit the methodological caveats associated with self-report that need to be considered in designing studies of emotional user experience. The self-report measures for competence and frustration are valid only if they have expected correlations, in this case with task performance. However, it seems that users' self-reports of competence and frustration are not mapped one-to-one with task performance. Instead, users have a certain 'baseline' feeling of competence and frustration, which should be visible as a correlation between pre-task and post-task measurements. As Jokinen (2015) and Saariluoma and Jokinen (2015) note, this finding poses a critical concern for the internal validity of many studies, which do not sufficiently take into account the details of the process in which emotional user experience occurs.

The study about interactive and non-interactive tasks reported by Saariluoma and Jokinen (2015) contained three experiments, two of which were reused by Jokinen, Silvennoinen, Perälä, and Saariluoma (unpublished manuscript) with partly different data that was collected during the experiments. This paper aims at uncovering the logic of how emotional experiences are formed by examining how brand experience affects visual experience. Following the observation that pre-use expectations correlate positively with experiences during the actual interaction (De Angeli, Hartmann, & Sutcliffe, 2009; Raita & Oulasvirta, 2010), the authors hypothesised that brand experience correlates positively with visual experience. This hypothesis was explained with the notion that apperception, which is the process in which meaningful mental representations are formed, depends on previous experiences. Mental representations are relatively consistent due to content-specific rules, which govern what makes sense in the representation (Saariluoma, 1997). These rules are applied in apperception, which assimilates perceptual stimuli along with conceptual memory into a self-consistent representation (Saariluoma, 1995). The criterion for consistency is that for each element, which is applied to a representation (via apperception), it should be possible to give reason why the element belongs to the representation.

In the experiments by Jokinen et al. (unpublished manuscript), participants reported their satisfaction and loyalty towards brands, and then either watched screenshots or conducted tasks in online shops of those brands and filled a semantic differential questionnaire concerning web site visual experience. Two experiments revealed that the positive effect of brand experience on visual experience was negatively moderated by the participant's ability to conduct tasks in the web shops. Brand experience predicted visual experience if the participants either did not have to do tasks at all, or were not able to do tasks at all (some of the tasks were designed to be impossible). The explanation for this finding is that people assimilate information using existing content-based rules, and thus brand experience affects visual experience. However, if the user completes tasks during the use, the visual design of a web site is apperceived from the perspective of these goal-congruent events. Thus the content-based rules are different than for tasks, which the participant was not able to conduct. This means that the logic of the aesthetic aspects of user experience is dependent on the nature of the interaction.

4.2.2 Extending the appraisal-based model of emotional user experience

The competence-frustration model of emotional user experience introduced by Saariluoma and Jokinen (2014) focuses primarily in uncovering what affective mental contents would be suitable for studying emotional user experience. Thus, the authors did not explicitly consider how the process of appraisal should be taken into account in analysing how either competence or frustration – or any other affective response to technology – occur. Above, studies by Jokinen (2015), Jokinen et al. (unpublished manuscript), and Saariluoma and Jokinen (2015) were presented as augmentations of the original model. Next, the model is further augmented by exploring the study of Jokinen (2015). Further, the usefulness and validity of appraisal theory for investigating emotional aspects of human-technology interaction is demonstrated by examining the study by Jokinen, Silvennoinen, Perälä, and Saariluoma (2015).

Secondary appraisal is related to the evaluation of the coping ability of the subject. This establishes how the subject is able to control an event and cope with its results. *Coping* is an adaptation effort of an individual, and manages the interaction between the individual and the environment (Folkman & Lazarus, 1985; Lazarus, 1966). Secondary appraisal is present in all appraisals, and thus the ability of an individual to control events is appraised in all situations, both pleasant and unpleasant. Thus, although intuitively coping would be more related to negative than positive emotions, both are associated with coping. In order to feel techno-competence, for example, the user needs to be in control of the interaction events in addition to perceiving goal-congruent events and understanding how these events were at least partly due to the her ability. Conversely, techno-frustration is the result of events, which obstruct the user from reaching goals. As frustration is associated with knowledge that one should have at least some power over the event (Scherer, 2009), techno-frustration necessarily occurs via the coping check of the appraisal process. For example, if a user has no control at all over an interaction, the user probably feels helplessness instead of frustration. Conversely, if there is an amount of control but the user is still not able to cope with problems during the interaction, frustration is more probable response.

People have different coping strategies, and what strategy is used is dependent on the situation and the individual. There are two general coping strategies: problem solving and emotion-centred approaches (Folkman & Lazarus, 1985; Lazarus, 1966, 2006). These strategies can be discussed in ideal terms in a relation to how much control the subject perceives to have. An appraisal of high control potential leads more probably to a problem solving coping strategy, and thus the subject can influence the event and try to make the situation more congruent with her personal goals. Conversely, if the possibility to influence the situation is appraised to be low, a more probable strategy is an attempt to deal with the emotional response. These strategies do not necessarily exclude each other: successful coping can involve problem solving and emotion-regulation strategies. Further, individual differences influence the frequency of the two strategies (Folkman & Lazarus, 1985).

Jokinen (2015) utilised the idea of two coping strategies and studied the role of coping in the competence-frustration model of emotional user experience. The hypothesis was that if a user adapts the problem solving coping strategy successfully when encountering a problematic interaction event, and is thus able to establish congruency between how the event unfolds and what the subjective goals are, the emotional response is competence. Jokinen (2015) called this coping trait *planful problem solving*, and hypothesised that there are individual differences in how apt people are at invoking this strategy. In other words, planful problem solving can be understood as a user trait, that is, an attribute that varies between individuals, but that is relatively stable over time within an individual. Utilising the notion of the emotion-regulation strategy, Jokinen (2015) further hypothesised that there are individual differences in how well people are able to cope with negative emotions, which arise in human-technology interaction. Due to the competence-frustration model, he called this second user-trait *frustration tendency*.

Jokinen (2015) started by operationalising a questionnaire to measure the individual coping traits of planful problem solving and frustration tendency. Participants had to answer this coping trait questionnaire a day before coming to a laboratory experiment. In the experiment, participants conducted tasks with ordinary software (e.g., text editing, image manipulation), and then filled the competence-frustration questionnaire. Results indicated that while the main predictor of competence and frustration is task performance, competence and frustration are also dependent on the coping traits of the user. The ability of a user to solve problems planfully predicts increased competence regardless of task performance, and the tendency of a user to get frustrated increases frustration regardless of task performance. As Jokinen (2015) noted, this is only a preliminary result, which demonstrates that these two scales of individual differences in coping work. The next step is a detailed study of how these coping traits are actually visible in what users do and experience during interaction with technologies. Planful problem solvers should increase their task performance and thus competence by skilful actions, whereas those with high frustration tendency should quickly report an increased frustration even with small interaction obstacles. Further, hypotheses relating to the possible interaction effects between these two traits will provide a fertile ground for various interesting experiments.

The coping traits study by Jokinen (2015) was able to connect the competence-frustration model of emotional user experience by Saariluoma and Jokinen (2014) to appraisal theory with a clear reference to both primary and secondary appraisal. While the original model was introduced and discussed in the context of basic emotion and core affect theories, Jokinen (2015) explicitly limited the discussion to appraisal theory by focusing on secondary appraisal. The results illustrate that appraisal theory is a fruitful background for investigating emotional user experience, as its long tradition in elaborating the emotion process can be utilised relatively straightforwardly in human-technology interaction research. However, as discussed, the results of Jokinen (2015) were still tentative and focused on the feeling component of appraisal and hence on the study of emotional user experience as affective contents of mental representation, not as a cognitive process of emotion. Thus, the study did not yet include a detailed exposition of the perhaps most important component of appraisal.

The classic intuitive understanding of emotion makes a clear distinction between emotion and reason. Appraisal theory does not abide to this dichotomy, but instead starts from the notion that emotion is a cognitive process, and thus it is not purposeful to separate emotion and reason (Power & Dalgleish, 1997, provide a good historical examination of this point). This notion was the starting point of an experimental paradigm for studying the cognitive appraisal component of affective mental contents (Jokinen et al., 2015). The paradigm is based on what the authors call *primed product comparisons*. The idea is to give a participant an affective prime, according to which the participant then has to make a preferential match between two products, shown side by side. The participants are asked to make this match as quickly as possible so that the responses can be used to investigate the participants' preferences as well as the time it takes to make these preferences. The method therefore combines the notion of the central representation of emotion as cognitive, partly non-conscious process, and subjective, conscious experience, which is analysable as mental contents.

In the actual experiment, participants were shown adjectives, such as 'timeless' or 'durable', and asked to quickly choose between two drinking glasses presented to them after the adjective. The participants were generally able to make their preferential match quickly (grand mean reaction time = 1.76 seconds), but the results also demonstrate that the judgment time depends on the adjective, as well as the stimulus pair. More abstract adjectives, such as 'timeless' or 'festive' took, on average, more time than more basic ones, such as 'durable' or 'light'. These findings are in line with the proposition about three distinct appraisal sources, perceptual stimuli, associative processing, and reasoning (Smith & Kirby, 2001). Similar classification from Norman (2004) labels the levels as visceral, behavioural, and reflective. While the appraisal sources and Norman's categorisation are not based on the same theoretical assumptions, the description of the levels is comparable. Visceral product attributes (e.g., 'heavy') are processed more readily than reflective (e.g., 'festive') which involve more culturally interpretable criteria. However, appraisal theory provides a firmer, cognitive-based methodological framework for investigating the process which leads to such evaluations. As Jokinen et al. (2015) suggest, experimentation with prime masking, for example, should be fruitful in uncovering the details of the appraisal process, which is behind affective mental contents.

4.2.3 Validity of the appraisal model of emotional user experience

All the studies reported here providing empirical support for the appraisal-based model of emotional user experience was conducted in laboratory, except for a third experiment of Saariluoma and Jokinen (2015). Laboratory experimentation is, of course, defendable, especially in the model building stages of a research project, as the amount of control a laboratory allows makes large effect sizes and thus observation of otherwise confounded phenomena possible. However, laboratory experiments also involve the problem of ecological validity. Do the competence and frustration, among other emotions, experienced in a laboratory environment, correspond to the ones that people would naturally have, when they interact freely with technologies in their daily lives? The participants come to the laboratory on their own volition, but the reason they conduct the experimental tasks is not related to their personal goals, but to the artificial setup of the experiment.

In order to strengthen the ecological validity of the competence-frustration model of emotional user experience, Saariluoma and Jokinen (2014) reported a field test alongside two laboratory experiments. The emotional responses of factory workers, who were asked to evaluate a new loading station prototype, corresponded to the responses of the student participants in the laboratory experiments. This finding provided ecological validity to the competence-frustration model, as it gives evidence that the clustering of competence and frustration -related questionnaire items was not an artefact created in the laboratory. However, the result does not obviously avoid the possibility that the competence-frustration model is due to the self-report instrument itself. Perhaps the participants are, for example, reporting what they think they are expected to report, and not their actual emotional experiences. The questionnaire would, in this case, be useful only for examining general knowledge concerning emotions, not emotional user experiences proper. This would be a grave problem for the internal validity of the competence-frustration model.

Although it is possible that participants are using general knowledge concerning emotions to review whether their questionnaire responses make sense, it is less plausible that they can quickly analyse how well they performed in the experimental tasks, and use this to predict what they should answer in the questionnaire. It is more likely that the correlations between observed task performance and competence and frustration (Jokinen, 2015; Saariluoma & Jokinen, 2015) are due to the participants conducting tasks as well as they can, and actually having emotional user experiences. One has to assume, that the participants were able to reflect their emotional experiences retrospectively as they responded to the questionnaire straight after completing the tasks instead of relying on general knowledge concerning emotions. Further, it is very unlikely, that the participants in the study reported by Jokinen (2015) recalled their answers to the coping trait questionnaire, which they filled the day before the experiments, and somehow used that information to determine how they should report their competence and frustration. Instead, it is probable that there was actual variance in the coping traits of the participants, and this was visible in the actual subjective emotional user experiences of the participants.

As suggested by Jokinen (2015) and Saariluoma and Jokinen (2014, 2015), the next steps in validating the competence-frustration model of emotional user experience is to widen its scope from people interacting with work-related user interfaces to other contexts, such as leisure (e.g., games). Further, although the focus of human-computer interaction is in technologies that can be considered as 'computers', there are also technologies from other domains. The study of reaction times for drinking glass judgments by Jokinen et al. (2015), exemplifies how the emotion process is relevant for all technology contexts, not only in the context of computers and user interfaces. This is also the reason for choosing the term 'human-technology interaction' in this thesis instead of the more widely recognised 'human-computer interaction'. Now that computers are becoming increasingly ubiquitous, and the distinction between an item and a computer (e.g., 'the internet of things' and wearable technology) becomes fuzzy, limiting the context of human-technology interaction research to only computers would be detrimental for the development of best possible design ontologies.

5 CONCLUSION

5.1 Emotional user experience and design

Designing new technology is a problem solving activity, in which the designer utilises existing domain-specific knowledge to create concepts, which serve as answers to certain design problems. This process was outlined in the second chapter of this thesis, and served as a motivator for the subsequent discussion. The central argument was that as designers are dependent on a well-structured body of knowledge concerning human-technology interaction, articulated as interaction ontologies, it should be the aim of user experience researchers to provide such ontologies. However, as the subsequent analysis revealed, the difficulties in defining what experience is result in difficulties for reliable designs that target good experiences. The third chapter of this thesis proposed, that this difficulty is related to the loose metascientific and methodological expositions of user experience research. Although the model of emotional user experience discussed in the fourth chapter does not serve as a conclusive interaction ontology of emotional user experience, it is methodologically explicit and can be used to create a robust understanding of what causes users to have certain feelings.

The studies by Saariluoma and Jokinen (2014) and Jokinen (2015), for example, can be used to give a 'prototypical narrative' for feeling of competence. A user feels competent, if she is able to efficiently accomplish tasks using her skills and knowledge. It is important, that the user understands how her skills helped her to complete the tasks; in other words, instead of exerting herself to be effective, she utilises her abilities to achieve this result. Further, the feeling of competence requires that the user is able to see this connection between ability and performance. Thus, an interface designer, aiming to construct an interface which supports user's feeling of competence, would investigate the skills that users need in order to conduct their tasks efficiently. A good interface – from the perspective of feeling of competence – would provide novice users advice for developing efficient skills and show advanced users how their abilities could be used in the most effective way. Conversely, an interface that automates most of the efficient features and obstruct the user from making skilful manipulations on the work task does not probably invoke feelings of competence. Further, an interface that supports feeling of competence should take into account the relationship between the actual competence (as in performing well) and feeling of competence (as in feeling that one performs well because one's abilities).

The prototypical narrative for feeling of frustration describes that users feel frustrated when they are obstructed from their goals. Further, people have different strategies for coping with such obstructions, and there are individual differences in how well they are able to follow these strategies (Jokinen, 2015). A designer, understanding the frustration as it is covered on the appraisal-based model of emotional user experience, would therefore anticipate interaction problems – that is, frustrations – by designing for individual differences in both problem solving and emotion-centred coping strategies. The designer would thus understand that some users may prefer to have helpful information available only on demand, and others may require active support in problem solving. Further, some people may cope better with frustration if they do not perceive the frustrating event as a threat to their self-esteem (Kuppens & Van Mechelen, 2007). Thus, the designer should find a way to indicate the user that she is not blamed because of the problem, and give her a chance to develop her skills to avoid such problems in the future. Of course, these suggestions are very general, and the construction of interaction ontologies, which can account for feelings of competence and frustration, should involve domain-specific empirical investigations. However, the structure of this investigation can follow the outlined theory of emotional user experience.

Further, the tool for primed product comparisons developed by Jokinen et al. (2015) can be used for quick iterative evaluation of early design products. The reaction time -based method can reveal unconscious mental processes associated with product evaluation, and thus designers can investigate the role of incremental concepts in the total product experience. For example, a designer of a new drinking glass can vary one single design property of the product, such as the curve of its base, and investigate how it changes the overall impression of the design. The results of such empirical work should be generalisable, and for example the study by Jokinen et al. (2015) indicated a very consistent agreement in how the participants experienced stimuli, which means that there is a possibility for valid generalisations of product experience using the method of primed product comparisons. In time, domain-specific, and perhaps even cross-domain ontologies, of emotional user experience should start to emerge. These could then be used to inform designers on what product aspects involve what experiences without the need for extensive empirical testing.

5.2 Methodology of appraisal-based emotional user experience research

Empirical inquiries of thought and behaviour make always certain assumptions about human beings. Here, two central assumptions, one concerning intentionality (do people have mental representations?), and one concerning causality (is a causal model of thought and behaviour useful?) were reviewed. An empirical research of human being always makes a stance – either negative or positive – concerning these two assumptions. This happens when researchers operationalise study designs, measurement instruments, and methods for analysing and interpreting data. These assumptions are here called methodological, because they deal with how the empirical reality is related to the scientific account of that reality (Kaplan, 1964). The analysis of what methodological positions different empirical studies make is called foundational analysis, because it aims to uncover the tacit assumptions behind operationalisations, and thus make scientific discussion, especially in case of disagreements, easier (Saariluoma, 1997). A brief review of current literature – both empirical and theoretical – on user experience reveals that the field needs foundational analysis. The lack of metascientific and methodological considerations in user experience research leads not only to difficulties in defining what user experience is, but especially to difficulties in discussing the different assumptions behind different theories of user experience.

While a thorough attempt to construct foundational analysis of user experience was not attempted here, hopefully the guidelines constructed in the third chapter above serve to attain this goal in the future. Meanwhile, the analysis was used to discuss the methodological differences between different theories of emotion in the fourth chapter of this thesis, where theories of basic emotion, core affect, and appraisal were positioned by their methodological implications. It should be reiterated here that no methodological choice is fundamentally inferior to others,[17] and hence, for example, foundational analysis cannot tell that a particular theory is ultimately better than another (what it can do, however, is to show that a particular theory has better explicated its methodological position). Instead, different methodologies are associated with different problems, and thus different methodologies are applicable for different problems.

Theory of emotional user experience, based on appraisal theory, aligns itself methodologically with subjectivist, cognitivist, and neuroscientific positions

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17 This does not mean, however, that theories cannot be ranked. Empirical evidence can be used to show that a certain theory, such as the Ptolemaic (geocentric) model of cosmos, is not plausible. Similarly, as reviewed in the second chapter, the behaviouristic insistence on not allowing reference to what occurs within human thought was shown untenable by empirical findings relating to the cognitive revolution. However, as argued in the third chapter, the behaviouristic methodology, assuming no intentionality and no causal explanations, can still be found useful for some studies, even if the researcher does not commit to behaviourism per se. One must also remember, that theories need to solve problems (Laudan, 1977), but it is probable that theories which can be empirically demonstrated to be false are not great at solving problems.

(Frijda, 1988; Lazarus, 2001; Moors et al., 2013; Roseman, 2013; Scherer, 2005, 2009). Researchers of user experience are – by definition – interested in the subjective feeling of the user, and thus any description of emotion in user experience should account for it. In appraisal theory, subjective feeling is the part of the whole emotion process, which is accessible to consciousness, and which can be communicated to others using basic or modal emotion words (e.g., angry or happy). Saariluoma and Jokinen (2014) demonstrated, how basic emotion words can be used to operationalise self-reports, which allow the users to reliably and validly report their subjective emotional experience about interaction with technology. Methodologically, the conscious emotional experience can be investigated with the concept of mental content. The formation of mental contents is dependent on content-based rules, as shown by Saariluoma and Jokinen (2015) and Jokinen et al. (unpublished manuscript), and thus, in order to explain emotion in human-technology interaction, one needs to uncover the meaning structures, which users associate with the interaction.

The feeling component of emotion is part of the total cognitive process of emotion, which is integrated by central representation. The central representation involves conscious part (feeling), but also unconscious processes. These processes can be investigated causally within the cognitivistic methodology. Jokinen et al. (2015) demonstrated unconscious aspects of appraisal process by asking participants to make affective judgments as quickly as possible, and showing that depending on the appraisal source, the processing time from the perceiving the stimulus to having a conscious representation of the feeling varies. Another demonstration of the unconscious aspect of emotion process is the individual differences perspective, which Jokinen (2015) took to investigate, how coping traits affect emotional experience. While his study did not methodologically investigate the details of the cognitive process, in which the ability of the user to cope with technological problems and subsequent emotions affects what the user experiences, the results do indicate that such a mechanism exists.

Thus, methodologically, appraisal-based theory of emotional user experience is not limited to the subjectivist position. Because subjective feeling is necessarily only part of the largely unconscious emotion process, the cognitivistic position plays a significant role in uncovering what and why people experience, when they interact with technology. This methodological extension to the purely subjectivist user experience research should in time provide researchers tools for making generalisations and thus for building ontologies of emotional user experience. While previous few studies of how appraisal theory can be utilised in user experience research have showed the ability of appraisal theory to make sense of the conscious part of emotion (e.g., Demir et al., 2009), so far the unconscious processes and actual explanations of why people experience what they experience when using technology have been left largely without investigation.

The empirical and methodological discussion covered here does not, however, give a definite conclusion to the relationship between the subjectivist and the cognitivist methodological positions. While the relationship between the two has been indicated, it is yet to be explicated in detail. For example, how does the model explain variance in processing time of different affective responses so that the explanation takes into account both the notions of spreading activation and semantic distance (Saariluoma & Kujala, 1996)? Spreading activation refers to the subsymbolic, connectionist account of how the probability of recall is dependent on how the object of recall is associated with other memory chunks (Anderson et al., 2004). However, while spreading activation explains why certain chunks are easier to recall when other certain chunks are active, it does not give content-specific explanation to this finding, that is, it does not explain why certain chunks are associated with each other. In order to do this, a notion of *semantic distance* is necessary. Semantic distance can be used to explain, for example, why people's first names feel to be more closely associated than words for animals: animal names are part of a different class, and thus have different content (Saariluoma & Kujala, 1996). Future extensions of appraisal-based model of emotional user experience should try to explain affective processing time differences with both concepts – spreading activation and semantic distance – and try to uncover what their relationship is.

On a further methodological note, not explored in the studies reported here, appraisal theory connects the central representation with neurophysiological patterns, and thus allows neuroergonomic investigation of emotion. However, current empirical work on the neural correlates of emotion does not yet provide enough evidence to warrant explicit neuroergonomic operationalisation of emotional user experience (Cacioppo et al., 2000; Elfenbein & Ambady, 2002; Jolij & Heussen, 2013). Perhaps now that methodologically explicit model of emotional user experience has been proposed, it should be easier to start extending this model to permit neuroergonomic studies in addition to studies based on self-reports, objective observations of task events, and processing times.

5.3 Summary

Researchers and designers of human-technology interaction have understandably become interested in what people experience when they interact with technological artefacts. However, experience is difficult to define, which makes it difficult for researchers to provide stable information concerning the experience process in human-technology interaction, and for designers to justify their design solutions. These problems, that of a researcher and that of a designer, are interrelated. If the researcher can provide a valid and reliable model, which explains why people experience what they experience during interaction, the designer can utilise this information to make justified design solutions. Moreover, the work of the researcher is not justified until the provided models have been used in solving problems (Laudan, 1977; Saariluoma & Oulasvirta, 2010).

Although research on user experience has started to deliver knowledge about what and why people experience when they use technology, this information has so far been scattered and methodologically unordered (Bargas-Avila & Hornbæk, 2011). For this reason, the first question of this dissertation inquired **the conceptual foundations of human-technology interaction research**. Foundational analysis (Saariluoma, 1997) was used to create a preliminary framework to study the methodological presuppositions in user experience research, and in human-technology interaction research in general. Following previous similar analysis (T. Johnson et al., 1984), two foundational assumptions, one concerning the capacity of people to have mental representations, and one concerning causal explanation of human behaviour and thought, were suggested as abstract ideal types. Every researcher has to position themselves – either implicitly or explicitly – on the two-dimensional methodological framework set by these two assumptions.

This methodological framework was used to understand the foundational differences between theories of emotion, which were reviewed to answer the second question of the thesis concerning **emotion in the context of human-technology interaction**. Three theories, basic emotion theory, core affect theory, and appraisal theory were reviewed and analysed according to their methodological assumptions. Each was discovered to have implications for studying emotional user experience. Basic emotion theory provides useful lists of emotions, which seem to be relatively universally recognised (Ekman & Friesen, 1971; Ekman, 1992a, 1992b; Izard, 2007). A model based on these words, or words related to them, should have cross-cultural validity, although this was not tested in the studies reported here. Core affect theory provides a circumplex framework for classifying emotions according to their valence and arousal (Russell, 1980, 2009); both dimensions are useful in describing emotional responses to technology use. However, neither basic emotion theory nor core affect theory was considered to offer methodologically a basis, which is methodologically extensive enough for constructing a model of emotional user experience. The main problem is the non-explicated connection between the conscious emotion and the non-conscious emotion process.

The third emotion theory reviewed in this thesis, appraisal theory, proved to be methodologically extensive enough for discussing this connection. Appraisal theory defines emotion as a cognitive process, which evaluates the subjective significance of an event (Arnold, 1960; Frijda, 1988; Lazarus, 2001; Scherer, 2009). In appraisal, conscious component of emotion, called *feeling*, interacts with the other components of emotion process, such as the cognitive and the neurophysiological (Scherer, 2009); this mechanism connects conscious and non-conscious parts of emotion together. The concept of affective mental content was utilised to bridge the gap between purely phenomenological and purely physicalist methodological account of emotion, as there are rules which govern how mental content is formed (Saariluoma, 1997). This treatment was then used to answer the third and final question in this thesis: **What is emotional user experience**.

This question was given an answer in the form of an appraisal-based model of emotional user experience. The starting point was a bi-polar competence-frustration model by Saariluoma and Jokinen (2014). The logic of the model was then investigated by asking if the content-based rules, responsible for the affective experience in human-technology interaction, were different depending on whether the user is only observing technological stimuli, or actually interacting with them (Saariluoma & Jokinen, 2015). The results, augmented by Jokinen et al. (unpublished manuscript), demonstrate that mental content and it's the logic of apperception which forms mental content are necessary theoretical elements, which are required to explain users' emotional responses. Depending on the nature and the intensity of the interaction, the users' conscious emotional experiences have a different logic. Self-confidence and brand experience, measured before the participant is otherwise introduced to the tasks of the experiment, predict emotion responses only, if this effect is not diminished by goal-congruent use events. The explanation for this is that although the self-report of competence, for example, is superficially same, the content of the actual emotional representation may vary.

The current relevance of the competence-frustration model of design is, that it provides the general description for these two emotional user experience factors. These descriptions can be used to derive design solutions, which for example support feelings of competence, or avoid feelings of frustration in the user. Further, the model provides an instrument for evaluating such solutions, as long as the evaluator takes into account the individual coping differences (Jokinen, 2015) and the nature of the interaction (Saariluoma & Jokinen, 2015; Jokinen et al., unpublished manuscript). The study by Jokinen et al. (2015) further demonstrates how the utilisation of appraisal theory for understanding emotion in human-technology interaction can help in product design. The qualitative results concerning the characteristics of the drinking glasses used in the study give direct feedback do designers, and as the authors suggest, the method of primed product correlations could be used in fast prototype evaluation. In addition, the method should prove helpful for investigating how small, incremental design solutions cause changes in product appraisals. For example, the relation of small changes in product shapes to product experience can be investigated by creating multiple prototypes of a single product, and slightly varying a chosen design characteristic.

As has been argued throughout this thesis, current user experience research has provided the field of human-technology interaction extensive understanding of the generalities and details concerning the experience process. However, it was further argued that only a methodologically robust and psychologically extensive dissemination of this process can function as a foundation, which can be used such as an explanatory framework for user experience that is capable of providing useful interaction ontologies to designers. The discussion, along with five empirical research articles, provide evidence for the effectiveness of utilising psychological appraisal theory alongside with content-based explanation, in the metascientifically and methodologically explicit framework of foundational analysis, in constructing a scientifically valid model for how people experience emotions in human-technology interaction. In other words, what was provided, was user psychology of emotional user experience.

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ORIGINAL ARTICLES

I

EMOTIONAL USER EXPERIENCE – A USER PSYCHOLOGICAL ANALYSIS

by

Saariluoma, Pertti & Jokinen, Jussi P. P. 2014

International Journal of Human-computer Interaction vol 30(4), 303–320.

Emotional Dimensions of User Experience – a User Psychological Analysis

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This research is supported by the Finnish Funding Agency for Technology and Innovation (TEKES) and Finnish Metals and Engineering Competence Cluster (FIMECC) programme UXUS (User experience and usability in complex systems).

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Abstract

User psychology is a human–technology interaction research approach which uses psychological concepts, theories, and findings to structure problems of human–technology interaction. As the notion of user experience has become central in human–technology interaction research and in product development, it is necessary to investigate the user psychology of user experience. We base our analysis of emotional human–technology interaction on the psychological theory of basic emotions. Three studies, two laboratory experiments, and one field study are used to investigate the basic emotions and the emotional mind involved in user experience. The first and second experiments study the measurement of subjective emotional experiences during novel human–technology interaction scenarios in a laboratory setting. The third study explores these aspects in a real-world environment. As a result of these experiments, we propose a bipolar competence–frustration model which can be used to understand the emotional aspects of user experience.

Keywords: user psychology, emotional computing, user experience, human–technology interaction

Emotional dimensions of user experience – a user psychological analysis

Human–technology interaction can be studied from many different scientific perspectives, such as sociology and social research (Rosenberg, 2004), ethnography (Millen, 2000), and neuroscience (Johnson & Proctor, 2013; Parasuraman & Rizzo, 2006). One important field in the investigation of human–technology interaction is psychology (Card, Moran, & Newell, 1983), and as a whole, psychological human–technology interaction research is known as *user psychology* (Moran, 1981; Saariluoma, 2004; Saariluoma & Oulasvirta, 2010). The goal in user psychological research is to explain phenomena typical to interaction between people and technology (Saariluoma, 2004). Such explanation requires explication of the phenomena and their associated problems in the language of psychological theory. The key reason for developing explanatory user psychology for analysis of human–technology interaction is to build a close connection between psychological research and design solutions, in the same way that research in the natural sciences is related to engineering design solutions (Pahl, Beitz, Feldhusen, & Groete, 2007; Ulrich & Eppinger, 2007).

Much attention today focuses on user experience (UX) research (Hassenzahl, 2008, 2010; Kuniavsky, 2003). Approaches such as *affective design* (Helander & Khalid, 2006; Khalid, 2004), *Kansei engineering* (Nagamachi, 2002, 2011), *emotional design* (Norman, 2004), *design for pleasure* (Jordan, 2000), and *funology* (Hassenzahl, Blythe, & Reed, 2002) emphasise investigating users as emotionally experiencing beings. Further, researchers maintain that it should also be possible to consider emotions when designing products and justifying design solutions. For full realisation of this agenda, the foundations of user experience research should be built on psychological concepts, principles, and theories. In other words, a user psychological analysis of user experience is required. We move in this direction by grounding the notion of user experience into the psychology of emotion and emotional human–technology interaction.

Emotion plays an indisputable and central position in psychological thinking (Beck, 1976; Ekman, 1999; Lazarus & Lazarus, 1994; Oatley, Keltner, & Jenkins, 2006; Power & Dalgleish, 1997). Rather than understanding emotion as the opposite of cognitive or rational behaviour and mere distraction, emotion can be understood as a critical part of effective decision making and learning (Damasio, 1994; Kahneman, 2011; Scherer, Schorr, & Johnstone, 2001). It is clear that emotion affects user behaviour and experience, but the exact role of emotion in user experience and human–technology interaction requires further investigation. How are emotions elicited when people interact with technology? How can we measure or otherwise investigate emotions during this interaction? How can we design for particular emotional user experiences?

Entertainment and art products, such as games, fashion, and films are designed to elicit emotional states, like pleasure, in people. Pleasing the user aesthetically is the goal of many design products like perfume, pottery, and furniture (Jordan, 2000). Achieving high aesthetic value in product design is based on understanding user emotion. From this perspective, it is understandable that the value of emotional research, that is, the research on emotional concepts, theories, and measurement practices, has increased its importance in human–technology interaction research. However, much of emotional design remains intuitive: designers ground their designs on how they feel and think, rather than on scientifically based objective measurements (Saariluoma & Maarttola, 2003).

Good designers conceive how our games, films, pottery, and clothes should appear and feel, and the emotional aspects of the products depend on their vision (Saariluoma & Maarttola, 2003). However, for some time now, the agenda has been to find a more scientific foundation for design solutions concerning the emotional dimensions of products. As an early example, Kansei engineering studied how one could measure emotional responses to products (Nagamachi, 2011). Domain-specific ‘Kansei-words’ were collected and used to generate measures, which were then used to acquire information about possible affective design goals (Nagamachi, 2011). Kansei engineering was founded on the Charles Osgood (1952) conception of psychology, which did not operate in a cognitivist framework. Osgood, and consequently Kansei engineering, did not use cognitive models of mind; hence this work lacks the power to explain the phenomena under investigation. Here, following the large cognitivist and emotional literature since Osgood, we take emotions and experiences as internal mental and thus representational states (Newell & Simon, 1972).

After Kansei engineering, the next, qualitatively different step in emotional human–technology interaction research was initiated by Donald Norman (2004). This author generated a psychological theory of emotions and wished to ground design argumentation on this description of emotional processes. He suggests that human emotions have three main conceptual levels: visceral (perception level), behavioural (expectation level), and reflective (intellectual level) (Norman, 2004; Norman & Ortony, 2003; Ortony, Norman, & Revelle, 2005). We maintain that, although this theory holds merit in deepening analysis of emotion in human–technology interaction, it does not sufficiently consider what emotional experience is like. This kind of analysis necessitates investigation of mental representations and mental content of users; we focus on these elements.

Modern psychology accepted mental representation as its basic analytical concept in the 1960s (Newell & Simon, 1972). Mental representation as a theoretical concept is used to describe how such information as memories, thoughts, ideas, precepts, motor movements, desires, and emotions exist in the human mind as representations (Fodor, 1987, 1990; Newell & Simon, 1972). To harmonise user experience research with modern psychology, it is essential to conceptualise emotions in human–technology interaction utilising the concept of mental representation (Moran, 1981; Saariluoma & Oulasvirta, 2010). This kind of analysis allows researchers to associate and to apply the achievements of 150 years of psychological research on the human mind to analysing and solving design problems (Saariluoma, 2004; Saariluoma & Oulasvirta, 2010).

Mental representation entails at least two layers of mental content. First, mental representation is cognitive and focuses on sensory and memory information. It can, then, contain information about space, objects, colours, movements, systems, laws, or non-perceivable elements. Second, mental representations entail emotional or other types of dynamic information. Emotional content contains such aspects of emotion as valence (positive and negative feelings), arousal (activating or deactivating feelings), mood, and emotional themes, such as fear, envy, rage, or happiness (Power & Dalgleish, 1997; Russell, 1980).

Mental representations also have conscious and subconscious parts. We can verbally express and explicate the contents of the conscious part (Allport, 1977), but the subconscious part is beyond our immediate explication. It is possible, however, to become conscious of the subconscious, as in the case of language grammar. Usually a native speaker cannot express the whole system of rules of the language, but these rules can be described by investigating what people speak (Berry & Dienes, 1993). Similarly, although it may not be always possible to explicate emotions during or after an experience, it is possible to study emotional user experience by analysing the representational systems that concern emotions. It is well known in clinical psychology that consciousness is the gate to subconscious emotional processes (Beck, 1976; Freud, 1917/2000). Representational systems of emotion can be explicated by experiment, as for example, in the classic Russell (1980).

In investigating conscious and subconscious aspects of user experience, it is essential to collect information about the mental content of conscious experience (Rauterberg, 2010).

This can be accomplished using various methods, such as verbal protocol analysis (Ericsson & Simon, 1984), retrospective interviews, observations, or questionnaires. Each of these methods have advantages and disadvantages, and their role in studying emotional user experience still needs further investigation (Vermeeren et al., 2010). We have previously used protocol analysis (Rousi, Saariluoma, & Leikas, 2010) and semantic differential scales (Saariluoma, Jokinen, Kuuva, & Leikas, 2013) to analyse user experience as mental contents. In the present article, our focus is on questionnaires about basic emotions.

The critical differentiating feature of modern user psychology compared to other approaches lies in explanation and explanatory thinking (Saariluoma, 2004). Basic psychological knowledge, such as the psychology of emotion, is taken as the basis of conceptualisation, operational definitions, interpretation of results, and explanation of outcomes. The classical theory of explanation thus provides us with a solid framework to rely on with respect to thinking about user (Achinstein 1983; Hempel & Oppenheim, 1948; Scriven, 1962; Sellars, 1963). In terms of user thinking, explanation is connected to both the phenomenon to be explained (explanandum) and the phenomenon which explains (explanans). In user psychology, conceptualisation and explanation are based on basic psychological concepts, for example basic emotions, and explanadum is the aspect of the user interaction process under investigation. The underlying structure of researcher thinking takes the schematic form: 1) define relevant interaction phenomenon, 2) conceptualise in terms of basic psychology, 3) respectively construct experiment, that is, operationalise theoretical concepts and design the testing process, and 4) use basic psychology in interpreting and explaining the outcome. In this way, user psychology allows systematic use of psychological knowledge, not just methodology, in working with interaction problems.

General Method

Operationalisation is a central step in any empirical research endeavour (Blalock, 1971; Bridgeman, 1927; Raykov & Marcoulides, 2011). In this process, theoretical concepts are transformed into empirical ones, which can be used in constructing empirical procedures. In our experiments, the focus is on the emotional dimensions of user experience. In the spirit of user psychology, psychological theory and empirical findings on emotion are applied to construct an empirical research approach. Thus, the content validity of the measures are supported by traditional psychological research.

In the studies reported here, emotional user experience is operationalised into questionnaire scales on subjective emotional experiences. In previous user experience research, questionnaires on affective or emotional responses of the user have included various semantic differentials (e.g., Hassenzahl, 2010; Hassenzahl, Burmester, & Koller, 2003; Mondragón, Company, & Vergara, 2005) and Likert-scaled questionnaires (e.g., Hassenzahl, 2008; Laugwitz, Held, & Schrepp, 2008). Emotion-related items in the questionnaires include, for example, enhancement, fascination, amusement, confidence, and satisfaction (Desmet, 2012), or inspiration, alertness, excitement, enthusiasm, determination, fear, nervousness, distress, competence, autonomy, and relatedness (Hassenzahl, 2008). Our experiments seek to determine the root of the emotional user experience by analysing the experiences of broadly understood basic emotions.

Our goal is to operationalise emotional user experience into questionnaire items of intuitively understandable basic emotions (Ekman, 2003; Power & Dalgleish, 1997; cf. Ortony & Turner, 1990; Scherer, 2005). This way, the participants could report the contents of their first-hand experience without too much interpretation and complexity. In user psychological concepts, human emotional experiences are based on emotional states. Emotional states are combinations of emotions in a representation. Basic emotions are not necessarily atomic, but are common and discriminating components of emotional states. It is also well known that the lists of what are basic emotions vary from 2 to over 15 (Power & Dalgleish, 1997; Spinoza, 1677/1955).

In investigating how people experience interaction with technologies, questionnaires allow subjects to report how they experienced the interaction situation. In comparison with open interviews or think-aloud procedures, questionnaires offer a more structured and standardised way to collect data, which can be analysed with statistical methods. In operationalising the questionnaire on emotional user experience, we consider emotion items from general sources of psychological studies of emotions (Ekman, 1993; Russell, 1980; Shaver, Schwartz, Kirson, & O'Connor, 1987; Yik, Russell, & Steiger, 2011), and sources in which emotions are studied especially as part of human–technology interaction (Hassenzahl, 2008; Juutinen & Saariluoma, 2007; Picard, 1997). The psychological ground theory relies on the theory of basic emotions (Ekman 1993, 1999; Oatley, 1992; Power & Dalgleish, 1997).

Efficacy and *excellence* are chosen as emotion-based questionnaire items, to represent participants' reflection of their own skills and capabilities. Efficacy means potency to produce effects and, respectively, the feeling of efficacy or self-efficacy refers to experienced personal efficacy (Bandura, 1982, 1993, 1995). *Determination* and *vigilance* are added to allow participants to reflect their autonomy, attentiveness, and exhaustion during interaction with the novel interfaces used in our experiments (Carroll & Thomas, 1988; Hassenzahl, 2008, 2010). *Pride* is included to determine whether successful interaction with novel interfaces is associated with being proud, that is, having joy over one's own performance, as suggested by Juutinen and Saariluoma (2007). To study the connection between pride and success in interaction, we add *successful*. Finally, we add an item for the amount of *control* the participants feel during the interaction. However, this item is not considered one of the emotion items, and is used only at the end of our analysis, where we combine the data from all experiments.

On the arguably negative side of interaction, we add *frustrated* (Juutinen & Saariluoma, 2007) and *anxious* (Liu, Agrawal, Sarkar, & Chen, 2009). Frustration is normally seen as the emotion arising when one cannot reach one's goal, and anxiety can be seen as fear of something unexpected and undefined (Lazarus & Lazarus, 1994). We expect these emotions to be visible after difficult interactions. To reflect the possible 'novelty problems' of the interaction, we add *confusion* and *annoyed* (Kuniavsky, 2003). To identify especially difficult interactions, *struggle* is added. Finally, *excited* is included to determine how arousing an experience the novel interaction would be (Hassenzahl, 2008).

The number of individual questionnaire items varies from 25 to 12 between the 3 experiments reported, but we choose to report only the emotion-related items listed above and relevant for our analysis. All questionnaire items for the three experiments are displayed in Appendices A, B, and C. The questionnaire for emotion-based items was presented to the participants at completion of the experiments, and participants were asked to reflect their experiences during the experiment using the questionnaire. The questionnaire is composed of statement-items such as '*During the test I felt determined*'. The items are scaled from one (*not at all*) to five (*very much*).

To study the nature of emotional user experience behind the questionnaire responses, we use multidimensional scaling (MDS). MDS is a statistical method which produces an *n*-dimensional representation of the similarities between the variables in the analysis. MDS is a good way of eliciting knowledge representations of individuals (Oldon & Biolsi, 1991), but it can also be used to explore more general inter-individual commonalities (Kruskal & Wish, 1978). The basic goal of MDS is to analyse proximity of the stimuli, such as questionnaire items (Nunnally & Bernstein, 1994). The S-Stress value from the MDS solution can be used to confirm how many dimensions are suitable for representing the data (Kruskal & Wish, 1978; Russell, 1980). Smaller stress values indicate better fit of the solution (Nunnally & Bernstein, 1994). There are no objective values for a good fit, but the stress values should stop decreasing during the first iterations. For our analyses, we report the first three stress values used to find the best fit of the MDS solution.

MDS has been used to analyse emotional response. In the classic study leading to the valence-arousal circumplex model of emotion, Russell (1980) asked participants to rate different emotions by their similarity and proceeded to generate a two-dimensional MDS configuration of the responses. In the same manner, similarities between emotional questionnaire items have been explored using MDS in the studies of, for example, musical expertise (Bigand, Vieillard, Madurell, Marozeau, & Dacquet, 2005), facial expression analysis (Alvarado & Jameson, 2002), and cultural differences (Fontaine, Poortinga, Setiadi, & Markam, 2002; Russell, 1991). Usually in such studies, the participants are asked to directly rate the similarities between two or more stimuli. In our experiments, however, the MDS was conducted to the correlation matrix of the emotion-based items. In the end, the result is the same: a proximity solution for the emotion-based items.

Often in MDS analyses of emotional response, the resulting solution is two-dimensional, and is interpreted by either naming the dimensions or creating groups of emotions to represent more general emotional factors. The groups of emotions, that is emotions that are closely related to each other, can be analysed by asking what general factors might be behind them. Dimensional analysis, on the other hand, often reveals at least one strong judgment category, *valence*, and possibly two more, *arousal* and *potency* (Desmet, 2012; Russell, 1991; Yik, Russell, & Steiger, 2011). As shown below, both of these ways of interpreting an MDS configuration can be used to study emotional user experience as mental contents.

In the present study, MDS is used to produce a two-dimensional, visualised configuration of the similarities or dissimilarities between the emotional questionnaire items. The MDS solution is obtained using the ALSCAL program in PASW Statistics 18. The program is instructed to create distances from the correlation matrix of the emotion items using Euclidian distance interval, and the transform values are Z-score standardised for better visualisation. From the observed configuration of the items, we aim to construct sum variables which could represent more general factors of emotional user experience. We use the terms ‘factor’ and ‘group’ to refer to the salient configuration of proximal emotion items. Cronbach’s alphas are calculated to confirm a suitable internal consistency of the items and the reliability of the sum variables. The sum variables are calculated as the mean of the emotional questionnaire items included in the sum variable. In this way, the sum variables retain the original scale (from one to five) of the questionnaire.

Experiment 1

Method

In the first experiment, the participants used a touch-screen–based interface to control automated features of a miniature crane. $N = 19$ participants (10 male, 9 female; age range 20–56, mean age 26.5, $SD = 8.9$) were recruited for usability tests of a new touch-screen based user interface. The participants were university students with no prior experience of crane operation. However, the experimental tasks required no prior knowledge, and all participants understood and accomplished the tasks. Although the participants had used touch screen devices before, the combination of crane driving and touch screen controls made the interaction novel and, at times, complex, as was evident in the verbal reports of the participants.

The participants used an ordinary game joystick (Logitech Extreme 3D pro) to control a miniature bridge crane with a working area of 0.6 metres times 1.5 metres. The miniature crane was a model of an overhead bridge crane, and was constructed for this experiment. It had three degrees of freedom (moving directions): the girder (bridge) could be moved forward of backward, the trolley left or right, and the hook up or down. Each of these directions could be controlled using the single joystick.

The crane was programmed with automated features which were used to position the crane automatically and control operating area limits. The touch screen user interface was implemented on a 7-inch Samsung Galaxy tablet with Android 2.3 operating system. Two differing user interface variations were constructed: one with an interactive map of the miniature crane's operating area and one with only buttons and symbols to achieve similar interaction. The user interface was designed to control the automated features implemented in the crane. The use of a joystick to control the three degrees of freedom of the crane, combined with the use of a touch-screen to control the automated features, made the control process novel and demanding to the participants.

This experiment was a between-subjects design, with the participants divided equally into two groups of ten participants. The first group used the map-based touch screen controller and the second group a buttons and symbols-based touch screen controller. The joystick controller was same for both groups. Both groups conducted four tasks which required utilisation of both the joystick and the touch screen controller. Each participant conducted the tasks in the same order, as the research interest was not in the difference between tasks, but on the participants' whole emotional experience during the experiment.

After the participants had completed given tasks using the miniature crane, they completed a questionnaire with emotion-based items concerning their experiences during the experiment. The emotions included are shown in Figure 1, and introduced in the general method section. In the data analysis, MDS was conducted on the emotional questionnaire items. Proximities between the items were analysed using visual inspection and Cronbach's alpha, and sum variables were constructed. The role of analysis in this experiment was exploratory, and we refrain from making hypotheses for the analyses. In the next two experiments, hypotheses created on the basis of the first experiment are stated.

Results

The stress values for the first three iterations of the MDS were .186, .160, and .158. The two-dimensional configuration of the emotional items is set forth in Figure 1. Two main emotional groups are identified from the configuration. The first group consists of feeling successful, efficacious, and vigilant. The second group consists of feeling frustrated, annoyed, confused, and anxious. These two emotional groups are situated on opposite sides of each other on the x-axis, which we interpreted as valence dimension (Russell, 1980, 1991).

Two sum variables were constructed to represent the two groups or factors of the emotional items. The first factor was designated *Competence*, and the internal consistency of the three items calculated into the sum variable was $\alpha = .768$. The mean of the Competence sum variable was 3.67 ($SD = 0.60$). The second factor, consisting of four items, was designated *Frustration* and had an internal consistency of $\alpha = .832$. The mean of the sum variables was 2.05 ($SD = 0.83$), which is considered relatively low (on the scale, 1 = '*none at all*' and 2 = '*a little*').

Competence was negatively associated with *Frustration*, as revealed by Spearman correlation, $\rho = -.579$, $p = .009$. This is expected, as the two groups are clearly situated on opposite sides of the MDS configuration. To see whether the two groups of participants (map- or symbol-based touch screen) gave different emotional responses as measured by the two factors, independent-sample t-tests were conducted. Somewhat surprisingly, we observed no difference in the means of the sum variables between the two user interface groups ($p > .05$ for both *Competence* and *Frustration*).

Discussion

By asking university students to perform tasks on unfamiliar technology, we aimed to elicit clear emotions associated with novel human technology interaction. The emotional experiences of the participants were collected using a questionnaire containing a collection of emotion-based items. Multidimensional scaling of the chosen questionnaire items revealed two main groups, or factors, of emotions, *Competence* and *Frustration*. The main dimension separating the two groups was identified as emotional valence: how pleasant or unpleasant the emotions were.

This finding is in line with classical studies of emotion (Russell, 1980, 1991), although the other commonly identified dimension, activation or arousal, was not observed. The lack of the arousal dimension seems, however, to be common in many studies of emotional experience (Desmet, 2012). Emotional arousal is perhaps more difficult to elicit during human–technology interaction than emotional valence: our questionnaire did not contain the necessary items to reveal such dimension, and our experiment did not create enough emotionally arousing conditions.

Valence is a basic content dimension of human emotion (Frijda, 1986; Russell, 1980, 1991), and as such, is compatible with our mental contents approach. Attributing valence to an emotion gives the emotion content-based significance. Another important consideration regarding the mental content of emotions is emotional theme, or narrative. The focus of this concept is the difference between different emotional states with respect to their contents. Anger, for example, differs from happiness, as the former is related to being threatened or offended, while the latter refers to a state of well-being and joy.

Of the emotion-based items of positive valence, efficacy, success, and vigilance were clustered. Feeling efficacious reflects being successful in producing intended results and controlling events (Bandura, 1982, 1993), and is very important in creating a pleasant user experience in novel interactions. Feeling of success is hence in line with the given emotional state. Feeling vigilant reflects being alert and watchful for risky events, which demands mental effort (Kahneman, 2011). In many cases of complex novel interaction, where safety is of concern, producing vigilance on both the cognitive and emotional levels is a requirement for good user experience. An experience of this sort is identified as one of the main goals of user–experience-focused design thinking (Hassenzahl, 2008). We feel that the label *Competence* best describes this emotional user experience factor (Gravill, Compeau, & Marcolin, 2006).

The other cluster of emotions was connected by negative valence. Frustration can be seen as an emotional response to opposition, obstacles, or blockade of action (Juutinen & Saariluoma, 2007). Confusion refers to the inability to get a clear picture of the demands of the interaction situation, and is especially critical in novel or complex interactions. Anxiety refers to feelings of uncertainty, fear, and uneasiness, when no definable object is present (Power & Dalgleish, 1997). Annoyance is a state close to aggression, and a typical accompaniment to frustration. These feelings are understandably closely linked to both confusion and frustration. Confusion covers a definable target and leads to frustration as well as to anxiety and annoyance. Here, we label this combination of feelings under the common label *Frustration*, and see it as opposite to competence (Juutinen & Saariluoma, 2007).

People who are able to use given technologies evidently see their competence in a positive light. They reach their goals in using the given technology, and consequently feel themselves to be skilled, capable, and able to focus on the tasks at hand. The lack of frustration follows from not being confused and angry with a piece of technology, and being able to reach personal goals with that technology. The experience of competence creates confidence, and this is based on the experience of smooth performance and interaction.

As the result of the first experiment, we suggest a bipolar *competence-frustration hypothesis*, which generalizes our earlier pride–frustration thinking (Juutinen & Saariluoma, 2007). The ability to use technology generates a positive user experience, which can be observed as emotions clustered around the *Competence*. On the other hand, the inability to successfully interact with technology causes negative user experiences, which can be observed as emotions clustered around the *Frustration*. We propose that the emotional experience associated with successful use of new technology varies between these two poles. This is evident in the negative correlation between *Competence* and *Frustration*.

Experiment 2

The first experiment resulted in a competence–frustration hypothesis of user experience in a novel interaction scenario. In the second experiment, we tested this hypothesis by again bringing participants into novel interaction and measured their emotional responses. Further, we repeated the same interaction with modifications to the interface, which resulted in two sets of emotional responses by one participant and hence allowed further tests for reliability of the measurement scales of emotional user experience. The hypotheses are:

H_1. Two emotional dimensions of user experience, separated by their valence, emerge in interaction novel user interface. These are *Competence* and *Frustration*.

H_2. There is a negative correlation between *Competence* and *Frustration*.

Method

Ten (N = 10) university students (5 male and 5 female, 19–29 years-old, M_{age} = 23.3, SD = 3.7) were recruited to perform interaction tasks using a computer simulation of a remotely controlled port gantry crane. None of the participants had participated in the first experiment, and operation of cranes was new to all of them. The simulator used two joysticks (Logitech Extreme 3D pro) to achieve five movement directions (east-west, north-south, up-down, tilt, and skew), which created a complex control situation in an environment unfamiliar to the student participants. The simulator had two remote operating layout designs: a layout without modifications and a modified interface with dynamic layout aids to help the user in controlling the crane. The simulator was designed at Tampere Unit for Computer-Human Interaction (TAUCHI). The goal of the user tests was to study whether the dynamic aids help the user to control the crane. However, here our focus is on the emotional questionnaire responses of the participants, not on the dynamic operating aids.

Participants were asked to perform a series of tasks using the simulator in two parts. A single task was either lowering a cargo container onto a truck, or lifting a container from a truck. Different container sizes and changing wind conditions were used to introduce variance into the tasks. In the first part of the experiment, the participants performed baseline tasks using the normal interface. In the second part of the experiment, they performed similar tasks using the interface with a dynamic layout, which consisted of automatic camera zooming and augmented reality aids: direction arrows showing the direction and speed of the crane, and arrows suggesting the correct placement of the crane in the task. A period of ten minutes was reserved to perform as many tasks as possible in both parts of the experiment. After both task blocks, the participants completed a questionnaire with emotion-based items.

We reduced the number of emotion-based questionnaire items to 12. This was done to lessen the participants' load of answering too many questions during the experiment, because the emotion-based questionnaire was completed twice during the experiment, and because the experiment involved additional questionnaire scales not reported here (such as feeling of presence, which is important with respect to the remote operation concept). H_1 was tested with visual inspection of the MDS solution, created in a similar manner as in the first experiment. Cronbach's alpha was also calculated for items clustered together to confirm the reliability of the scales for the *Competence* and *Frustration* factors. H_2 was tested with Spearman correlation of the sum variables of these two scales.

Results

The stress values of the first three iterations for the emotional responses for the first part of the experiment were .122, .105, and .105. The MDS configuration of the responses is shown in Figure 2. As in the first experiment, and supporting the first hypothesis, two groups of emotions were observed. The sum variable *Competence* in the baseline tasks had an internal consistency of $\alpha = .874$, and included emotional items efficacy, excellence, pride, determination, and vigilance. Its mean was 3.32 ($SD = 0.81$). The sum variable *Frustration* in the baseline tasks include variables annoyance, confusion, anxiety, frustration, struggle, and excitement. It had an internal consistency of $\alpha = .908$ and its mean was 2.13 ($SD = 0.76$). Regarding H_2, the Spearman correlation between the factors was negative, but statistically non-significant, $\rho = -.346$, $p = .328$.

For the emotion-based items from the second part of the experiment, with the tasks with dynamic layout, the stress values of MDS were .206, .163, and .161. The configuration is shown in Figure 3, and shows a similar grouping of emotion-based items as in the first part of this experiment. The sum variable for the *Competence* factor had the same five items as in the first part of the experiment, an internal consistency of $\alpha = .821$, and a mean of 3.40 ($SD = 0.67$). The sum variable for the *Frustration* factor also had the same items as in the first part of this experiment, although this time the items were not as close to each other. This is evident in a slightly lower consistency of $\alpha = .794$. The mean of the sum variable was 2.03 ($SD = 0.67$). Visual inspection and Cronbach's alphas confirm H_1 again. Regarding H_2, Spearman correlation revealed no association between feeling competent and frustrated, $\rho = .053$, $p = .884$.

Discussion

The second experiment resulted in similar clusters of emotion-based items as the first experiment, confirming H_1. Similarly, the emotional groups were separated from each other along a clear emotional valence dimension. Six emotion items of positive valence, and five of negative valence, were identified and included in the summated scales for the *Competence* and *Frustration* factors. Contrary to the results of the first experiment and H_2, we observed no correlation between feeling competent and feeling frustrated. It is possible that the association between these two emotional user experience factors is dependent on the nature of the interaction. Closer inspection of the items of the factors and their correlations with each other may reveal some details of the relationship between the two factors. This analysis is conducted in the end-section of experiment three of this article.

With the addition of determination and pride into the *Competence* factor, the description of this hypothesised emotional user experience factor becomes clearer. Feeling proud refers to satisfaction elicited from successful technology use (Juutinen & Saariluoma, 2007), and feeling determined shows how competence is associated with autonomy during such use (Hassenzahl, 2008). Especially in the case of novel or complex user interfaces, these emotions are clearly important for the feeling of competence. Regarding the new items of the *Frustration* factor, excitement and struggle both indicate how frustrating situations can also be accompanied by emotions of high activation or arousal. These emotions are elicited when the interface cannot provide sufficient support for work tasks, and the user must struggle to accomplish them.

The results of the first two experiments show that the factors of emotional user experience can be analysed using different emotional items. Our contention is that, although different emotions are elicited in different interactions, and although the same interaction can be analysed with different methods comprising different sets of emotion-based items, in the end, the emotional user experience can be analysed via the same two factors, *Competence* and *Frustration*. The reliability of these two scales is supported by the fact that very similar patterns emerged during two distinct interaction tasks. However, these results are from a controlled laboratory environment. To confirm that our results are not artefacts of laboratory experimentation, they need to be replicated in a naturalistic setting.

Experiment 3

The first and second experiments reported above were conducted in a laboratory environment with user interfaces and tasks, which were novel to the participants. In the third experiment, we used the same basic concept of using questionnaires immediately after a novel interaction scenario to analyse emotional user experience. However, this time we wished to test the ecological validity of our model (Neisser, 1976), and analyse how the participants would accept a new interaction concept into their existing work routines in an environment familiar to them. The study was conducted as a part of an evaluation of a new gesture-based, loading-station control concept.

For the hypotheses of this experiment, we included the two from the previous experiment, but now the goal was to confirm or reject these hypotheses in the field. In addition, because now there was interest in user acceptance of the new interaction concept, two hypotheses concerning acceptance were added. The logic behind the third and fourth hypotheses is that technologies supporting competence are more easily accepted than technologies causing frustration, as is argued in studies of online-learning tools (Juutinen & Saariluoma, 2007).

H_1. Two emotional dimensions of user experience, separated by their valence, emerge in interaction novel user interface. These are *Competence* and *Frustration*.

H_2. There is a negative correlation between *Competence* and *Frustration*.

H_3. Feeling frustrated during the use of novel interaction technologies decreases technology acceptance.

H_4. Feeling competent during the use of novel interaction technologies increases technology acceptance.

Method

N = 21 operators and designers (19 male, 2 female; age range 18–54, mean age 35.7, *SD* = 9.4) participated in a usability study of a loading platform controlled via gestures. A loading station is a part of a manufacturing automation system: the user of a loading station attaches raw material to a pallet in the station and sends it to the next step in the manufacturing process. A control panel is used from a safe distance to control the pallet, and the new concept evaluated in this experiment is to replace the manual controllers with gesture-based controls. All participants were familiar with the tested loading station operations, and worked at the site chosen for the user evaluations.

Eight gestures were designed to be used to fully control the normal operations involved with loading station work. Participants were asked to perform gestures in front of a loading station simulator, which consisted of a large computer screen (40 inches) and a gesture detector (Microsoft Kinect). The simulator was created in Tampere Unit for Computer-Human Interaction (TAUCHI), and its specifics are reported by Heimonen et al. (2013). Gesture-based interaction was a novel concept in the factory environment, and the participants had no experience of using gestures to control factory automation.

After trying out the simulator with a number of example tasks, the participants completed a questionnaire with the emotion-based items. Further, to test H_3 and H_4, a scale of acceptance of the gesture-based interaction was included. The scale consisted of the following items used to appraise the gestures: ‘intelligent’, ‘professional’, ‘safe’, and ‘needful’. We also asked about the physical demand of the gestures, but the responses to this question are not part of the analysis conducted here.

The data were analysed in a similar manner as in the two experiments reported above. H_1 was tested using visual inspection of MDS results, as well as calculating Cronbach’s alphas for the two groups of emotions. H_2 was tested, as in the second experiment, by taking the Spearman correlation of the two sum variables representing the two factors of emotional user experience. H_3 and H_4 were tested by correlating the two sum variables with the four items of the acceptance scale.

Finally, to explore first and the second hypotheses in more detail, a combined dataset of the three experiments was constructed. Since no participant took part in more than one experiment, the data consist of $N = 50$ individual participants: 19 from the first experiment and 21 from the current, third experiment; from the second experiment, we chose the 10 responses from the second task. There are only seven emotional questionnaire items common in all three experiments, and all were included in the dataset. Principal Axis Factoring was used to confirm H_1. Promax rotation, allowing correlation of the factors, was used to investigate possible correlations between *Competence* and *Frustration*.

In addition, all three experiments had a questionnaire item concerning feeling of control during the experiments. The experienced control potential is an essential part of the emotional appraisal of a situation (Roseman, 2001). Feeling of control has been studied as an important factor in flow experience, for example, and on an emotional level has been argued to be connected to enjoyment (Sweetser & Wyeth, 2005). Although feeling of control was not part of our main investigation of emotional user experience, we analyse, post hoc, the association between the *Competence* and *Frustration* factors and feeling of control. Is feeling of control positively associated with *Competence*, and negatively associated with *Frustration*, and what is the strength of this association?

Results

First, the data from the field experiment alone were analysed. The stress values for the first three iterations of the MDS of the emotion-based items were .181, .160, and .158. The configuration of the two-dimensional solution is shown in Figure 4. As in the first and second experiments, two groups of emotion-based items are observable. The sum variable for the *Competence* factor included pride, determination, vigilance, efficacy, success, and excellence, and had a consistency of $\alpha = .847$; its mean was 2.94 (*SD* = 0.84). The sum variable for the *Frustration* factor included frustration, desperation, and anxiety. We excluded feeling excited, because it was not very closely associated with the other three variables. The reliability of the three items were $\alpha = .804$, and the mean of the sum variable was 1.40 (*SD* = 0.51). The results confirm H_1. As in the second experiment, but unlike in the first, we observed no association between the two emotion-based variables, Spearman correlation $\rho = –.292$, $p = .199$. We hence reject H_2.

The summated scale for the *Frustration* factor had high correlation with acceptance of the gesture-based interaction concept. The Spearman correlations of *Frustration* and the acceptance scale items were following: intelligent, $\rho = –.542$, $p = .011$; professional, $\rho = –.587$, $p = .005$; safe, $\rho = –.671$, $p = .001$; and needful, $\rho = –.509$, $p = .018$. We accept H_3: feeling frustrated during novel technology use predicts non-acceptance of the technology. However, no statistically significant correlations were observed with the summated scale of the *Competence* factor and the items in the acceptance scale. We reject H_4.

Finally, for a deeper inspection of emotional user experience, especially regarding H_1 and H_2, the data of the three experiments were combined. The stress values of the MDS for the combined dataset for the three experiments were .145, .125, and .123. The resulting two-dimensional configuration is displayed in Figure 5. The emotional valence is once again clearly visible, but it is now also possible to observe the second dimension, arousal. Although arousal creates weaker segregation of emotions than valence, it seems that excellence, for example, is more arousing emotion than efficacy. The dimensions of emotional user experience are now named accordingly in Figure 5.

The Promax-rotated factor matrix of the Principal Axis Factoring is displayed in Table 1. We observed the expected factors of emotional user experience, again supporting H_1. These factors explained 62.0% of the total variance of the emotional questionnaire items. This, and sufficient factor loadings of the items, is taken as evidence supporting H_1. Because Promax rotation allows correlation between the factors, the results displayed in Table 1 can also be used to analyse H_2 hypothesis two in more detail. It seems that efficacy is the only item with strong negative loading on the factor of opposing valence, whereas excitement has positive correlation with both factors.

Based on factor analysis, sum variables for *Competence* and *Frustration* were calculated using a regression method, in which individual emotions contribute to the summated scale according to their factor scores. Although some items had cross-factor loadings, no correlation between *Competence* and *Frustration* was observed, $\rho = –.040$, $p = .785$. In the post hoc analysis of feeling of control, we observed, as expected, a positive correlation between feeling of control and *Competence*, $\rho = .435$, $p = .002$, and a negative correlation between feeling of control and *Frustration*, $\rho = –.472$, $p = .001$.

Discussion

The context of the experiments reported here was that of novel or complex human–technology interaction. The students in experiments one and two were faced with unfamiliar crane operation tasks (either with miniature crane or a crane simulator), and had to use a combination of joystick and touch screen (first experiment), or a combination of two joysticks (second experiment). In the third experiment, the industrial work environment and the context of factory automation added an element of complexity, and the use of gestures to manipulate the loading station was a novel control scheme for participants. Hence we limit our discussion to novel interfaces. However, further study of competence and frustration in other contexts is warranted.

The third experiment yields the same general result as the first and second experiments, by confirming H_1 about the bipolar competence–frustration model of emotional user experience. However, this time the study was conducted ‘on the field’ to test the ecological validity of our hypothetical model. Although the experiment involved using a simulated environment, the participants were familiar with the loading station used in the simulation, and knew the environment in which the experiment was conducted. This allowed us to confirm that the results were not artefacts of a laboratory environment, but reflect the emotional experience of novel interaction situations. In other words, we can now maintain, with strong evidence, that the scales presented for measuring *Competence* and *Frustration* have validity.

The two factors of emotional user experience were again separated by their valence. This time, the emotion-based items of the *Competence* factor were determination, excellence, pride, efficacy, and vigilance. Items for the *Frustration* factor were anxiety, desperation, and frustration. Since the experiment concerned real users of the proposed novel interaction concept, we were also interested in how the emotional user experience was associated with acceptance of the new technology. The results indicated that negative emotions, summated as the *Frustration* factor, were strongly associated with not accepting the proposed technology. The *Competence* factor, on the other hand, was not observed to have such associations. It may be possible that, whereas feeling competent is associated with own skills and capacities, feeling frustrated is more easily attributed to faults in the technology.

Minimising frustration in interaction with new interfaces is important regardless of how competent the user feels. This is an important notion in relation to much of current user experience research, which advocates the study of mainly positive user experience (e.g., Desmet, 2012; Hassenzahl, 2008). The negative emotional user experience has been shown to have its own relevance, which cannot be reduced to non-positive emotional user experience. The positive *Competence* factor and the negative *Frustration* factor are not necessarily correlated, and they clearly have differing associations, for example with acceptance of new technology. Negative user experience needs to be taken explicitly into account in design.

By combining data from all three experiments, we were able to analyse $H_{1,}$ that is, the competence-frustration hypothesis, in more detail. The resulting factor matrix is useful in determining how relevant the individual emotion-based items are for the user experience factors. It seems that vigilance, excellence, and determination all have very similar correlation to feeling competent, whereas the role of efficacy in the formation of self-perceived competence seems to be, although clear, not as strong. Also, H_2, that is, the association between the two factors can now be analysed. It seems that *Frustration* is negatively associated with efficacy, but not with other items of *Competence*. This is one more argument for supporting the separate treatment of positive and negative factors of emotional user experience.

Of the emotion items analysed with the factor analysis, only excitement seems to load positively on both factors. This suggests that feeling excited during novel interaction can be either pleasant or unpleasant, depending on the other emotions experienced. This is understandable, but leaves open the question of whether user experience focused design should aim for exciting interaction. Excitement is often linked to positive user experience (Mandryk, Inkpen, & Calvert, 2006; Hassenzahl, 2008), but it seems that the case is not so straightforward. Our result also differs from the results of Hassenzahl (2008, pp. 13–14), who expect excitement to be associated with competence. Whereas we observed the positive correlation of excitement and competence suggested by Hassenzahl (2008), excitement was also observed to correlate positively with frustration. The role of excitement in emotional user experience remains, hence, to be investigated further. This line of research could also provide more detailed understanding for the notion of arousal as a dimension of emotional user experience.

In interaction with novel or complex interfaces, feeling of control is an important source of positive emotional user experience (Desmet, 2012). Our studies were not designed to investigate feeling of control, but in each of our experiments one questionnaire item was dedicated to it. Post hoc analysis suggests that feeling of control is strongly associated with emotional user experience, but more detailed investigation of this association would require its own experiments and field tests, as well as good and theoretically coherent operationalisation of feeling of control. However, once again it is evident that feeling of control is related to both positive and negative user experience, and hence feelings of competence and frustration may have unique associations with it.

In further studies analysing the competence–frustration model of emotional user experience, it becomes important to fix the emotion items to those best suited for analysing the factors. The reliability of the factors in different experiments was good despite the change in emotion-based items between the experiments; but in order to create a consistent measurement model, the items should be fixed. We suggest that to measure the *Competence* factor, the four bolded items in Table 1 suffice. As for the *Frustration* factor, anxiety and frustration are evident items. We further suggest completing this scale with annoyance and confusion, as they were most consistently associated with anxiety and frustration. The composition of the two factors of emotional user experience in the three experiments is displayed in Table 2. Further studies confirming the chosen four-item scales in different contexts are warranted, and the next step would be to show that the interface design can cause noticeable variation in emotional user experience as measured by the *Competence* and

Frustration factors. Also of future interest is the relation between the traits of the users (such as the capacity to adapt to new technologies) and the states of emotional user experience (for a discussion on the trait/state problem of the subjective measurement of emotions, see Schorr, 2001).

General Discussion

User psychology begins with the idea that human–technology interaction phenomena can be analysed, conceptualised, tested, understood, and explained using psychological concepts, theories, facts, and methods (Saariluoma, 2004; Saariluoma & Oulasvirta, 2010). As such, user psychology does not differ, but in its topic of research, from such established directions of psychology as child psychology (Piaget, 1970), engineering psychology (Hollands & Wickens, 2000), and clinical psychology (Beck, 1976). In the same way, user psychology sets its questions and answers in the context of general psychological knowledge and research.

On the other hand, user psychology differs from the other paradigms of user experience research, as it begins with psychological concepts, methods and theories. The operationalisation, research, and analysis of results can and should be intimately connected and explainable in terms of modern psychology (Saariluoma, 2004). In the studies reported here, we follow the user psychology methodology by conceptualising emotional user experience in terms of mental representations. Scales for measuring emotional user experience are operationalised and formulated in concepts of established theories of emotion. As a result, the major concepts of emotional user experience are expressed psychologically, and connected to general psychological knowledge.

A central theoretical concept of modern psychology has been mental representation (Newell & Simon, 1972), and its content (Fodor, 1990; Saariluoma, 2003). Experience is always with content, as experience without content could hardly be experienced. Thus, it is logical to investigate emotional user experience using the psychological concept of mental contents. The goal is to open the structure of contents and give clarity to the contents of experience as well as underlying systems of subconscious associations.

As the result of our experiments, we postulate mental representations underlying emotional user experience and concentrate on analysing the role of basic emotions in user experience (Power & Dalgleish, 1997). The core idea of theories of basic emotions is that people have a set of basic emotions which are used to construct human emotional experience (Ekman, 1999; Oatley 1992; Power & Dalgleish, 1997). This idea has several times been proposed in history by such thinkers as Aristotle and Darwin, although it also has been criticised as difficult to validate empirically (Ortony & Turner, 1990; Scherer, 2005). However, we contend that asking users to reflect their emotional experience, using basic emotion words, is a valid way of investigating emotional user experience. This helps in understanding the contents of constructed situations and specific emotional states, and provides a way to carry out psychologically valid user experience research.

In the spirit of basic emotion theory, all experiments result in two different clusters of constructed emotional states, which are divided by valence. In the concluding analysis, all clusters were analysed using factor analysis, resulting in two factors of emotional user experience. The first factor, located on the positive side of the valence dimension of emotional user experience, is labelled *Competence*. The second factor, organized on the negative side of the valence dimension, is labelled *Frustration*. If an explicit emphasis on the technological nature of these factors is required, the labels *Techno-competence* and *Techno-frustration* can be used.

In our study, techno-competence was a feeling based on such basic emotions and experiences as determination, vigilance, pride, excellence, and efficacy. Together, all these emotions express a mental state, which people have when they can use technology to reach what they need to reach. Overall, the valence of such a mental state is positive, because all the involved feelings are positive. Techno-frustration is not the direct opposite of techno-competence, as revealed by different correlation analyses and the concluding factor structure. Nevertheless, it is a negative state of mind characterized by such emotional states as frustration, annoyance, anxiety, confusion, and struggle. This emotional state typically expresses what people feel when they are unable to or uncertain in using technologies in a specific situation, and was shown to negatively predict acceptance of new interfaces.

It is important to acknowledge the presence of negative, or unpleasant, emotions in human–technology interaction. Many sources understandably emphasise positive emotions (e.g. Desmet, 2012; Hassenzahl, 2008), but the design of technology should always take into account both pleasant and unpleasant emotions. Our model of frustration, for example, can be used to improve the content validity of studies of negative emotions during technology use. Liu, Agrawal, Sarkar, and Chen (2009) examine anxiety levels using both subjective measurement scales and physiological data, but do not explicate their measurement of the subjective experienced anxiety. Although objective, physiological and neuropsychological methods are increasingly important in studying emotional user experience (Mandryk, Inkpen, & Calvert, 2008; Pecchinenda, 2001), the results of these objective measurements need to be content-validated in the context of subjective experience.

To understand the proposed competence–frustration model correctly, it is important to understand that in our experiments the participants interacted with user interfaces which were new to them. The experimental situations were organized around the issue of whether people can use the given new technologies, and what immediate emotional experiences were associated with this question. The ‘can’ questions are currently one of the main issues in usability research and design. If technologies have poor usability, people cannot use them.

Hence the extracted emotional mental contents are relevant for usability and subjects' ability to use technologies.

The deeper meaning of the competence–frustration model is that it associates two main concepts and problems of interaction research with each other. The model illustrates what kinds of emotional consequences are associated with difficulties in using technology. The user experience of poor usability activates negative emotional contents of different types, while good usability generates positive feelings. Our experiments thus illustrate that poor usability has essential emotional costs and this explains why people are often poorly motivated in using technologies with poor usability or that are difficult to learn. In sum, we suggest that analysis of emotional interaction can be based on resolving the contents of total emotional states in component emotions, and that this is a fruitful way of approaching user experience research. These emotional user experience factors and dimensions can then be connected to what is known about the contents of these emotional states. It is thus possible to gain a more elaborated conception of the emotional state which prevails during a human–technology interaction process.

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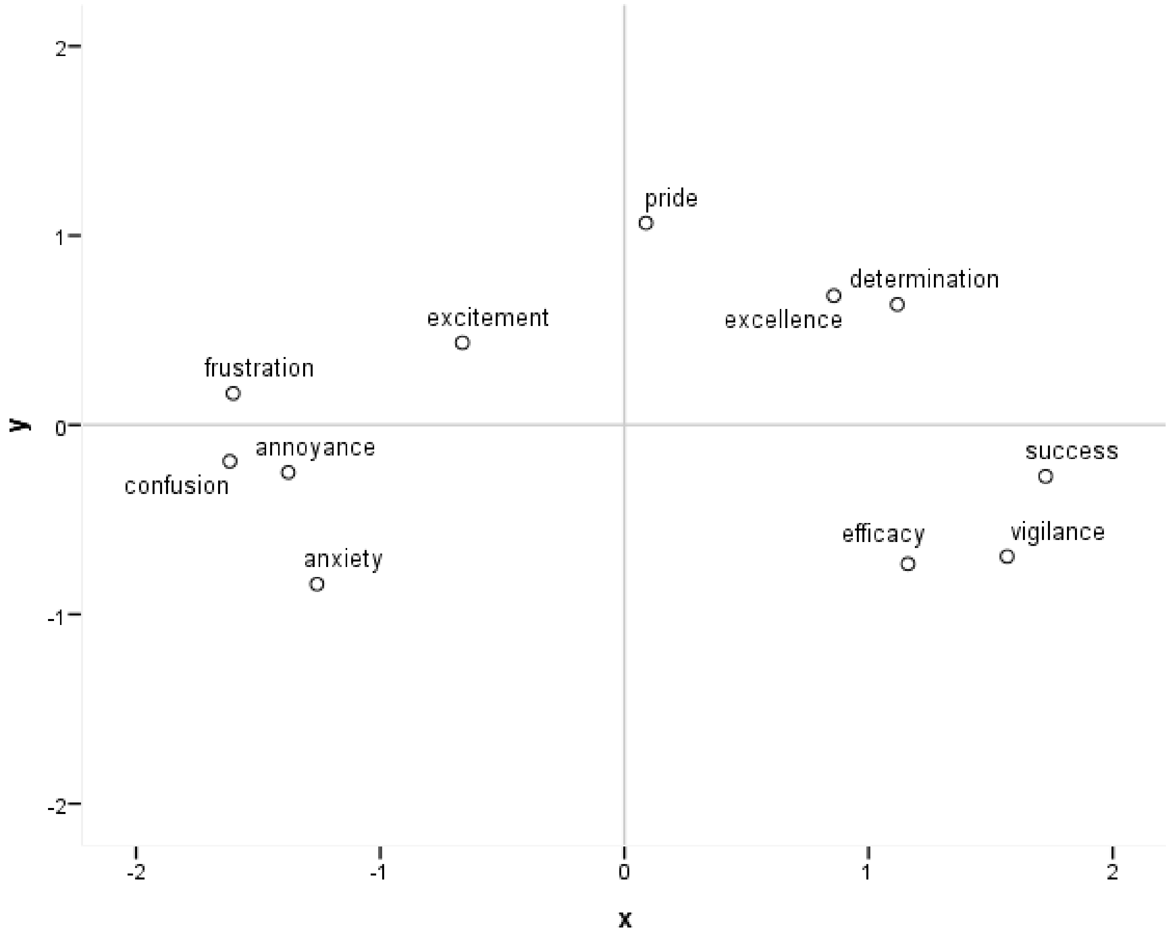

Figure 1. MDS configuration of emotional questionnaire items. First experiment.

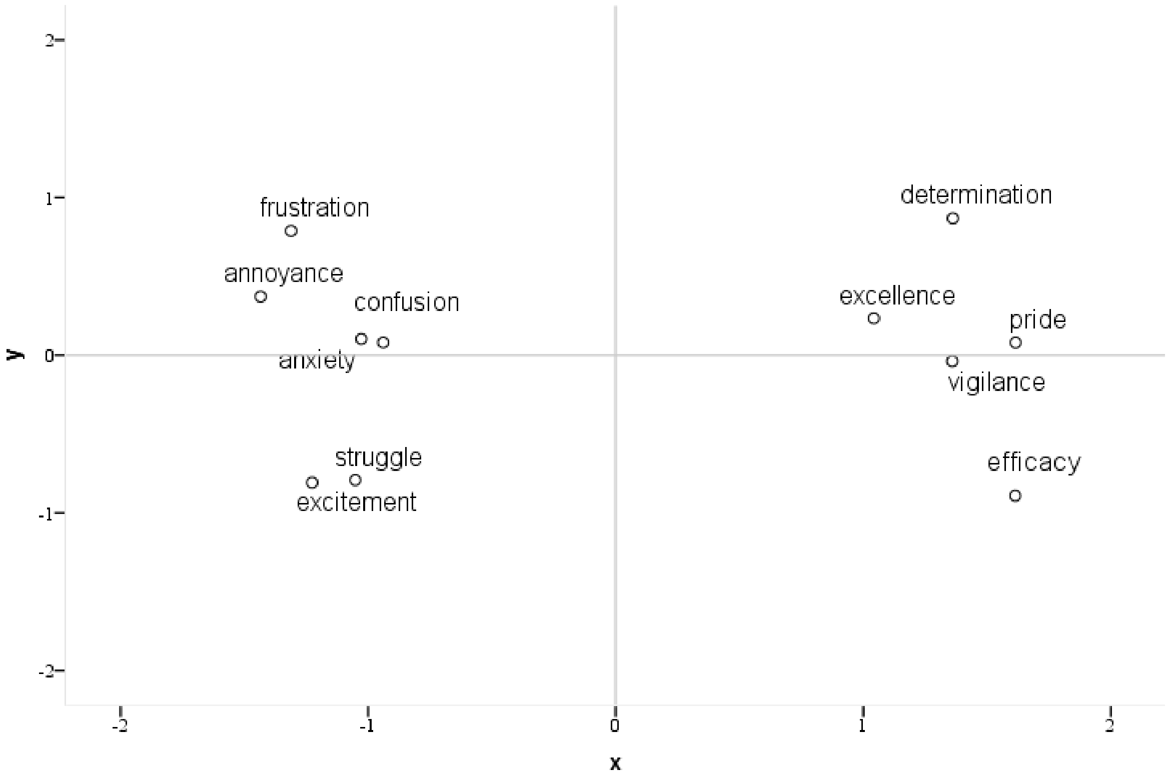

Figure 2. MDS configuration of emotional questionnaire items. Second experiment, baseline tasks (no dynamic layout).

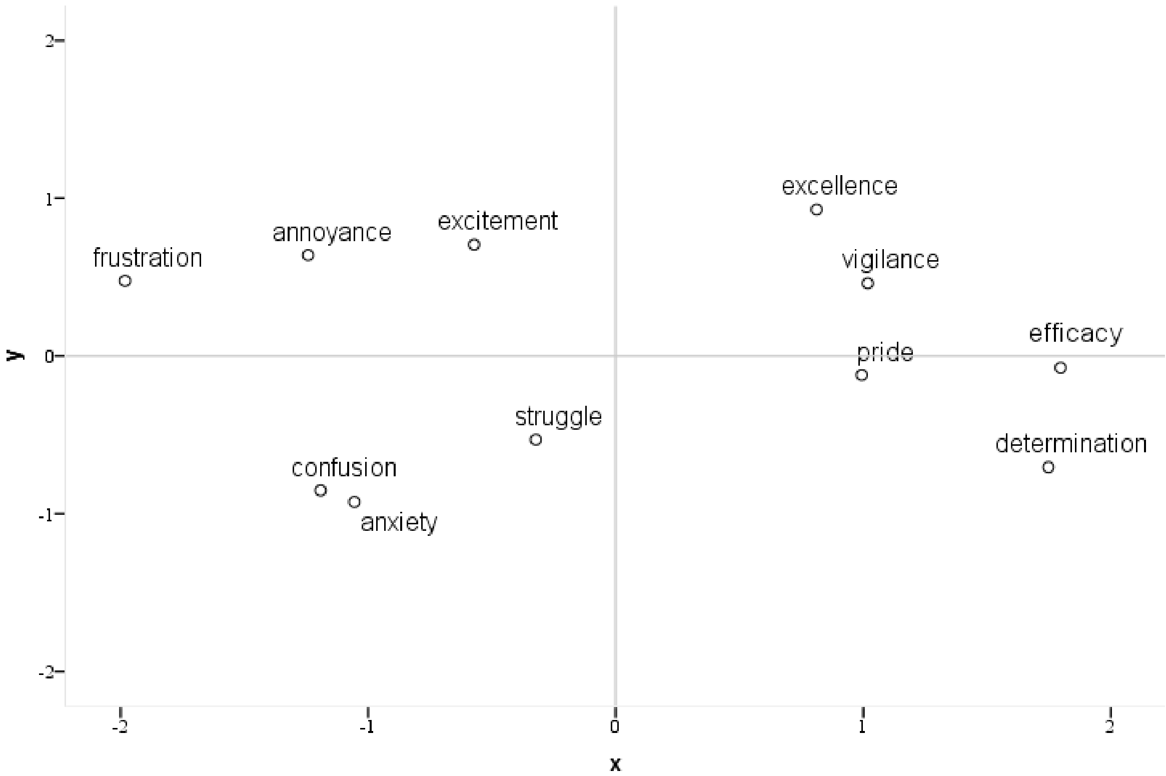

Figure 3. MDS configuration of emotional questionnaire items. Second experiment, dynamic layout tasks.

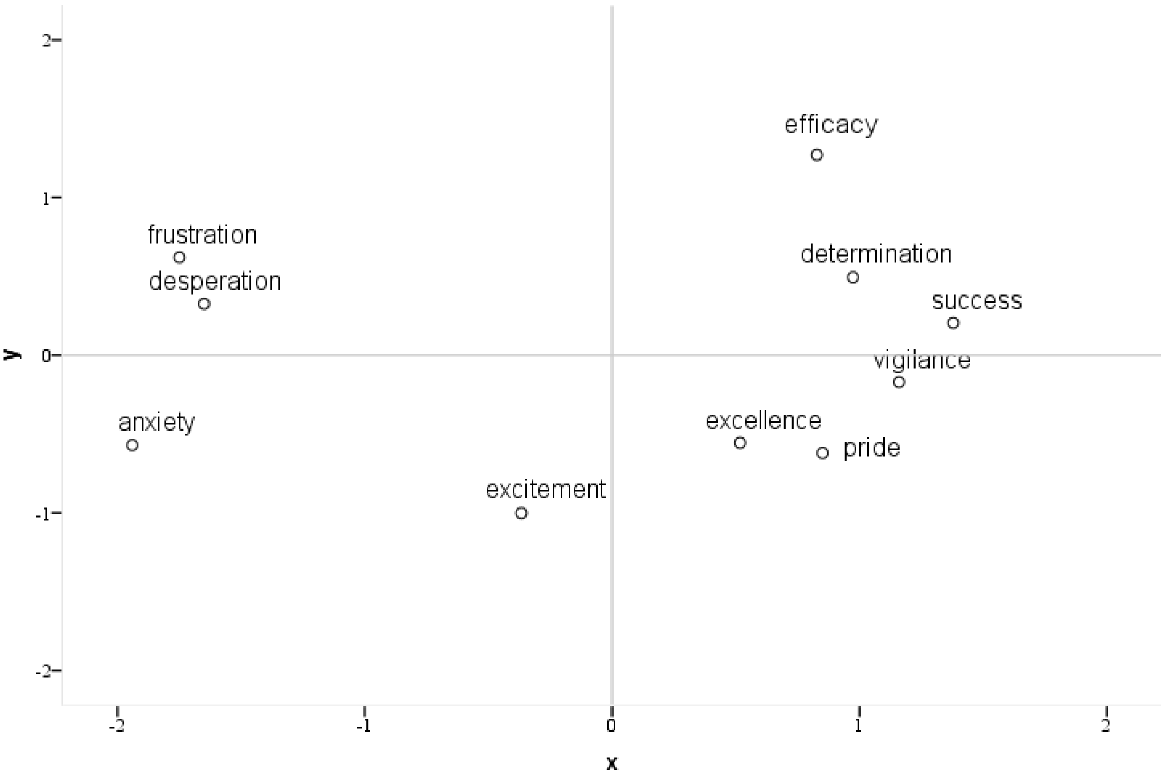

Figure 4. MDS configuration of emotional questionnaire items. Third experiment.

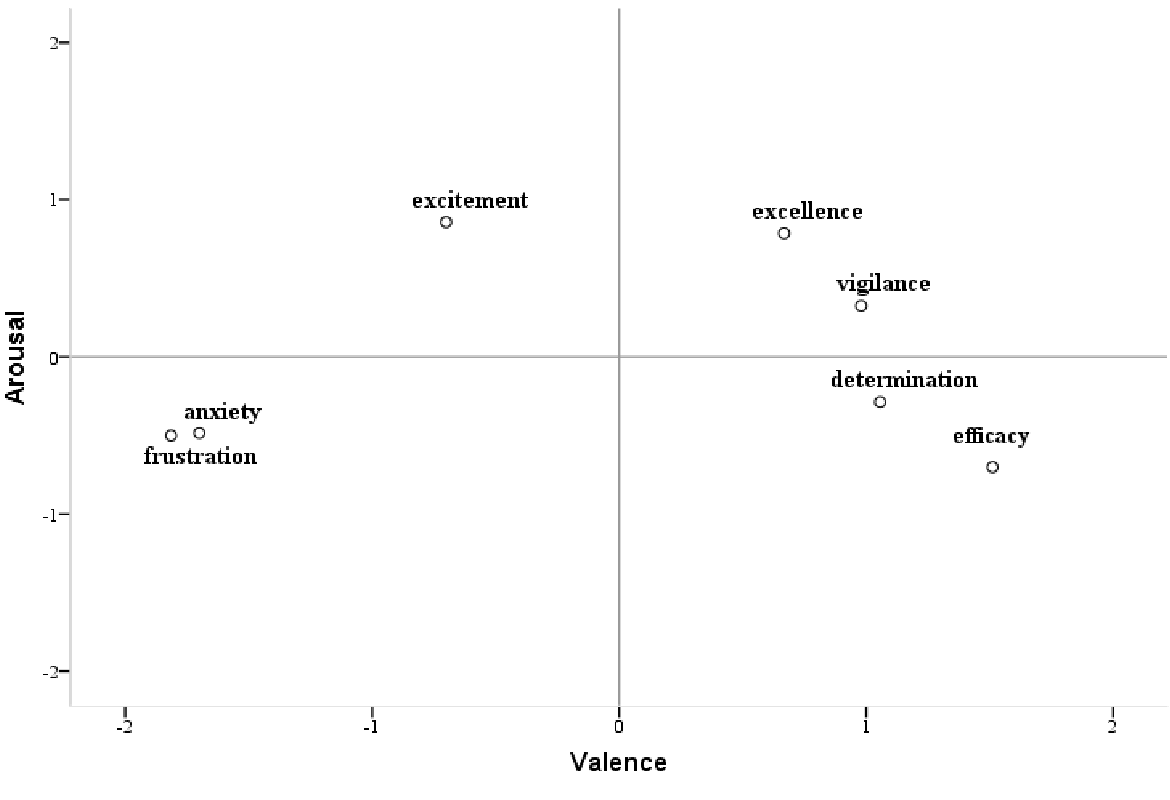

Figure 5. MDS solution of combined data.

Table 1

Factor loadings of the Promax rotated Principal Axis Factoring of emotional items, combined dataset.

	Factor	
	Competence	Frustration
vigilance	**.709**	–.051
excellence	**.694**	.097
determination	**.659**	–.099
efficacy	**.472**	–.342
anxiety	–.090	**.702**
frustration	–.148	**.665**
excitement	.450	**.558**

Note. *N* = 50. Highest factor loading is in boldface.

Table 2

Emotional questionnaire items included in the two emotional user experience factors in each of the experiments (experiment 2 had two parts). Internal consistencies (Cronbach's α) of the items in the list and the means of the summated scales are also displayed. The potential range of all the summated scales is 1–5.

	Factor					
Experiment	Competence			Frustration		
	Items	α	Mean	Items	α	Mean
1 (*N* = 19)	efficacy success vigilance	.768	3.67	annoyance anxiety confusion frustration	.832	2.05
2 (*N* = 10)	determination efficacy excellence pride vigilance	.874, .821	3.32, 3.40	annoyance anxiety confusion excitement frustration struggle	.908, .794	2.13, 2.03
3 (*N* = 21)	determination efficacy excellence pride success vigilance	.847	2.94	anxiety desperation frustration	.804	1.40

Appendix A

Questionnaire of the first experiment (translated from Finnish to English)

Questionnaire, please fill in after the experiment

The experiment is now complete. We ask you to reflect the experiment and carefully answer following questions. Please circle the most appropriate choice for each item. The scale is **1** = not at all, **2** = a little, **3** = somewhat, **4** = much, **5** = very much.

During the experiment I felt… (1=Not at all, 5=Very much)

efficacy	**1**	**2**	**3**	**4**	**5**
success	1	2	3	4	5
excellence	1	2	3	4	5
in control	1	2	3	4	5
confusion	1	2	3	4	5

delighted	**1**	**2**	**3**	**4**	**5**
angry	1	2	3	4	5
anxiety	1	2	3	4	5
surprised	1	2	3	4	5
giving up	1	2	3	4	5
afraid	1	2	3	4	5
wonder	1	2	3	4	5
annoyance	1	2	3	4	5
calm	1	2	3	4	5
guilty	1	2	3	4	5
disgusted	1	2	3	4	5
satisfied	1	2	3	4	5
distressed	1	2	3	4	5

enthusiastic	1	2	3	4	5
desperation	1	2	3	4	5
pride	1	2	3	4	5
excitement	1	2	3	4	5
frustration	1	2	3	4	5
determination	1	2	3	4	5
vigilance	1	2	3	4	5

Thank you for your participation!

Appendix B

Questionnaire of the second experiment (translated from Finnish to English)

Remote operation of a crane – Experience questionnaire

Please answer following questions concerning the simulator tasks you've just completed. In the questions, "environment" refers to the virtual environment.

The scale of the questionnaire is **1** = not at all, **2** = a little, **3** = somewhat, **4** = much, **5** = very much. For each proposition circle the best fitting value.

During the tasks …

	Not at all	A little	Somewhat	Much	Very much
1. I was in control of the events	1	2	3	4	5
2. the environment was responsive to my actions	1	2	3	4	5
3. my interactions with the environment seemed natural	1	2	3	4	5
4. the mechanism which controlled the movement through the environment was natural	1	2	3	4	5
5. I was able to anticipate what would happen next in response to the actions I performed	1	2	3	4	5
6. I was able to survey the environment using vision	1	2	3	4	5
7. I was able to examine objects from multiple viewpoints	1	2	3	4	5
8. I was able to move objects in the environment	1	2	3	4	5
9. the control mechanism was distracting	1	2	3	4	5
10. there was delay between my actions and expected outcomes	1	2	3	4	5
11. I could concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities	1	2	3	4	5
12. I learned new techniques that enabled me to improve my performance	1	2	3	4	5

During the tasks …

	Not at all	A little	Somewhat	Much	Very much
13. I was aware of the weight of the load	1	2	3	4	5
14. I was aware of the speed of the crane	1	2	3	4	5
15. I was aware of the wind speed	1	2	3	4	5
16. I felt that my actions and operations were safe	1	2	3	4	5
17. I was worried about the safety of other personnel	1	2	3	4	5
18. I was worried for the breakage of material (containers, their contents, trucks)	1	2	3	4	5
19. I was given feedback on the unsafety of my actions	1	2	3	4	5

During the tasks I felt …

	Not at all	A little	Somew hat	Much	Very much
20. efficacy	1	2	3	4	5
21. excellence	1	2	3	4	5
22. annoyance	1	2	3	4	5
23. confusion	1	2	3	4	5
24. anxiety	1	2	3	4	5
25. pride	1	2	3	4	5
26. frustration	1	2	3	4	5
27. I had to struggle	1	2	3	4	5
28. determination	1	2	3	4	5
29. excitement	1	2	3	4	5
30. vigilance	1	2	3	4	5
31. surprise	1	2	3	4	5

Appendix C

Questionnaire of the third experiment (translated from Finnish to English)

Questionnaire

Please recall your experiences during the interaction. Please circle the most appropriate choice for each item. The scale is **1** = not at all, **2** = a little, **3** = somewhat, **4** = much, **5** = very much.

Gesture-based interaction was a … experience (1=not at all, 5=very much)

Pleasant	**1**	**2**	**3**	**4**	**5**
Unpleasant	1	2	3	4	5

During the test I experienced… (1=not at all, 5=very much)

efficacy	**1**	**2**	**3**	**4**	**5**
success	1	2	3	4	5
excellence	1	2	3	4	5
in control	1	2	3	4	5

Please use the following statements to evaluate the gestures: *"The gestures were…"* (1=not at all, 5=very much)

practical	**1**	**2**	**3**	**4**	**5**
intelligent	1	2	3	4	5
professional	1	2	3	4	5
safe	1	2	3	4	5
needful	1	2	3	4	5
physically demanding	1	2	3	4	5

During the experiment I felt… (1=not at all, 5=very much)

sad	1	2	3	4	5
delighted	1	2	3	4	5
angry	1	2	3	4	5
anxiety	1	2	3	4	5
surprised	1	2	3	4	5
afraid	1	2	3	4	5
frustration	1	2	3	4	5
guilt	1	2	3	4	5
displeasure	1	2	3	4	5
satisfied	1	2	3	4	5
desperation	1	2	3	4	5
pride	1	2	3	4	5
excitement	1	2	3	4	5
determination	1	2	3	4	5
vigilance	1	2	3	4	5

Thank you for participating in the usability testing!

II

APPRAISAL AND MENTAL CONTENTS IN HUMAN-TECHNOLOGY INTERACTION

by

Saariluoma, Pertti & Jokinen, Jussi P. P. (2015)

International Journal of Technology and Human Interaction, 11(2), 1–32.

Appraisal and Mental Contents in Human-Technology Interaction

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ABSTRACT

User experience has become a key concept in investigating human-technology interaction. Therefore it has become essential to consider how user experience can be explicated using psychological concepts. Emotion has been widely considered to be an important dimension of user experience, and one obvious link between modern psychology and the analysis of user experience assumes the analysis of emotion in interaction processes. In this paper, the focus is on the relationship between action types and elicited emotional patterns. In three experiments including N = 40 participants each, it is demonstrated that the types of emotions experienced when people evaluate and use technical artefacts differ based on the stances they take toward these artefacts. One cannot approach user experience irrespective of the careful analysis of the situation-specific emotional themes. It is essential to any theory of user experience to consider the nature of the situation and relevant actions.

Keywords: *Action, Cognition, Competence, Emotion, Frustration, Human-Technology Interaction, User Experience, User Psychology*

INTRODUCTION

User experience research has made its way among traditional ways of approaching emotional and aesthetic human-technology interactions, such as Kansei engineering, funology, design for pleasure, affective design, emotional design, and affective ergonomics (Hassenzahl & Tractinsky, 2006; Kuniavsky, 2003; Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009; Nagamachi, 2011; Norman, Miller, & Henderson, 1995; Wright & McCarthy, 2005). User experience, from a user psychological point of view, can be thought to entail, among other things, a person's emotions and perceptions of interaction (Bargas-Avila & Hornbaek, 2011; Moran, 1981; Saariluoma, 2003; Saariluoma & Jokinen, 2014; Saariluoma & Oulasvirta, 2010). Behind all these research paradigms with very similar goals one can find different ways of applying psychological thinking to understand how people meet technical artefacts, and for this reason it makes sense to ask if the efforts of different approaches in human-technology interaction can be conceptually unified within a common framework (Saariluoma, 2004; Saariluoma & Oulasvirta, 2010).

In the search for unification, it reasonable to explicate and operationalise modern paradigms within the framework of user psychology

DOI: 10.4018/ijthi.2015040101

(Saariluoma, 2005; Saariluoma & Oulasvirta, 2010). This presupposes using empirical methodologies, experimental paradigms, theoretical concepts, and modern psychological theoretical generalisation. Thus, user psychology could be seen as a similar application area of modern psychology as traffic psychology, school psychology, work psychology, clinical psychology, or geropsychology, which are all divisions within psychology based on an importance of the practical field. This new field of applying psychological thinking would thus entail the whole human dimension of human-technology interaction (Moran, 1981; Saariluoma, 2003). Psychology is, of course, not the only relevant research field in studying user experience. For example, marketing, art research and design, information systems work, and engineering also have important roles in this discourse. However, psychology and cognitive science, as the basic sciences working with the details of human mind, must take part in the discourse on user experience. Thus, it is possible that the other approaches to user experience could eventually be reduced to applied human research and psychology.

The key theoretical notions of modern cognitive scientific and the psychological concept of the mind are anchored to the notions of mental representation, as such derivatives as schemas, productions, or mental models (Anderson, Farrell, & Sauers, 1984; Johnson-Laird, 1983; Markman, 1999; Neisser, 1976; Newell & Simon, 1972). The knowledge of mental representations enables psychologists to explain why people behave as they do (Markman, 1999). The very idea of representation is historical and can be found in different forms in the works of philosophers such as Locke and Hume (ideas and impressions), as well as Kant (1781) and Schoepenhauer (1818-1819/1969) (Vorstellung, i.e., representation). However, despite the intuitive clarity of the concept, psychological interpretations of mental representation have varied over the last 40 or 50 years. During this time, representations of emotions have received their own treatment (e.g., Beck, 1976; Dolan, 2002; Maio, 2010; Oatley, 1992; Power & Dalgleish, 1997).

In modern psychology, the link between emotion and cognition has been justly perceived as important (Schachter & Singer, 1962). The mental process responsible for combining emotion with cognition is called *appraisal* (Arnold, 1960; Beck, 1976; Lazarus, 1991; Lazarus & Lazarus, 1994; Scherer, 2005, 2009). Bower (1981), for example, demonstrated conceptual and empirical connections between cognitions, actions, and the emotional dimensions of memory. Later, representational concepts, such as mental models, semantic networks, and schemas, have become common in discussing emotion and its relation to cognition and action (Ivonin, Chan, Chen, & Rauterberg. 2013; Oatley, 1992; Ortony, Clore, & Collins, 1988; Power & Dalgleish, 1997). Appraisal can be seen as the core process in combining emotional and cognitive mental content. Modern theorists connect appraisal with concurrent action and reaching one's goals (Frijda, 1986; Lazarus, 2001; Scherer, 2005, 2009). Psychologically, personal motivation and action goals are central in the emotion process (Oatley, 1992; Power & Dalgleish, 1997; Lazarus, 1991), and therefore, in the user psychological framework, it is logical to ask whether the nature of ongoing actions could explain what kind of emotional representations and user experiences people have.

EMOTIONAL USER EXPERIENCE AS A MENTAL PROCESS

There are several ways of developing theoretical concepts for the mental mechanisms relevant to investigating emotion. First, much research has adopted various system-theoretical models, which assume that emotion processes are carried out by a number of integrated subsystems (Teasdale & Barnard, 1993). Secondly, one can find representational ideas, such as network-based models for combining cognition with emotion (Bower, 1981). Both models have problems in discussing what people feel, whether these feelings are relevant, what the cognitive interpretations of situations are like, and whether cognitive and emotional interpretations make any sense at all. The problem lies in the inherent ambiguity of subsystems and network concepts. A subsystem can produce irrational emotional states, as well as rational ones, and these can entail correct and incorrect information about the reality. Questions pertaining to the relevance and truth of these representations do not make sense unless theories precisely define what the contents of the active information in the mind are. Therefore, we have begun to develop a third line of theoretical thinking within user psychology.

Already, Newell and Simon (1972), Allport (1980), and Fodor (1990) have called the attention of psychologists to the importance of the information contents of mental representations, or mental contents. This notion opens a number of new possibilities for discussing how mental representations can explain human behaviour. Allport (1980) correctly pointed out that many modules of the human nervous system are content-specific. Systems of depth vision, or space and colour, for example, are content-specific and neurally 'hardwired'. Our thinking goes to a slightly different but not contradictory direction, with a leading assumption that each situation, physical or social, activates mental representations in the mind. These mental representations have mental contents, that is, their informational contents. Understanding the information content and its properties within mental representations allows user psychologists to analyse and explain human behaviour during interactions. Therefore, when we examine specific psychological problems, such as aspects of human mental representation, we should analyse the mental contents of relevant representations; operationalise experiments regarding these concepts; and *explain human actions, responses, and behaviours on the grounds of the explicated contents of mental representations*.

It may be difficult to understand what the notions of mental contents add to the notions of mental representation. The crucial reason is the necessity to investigate *differences between different representations*. If a group of people hates computer games, they represent their hate in their minds. If another group loves computer games, they represent their love in their minds. Thus, the difference between the first and the second group is not in representing but in the *information contents of representations*, such as between hate and love. Thus, the groups have different mental contents when they interact with computer games. Consequently, the differences in behaviours between the groups can be explained by means of their emotional contents. People who hate computer games, avoid playing them, and people who love them, do play. The main explanatory ground must be approached from the perspective of the differences in the contents of mental representations, and the respective behaviours must be explained on the ground of mental contents. The approach which studies mental contents and bases the explanation of it, can be called *content-based psychology* as the explanation of behaviour is based on mental contents (Saariluoma, 2003).

From our point of view, all mental representations have, on one hand, cognitive content elements, including such information as precepts, images, linguistic expressions, concepts, action schemas, and thoughts (e.g., propositions), with specifiable mental contents. On the other hand, active representations have emotional content elements, such as fear and joy, which in the context of appraisal theory of emotion are called feelings to distinguish them from the whole emotion process (Scherer, 2009). This emotional content can be considered in terms of different appraisal dimensions (Smith & Ellsworth, 1985), such as valence (positive and negative, i.e., pleasant and unpleasant), and in terms of relational theme, that is, what the specific emotion is, such as fear, joy, happiness, or anger (Lazarus, 2001). Thus, for example, fear can be seen as perception or experience of danger in front of a definite target such as death, open spaces, a definite person, or an animal. Conversely, angst can be seen as fear without a definite target (Izard, 2009; Öhman, 2008).

These two aspects of mental representation are integrated within the process of appraisal (Arnold, 1960; Lazarus, 1991 Moors, Ellsworth, Scherer, & Frijda, 2013; Power & Dalgleish, 1997). Thus, the mental contents of an active representation can be seen as a combination of cognitive and emotional contents. The task of psychologists is to uncover the structure of representational contents and use this knowledge to explain and to make understandable the connections between representational content elements and ongoing action.

To take a step forward and to move from abstract principles to concrete empirical settings, it is good to create an empirical investigation that can demonstrate how it is possible to work with combinations of actions, cognitions, and their emotional representations on an empirical level. This presupposes experimental conditions, in which the combination of these three elements, that is, actions, activated cognitions, and their relationships with the activated emotional contents, can be examined. A close reading of user experience literature illustrates that experimental designs often use various types of actions to create measurable experiences (Bargas-Avila & Hornbaek, 2011; Vermeeren, Law, Obrist, Hoonhout, & Väänänen-Vainio-Mattila, 2010). The nature of action in experiments can be understood as an experimental presupposition, that is, a tacit assumption built into the way the research problem is operationalised (Saariluoma, 1997). Subjects are, for example, often asked to evaluate and express how they feel when they encounter an interface, but they can also be asked to do tasks with the technical artefacts (e.g., McCarthy, Wright, & Meekison, 2005; Norman, 2004; Saariluoma & Jokinen, 2014). We call the first type of situation *contemplative* to emphasise that the elicited feelings are due to a non-interactive evaluation. The second type is called *functional* to emphasise that there is interaction. From the present point of view, it is important to ask whether there is a difference in the cognitive and emotional mental contents in the two types of situations, and how the differences in representation should be understood when analysing user experience.

By keeping the stimuli the same when investigating the properties of the two basic types of actions, it is possible to ensure that the differences in mental contents are caused by the way in which subjects encode the stimuli. One could say that the subjects in functional situations have a different *stance* than the subjects in contemplative situations. As a consequence of these differing stances, they encode different *aspects of the same stimuli*, which can be seen in their differing cognitive mental contents. Aspect itself is a concept present in Wittgenstein's (1958) theory of mind. A good example of it is provided by ambiguous figures. Here, we assume that different types of tasks and task-relevant actions activate different mental stances and lead to different cognitive and emotional contents. In this sense, stance differs from other dispositional concepts such as *attitude*. By stance we refer to the prevailing and active way of directing oneself in a situation, while attitude is a long-term memory scheme, which can activate in any time, but which is like French grammar for someone momentarily speaking English. It is a passive long-term resource, while stance is the active ongoing way of looking things now.

Finally, a reader may ask what the relation between a given stance and mental content is. The answer is that two stances will differ in terms of their content. Thus, to understand what the role of stance in causing differences in behaviour is, we must ask what the cognitive and emotional contents of a particular stance are, as compared to another stance. In clinical psychology, Beck (1976), for example, argued that depressive people encode the world in a more negative manner than normal, that is, they have a more negative stance towards their environments. Our argument is that the stance of the user is one of key factors in user experience.

The concept of stance leads us to a final conceptual nuance. Mental representations control and steer human behaviour (Newell

& Simon, 1972). Therefore, the information contents of these representations give people actions and direct them. People often pursuit towards objects and goals which give pleasure and avoid objects and situation which make them feel pain. Thus there is an intimate connection between mental contents and the reasons for why people pursuit towards some specific goals. To content-based psychological thinking, the intimate connection between the direction of action and behaviour and the activated mental contents is a basic assumption. Consequently, prevailing stance, which is a mental content, explain many essential aspect of ongoing action.

The ultimate motivation for our research and explanation for the hypotheses below is to illustrate that emotional states and user experiences depend effectively on the nature of ongoing actions. Different actions elicit different emotional patters and for this reason it is essential to set the questions concerning user experiences in the context of what is done with the given technology, and how it is used. To study how user emotional experience depends on the stance of the user, a set of experiments were designed. The critical experimental manipulation concerned influencing the stance of the user and thus the logic of their emotional user experience responses to the stimuli. The stance of the participants was primarily induced by giving them different tasks for same stimuli, and emotional user experience was measured using a questionnaire. Task performance was also measured. The following hypotheses are presented and investigated in three experiments reported below (see Table 7 in the General discussion section for list of all the hypotheses tested in the experiments reported here):

H1: The stance of the participant affects how different stimuli elicit emotional user experience;

H2: The stance of the participant has an impact on emotional user experience;

H3: Task efficiency has an impact on emotional user experience.

GENERAL METHOD

Stimuli and Tasks

Online shopping was chosen as the context of the study because of its familiarity. Currently, most of the people have used or at least heard about online shopping. Furthermore, webpages offer the chance to conduct relatively naturalistic tasks, even in laboratory settings, because the experimental tasks can be conducted using an ordinary computer, just like in real life. Five online shops were chosen as stimuli: Amazon, Apple, Ikea, Boostep, and Jasmine Jewels. The first three were chosen because they were supposedly familiar to most of the participants, and the last two were chosen for their unfamiliarity (each participant also reported his or her familiarity with each of the brands before starting the experiment). The tasks were slightly different in each of the experiments reported below because the questions concerning the nature of emotional user experience varied between the experiments.

The primary experimental manipulation was the stance of the user. This manipulation was performed by asking the user to either just observe the webpages, conduct easy tasks, conduct hard tasks, or conduct impossible tasks. The first stance is called contemplative, and the second is called functional. In terms of the degree of intensity, functional stance varied between the experiments. To induce a contemplative stance, the participants were given a simple task: explore the stimuli passively and look for any stimulating objects. Although this is referred to below as a "contemplative task", no real performance was expected of the participants, and they could not fail or pass the task. To induce a functional stance, the participants were explicitly given tasks and asked to perform them effectively. For each stimulus, there were a number of tasks. In the first experiment, all tasks had to be completed, and in the subsequent experiments, as many of the tasks as possible needed to be completed in the given time.

Questionnaires

Experience refers to the conscious part of mental representations, and the contents of experience form this part. The task of the user psychologist is the operationalization of conscious experience in human-technology interaction. Consciousness can be associated with verbalized representational information, that is, people can express their thoughts verbally by having something to say about them (Allport, 1977; Ericsson & Simon, 1984; e.g., McCarthy, Wright, & Meekison, 2005). Indeed, in the research on emotion, it has been proposed that self-reports are perhaps the main resource on information about emotional experience (Schorr, 2001). Hence, we assume that questionnaires elicit valid information on the emotional contents of participants. This assumption can be validated by demonstrating how the emotional responses have the expected covariance structures in relation to other measures used in the experiment (Campbell & Fiske, 1959).

Emotional user experience was measured using questionnaires that were administered after each stimulus. The questionnaire was constructed using a bipolar competence-frustration factor model of emotional user experience (Saariluoma & Jokinen, 2014). *Competence* refers to the user's perception that his or her abilities helped in good task performance. Therefore, being efficient, skilful, determined, and vigilant during tasks results in competent feeling (Saariluoma & Jokinen, 2014). On the other hand, frustration results from goal-incongruent events, that is, when the user faces obstructions for accomplishing tasks (Saariluoma & Jokinen, 2014). Both factors were operationalized into Likert-scales containing four emotion items. For Competence, these were successful, efficient, determined, and vigilant. The first two let the participants reflect on their own skills and actions related to the notion of self-efficacy (Bandura, 1982). The last two let the participants reflect on their autonomy and attentiveness during their interactions with technology (Carroll & Thomas, 1988; Hassenzahl, 2008). The items for Frustration were frustrated, anxious, confused, and annoyed. As stated above, experiencing frustration and annoyance is the result of not being able to reach one's goals, and anxiety results from unexpected or undefined situations, which can also be confusing (Lazarus & Lazarus, 1994), making these items suitable for investigating negative emotional responses during interaction with technology.

While the origin of the emotional questionnaire items lies in theories of basic emotion and folk concepts regarding emotion, methodologically, their use does not assume any single theory of emotion. Whether emotions, such as anger, disgust, and fear, are basic (Ekman, 1993; Power & Dalgleish, 1997) or useful and frequent in communication but not necessarily hardwired (Barrett, 2006; see also Scherer, 2005), the important aspect of the questionnaire is that the participants can reliably report their personal emotional experience with familiar emotion words (Saariluoma & Jokinen, 2014). The validity of the scales will, of course, be investigated throughout the experiments via repeated reliability tests and via observing the expected correlations with other self-ratings and objective experimental measurements (Campbell & Fiske, 1959; Nunnally & Bernstein, 1994).

In addition to the aspects of emotional user experience, the questionnaire also contained scales regarding the feeling of control and a semantic differential scale for appraising the hedonic qualities of the stimuli. However, only the two emotional user experience factors used in the analyses are reported here. In addition to the questionnaires filled out during the experiment, the participants filled out a questionnaire concerning their brand experience with the brands used in the experiment. This questionnaire was filled out before the tasks, and its purpose was to control for brand satisfaction (for discussion of brand experience and user experience, see Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009). For example, if a participant was very satisfied with the products and user experience of a given brand, it was likely that this would influence the user experience during the experimental tasks. The brand questionnaire contained two factors, brand satisfaction and brand trust. Brand Satisfaction was used as a control variable in the models reported here, but brand trust will not be utilized in analyses in this article, because it was reserved for different investigations. In addition to the brand questionnaire, the participants used a four-item scale to assess their amounts of self-confidence at the start of the experiment. The items were certain, determined, ready, and vigilant, but based on the reliability analysis, vigilance was retained from the summated scale, and only the remaining three items were used to construct the Self-confidence scale. Self-confidence was measured for control purposes as a 'baseline variable' because it is known that some amount of variance in emotional experience can be explained by the overall mood of the respondent (Schorr, 2001). Specifically, the studies of self-efficacy demonstrate how the individual's perception of her own operational abilities have an effect on how well the individual performs (e.g., Bandura, 1982). All questionnaire items are included in Tables 8-9 (see Appendix A).

Analysis

The reliability of the scales was investigated with multidimensional scaling (MDS), Cronbach's alpha, and factor analysis. MDS is a statistical method that is useful for producing two-dimensional representations of the correlations between items (Kruskal & Wish, 1978), and it was used to confirm the bipolarity of the competence-frustration model of emotional user experience (Saariluoma & Jokinen, 2014). Two-dimensional configurations, displaying the Euclidian distances between the Z-score standardized emotional questionnaire items are displayed in the results sections. This is similar to the method used by Russell (1980) in his studies of circumplex model of affect, later generalized as the theory of core affect (Russell, 2003). However, while core affect theory provides a useful model for the analysis of valence and arousal in emotional user experience, we feel that appraisal theory offers better understanding on the relationship between the stance of the user and her emotional process.

Cronbach's alpha was used to assess the reliability of all scales of the study. The summated scales were constructed by using a regression method on the factor scores obtained with a maximum likelihood factor analysis. This resulted in standardized sum variables, the mean of which was 0 and the variance of which was the factor score covariance of the items. The data for the factor analysis were pooled so that the analysis for all five stimuli would be conducted at the same time. Hence, although the grand mean of Competence and Frustration for any experiment was 0, differences between the groups and within stimuli were possible. However, the reliabilities were also tested between experimental groups.

Hypotheses were tested using multilevel modelling, which allows for complex within-subject data structures (Hox, 2010). In models reported here, the five stimuli are nested within the participants and treated as random variables, except when testing for H1, which requires stimuli to be a fixed effect. Each hypothesis was tested separately for Competence and Frustration. H1 was investigated with a simple interaction model, testing the interaction effect of the stimuli and the stance of the participant on the mean emotional user experience. H2–4 were tested with a more complex model. The continuous fixed effects in the models were Brand Satisfaction and Self-confidence. The categorical fixed effect was the stance of the participants. In the results sections, we report the coefficients (with errors) and the standardized coefficients or the fixed effects (Hox, 2010). The effect sizes for the models in the three experiments reported here are included in Appendix B. Finally, at the end of the analysis of each experiment, an item-level analysis of the emotional items was conducted.

EXPERIMENT 1

Method

N = 40 participants, 19 men and 21 women, were recruited for the experiment. Their mean age was 27.9 (*SD* = 7.7), and their age range was 18–57. The participants were recruited from an introductory university course on human-technology interaction. Participating in an experiment was not compulsory for the students, but they had to choose between a written assignment and participation in a laboratory experiment. All participants were familiar with the online shopping context: all had heard about some of the brands and visited at least some of the web pages used in the experiment. Nine participants had never bought anything from any of the listed online shops, but the others had.

The experimental design was a between-subjects design with within-subjects tasks. Half of the participants were assigned to the contemplative group, and the other half were assigned to the functional group. The groups were balanced in terms of gender and age and did not differ significantly in their online shopping experience (non-significant χ^2 and *t*-tests for all relevant background variables between the groups). Participants in both groups were presented with five stimuli (the five online shops) in a counterbalanced order.

The task of the contemplative group was to examine a series of screenshots of an online shopping webpage, and the task of the functional group was to conduct two tasks: look for a certain product and add it to the shopping chart, and find the feedback form. The contemplative group were shown three screenshots for each webpage, 30 seconds each (90 seconds total). The screenshots were taken from the locations of the pages at which the functional group would conduct the tasks. The functional group was given as much time as needed to complete the tasks, and they took 199 seconds on average (*mdn* = 182 s., *SD* = 138 s.). In the analysis, completion time is taken to indicate task efficiency: more efficient task completion results in faster completion time, as this was the only criteria of performance.

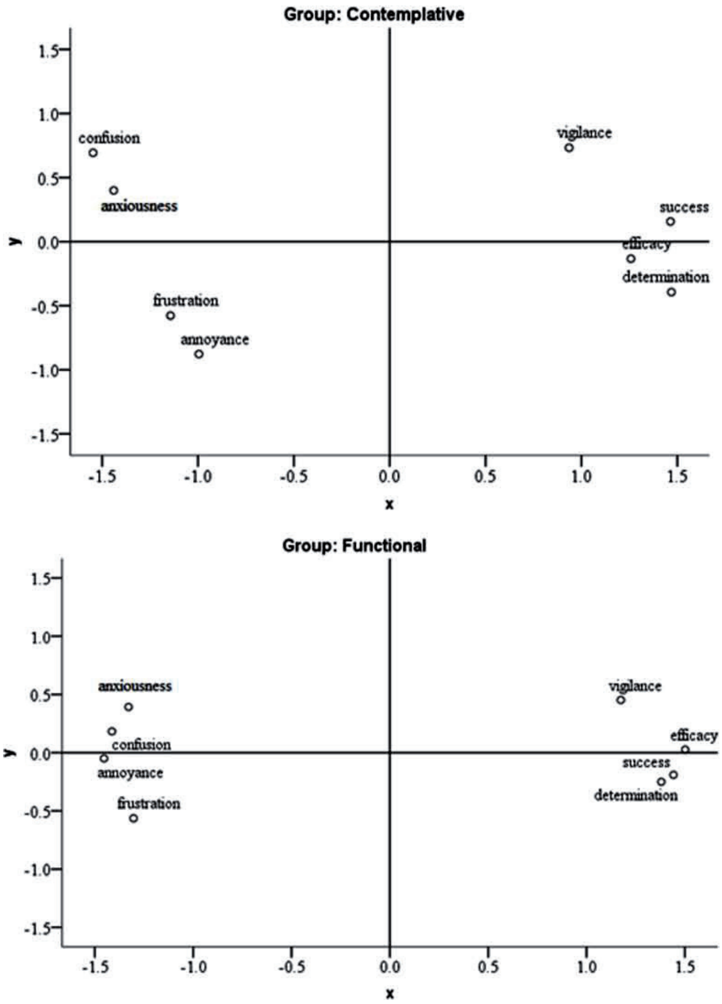
Results

The two-dimensional configuration of the emotional user experience questionnaire items between the contemplative and functional groups is shown in Figure 1, which shows a clear bipolar configuration (factor loadings are listed in Appendix B). The reliability of Competence was $\alpha = .87$ for the contemplative group and $\alpha = .92$ for the functional group. The reliability of Frustration was $\alpha = .77$ for the contemplative group and $\alpha = .89$ for the functional group. Both the bipolar structure and high reliabilities provided support to the measurement model used for emotional user experience.

Figure 2 depicts the mean Competence by webpage and by group and illustrates how, in the contemplative group, no difference between the webpages was observed, whereas in the functional group, the stimuli are clearly differentiated according to their mean Competence. A similar differentiation can be observed in the means for Frustration. The difference in the means for Competence was statistically significant in the functional group, $F(4, 190) = 12.8$, $p < .001$, but not in the contemplative group, $F(4, 190) = 0.6$, $p = 0.687$. The interaction effect between the group and the stimulus was statistically significant, $F(9, 190) = 6.0$, $p < .001$. Likewise, Frustration had differing means between the stimuli in the functional group, $F(4, 190) = 12.9$, $p < .001$, but not in the contemplative group $F(4, 190) = 0.9$, $p = 0.478$. The interaction effect between group and stimulus was statistically significant, $F(9. 190) = 6.1$, $p < .001$. These results support H1 and illustrate that only the participants with the functional stance had variance in terms of emotional experience based on the stimulus.

Although a clear effect of stance on emotional response was observed, there were relatively small group differences in terms of the grand means of emotional user experience. This is shown in the multilevel model (Model 1, Table 1), in which no between-subjects group effects, that is, support for H2, are found. This result will be discussed below; a post-hoc analysis shows how this result can be explained by differing sources of variation in emotional user experience between the two experimental groups. The second multilevel

Figure 1. Configuration of emotional questionnaire items between the groups



models for Competence and Frustration (Model 2, Table 1) including only participants from the functional group indicate that the variance in emotional user experience in this group can be explained by task efficiency (H3). Increased task times predict decreased Competence and increased Frustration. In other words, failure to perform tasks efficiently causes frustration, while efficient task completion has a positive impact on competence.

To assess the possibility that the emotional responses of the contemplative group actually reflected their overall self-confidence and not the emotions elicited by the stimuli, we performed a post-hoc analysis and correlated Self-confidence before the test with

Figure 2. Mean competence between the web shops in functional and contemplative groups

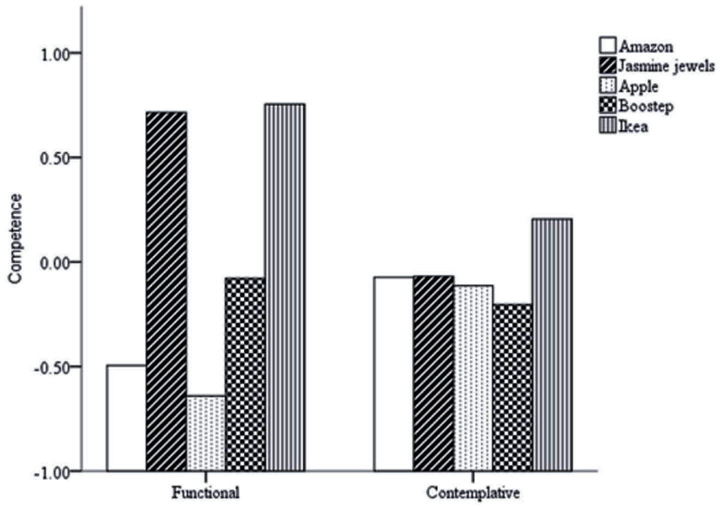


Table 1. Fixed coefficients and random level variances in multilevel models of competence and frustration

	Competence		Frustration	
	Coefficient (s.e.)	**Std. Coef.**	**Coefficient (s.e.)**	**Std. Coef.**
	Model 1			
Intercept	3.26** (0.07)		1.56** (0.06)	
Brand satisfaction	0.04 (0.06)		0.06 (0.05)	
Self-confidence	0.29** (0.06)	0.29	–0.20** (0.04)	0.21
Group	–0.02 (0.11)		0.04 (0.08)	
	Model 2			
Intercept	11.21** (0.95)		–2.48** (0.78)	
Brand satisfaction	0.14 (0.08)		–0.13 (0.06)	
Self-confidence	0.11 (0.08)		0.08 (0.07)	
Time	–0.66** (0.08)	–0.58	0.34** (0.07)	0.31

Note: Model 1: $N = 40$. Cases included = 200. Model 2: $N = 19$. Cases included = 95. ** $p < .01$, * $p < .05$. The reference for group effect is contemplative.

Competence and Frustration separately for the contemplative and functional groups (the mean of self-confidence between the groups was not different). The result was as expected. In the functional group, Self-confidence correlated only weakly with Competence (r = .15) and moderately with Frustration (r = –.28), but in the contemplative group, the correlations were stronger: Competence r = .56 and Frustration r = –.36. Although the differences in the correlation coefficients are not statistically significant, the trend is clear and expected. Because the emotional user experience responses in the contemplative group did not reflect the stimuli (H1, see above), this analysis seems to conclude that the Self-confidence before the experiments affects the emotional user experience responses more for the participants with the contemplative stance. This was especially true for Competence, but it was also true for Frustration.

Next, post-hoc item-level analyses were conducted to explore the details of emotional user experience. This is also one way to analyse the mental contents, especially their changes, in detail; this knowledge supports the interpretation of the relevant mental contents. Table 2 presents the means of the eight emotional user experience items. It also presents the Spearman correlation between Self-confidence and the items, and the Mann-Whitney U-tests for the difference in the distributions of the items between the contemplative and functional groups. Spearman correlation was used, because the individual questionnaire items cannot be considered as continuous variables. The α-level for the Mann-Whitney U-tests was calculated using a Bonferroni correction by dividing 0.05 by the number of tests for each factor (four), resulting in $\alpha = 0.0125$. The results of post-hoc analysis illustrate that while the majority of the distributions of the emotional items did not differ between groups, the effect of Self-confidence (Spearman correlations) was larger in the contemplative group.

Discussion

The first experiment resulted in two major notions. First, emotional user experience can be observed in terms of two different clusters, which in terms of content, can be interpret as competence and frustration. The same bipolar clustering of emotions, as defined by variation between the emotional questionnaire items,

Table 2. Spearman correlation coefficients between self-confidence at the start of the experiment and the items of the emotional user experience factors. Means and the standardised Mann-Whitney U-test for the difference in the distributions between the functional and contemplative groups are also displayed.

Item	Functional		Contemplative		MWU
	ρ	M	ρ	M	
success	.22	3.5	.64	3.4	-0.7
determination	.15	3.4	.59	3.3	-0.7
efficacy	.11	3.1	.44	3.0	-0.7
vigilance	.07	3.3	.41	3.4	0.3
frustration	-.44	1.6	-.30	1.3	-1.9
anxiousness	-.48	1.6	-.49	1.9	1.5
confusion	-.29	2.0	-.55	2.0	0.8
annoyance	-.41	1.6	-.50	1.2	-3.6*

Note: N = 40 (20 each group). ρ = Spearman correlation coefficient. MWU = Standardised Mann-Whitney U-test statistic. * $p < .0125$.

had been observed earlier (Saariluoma & Jokinen, 2014). The second notion concerns the hypotheses, two of which were supported and one of which was not. H1 was supported by confirming the interaction effect between the stimulus and the stance of the participant. Only in the functional group were there observable differences between the stimuli in terms of emotional user experience. However, contrary to H2, there were no observable differences in the mean Competence or Frustration between the functional and contemplative groups.

There is a confounding factor in the results, because the contemplative tasks were shorter than the functional tasks. However, there are no previous models or evidence to suggest that the contemplative evaluation of a task would differ significantly depending on whether the contemplation lasts 90 or 200 seconds. Instead, we propose that the observed differences between the groups in the logic of emotional user experience process is indeed due to the different stances of the users. This differs notably from the discussion of the time-span of user experience, in which the distinction between experience before and experience after use is made (Roto, Law, Vermeeren, & Hoonhout, 2011). Instead, the argument here is that the logic of momentary user experience, that is the experience during the actual use, is different depending on the stance of the user. Further, as the post-hoc analysis demonstrates, the logic of how experience before the use affects the experience during or straight after the use is different depending on the stance of the user.

The results above can therefore be understood in more detail with the help of the post-hoc analysis, which suggests that in the contemplative group, the role of the pre-test self-confidence of the participants had a larger impact on the self-reports of emotional experience. It is probable that while the participants concerned with the functional tasks were able to have emotional user experience as a response to what happened during the interaction, the participants concerned with the contemplative tasks were not emotionally affected by the stimuli and thus returned to their baseline self-confidence. This line of thought receives further support from the investigation of H3. An increase in task time can be interpreted to indicate difficulty in completing the tasks, which is visible in increased frustration and decreased competence. This finding makes an interesting addition to discussion to self-efficacy (e.g., Bandura, 1982). It is known that the belief in one's own operational abilities affects emotional experience, but here it is demonstrated that this connection is dependent on the stance of the individual during the task.

Contemplative tasks are not therefore sufficient stimuli for studying emotional user experience in its totality. Comparing the standardized coefficients, it seems that competence is especially dependent on task efficiency, supporting the interpretation that competence is related to experienced self-efficacy and control (Bandura, 1982). However, competence is not the same as self-efficacy or control. While self-efficacy is the individual's perception of her own operational abilities (Bandura, 1982), competence as emotional user experience factor is reflects how the user was actually able to bring out efficient task performance. On the other hand, the ability to cope with the task and exert control over the task events is necessary for feeling competent, but feeling of control is thematically different from feeling of competence. The negative relationship between task efficiency and frustration is also understandable: obstructions and other difficulties in tasks are visible in the form of frustration (Lazarus & Lazarus, 1994). Frustration is the result of obstructive task events which are perceived to be goal-incongruent, but which cannot be solved efficiently in order to maintain goal-congruence.

The discussion above illustrates how appraisal theory of emotion provides understandable explanation to why the studies of emotional user experience need to take into account the stance of the user. While the circumplex model of affect (Russell, 1980) is useful in grouping the emotional items and thus confirming the bi-polarity of the competence-frustration model of emotional user experience, its ability to explain differences between contemplative and functional stance is lower than that of the appraisal theory. Of course, one could argue that the arousal dimension could explain differences between the groups, but this dimension has been observed to be less definitive than valence (Saariluoma & Jokinen, 2014), and it is not clear how differences in arousal alone could explain the results.

EXPERIMENT 2

The first experiment suggested that emotional user experience in functional tasks might depend on the difficulty of the tasks. This was visible in the differing explanations for Competence and Frustration between the functional and contemplative groups. What was it about the functional tasks, besides task time, that caused emotional responses? Was frustration, for example, caused by difficulties during the task, or can competence be explained by successful conduct? To investigate this, the second experiment concentrated on the difficulty of the functional tasks. Participants conducted either easy or difficult tasks. Easy tasks were designed to be accomplishable quickly: the relevant hyperlinks were easy to locate and the average amount of steps one needed to complete was small. Difficult tasks, on the other hand, had obscure links which the user had to find, and the number of steps in the task process was large.

Emotional user experience can be shown to be the result of the type of the stance (H1 and H2). It is interesting to contrast this with H3, which posits that the number of successfully conducted tasks affects emotional user experience. Therefore, the question is whether it is the nature of the stance or the actual events during the tasks that elicit emotional responses. In order to investigate this question, we hypothesize that the effect of task efficiency on user experience is mediated by task difficulty, which can be stated as follows:

H4: The stance of the participant affects the impact of task efficiency on emotional user experience.

Method

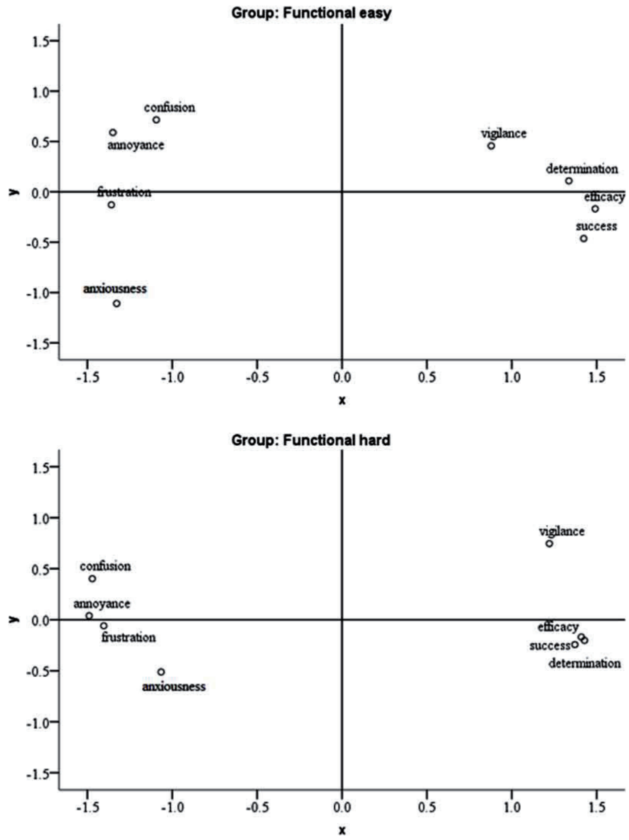
$N = 40$ participants, 20 men and 20 women, were recruited for the experiment. Their mean age was 27.2 ($SD = 9.5$), and their age range was 19–56. None of the participants from the first experiment participated in the second experiment. The participants were recruited from the same course as in the first experiment, and all had at least some experience with visiting online shops or buying products from them. The experimental design was a between-subjects design. Half of the participants were assigned to an easy-tasks group, and the other half were assigned to a difficult-tasks group. The groups were balanced in terms of gender and age and did not differ in online shopping experience (non-significant χ^2 and t-tests for all relevant background variables between the groups). Participants in both groups were presented with five stimuli in a counterbalanced order. Each participant was given 300 seconds for each stimulus, and they were instructed to perform as many tasks as possible. A successful task completion was indicated by the experimenter, who then provided the next task. The number of tasks accomplished was recorded (the ongoing task upon reaching the time limit was not counted).

Results

The two-dimensional configuration of the emotional user experience items between the easy-tasks and the hard-tasks groups are shown in Figure 3, which shows a clear bipolar configuration. The factor loadings of the emotional factors are presented in Appendix B. The reliability of Competence was $\alpha = .83$ for the easy-tasks group and $\alpha = .86$ for the hard-tasks group. The reliability of Frustration was $\alpha = .72$ for the easy-tasks group and $\alpha = .88$ for the hard-tasks group. As in the first experiment, a clear bipolar configuration and adequate reliabilities were observed.

In the first experiment, a difference in emotional user experience responses between the stimuli was observed in the functional group,

Figure 3. Configuration of the emotional questionnaire items between the groups



but not in the contemplative group. In the second experiment, a similar effect was observed between the easy- and hard-tasks groups. The mean of Competence differed between the stimuli in the hard-tasks group, $F(4, 190) = 5.4, p < .001$, but not in easy tasks group, $F(4, 190) = 2.2, p = .069$. The interaction effect between the group and the stimulus was statistically significant, $F(9, 190) = 4.0, p < .001$. Likewise, Frustration had differing means between the stimuli in the hard-tasks group, $F(4, 190) = 4.3, p < .001$, but not in the easy-tasks group, $F(4, 190) = 1.3, p = 0.282$. The interaction effect between group and stimulus was statistically significant, $F(9. 190) = 5.1, p < .001$. As in the first experiment, these results support H1 and illustrate how the stance of the participant influences his or her emotional user experience responses.

The means of Competence and Frustration by task difficulty group are shown in Figure 4. As hypothesized (H2), the mean emotional user experience differs between the stances. The multilevel models, as shown in Table 3, support this result by showing a statistically significant group effect for both Competence and Frustration. The models also provide support for H3, suggesting that the number of tasks completed affects both Competence and

Figure 4. Means of competence and frustration by group

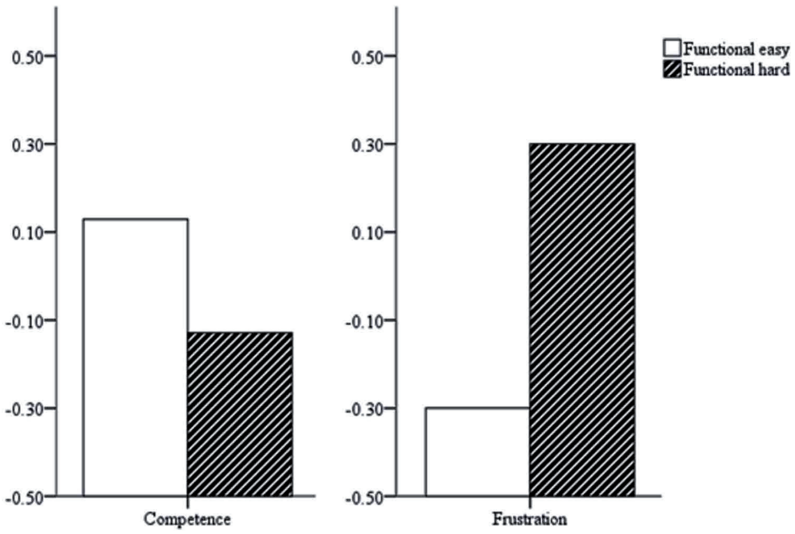


Table 3. Fixed coefficients and random level variances in multilevel models of competence and frustration

Intercept	Competence		Frustration	
	Coefficient (s.e.)	Std. Coef.	Coefficient (s.e.)	Std. Coef.
	–0.92** (0.19)		0.29 (0.19)	
Brand satisfaction	0.14* (0.06)	0.16	–0.06 (0.06)	
Self-confidence	0.05 (0.07)		0.02 (0.06)	
Group	–0.54* (0.27)		1.07** (0.27)	
Tasks	0.22** (0.03)	0.52	–0.13** (0.03)	–0.29
Group × tasks	0.18** (0.06)		–0.20** (0.06)	

Note: $N = 40$. Cases included = 200. ** $p < .01$, * $p < .05$. The reference for group effect is contemplative.

Frustration. Further, the statistically significant interaction effect (Group × tasks) in the models supports H4, that is, the magnitude of the effect of task efficiency on emotional user experience is dependent on the task difficulty. Figures 5 and 6 illustrate the effect of the number of tasks completed on Competence and Frustration by task difficulty. Low competence is observed in both groups if the participant is unable to complete tasks, but as the number of completed tasks increases, Competence increases also. This effect is larger for the group conducting difficult tasks: being able to accomplish difficult tasks provides for a greater feeling of competence than being able to accomplish the same number of easy tasks. The same is true, but inversely, for

Figure 5. Regression lines for competence by tasks completed and by task difficulty

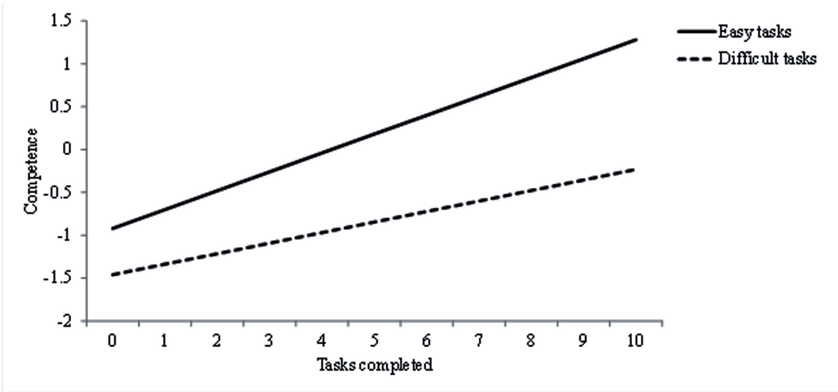
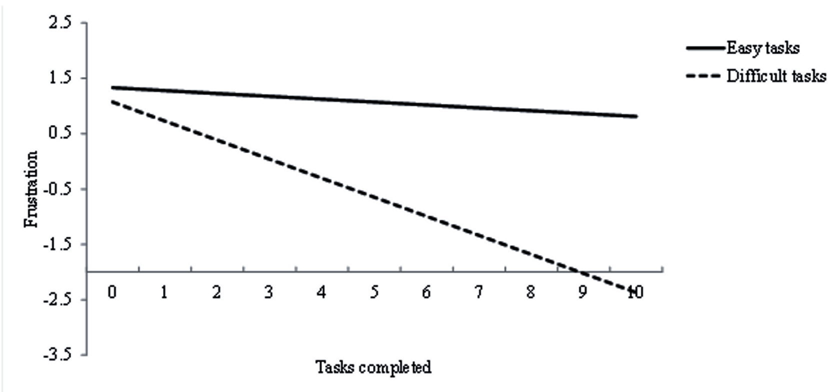


Figure 6. Regression lines for frustration by tasks completed and by task difficult



frustration. Being able to conduct many tasks will result in the same relatively low level of frustration for both groups, but failing at difficult tasks causes more frustration than failing at easy tasks.

The item-level analysis, shown in Table 4, supports the findings of the multilevel model, especially for Frustration. However, not all of the results are statistically significant, reflecting the fact that item-level analysis and averaging across tasks decreases the statistical power of the analyses. The directions of the effects are, however, as hypothesized. Also, it is evident that baseline Self-confidence more greatly determines emotional user experience when conducting easy tasks than when conducting hard tasks. As in the previous experiment, the mean of self-confidence did not differ between the groups.

Discussion

The second experiment investigates the suggestion from the first experiment, emotional user

Table 4. Spearman correlation coefficients between self-confidence at the start of the experiment and the items of emotional user experience factors. Means and the standardised Mann-Whitney U-test for the difference in the distributions between easy and hard-task groups are also displayed.

Item	Functional Easy		Functional Hard		MWU
	ρ	M	ρ	M	
success	-.02	3.2	.33	3.0	-1.7
determination	.22	3.2	.25	3.0	-1.6
efficacy	.13	2.9	.12	2.6	-1.8
vigilance	-.04	3.2	.14	3.1	-0.42
frustration	-.30	1.7	.16	2.3	2.7*
anxiousness	-.33	1.6	.05	2.1	2.4
confusion	-.04	2.3	.09	2.8	2.7*
annoyance	-.25	1.7	-.01	2.2	2.4

Note: N = 40 (20 each group). ρ = Spearman correlation coefficient. MWU = Mann-Whitney U-test score. * $p < .0125$.

experience in functional situations depends on task difficulty, in more detail. The results start to build an understandable picture of emotional user experience as a function of what happens during the interaction. The interaction effect of the stance of the participant and the effect of stimulus on emotional user experience responses was supported (H1). Furthermore, the multilevel models display statistically significant main effects for task difficulty (H2) and tasks completed (H3), as well as for the interaction between these two (H4). This means that failing at tasks causes frustration and succeeding at tasks supports competence and that merely by having to perform difficult tasks, the user becomes frustrated. However, if the user does succeed in difficult tasks, frustration decreases more quickly. Being able to overcome challenging and frustrating situations has a greater effect on emotional user experience than being able to conduct easy tasks. The support provided for all hypotheses increases the plausibility of the assertion that the stance of the user is a major contributor to emotional user experience.

The item-level analyses reflect the results of the first experiment. While, in the first experiment, it was found that baseline Self-confidence predicts emotional responses more greatly in the contemplative group than in the functional group, this same effect can be observed as a function of the intensity of the tasks. Baseline Self-confidence was more predictive of emotional responses in the group performing easy tasks than in the group performing difficult tasks. In other words, when investigating emotional user experience, when assessing the validity of the measurements, a careful analysis of the stance of the user based on the analysis of individual differences and task nature is necessary.

EXPERIMENT 3

The second experiment explored our main thesis about the functionality of emotional user experience in more detail. Based on the two experiments, we maintain that the stance of the user is a determinant of emotional user experience. Furthermore, it is maintained that stance affects how the other determinants of emotional user experience cause emotional states. In the final experiment, the contemplative stance, the functional stance, and varying levels of difficulty are brought together and investigated in a within-subjects experiment in which all subjects adopt contemplative and functional stances.

Method

N = 40 participants, 20 men and 20 women, were recruited for the experiment. Their mean age was 23.3 (SD = 5.9), and their age range was 18-44. The participants in this experiment did not participate in the first two experiments described above. The participants were recruited from the same introductory course as those for the first two experiments, and all had at least some experience visiting or shopping at online shops. The first and second experiment had a between-subjects design in which the participants were grouped either into functional or contemplative groups or easy- and hard-tasks groups. In the third experiment, these two experimental manipulations were brought together. A within-subjects design was used, with all participants conducting contemplative, easy functional, and hard functional tasks.

The experiment was conducted in two task blocks. In the first task block, each participant conducted contemplative tasks by looking at screen shots of webpages for 90 seconds, and then filling out the user experience questionnaire. After five webpages had been evaluated in this way, in the second task block, the participants conducted functional tasks with the five webpages and used questionnaires to assess their user experience. For three of the five stimuli, the participants were asked to complete as many easy everyday tasks as they could in 300 seconds. For the other two stimuli, the participants were also given 300 seconds to complete as many tasks as possible, but the given task was impossible to complete. Impossible tasks were designed so that they sounded genuine tasks, but it was actually impossible to perform them (e.g., asking to check the price of a non-existing product). The assignment of impossible tasks for various stimuli was counter-balanced so that each webpage had participants performing easy and impossible tasks. This resulted in three task levels: contemplative (in the first task block), easy (in the second task block), and impossible (in the second task block). The order of the pages was counterbalanced in both the contemplative and functional task blocks.

Results

The two-dimensional configuration of the emotional user-experience items between the contemplative-tasks, easy-tasks, and impossible-tasks groups is shown in Figure 7, which displays a clear bipolar configuration. The factor loadings of the items regarding emotional user experience factors are presented in Appendix B. The reliability of Competence was $\alpha = .85$ for the contemplative group, $\alpha = .88$ for the easy-tasks group, and $\alpha = .84$ for the impossible-tasks group. For Frustration, the reliabilities were $\alpha = .76$ for the contemplative group, $\alpha = .85$ for the easy-tasks group, and $\alpha = .81$ for the impossible-tasks group. The results replicate the results of the dimensional and reliability analyses from the first two experiments.

An interaction effect between the stance of the participant and the stimulus was observed, as in the first and the second experiments. The interaction effect for Competence was $F(14, 385) = 11.6$, $p < .001$, and the interaction effect for Frustration was $F(14, 385) = 18.9$, $p < .001$, providing yet more support for H1, which states that stance has an impact on how emotional responses are elicited. The difference between the means of Competence and Frustration between the three stances (H2) is shown in Figure 8. Competence for impossible tasks is significantly lower than for easy or contemplative tasks, but there is no statistically significant difference between contemplative and easy tasks, as shown in the multilevel model in Table 5. With Frustration, the effect is clearer: Frustration was observed to be higher in both the easy and impossible task levels than in contemplative task level and higher in impossible tasks than in easy tasks. Task efficiency affected user experience as hypothesized (H3) by increasing Competence and decreasing Frustration. The effect was, of course, observed only in the easy-tasks group. In the contemplative-stance group there were no tasks to accomplish, and number of impossible tasks accomplished was always zero.

Item-level analyses are shown in Table 6 and restate the findings from previous ex-

Figure 7. Configuration of the emotional questionnaire items between the task levels

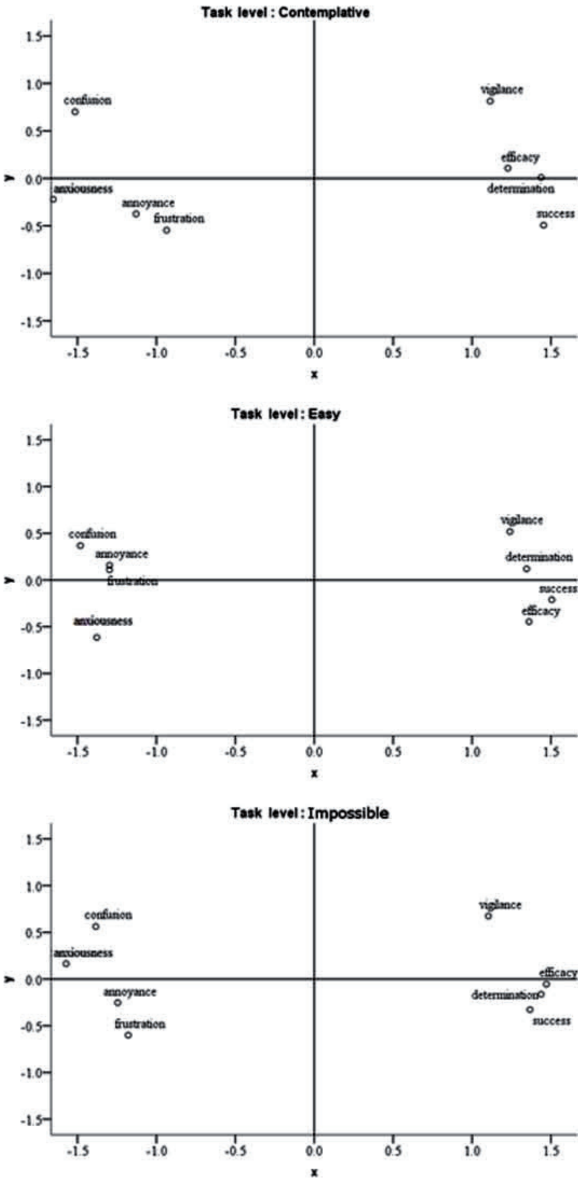


Figure 8. Means of competence and frustration by task level

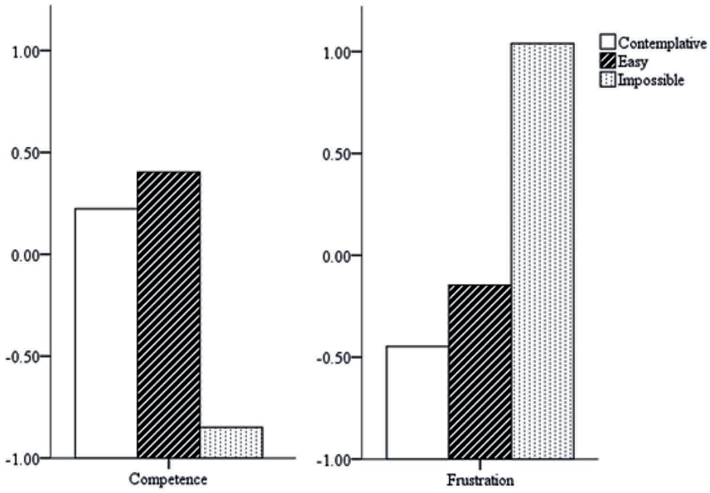


Table 5. Fixed coefficients and random level variances in multilevel models of competence and frustration

	Competence		Frustration	
	Coefficient (s.e.)	Std. Coef.	Coefficient (s.e.)	Std. Coef.
	Model 1			
Intercept	0.22** (0.05)		–0.48** (0.03)	
Brand satisfaction	0.14** (0.04)		–0.07* (0.03)	0.07
Self-confidence	0.28** (0.04)		–0.04 (0.03)	
Tasks = impossible	–1.08** (0.10)		1.5** (0.09)	
Tasks = easy	0.19 (0.10)		0.30** (0.09)	
	Model 2			
Intercept	–0.65** (0.24)		0.84** (0.23)	
Brand satisfaction	0.14 (0.07)		–0.13 (0.07)	
Self-confidence	0.20* (0.08)		–0.05 (0.07)	
Tasks	0.14** (0.03)	0.62	–0.14** (0.03)	–0.63

Note: Model 1: $N = 40$. Cases included = 200. Model 2: $N = 40$. Cases included = 100. ** $p < .01$, * $p < .05$. The reference for the task's effect is contemplative.

Table 6. Spearman correlation coefficients between self-confidence at the start of the experiment and the items of emotional user experience factors. Means and Friedman test statistics for the difference in the distributions between contemplative, easy, and impossible tasks are also displayed.

Item	Contemplative		Functional Easy		Functional Hard		$\chi^2(2)$
	ρ	M	ρ	M	ρ	M	
Success	.26	3.7	.30	3.8	.12	2.0	62.5*
determination	.41	3.4	.40	3.7	.11	2.7	42.8*
Efficacy	.43	3.3	.04	3.5	.00	2.1	48.6*
Vigilance	.46	3.5	.45	3.6	.15	3.1	19.7*
frustration	.24	1.2	.10	1.5	.07	2.4	49.9*
anxiousness	-.25	1.6	-.15	1.5	-.05	2.2	39.9*
confusion	-.07	1.5	.05	1.9	.07	3.1	62.7*
annoyance	-.10	1.1	-.05	1.4	.13	2.5	59.1*

Note: $N = 40$ (20 each group). ρ = Spearman correlation coefficient. χ^2 = Friedman test statistic with $df = 2$. * $p < .0125$.

periments. The difference between the items is visible, especially between impossible tasks and contemplative tasks but also between easy and contemplative tasks. Further, Spearman correlations suggest, as previously observed, that baseline Self-confidence can better explain emotional responses during contemplative tasks than during functional tasks. This is especially evident for the items of Competence.

Discussion

The third experiment gave further support for the conclusions drawn from the first two experiments: the stance of the user affects his or her emotional experience. Stance not only has a direct effect on emotional user experience (H2) but also moderates the other determinants of emotional user experience, such as the stimulus itself (H1), task efficiency (H4), or self-confidence (post-hoc analysis). However, the emotional responses of the participants were not reflective only of stance in all three experiments, a strong correlation between task efficiency and emotional user experience factors was found (H3). Because task efficiency clearly affects emotional user experience (standardized coefficients larger than .60 were observed), one must ask the following: what would the emotional responses to contemplative tasks reflect? More detailed analyses in the three experiments suggest an answer to this question in contemplative tasks, emotional responses are, in fact, reflective of the self-confidence of the participant. The summary of the hypotheses and the results from all three experiments reported here are presented in Table 7.

The post-hoc analyses at the end of each experiment resulted in connecting the baseline self-confidence of the participant, measured as self-confidence before the experiment, and emotional user-experience factors. The main result of the comparisons between stances was to show that the intensity of the stance tends to decrease the correlation between Self-confidence, as reported at the start of the experiment, and emotional user experience, as reported after conducting tasks. This is important result because it suggests problems in terms of the internal validity of studies using the contemplative stance to study emotional user experience.

GENERAL DISCUSSION

As a whole, the results of the three experiments suggest that in a systematic manner, user experience depends on the properties of ongoing action and the respective stances. The activation

Table 7. Summary of the results of the three experiments

Hypothesis	Experiment		
	1	2	3
H1. The stance of the participant affects how different stimuli elicit emotional user experience.	s	s	s
H2. The stance of the participant has an impact on emotional user experience.	ns	s	s
H3. Task efficiency has an impact on emotional user experience.	s	s	s
H4. The stance of the participant affects the impact of task efficiency on emotional user experience	–	s	–

Note: ns = not supported, s = supported. H4 was considered only in the second experiment.

of two opposite emotional clusters, competence and frustration, was observed in the participants. This competence-frustration model has been found earlier and is central to the analysis of user experience in human-technology interaction (Saariluoma & Jokinen, 2014). Content-wise, competence is associated with such emotions as success, determinacy, efficacy, and vigilance, while frustration is associated with anxiousness, confusion, and annoyance. Thus, the successful use of technical artefacts seems to be linked with feeling competent, while feeling frustrated is characterized by failures and difficulties. These results are linked with both the tasks and the stances.

The second and the third experiments illustrated that the difficulty of a task is associated with the amount of frustration produced. Because contemplative tasks are often less demanding than functional ones, it is understandable that frustration is more common emotional content in functional tasks than in contemplative tasks. Indeed, frustration is generally seen as an aggression-related emotion caused by obstacles (Berkovitz, 1989; Miller, 1941; Power & Dalgleish, 1997). The general nature of frustration can thus make our results understandable and explain why frustration is a relevant emotional state in functional tasks. The emotional theme of frustration is consistent with the mental contents of users when they fail in using a technical device. Failures in tasks, particularly in reaching task goals, provoke frustration.

In contrast, successful performance leads to feelings of competence. These feelings are intimately related to such motive constructions as satisfaction, happiness, self-efficacy, self-confidence, self-esteem, and trust (Bandura, 1982; Barbeite & Weis, 2004). These concepts are important in analysing and understanding how people overcome their fear of technologies and using them. Also, the feeling of control belongs to this family of emotional and motivational phenomena, although the results reported here did not address this issue. The general results implicate that the emotional experience of the user is dependent on the stance, which the user adapts while interacting with technology. Thus, just looking at technical objects, such as web pages or a cars in a car show, calls different emotions than actually using these technical artefacts. It is therefore important, that user experience is always considered from the perspective of what people are really doing with the artefact or as one could also say the nature of the interaction. In the very least, the assumptions concerning the stances of the users, built within the experimental designs, need to be always explicated.

Explaining and analysing behavioural phenomena relevant to interacting with technical artefacts in user psychology is consistency-based, which means that the results in user psychological research should be consistent with generally known psychological facts and theories concerning the relevant phenomena so that they can be used to explain interaction phenomena (Saariluoma, 2005; Saariluoma & Oulasvirta, 2010). The above discussion illustrates that the results are understandable in the light of psychological research.

From a user experience point of view, one can think about relationship between user experience and cognition and emotion in terms of mental contents. Human performance is always intentional and intention defines the prevailing stance towards a technical artefact (Brentano, 1874/1973; Dennett, 1989; Husserl, 1901-2, 1936; Searle, 1983). In the traditional psychology of perception, the meaning of stance to how people perceive objects has long ago empirically demonstrated in the phenomenon of accordance (Gibson, 1979), and similarly, attentional schema theories state that people may attend very differently to same environments (Neisser, 1976). It has been also shown that people can perceive and attend similarly an object such as a chessboard, but mentally represent them very differently so that bad ideas blocked good ones (Bilalic & McLeod 2014; Saariluoma, 1995, 2001). In this family of selective encoding phenomena, the notion of stance refers to what people are doing. People encode information depending on what is relevant to their performance. Thus, failure and success refer to whether the goal of a given task is reached. Reaching the goal increases the feeling of competence, and failure increases the feeling of frustration. The different stances activate mental representations with different cognitive and emotional mental contents as well as respective user experiences, though the technical artefacts and environments are same. Different stances lead to different appraisal processes and respective user experiences. Appraisal combines these elements into cognitive and emotional contents (Lazarus, 2001; Scherer, 2009).

On a general level, user experience, as a psychological phenomenon, must be investigated by asking what people are doing with technical artefacts and what their mental contents are. It is essential to consider user experiences given the types of actions and situations people are involved in when they experience interaction. From our point of view, it is problematic to think that there are general, situation-free attributes of user experience. Emotions vary depending on what people are doing and how they mentally represent their actions. This is why all measurements should be related to the actions in question. The analysis of the relevant emotional and cognitive mental contents is essential, because it allows researchers to differentiate between different stances, tasks, and behaviours. Theoretically, it is not sufficient to assume that people have schemas, mental models, or other mental representations, because it is necessary to also know what the mental contents are in different situations. This leads to understanding how people act and experience.

Finally, one of the main goals of our investigation is to illustrate that user psychological discourse enables us to elaborate the standard discussion on user experience. Psychological concepts, methods, and theoretical ideas enable researchers to find new perspectives to old phenomena within user experience research. This does not mean that user experience research, or an earlier experience-focused paradigm, Kansei-engineering, would not be psychologically indifferent. They both are built on psychological methods such as Osgood's semantic differentials or modern emotional questionnaire practices (Nagamachi, 2011; Hassenzahl, 2010; Hassenzahl, Burmester, & Koller, 2003). However, it is possible to use also the full scale of core theoretical concepts of modern psychology, such as mental representation, in studying user experience phenomena. In usability research and ergonomics this has been common (Anderson, Farell, & Sauers, 1984; Hollnagel, 2006) Nevertheless, content-based psychological thinking, which sees that the information contents of mental representations or mental contents as the core concept in analysing and explaining human behaviours, provides further theoretical power to analysis of cognitive and emotional aspects of user experiences (Saariluoma & Jokinen, 2014). This also justifies adopting the notion of *user psychology* as an equally logical concept in psychology as economic psychology or child psychology (Moran, 1981; Saariluoma, 2005). Most importantly, understanding human-technology interaction in a scientific valid and coherent manner allows for justifying design solutions (Saariluoma & Nevala, 2006). When designing for better user experience, and finally, when designing for better quality of technological life, it is therefore necessary for scientists of human-technology interaction to offer this kind of understanding.

CONCLUSION AND OUTLOOK

It is important to remember that there exists not just a single psychology, but many different practical fields, such as child psychology, personality psychology, and traffic psychology. Similarly, problem of human-technology interaction can open its own subfield and kind of psychology. Our work is just one minor example about a huge system of knowledge, which can be used to improve human relation to human technology. Further, our empirical findings illustrate that human action and the cognitive and emotional contents of mental representations make differences in ways we experience interaction with technical tools. Frustration and competence are just examples of feelings that can be elicited in users when they interact with technology. Intuitively, one could argue that there are numerous other important action contexts, which elicit emotional representations. Thus, the idea of investigating other types of interaction situations and associated emotions opens new challenges for a user psychologically oriented interaction research in future. With these caveats, we can summarise the main points and thus clarify the scientific message for future investigations of emotional user experience:

1. Our main framework can be called user psychology as it approaches and explains the phenomena of human technology interaction using concepts, methods, facts and theories of modern psychology (Moran, 1981; Saariluoma, 2004);
2. User experience is a well-documented area of interaction design (Hassenzahl & Tractinsky, 2006; Kuniavsky, 2003; Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009; Nagamachi, 2011; Norman, Miller, & Henderson, 1995; Wright & McCarthy, 2005), and hence it is reasonable to apply user psychological thinking to refine the analysis this phenomenon;
3. Emotional information processes form the most natural basis of analysing user experience. However, emotions are intimately linked with cognitions and hence also with actions. Thus, psychological process of appraisal becomes central when analysing user experience;
4. In modern psychology, mental representation is a central concept. Nevertheless, so far, relatively little attention has been paid to its information contents or mental contents as the explanatory concept (Allport, 1980; Fodor, 1990; Newell & Simon, 1972). Mental content provides researcher with a natural ground concept in analysis experience as one experience differs from another with respect to its contents;
5. Different types of actions can be analysed, understood, explained by investigating the differences in mental contents in the minds of people. The main benefit of this approach is that it integrates existent psychological knowledge with the analysis of interaction, and enables the consideration of the underlying mental processes behind conscious experiences on which user experience is based using the whole intellectual capacity of modern psychology;
6. The goal of human-technology interaction research and subsequent informed design of technologies is better interaction in terms of human life and its quality (Leikas 2009, Saariluoma & Leikas, 2010). Emotion is one central theme in understanding life and designing for it.

ACKNOWLEDGMENT

The authors thank Piia Perälä and Johanna Silvennoinen for helping with carrying out the experiments reported here. The research has been supported by a Fimecc/Tekes programme UXUS (User Experience and Usability in Complex Systems).

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APPENDIX A

Questionnaire Items

Table 8. Participant pre-task questionnaire

Brand Satisfaction
The brand offers me solutions.
The brand offers me professionalism.
The brand supports my intentions.
I could use the products of this brand more than once.
Brand Trust
The brand has a good reputation.
The brand is safe.
The actions of the brand are trustworthy.
Honesty describes the brand.
Self-Confidence
I feel certain.
I feel determined.
I feel ready.
I feel vigilant.

Note: Items for brand experience were rated on a 5-point Likert scale from 'strongly disagree' to 'strongly agree'. Items for Self-confidence were rated on a 5-point Likert scale: 'not at all', 'a little', 'somewhat', 'much', and 'very much'.

Table 9. Participant emotional questionnaire

Competence
I felt successful.
I felt determined.
I felt efficient.
I felt vigilant.
Frustration
I felt frustrated.
I felt anxious.
I felt confused.
I felt annoyed.

Note: Items rated on a 5-point likert scale: 'not at all', 'a little', 'somewhat', 'much', and 'very much'.

APPENDIX B

Factor Loadings and Multilevel Model Effects

Table 10. Factor loadings for competence and frustration in the two groups, experiment 1

Item	Factor Loading	
	Cont.	**Funct.**
Competence		
success	.89	.89
determination	.85	.92
efficacy	.85	.93
vigilance	.59	.73
Frustration		
frustration	.73	.75
anxiousness	.81	.77
confusion	.64	.87
annoyance	.58	.90

Note: *N* = 40 (20 for each group) Funct. = functional tasks. Cont. = contemplative tasks.

Table 11. Factor loadings for competence and frustration in the two groups, experiment 2

Item	Factor Loading	
	Easy	**Hard**
Competence		
success	.80	.89
determination	.74	.74
efficacy	.93	.88
vigilance	.53	.61
Frustration		
frustration	.82	.83
anxiousness	.43	.70
confusion	.57	.75
annoyance	.67	.92

Note: *N* = 40 (20 for each group). Easy = easy tasks. Hard = difficult tasks.

Table 12. Factor loadings for competence and frustration in the three groups, experiment 3

Item	Factor Loading		
	Cont.	Easy	Imp.
Competence			
success	.71	.84	.79
determination	.91	.87	.81
efficacy	.83	.79	.85
vigilance	.61	.72	.58
Frustration			
frustration	.66	.81	.75
anxiousness	.70	.72	.80
confusion	.66	.74	.57
annoyance	.71	.80	.79

Note: *N* = 40. Cont. = contemplative tasks. Easy = easy tasks. Imp. = Impossible tasks.

Table 13. The effect sizes for multilevel models predicting competence and frustration, experiment 1

	Competence			Frustration		
	F	df1	df2	F	df1	df2
	Model 1					
Model	8.8**	3	183	7.3**	3	162
Brand satisfaction	0.6	1	188	1.6	1	186
Certainty	25.3**	1	180	20.8**	1	148
Group	0.0	1	187	0.2	1	147
	Model 2					
Model	23.3**	3	67	13.3**	3	56
Brand satisfaction	1.8	1	77	1.3	1	47
Certainty	3.1	1	81	4.5*	1	80
Time	66.0**	1	77	26.7**	1	66

Note: Model 1: $N = 40$, Model 2: $n = 19$. ** $p < .01$, * $p < .05$.

Table 14. The effect sizes for multilevel models predicting competence and frustration, experiment 2

	Competence			Frustration		
	F	df1	df2	F	df1	df2
Model	20.1**	5	179	17.2**	5	163
Brand satisfaction	5.1*	1	190	1.0	1	161
Self-confidence	0.6	1	187	0.1	1	176
Group	4.0*	1	175	15.8**	1	179
Tasks	92.3**	1	177	54.6**	1	162
Group × tasks	8.1**	1	179	10.9**	1	163

Note: *N* = 40. ** *p* < .01, * *p* < .05.

Table 15. The effect sizes for multilevel models predicting competence and frustration, experiment 3

	Competence			Frustration		
	F	df1	df2	F	df1	df2
	Model 1					
Model	50.9**	4	300	67.1**	4	234
Brand satisfaction	14.0**	1	342	4.8*	1	225
Self-confidence	44.3**	1	359	1.2	1	244
Task group	74.2**	2	262	131.2**	1	234
	Model 2					
Model	9.9**	3	90	7.7**	3	78
Brand satisfaction	3.9	1	93	3.8	1	84
Self-confidence	6.6*	1	80	0.4	1	66
Tasks	22.6**	1	90	23.1**	1	89

Note: Model 1: *N* = 40. Included cases = 400. Model 2: *N* = 40. Included cases = 100. ** *p* < .01, * *p* < .05.

III

THE EFFECT OF BRAND EXPERIENCE AND INTERACTION EVENTS ON CONTENTS OF VISUAL EXPERIENCE IN WEB PAGE APPRAISAL

by

Jokinen, Jussi P. P., Silvennoinen, Johanna, Perälä, Piia, & Saariluoma, Pertti

Unpublished manuscript.

IV

EMOTIONAL USER EXPERIENCE: TRAITS, EVENTS, AND STATES

by

Jokinen, Jussi P. P. 2015

International Journal of Human-computer Studies vol 76, 67-77
http://dx.doi.org/10.1016/j.ijhcs.2014.12.006

Int. J. Human-Computer Studies 76 (2015) 67–77

Contents lists available at ScienceDirect

Int. J. Human-Computer Studies

journal homepage: www.elsevier.com/locate/ijhcs

Emotional user experience: Traits, events, and states☆

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ARTICLE INFO

Article history:
Received 11 March 2014
Received in revised form
19 December 2014
Accepted 22 December 2014
Communicated by Paul Van Schaik
Available online 31 December 2014

Keywords:
Emotion
Appraisal
User experience
Human–technology interaction
Coping
Individual differences

ABSTRACT

Emotional experience has become an important topic in human–technology interaction research and design. Nevertheless, such research and design often lacks a proper explanatory basis and methodologically robust operationalisation. In this article, a conceptualisation of emotional user experience is formulated based on the appraisal theory of emotion, where the goal congruence of the interaction events and the task-independent individual traits are thought to underlie the user's emotional response. A laboratory study with $N=50$ participants conducting ordinary computer tasks is reported. The results suggest that subjective emotional experience depends on a number of factors relating to individual differences in coping and task events. Emotional user experience, as analysed according to a competence–frustration model of emotion, is dependent on the user's technological problem-solving tendency, frustration tendency, pre-task self-confidence, and task performance.

1. Introduction

1.1. The appraisal process and emotion in human–technology interaction

Subjective experience has recently received much attention in human–technology interaction research and design. Moreover, terms such as *user experience* have been introduced to emphasise the importance of the feelings that users experience as they interact with technological artefacts (Bødker, 2006; Hassenzahl, 2010; Desmet and Hekkert, 2007; Norman, 2004; Wright et al., 2008). Most scholars in the field agree that emotion is one of the main dimensions of user experience (Bargas-Avila and Hornbæk, 2011; Hassenzahl and Tractinsky, 2006; Norman, 2004; Saariluoma and Jokinen, 2014; Thüring and Mahlke, 2007). However, a psychologically valid theory of emotional user experience is still lacking (Saariluoma and Jokinen, 2014). This shortcoming is especially visible in empirical studies, where theoretical operationalisation of emotional user experience would be required (Bargas-Avila and Hornbæk, 2011). One problem resulting from the lack of a complete and theoretically sound operationalisation of emotional user experience is that more room is left for pre-scientific intuitions to affect the design of experiments and new interaction technologies (Saariluoma, 1997). With clearer systematic operationalisations, human–technology interaction researchers and designers could better explicate and conceptualise their intuitions concerning such elusive concept as subjective experience, thus benefiting the field from both the perspective of basic research and applied design (Saariluoma, 1997; Saariluoma and Jokinen, 2014; Saariluoma and Oulasvirta, 2010).

The capacity of psychological theory to explain why people have certain emotional experiences or behave in certain ways is one of the most critical prospects for conceptualising emotional user experience in psychological terms (Saariluoma, 2004). While the prospect is obviously important for scientific pursuits, it is also important in the design process, as showing how and why certain experiences occur in human–technology interaction lets designers create concepts and test their ideas theoretically, giving a formal basis for design solutions. This is highly important, for example, in experience-driven design (Hekkert et al., 2003), where being able to evaluate concepts theoretically in the very beginning of the design process is essential. In the same manner, as an engineer utilises scientific concepts and laws while making construction plans, an interaction designer needs to be able to utilise psychological concepts and theories concerning human–technology interaction (Saariluoma and Oulasvirta, 2010).

Although there is much discussion about measuring emotion and user experience, many researchers and designers still think that the operationalisation of valid user experience measurement instruments is not possible (Law et al., 2014). This is understandable for two reasons. First, emotion is still a debated topic in psychological theory. Interest in emotion has always been a part of philosophical and scientific inquiries, but the theoretical and experimental psychology of the last century focused mainly on other aspects of human mental life, especially on the information-processing aspect of human cognition (Baddeley, 2007; Power and

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http://dx.doi.org/10.1016/j.ijhcs.2014.12.006
1071-5819/

Dalgleish, 1997). Only recently there has been a proliferation of emotion research, but despite this increased interest, fundamental disagreements on what emotion actually is still exist (Barrett, 2006; Izard, 2007; Scherer, 2009). Disputes arise between positions, such as there is a set of biologically hard-wired basic emotions (Izard, 2007), emotion is the result of a complex process of cognitive computation (Scherer, 2009), and conscious emotional experience is a conceptual and cultural reflection of a core physiological valence–arousal structure (Barrett, 2006; Russell, 1980). Many of these and other perspectives on what emotion is have been considered in human–technology interaction research (Lichtenstein et al., 2008; Mahlke and Minge, 2008), and it seems that it is too early for interaction researchers to side with a single psychological theory of emotion. In this article, appraisal theory is utilised (Scherer, 2009), but its use reflects its practical value in understanding emotional user experience as a process more so than an exclusive commitment to its meta-theoretical foundations.

The second apparent reason for reluctance to theorise and operationalise emotional user experience stems from the foundational notion that user experience is holistic (Hassenzahl and Tractinsky, 2006). This notion entails that user experience is all encompassing, contextual, and non-reducible, which makes a dimensional analysis of user experience and its subsequent operationalisations conceptually difficult (Boehner et al., 2007). The objective study of subjective experience indeed has methodological challenges associated with both the nature of consciousness and the quality of experience. Subjective experience is private and immediate, and it seems impossible or at least extremely difficult to put experience into explicit words and to analyse it objectively (Dennett, 1988). However, it is maintained here that emotional user experience can be theorised in psychological terms and that valid operationalisations of it can be used to measure emotional experience during or after technology use. This assumption, of course, entails a theoretical and a methodological question: what is emotion, and how can it be studied?

The standardised definition suggests that *user experience* is an individual's response to the use of technology (ISO 9241-210; Law et al., 2009), and, in such definition, it is therefore assumed that experience – emotional or otherwise – occurs in a process (see also Roto et al., 2011). A psychological theory of emotional user experience would hence benefit from an approach that would explain emotion as likewise occurring in a process. Suitably, one of the influential theories of emotion, *appraisal theory*, states that emotion can be understood as a cognitive process (Power and Dalgleish, 1997; Scherer, 2001, 2009). Appraisal theory proposes that emotion arises as a function of meaning structures, which are used to evaluate, or appraise, the personal significance of an event (Frijda, 1988; Lazarus, 2001; Scherer, 2005, 2009). This proposition focuses on the subjective interpretation of the event when explaining emotion, a perspective that is in line with the general user experience discourse. Hence, it further supports the use of appraisal theory as the theoretical framework for a psychology of emotional user experience.

While the process of appraisal consists of multiple levels, layers, interconnections, and phases (Scherer, 2009), two main appraisal types can be explicated (Lazarus, 2001; Lazarus et al., 1970). The first, *primary appraisal*, refers to the evaluation of a situation from the perspective of personal goals and values. Primary appraisal establishes the subjective significance, or meaning, of an event: whether or not the event is relevant to the individual's goals, and whether the event is pleasant or not. In *secondary appraisal*, the subject's ability to cope with the consequences of the event is assessed; that is, what is the subject's control over the event, and how can the subject adjust to it. These two forms of appraisal are responsible for changes in autonomic physiology, action tendencies, motor expression, and subjective feeling, which produce relevant emotional responses to events (Scherer, 2009). In this paper, appraisal theory is utilised to derive hypotheses concerning goal-congruency of interaction events, and individual differences in coping traits, both of which are closely related to the appraisal process. The experimental investigation will focus on how traits, events, and states influence the appraisal process, which explains emotion responses during human–technology interaction.

To understand how people consciously experience their emotions, a distinction between an implicit emotional process and explicit representation of emotion is necessary. The appraisal process is largely unconscious; it occurs without our explicit knowledge of it (Scherer, 2009). However, we are conscious of our emotions and are able to explicate our emotional experience. In the appraisal model, conscious experience of emotion is called *feeling* (Scherer, 2005, 2009), which can be defined as a mental representation of an emotional experience (Saariluoma and Jokinen, 2014; Scherer, 2005). Mental representations are entities that are about something, and, in this case, they are about emotional states. The emotional content of a mental representation refers to the conscious experience of emotional states. Some of the states occur more frequently than others do, and these are called *modal states* (Scherer, 1994, 2005). Modal emotions such as anger, fear, or joy are not assumed to be from a small set of physiologically hard-wired emotions, as posited in the theory of basic emotions (Scherer, 1994, 2005; c.f. Ekman, 1992; Izard, 2007). Basic emotion theory is nevertheless useful in operationalising and understanding the most important emotions associated with human–technology interaction, because research in its framework has a long tradition of identifying and describing these emotions (Saariluoma and Jokinen, 2014).

Emotional contents of mental representation are the methodological key to both the study of emotional user experience, and explanation of emotion in human–technology interaction (Saariluoma and Jokinen, 2014). Assuming that mental representations cause other mental states and behaviour (Fodor, 1985), the emotional contents of mental representation can be used to explain thinking and behaviour. In human–technology interaction, the user appraises the events of the interaction. This is a continuous and mostly unconscious process, but the user is able to mentally represent emotional states and thus have a conscious emotional experience. The contents of these representations can vary, but, as discussed previously, a certain set of modal (or 'basic') emotions is familiar to all of us and frequently useful in describing our feelings (Ekman, 1992; Saariluoma and Jokinen, 2014; Scherer, 2005). Emotional user experiences can therefore be investigated by asking the users to verbalise or otherwise indicate the emotional contents of their mental representations in terms of these modal emotions. Protocol analysis (Ericsson and Simon, 1984) and questionnaires (Saariluoma and Jokinen, 2014; Schorr, 2001), for example, are established means of obtaining information concerning the contents of mental representations.

1.2. The competence–frustration model of emotional user experience

Any appraisal process starts with an event, which starts the cognitive process in which the subjective relevance of the event and the person's coping capacity are evaluated (Scherer, 2005). An example of such an event and subsequent emotional response in human–technology interaction is the positive correlation between task performance and user satisfaction (Hornbæk and Law, 2007). Generally, successful events during the use of technology are appraised as pleasant because they are congruent with the goals of the user.

On the contrary, frustration, anxiety, and confusion arise when there are obstructions in the interaction, and these are appraised as incongruent with the goals of the user. The relation of emotional user experience to interaction events can be analysed with the bipolar *competence–frustration model*, in which feelings of *competence* (or techno-competence) arise from successful task completion and the users perceiving their own skills in a positive light, whereas, *frustration* (or techno-frustration) is the result of being obstructed and unable to accomplish task goals (Saariluoma and Jokinen, 2014).

The main benefit of using the competence–frustration model is that it is grounded on the psychological theory of emotion, and, hence, it supports the goals of the study. Methodologically, appraisal theory posits that the key to user's conscious experiences is in the subjective feeling component of appraisal (Scherer, 2009). This component is theorised as the emotional content of a mental representation. This is the same starting point as in the competence–frustration model, where the concept of mental representation is used to formalise how people experience interactive events (Saariluoma and Jokinen, 2014). Further, the competence–frustration model has been constructed for the domain of human–technology interaction, and as such, it is more concentrated on the topic of this study than more general models of emotions, such as the positive and negative affect schedule (Watson et al., 1988). However, it should be noted that the choice of competence–frustration model does not mean, that other emotions would not be possible in human–technology interaction. Instead, as will become evident below when discussing secondary appraisal, both competence and frustration fit well into the investigation of primary and secondary appraisal.

Appraising the pleasantness of an interaction event is the primary part of the appraisal process in human–technology interaction. Task effectiveness leads to techno-competence, and, because accomplishing tasks is congruent with the goals of the users, the users perceive that their accomplishments are due to their skills and knowledge (Saariluoma and Jokinen, 2014). Feelings of competence are closely related to *self-efficacy*, which is the self-appraisal of operational capability or the self-referential representation about the capabilities of the subject to perform in a given domain (Bandura, 1977, 1982). Self-efficacy is therefore closely linked to feelings of competence: both refer to the individual's self-perceived capacities. However, competence is not the same as self-efficacy. Whereas self-efficacy refers to people's beliefs in their own operational abilities, competence is the emotional associate of the successful employment of such abilities (Saariluoma and Jokinen, 2014).

Primary appraisal of an interaction event can also result in a negative emotional response, such as anxiety or frustration. Frustration is the result of a goal-incongruent event or obstruction (Saariluoma and Jokinen, 2014). Reflecting the subjective nature of the appraisal process, the same obstructive event may result in different amounts of frustration, depending on how important the obstructed goal was to the user. What is important is that frustration as an emotional user experience response presupposes the existence of a subjective goal, and an event that the user perceives as obstructive. In other words, experiencing frustration requires conscious attribution of the source of the frustration to an obstructive event (Scherer, 2001, 2009). In acute forms, this can lead to aggressive behaviour towards the attributed source of frustration (Berkowitz, 1989), as demonstrated in human–computer-interaction research (Brinks, 2005; Lazar et al., 2006).

The bipolarity of the competence–frustration model indicates that these two emotional parts of user experience are separated by their valence, which is a basic content-dimension of human emotional experience (Frijda, 1988; Russell, 1980; Saariluoma and Jokinen, 2014). Although events are usually appraised by their valence as either pleasant or unpleasant, competence or frustration are not necessarily negatively correlated. It is possible to imagine a scenario, where an obstructive interaction event causes frustration in the user, but the user is nevertheless able to solve the problem and thus experience competence. In this case, the user's feeling of competence may still be accompanied by frustration, for example if the cause of the obstruction was in a bad interface design. Frustration is indeed empirically associated with how professional, needful, and safe the technology is considered, whereas competence is more associated with the user's own abilities than the features of the technology (Saariluoma and Jokinen, 2014). There is a difference in achieving task performance with *effort* and with *ability* (Schunk, 1983), and hence the relation of feeling of competence to successful interaction is more complex than with feeling of frustration.

Research on emotion in human–technology interaction has long maintained that task performance during technology use correlates with emotional responses, and since the 1980s, usability research has produced a strong body of evidence for this association (Hornbæk, 2006; Hornbæk and Law, 2007). Although the competence–frustration model of emotional user experience is theoretically in line with this notion, the model does not currently have empirical support for this thesis. The first hypothesis of the study is therefore the validation of the argument that techno-competence and techno-frustration correlate with task performance. The establishment of this association is important for two reasons. First, before empirical support has been provided, the whole competence–frustration measurement model of emotional user experience lacks construct validity in the sense that the correlations expected from the model have not been investigated. Second, it is important to establish the effect sizes of the correlations, that is, the strength of the association between task performance and emotional user experience. The first hypothesis is stated separately for both factors of the competence–frustration model.

H1a. Task performance affects feelings of competence.

H1b. Task performance affects feelings of frustration.

1.3. The appraisal process and coping in emotional user experience

Primary appraisal establishes the personal relevance of the event: goal-congruent events result in pleasant emotional responses, and goal-incongruent events result in unpleasant emotional responses. In secondary appraisal, the user's ability to cope with the event is evaluated. *Coping* is an important part of the emotional process, and it can be understood as the individual's adaptation effort in managing interaction with the environment (Folkman and Lazarus, 1985; Lazarus, 1991; Lazarus and Lazarus, 1994). In this sense, coping is not associated only with problems and obstructions: the capacity to exert control over the event is appraised in all situations, and it can be relevant in both pleasant and unpleasant situations. Feelings of techno-competence, for example, are the result of being able to control events and perceive the results of the interaction as pleasant. Feelings of techno-frustration, on the contrary, are the result of goal-incongruent obstructions in a situation where the user should have some power over the event.

People have different strategies for coping, and the choice of a strategy depends on the situation and the individual. There are two general coping strategies: problem-solving and emotion-centred approaches (Folkman and Lazarus, 1985; Lazarus, 1991; Lazarus and Lazarus, 1994). In ideal terms, if a high control potential over an event is appraised, a problem-solving coping strategy can be utilised to influence the event, exert power over it, and make the situation more congruent with personal goals. However, if the power to influence the situation is appraised as low, a better strategy is to attempt to deal with the emotional response (Folkman and Lazarus, 1985). The choice of a strategy is, of course, not dichotomous: successful coping can encompass both problem-solving and emotion-regulation strategies. There are also individual differences in the use frequency of these two strategies (Folkman and Lazarus, 1985).

In human–technology interaction, for example, some users may try to restore their emotional stability after a problematic use event, whereas others may try to push their limits and learn something new during the process (Beaudry and Pinsonneault, 2005). If the problem-solving coping strategy is utilised successfully and, therefore, a goal-congruent state of events is established, the emotional response is positive. For example, solving a problem and understanding that the solution was due to the user's skills and determination causes the user to feel competent (Saariluoma and Jokinen, 2014). This trait is here called *planful problem-solving*. However, even if the user does not solve the problem, individuals who are able to cope with the frustration response experience less feelings of frustration in the face of goal-incongruent events than do individuals who are not able to cope with their emotions (Lazarus, 2001; Lazarus et al., 1970). This trait is here called *frustration tendency*. These notions serve as the basis for the second and third hypotheses of this study.

H2. Having a tendency to solve technological problems planfully has a positive influence on competence.

H3. Having a tendency to get frustrated with technological problems has a positive influence on frustration.

The hypotheses are stated as direct effects of coping traits on emotional response. It is important, however, to understand that while coping traits are an intrinsic part of the appraisal process, they are not the primary cause of emotion. Rather, coping traits moderate the effect of events on emotional response. Frustration, for example, presupposes an event that is appraised as goal incongruent, and coping traits moderate the effect of the event on frustration, by weakening or strengthening the frustration. However, the study is the first of its kind to investigate experimentally coping traits and emotional responses in human–technology interaction, and establishing the main effect that precedes moderation effects is a priority. Therefore, while H2 and H3 are stated as direct effects, it is better to think of the relation as associative rather than causal. The main proposition of the study is the association between coping traits and emotional responses, and the hypotheses relate to it. Detailed study of moderation is left for further studies, which could use the study's findings on coping effects.

1.4. Self-confidence and emotional user experience

Users' emotional responses to the events of an interaction are therefore dependent on their individual coping tendencies. However, there is also within-individual variance in emotional responses to events. Small annoyances during the use of technology can build up to a disproportionately aggressive response to a single obstructing event. Further, the user always comes into the interaction situation with an underlying emotional state, or a mood. Compared to emotions, moods are more persistent in time and lacking a clear antecedent (Sedikides, 1995). Whether a person is in a positive or negative mood has been shown to influence cognitive processes (Bower, 1981), judgments of others (Forgas and Bower, 1987), and self-conceptions (Sedikides, 1995). Mood is also considered an important antecedent of user experience (Hassenzahl and Tractinsky, 2006), but the effect of mood on the user's emotional states has not been studied in the same depth as it has been in the context of general psychological research.

Mood affects emotional responses, but it also affects the beliefs individuals have about themselves. A negative mood predicts decreased belief in one's own abilities, whereas a positive mood strengthens this belief (Kavanagh and Bower, 1985). Assessing a person's mood is a challenging problem, preferably requiring multiple repeated measurements to control for day-to-day variance (Watson and Clark, 1997). However, assessing one's belief in one's own abilities is easier. Self-confidence before starting tasks, for example, while not a direct measure of mood, is influenced by the mood of the user and, hypothetically, affects the emotional responses of the user (Kavanagh and Bower, 1985). Although this is not the same as predicting the effect of mood on emotional user experience, it is the starting point of analysing such mechanism. Therefore, the final, two-fold hypothesis of the study is as follows.

H4a. Self-confidence before the use event has a positive influence on competence.

H4b. Self-confidence before the use event has a negative influence on frustration.

In conclusion, in the user experience literature, user characteristics such as traits and moods have been noted in to influence the user's emotional responses (Hassenzahl and Tractinsky, 2006; Mahlke and Thüring, 2007); however, the influences of individual differences in coping strategies and moods have not been thoroughly investigated in the context of human–technology interaction research. In general, individual differences in human–technology interaction have been acknowledged from the perspective of information processing (e.g., Allen, 2000; Saracevic, 1991), and some research on individual differences on emotional experience exists (Brave and Nass, 2003). In technology acceptance models, for example, individuals' beliefs about their abilities to competently use computers has been shown to influence their expectations of computer use and their recollected emotional reactions to computers (Compeau and Higgins, 1995; Shu et al., 2011). Further studies have extended this model, demonstrating a connexion between the individuals' fears concerning computer use and their perceived ease of use in technology adoption (Venkatesh, 2000).

These models consistently show associations between user traits and emotional responses towards technology; however, they do not observe these responses at the time of use nor connect them with use events. Therefore, it is difficult to analyse the confounding effects of individual dispositions and use events on emotional responses. In other words, with such models, it is difficult to explain the user's emotional response and resulting behaviour. What is the mechanism, for example, between fear of using computers and perceived ease of use? Does the 'fear trait' lead to poor performance, which leads to perceived difficulties in use, or do the technology-use traits correlate with emotional responses regardless of effectiveness? A detailed model of emotional user experience, taking into account the individual antecedents in sources of variance, such as coping and mood, is still missing.

2. Method

2.1. Participants, stimuli, and procedure

$N=50$ participants (37 men and 13 women) were recruited for the experiment (age $M=22.8$ years, $SD=5.0$, and range=18–43). The participants were university students, recruited from an introductory course for human–technology interaction. A day before coming to the laboratory, the participants were asked to answer a questionnaire concerning the traits they use to cope with technology (the questionnaire was filled online). In addition, the participants reported their self-confidence at the start of the experiment. In the experiment, the participants conducted tasks using four desktop applications used in everyday office work and then reported their emotional states during the tasks. Four points of data were therefore attained and used to investigate the hypotheses: coping traits of the user (a questionnaire administered a day before the experiment), self-confidence of the user (a questionnaire administered just before the experiment), events of the use (recorded at the time of the use), and emotional responses to the use (a questionnaire administered immediately after the use).

The tasks were conducted with four applications: a text processor (Microsoft Office 2010 Word), an image editor (Microsoft Paint), a presentation editor (Microsoft Office 2010 PowerPoint), and an internet browser (Google Chrome). All four have been associated with workplace frustration (Lazar et al., 2006), which supports their usefulness in studying emotional user experience. Ordinary desktop applications and tasks were chosen because most people are familiar with the context. Indeed, each participant had at least some experience with each of the applications used in the experiment, and everyone reported having at least basic computer skills. The tasks ranged from opening and saving a document or adding a new presentation slide, to drawing an ellipse of a certain colour. All tasks were possible to do without advanced computer skills, but some required more thinking and problem solving than the others did. Participants were given one task at a time to complete, and five minutes for each application. Task completion was confirmed by the experimenter, who then gave the participant a new task. At the end of the five minutes, the number of completed tasks was recorded and used as a measure for *task performance. Task performance* was therefore operationalised as the effectiveness of the user (Hornbæk, 2006). After completing tasks for five minutes, the participants were given a questionnaire regarding emotional user experience. This procedure was repeated four times for each participant, once for each application. Task order was counterbalanced between the participants by randomisation.

2.2. Questionnaires

The two technology coping dimensions, problem solving and emotional coping, were operationalised into a questionnaire. All questionnaire items, their factor loadings, and the reliabilities of the scales are presented in Table 1. Previously used coping questionnaires include, for example, the Ways of Coping Questionnaire (Folkman and Lazarus, 1988), for investigating general coping traits, and Computer Self-Efficacy (Compeau and Higgins, 1995; Shu et al., 2011) and Computer Anxiety (Venkatesh, 2000) for investigating technology traits specifically. Items from these sources were used to create new scales for the two coping strategies: planful problem solving and frustration tendency. For example, an item from the Ways of Coping Questionnaire, ‘I drew on my past experiences; I was in a similar situation before.’ was used as a basis for an item in *planful problem solving*: ‘When I encounter a technological problem, I utilise my prior knowledge and experience in solving it.’ Hence, *planful problem solving* measures the individual's perseverance with problems and capacity for utilising problem-solving resources. *Frustration tendency*, on the contrary, concerns the individual's tendency to get frustrated with technological problems to the extent that it interferes with the individual's emotional stability and self-control.

Immediately after the participants arrived at the laboratory, *self-confidence* was measured at the start of the experiment with a four-item Likert-scale. The scale was taken from the competence–frustration model of emotional user experience (Saariluoma and Jokinen, 2014). However, the reliability analysis indicated that the scale for self-confidence was not reliable with the item ‘Before the experiment, I felt vigilant’; removing the item resulted in a reliable scale. The questionnaire for emotional user experience was constructed from the bipolar factor model of emotional user experience, consisting of scales for competence and frustration (Saariluoma and Jokinen, 2014). The questionnaire items consisted of four basic or modal emotions for each factor, presented as Likert-scales.

All factors (planful problem solving, frustration tendency, self-confidence, competence, and frustration) were calculated into summated scales using a regression method for factor scores of a maximum likelihood factor analysis (DiStefano et al., 2009). This practice aims to maximise the reliability of the scale by using an item's factor loadings and its correlations with the others as weights, and results are given in standardised scales with a mean of 0 and variance of approximately 1. Although the number of participants was relatively small for a factor analysis, the number of items in the factors was likewise small: an individual factor had three or four items, resulting in over ten times as many observations as items. The scales for competence and frustration were calculated by pooling the data from the four tasks.

Both Cronbach's alpha and factor score covariance coefficients were calculated for assessing reliability, whereas factor score covariance coefficient is a better estimator of the reliability of the scale constructed using the regression method (DiStefano et al., 2009; Osburn, 2000), reporting Cronbach's alpha is the standard practice. The alpha of both frustration tendency and self-confidence was slightly below the generally accepted cut-off line of .70, but the factors were accepted in the analysis, as their factor score covariance was still acceptable. Other factors were acceptable using both measures of reliability. For the factors constructed by pooling the repeated measures data, reliabilities for each repeated measure was calculated to confirm uniform reliability. The reliability of competence was atleast .87, and it was atleast .84 for frustration, confirming that the measures were reliable in all tasks. None of the factors described previously were observed to depend on the background variables of the participants, namely age or gender.

2.3. Data analysis

The hypotheses of the study were tested with linear mixed modelling using the ‘generalised linear mixed model’ procedure in SPSS 20. Separate models with either competence or frustration as the dependent variable were constructed. Both models included an intercept, the task performance scale (H1), and the self-confidence scale (H4). Further, the model for competence included the planful problem solving scale (H2), and the model for frustration included the frustration tendency scale (H3). In order to control for confounding interaction effects, such as frustration tendency having an effect on task performance, which then has an effect on frustration, interaction effects between the background variables and task performance were added (all interaction effects are listed in the results section). However, the two coping traits were not mixed between the models, and, therefore, the model for competence did not include frustration tendency, and the model for frustration did not include planful problem solving. The reason for this is that mixing the models would have greatly increased the number of independent variables and their interactions, which would have affected the model's robustness.

As the models consisted of four repeated measures conducted with the same participants (four different applications), task was included as a random effect in the model and will be reported as random variance in the models. Satterthwaite's (1941) approximation for degrees of freedom was used in the models, as it increases the power of the analysis on small sample sizes in repeated measures testing (Hox, 2010). It assumes heterogeneous sample variances and

Table 1
Questionnaire items of the factors used in the experiment and reliabilities, presented as both factor score covariance coefficients and Cronbach's alpha. Scores for competence and frustration are calculated for the pooled data.

Factors and items	Factor loading	Cov.	Alpha
Planful problem solving		.82	.77
When I encounter a technological problem …			
I am capable of searching the internet or the manual for solutions.	.46		
I would not give up before solving it.	.79		
I try to solve it independently.	.81		
I utilise my prior knowledge and experience in solving it.	.68		
Frustration tendency		.71	.69
When a technological equipment, application, or service does not work as expected or otherwise works exceedingly badly and is frustrating …			
I vent my frustration physically.	.61		
I blame the equipment, application, or service.	.59		
I am not able to cope calmly with the problem.	.71		
it takes a long time for me to recover from my frustration.	.49		
Self-confidence before the test		.85	.68
Currently, I feel …			
Certain.	.62		
Determined.	.91		
Ready.	.49		
Competence		.92	.91
During the tasks I felt …			
Successful.	.86		
Determined.	.90		
Efficacious.	.88		
Vigilant.	.75		
Frustration		.84	.83
During the tasks I felt …			
Frustration.	.79		
Anxiety.	.70		
Confusion.	.69		
Annoyance.	.80		

Note: $N=50$.

adjusts degrees of freedom to account for this, which can be seen as different *df*2 values between the fixed effects in the results. All 50 participants conducted four tasks each, resulting in 200 cases, but, two participants failed once to fill the emotional questionnaire properly, and these two cases were discarded from the analysis. Therefore, the number of cases included in the two models was 198. Otherwise, there were no missing data.

Finally, it should be noted that the modelling procedure used does not indicate the model fit in terms of R^2 (Hox, 2010). It is, however, possible to compare models with each other using the Akaike information criterion (AIC): lower numbers indicate better fitting models, but the number is relevant only for comparing competing models with each other (Hox, 2010). AIC change when adding the main fixed effects are reported in the results.

3. Results

On average, the participants were able to complete 4.5 tasks ($SD=1.3$). There were no notable differences in task performance between the four desktop applications: the mean task completion were 3.8 for word processing, 5.0 for image manipulation, 4.9 for web browsing, and 4.3 for presentation editing. The maximum number of tasks for each application was 15, but no one was able to complete all of them in the allocated time. Because the mean of the tasks completed was closer to its theoretical minimum than the maximum, it had a slight positive skew of .28 (s.e.=.17). However, the distribution was approximately normal, and the residuals from the linear models revealed that the results were not caused by any outliers. The number of tasks completed was not dependent on the age or the gender of the participant, as revealed by non-significant correlation and *t*-tests. Similar analysis for the emotional user experience factors revealed that competence and frustration were not dependent on the computer application, gender, or age.

There was no correlation between the coping traits factors, planful problem solving, and frustration tendency ($r=.04$). Self-confidence had a small correlation with planful problem solving ($r=.27$), but not with frustration tendency ($r=.01$), indicating that the self-confidence at the start of the experiment was not, at least not largely, dependent on the coping traits of the participant. No correlations between the number of successfully conducted tasks and planful problem solving ($r=.07$), frustration tendency ($r=.02$), or self-confidence ($r=.04$) were observed, indicating that individual differences in coping did not influence task performance directly and suggesting that the tasks were relatively easy to conduct. Although these correlations were not the main interest in the study, the small observable correlation between the explanatory variables make the models predicting competence and frustration more robust (Shieh and Fouladi, 2003).

The AIC was 453.9 for the linear mixed model for competence with task performance, 441.7 with task performance and planful problem solving, and 440.1 with task performance, planful problem solving, and self-confidence. The respective AICs for the frustration model, in which frustration tendency was used in place of planful problem solving, were 474.8, 466.5, and 466.1. The decrease in AICs of both models indicates that the main effects increased the model fit. The linear mixed model for competence is displayed in Table 2, and the model for frustration is shown in Table 3, which presents the fixed coefficients of the models with standard errors and standardised coefficients, as well as the random part of the model, signifying the repeated measurements in the experiment.

The results support H1–H3, and give partial support to H4. Planful problem solving tendency increases competence as hypothesised (H2), and frustration tendency can be used to predict frustration during the use of technology (H3). Self-confidence, reported at the start of the experiment, increases competence (H4a), but it has no statistically significant effect on frustration, although the direction of the effect is as hypothesised (H4b). Clearly, however, the largest predictor of emotional user experience in the models is task

Table 2
The linear mixed model for competence displaying the fixed coefficients with standard errors and standardised coefficients. The repeated measures are given as the random part of the model.

	Fixed part			
	F	df1, df2	Coefficient (s.e.)	Std. coef.
Intercept	41.7**	5, 174	−.87** (.08)	
Task performance	162.8**	1, 183	.19** (.02)	.63
Planful problem solving	5.6*	1, 178	.22* (.09)	.19
Self-confidence	13.8**	1, 160	.34** (.09)	.33
Planful problem solving × task performance	.2	1, 166	−.01 (.02)	
Self-confidence × task performance	8.0**	1, 184	−.05** (.02)	
			Random part	
σ_1 (s.e.)			.52 (.11)	
σ_2 (s.e.)			.35 (.08)	
σ_3 (s.e.)			.53 (.11)	
σ_4 (s.e.)			.45 (.09)	

Note: $N=50$, cases included = 198. s.e. = standard error. Std. coef. = standardised coefficient. σ = standard deviation of the random parameter; 1 = text processor; 2 = image editor; 3 = web browser; and 4 = presentation editor. Because of the Satterthwaite's approximation, the degrees of freedom (df2) vary between the independent variables.

* $p < .05$.

** $p < .01$.

Table 3
The linear mixed model for frustration displaying the fixed coefficients with standard errors and standardised coefficients. The repeated measures are given as the random part of the model.

	Fixed part			
	F	df1, df2	Coefficient (s.e.)	Std. coef.
Intercept	23.6**	5, 184	.76** (.09)	
Task performance	98.8**	1, 193	−.17** (.02)	−.59
Frustration tendency	9.7**	1, 181	.35** (.11)	.35
Self-confidence	3.4	1, 186	−.18 (.10)	
Frustration tendency × task performance	2.1	1, 193	−.03 (.02)	
Self-confidence × task performance	.6	1, 190	.01 (.02)	
			Random part	
σ_1 (s.e.)			.70 (.15)	
σ_2 (s.e.)			.47 (.10)	
σ_3 (s.e.)			.47 (.10)	
σ_4 (s.e.)			.55 (.11)	

Note: $N=50$, cases included = 198. s.e. = standard error. Std. coef. = standardised coefficient. σ = standard deviation of the random parameter; 1 = text processor; 2 = image editor; 3 = web browser; and 4 = presentation editor. Because of the Satterthwaite's approximation, the degrees of freedom (df2) vary between the independent variables. *$p < .05$.

** $p < .01$.

performance (H1a and b): being able to complete tasks increased competence and decreased frustration. In the competence model, the standardised coefficient of task performance is .63, which is clearly greater than the standardised coefficients of self-confidence (.33) or planful problem solving (.19). In the frustration model, the standardised coefficient of task performance (−.59) is likewise larger than that of frustration tendency (.35).

The interaction effects, while not stated as hypotheses, and only included in the model as controls, revealed one preliminarily interesting effect. The model suggests that self-confidence moderates the effect of task performance on competence. Interpreting interaction effects of two continuous variables is difficult (Hox, 2010), and, hence, the interaction is visualised in Fig. 1 as a regression of the effects of task performance on competence by two extremities: two standard deviations below the mean self-confidence and two standard deviations above. The interpretation is now easier: those with very little self-confidence at the start of the experiment report, on average, less competence than those with much self- confidence do, but if they are successful in completing tasks, competence is influenced more than it is for those with more self-confidence.

4. Discussion

4.1. Individual coping differences and task performance in emotional user experience

The empirical results support the hypotheses of the study. The main antecedents of the user's emotional experience, measured as techno-competence and techno-frustration (Saariluoma and Jokinen, 2014), were revealed to be task performance (H1), individual differences in coping traits (H2 and H3), and, partly, confidence before the experiment (H4a, but not H4b). The practical implication of the support for H2 and H3, and partial support for H4, is that these effects need to be considered when analysing the effect of technology use on the emotions of the user. Psychological theory on emotion is clear on this matter: there are individual differences in how events are appraised, and this influences the emotional responses (Folkman and Lazarus, 1985; Lazarus, 1991; Lazarus and Lazarus, 1994). The results of this study support this theory in the context of human–technology interaction and emotional user experience and underline the importance of a detailed and organised analysis of such a complex phenomenon as emotion in interaction with technology. Although the role of individual differences in the user's emotional experience has been noted before (e.g., Compeau and Higgins, 1995; Shu et al., 2011), this notion has not been tested sufficiently 'in action', that is, with real use tasks, while still maintaining experimental control for sufficient observation and manipulation.

Feeling competent during or immediately after an interaction event is the result of being successful in conducting the tasks and, therefore, of viewing one's own skills in a positive light (Saariluoma and Jokinen, 2014). Hence, the effect of the trait of planful problem solving on competence (H2) is understandable: being able to cope with task problems with a problem-solving strategy results in experiencing one's own capabilities in a positive light. A user who is inclined to planful problem solving appraises an interaction event with high control potential, which is reflected in feeling more competent. This connexion has already been noted in investigations of self-efficacy (Bandura, 1982) and in the context of human–technology interaction (Compeau and Higgins, 1995; Conati and Maclaren, 2009). However, the connexion of being inclined towards planful problem solving and feeling competent during technological tasks has not been previously shown in an experimental setting, within the theoretical framework of the appraisal process of emotion.

Frustration, on the contrary, is the result of encountering obstructions to one's own goals during an interaction (Saariluoma and Jokinen, 2014). Although many sources understandably emphasise the focus on positive experiences (e.g., Desmet, 2012; Hassenzahl, 2008), negative experiences should not be dismissed. Frustration, for example, is a major part of our daily experience with technology (Brinks, 2005; Lazar et al., 2006). Therefore, the support for H3 that individual differences in frustration tendency have an impact on experiencing frustration is significant. Frustration is indeed a relevant aspect of emotional user experience; however, there are individual differences in how it is experienced. Facing an obstacle during the use of technology does not necessarily lead to frustration because, in the face of goal-incongruent events, the user may still cope with the arising emotions.

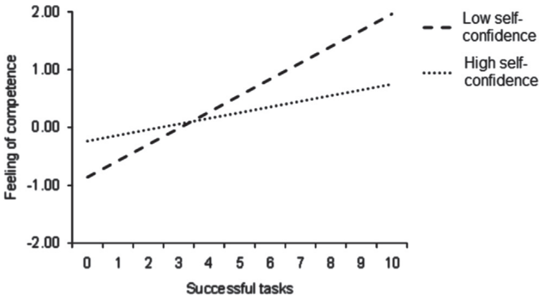

Fig. 1. Regression lines for competence by tasks completed and by self-confidence. Low and high self-confidence are calculated as two standard deviations from the mean.

The competence–frustration model has been developed with experiments and field-testing in which people interact with technology (Saariluoma and Jokinen, 2014). It is hence, from its inception, a tool focused on evaluating the emotion process in human–technology interaction. Competence and frustration are closely related to interaction situations in which the user needs to solve problems. Competence is related to successfully completing tasks with ability, and frustration is related to being obstructed from the goals. These circumstances involve primary and secondary appraisal, that is, how the events are related to the goals of the user, and how the user copes with problems using problem-solving or emotion-cantered approach. This implies the usefulness of the competence–frustration model in investigating emotional user experience in demanding human–technology interaction situations. This does not mean that the model covers the totality of what emotional user experience is, but modelling it with psychological theory allows for expanding the model. For example, one important aspect of experience in human–technology interaction, feeling of control (Hassenzahl et al., 2010), can be stated in terms of appraisal theory (Folkman and Lazarus, 1985; Scherer, 2009), which mediates its addition to the model of emotional user experience.

H2 and H3 are in line with the notion that people generally have two ways to cope during appraisal: problem-solving and emotion-centred approaches (Folkman and Lazarus, 1985; Lazarus, 1991; Lazarus and Lazarus, 1994). As no correlation was observed between the trait factors operationalised from these two ways to cope, it is probable that these traits do not dismiss each other. Therefore, it may be plausible that an individual may have both a high frustration tendency and a high planful problem-solving trait. Questions concerning the connexion between the traits, however, would require a larger survey study. The interaction between the two traits was also ignored in the statistical analysis of the study, as the linear mixed model for competence did not include frustration tendency as an independent variable, and vice versa. These omissions should be mended in future studies, after a survey revealing the possible combinations of the two traits has been conducted.

The empirical support for H2 and H3 already describes how emotional user experience is dependent on the individual differences in coping traits. However, also important is what the user feels right before the use events. The result of the linear mixed model for competence gives support for H4a: self-confidence before the tasks increases competence. The direction of the effect for frustration was as hypothesised (self-confidence decreasing frustration), but the effect was not statistically significant. One possible reason for the larger effect of self-confidence on competence is the similarity between self-confidence and competence scales. Perhaps a scale for measuring states other than self-confidence at the start of the experiment would have correlated with frustration. Although the study reveals a number of relevant individual factors related to emotional experience during human–technology interaction, future studies should focus on finding more of them.

The partial support for H4 raises an important point. Although mood has been noted as an important antecedent of user experience (Hassenzahl, 2008; Hassenzahl and Tractinsky, 2006), the connexion between the user's emotional state before the interaction and emotional user experience responses has not previously been stated as the result of an experimental investigation. The results reported here do not deal with the long-term mood of the participants, but rather their self-confidence immediately before the experimental tasks. However, these results suggest that part of the emotional response to use events is carried from emotional states before the experiment, which suggests a mood effect on emotional user experience. Also of interest is the observed interaction effect between self-confidence and task performance: self-confidence moderates negatively the effect of task performance on competence. If a person is already in a confident state, then the competence resulting from being able to conduct tasks is not as visible as it would be for a person who is not as self-confident but is able to complete the tasks.

These findings open up a large set of future investigations on the effects of the emotional state at the start of the technology use on the emotional states during or immediately after the use. Of course, to measure mood as a time-persistent emotional state, further time points should be used to assess the emotional states of the participants prior to the experiment. The model established herein, therefore, serves as a preliminary demonstration of the effect of mood-congruence. Further, the interaction effect observed between self-confidence and task performance serves as a preliminary result, which should be used to operationalise experiment, which studies this moderation effect, as well as similar possible moderation effects of planful problem solving and frustration tendency, in more detail. As discussed in the introduction, because of appraisal theory, one should expect that the coping traits moderate the effect of task performance on emotion responses, but the investigation of this effect will require further studies.

Emotional user experience is not, of course, only the function of individual differences in coping traits, and in pre-use self-confidence. The influence of task performance on emotional user experience (H1) was observed to be large. This finding provides construct validity to the competence–frustration model of emotional user experience, and suggests effect sizes for further studies. The standardised coefficients of task performance in the two models (.63 for competence and −.59 for frustration) can be contrasted with a meta-analysis, in which correlations between objective task-performance measures and subjective measures of satisfaction were found to be relatively small, from .16 to .25 (Hornbæk and Law, 2007). It is possible that the role of task performance was emphasised, because the participants were restricted to conduct the tasks in a limited timeframe. However, it is also possible that because the studies reviewed by Hornbæk and Law (2007) did not consider the complete framework of emotional user experience presented herein, the effects of coping traits and self-confidence – not measured in the reviewed studies – were confounding the results, which resulted in small effect sizes of objective performance on subjective experience. This supports the use of a competence–frustration model, augmented with the notions of coping and self-confidence antecedents, for investigating the emotion process in human–technology interaction.

The context of the study, ordinary desktop applications, was chosen because the discussion and experimentation on the effects of coping traits on emotional user experience is easier in very familiar settings. It should be noted, however, that the results do not necessarily generalise to, for example, leisure context, such as games, or more complex interaction scenarios. With computer games, for example, a certain amount of frustration may be necessary for good experience (Baker et al., 2010), a notion that is not considered in the hypotheses of this study. However, it is still maintained that the overall model of how coping affects the user's emotional experience is also valid in a leisure context. In a computer game, challenge is expected, but, to enjoy the challenges, the player needs to be able to solve the challenges and cope with the frustrations. Therefore, while the competence–frustration model has not been tested with computer games or in other leisure contexts, it a plausible hypothesis for future studies that the mechanism of feeling competent or feeling frustrated in a leisure context is similar to that in work contexts. The relative strengths of the associations explored herein, of course, can vary notably in different contexts, so that, for example, frustration tendency may play a larger role in computer games than it does in a work environment. Moreover, the competence–frustration model has been tested with complex interaction (Saariluoma and Jokinen, 2014), and it should therefore be possible to translate the results of this study to complex environments.

Further, it should be noted that performance is certainly not the only goal of the user in human–technology interaction. Rather, people use technology for a variety of personal goals, and, thus, good task performance is goal-congruent only in the sense that the completed tasks support the psychological needs of the user, such as the need to feel safe or competent (Hassenzahl et al., 2010). However, while the connexion between the artificial tasks and the needs of the user is not the same as it would be in a natural setting, it is probable that the participants wanted to perform well and wanted to feel competent during the experiment. In this case, it was also helpful that the tasks were derived from ordinary office work, because in all likelihood, the participants felt that being able to perform well in them is relevant for their current life goals, such as being able to use information technology in daily student work.

4.2. Methodological considerations

Although the main result of the study is the support for the proposed model of individual differences in the competence–frustration model of emotional user experience, the results also serve to support the methodological position of user experience as mental contents (Saariluoma and Jokinen, 2014). As discussed in the introduction, emotional user experience occurs in the process of appraisal, in which the personal significance of an event and the coping potential of the user are appraised. While the appraisal process is not completely conscious, it does have a conscious aspect, represented as feelings (Scherer, 2009). The study of these feelings, for example, in such concepts as techno-competence or techno-frustration, is possible via conceptualising emotional user experience as the emotional contents of the user's mental representations concerning the interaction. This methodological position, however, still requires further defence.

The use of questionnaires to elicit data on emotional experience has been criticised from various perspectives (Schorr, 2001). It is possible, for example, that participants are reporting their general knowledge concerning emotions, not their emotional states. If this was the case in the study, then the observed emotional responses would not reflect the participants' actual emotional responses, but rather, for example, how the participants expect that they should respond. While this is of course possible, the statistical model from the experiment provides validity for the competence–frustration model. Task performance is shown to have a strong correlation with emotional user experience (H1). This of course could reflect at least partially the fact that the participants think, in general, that if they are not successful in their tasks, they should report low competence and high frustration. In this case, the variances of competence and frustration at least partially would be accounted by the participant's general knowledge about what is expected of them. However, it is less feasible to claim that the participants could reflect on the constructs about their coping tendencies and use this information to respond to the questionnaires, inferring, for example, that having reported a high frustration tendency, that a high frustration response would be expected of them. Correlations between individual coping traits and in the models for competence and frustration are more complex than what can be accounted for by the participants utilising their general information to reflect on what they believe is assumed of them.

Although observing the expected correlations between the pre- and post-test questionnaire responses and task events provides validity for the utilised methodology, it is true that the two trait factors of the study are not the same as actual coping during the tasks. The results therefore suggest that individual differences in coping are relevant in emotion research in human–technology interaction; however, the mechanisms of coping during different tasks, different goals, and different means of problem solving still need to be examined in greater detail. Conducting an experiment utilising protocol analysis with a focus on problem solving and emotional experience during interaction tasks and connecting the findings to the coping traits of the participants would be one interesting option in connecting the mechanisms of coping with coping traits.

Another criticism of the study's methodology is the argument that emotion should not be measured nor theorised within the information-processing model of human activity (Boehner et al., 2007). This line of thought follows the cultural or constructivist perspective of human activity (Law et al., 2014): conscious emotional experience is conceptualised using cultural categories, and, hence, its measurement and reduction back to cognitive processes is not possible (Barrett, 2006; Boehner et al., 2007). It is possible, however, to accept that experience and communication of emotion rely on cultural constructs and still accept that there are cognitive, non-conscious processes that underlie our emotional states (Scherer, 2009). For example, to understand why a user is frustrated, it is necessary to understand how the experience of frustration occurs during an appraisal process. However, in the end, what is relevant is the explanation of the experience from all relevant perspectives. The appraisal process can explicate the mechanism from an interaction event to emotional user experience, but the explanation of techno-frustration requires facts about the circumstances of the use, as well as the beliefs and desires of the user. Only after these facts are understood does the explanation of frustration via the process of appraisal become meaningful.

Understanding emotion in terms of the appraisal process establishes an important connexion between emotion and cognition. This connexion has been demonstrated theoretically and empirically, in terms of how emotion influences cognitive processes (Bower, 1981) and how cognitive factors determine emotional states (Schachter and Singer, 1962). Hence, the discussion on whether to focus on cognition or emotion in human–technology interaction research is not relevant (Bødker, 2006): research on either assumes the other. As the model of emotional user experience explored herein states, it is as important to consider the performance of the use, as it is to consider the individual differences coping with problems during the interaction. These are all related to the mental processes of the user, and to the experience that the user has about the technology.

4.3. Emotional user experience and design

The notion of designing for experiences or facilitating certain experiences with design solutions has been adapted in a variety of applications, from consumer-oriented e-commerce (Nielsen et al.,

2000) and drinking glasses (Saariluoma et al., 2013) to business-oriented elevators (Rousi, 2013) and port cranes (Koskinen et al., 2013). To make the most of user- experience design, it is important to be able to understand scientifically what user experience is. This entails analysis, operationalisation, and study of the dimensions of user experience. One of the main dimensions of user experience, emotion, has been investigated in this article, with modern psychological theorising and methodology, namely, with a cognitive theory of emotion. The results indicate that individual coping traits have a significant role in the appraisal of everyday technological interactions and subsequent conscious emotional representations. The results can be utilised to make evaluations of emotional user experience of different products more valid, because theorising a measurement instrument for user experience with a cognitive theory of emotion gives credibility to evaluations using that instrument. Further, the insight offered by the extensive theoretical and empirical psychological work on this topic can be used to make sense of the results from those instruments. In the experiments reported here, for example, some amount of the emotional responses was explained by individual differences in factors, which did not relate to the used technologies. This makes the results, which are directly related to the technology, less confounded.

The results remind that individual differences should be considered in technology design, and not only in basic research on user experience. For example, whereas some people may prefer to have helpful information available only on demand, others may require active support in problem solving. This notion is well discussed in research on user modelling. In addition, modelling user's emotional states for developing adaptive interfaces has also been studied (Picard et al., 2001). User traits have, for example, been linked to emotional states in modelling user affect (Conati and Maclaren, 2009), but, although the existence of traits as emotional antecedents has been acknowledged, detailed discussion on what these traits are and what the mechanisms from traits to emotional states are is necessary, and the present study provides outlines for it. Understanding the relevant individuating factors in emotional user experience is an important aspect in explaining emotional experience in human–technology interaction, and it is advantageous, for example, in designing efficient user modelling and adaptive, personified interfaces.

The competence–frustration model of emotional user experience explored still needs further research to simplify its use in technology design. Laboratory experimentation is, up to a point, suitable for model building, but the real user experience occurs, of course, in naturalistic settings, with users who have actual goals, both work-related and life-related, and with actual work tasks. Therefore, one crucial step in constructing the competence–frustration model of emotional user experience as the function of individual differences and events during the use should hence be to investigate the working of the model in field settings. The competence–frustration model of emotional user experience has been validated in naturalistic settings (Saariluoma and Jokinen, 2014), and the process should be taken as a model for further studies of ecological validity.

Acknowledgements

This research is supported by the Finnish Funding Agency for Technology and Innovation (TEKES) and the Finnish Metals and Engineering Competence Cluster (FIMECC) programme UXUS (User experience and usability in complex systems).

The author thanks Piia Perälä (University of Jyväskylä), who helped in conducting the experiment reported herein, and prof. Pertti Saariluoma and Dr. Tuomo Kujala (University of Jyväskylä), for helpful comments about the manuscript.

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V

QUICK AFFECTIVE JUDGMENTS: VALIDATION OF A METHOD FOR PRIMED PRODUCT COMPARISONS

by

Jokinen, Jussi P. P., Silvennoinen, Johanna, Perälä, Piia, & Saariluoma, Pertti (2015)

In *Proceedings of the 2015 conference on Human factors in computing systems - CHI '15* (pp. 2221–2230). New York: ACM.