Aalto University
School of Business

Aesthetics, affect and user preference - Finding objective measures for subjective experiences

Information Systems Science

Master's thesis

Satu Lipponen

2013

Department of Information and Service Economy
Aalto University
School of Business

Aalto University
School of Business

Aalto University, P.O. BOX 11000, 00076
AALTO
www.aalto.fi
Abstract of master's thesis

Author Satu Lipponen

Title of thesis Aesthetics, affect and user preference – Finding objective measures for subjective experiences

Degree Master of Science

Degree programme Information and Service Management, Information Systems Science

Thesis advisor(s) Anssi Öörni

Year of approval 2013 **Number of pages** 65 **Language** English

Abstract

Objectives of the study

The Human-Computer Interaction (HCI) field has long concentrated on easily measured variables such as effectiveness, adoption and ease of use to study technology usage. In order to study user preference in particular, the inclusion of more socio-cognitive variables such aesthetics and emotions is necessary. However, these subjective experiences are intrinsically harder to measure: using subjective measures like questionnaires give results that are colored by cognitive processing, whereas subjective evaluations are formed instantly after exposure. The objective is to find what the effect of aesthetics and emotions are to user preference, and to test whether eye movement could provide an objective measure to support and validate subjective measures.

Academic background and methodology

Based on previous literature and studies, a model predicting user preference is developed. For eye movement tracking, modern abstract and representative art are used as test material. It is hypothesized that user preference is predicted by aesthetics, fixations (static eye movement), valence, arousal and dominance (emotions). The direct effect of these variables as well as the mediating effect of emotions is studied. The direct effect is tested by regression analysis, and the results are used for modify the model accordingly. The results are verified by path analysis which is also used to test the mediation effect of emotions and group differences of abstract and representative images.

Findings and conclusions

The research hypotheses were mainly confirmed by the study. It was found that aesthetics, valence and arousal explain and predict preference. Only dominance did not significantly predict preference. Aesthetic and affect reactions are formed instantly after viewing an object, they are involuntary in nature and the effect of these rapid evaluations is long lasting. Measuring such swift decisions is challenging, but it was found that eye movement and fixations in particular predict preference. In practical terms, it means fixations can be used along with self-reported measures to corroborate subjective evaluations.

Keywords aesthetics, affect, valence, arousal, dominance, user preference, eye movement, fixations

CONTENTS

1. INTRODUCTION

This chapter gives an introductory overview on the topic of this study and addresses the research gap from previous studies. Research objective and questions are presented, and definitions to some more specific terminology are given.

1.1 Background

In today's modern societies, we are constantly surrounded by information systems, some of them to our annoyance, some to our enjoyment. As the systems and tools in our environment become more varied - ranging from ERP systems to car navigation systems to social platforms - we are more and more exposed to plethora of user interfaces. From an interface design perspective, the challenge is to create systems that are not only usable and effective, but also easy to use and even enjoyable. Effectiveness of information systems has been under scrutiny in Human-Computer Interaction (HCI) field for quite some time, but along with the rise of the information society and ubiquitous computing, the focus is turning to the user experience as a whole. The user's experience of interacting with interfaces is shaped not only by the practical level (task completion etc.) but also on the cognitive and emotional levels, which may ultimately define the success of a system.

How are designers able to see whether or not the interface design works, how to improve design or what to design in the future? Designers have to able to determine how users interact with the systems and what makes the users "tick". User interface design has long concentrated on effective design driving user behavior and acceptance, which is perhaps more objectively and conveniently measured than more elusive concepts like experience and enjoyment. However, studying user preference requires a more extensive view that builds on the traditional concepts by adding in more socio-cognitive aspects that take part in forming the user experience.

Aesthetics is an emerging topic in HCI but has been extensively studied in the fields of marketing and psychology. Widening the perspective from merely looking at low-level concepts such as symmetry, layout, colors and so forth, aesthetics provides a more holistic and high-level concept for discovering how users respond to visually pleasing interfaces. Emotions are even less studied area in HCI, due to their ambiguous nature and complexity. Whereas aesthetics can be easily considered as a major aspect of user interface design, especially in today's app centric end user market, emotions are harder to pigeonhole. Their effect, importance and utility in creating enjoyable and usable information systems are unclear and mainly unexplored in HCI.

As historically HCI has focused on studying aspects of information systems that can be fairly easily categorized, measured and defined, aesthetics and emotions present a new kind of challenge. Moving to territories more familiar to other fields of study, there is a sense of worry of not being able to produce as accurate, measurable results as with traditional methods, like for example time to task completion or rate of errors. However, as information systems have become an integral part of the modern way of life, so should HCI studies encompass and exploit other fields in the development of their own. To overcome the obscurity of aesthetics and emotions, physiological phenomenon such as eye movement can assist in finding the concrete measurable results to support HCI research.

1.2 Research gap

Palmer et al. (2013) give an overview on the current state of aesthetics research in HCI and collate some critical issues for future research which will offer guidelines for this study as well.

First, Palmer et al. suggest that art and visual aesthetic experiences are separate concepts that should be treated as such. However, the question remains whether complex appreciation for art and aesthetic preference for simple features (colors, form, spatial composition etc.) could be combined in order to gain a better understanding of the aesthetic experience. It has been found that processing aesthetics stimuli involves brains the same way as when processing any other kind of visual stimuli (Chatterjee 2003). Although research on aesthetic aspects on usability and preference already exists, majority of the studies in HCI have used websites to test their hypothesis. User interface design however goes beyond websites: Although Internet usage may cover a large part of users' interaction with interfaces, people still encounter plenty of other user interfaces. Although dimensions like classical and expressive aesthetics (Lavie and Trackinsky 2004) have been develop to represent high-level aesthetic concepts, the use of art works is rare in HCI studies. From previous research in psychology for example, it is known that although preference ratings for representative and abstract do not differ much, the participants have found representational artworks more interesting. On the other hand, representative and abstract artworks are also processed differently in the brain (Lengger et al. 2007) As using art may open new insights to HCI research, this study uses representative and abstract modern art for testing people's aesthetic preference.

Second, much of the previous research on aesthetic has been focused on what Palmer et al. call "formal characteristics of aesthetic appreciation". It is suggested that including affect,

emotions and cognitive meaning to the research in a systematic manner would be beneficial to the study of aesthetics in HCI, as it's already known from the field of psychology that emotions do affect aesthetic experiences. The role of emotions in predicting and facilitating usability and preference evaluations has been studied to some extent, and significant relationships have been found (for example Porat & Trackinsky 2012). Also, none of the existing studies in HCI has combined the study of emotions to eye movement data, so this study will attempt to confirm these previous findings on emotional responses in relation to eye movement data.

Third, the emerging field of neuroaesthetics shows promise in providing further insight to aesthetic preferences. This is however dependent on the development of behavioral methods, as physiological measures have to be validated against behavioral ones. It has been found that users can make rapid judgments on interfaces based on their visual aspects (Lindgaard et al. 2006). These judgments are also influenced by affective responses of the user, which present a challenge if using only questionnaires or other subjective measurements that lag behind such quick responses. The lack of objective measures to support the subjective ones hinders the progress in preference research. Physiological measures like eye movement have been found to be reliable methods in tracing the process of decision making. Eye movement tracking captures both conscious and unconscious processes and supports subjective reports from users. For example, fixations (steady eye movement focused on a certain area) are a good indicative of visual attention. (Glaholt and Reingold 2011) This study will test whether eye movement could become an objective indicator that supports subjective preference evaluations.

1.3 Research objective

Based on the above review on the research gaps in HCI, the main purpose of this study is to find out what the relationship between preference, aesthetics and emotions is, and whether an objective measure like eye movement could be used to explain and predict preference. This study attempts to answer the following research questions:

1) How does eye movement predict preference?
2) How does the level of representativeness influence preference?
3) What is the effect of emotions to preference?
4) What is the relationship between emotions, aesthetics and eye movement?

A more detailed review of the theoretical justifications and more distinct hypothesis for the research questions will be given in section 3, Methodology.

1.4 Definitions

Aesthetics	A *branch of philosophy dealing with the nature of art, beauty, and taste, with the creation and appreciation of beauty* *The study of human minds and emotions in relation to the sense of beauty*
Abstract (art)	*Visual composition which may exist with a degree of independence from visual references in the world*
Affect	*The experience of feeling or emotion*
Arousal (affect)	*The degree of stimulation caused by an atmosphere*
Dominance (affect)	*The degree to which a person feels that she has influence over her surroundings and is in control of a situation*
Fixation	*A relatively stable eye-in-head position within some threshold of dispersion (typically ~2°) over some minimum duration (typically 100–200 ms), and with a velocity below some threshold (typically 15–100 degrees per second)*
Neuroaesthetics	*Study of aesthetics using neuroscience as method of inquiry*
Representative (art)	*Depicts the physical appearance of reality*
Saccade	*Rapid eye movement between fixations*
Valence (affect)	*The degree of intrinsic attractiveness or averseness to an event, object, or situation* *Also known as pleasure: The degree to which a person feels happy or satisfied in a place*

1.5 Organization of the study

This study has been divided into 5 sections, with this Introduction being the first. Next, the relevant literature will be reviewed and a theoretical model presented in the second section, Literature review. In the third section, Methodology, the research model and accompanying hypothesis are put forth. Also methods for the empirical research and statistical methods are articulated. In the fourth section, Analysis, the analyses and results of the study are presented. In final fifth section, Discussion and conclusions, the results are

reflected in more practical and managerial terms, and conclusions are drawn. Also limitations and future research are addressed in this section.

2. LITERATURE REVIEW

This section will present the relevant literature and research found on aesthetics, emotions and objective measures for both. First, the role and status of aesthetics and emotions in HCI research is addressed. Next, the subjective and objective methods for measuring these variables are looked, with special focus on physiological measures. Finally, a theoretical framework is presented to enable the model development for analysis.

2.1 Aesthetics and preference

Although there are lots of factors affecting an individual's usage of information systems, major part of the research in HCI has focused on issues like technology adoption, usability and effectiveness, with focus on a variety of sub-areas like for example ease-of-use, perceived usefulness and satisfaction. Interface design has focused more on finding the correct building blocks for creating information systems, and less on the user experience as a whole. Traditionally usability has been achieved when the system under scrutiny is effective in reaching its purpose, in time and without errors. Newer research extends the aspect of user experience to incorporate the subjective factors affecting the experience of using information systems, such as cognitive, socio-cognitive and affective factors (Schaik & Ling 2011). It represents a move from the objective and easily measurable qualities of the user experience to more subjective concepts like emotion, pleasure, engagability, ambiguity and aesthetics (Pandir & Knight 2006).

Factors affecting IT usage	
Adoption	Ease-of-use
Effectiveness and usefulness	Perceived usefulness
Preference and satisfaction	Usability
User experience	
- -	
Cognitive influences	Aesthetic experiences
Affective influences	Socio-cognitive influences

Figure 1. Factors affecting IT usage

Referred to sometimes as an "evasive beast", user satisfaction is a combination of usability and affective components, which are being shaped by the user's expectations. The interactive experience in general is influenced by aesthetics, emotion, expectations,

likeability and usability. (Lindgaard and Dudek 2003) The aesthetic experience, on the other hand, is more than pleasure and enjoyment experienced when viewing something visually pleasing. An ordinary event may become an aesthetics experience while an event fulfilling all requirements is still not an aesthetic experience. Rather, what makes the experience aesthetic is a judgment call by the viewer and his or her own beliefs on what is aesthetics (these beliefs are of course culturally and socially bound). (Averill et al. 1998) Even the subject whether the beauty or aesthetics of an object is intrinsic or subjective to the viewer, has been debated. These days, a more interactionist viewpoint that combines both is more popular (Reber et al. 2004, Moshagen & Thielsch 2010).

Although HCI research on aesthetics exists, especially from the last decade or so, there's a lack of a unifying view on what aesthetics in HCI really is and how it is defined. Aesthetics seems to carry an important role in today's information societies, where conveying information through visual tools may be more convenient than with other methods. This role may stem from the immediate effect on our senses, which is followed by our judgments. However, this is dependent on the speed of aesthetic impressions as well as their tenacity. Testing users' aesthetic reactions within 0.5 seconds of exposure and comparing them to the reactions after 10 seconds exposure confirms that both hold dependencies hold true. Results show that aesthetic evaluations are immediate and consistent. (Lindgaard et al. 2006, Tractinsky et al. 2006)

Some theories around aesthetic perceptions have been developed in other fields (Palmer et al. 2013) that formalize and develop aesthetics research in HCI:

Mere exposure effect refers to preferring more frequently seen images and objects over less frequently seen ones. Mere exposure effect explains perpetuation and amplification of bias across time, but only partly answers to the questions on aesthetic preference. There's a limit to using mere exposure effect for explaining preference: for example, people prefer representative art works over abstract. Mere exposure effect suggests that it is because people see more representative works, which causes the preference. But why are painters painting more representative works? If the answer is that they prefer them more, we cannot use the mere exposure effect to explain painters' preference as well, or we are in an infinite loop where mere exposure effect explains itself. In HCI research, it has been found that users of certain types of web sites (classical aesthetics, information-oriented) expect also certain types of aesthetics and over time, users may come accustomed to certain

designs. These become conventions that designers adhere to induce positive reaction from users (van Schaik & Ling 2009). This could be considered as a mere exposure effect.

Arousal dynamics is a theory developed by Daniel Berlyne on aesthetic response. It states that depending on a psychobiological response to collative (viewer's expectations), psychophysical (sensory dimension of stimulus) and ecological (meaningfulness) variables, each which will produce a primary reward system and a primary aversion system. The effect of the two systems (reward and aversion) lead to an inverted U-shape function where arousal first increases when aesthetic pleasure and complexity increase, and then decreases as complexity becomes too high. In other words, arousal is beneficial in to a certain extent. The theory has been utilized in especially psychology research and seems reasonably solid. Some works in HCI research has confirmed that arousal has a significant relationship to both pleasure and preference (Mummaleni 2005, Porat and Tractinsky 2012).

Prototype theory was developed by Eleanor Rosch. The theory simply states that prototypical examples of categories are preferred over non-prototypical ones. All in all, the prototype theory's contribution to understanding aesthetic preference is limited due to its general nature and inability to explain why prototypes are preferred. However, it has been incorporated as a factor for example in Leder et al.'s (2004) model of aesthetic experience (see section 2.4 in this study).

Fluency theory states that more easily processed visual objects are preferred more. Research has confirmed that the predictive power of fluency theory holds true at least for low-level features, and may also explain why prototype effects take place (prototypes are known to be easily and rapidly processed). Fluency theory may also explain mere exposure effects as more often an object is seen, more fluently it is processed each time, thus increasing preference. However, fluency has a complex relationship with preference: as complexity increases, fluency as well as preference should decrease. However, this is not the case according to Berlyne's model of the U-shaped curve where complexity increases pleasure until at certain level of complexity pleasure starts to decrease. Also, the fluency theory is challenged by the experience of art: the nature of art is not to depict something to be easily processed but rather the opposite; it requires cognitive processing and is less fluent. HCI research has found that in general, the more fluently the viewer is able to process the object, the more positive is the aesthetic response of the viewer (Moshagen & Thielsch 2010).

These theories represent some of the efforts in trying to formalize the study of aesthetic preference, and can be useful in HCI research as well. However, they still provide only a partial understanding on how aesthetic preference is formed. Creating guidelines for aesthetically pleasing design is difficult as objects are not necessarily defined by their objective identity but rather how they are perceived by the viewer. User preference is based on subjective factors such as individual motivations, knowledge, previous exposure and also common opinion and trends (Sutcliffe et al, 2006). This has major implications for designers: if viewers' perceptions do not reflect objective reality, the designers face a significant challenge in creating interfaces that will make a positive impact and encourage usage (Lindgaard et al. 2006).

2.2 Inferring usability from aesthetics

Even though the importance of aesthetics is recognized, some research indicates that usability still holds more importance for example in consumers purchasing decision and that aesthetics serve merely a supporting role in achieving the goal. However, this may be offset by other benefits of aesthetics experience, like propensity of the user to explore more, increasing the probability of future purchases. (Wang et al. 2010) Not only are usability and preference connected to aesthetics, some research also suggests causality between beauty and usability. Perhaps most famous of those studies is Tractinsky's (2000) "What is beautiful is usable". In the study the relationship of interface aesthetics and perception of usability was tested via ATMs (automated teller machine). A high correlation between the variables was found, thus concluding that beautiful interfaces are more usable. In addition, the post-use perceptions of usability were affected by aesthetics rather than actual usability. Later research (Hassenzahl et al. 2010) has also challenged the value in usability or pragmatic quality (product's potential in supporting task completion) of technology in itself. It is suggested that hedonic quality (product's potential in supporting pleasure in use) would be more influential in positive user experiences than pragmatic quality, which mediates the user experiences rather than is the source of needs fulfillment. Subjective views may even override usability considerations (van Schaik and Ling 2003).

Although Tractinsky's claim of beautiful things being more usable has been questioned in later research (Lindgaard and Dudek 2003, Hassenzahl 2004), there at least seems to exist a relationship between aesthetics and usability. Hassenzahl and Monk (2010) present a

model for user experience that builds on the traditional way of looking at usability to include hedonic (pleasure) and aesthetic (beauty) components.

A more conventional approach to usability stems from product qualities (Fig. 2.a) where the user has information available on the attributes to deduct the level of usability. However, as the information availability is recognized to be lacking, the model is extended to users having to infer usability through other factors. In the next construct (Fig. 2.b), usability is inferred from beauty, with goodness mediating the relationship between beauty and usability. In other words, beautiful things are good and good things are thus evaluated to be usable as well.

The third construct goes even further (Fig. 2.c) in suggesting that beauty directly predicts usability, without any mediating factors. The difference is best described as construct b representing a halo effect to usability from the correlation between beauty and goodness, whereas in construct c, the effect is direct. As several studies have discovered correlation between beauty and hedonic quality, the last construct (Fig. 2.d) suggest that the effect of beauty is entirely mediated by goodness, but has a direct effect to the hedonic qualities.

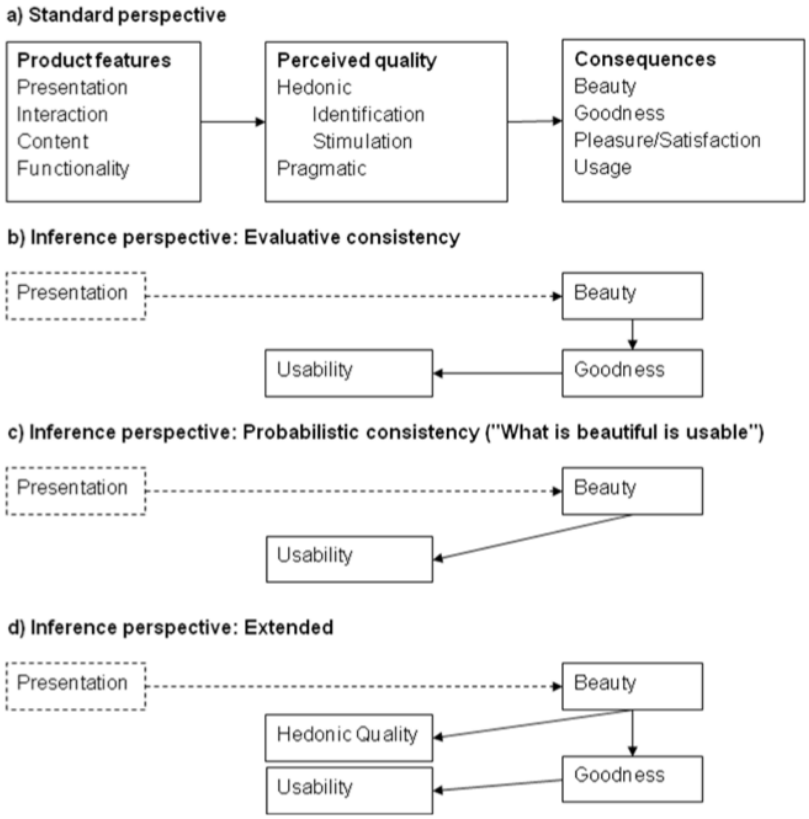


Figure 2. Four constructs on defining user experience (Hassenzahl, M. and Monk, M. 2010)

The model represents an important shift from the traditional perspective, where the user makes evaluations based on product attributes, to the inference perspectives, where the user evaluations on usability and hedonic quality are affected by the visual attributes, i.e. beauty. The strength of pragmatic and hedonic qualities' effect to attractiveness has been tested on business management software as well (Schrepp et al. 2006). Interesting in the experiment is that system meant for work alone would not necessarily be expected to benefit from strong hedonic qualities, and that pragmatic qualities would clearly be more defining for the system attractiveness. However, the findings confirm that the hedonic quality does affect system attractiveness which will have an effect on users' willingness to engage with the system. Also, pragmatic qualities do not override in forming the preference evaluations. (Schrepp et al. 2006)

Even though the relationship of aesthetics and usability has been confirmed, a divide seems to exist between aesthetics and usability designers, and the role of aesthetics is to mainly facilitate information processing. However, it has been found that aesthetics plays a major role in acceptability of technology and may influence the attitudes also long-term. For example, aesthetics is a significant determinant for use intention for smart phones: smartphones perceived more aesthetically pleasing are viewed more usable compared to devices with higher performance but lower aesthetics. (Shin 2012) This supports the notion that the role of aesthetics may be more significant than just supporting preference decisions. For example, Hartmann et al. (2008) found that websites with better expressive aesthetics are preferred, even if they are considered worse in perceived usability. This halo effect could override poor usability evaluations. In practical terms, it suggests that aesthetics could be important in increasing user satisfaction as well as system acceptability long term.

2.3 Emotions facilitating aesthetic experience

Another factor less dealt within HCI research is the role of emotions and their effect on user interface design. Affective responses have been widely addressed in other fields and studies have shown affect to be a significant explaining factor of variance in user behavior. Damasio (2011, Damasio and Carvalho 2013) describes emotions as action programs (innate physiological actions) that are mainly triggered by external stimuli processed by our exteroceptive senses (vision, hearing, touch, taste and smell). This is a separate concept from feelings that are mental experiences that accompany internal body states. In practical terms, examples of feelings are thirst and pain, whereas examples of emotions are

pleasure and boredom. Affective actions, on the other hand, can be distinguished from cognitive actions by describing an action that a person knows is sensible (for example cleaning) but finds it a displeasing task and has a tired attitude towards the task (low valence, low arousal) (Hassenzahl 2004, Sun and Zhang 2006).

The emotion variables commonly referred to and used in this study are based on the PAD (pleasure, arousal, dominance) model developed by Albert Mehrabian (1980). The model is used for measuring emotional states via numerical scales.

Pleasure dimension (also known as valence) refers to emotions that are either pleasant or displeasing. For example joy and excitement are pleasant, whereas anger and disgust are displeasing emotions. Although pleasure often correlates with preference, it does not describe the same concept. For example, although disgust may be a displeasing emotion, it may be preferred (for example when an image elicits disgust due to context but it may still be considered likable by the viewer due to the message entailed). In HCI research, it has been found that for example well-designed systems elicit higher valence (e.g. pleasure) and ill-designed lower valence (Thüring and Mahlke 2007).

Arousal dimension refers to the degree of stimulation and intensity caused by an environmental factor. For example, boredom has milder arousal intensity than anger. Arousal is often connected to pleasure, as described by the arousal dynamics theory in section 2.1 In HCI research, it has been found for example low arousal seems to be connected with higher usability in goal mode and high arousal in action mode (Hassenzahl 2003).

Dominance dimension refers to the degree of control over a situation or surroundings. Boredom and fear are submissive emotions, whereas anger is dominant. The role of dominance in the PAD model has been under dispute and it has been suggested it is a more cognitive reaction than an affective state. In marketing research dominance has been found to affect purchase decision, but in HCI research no relation between dominance and attitudes or behavior decision has been found (Porat and Tractinsky 2012).

One model addressing the role of emotions and aesthetics in information systems is the Componens of User Experience Model, or CUE-model (Thüring and Mahlke 2007). It comprises of the well-established components affecting usage and evaluation of systems, such as task and system properties and user and interaction characteristics (Figure 3). The model builds on the traditional HCI research by combining instrumental qualities (e.g.

effectiveness) to non-instrumental qualities (e.g. aesthetics) and emotional responses. The proposed model was tested with comparing subjective emotions (valence, arousal) and cognitive appraisals (pleasantness, goal relevance, coping potential, norm/self-compatibility) to physiological reactions (electroderman activity, heart rate, electromyography, pupil responses) and motor expressions (facial expressions) when using a well-designed and an ill-designed system.

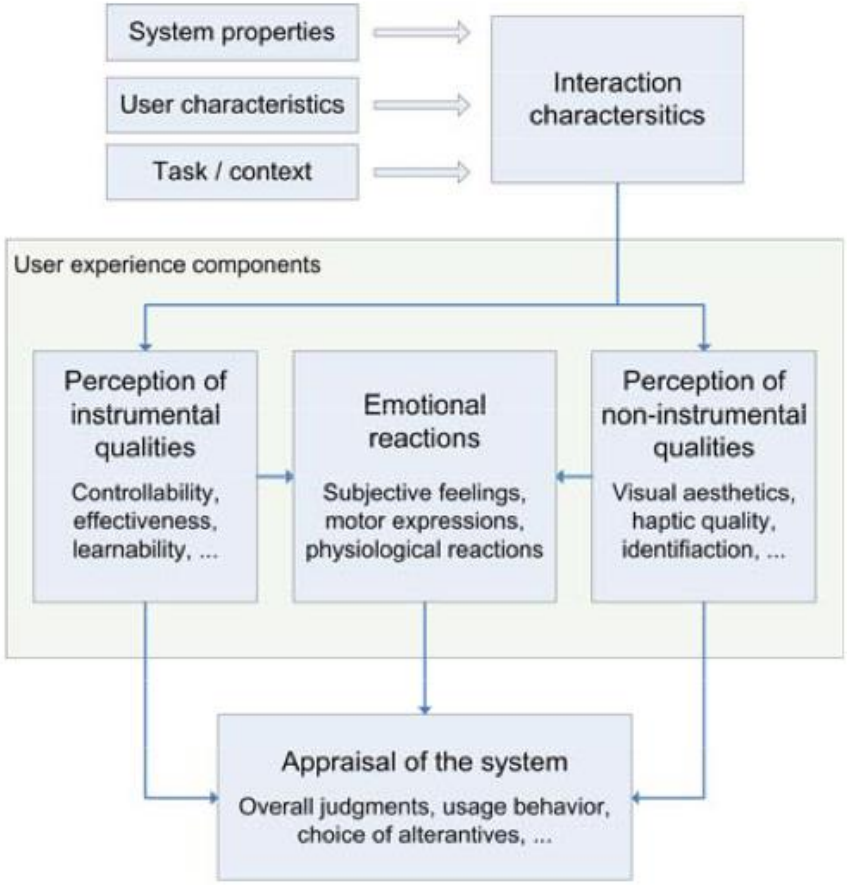


Figure 3. Components of User Experience model (Thüring and Mahlke 2007)

It was found that usability influences the emotional reactions of users (confirmed by both subjective and physiological responses). The well-designed system received positive valence and lower arousal ratings, and vice versa for the ill-designed one. However, for the influence of aesthetics to usability, only a trend was discovered. This would point to the direction of beauty correlating with usability but no definite conclusion could be drawn. Together however, usability and aesthetics do significantly contribute to the overall evaluation of the system, although the effect of perceived usability was found to be higher than that of aesthetics. Finally, it was discovered that for higher usability and attractiveness versus less usability and attractiveness, the corresponding differences for

subjective feelings were showing in the data. A meta-study of several other HCI studies on affect (Sun and Zhang 2006) found that previous research supports the notion that traits like computer playfulness and personal innovativeness of IT predict the affective reactions of the user. However, whether affective reactions would have a direct effect on behavioral intention and usage is not so clear, with results for and against.

2.4 The role of aesthetics and affect in information processing

Based on the literature reviewed so far, it seems that aesthetics and emotions form an interconnected part of the evaluation process and preference judgments. For example, when studying the relationship between users' judgments of web pages, Zheng et al. (2009) found that "…even seemingly high-level judgments of about the aesthetic and affective aspects of an image are likely computed by the brain using low-level features that are agnostic about objects, meanings, cultural context, etc." It has been discovered that rapid aesthetic and affective judgments on attractiveness are produced without cognitive process (Lindgaard et al. 2006, Damasio and Corvalho 2013) Although immediate judgments on preference are made by users, the aesthetic experiences and affective responses are processed together to form informed decisions and subjective evaluations.

Leder et al. (2004) have proposed a model to understand the processing of aesthetic experience. An aesthetic experience is described as a "cognitive process accompanied by continuously upgrading affective stage that vice versa are appraised, resulting in an (aesthetic) emotion". The five stages of information processing are 1) perceptual analyses, 2) implicit memory integration, 3) explicit classification, 4) cognitive mastering and 5) evaluation. The first stage is the processing of perceptual features (for example color, balance), which has been studied extensively in HCI research.

The second stage contains the unconscious processing of features. The familiarity component increases preference, but it is uncertain how. Prototypicality also increases preference, but is dependent on individual experiences, which could in turn explain the different viewing patterns between expert and naïve art viewers. These concepts are very close to the mere exposure effect and prototype theory mentioned in the section 2.1.

The third stage contains the conscious and deliberate processing of aesthetic object (classification of style and content). Leder et al. suggest that recognition of style is not limited to art but classifying visual objects in general according to surface details may

require similar cognitive processing as when viewing art. Combined with style, the process of generalization enables the viewer to produce new classifications to unfamiliar stimuli. Applying for example certain style used in existing interface and applied to a new one, even if modified, could improve the initial processing of the interface. Since the initial effort required to process the visual object will affect the preference, using familiar and generalized design may assist overcoming this.

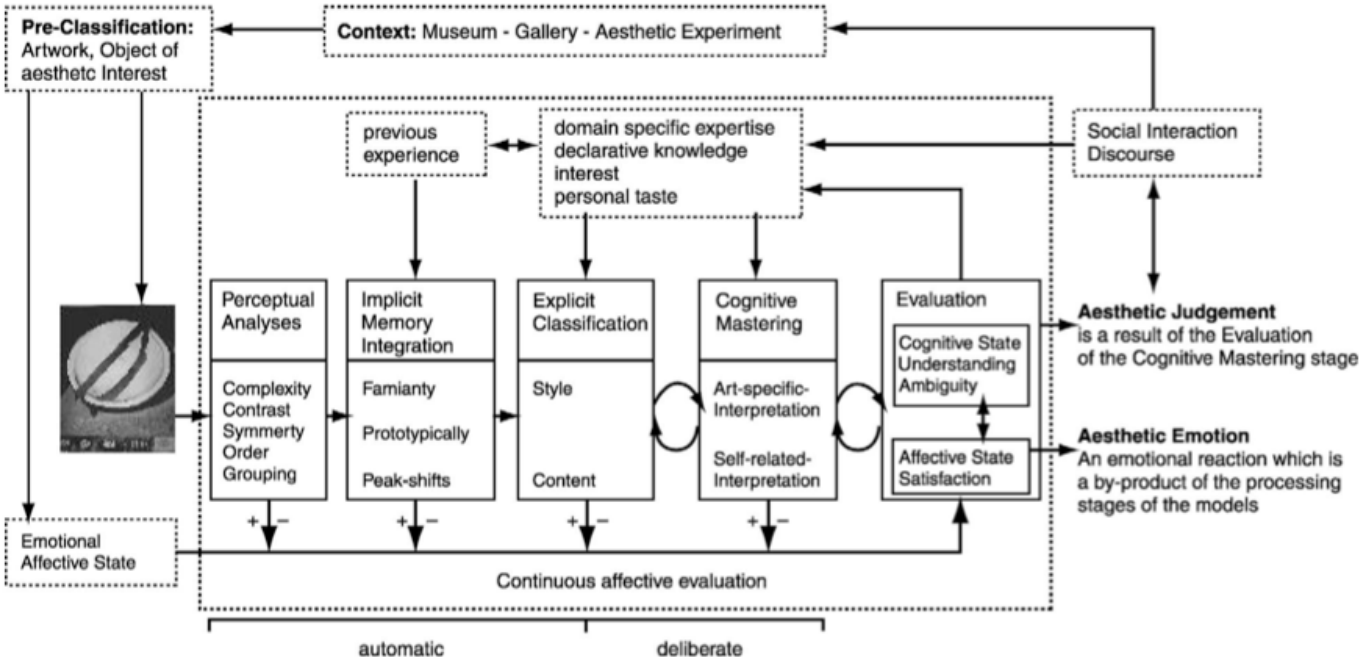


Figure 4. A model of aesthetic experience (Leder et al. 2004)

The first three stages represent the automatic or unconscious processing of information. The fourth and fifth stages contain the feedback loop where cognitive interpretation meets preference judgments. Cognitive mastering relates to reaching a satisfying understanding, successful cognitive mastering or revealing changes in the level of ambiguity. The evaluation of aesthetics processing is experienced successful or unsuccessful. In the latter case the feedback loop the cognitive mastering and other stages will initialize further information processing. At this stage, the viewer is already making deliberate or conscious evaluations based the information received.

According to the model, affective evaluation is an ongoing process in developing the aesthetic judgment, and the continuous build-up of affective states will influence the outcome of each stage. Although the Leder et al. question whether the affective responses precede cognitive processes, they do acknowledge that prior affective state before viewing

art will affect the entire aesthetic experience. Also, a distinction between the aesthetic judgment and aesthetic emotion is made: the former describes of visual object itself, and the latter to the affective processing of the object. In other words, the art piece may be considered poor but the information processing, or the experience of viewing was rewarding. However, it should be noted that there may be differences between expert and naïve viewers in that less experienced viewers show a stronger interdependence between the aesthetics judgment and aesthetic emotion.

The model describes more extensively the role of emotions as continuous, automatic and deliberate in forming aesthetic judgments. Although the model is based on viewing art, it could be generalized for HCI research in general.

2.5 Measuring aesthetics experience and affective responses

Classical HCI evaluation methods have focused strongly on the usability aspect of information systems, and even assuming that high usability equals high preference, which of course is not always correct (Lee & Koubek 2010). Preference has been found to be highly subjective which raises the question whether results on preference can be generalized into interface design. For example, people may agree on the complexity of websites even though there's a high variation on complexity. This suggests that complexity is a design factor that is independent from the user as assumed by the traditional design paradigm. On the other hand, when measuring pleasure experienced, people may feel significantly differently about the same web pages. This means that individual differences affect some parts of the user experience (pleasure) but not all (complexity) (Pandir and Knight 2006). Viewer's responses to aesthetic objects are also influenced by their own individual or collective attributes (age, gender, expectations, values etc.) and context (immediate physical surroundings or milieu) (Park, Woods & DeLong 2010). When differences in tastes, lifestyle and curiosity have an effect of preference, the designers are facing an impossible task in trying to design interfaces that would appeal to at least major part of the users.

In the user interface design, usability is measured in many subjective and objective methods: expert reviews, usability labs, surveys and questionnaires, acceptance tests, user-performance data logging, discussion groups, automated evaluation, controlled psychological-oriented experiments etc. (Galitz 2007) Design goals like effectiveness, efficiency and satisfaction are evaluated through measures such as time to learn, speed of

performance, rate of errors by users, retention over time and subjective satisfaction. User satisfaction specifically is measured by for example interviews, satisfaction scales and free-form comments (Schneiderman and Plaisant 2010). Although objective measures are common when measuring usability of web sites, research has moved towards using subjective measures for preference. For example visual aesthetics that influence preference, have been measured in many ways, most of which are based on self-reported measures that may be unreliable in their premises (Moshagen & Thielsch 2010).

There may be an evolutionary reason for aesthetic preferences: It is suggested that several biological behaviors, for example mating, attachment, aggressive and foraging behaviors, as well as harmavoidance (escape from danger and pursuit of safety) and exploration, explain aesthetic preferences (Averall et al. 1998). Without going too much into detail on them, these partial theories reveal the fact that humans are entities driven by their biology, and that should be taken into consideration while researching the aesthetic experience. The usage of neuroaesthetics, for example, is important in studying aesthetic functions: Several studies have used a variety of physiological measures to study individual responses, in order to isolate objective indicators of preference, and address the variance created by subjective cognitive processes (Skov & Vartanian 2009). One study used several physiological measures (heart rate, electrodermal activity or EDA, electromyography or EMG) to test whether the subjects' physiological responses on usability would correlate with their subjective evaluations. EDA and EMG were measured to be higher for the ill-usability test, whereas heart rate did not differ. (Thüring and Mahlke 2007) Another study found corrugator EMG negatively correlated with affective pleasure ratings (Tuch et al. 2009).

Psychophysical measures have also been used when studying art. A study on neuroanatomical correlates of aesthetic preference using paintings was conducted in order to see what brain regions were involved in processing pictures that affected emotional valence, which is relevant to the aesthetic preference. Twenty representative and abstract paintings were showed in original form and manipulated form, in order to test the effect of compositional arrangement to aesthetic preference. The results indicate that there was a significant correlation between preference and response latency, i.e. preference for a painting increased the longer it was viewed. Also, fMRI (functional magnetic resonance imaging) results indicate that preference could be determined by neuroanatomical indicators. (Vartanian and Goel 2004)

In addition to challenges of measuring aesthetic experiences, the study of emotions has presented HCI research (and the scientific community in general) a challenge due to the subjective nature of emotions. Emotions are defined by Boehner et al. (2007) as "…an internal, individual, and delineable phenomenon, which operates in concert with and in the context of traditional cognitive behavior". Boehner et al. address some of the issues relating to measurement of emotions: delineability and objectivity.

The delineable versus ambiguous nature of emotions is an important distinction. If emotions are delineable, then they can be measured and their effect can be clearly defined. However, evaluation methods based on assumption of delineability (for example 9-point Self-Assessment Manikin scale) foreclose the potential ambiguity of the emotional experience. These methods may not take into account situations where multiple emotions arise at once or nature of the emotions is unclear. Some methods address emotions as interaction, avoiding categorization and drawing from interviews and open-ended reports of emotional experience. The delineability versus ambiguous question is also borne from the physiological aspect of emotions.

With the increasing usage of physiological indicators for emotions and behaviors, there's a trend for subjective self-reported measures to be deemed as less reliable than the objective physiological ones. Even though the reliability of the physiological measures are dependent at first on the validations against self-reported measures of emotions, it may lead to a situation where self-reported measures are positioned as inferior and even discarded once reliability of physiological measures are validated. When studying emotions, one has to also consider the interactive nature of the cognition and subconscious mind. Rather than just focusing on the physiological, measurable part of emotions, a more extensive method of combining quantitative and qualitative could benefit the research.

Although measuring aesthetic experiences and affective responses has been notably difficult, eye movement tracking has provided a tool that goes beyond speculation (Park et al, 2010). The human visual system (HVS) works so that the eye's high-resolution fovea (the area of the eye which allows people to see with clarity and precision) enables people to look at objects with accuracy while the peripheral vision gives a less detailed vision of the surrounding objects. This requires people to move their eyes in order to see the entire "picture". These eye movements between objects are called saccades, and the longer periods when the eye is stable, are called fixations. Two processes describing the eye-movements are bottom-up and top-down. In the former, the gaze is guided by so called

low-level primitives (contrast, luminance etc.) and the gaze is fast and involuntary. In the latter, the viewing process is affected by higher cognitive factors such as task, goals, etc. How they affect control of eye-guidance is an open issue and one very relevant also to interface design. (Nyström & Holmqvist 2011)

Although used more in other fields, leveraging eye tracking technology in HCI research is still in its infancy. Djamasbi et al. (2011) studied generational differences on preference by applying the eye tracking technology and subjective measures. One of the questions their study attempted to answer was whether or not it would be possible to predict preference of the users directly from the fixations. The results showed that fixations were a strong predictor for visual appeal. The authors suggest that the more cognitive effort is required for processing a page, the more likely is a negative first impression.

Although using eye tracking technology has develop significantly in recent years and has a lot of promise for HCI study, some issues should be considered when moving forward. Physiological readings in general are not consistent. Different metrics can give inconsistent results, and there may be considerable differences between individuals or even differences within individuals in different settings. Also, as physiological measurements are highly changeable, problems with identifying differences and changes (for example significance thresholds for latency, duration and magnitude of responses) arise. Another difficulty lies in identifying what each mental event and each physical response stands for. (Ward and Marsden 2003) Finally, the data extraction itself is labor-intensive due to large amount of detailed data; however, the eye tracking devices usually come with software meant for data processing. The way the software processes data can vary between providers so for example slightly different parameters in the automated fixation detection algorithm may make comparisons unfeasible. (Jacob and Karn 2003) All these issues should be considered when using eye tracking as a research method.

2.6 Theoretical framework

In order to study the relationships between aesthetics experiences, affective responses and preference evaluations, and discover the potential of eye movement data to indicate preference, a research model is proposed based on the recent model developed by Porat and Tractinsky (2012). They attempt to bridge the gap between traditional HCI research (more focused on accuracy and execution) and marketing research (focused on affecting the information processing) to explain the attitudes and emotions that user's experience.

Their research model (Figure 5) is modified from the Mehrabian and Russell (M-R) model that describes how environmental stimuli affect the emotional states, which in turn lead to lead to certain behaviors.

Main purpose of their research is to study the effect of perceived usability and perceived classical and expressive aesthetics to user emotions that in turn result in responses of approach and avoidance by the user. The focus is in studying higher-level attributes like aesthetics and usability due to their pivotal role interface design and user interaction. Those variables also absorb majority of the low-level design features. The notions of classical and expressive aesthetics make a distinction between clean, balanced and orderly design, and creative, innovative and novel design. Usability is studied in the context of web site usability and mainly in the spirit of the ease-of-use construct of the technology acceptance model. Emotions on the other hand play a significant role in shaping behavior: it is suggested that aesthetics and usability affect user's emotions via first impression that will linger on and affect evaluations later on. According to the M-R model, this will lead to a diversity of behaviors, for example verbally or non-verbally expressed preference.

Based on previous research, Porat and Trackinsky suggest that classical aesthetics induces higher levels of pleasure, and whereas expressive aesthetics induces higher levels pleasure and arousal. Classical aesthetics is seen to have a more calming effect so no arousal is expected (H1-H4). Usability as well is expected to affect pleasure but also dominance (as being in control is an important factor in technology usage environment) (H5-H6). Pleasure is expected to significantly increase approach response, whereas the effect of arousal is unclear. Also dominance is expected to increase approach response (H7-H8).

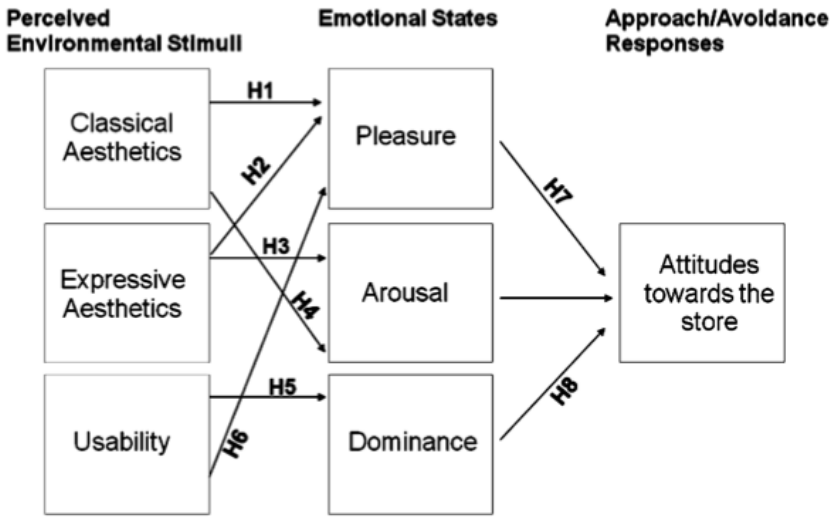


Figure 5. The effect of perceived usability and aesthetics to user responses (Porat & Tractinsky 2012)

Their findings confirm that aesthetics and usability significantly affect emotions that in turn affect the attitudes of online store users. Especially pleasure was key determinant for attitudes, as all design variables significantly influenced pleasure, but arousal also was affected by expressive aesthetics and usability and affect attitudes. The conclusion is that experiencing pleasure is a key component in inducing positive attitudes towards web stores. Dominance however, was not found to be a significant indicator of attitudes. Although emotions seem to play an important role in mediating action, it was noticed in the study that perceived usability and expressive aesthetics also had a direct effect to attitudes. This would suggest that building solely on usability is less effective than trying to induce user actions by usability and aesthetics.

Porat and Tractinsky's study contains many of the components present also in this study. Using these discoveries as the basis, this study will test the results found on their study and add the objective measure component to improve on the existing model. The next section will present the research model as well as the hypothesis.

3. METHODOLOGY

This section will present the model and methods for performing the analyses for the study. First, a research model developed based on the theoretical framework and accompanying hypotheses are presented. Then the chosen methods for both statistical analyses and empirical study are reviewed. Next, the study procedures are covered in detail. Finally, the preliminary data processing is reviewed before actual analyses.

3.1 Model development and hypotheses

Building on Porat and Tractinsky's (2012) model, a research framework was developed to study the relationship between eye movement, aesthetics, emotions and preference (Figure 6). Porat & Tractinsky's approach was to study the effect of aesthetics and usability to emotions and their effect to attitudes, and then proceed to see if there exists a direct relationship between aesthetics and attitudes, and usability and attitudes, or are they mediated by emotions. This study on the other hand takes the opposite route and looks at the direct relationships affecting preference first and then it is checked whether the relationships are really direct or are aesthetics' and eye movement's effect to preference mediated by emotions.

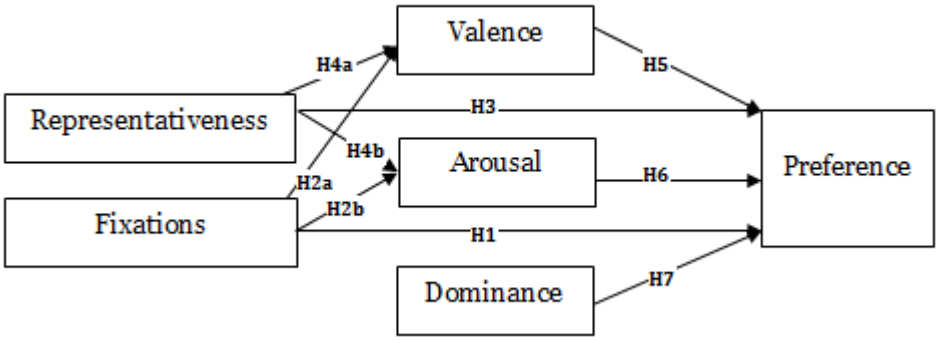


Figure 6. The developed research framework

In the proposed model, classical and expressive aesthetics are replaced by a single variable to represent the continuum that representative and abstract images exist on. What one perceives as representative, may seem abstract to another. Also, with contemporary art, the distinction is not that clear. As the purpose is to focus on the explanatory power of aesthetics in general, the division to classical and expressive was not deemed necessary in this study. Also, the usability aspect is replaced with fixations, as the focus of this work is to discover objective indicators for predicting preference. Instead of pleasure, we use the

term valence – however, these terms have been used synonymously in previous research. Finally, the approach/avoidance behavior is replaced by preference, i.e. either the subjects' response to the object by liking it or disliking it.

The hypotheses in the model are listed and described below:

H1: *Fixations significantly predict preference*

The main purpose of this study is to find objective measures to support the existing subjective measures used to determine user preference. Eye movement and fixations specifically, could be used as an objective indicator for preference if a significant relationship is found. Zheng et al. (2009) found that high-level judgments about image features are likely computed by the brain using low-level features. Also Djamasbi et al. (2011) found that fixations were a strong predictor for visual appeal when testing the web site experience between different generations. Locher et al. (2007) also found that viewers were able to generate a holistic reaction to the artworks prior to the first saccade. These results support the first hypothesis of eye movement significantly predicting preference.

H2a: *Effect of fixations to preference are mediated by valence*
H2b: *Effect of fixations to preference are mediated by arousal*

As previous research suggests that emotions influence the formation of preference, the effect is also considered in this study. Not many studies were found focusing on physiological measures and emotions. One study found that the effect of visual complexity on the EMG is almost completely mediated through valence (Tuch et al. 2009). Some studies on arousal have also found that arousal can be seen from data collected via different physiological measures (heart rate, skin conductivity, finger blood volume). For example, the effect of ill-designed web site to arousal was significantly different from a well-designed one. (Ward and Marsden 2003)

As the model predicts a direct relationship between fixations and preference and it is known that emotions mediate preference evaluations, it is reasonable to also test the potential mediation effect from valence and arousal when using fixations to predict preference.

H3: *Representativeness significantly explains preference*

Several studies have found that aesthetics predicts user preference. Lavie & Tractinsky (2004) found that when measuring both classical and expressive aesthetics, both aesthetics dimensions contributed to user satisfaction. However, there are different results on which dimension, classical or expressive, has a larger effect on preference. For example Lindgaard (2003) found that when studying aesthetics by using real-world stimuli, representativeness proved to be an effective predictor of preference. Trackinsky et al. (2006) on the other hand found that expressive aesthetics was a better determinant of attractiveness. There have been even results suggesting aesthetics could overcome usability issues: De Angeli et al. (2006) found that interface evaluated as more attractive on the expressive aesthetics dimension, was preferred more regardless of acknowledged inferior usability. In this study, the aesthetics variable isn't divided into abstract or representative but as one variable, thus no direction of effect (positive or negative) is hypothesized.

H4a: *Effect of representativeness to preference is mediated by valence*
H4a: *Effect of representativeness to preference is mediated by arousal*

As per previous research, it is hypothesized that the relationship between representativeness and preference is mediated by both valence and arousal. For example, in an online shopping environment, web site characteristics (design and ambiance) were perfectly mediated by pleasure and arousal (Mummaleni 2005). On the other Porat and Trackinsky (2012) found that the effect of classical aesthetics to behavior was entirely mediated by emotions, whereas for expressive aesthetics the mediation effect was only partial. These findings support the hypotheses that representativeness is mediated by valence and arousal.

H5: *Valence significantly explains preference*
H6: *Arousal significantly explains preference*

Several studies have found a direct effect of emotions to user behavior, either in approach or avoidance behavior, preference evaluations or purchase decision (Porat and Tractinsky 2012, 2007 Thuring & Mahlke, Hassenzahl 2003). As pleasure has been found to positively correlate with approach behavior, it is hypothesized that a positive relationship between valence and preference. Also, as arousal has a close relationship to valence and has been found to negatively correlate with preference, a significant relationship between arousal and preference is hypothesized.

H7: *Dominance significantly explains preference*

Although dominance has not been shown to directly affect preference and behavioral intent, dominance or control may be an important factor when considering information systems and user experience. In their research, Porat & Tractinsky (2013) found that dominance did not significantly explain attitudes towards web stores. The role of dominance in marketing research has been under dispute with results for and against on dominance affecting behavior or preference (Yani-de-Soriano and Foxall 2006). However, as the test material in this study consists of art work rather than web stores or commercials, dominance is included to see if there is a relationship that could reveal something about the relationship between dominance and preference, and whether that could be leveraged, if not directly in web stores, then in information systems design in general.

3.2 Research method

3.2.1 Linear regression analysis

Linear regression analysis is a statistical technique that allows predicting an outcome variable from several predictor variables (multiple regression analysis). In other words, fitting a model to the data set will enable one to predict the changes in the relationships between the variables. The purpose of regression analysis is to find a model that best fits the data, not necessarily the perfect model. An important assumption for regression analysis is linearity. (Field and Miles 2010)

For this study, multiple regression analysis was chosen in order to see what variables are affecting user preference. The main purpose is to see if fixations significantly explain preference. In addition, based on previous literature it is known that aesthetics evaluations and affective reactions form rapidly after first visual contact, and are thus included in the model. Other background variables and variables relating to the test situation, serve as control variables. Variables found to significantly explain preference in the regression model, will be used in the following path analysis.

IBM's SPSS Statistics 21 was used for the regression analysis.

3.2.2 Path analysis

Path analysis is a method for describing relationships and direct dependencies among a set of variables. Path analysis is a special case structural equation modeling (SEM): it is a sub-

section of SEM with the difference that it consists of only a structural model, and no measurement model. Path analysis has been also referred to as causal modeling, analysis of covariance structures and latent variable models. (Path analysis (statistics), 2013) Path analysis differs from regression analysis in that is a highly flexible and comprehensive methodology, where multiple, related equations are solved simultaneously to determine parameter estimates. It requires formal specification of a model to be estimated a priori and then tested, and allows for specification of error or unexplained variance. (Suhr 2008)

For this study, the purpose of path analysis is to address the mediation effect of emotions. Regression analysis can be used to determine mediation effects, but using path analysis is more convenient way of performing it, especially with large number of independent variables in the model. Also group differences (for example representative and abstract groups) can be sought out with path analysis.

IBM's SPSS Amos 21 was used for the path and mediation analysis.

3.2.3 Empirical test

Representative and abstract contemporary art works were used in the empirical test to determine viewers' eye movement and preference. For example, Porat & Tractinsky's (2012) research using online web stores is a tradeoff between control and internal validity, and ecological and external validity, hindering the causal inference. In order to have results that are more applicable in general, using art works is a method for increasing causal inference.

Using modern art or art in general in HCI research has been quite rare, and no articles testing preference on art works in HCI journals could be located for reference. Although aesthetics and art has been studied extensively in psychology, for some reason using artworks in aesthetics studies has not occurred in HCI. Perhaps due to the distinction between art and graphical design, we have not mentally yet recognized that design in HCI could be as much art as any other traditional form of art. This distinction is made even in the latest work on aesthetics and HCI research: Palmer et al. (2013) reflect on why visual aesthetics should be kept separate from art. First, art is human artifacts that are meant to be viewed as art whereas visual aesthetics is anything and everything around us. However, it has been found that people view art works similarly to any other aesthetics objects (Chatterjee 2003), regardless of their form and meaning. For HCI study, this would mean that art can be then used as study material as well as web sites etc. Secondly, Palmer et al. suggest that art is related to more positive aesthetic experiences whereas aesthetic

response ranges from positive to negative. Also, art is more than just the aesthetic responses it generates, but also cultural, social, etc., and even though art is related to aesthetics, they are distinctly separate concepts. Without explaining this distinction in detail, it could be claimed that art experiences as well range from positive to negative, and aesthetics responses are as well related to cultural and social aspects of life.

In addition, the subjective measures were employed to determine evaluations on preference, representativeness and affect responses. Eye tracking technology was employed to provide an objective physiological measure to compare subjective evaluations against. The challenges and benefits of both methodologies have been discussed separately in section 2.5, and will not be separate dealt with here.

3.3 The study

Participants
A sample of 32 volunteers (56 % female, 44 % male) representing an average middle-aged population (mean age 38.2) in Finland participated in the experiment. Data from 31 participants was used in the final analysis after data processing revealed problems with the eye tracking data from one volunteer.

Stimuli
The artworks used in the study consisted of 40 recently created, contemporary paintings (Appendix 2). Four persons representing the same population but not taking part in the experiment rated the about half the paintings as representative and half as representative in the selection stage. The final categorization into abstract vs. representative art was defined on the basis of the participants' evaluation (on a 9-point scale definitely representative [1]—definitely abstract [9]).

Design
A Tobii 120X remote eye-tracking system was used to participants' eye movements. Prior to the test, the eye-tracking system was calibrated for each participant by requiring participants to fix their gaze to five points covering the whole screen area, from a viewing distance of approximately 70cm. During the test itself, each painting was shown on a 22-inch screen for ten seconds, after which a gray screen with a fixation cross in the middle was shown for three seconds in order to control the position of the initial eye fixation on the paintings.

On the second phase, the same paintings were shown on a 15-inch screen using Psychophysics Toolbox run by Matlab, and participants were asked to rate them after each painting. The participants rated whether they viewed the artwork as abstract or representative and whether they liked it or not (preference), on a scale from 1 to 9. The participants also rated their affective state using the SAM non-verbal scales (Appendix 1) after each painting at their own pace. The valence scale consisted of nine graphic depictions of human faces in expressions ranging from a severe frown (most negative) to a broad smile (most positive). In arousal scale, there were nine graphical characters varying from a state of low visceral agitation to a state of high visceral agitation. The dominance scale consisted of nine characters varying in size from a very small figure (low feeling of dominance) to a very large figure (high dominance). The ratings were given by typing in a number corresponding to an appropriate figure. The scales are modified versions of the Self-Assessment-Manikin scales developed by Lang (1980).

In order to exclude the effects of the order of presentation, the paintings were presented in randomized order during both viewings.

3.4 Data processing

Data processing started from deleting unnecessary data columns and invalid data rows, in order to reduce the amount of data to a manageable level. Data files were then de-randomized to allow for data checkups. Deviations of the fixations from the center of the fix-pictures (640x512) were calculated to ensure there were no problems before viewing the art data.

Next step was to process the eye tracking data, i.e. calculate the amount of fixations, the entire duration of fixations, the average duration of a fixation, the standard deviations of fixations, the entire duration of saccades, the length of a saccade in pixels, and the averages and standard deviations of saccades. These values were calculated per person and per picture. Fixations that exceeded two standard deviations from the average duration were excluded from the data (large number of these were the first fixation which means they might have been caused by the technology). For the remaining data, fixation durations that exceeded 12 seconds or fell below 5 seconds were excluded from the analysis. Data from these were combined to one file with all the test persons and all pictures. Included was also background information on test persons (age, handedness,

gender, and visits to art galleries) and preferences (preference over each picture, categorizing to abstract/representative, valence, arousal, dominance).

Next, missing data was dealt with by replacing the value for either the median (likert variables) or mean (other variables). The data was also checked for outliers: the age variable had some outliers, with some more elderly subjects, but those were not removed from the data due to the data being valid measurements. Couple of the subjects also had high amount of gallery visits, but especially for the 71 year old subject that can be expected. On the other hand, there was a 24 year old subject that had 24 gallery visits, but that may be possible if the subject is an active art viewer. Thus, these outliers were not removed from the data. The image duration, fixations and saccades had also some outliers, but as we had already removed data with anything more than two standard deviations from the mean, those outliers were acknowledged but not removed.

Next it was confirmed that the data set would comply with the assumptions of normality. The test revealed that some of the variables were suffering from non-normality: for example representativeness was skewed to right, suggesting that painting used for the study were evaluated to be more abstract than representative. However, since the sample data set was N=877, it was considered large enough to fulfill the requirement for normalcy. Data was also checked for unengaged responses by checking the standard deviation for evaluation variables. Data with STD of 0 for evaluation variables were removed from the data, as their usefulness for finding significant relationships was non-existent.

4. ANALYSIS

4.1 Statistical analysis

Table 1 summarizes the descriptive statistics for the analysis variables. The sample size is large with N=877, with 31 participants in the final data set. The mean age of participants was around 35 years with a quite a large variance. Majority of participants were between 22 and 36, with the oldest person participating at the respectable age of 71. Majority, e.g. over 60% of the participants were women. The previous experience of viewing art had a mean of 6 visits to a gallery. However, the most experienced art viewers had over 20 visits. Also, majority of the participants were right handed, as could be expected, with also two left-handed and three both handed participants. This variable was included to the study as it has been long known that the processing of information in the brain differs between right and left handed people. (Hardyck and Petrinovich 1977).

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age	877	23	71	34,83	13,628
Gender	877	1	2	1,34	,475
Galleryvisits	877	0	24	6,17	6,503
Handedness	877	1	3	1,27	,616
Distance from center	877	0	2	,14	,397
Imageduration	877	9460	11827	10453,06	238,743
Pupil, left	877	-840542	902062	14993,96	265889,674
Pupil, right	877	-818002	1163080	11966,82	272908,787
Fixations	877	9	38	24,17	5,705
Fixation duration	877	5021	11883	8985,58	1366,164
Fixation average duration	877	92	1183	399,95	142,569
Fixations STD	877	0	1569	285,37	177,256
Saccades	877	28	569	205,09	61,974
Saccades STD	877	33	1114	149,44	65,664
Preference	877	1	9	5,03	2,370
Valence	877	1	9	4,93	1,852
Arousal	877	1	9	4,78	2,053
Dominance	877	1	9	5,00	1,733
Representativeness	877	1	9	5,97	2,628
Valid N (listwise)	877				

Table 1. Descriptive statistics

Distance from the center, image duration and distance of both pupils were control variables for the eye tracking experiment to ensure the test situation does not affect the results of data analysis. Before viewing the actual image, the participants were shown a cross in the middle, in order to focus their gaze and remove the effect of any wandering

gaze. The mean of .14 suggest that majority had their gaze moving towards the cross before the image was showed. The images were viewed for around 10.4 seconds.

For fixations, the mean total number of fixations per picture was 24.17. The normality for fixations was tested to be close to normal distribution. The total duration of fixations per picture was almost nine seconds with an average 0.4 seconds per fixation. The normal distribution was slightly skewed to the right, i.e. there were total durations around 10 seconds.

For saccades, the mean length of a saccade was 205 pixels with a standard deviation of 62 pixels. The histograms showed the distribution to be very close to normal.

The evaluation variables were centered quite clearly around the mean of 5, except for representativeness that was slightly higher by 6. This would suggest the paintings were considered slightly more abstract than representative. However, there was most variance around decisions on that representativeness than the other variables. The histogram showed skewness towards the abstract, suggesting that the test pictures may not be quite evenly distributed. This can be noted as a limitation in the following analysis.

4.1.1 Regression analysis

The multiple regression analysis began by choosing the method. Blockwise entry was discarded, as it could not be reliably returned in which order the predictor variables should be entered to analysis. From the stepwise methods, both forward and backward methods were tested on the data, but backward method was preferred due to the suppressor effects which are less likely to be excluded by the backward method. Forward method has a higher risk of excluding variables that in fact would predict the outcome and should be included in the model. Although stepwise methods are not recommended due to over- and under-fitting, and are better used in exploratory model fitting (Field & Miles 2010), the decision was taken to do a forced test and then exploratory tests with stepwise, backward and forward methods to see which variables would generate the best model fit. Regression analysis was in several steps to test which variables would fit the model best. Age for example was significant in explaining preference in backward elimination model, but not on others. Gender was significant explaining factor in all models. Handedness also was significant in all but full forced method. In the full forced model, fixations (amount, duration or average duration) were not significant, however in the backwards elimination, fixations were significant and stepwise selection and forwards selection average duration

of fixations (a derivative of fixations amount) was significant. Finally, the backwards elimination was chosen due to best model fit.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,769[a]	,592	,588	1,522

a. Predictors: (Constant), Dominance, Fixations, Representativeness, Age, Gender, Handedness, Valence, Arousal

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2912,420	8	364,053	157,223	,000[b]
	Residual	2009,867	868	2,316		
	Total	4922,287	876			

a. Dependent Variable: Preference

b. Predictors: (Constant), Dominance, Fixations, Representativeness, Age, Gender, Handedness, Valence, Arousal

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	,014	,396		,035	,972	-,763	,790
	Age	,008	,004	,049	2,061	,040	,000	,017
	Gender	,363	,114	,073	3,189	,001	,140	,586
	Handedness	,184	,090	,048	2,031	,043	,006	,361
	Fixations	-,026	,010	-,062	-2,698	,007	-,045	-,007
	Representativeness	-,086	,020	-,095	-4,255	,000	-,126	-,046
	Valence	,870	,032	,680	27,129	,000	,808	,933
	Arousal	,097	,030	,084	3,284	,001	,039	,155
	Dominance	,077	,038	,056	2,012	,045	,002	,152

a. Dependent Variable: Preference

Table 2: Linear multiple regression model explaining preference

Looking at the model summary (Table 2), both R^2 and adjusted R^2 are quite high, the overall model fit being $R^2 = 0.592$. In other words around 59% of the variance in preference is explained by age, gender, handedness, fixations, representativeness, valence, arousal and dominance. This would suggest that the model fit and its explanatory power is good. The preference differed significantly as a function of the independent variables, $F(8,868) = 157.223$, $MSE = 364.053$, $p < .000$, which supports the conclusion that the independent variables can explain the dependent. The standard error of estimate is quite small at 1.522, which means the model can quite accurately predict preference.

Looking at the individual variables, we can see that all variables are significant on the $p<.05$ level. When predicting preference, it was found that valence (Beta = 0.680, $p < .000$), representativeness (Beta = -0.095, $p < .000$), arousal (Beta = 0.084, $p < .001$), gender (Beta = 0.073, $p < .001$), fixations (Beta = -0.062, $p < .007$), dominance (Beta =

0.056, p < .045), age (Beta = 0.049, p < .040) and handedness (Beta = 0.048, p < .043) were significant predictors. All the variables have a positive relationship except for representativeness and fixations. For these variables, there is a negative linear relationship, i.e. when preference increases by one unit, the images are considered less abstract by 0.095 units and have fewer fixations by .062 units.

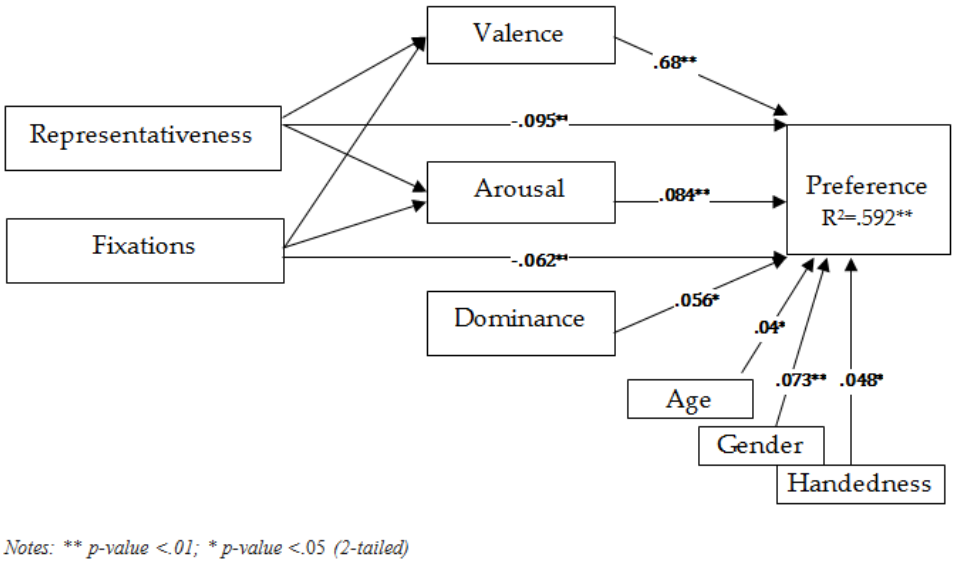


Figure 8. The updated research framework

As proposed in the research model, fixations, representativeness, valence, arousal and dominance significantly explain preference. As the regression model suggest that also age, gender and handedness significantly explain preference, they are added to the research model before continuing with the analysis (Figure 8).

Next, the updated research model was used to create a path analysis model to test all the relationships in the model, especially the potential mediation effect of affect variables.

4.1.2 Path analysis and mediation effect

The path analysis began by checking that the correlations between variables supported hypothesized relationships (Table 3).

Fixations correlate significantly with all other variables except representativeness and dominance. This is in accordance of the hypothesized research model. Fixations seem to correlate surprisingly strongly with the background variables (age, gender and handedness). The correlation with fixations and preference seems to be negative, meaning

less fixations per image as the preferences increases. Representativeness correlates with all the emotions, even dominance even though relationship was not predicted in the research model. Also what is interesting that even though there's no significant correlation between fixations and representativeness, handedness and representativeness correlate. As both are physiological phenomenon, a similar relationship could have been expected.

From the emotion variables, valence correlates significantly with everything except age. The correlation with preference is very high as can be expected but it is surprising how high the correlation with dominance is, effect size is almost double to the established relationship between valence and arousal. Arousal on the other hand correlates with everything except age and handedness. Again the effect size between arousal and dominance is surprisingly high. Dominance correlates with everything except fixations. The lack of correlation is in accordance to the predictions of the research model. In addition to correlating with other emotions, the correlation with preference is quite high. This is also somewhat surprising as the relationship of dominance to preference has been unclear at best. Dominance behaves somewhat oddly in the data, but rather than removing it from the analysis, we will keep it in the analysis as both the regression model and the correlation suggest its effect is significant.

Model Constructs	**Correlations**								
	1	2	3	4	5	6	7	8	9
1. Representativeness	—								
2. Fixations	.204	—							
3. Valence	-.208*	-.076**	—						
4. Arousal	-.125*	-.137*	.261*	—					
5. Dominance	-.118*	-.033	.471*	.497*	—				
6. Age	.007	.167*	-.064	.019	-.092*	—			
7. Gender	.018	.179*	-.083**	-.164*	-.208*	.164*	—		
8. Handedness	-.138*	.157*	.091*	.064	.106*	-.284*	.005	—	
9. Preference	-.256*	-.095*	.748*	.302*	.417*	-.011	-.014	.110*	—

*Notes: ** p< .01, * p< .05 (2-tailed)*

Table 3. Correlation matrix of model constructs

From the background variables, age correlates with fixations, dominance and preference. Interestingly, this would suggest that older people look at paintings differently (more fixations) but feel less in control. These should be taken with reservation as there were some outliers in the data set and the age group was skewed. Gender correlates significantly with fixations, valence, arousal and dominance. There are slightly more women in the data set, which may affect the result. However, it may also indicate gender differences in how the images are viewed and emotional responses. Handedness correlates with

representativeness, fixations, valence and dominance but not with arousal or preference, even though in the regression model handedness significantly explained preference.

All correlations except age/preference and gender/preference support the model developed based on the regression analysis. To continue with the path analysis, linearity and multicollinearity of the data was tested. Curve estimation for all variables in the model was done and all relationships were sufficiently linear to be tested in a covariance based the algorithm as used in AMOS. Two variables, age and gender, did not have a linear relationship, but this limitation was acceptable as age and gender are control variables in the suggested model. Also there was no linear relationship between representativeness and dominance or fixations and dominance, but this did not affect the model as no causality was expected between those variables. Multicollinearity was checked for valence, arousal and dominance, and none was found between those variables.

In order the find a good model fit, all other variables were allowed to covary, except for representativeness and fixations, and fixations and dominance. For both, no relationship between the variables was discovered and no improvement to the model was found by letting them covary. Error terms were presented to the endogenous (predicted) variables.

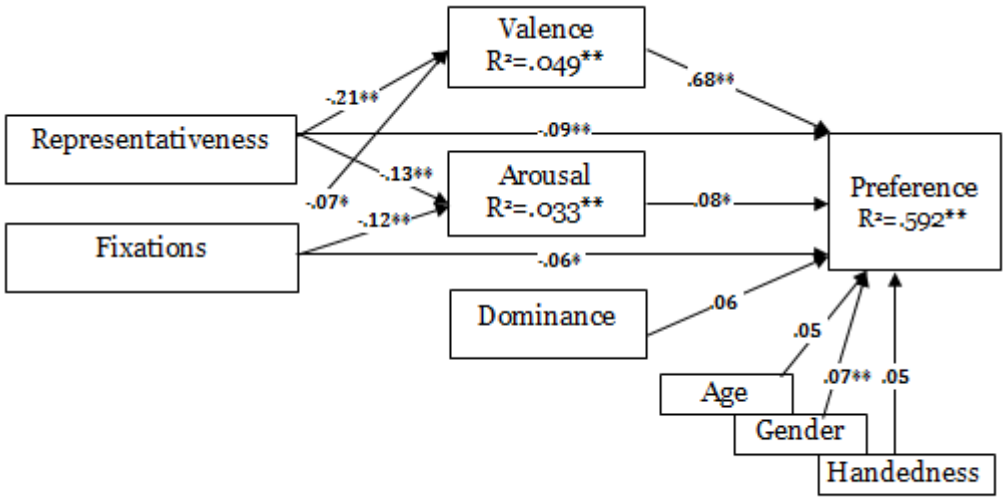
The path analysis complies with the results of the regression model, including the added background variables. The final model fit (Table 4) was quite good with the CMIN/DF=1.9462, CFI=.993 and RMSEA=.019 (1.000).

Fit index	Recommended cut off	Research model
X2	Nonsignificant X2	58.386 p<.001
X2/*df*	≥.9	1.9462
GFI	≥.9	.995
CFI	≥.9	.993
TLI	<.05 good fit	.957
RMSEA	<.08 acceptable fit	.019
Intervals		.011-.026
PCLOSE		1

Table 4. Fit indices for the research model

The variance in preference explained by the variables complied with the 59% found in the regression model. Also the standardized coefficients match between the models (Table 2 and Figure 8). All relationships are significant except for age and preference and handedness and preference. Valence had the biggest influence on preference, followed by

representativeness, arousal, gender and fixations. Looking at valence and arousal, we found that 4.9 and 3.3 percent of the variance were explained by representativeness and fixations respectively. Representativeness had a larger effect to valence than arousal, and fixations the other way around. In both cases representativeness had a larger effect than fixations.



*Notes: ** p-value <.01; * p-value <.05 (2-tailed)*

Figure 8. The final research model

As the relationships between representativeness, fixations and the affect responses are significant, the next step is to test the potential mediation effect of valence and arousal. As shown in Table 5, the indirect effect of fixations is slightly more significant than the direct effect, with similar effect size. The total effect to preference is -.12 which means the effect of fixations is partially mediated by valence and arousal. The mediation through arousal is most likely stronger due to the higher effect of fixations to arousal.

	Valence			Arousal			Preference		
Effect	Indirect	Direct	Total	Indirect	Direct	Total	Indirect	Direct	Total
Representativenes	-	-.211**	-.211**	-	-.131**	-.131**	-.154**	-.095**	-.249**
Fixations	-	-.069*	-.069*	-	-.125**	-.125**	-.057**	-.062*	-.120**
Valence	-	-	-	-	-	-		.679**	.679**
Arousal	-	-	-	-	-	-		.084*	.084*
Dominance	-	-	-	-	-	-		.056	.056
Age	-	-	-	-	-	-		.049	.049
Gender	-	-	-	-	-	-		.073**	.073**
Handedness	-	-	-	-	-	-		.048	.048
R^2			.049**			.033**			.592**

*Notes: ** p< .01, * p< .05 (2-tailed)*

Table 5. Indirect, direct and total effects of predictor variables

For representativeness the mediation effect is even larger: the indirect effect is 60% larger than the direct effect. Both are significant and the total effect to preference is -.249. This suggests that around 30 percent of the effect of valence and arousal to preference is actually mediation effect from valence and arousal, and that the effect of the emotions is then not that overpowering (although still large).

4.1.3 Group differences

Another test possible to perform with path analysis is to compare different groups. The preference evaluations were divided into high and low categories, with values 1-4 assigned to *low preference* group and values 5-9 to *high preference* group. New categorical variable was formed with 56,4% of low preference and 43,6% high preference evaluations.

		Low preference		High preference		
		Estimate	P	Estimate	P	z-score
Arousal ←	Representativeness	-0.014	.664	-0.135	.002	-2.274*
Valence ←	Representativeness	-0.022	.343	-0.093	.002	-1.858
Arousal ←	Fixations	-0.024	.071	-0.070	.000	-2.151*
Valence ←	Fixations	-0.003	.752	-0.025	.046	-1.357
Preference ←	Representativeness	-0.032	.073	-0.062	.000	-1.171
Preference ←	Valence	0.355	.000	0.400	.000	0.945
Preference ←	Arousal	0.124	.000	0.026	.302	-2.635**
Preference ←	Dominance	0.054	.151	-0.017	.581	-1.466
Preference ←	Age	0.008	.019	-0.009	.020	-3.294**
Preference ←	Gender	0.056	.585	0.271	.007	1.501
Preference ←	Handedness	0.090	.232	-0.104	.250	1.501
Preference ←	Fixations	-0.017	.050	-0.012	.139	0.415

*Notes: ** p-value <.01; * p-value <.05 (2-tailed)*

Table 6. Group differences for low preference and high preference

Significant differences between groups were found for several of the relationships (Table 6). The effect of representativeness to arousal was significant for the high preference group but not for the low preference. The effect size was also larger for the high preference group. Also, the effect of fixations to arousal was significant for the high preference group with a slightly higher effect than in low preference group. Interestingly, the effect of arousal to preference was only significant for the low preference group, but not the high preference, with the effect size being also larger. Finally, the impact of age was surprising as for low preference group age had a positive relationship with preference compared to

high preference group where age had a negative relationship with preference. In other words, for the low preference group, preference increased when the viewer's age was higher, and for the high preference group, preference increased when the viewer's age was lower. Though the effect of both was very small, it's an interesting, and significant, difference.

Next, it was tested whether relationships with variables differed among representative and abstract groups, and significant differences between groups were found for a couple of the relationships. Similar to Porat and Tractinsky's (2012) model with classical and expressive aesthetics separated, here the variable representativeness was separated to more abstract and more representative evaluations, with values 1-6 assigned to the *representative* group and values 7-9 to the *abstract* group. New categorical variable was formed with 47,3% of representative and 52,7% abstract evaluations.

		Representative		Abstract		
		Estimate	P	Estimate	P	z-score
Arousal ←	Representativeness	-0.043	.520	-0.489	.000	-3.398**
Valence ←	Representativeness	-0.155	.007	-0.369	.000	-1.789
Arousal ←	Fixations	-0.045	.005	-0.044	.001	0.046
Valence ←	Fixations	0.012	.392	-0.048	.000	-3.16**
Preference ←	Representativeness	-0.094	.065	-0.155	.088	-0.593
Preference ←	Valence	0.831	.000	0.927	.000	1.491
Preference ←	Arousal	0.126	.002	0.063	.146	-1.055
Preference ←	Dominance	0.078	.139	0.073	.179	-0.068
Preference ←	Age	0.003	.593	0.015	.014	1.400
Preference ←	Gender	0.202	.205	0.443	.007	1.055
Preference ←	Handedness	0.237	.041	0.114	.421	-0.671
Preference ←	Fixations	-0.038	.008	-0.013	.334	1.299

*Notes: ** p-value <.01; * p-value <.05 (2-tailed)*

Table 7. Group differences for representative and abstract

It was found that the effect of representativeness to arousal was significantly different for the abstract group but not to for the representative group. This most likely refers to the relationship between the high preference group and representativeness and arousal. More importantly, the effect of fixations to valence differed for representative and abstract images: The effect of fixations to valence was significant only for abstract images. The effect was also negative (i.e. less fixations when valence increases) compared to the positive relationship with representative group.

Next, these finding from the regression and path analysis will be addressed in regards to the proposed hypothesis and previous research on the subject areas.

4.2 Results

4.2.1 Eye movement indicates preference

H1: *Fixations significantly predict preference*

Based on the results of the regression and path analysis, it can be stated that hypothesis one holds and fixations explain user preference. Although the effect is not large, it is statistically significant in both models. This would support the previous findings (Djamasbi et al. 2011, Locher et al. 2007) which suggest eye movement predicts preference evaluations.

The relationship is negative suggesting that the more preferred images have less eye movement, and viewers fixate more on certain fewer points. In the usability field, longer fixations have been interpreted as an indication of the difficulty a participant has in extracting information from a display. On the other hand, many short fixations across a web page can be indicative of the specific usability problem, where a user goes to a page on the site, expecting to find specific details, but which are not provided. (Ehmke and Wilson 2007) In a study addressing the effects of training to eye movement, it was found that training was significantly related to enjoyment. In a simple context, trained group tended to examine the wider areas on the image, whereas the less trained had more fixations and longer scanning times. The trained group scans the entire image while the untrained looks at particular areas. On the other hand, it has been found that short gaze duration seeks out attractive, novel visual interests, which is related to untrained viewers and the prolonged gaze duration that searches meaning and significance to the overall visual image tends to be linked to trained viewers. (Park, Woods & DeLong 2010) Thus it remains uncertain, whether the negative relationship may is a sign of problems with processing the information or just an indication of an interesting object.

All in all, this analysis suggests that eye movement could be used as an objective indicator of preference, along with subjective evaluations. Subjective evaluations may depend on individual differences but using involuntary eye movement corroborating the preference evaluations will assist in ensuring that the data is valid and useful in interface design. In previous studies, it has been found that the subjects' self-evaluation of visual attention was

compatible with the data on their eye movement (Park et al, 2010). Consisting of more than just pictorial features (symmetry etc.), viewers acquire the initial impression (gist) of structural arrangement and semantic meaning in a single brief glance. Also, the pleasingness results from brief glance significantly correlate with results of unlimited viewing. (Locher et al. 2007) This would indicate that people would be able to express their individual interest accurately.

4.2.2 Aesthetics influences preference

H3: *Representativeness significantly explains preference*

Representativeness was also found to explain preference both in the regression and the path analyses, and thus we can state that hypothesis two holds. The effect was not very large but statistically significant nevertheless. This is in accordance to the previous studies (Lavie & Tractinksy 2004, Lindgaard 2003).

The effect was found to be negative, suggesting that more representative artworks were preferred over abstract ones. This in accordance when viewing art (Vartanian and Goel 2004), but in contrast of studies in HCI where expressive aesthetics was more preferred (Tractinsky et al. 2006, De Angeli et al. 2006). Also, Porat & Tractinsky's (2012) found expressive aesthetics to directly explain attitude, but classical aesthetics did not. The discrepancy in the findings is may be affected by the fact that the images in this study were reported more abstract than representative (mean=5.97). Nevertheless, this may suggest that the aesthetic experience is really different when viewing art and when viewing other visual objects, as proposed by Palmer et al. (2013). It may be that viewer criteria for judging art objects differs from other visual objects due to expectations on the experience of viewing art works versus other objects.

When looking at the correlations, significant relationships were found with preference, all affect variables and handedness. Perhaps most notable here is that all the relationships are negative, which would perhaps imply a problem with the scaling of the item. Perhaps it would make more sense to use an opposite scale where abstract would be in the lower end, and representative in the higher end of the scale.

4.2.3 Emotions influence preference

H5: *Valence significantly explains preference*
H6: *Arousal significantly explains preference*

As per previous studies, valence and arousal both significantly and positively predict preference. The effect of valence especially was very large (.68). The positive relationship of arousal and preference on the other hand was somewhat surprising as previous studies have found lower arousal connected to preference. Perhaps the result is influenced by the art works as test material: when viewing art, arousal may be a welcomed and even expected emotion, whereas when using an information system, arousal may be seen as an unwanted emotion.

When looking at the correlations valence and arousal were both found to significantly correlate with preference. The effect size of valence especially was very large (.748), indicating that the connection between pleasure and preference may have been understood to be too similar. Valence had a significant relationship between all the other variables except age and arousal with all except age and handedness. This is in line with the findings that age and handedness did not predict preference in the path analysis, and since the correlation with valence and arousal to preference was quite high, it makes sense that there is no significant correlation between valence, arousal, age and handedness.

For group differences, it was found that the effect of arousal to preference was only significant and positive for the low preference group. In other words, the less arousal induced, the less the images were preferred. This would indicate that the lack of arousal had an important role in not liking pictures.

H7: *Dominance significantly explains preference*

The effect of dominance to preference was found significant in the regression model, but non-significant in the path analysis. The latter finding is accordance to Porat and Tractinsky (2012). However, the discrepancy in findings reflects the difficult nature of dominance which has been found to have varying level of effect in different studies. Yani-de-Soriano and Foxall (2006) reviewed the use of and dispute over dominance in marketing literature. They referred to Russell and Mehrabian (1978) study that indicated approach-avoidance behaviors to be inversely varied with dominance. In this study,

dominance was found to have a small positive relationship with preference on the regression analysis and large positive relationship when looking at the correlations.

When looking at the other correlations, dominance was found to be highly correlated with all the variables except fixations. For example, for valence and arousal, there is a very high positive correlation, higher than for valence and arousal even though they are traditionally more connected together. Dominance also had a negative correlation with representativeness which suggests that representative images yielded more feelings of control than abstract images which sounds reasonable.

However, based on these results, no definite conclusions on the effect to preference or the relationship to other variables can be drawn from this study.

H2a: *Effect of fixations to preference are mediated by valence*
H2b: *Effect of fixations to preference are mediated by arousal*

This study found that valence and arousal partially and significantly mediate the effect of fixations to preference. Although not much previous research on the relationship between eye movement and emotions exists, previous studies have found that emotions do correlate with physiological phenomenon like heart rate, EMG, skin conductivity, finger blood volume (Tuch et al. 2009, Ward and Marsden 2003). Eye movement explained more of arousal than valence, suggesting perhaps that people view pictures differently when they induce arousal. This was also confirmed by the significant correlations. The negative relationship between fixations and valence and fixations and arousal means that with more pleasurable and aroused the viewer feels the less the gaze moves and fixates on fewer points. This is in accordance of the relationship between preference and eye movement.

Also, some group differences on the effect of fixations to valence and arousal was found. The effect of fixations to arousal was significantly only for the high preference group. That suggests that there was a significant difference on how viewers fixated on images that induced arousal between the viewers that liked the images and the ones that didn't. In other words, when attempting to design preferred interfaces, it could be considered that the eye movement is different for designs that induce arousal. Also, there was a significant difference on how viewers fixated on images that induced valence between the abstract and representative images. For abstract images, the relationship was significant and negative, suggesting that viewer's fixated on fewer points when the images were pleasurable. For

design purposes, it could be considered that eye movement is different for abstract objects and inducing valence will affect the design.

Same as eye movements are involuntary and rapid, the same it seems that emotions and preference formation are as rapid and distinct from cognitive processes. If the usage of fixations is to be considered as an indicator for preference, it should be noted that the formation of emotions plays a part in the process.

H4a: *Effect of representativeness to preference is mediated by valence*
H4a: *Effect of representativeness to preference is mediated by arousal*

The effect of representativeness to preference was found to be partially mediated by valence and arousal. This is in accordance to previous studies (Porat & Tractinsky 2012, Mummaleni 2005). Significant negative correlations between representativeness and valence, and representativeness and arousal support the finding. This would suggest that emotions influence the relationship between representativeness and preference.

Some group differences were also discovered for representativeness. The effect of representativeness to arousal was found significant and negative for both high preference and abstract groups. In other words viewers who liked the images and viewers who thought they were more abstract, found them inducing less arousal. This is surprising as based on previous research on expressive aesthetics, more novel images have induced more arousal, and less preference. Here, the opposite is found with less arousal and more preference on abstract images (which are juxtaposed to expressive aesthetics). Perhaps this is an indicator of more experienced viewers that feel at home with more abstract images due to their familiarity and thus are less aroused.

In any case, it is evident based on these results that emotions do in fact influence the relationship between representativeness and preference.

4.2.4 The effect of background variables

Although in their study, Porat & Tractinsky (2012) did not find that background variables like age and gender would significantly affect attitudes, this study found the opposite. Age, gender and handedness all significantly explained preference in the regression model. Correlations also revealed several significant relationships between the background variables and fixations and evaluations variables. In the path analysis, however, only gender's effect remained significant.

Although age was in the end non-significant variable in the path analysis, we cannot say for certain that age wouldn't affect preference. It can be theorized that experience trough age may influence what people like. For example the mere exposure effect and fluency theory may affect why age is significant, i.e. the older you get, the more you are exposed to certain kinds of images and the more fluent you become in viewing those images. This could then affect the preference evaluations. Also, the correlations revealed significant relationships that were not tested in the regression and path analyses. For example age positively correlated with fixations, meaning older viewers had more fixations per image. In other words, age may change how the visual object is viewed in that the gaze moves around more and fixates on more places. Age also had small but significant negative correlation with dominance. This is somewhat surprising as one could expect the feeling of control increasing over age rather decrease. Also, age was not found significantly correlated with representativeness, suggesting that the evaluation of what is representative and what is abstract does not change over age.

Gender was found to be a significant predictor in both analyses. Studies have found previously that there are differences on how genders experience visual objects. Also, gender had significant relationships with many of the other variables. There was a significant positive relationship between fixations and gender, which would suggest that men had more fixations than women. Also, for valence, arousal and dominance, there was a negative relationship, suggesting that women felt more pleasure, arousal and dominance while viewing the images. Like with age, gender was not found to correlate with representativeness, suggesting that women and men tend to evaluate representative and abstract images in the same way.

Finally, handedness was found to significantly explain preference in the regression model but not in the path analysis, suggesting a potential positive relationship, i.e. preference increasing with left-handedness. Usually handedness is something that is not cognitively chosen, but rather a physiological phenomenon where the brain is hardwired differently than with right-handed people. Handedness could potentially corroborate the finding that physiological phenomenon do predict preference. When looking at the correlations, it was found that handedness significantly correlated with all other variables except arousal and gender. For fixations, the positive relationship suggested that left- and both-handed viewers moved their gaze more and had more fixations points. Also, the relationship between handedness and representativeness was negative, suggesting left- and both-handed regarded more of the images as representative than right-handed. For emotions,

there was a positive relationship for valence and dominance suggesting that both emotions were experienced more strongly by left- and both-handed viewers. Handedness had a quite strong negative correlation with age. All the left- and both-handed participants were 44 years old or less, although there were 9 participants older than 44 years. Previously it has been common to learn to use the right-hand regardless of what comes naturally, as being left-handed has carried a social stigma. In that case, the results on handedness could not be generalized beyond this study.

5. DISCUSSION & CONCLUSION

This chapter will first review the analysis results in light of their practical implications to interface design. Then the limitations and future research potential is reviewed. Finally, the conclusions from this study are drawn.

5.1 Practical implications

Returning to the research gaps that was presented in the beginning of this paper, the practical and managerial implications are reviewed in light of those gaps and research questions posed in accordance.

There has been a lack of objective measures to support subjective evaluations, and physiological measures have shown promise to fill this gap. Thus, this study attempted to see if eye movement data could bring more objectively measured indicator to predicting user preference. A research question *"how does eye movement predict preference"* was posed.

This study found that the number of fixations do predict user preference. Of course, this alone does not say much about why something is preferred or not. However, it does offer an objective indicator for ensuring that the preference evaluation holds true. Although subjective evaluations are honestly narrated, the time between viewing the image and expressing the evaluation may have already changed the original preference evaluation through cognitive processing. As found in other studies, aesthetic preference is formed within milliseconds after first encounter and is not affected by the cognitive processing, thus needing measures as rapid as the evaluation formation. Rapid judgments last over time and first impressions have the potential to affect the overall evaluations of the visual object (Lindgaard et al. 2006, Tractinsky et al. 2006, Locher et. Al 2007). Physiological responses can provide those objective measures: for example heart rate, electrodermal activity and electromyography have been successful indicators of emotional and preference evaluations. Eye movement tracking has also been successfully used to predict user evaluations.

In practice, fixations can be used to confirm the preference of the user by researching what kind of interfaces elicit most preference. That knowledge could be then applied to interface design along with effectiveness and usability considerations. One interesting finding was the negative relationship between fixations and preference: the less fixations there are, the

more image is usually preferred. More research on this is needed, but we can theorize that this could indicate the for example less objects within an image is preferred, or a few prominent objects draw the attention of the viewer – enabling fluent information processing.

Of course, the implications of using eye movement to predict preference is not that straightforward as there are other factors like aesthetics and emotions that influence preference evaluations. Another research questions posed in the beginning of this study was related to art and other visual objects as separate aesthetic experiences. Based on the results from the analysis, the question *"how does the aesthetics of an image affect user preference"* can be answered by saying that representativeness predicts preference. In other words, the aesthetic evaluations of the users will have a direct affect to their preference evaluations.

In practice, interface designers could apply these results by designing more illustrative or representative interfaces that utilize the familiarity and prototypicality concepts to induce more fluent processing of interfaces and information contained by them. On the other, using more abstract design would elicit arousal which could facilitate memorability of the interface. The decision on which method to apply will be affected by the use context and goals of the design. On the other, there's no reason why for example ERP systems couldn't benefit from more abstract or expressive aesthetics.

However, the questions whether we can user art works as a basis to draw conclusions that could be generalized to user interface design, remains open. If we consider the notion of expressive aesthetics used in HCI research to be similar to abstract art works, then the results seem contradictory: expressive aesthetics are more preferred than classical in web sites, whereas representative images are preferred over abstract ones in contemporary art. The distinction between art and non-art in general is blurring and artworks may be difficult to recognize as art works per se as nearly all existing objects known to man have been used for artistic creations (Leder et al. 2004). From another point of view, the design of technology, information systems and even interfaces may be moving towards a more expressive aesthetics and less traditional direction. If the technological development as rapid as previously, we can only imagine what the interfaces in the future will look like. But we can already tell that design has a significant meaning to users, whether it is the hardware or the software.

But why are aesthetics experiences so influential that they affect preference choices and even overcome usability issues? Perhaps the explanation lies in the emotional responses they ignite inside of all people. One of the questions this study attempted to answer was *"what is the effect of emotions to preference"*. The answer is that emotions both directly predict preference but also mediate the effect of aesthetics. These effects can be corroborated by the eye movement data. The role of valence or pleasure especially seems to play a key part in determining preference, but how interface designers are able to induce positive emotions that ensure preference, is a complex issue. On the other hand arousal could be useful for designers when trying to get attention, or creating memorable experiences. But arousal is delicate emotions – when arousal reaches higher levels, users preference may turn into displeasure and avoidance behaviors.

Also art in relation to emotions has some interesting implications that could be useful for interface design. Art in itself is something that is not meant to be easily processed: modern art especially needs interpretation and when the viewer is able to successfully subtract meaning from the image, it results in emotionally positive experience. The concept of understanding could provide a further explanation on why we can experience valence or pleasure in such a short period of initial contact with a visual object. As our brains understand in the object, a positive feeling is experienced. This would suggest for example that complexity may not be a design feature to be so easily discarded: if implemented correctly, it could provide a sense of discovery for the user. Perhaps understanding also relates to the concept of dominance as well, where understanding can exert a feeling of being in control.

The role of dominance is an interesting one. It has been suggested that being in control could potentially affect information systems usage, however, not much research on its role has been done. Dominance is a complex concept; no common understanding has been reach in the scientific community on its significance to behavior. As this study found dominance to significantly affect preference, being in control could be of interest to interface design. However, whether or not these results can really be generalized from modern art to information systems is unclear. If a relevant concept to interface design, it could be a useful feature when designing preferred systems. Often users want to be able to customize systems to their own customs and liking, whether it would be more compositional (placement of icons) to aesthetic factors (desktop background images). One could suspect on the hand that too much control over the customization of an interface would leave users more stressed due to the choices available. One of the major benefits of

the dominance concept is its ability to discriminate between frustration and aggression (Yani-de-Soriano and Foxall 2006), and frustration is most likely an emotion every user of information systems has experienced at some point. So there most likely exists a fine balance on how dominance could be employed to benefit interface design.

In conclusion, it seems that using these concepts of aesthetics and emotions to be applied for the research in HCI as well as interface design will improve not only preference evaluations but affect the entire user experience. Instead of having aesthetic considerations as supportive to usability or effectiveness of information system, aesthetics and emotions can be used to steer users in the wanted behaviors, which will result in effective use.

5.2 Limitations and future research

Limitations
This study has some limitations as described below.

First, the self-reported measures on emotional state were measured only after exposure. However, Leder et al. (2004) suggest that the affective state preceding the aesthetic experience could affect the actual test result. They propose including considerations of the affective state prior to viewing aesthetic objects. On this study, prior affective state was not included and can be considered a limitation.

Second, the role of dominance in explaining behavior has been debated. For this study dominance was found to significantly explain preference. However, other HCI research with web sites has found opposite results. On the other hand, studies where art works have been used have found significant effect of dominance. Thus, it may be that the result on dominance in this study cannot be generalized in HCI without further research.

Third, the set of contemporary art was pre-tested to have a good distribution of both representative and abstract works. However, based on the evaluations of the participants the images were evaluated slightly more abstract than representative, causing the distribution to be skewed to right. This may have an effect on the findings and could limit the generalizability of the results in HCI research.

Fourth, some of the background variables had issues. Gender was slightly skewed to the left with 60% of the participants being women. Age on the other hand had a participant of the age 71 which showed as an outlier in the data, but was not removed due to the

observations being valid. Neither variable didn't have a linear relationship between preference which of course is an assumption path analysis is based on. However, as both age and gender were background variables and added to the path analysis model as control variables, these limitations were acceptable. Also, as discovered in the final model, age did not significantly predict preference. Gender however did have a significant relationship with preference, but the results have to be considered within these limitations.

Future research

Using eye-tracking data is not that uncommon in today's HCI research, although it has long held the status of a promising, yet underutilized research method. One area of future study area relates to the number of fixations: Jacob and Karn (2003) refer to the Graf and Kruger (1989) who have proposed studying short (<240ms) and long (<320ms) fixations as classified into involuntary and voluntary fixations. Combining the research of unconscious and cognitive responses as per Leder et al.'s (2004) model of aesthetics experience could reveal more on who aesthetic evaluations are formed.

Some research has already been done on visual aesthetics of interfaces but the problem with these has been that the concepts used in these studies remain too abstract to be practically and fully utilized in interface design. For example an interface may be less visually appealing for users but the terms like representativeness or classical and expressive aesthetics need more definition to pinpoint the areas that need improvement. For example, if expressive aesthetics can even assist in overcome usability issues, it could be very useful for interface design.

Emotions are an interest area of study that has a lot to be uncovered. As it has been shown in this and previous studies, affective responses are rapid and facilitate the aesthetic experience. However, emotions are not just the unconscious elements produced by our brain but cognitive as well. Although preference ratings seem to endure the passing of time, emotions may change. How the cognitive processing affects emotions and how that in turn affects preference and other aspects of information systems adoption and usage, would be interesting to study.

5.3 Concluding remarks

This study has addressed the relationship of aesthetics, emotions and user preference in HCI research. The motivation for the study was to found an objective indicator to support subject evaluations, especially regarding preference.

It was found that aesthetics and emotions explain and predict preference. Both are formed instantly after viewing an object, they are involuntary in nature and the effect of these rapid evaluations is long lasting. Measuring such swift decisions has been challenging, but it was found that eye movement, and fixations in particular, predict preference. In practical terms, it means fixations can be used along with self-reported measure to corroborate subjective evaluations.

These findings may be beneficial for user interface design in many forms. Using art works as to identify design possibilities may open new doors from more conventional design paradigms to new ideas. Design may be even used to overcome usability issues. Using fixations and subjective evaluations will ensure that research done for interface design will be reliable and results valid. Finally, the using design to elicit positive and negative emotions in the right moment may ensure user engagement.

REFERENCES

Averill, J.R., Stanat, P. & More. T.A. 1998. Aesthetics and the environment. *Review of General Psychology*. Vol. 2, No. 2, 153-174.

Boehner,K., DePaula, R. & Sengers, P. 2007. How emotion is made and measured. *International Journal of Human-Computer Studies*. Vol. 65, Iss. 4, 275-291.

Chatterjee, A. 2003. Prospects for a cognitive neuroscience of visual aesthetics. *Bulletin of Psychology and the Arts*. Vol. 4, 55-60.

Damasio, A. 2011. Neural basis of emotions. *Scolarpedia*. Retrieved on November 9th 2013. http://www.scholarpedia.org/article/wiki/index.php?title=Emotion&oldid=85881

Damasio, A. and Carvalho, G.B. 2013. The nature of feelings: evolutionary and neurobiological origins. *Nature Reviews of Neuroscience*. Vol 14, Iss. 2, 143-152.

De Angeli, A., Sutcliffe, A. and Hartmann, J. 2006. Interaction, Usability and Aesthetics: What influences user's preference? *Proceedings of the 6th conference on Designing Interactive systems*. 271-280.

Djamasbi, S., Siegel, M., Skorinko J. & Tullis, T. 2011. Online Viewing and aesthetic preferences of Generation Y and the Baby Boom Generation: Testing user web site experience through eye tracking. *International Journal of Electronic Commerce*. Vol. 15, No. 4, 121-157.

Emhke, C. & Wilson, S. 2007. Identifying usability problems from eye-tracking data. *BCS-HCI '07 Proceedings of the 21st British HCI Group Annual Conference on People and Computers: HCI...but not as we know it*. Vol. 1, 119-128.

Field, A. & Miles, J. 2010. Discovering statistics using SAS. *Sage Publications Ltd*.

Galitz, W.O. 2007. The essential guide to user interface design. Indianapolis, Wiley Publishing Inc.

Glaholt, M.G. & Reingold, E.M. 2011. Eye movement monitoring as a process tracing methodology in decision making research. *Journal of Neurosciencem, Psychology and Economics*. Vol. 4, No. 2, 125-146.

Hardyck, C. & Petrinovich, L.F. 1977. Left-handedness. *Psychological Bulletin*. Vol. 84, No. 3, 385-404.

Hartmann, J., Sutcliffe, A. & De Angeli, A. 2008. Towards a theory of user judgment of aesthetics and user interface quality. *ACM Transactions on Computer-Human Interaction*. Vol. 15, No. 4, 1-30.

Hassenzahl, M. 2004. The interplay of beauty, goodness, and usability in interactive products. *Human-Computer Interaction*. Vol. 19, 319-349.

Hassenzahl, M. & Monk, M. 2010. The inference of perceived usability from beauty. *Human-Computer Interaction*. Vol. 25, 236-260.

Hassenzahl, M., Diefenback, S. & Göritz, A. 2010. Needs, affect and interactive products – Facets of user experience. *Interacting with Computers*. Vol. 22, 353-362.

Jacob, R.J.K. & Karn, K.S. 2003. Eye Tracking in Human-Computer Interaction and Usability Research: Ready to Deliver the Promises (Section Commentary). *The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research*. J. Hyona, Radach, R., and Deubel, H., Editor 2003, Elsevier Science. Amsterdam. 573-605.

Lang, P.J. 1980. Behavioral treatment and bio-behavioral assessment: computer applications. In J. B. Sidowski, J. H. Johnson & T. A. Williams (Eds.), *Technology in mental health care delivery systems*. 119-137.

Lavie, T. & Tractinsky, N. 2004. Assessing dimensions of perceived visual aesthetics of web sites. *International Journal of Human-Computer Studies*. Vol. 60, 269-298.

Leder, H., Belke, B., Oeberst, A. and Augustin, D. 2004. A model of aesthetic appreciation and aesthetic judgments. *British Journal of Psychology*. Vol. 95, 489-508.

Lee, S. & Koubek, R. 2011. The impact of cognitive style on user preference based on usability and aesthetics for computer-based systems. *International Journal of Human-Computer Interaction*. Vol. 27:11, 1083-1114.

Lee, S. & Koubek, R. 2010. The effects of usability and web design attributes on user preference for e-commerce web sites. *Computers in Industry*. Vol. 61, 329-341.

Lengger, P.G., Fischmeister, F.Ph.S., Leder, H. & Bauer, H. 2007. Functional neuroanatomy of the perception of modern art: A DE-EEG study on the influence of stylistic information on aesthetic experience. *Brain Research*. Vol. 1158: 93-102.

Lindgaard, G. & Dudek, C. 2003. What is this evasive beast we call user satisfaction? *Interacting with Computers*. Vol. 15, 429-452.

Lindgaard, G., Fernandes, G., Dudek, C. and Brown, J. 2006. Attention web designers: You have 50 milliseconds to make a good first impression! *Behaviour & Information Technology*. Vol. 25, No. 2, 115-126.

Locher, P., Krupinski, E., Mello-Thoms, C. and Nodine, C. 2007. Visual interest in pictorial art during an aesthetic experience. *Spatial Vision*. Vol. 21, No. 1-2, 55-77.

Mehrabian, A. 1980. Basic Dimensions for a General Psychological Theory: Implications for Personality, Social, Environmental, and Developmental Studies. Cambridge, Oelgeschlager, Gunn & Hain.

Moshagen, M. & Thielsch, M. 2010. Facets of visual aesthetics. *International Journal of Human-Computer Studies*. Vol. 68, 689-709.

Mummaleni, V. 2005. An empirical investigation of Web site characteristics, consumer emotional states and on-line shopping behaviors. *Journal of Business Research*. Vol. 58, 526-532.

Nyström, M. & Holmqvist, K. 2008. Semantic override of low-level features in image viewing – both initially and overall. *Journal of Eye Movement Research*. Vol. 2(2), 2, 1-11.

Palmer, S.E. Schloss, K.B. and Sammartino, J. 2013. Visual aesthetics and human preference. *Annual Review of Psychology*. Vol. 64: 77-107.

Pandir, M. & Knight, J. 2006. Homepage aesthetics: The search for preference factors and the challenges of subjectivity. *Interacting with Computers*. Vol. 18, 1351-1370.

Park, J., Woods, E. & DeLong, M. 2010. Quantification of aesthetic viewing using eye-tracking technology: The influence of previous training in apparel design. *ETRA*. March 22-24, 153-156.

Path analysis (statistics). *Wikipedia*. Retrieved October 28th 2013, from http://en.wikipedia.org/wiki/Path_analysis_(statistics)

Porat, T. & Tractinsky, N. 2012. It's a pleasure buying here: The effects of web-store design on consumers' emotions and attitudes. *Human-Computer Interaction*. Vol. 27, 235-276.

Reber, R., Schwartz, N. & Winkielman, P. 2004. Processing fluency and aesthetic pleasure: Is beauty in the perceiver's processing experience. *Personality and Social Psychology Review*. Vol. 8, No. 4, 364-382.

Schrepp, M., Held, T. & Laugwitz, B. 2006. The influence of hedonic quality on the attractiveness of user interfaces of business management software. *Interacting with Computers*. Vol. 18, 1055-1069.

Shin, D.-H., 2012. Cross-analysis of usability and aesthetic in smart devices: What influences users' preferences? *Cross Cultural Management*. Vol. 19, No. 4, 563-587.

Skov, M. & Vartanian, O. 2009. Neuroaesthetics. *Baywood Publishing Company, Inc.*

Suhr, D. 2008. Step your war trough path analysis. *Western Users of SAS Software Conference*. Retrieved October 28th 2013, from http://wuss.org/proceedings08/08WUSS%20Proceedings/papers/pos/pos04.pdf

Sun, H. & Zhang, P. 2006. The role of affect in information systems research. *Human-Computer Interaction and Management Information Systems: Foundations*. M.E. Sharpe. 295-329.

Sutcliffe, A., Kurniawasn, S. & Shin, J-E. 2006. A method and advisor tool for multimedia user interface design. *International Journal of Human-Computer Studies*. Vol. 64, 375-392.

Thüring, M. & Mahlke, S. 2007. Usability, aesthetics and emotions in human-technology interaction. *International Journal of Psychology*. Vol. 42 (4), 253-264.

Tractinsky, N., Cokhavi, A., Kirschenbaum, M. and Shafri, T. 2006. Evaluating the consistency of immediate aesthetic perceptions of web pages. *International Journal of Human-Computer Studies*. Vol. 64, 1071-1083.

Tractinsky, N., Katz, A.S. and Ikar, D. 2000. What is beautiful is usable. *Interacting with Computers*. Vol. 13, 127-145.

Tuch, A.N., Bargas-Avila, A., Opwis, K. & Wilhelm, F.H. 2009. Visual complexity of websites: Effects on users' experience, physiology, performance, and memory. *International Journal of Human-Computer Studies*. Vol. 67, 703-715.

van Schaik, P. & Ling, J. 2011. An integrated model of interaction experience for information retrieval in a Web-based encyclopedia. *Interacting with Computers*. Vol. 23, Iss. 1, 18-32.

van Schaik, P. & Ling, J. 2009. The role of context in perceptions of the aesthetics of web pages over time. *International Journal of Human-Computer Studies*. Vol. 67, 79-89.

van Schaik, P. & Ling, J. 2003. The effects of screen ratio and order information retrieval in web pages. *Displays*. Vol. 24, 187-195.

Vartanian, O. and Goel, V. 2004. Neuroanatomical correlates of aesthetic preference for paintings. *Cognitive Neuroscience and Neuropsychology*. Vol. 15, No.5, 893-897.

Wang, Y.J., Hong, S. & Lou, H. 2010. Beautiful beyond useful? The role of web aesthetics. *Journal of Computer Information Systems*. Spring 2010, 121-129.

Ward, R.D. & Marsden, P.H. 2003. Physiological responses to different WEB page designs. *International Journal of Human-Computer Studies*. Vol. 59, 199-212.

Yani-de-Soriano, M.M. and Foxall, G.R. 2006. The emotional power of place: The fall and rise of dominance in retail research. *Journal of Retailing and Consumer Services*. Vol. 13, 403-416.

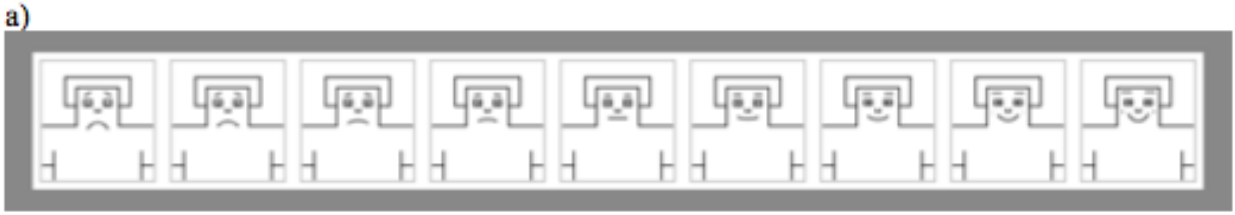
Zheng, X., Lin, J., Chakraborty, I. & Rauschenberger, R. 2009. Correlating low-level image statistics with users' rapid aesthetic and affective judgments of web pages. *CHI '09 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 1-10.

APPENDICES

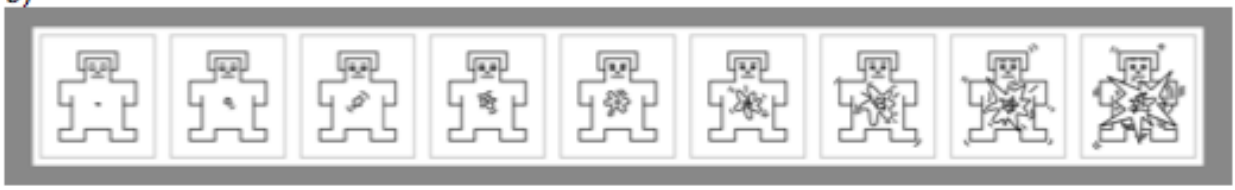
Appendix 1. 9-point Self-Assessment Manikin (SAM) scale

Scale a: Valence
Scale b: Arousal
Scale c: Dominance

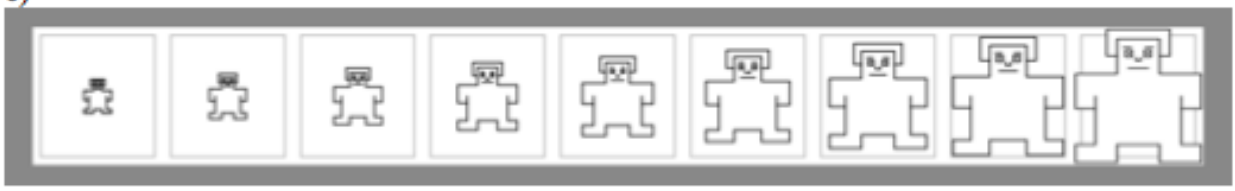
a)



b)



c)



Appendix 2. Modern representative and abstract paintings used in the test