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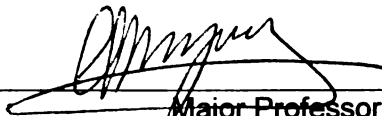
Web Aesthetics and Usability:
An Empirical Evaluation of White Space

presented by

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**WEB AESTHETICS AND USABILITY:
AN EMPIRICAL EVALUATION OF WHITE SPACE**

By

Konstantinos Efstratios Kripintiris

A THESIS

**Submitted to
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ABSTRACT

WEB AESTHETICS AND USABILITY: AN EMPIRICAL EVALUATION OF WHITE SPACE

By

Konstantinos Efstratios Kripintiris

The Human Computer Interaction (HCI) research community constantly seeks to improve of the users' web experience. Usability is arguably the most essential component of a user's online experience on the Web. Nevertheless, in recent years, the need to explore new and non-traditional factors (such as visual aesthetics and perceived attractiveness) that may impact usability has arisen. This study contributes to the field by exploring the relationships between the classical design element of white space, the perceived attractiveness of the website, and the latter's usability. A between-subject research design involves the manipulation a website's utilized white space. Three different versions were constructed, using 25, 50 and 75 percent of the website's white space respectively. Findings include a strong relationship between, the perceived attractiveness and the perceived usability of a website. The study suggests that the usability of a website is impacted more negatively when the white space increases over 50 percent. When the white space decreases lower than 50% the impact is not significant. Both practitioners and researchers should consider that in the context of eCommerce Web design, subtraction of content and shrink of visual elements may negatively impact the usability of a website.

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In memory of my beloved grandfather Konstantinos

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Introduction

The expansion of the Internet has seen tremendous acceleration during the past two decades. According to the Internet World Statistics (2008), 1.3 billion people worldwide use the Internet, as of December 2007. The Web has been one of the primary reasons for the Internet's expansion. Currently, it is the protagonist in terms of providing any kind of information (Schmidt et al. 2003). While the Web used to be a complementary asset for companies, institutions, organizations, and other parties, it has been transformed to being their vital component.

In the late 1990s, the massive usage of the Web had made the design of websites a complicated process. Due to the need for effective flow of information, website design started requiring the collaborative work of scientists, designers, and artists across disciplines. More effort had been put into Web design, since it was no longer sufficient to have a website unless it was usable to its audience (Tarasewich et al. 2001).

Currently, human-centered research is required in several points of the design process for effective Web products. The Human-Computer Interaction (HCI) community studies the Web from an anthropocentric point of view. Different approaches have been developed to analyze and explore the foundations of the users' experience (Norman 1998). Schenkman and Jonsson (2000) state that the use of Web consists of three different factors: the provided information (content), the given impression to the user (aesthetics), and the usability of the website. The latter factor has been the least researched and many of its potentials are yet to be explored (Lavie and Tractinsky 2004).

Traditionally, usefulness, utility, and usability have been the fundamental qualities of the Web experience (Hartmann 2006). Their impact has been tremendous,

and the HCI community has been significantly focused on them for more than a decade. Nevertheless, the complexity of user experience has generated a continuous growth of the HCI literature towards the investigation of new, non-traditional, factors. There seems to be a growing tendency of exploring visual aesthetics and perceived attractiveness over the last few years (Hartmann 2006). A few earlier studies from different domains had shown an impact of aesthetics in the daily interaction of humans with artifacts (Norman 1998, Jordan 1998, Tractinsky 1997, Lavie and Tractinsky 2004). In addition, claims for a potential correlation between feelings and usability had been apparent (Schenkman and Jonsson 2000, Norman 1998). The recent trend of exploring aesthetics has led researchers to keep a balance between traditional HCI concerns and aesthetics. There is limited research on whether or not the perceived attractiveness of an information system, caused by aesthetic considerations, impacts its usability (Lavie and Tractinsky 2004). But, there is enough evidence, both from the currently limited studies in the HCI field and from studies conducted in different domains that a potential relationship between aesthetics and usability exists.

Research Objectives

This study explores how aesthetics impact a website's perceived attractiveness and usability by expanding the findings of Lavie and Tractinsky (2004). Lavie and Tractinsky (2004) separate aesthetics into two subcategories: classical and expressive. Their study showed a significant association between both classical and expressive aesthetics with usability. They consequently developed a measurement instrument consisting of five-item scale for each of the aesthetics subcategories. They claim that the reliabilities, factor structure, and validity of those items reflect the aesthetics scales

adequately. Lavie and Tractinsky (2004) developed a formula of measuring the aesthetic quality of interactive artifacts. Although their findings are limited only in the area of user perception (Lim et al. 2007), their work has been fundamental and used heavily in the existing HCI and aesthetics literature, including this study. This empirical evaluation explores more in depth those findings by focusing only on the sub-category of classical aesthetics, which consist of sets of design principles and elements. Although many of those principles and elements are coming from various different domains such as architecture, graphic design, desktop publishing, studio art, etc., they construct a solid theoretical foundation, which has been utilized and followed by professionals and theoreticians across the disciplines. Current literature discusses several approaches of the role of aesthetics in HCI. Some studies consider aesthetics not just part of the visual appeal of interactive artifacts, but an integral component of the holistic user experience. Other studies are discussing the relationships between the perceptions of aesthetics and usability. This current study places itself closer to the latter category of literature; the goal is to identify patterns of the aesthetics' role in the perceptions of attractiveness and usability. In terms of usability, this empirical study uses the definition of the International Organization for Standardization (ISO 9241-11), which defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." Additional information about usability will be presented in chapter two.

Therefore, the broader research question of this study is: *How do classical aesthetics impact the perceived attractiveness and usability of a website?*

Since, classical aesthetics cannot be treated as an individual research construct because they consist of numerous different dimensions and sets of principles, breaking down classical aesthetics seems mandatory and, thus, is examined in chapter two.

Considering the various principles and elements behind the classical aesthetics, several research questions may emerge after incorporating principles and elements such as contrast, unity, white space, proximity, alignment and others. Also, the potential combinations of two or more classical aesthetic dimensions generate more research questions (e.g. What, if any, are the interaction effects between the website's symmetry and use of white space on a website's perceived attractiveness and usability?).

All the potential research questions are worth investigating. However, due to the lack of literature, a solid theoretical foundation is not provided. The purpose of this study is to provide empirical evidence and subsequently contribute to the development of a strong theoretical and practical basis. Thus, the focus is only on one dimension of classical aesthetics, on the principle of white space. The three main research questions coming forward are:

Q1: How does white space impact a website's perceived attractiveness?

Q2: How does white space impact a website's perceived usability?

Q3: How does perceived attractiveness impact a website's perceived usability?

In the next section, the study goes through a literature review in order to explore several relevant publications, which enlighten the path of how aesthetics may impact websites' perceived attractiveness and usability. It starts with an introduction to

aesthetics, and information regarding their potential relationship with perceived attractiveness and usability. The subsequent chapters present the research framework, the proposed research model, and the methods followed in the experimental evaluation. Lastly, the results are reported and the study concludes with a discussion of the implications and the limitations of this empirical evaluation.

Chapter 1 - Literature Review

Aesthetics and their relationship with Human-Computer Interaction

Aesthetics originate from the Greek adjective *aesthetikos*, which derives from the verb *aesthesthai* that means, “perceive” (Oxford American Dictionary 2008). Aesthetics are a set of principles concerned with the nature and appreciation of beauty. They are interlinked with the philosophy of art and are considered to be a particular theory of the conception of beauty; a particular approach to what is pleasing to the senses (Hoffman and Krauss 2004). That sense, the appreciation of beauty, was coined in Germany in the 18th century with the series of articles on “The pleasures of the imagination” written by the journalist Joseph Addison in the magazine *The Spectator* in 1712. Before that, some significant thinkers of that era had generated some thoughts, which had made a few appearances into this ground. An example is the formulation of general theories of proportion and harmony, detailed most specifically in architecture and music. However, philosophical reflection on Aesthetics did not begin to grow until the widening of leisure activities in the eighteenth century (Slater 2006). After the interest in beauty broadened, aesthetics started to encompass the art-world, and since late ‘50s the number of pure aesthetic ideas discussed in the literature has expanded even more. Building upon traditional philosophies of art, current trends carefully examine the aesthetical aspects of art (Slater 2006).

People throughout the centuries have been highly interested in aesthetics. The appreciation of beauty is a classical quality and applied to many aspects of life, such as senses, imagination, and understanding (Lavie and Tractinsky 2004). Aesthetics have

been a topic of study and research over the ages by many schools of thought, and consequently have been approached from many different angles and points of view.

Through their discussion, Lavie and Tractinsky (2004) present aesthetics possessing multiple meanings. However, they discuss the existence of two major approaches of aesthetics, the philosophical approach and the empirical one. Both are based on studies of works of art. A commonality among aesthetics across the centuries is its dynamic nature. Beauty has been being reformulated to address and reflect the propensities and tendencies of the era to which it belongs. It is observed and studied that aesthetical preferences of the present come to replace those of the past and so forth (Lavie and Tractinsky 2004).

Tarasewich et al. (2001), cite Eysenck (1983) addressing two conflicting points on aesthetics. The first considers aesthetics as something completely subjective and that beauty is a quality not able to be shown. The second point of view sees aesthetics as an objective quality, which can be understood and shown to people. Eysenck (1983) ends up believing that there is some sort of objectivity in aesthetic judgments.

Since aesthetics are a greatly broad and ambiguous area of study, putting them into context is essential and required for any type of scientific research (Lavie and Tractinsky 2004). This current study focuses on electronic design and communication via Web related technologies. Technology, communication, and design have been evolving synchronously in each period of our history. Muriel Cooper (1989) talks about the analogous evolution of communication design and technology. Each and every technological advance pushes the limits of communication and design and sets new standards. Classical design qualities are being inherited while new practices are being

invented and applied. The passage, from print design and visual communication to electronic media, followed a similar pattern. Traditional design techniques and principles were carried over, usually in the form of metaphors (e.g. brushes, color palettes, etc.). New techniques were quickly discovered and exploited, giving us a predictable and traditional transition from an older medium to a newer one (Cooper 1989). Aesthetics in visual communication were transitioned along the way. According to Tractinsky et al. (1997) the importance of application of visual aesthetics on computer graphic environments and information systems is significant in terms of system usability.

The function of visual aesthetics in computing environments is mostly based on the Greek origin of perception, which is conventionally concerned with the beauty and potentially with the judgment of it (Zettl 1999). However, a different approach by Lavie and Tractinsky (2004) suggests that visual aesthetics is not only concerned with beauty, but also with the appreciation of beauty. This statement supports Zettl's (1999) earlier claim about visual aesthetics not being just an abstract concept but a specific procedure, through which, people are able to examine and evaluate displayed visual elements.

In this context of computer communication, the application of visual aesthetics is the juxtaposition of appropriate visual stimuli, which can support and enhance visual communication (Hoffman and Krauss 2004). Klett (2002) found that specific visualizations tend to attract attention and cause users' curiosity due to the presentation of facts through affective stimuli, and therefore lead to an augmented understanding of the transmitted message. Klett (2002) also claims that visual organization is the most important aid in representing information. Zettl (1999) states that various categories of

applied visual aesthetics such as the effect of light, space, time, and motion interact to produce the final message.

Since visual communication and organization are integral parts of Web design, visual aesthetics can play a critical role in the Web design process. Selecting and incorporating visual elements and techniques within a Website can affect the provided message, content, and information (Hoffmann and Krauss 2004). Current literature does not provide us with a standard definition or operationalization of visual aesthetics or attractiveness. However, the first endeavors towards a deeper understanding of visual aesthetics in the context of HCI, clearly belong to Noam Tractinsky. His contributions to the field have been significant (Tractinsky 1997, 2000, 2005, Lavie and Tractinsky 2004). and used by anyone who attempts to explore the relationship between aesthetics and usability.

Lavie and Tractinsky (2004) separate visual aesthetics into two subsets: classical aesthetics and expressive aesthetics. Consequently, they connect those definitions with Nasar's (1999) concept of visual richness and visual clarity. Visual richness addresses the originality, sophistication, and creativity in terms of graphics, layout, and typography. On the other hand, visual clarity consists of attributes such as clarity, cleanliness, symmetry, contrast, and others. Tarasewich (2004), attempting a step further, associates visual aesthetics with web design elements such as: animation, graphics, uniformity, colors, fonts, background, hyperlinks, appearance and content information. His work, along with other scholars in the field of HCI is explored further in later chapters.

This study provides insight towards the disambiguation of aesthetics in HCI and specifically in Web design. It is based on Lavie and Tractinsky's separation of aesthetics

into expressive and classical. Despite the initial evidence that some connection between classical and expressive aesthetics exists (Coursaris et al. 2008), the focus of this study will not be on expressive aesthetics due to their highly subjective nature and the difficulty of measuring them. After the establishment of a clear understanding of classical aesthetics, future research will be able to step more steadily towards a further exploration of expressive aesthetics.

Although such an assumption may be considered precarious, this study assumes that the “expressive” aesthetic level of the design that will be tested and studied is of a high and stable level. Thus, the study concentrates only on classical principles and elements, which have been utilized in any discipline from ancient and traditional to contemporary designs. Those principles are under the umbrella of classical visual aesthetics or visual clarity according to Nasar (1999). Tractinsky (2004) points out Nasar (1999) as the first scholar to make use of the term “visual clarity.” Visual clarity reflects qualities held by classical notions of what comprises aesthetic visual design. Even though aesthetics has been typically considered as something subjective, Ngo et al. (2000) developed several computational algorithms, which could measure aesthetics objectively in the context of interactive interface design.

Next, this study explores briefly fundamental principles and elements of design (including some Gestalt laws), as a relationship to visual communication and usability has already been apparent. Gestalt psychology has promoted the principles of visual organization since the early twentieth century. For the operationalization of the design being studied, researchers often turn to Gestalt laws and principles, which may in turn be used as design guidelines. The importance of those laws, along with other principles and

elements has been emphasized and distribute across the design disciplines (Ngo 2001).

These principles offer insight on how visual connections are shaped among different elements and principles and how individuals perceive visual stimuli such as images, colors, separation figure from ground, etc. (Smith 2005).

Design principles, elements, and visual communication

“Designers can create normalcy out of chaos; they can clearly communicate ideas through the organizing and manipulating of words and pictures” (Veen 2000). That is an indisputable quality of designers across the disciplines. However, within the context of this study it is critically important to pay attention to the disambiguation of web design. Web design follows inherited principles and elements from other types of design, but also has its own unique characteristics. It is a mixture of graphic arts, technology and psychology (Wroblewski 2003). That mixture makes Web design a complicated process, which requires the expertise of several different professionals including information technologists, programmers, user experience architects, web designers, etc. Their expertise is usually a combination of academic training along with hands-on experience acquired by long-term exposure to the web developments practices. Wroblewski (2003) discusses the current qualifications of web related professionals. He claims that although they have the tools to produce effective information design, there seems to be a need for a further immersion into Gestalt and design literature. Wroblewski (2003) states that web design requires extensive knowledge of visual communication. He defines visual communication as the combination of visual personality (expressive aesthetics) and visual organization (classical aesthetics). He refers to visual organization as the ability of humans to make sense out of the relationships and the differences among elements and

consequently put together entire stories of understanding of what is seen. Design principles and design elements offer valuable insight regarding how humans visually group information. They are not definite due to the complexity of Web design and occasionally it may even seem imperative to deviate from these principles. Nevertheless, a deeper understanding of visual organization and hierarchy may enhance the ability of Web design professionals, to produce more effective, efficient and satisfactory solutions (Wroblewski 2003).

Design principles and elements are not stand-alone guidelines. They are fundamental tools, attributes and values of visual perception that always function and apply in relation to their surroundings (White 2002). The human mind constantly searches for meaning. When modern individuals look at a printed document, a painting or a computer screen, their eyes and minds are trying to instinctively and subconsciously create meaning (White 2002). That meaning is being shaped from looking into similarities and differences among visual elements, which function according to the design principles. Therefore, designing is a process of bringing out that meaning that lies among differences and similarities. Successful designs are able to show off that inherent meaning fully and simply (White 2002). Various design principles have been used across the centuries in countless styles and schools of design. Certainly the value of those principles is diachronic and unimpaired. Within this study, design principles are discussed in the context of website design. Although slightly different from print, website design also shares these principles.

Alignment - Symmetry

Intuitively, designers do not place visual elements in space arbitrarily. Every item on a Web page logically connects with other surrounding elements. Many of those visual connections are a result of the alignment principle (Williams 2004). Saw (2001) separates alignment into two subsets: the edge alignment and the center alignment. Visual items that have flat edges form patterns of edge alignment while center alignment may be formed with any visual objects or shapes.

Alignment makes the user conscious of the website's logical order. When visual elements are aligned on a Web page they create a stronger cohesive unit. The human eye and mind tend to create invisible lines, which connect similar elements on the Web page (Williams 2004). When those elements follow the rules of alignment, the human eye scans the page with greater ease and it creates those invisible lines instantly. Therefore, lack of alignment may be a significant detriment to a website's usability. Human eyes prefer to see order, which creates a calm and secure feeling.

Similarly, the principle of continuity enhances the predictability of a design by juxtaposing continuous and coherent stimuli. Having a design follow the principle of continuity, it results in evoking the human eye to move through one object and continue to another within a particular composition (Skaalid 1999). Since the user's eyes scan a Web page instead of reading it, it is imperative that a page follows the principle of continuity, which makes it more intuitive (Krug 2000). That repetition of similar visual stimuli enhances a design and creates a visual rhythm. Consequently, the visual rhythm brings the repeated visual elements of space into motion, and therefore creates an effective flow within the design. The human eye tends to follow that flow and the whole

process of going through a design becomes more spontaneous for the user. During this process a user may complete the visual organization in a predictable way. For example, the user may fill in details that were purposely omitted from the design to achieve other benefits including a sense of cleanliness (Krug 2000, Williams 2004).

Aligning visual stimuli many times lead to the essential design principle of symmetry, a fundamental dimension of visual aesthetics in any context of use and any discipline. It implies that the position and size of objects at one side of an axis are identical on the other side. A half object seems to be a reflection of its other half (Balinsky 2006). Designs that follow the principle of symmetry and asymmetry may be affected in terms of feeling. Symmetry gives a feeling of permanence and stability, while asymmetry creates feelings of interest and curiosity (Balinsky 2006). Designers apply symmetry into designs in order to communicate principles such as quality, stability and trust (Balinsky 2006).

Symmetrical elements on a design do not need to have the same content. Exact duplication across the axis is not required due to the limited resolution of the human eye (Balinsky 2006). Application of symmetry that does not obey mathematical laws, and it is different from classical symmetry, it is called visual symmetry (Balinsky 2006). Therefore, visual symmetry becomes more important in print or website design than classical symmetry, which obeys strictly to mathematical laws.

McClurg (2005) associates symmetry and asymmetry with visual balance. Visual balance is “the arrangement of the objects in a given design as it relates to their visual weight within a composition.” McClurg also refers to the approximate symmetry, which occurs with similar but not identical visual objects. Lastly, Krug (2000) addresses the

need for strict structures on the Web, which enhance a Website's readability. According to Krug (2000), when users visit a Web page they do not read its text or look carefully at its visual elements. Users usually scan a page and focus on something that catches their attention. By utilizing symmetry, a redundancy and predictability of visual information is achieved, which increases simplicity, clarity, and in turn, usability (Krug 2000).

Contrast

Distinguishing the visual and logical roles of visual items is fundamental in design. The designers, usually intuitively, turn to contrast for that purpose. The term contrast is a little ambiguous since it applies to a few different concepts (vision contrast, formula contrast, contrast in statistics, color contrast, etc.). Within this study any reference to the term contrast indicates the concept of dissimilarities among visual stimuli (Williams 2004). Contrast is immensely powerful, perhaps the most powerful among the design principles. Initially, applying contrast in any type of design might be considered a simple, intuitive and even primitive concept. However, the level of contrast in any design plays a significant role in the overall visual composition (Kirsanov 2007). According to Williams (2004), applying contrast is most important to visual attraction and one of the best ways to effectively add visual interest to any design. Successful application of contrast addresses the concept of dynamic tension and the degree of the existing conflict between the visual elements in any design (McClurg 2005). Contrast can be created when two or more visual elements are characteristically different; otherwise (if the elements are slightly different) there is visual conflict between them. According to Williams (2004), contrast can be applied in many ways such as: "large type with small type; a graceful old style font with a bold sans serif font; a thin line with a thick line; a cool color with a

warm color; a smooth texture with a rough texture; a horizontal element (such as a long line of text) with a vertical element (such as a tall, narrow column of text); widely spaced lines with closely packed lines; a small graphic with a large graphic.” Applying contrast can add a significant visual appeal to the overall design and catch the attention of the user.

Similarity

Absence of contrasting visual elements may sound catastrophic but if it is used effectively it leads to another essential design principle - similarity. Skaalid (1999) states that visual elements that share similar characteristics such as shape, size, color, texture, or value, will be seen as belonging together. The human brain tends to create groups of similar objects and therefore a semantic relationship between the visual objects is formed (McClurg 2005). A sense of belongingness is also achieved by placing design elements closer together (Gestalt principle of proximity). Users are able to recognize the logical differences between visually similar objects, however that cognitive process becomes more intuitive when there is a correlation between visual similarity and logical similarity (Krug 2000). Williams (2004) also described the underlined concept of similarity, although she labeled it proximity.

Golden ratio and Fibonacci numbers

Designers have frequently utilized the golden ratio and Fibonacci numbers across the centuries. However, the golden ratio and the Fibonacci numbers themselves are not design principles (Kyrmin 2008). The golden ratio is a visual representation of the number ϕ (1.618033988749895). It is an irrational number similar to the π , that is defined to be $(1+\sqrt{5})/2$. The Fibonacci numbers are a sequence of numbers named after Leonardo of

Pisa or Fibonacci. The ratios of successive Fibonacci numbers approach a value of 1.61803.... n . The limit of this equation as n approaches infinity, is the irrational number ϕ (Dunlap 1997).

The first use of the golden ratio as a design guideline was found to be in ancient Egyptian and Greek architecture, where the golden ratio was used for the development of the *golden rectangle* (Dunlap 1997). The golden rectangle's width ratio is the number ϕ . It has been documented that this certain rectangle is considered more aesthetically pleasing (Dunlap 1997).

The concept of the golden rectangle and generally the golden ratio and the Fibonacci numbers have been used extensively across multiple disciplines including mathematics, philosophy, physics, architecture, music, and of course, design (Dunlap 1997). The golden ratio has been used since the antiquity to create a design that is aesthetic and pleasing to most people (Kyrin 2008). Its aesthetic appeal has been heavily applied to forms of art, although often in a more subconscious level. Nevertheless, many modern artifacts consist of deliberately used golden rectangles (Dunlap 1997). When the golden ratio and the Fibonacci numbers are used in design, they construct a natural language that humans tend to understand and appreciate. That is because ϕ can be found freely in nature (Kyrin 2008, Dunlap 1997). The implications of the golden ratio in Web design may be found in the overall layout of a website or even in the design of individual visual components such as navigation columns and content blocks (Kyrin 2008).

White space

As mentioned earlier, this study focuses on white space (or negative space) and its relationship to websites usability. Throughout this study the terms *white space* and *negative space* imply the exact same design elements and they are used interchangeably. Space as it applies to design is difficult to be defined, because it encompasses several visual elements. Bennett (2005) states that visual space consists of three distinct concepts: the format that is associated with the actual size of visual elements, the negative and the positive space (where the smaller of two overlapping visual objects is identified as figure while the larger is regarded as ground) and the illusionary space (which is the pseudo three-dimensional space created by using two-dimensional visual elements). In addition, White (2002) claims that white space is the result of figure-ground relationships. Such relationships are juxtapositions of figure and ground in design compositions. The visual elements in a given environment correspond to the positive space, and the environment itself is the negative space (McClurg 2005, Tittel et al. 1997). According to Palmer (1999), a figure-ground relationship is a type of “perceptual organization” in human vision. Designers use figure-ground relationships in two-dimensional compositions by manipulating the emptiness within specific designs (White 2002). Emptiness in design is as important as fullness, activity, and content. Manipulation of emptiness may lead to the achievement of contrast and visual rest (White 2002). There are three types of figure-ground relationships: the stable one, where elements shape unchangeable bonds; the reversible one, where visual elements may take reversible roles; and the ambiguous one, where the roles are not identifiable (White 2002).

In the context of website design, white space seems to be interconnected with readability (White 2002). The term readability refers to the adequacy of a visual element to attract readers. Within Web pages, areas of white space are used in order to frame important “figure” visual items containing valuable content (Loewen 2006). Effective use of negative space may convey large portion of cleanliness. White (2002) connects that cleanliness to quality. Ken Hiebert, a design professor at Carnegie Mellon University in the 60s, states: “It is common to use space as a kind of luxury, projecting generosity or classic simplicity – a formula for ‘class.’ But if space is used only as a formula or device, it is also readily suspect as being wasteful, arrogant, or elitist. Yet space is a human need, and the experience of space is typically an exhilarating one” (White 2002).

From all the above, the importance of white space as a critical design element becomes apparent. White space shapes the context where the visual connections among visual stimuli occur (Vega-Riveros and Villalobos, 2006 and White 2002). Without sufficient negative space surrounding individual visual elements, the information’s visual density increases and inhibits a user’s ability to focus on separate items at separate times. This leads the focus of the user out of the informational context. A website cluttered with large items results in tawdriness and it makes the communication of individual items difficult (Loewen 2006). Furthermore, in a cluttered design figures do not communicate a strong individual message because they operate more as a group (Loewen 2006). Lastly, in an attempt to operationalize white space, Harrington et al. (2004) state that in the context of print design “white space should total about half of the total page area. The non white-space area can be estimated by totaling the areas of the content objects.”

This overview of the design principles is certainly not exhaustive. A significant volume of literature is dedicated to these principles since they have been utilized across multiple disciplines. Although many of these principles are coming from various different domains such as architecture, graphic design, desktop publishing, studio art, etc., they construct a solid theoretical foundation, which have been utilized and followed by professionals and theoreticians across the disciplines. The scope of this study is not an in-depth exploration of those principles, but their connection with HCI and specifically Web design. Next, this study goes through the existing literature of aesthetics in the context of HCI. Although significantly limited, the current findings lay a fruitful path to a more extensive examination.

Aesthetics, perceived attractiveness, emotions, and HCI

While the role of aesthetics in human affairs has been well documented across many disciplines, there is a significantly limited literature regarding that role in HCI (Tractinsky 2004). A significant volume of HCI research has focused on usability. The important factor of aesthetics and its potential impact on usability have not been investigated sufficiently. Huh et. al (2007) highlight the growing need of moving beyond usability and integrate aesthetics into the HCI research agenda. Recent HCI research calls for a balance between usability and aesthetic considerations (Lavie and Tractinsky 2004, Nakarada and Lobb 2005, Huh et al. 2007, Coursaris et al. 2008). Thus far, a limited set of findings clearly indicates the existence of a relationship between aesthetics and usability (Tractinsky 1997, Lavie and Tractinsky 2004, Huh et al. 2007). Tractinsky (2004) refers to Vitruvius, the first know theoretician of the design discipline, active in the 1st Century B.C. According to Vitruvius, an effective architectural structure consists

of three fundamentals factors: the strength and the durability (Firmitas), the suitability and the convenience (Utilitas), and lastly the beauty (Venustas). It is not complicated to see parallels between Vitruvius' principles and principles of Information Systems (IS). Traditionally, professionals in the IS field and specifically in Website design expended significant effort in order to build robust information systems, which follow some basic principles of stability correctness. Also, in Management Information Systems (MIS) and HCI, usability (approximates utilitas) is one of the five main research areas (Banker & Kauffman 2004). Professionals try to create functional systems that are easy to use. The latter principle (Venustas), which has to do with the beauty and the attractiveness, has received minimal attention in MIS and HCI research.

The first empirical results in this field came from Kurosu and Kashimura (1995), who were the first to study the relationship between interface aesthetics and usability (Tractinsky 1997). They found an unexpectedly robust relationship between Automatic Teller Machine (ATM) user interface aesthetics and perceived usability. Tractinsky et al. (1997) expanded on Kurosu and Kashimura's findings by proving empirically that the relationship between aesthetics and perceived usability was still present beyond initial impressions even in a different cultural context. They showed a high correlation between visual aesthetics and the system's perceived usability before, during, and after the interaction. Although these two studies were not measuring an aesthetic consideration within website environments, they are considered to be the initial efforts towards a deeper understanding of aesthetics and usability.

Lavie and Tractinsky (2004) found a high correlation between perceived attractiveness and usability in the context of website design, which supported

Tractinsky's (1997) and Kurosu's and Kashimura's (1995) earlier findings that were coming from a different context (ATM user interface). In particular, their study showed a significant association between both classical and expressive aesthetics with usability. They consequently built a measurement instrument consisting of five-item scale for each of the aesthetics subcategories. They claim that the reliabilities, factor structure and validity of those items reflect the aesthetics scales adequately. Their study has been fundamental and used heavily in the existing HCI and aesthetics literature. Nevertheless, their findings are limited in the area of user perception (Lim et al. 2007). Recently the literature tends to lean toward the direction of how such approaches to aesthetics can be used and utilized by both practitioners and theoreticians in order to lay the foundation of web aesthetics (Lim et. al 2007).

Nakarada and Lobb (2005) found through an empirical study that perceived attractiveness impacts search perseverance. Consequently, they suggested that a user is mostly likely to keep searching when the environment, where the search occurs, has a higher aesthetic level. Mahlke (2002) presented a different approach to explaining users' online behavior and suggested that the starting points of the users' experience are the qualities of the system by four captured dimensions: perceived usefulness, perceived ease of use, perceived hedonic quality and perceived attractiveness. An empirical study that followed the conceptual theory showed that users could perceive those qualities consistently and independently. Although perceived usefulness was the prevalent predictor of intention of use and subsequent actual usage behavior, perceived attractiveness was also shown to be significant (Mahlke 2002). Furthermore, Karvonen (2000) suggested that simplicity, which is a key component of usability, could be the

connection between aesthetics and usability, because simplicity is also considered an aesthetic notion.

Sutcliffe's (2002) heuristics suggest that a highly structured layout along with information accessibility impact the system's usability. Schenkman and Jonsson (2000) separate Web users into two distinct categories: users who look up a specific web page because they need a particular piece of information and users who "surf" around the Internet without a predefined purpose. The latter set of users is more difficult to satisfy with a Web page because they can easily move to a different one. According to Schenkman and Jonsson (2000), the initial impression (perceived attractiveness) of a Web page is very important. A website needs to be appealing to its users, especially to the random ones, who are not looking for something specific. In addition, the first impression may influence later perceptions of usability and satisfaction, gaining in that manner the interest of a "difficult" user (Lindgaard, 2007).

Petersen et al. (2004) address the ambiguity of the use of aesthetics in interactive environments by turning to the theory of pragmatic aesthetics. They discuss Shusterman's (1998) propagation of pragmatic and analytical aesthetics. Pragmatic aesthetics may be seen as integral parts of interactive systems and highly connected with the context of use. Consequently, Petersen et al. (2004) construct a framework in order to distinguish aesthetics of use and appearance. Although their study is conceptual, it provides strong theoretical foundation for further exploration of pragmatic aesthetics in interactive systems.

In a more utilitarian scope, Coursaris et al. (2008) investigate color as a fundamental aesthetic principle. Their study was task-oriented in the context of online

hotel booking. They tested split-complimentary color schemes that utilized combinations of cool and warm colors. Their findings offer support to prior studies on color combinations (Brandy and Phillips 2003, Papachristos et. al. 2005). Coursaris et al. (2008) found that users perceived Web layouts, which combine a cool primary color and a cool or warm secondary color, as the most appealing. They also expanded Lavie and Tractinsky's findings regarding classical and expressive aesthetics by identifying an impact of classical aesthetics to expressive ones.

Following a similar pattern, Cai et al. (2008) explore the effects of Web aesthetics on consumers' online behavior. The main purpose of their study is to investigate the effects of aesthetics across different online shopping sites. They claim that Web aesthetics are capable of influencing the users' mood in an online store environment and consequently their entire perception regarding the whole online shopping experience. They also see Web aesthetics impacting the *e-Atmospherics* (Sautter et al. 2004) of online stores, which may subsequently impact the overall perceived quality of the online shopping experience (Cai et al. 2008).

Hartmann et al. (2007) introduced a theoretical framework for the assessment of websites' attractiveness. They constructed a questionnaire based to the Adaptive Decision Making (ADM) theory and they used it to evaluate three websites, which shared the same topic but were different in terms of aesthetics. The ADM theory alleges that people's ability to make decision is adaptive and contingent upon the required task, the context and their background, and experiences (Payne et al. 1993). They hypothesized that users would judge according to their background, culture, training, the importance and the nature of the tasks, and the interactions between decision-make criteria. Hartman et al.

(2007) proposed five different judgment criteria: usability, content, aesthetics, reputation and customizability. The participants were categorized in three different groups depending on the national origin and academic background. Their findings showed a significant correlation between aesthetics and usability. Interestingly, the investigators found a difference between objective usability (reported problems) and subjective usability. Thus, it could be argued that overall favorable aesthetic impression of a website, augmented by aesthetics, may overcome poor usability experience (Hartmann et al. 2007).

Lim et al. (2007) introduce their concept of designing aesthetic interactions. They name it *interaction gestalt*. According to them, an interaction gestalt is an autonomous entity laid between the user experience and the interactive artifact. They define interaction gestalt as a language through which designers may manipulate the aesthetics of interaction. A unified code system that allows designers to understand what attributes (design principles) may be considered in order to result desirable designs. Lim et al. (2007) state that visual designers know how to design based on their intuitions and insights, similar to other craftsmen like carpenters. However, they usually do not possess any theoretical knowledge of use experience in the specific context that they design into. They trust the internalized knowledge in order to produce both aesthetically pleasing and usable products. Lim et al. (2007) aim to provide designers with a set of interaction attributes which can be consciously manipulated to produce successful “gestalt interactions,” namely the aesthetic perceptions that emerge between the user experience and the interactive artifact.

Donald Norman and his insightful and influential books regarding emotions and design have evoked several scholars to discuss aesthetics and emotions as an important element of HCI. There has been a keen interest in user interfaces, which elicit emotions (Lottridge 2008). Individuals can easily assess aesthetics. Consequently, aesthetic appeal is perceived early during any human-interface interaction, although aesthetic properties can also affect later perceptions. Humans tend to be attracted to beauty in any context. Jordan (1998) found that several products, which could engender pleasurable feelings, were considered more usable than those, which did not convey some visual attractiveness. Nakarada and Lobb (2005) found that a user is most likely, either consciously or subconsciously, to remain in an attractive environment more than in a less attractive one. That is partly due to positive feelings associated with the visually attractive stimuli.

In one of her latest studies, Lindgaard (2007) explains a paradox she encountered when she was participating in a usability study in the late 90s. In one of the evaluations, a group of participants faced serious difficulties when attempted to complete the tasks. Only half of the tasks were completed. However, their ratings regarding perceived usability and satisfaction were as low as another group of participants, who had to merely browse the site without completing any tasks or face any usability issues. First impression seemed to be a key criterion because it could evoke emotions, which impact the initial perception of a website and also later perceptions of usability and satisfaction.

Usability

According the Usability Professionals Association (2008) “usability is the degree to which something - software, hardware or anything else - is easy to use and a good fit for the people who use it”. Also, frequently the term usability refers to the techniques and processes used for the design and development of usable products. Software psychology that started being used in early 70s is considered to be the first form of usability.

“Software psychology dealt with the utility of a behavioral approach to understanding software design, programming, and the use of interactive systems, and to motivate and guide system developers to consider the characteristics of human beings (Carroll 1997).”

There have been several definitions of usability put forth by scholars. Jacob Nielsen (1993) proposed a definition where usability was encapsulated as the process of testing with a handful of techniques to gain a system’s learnability, efficiency, memorability, less errors, and user satisfaction. Rubin (1994) proposed similar usability attributes, including learnability, effectiveness, usefulness, and attitude. A third definition is put forth by the International Organization for Standardization (ISO 9241-11), which defines usability as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” (Bevan 2001). This definition is the most commonly used in the operationalization of usability in related studies since the constructs of the first two seem to coexist in the constructs of the ISO 9241-11 definition:

- *Efficiency*: the level of resource consumed in performing tasks,
- *Effectiveness*: the ability of users to complete tasks using the system, and the quality of output of those tasks,

- *Satisfaction*: users' subjective satisfaction to using the system

As it was mentioned previously, usability also refers to human centered design techniques, which are utilized across the design process to assure usable and desirable products. According to ISO 13407 "Human-centered design is characterized by: the active involvement of users and a clear understanding of user and task requirements; an appropriate allocation of function between users and technology; the iteration of design solutions; multi-disciplinary design" (ISO 13407, 1999).

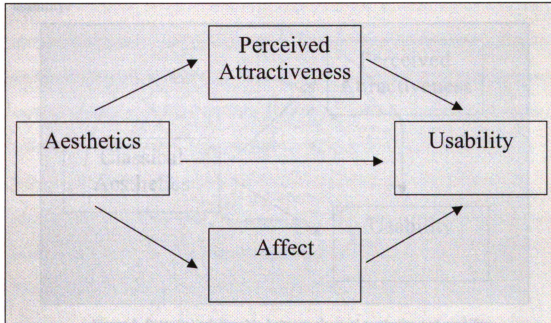


Figure 1. Research framework

Thus far it was examined how aesthetics may potentially impact the usability of websites either directly or by altering the users' perceived attractiveness, and mood (feelings). This theoretical research framework presented in the Figure 1, may be leveraged for future research, as several research models may emerge out of it. In the next chapter, the focus of this study on classical aesthetics, perceived attractiveness and usability is disclosed.

Chapter 2 - Theoretical Foundations & Research Framework

The above literature described in the previous chapter although coming from different disciplines and backgrounds, may be used to construct a theoretical foundation for the existence of a relationship between aesthetics and usability. As it has been examined so far, visual aesthetics, in the context of website design, have been separated into two distinct categories. Figure 2 depicts the focus of this study, which proposes the relationship between classical aesthetics (visual clarity), perceived attractiveness, and usability.

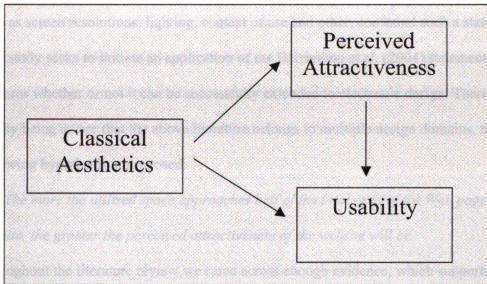


Figure 2. Potential relationship between classical aesthetics and usability

Numerous research conditions can potentially be investigated and studied. Throughout the literature review, various factors were examined, which led to the assumption that various types of connections and relationships exist between aesthetics and usability. Considering the lack of a solid theoretical background and ambiguity of the topic, attempts of studying design principles and elements in pairs may be misleading and ambiguous, thus this study concentrates only on the fundamental design element of white

space. Operationalizing white space can enormously contribute to future research and pave the path for the disambiguation of aesthetics in this particular domain.

The emerging research model (figure 2) allows the investigation of how different percentages of utilized white space may impact the perceived attractiveness and usability of websites. Subsequently, it is explored how a higher level of perceived attractiveness may impact the perceived usability of a particular design.

Harrington's et al. (2004) statement of optimal white space use could not be applied to electronic design without an in depth investigation. Many different factors, such as screen resolutions, lighting, context of use and other, confound such a statement. This study seeks to initiate an application of the Harrington et al. (2004) statement and explores whether or not it can be successfully extended to electronic design. Therefore, and by being aware that the above literature belongs to multiple design domains, the following hypothesis is proposed:

H1. The more the utilized space approaches half of the total area of the Web pages of a website, the greater the perceived attractiveness of the website will be.

Throughout the literature review we came across enough evidence, which supports potential relationships between perceived attractiveness and usability. Thus, a number of relationships are proposed:

H2. The more the utilized space approaches half of the total area of the Web pages of a website, the greater the perceived efficiency of the website will be.

H3. The more the utilized space approaches half of the total area of the Web pages of a website, the greater the perceived effectiveness of the website will be.

H4. *The more the utilized space approaches half of the total area of the Web pages of a website, the greater the perceived satisfaction of the website will be.*

H5. *The greater the level of perceived attractiveness of a website is, the greater its perceived efficiency will be.*

H6. *The greater the level of perceived attractiveness of a website is, the greater its perceived effectiveness will be.*

H7. *The greater the level of perceived attractiveness of a website is, the greater its perceived satisfaction will be.*

These seven hypotheses may illuminate the path of how white space could possibly impact the perceived usability and perceived attractiveness of websites. Current literature supports that perceived attractiveness and emotions seem to be highly connected with the perceived usability of interactive artifacts.

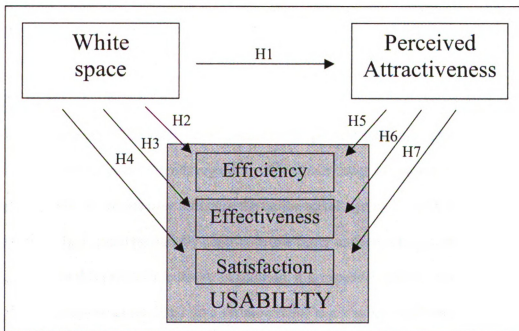


Figure 3. Proposed Research Model

Context of study

Ideally, the heuristics of this study would be able to be greatly generalized and applied to a variety of websites with different scopes and purposes. However, the current range of websites and the versatility of the Web will not allow such attempt. The Web provides a great plethora of any type of information. Visual communication puts that farrago of information into order by utilizing several principles including aesthetics. As we have examined so far, people's tastes regarding aesthetics are constantly changing. It becomes even more complicated, when we are referring to consumption and delivery of information in an era that e-commerce, electronic advertising and social networking are dominating the World Wide Web (Kroski 2007). The online behavior of the user, although sometimes shares similarities, is usually diverse depending on the context. The current study is leaning towards the e-commerce domain following a path of similar studies (Cai et al. 2008, Coursaris et al. 2008). The website created for the online experiment represents a fictional travel agency. Its design follows the current "online travel agency" standards in terms of layout and presentation of information. Such websites are prominent for the plethora and condense of information, while white space is minimally apparent. The users' experience with the present study may bring into light whether or not the current trends regarding white space usage are accurate. Also, insights regarding how aesthetics may influence the online travel agency industry may be provided, which could potentially contribute to a better understanding of the user experience in this particular context. In addition, it is expected that the potential patterns of this study can be generalized (to a certain extent) in a way that could be applied to other websites in similar domains, mainly under the umbrella of e-commerce.

Chapter 3 - Research Methodology

Experiment design and procedure

An empirical study was conducted to validate the proposed research model (shown in figure 3). The study employed a three-groups between-subjects design, where white space was manipulated at three levels. Each treatment represented an increased level of utilized white space. The operationalization of white space in this study follows the definition stated by Harrington et al. (2004) in the context of automated document layout. The definition states that for an effective use of the overall space of a document, the “white space should total about half of the total page area. The non white-space area can be estimated by totaling the areas of the content objects.” This study applies this measuring method into Web design.

Three different versions of a website were developed. The website is a mock-up design of a fictional travel agency. The three versions differentiated only in terms of how much white space was used. The manipulation of white space was done by increasing or decreasing the amount of information within the content blocks, by escalating or declining the fonts’ size, the buttons, the navigation bar and generally all the visual elements within the fixed sized pages. Nevertheless, the width and height of the pages remained the same across the three versions in order to provide “as much as possible” similar user experience across different browsers and platforms. The deviation due to the white space manipulation among the three versions resulted in users receiving similar amount of information across the versions.

Harrington et al. (2004) state that the content blocks must occupy 50% of the total area of a page. Thus, within the first version, the white space occupied approximately

50% of the total area. This version is functioning as the baseline while the other two are deviating from this optimal point. Subsequently, the second version utilized less negative space (approximately 25%). This reduction occurred by increasing the amount of detailed information within the content blocks and by escalating sizes of the font and the other visual elements (e.g. search bars, button, etc.). The third version utilized a greater amount of white space (approximately 75%). To reach the 75% white space, the content of the information blocks was decreased in terms of detailed information, fonts sizes and sizes of the other visual elements. The scaling occurred using the *Adobe Dreamweaver* web-authoring tool. The pages were divided into distinct content blocks. They all had a width of 780 pixels, which considered even the lowest-end users using monitors of 800 by 600 resolution.

The home page consisted of the banner, the navigation, the main advertisement box, the booking form, the special offers box, the vacation packages box and the secondary advertisement block. Each of those content blocks was manipulated in order to construct the three different versions. The banner division included three lines of text, the title of the firm and the “sign-in” (personalized content) lines. All text was manipulated to achieve different amounts of white space within the block. In the 25% of white space version, the firm’s title had a font size of 18 points, which was increased to 24 and 30 point for the 50% and 75% of white space versions respectively. Similarly, the sign-in lines were increased from 10 and 12 points in the high white space version (75%) to 12 and 14, and 14 and 16 points in the other two treatments. The navigation bar consisted of 5 buttons. The text within the buttons increased across each version to achieve either lesser or greater amount of white space. The buttons of the 50% had text of 16 points

size, which decreased to 12 points for the 75% version and increased to 20 points on third treatment. The middle part of the front page was divided into two parts. The left one accommodated the main advertisement block, while the right one was used for the placement of the interactive booking form. The main advertisement box consisted of one main picture, which was depicting an exotic destination of a special offer. In the version with lower white space (25%), the picture did not have any marginal frame around it, and occupied 520 by 260 pixels of space. While a frame was placed around the picture in order to add white space in the other two versions, which resulted in decline of the picture's size to 460 by 230 and 400 by 200 in the consequent versions. Meanwhile, the decline of fonts' and forms' sizes within the interactive booking form at the right part resulted in an increased amount of white space. The fonts sizes used across each version were: 12pt., 14pt., and 16pt. The forms' width increased from 100 to 160 and 220 pixels for the 25%, 50%, and 75% of white space treatments respectively. The lower part of the page was also divided into two divisions. The right part was occupied by the "vacations packages" section and the left one by the "hot destinations" section. Both sections utilized icons with accompanying text to promote vacation packages and popular destinations. The initial treatment of 50% white space accommodated two popular destinations and two vacations packages. The deviation towards lesser white space (25%) was achieved by increasing the size of the content in a similar manner as the upper parts of the page. In the third manipulation (75%), one of the vacation packages and one of the popular destinations were removed in order to increase the amount of white space.

The manipulation of white space for the remaining pages of each version followed an identical manner. In terms of content, it was ensured that the text removed did not alter

the adequacy of the delivered content by removing superfluous words.

The experiment was entirely web-based. The participants were recruited via an email advertisement and their participation was voluntarily. Through a hyperlink included in the email advertisement, participants were led to a Web page where they were informed about the study and its procedures. On the same page, they had to give their consent in order to proceed. A randomizer, which was developed with a server side technology (PHP), assigned one of the three versions to each participant. Tasks prompted the subjects to browse through the experimental version and search for specific information. The participants were informed that the tasks were only meant to offer an opportunity to explore the website and its design. They were also informed that their performance was not going to be evaluated. After having them navigate one of the three websites, the participants were asked to rank the website design in terms of their respectively perceived aesthetics, efficiency, effectiveness and satisfaction.

Subjects

A convenience sample was gathered via email through several Michigan State University mailing lists. The entire subject population consists of university students, faculty and staff. A total of 94 subjects participated. Out of those data sets that were collected, 90 sets of data were actually usable, with a minimum of 30 subjects per group. Each participant was randomly assigned one of the three treatments in order to control perplexing effects due to differences in subjects' characteristics. The sample showed that 62% of the participants were females with the rest of the percentages belonging to opposite gender. The average age was 27 (ranging from 19 to 52). All the participants had at least some college education, with over 50% of them either holding or pursuing an

advanced degree. ANOVA tests did not find significant differences for subjects in the various treatment groups, thus confirming the successful randomization of assignment across groups.

Instruments scales and validity

The questionnaire used for data collection contains scales that measure the various constructs shown in the research model (figure 3). All scales were adapted from prior studies. Scales for perceived efficiency and effectiveness were borrowed from Coursaris (2005). Scales for perceived attractiveness were borrowed from Lavie and Tractinsky (2004), and lastly, scales for perceived satisfaction and some scales for perceived efficiency were taken from Davis (1989). All these scales had established their reliability and validity, thereby satisfying content validity. All the perceived usability studies were reworded to better fit in the context of this study. The scales were used to measure the users' perceived attractiveness of the three distinct version of the website, through assessments of "classical aesthetics." These 7-point Likert items (anchored "Strongly Disagree/Agree") measured responses to the shared question, "I consider the website's design to be" for each of the following items: clean, clear, aesthetic, pleasant, symmetrical and organized.

Since the items used for the measurement of the aesthetic perceptions of the users are relevantly new, a reliability analysis was run to identify potentially latent items. The initial analysis showed a first total Cronbach's alpha of .899 and satisfactory item-total correlations (table 1).

Table 1. Perceived attractiveness construct items and their total correlations

Item	Question: Likert 7-scale strongly disagree to strongly agree	Item-Total correlation	Cronbach's alpha	Cronbach's a if item deleted
Aesthetics			.899	
Aesthetics1	Clean	.787		.872
Aesthetics2	Clear	.746		.879
Aesthetics3	Aesthetic	.758		.877
Aesthetics4	Pleasant	.811		.868
Aesthetics5	Symmetrical	.516		.913
Aesthetics6	Organized	.757		.877

(Note: * denotes that the specific item was removed from the subsequent analysis)

Only one item (Aesthe5) did not meet the criterion of an at least 0.7 total correlation as addressed from the literature (Hulland 1999). Adherence to that criterion required the removal of the specific item in the subsequent analysis. After the removal of the non-valid item, every item was re-validated by testing again its item-total correlation (table 2).

In terms of usability three scales were used to measure the users' perceived efficiency, effectiveness and satisfaction. Similar 7-point Likert scales were used, anchored "Strongly disagree/agree" responses to corresponding questions. All items used within the survey are listed in the Appendix 2. Since all the items were taken from significant previous studies (Coursaris et al. 2005, Davis 1989) the reliability analysis, expectably, offered strong results (table 3.) Construct statistics are presented in Table 4.

Table 2. Perceived attractiveness Cronbach's alpha, construct items and their item-total correlations

Item	Question: Likert 7-scale strongly disagree to strongly agree	Item-Total correlations	Cronbach's a
Aesthetics			.913
Aesth1	Clean	.775	
Aesth2	Clear	.763	
Aesth3	Aesthetic	.766	
Aesth4	Pleasant	.820	
Aesth6	Organized	.767	

Table 3. Usability constructs' Cronbach's alpha, construct items and their item-total correlations

Item	Question: Likert 7-scale strongly disagree to strongly agree	Item-Total correlation	Cronbach's alpha
Efficiency			.954
Efficie1	Easy to learn how to use	.892	
Efficie2	Easy to use	.922	
Efficie3	Fast	.840	
Efficie4	User friendly	.897	
Effectiveness			.962
Effecti1	Successful task completion	.929	
Effecti2	Accurate task completion	.929	
Satisfaction			.970
Satisfa1	Feeling pleased	.935	
Satisfa2	Feeling satisfied	.940	
Satisfa3	Feeling contended	.935	
Satisfa4	Feeling happy	.902	

Table 4. Construct statistics

	Aesthetics	Efficiency	Effectiveness	Satisfaction
Arithmetic means (all items)	5.444	5.7278	5.405	5.041
Arithmetic means (used items)	5.486	5.7278	5.405	5.041
Cronbach's a reliability	.913	.954	.954	.970
Standard deviation	1.232	1.512	1.906	1.490

Continuing the discussion regarding the instrument' validity, Table 5 presents statistics regarding all the significant and validated items and constructs that were used in the statistical analysis.

Table 5. Items and Construct statistics

	Mean	Std. Dev	Error	Item-Total correlation	Alpha	Alpha if item deleted
Aesthetics	5.486	1.232	0.129		0.913	
Clean	5.700	1.393	0.146	0.775		0.894
Clear	5.566	1.390	0.146	0.763		0.896
Aesthetic	5.222	1.443	0.152	0.766		0.896
Pleasant	5.411	1.549	0.163	0.820		0.884
Organized	5.533	1.375	0.145	0.767		0.895
Efficiency					0.954	
Efficie1	5.877	1.534	0.161	0.892		0.938
Efficie2	5.666	1.682	0.177	0.922		0.928
Efficie3	5.811	1.592	0.167	0.840		0.953
Efficie4	5.555	1.642	0.173	0.897		0.936
Effectiveness					0.962	
Effecti1	5.411	1.999	0.210	0.929		N/A
Effecti2	5.400	1.883	0.198	0.929		N/A
Satisfaction					0.970	
Satisfal	5.066	1.613	0.170	0.935		0.958
Satisfal2	5.088	1.583	0.166	0.940		0.957
Satisfal3	5.011	1.624	0.171	0.935		0.958
Satisfal4	5.000	1.390	0.146	0.902		0.969

Chapter 4 – Results and Discussion

Results

The first hypothesis stated that *“The more the utilized space approaches half of the total area of the Web pages of a website, the greater the perceived attractiveness of the website will be.”* Table 1 depicts the ANOVA test results, which suggested that there was no significant difference among the three groups ($p = 0.161$). Thus within the context of this study, white space does not appear to have a significant impact on how attractive the design was perceived by the subjects. However, comparing the means of the three groups (table 6), a difference between the 50% and the 75% groups was revealed. The directionality of the study follows the pattern proposed by the hypothesis. The perceived aesthetic appeal decrease once the percentage of white space increases higher than 50% of the total area. The Tukey test results shown in Table 8, illustrate these differences between the three groups. Also, although there is no statistical significance, it can be seen that the p value is lower (therefore more significant) when the white space deviates from the optimal point (50%), and especially when it goes over 50%. Thus, it could be implied that differences occur as the white space is drastically increased, although the findings of this study do not offer statistical support.

Table 6. Perceived attractiveness rankings between groups

White space used	N	Mean	Std. Dev.	Error
25%	30	5.580	1.151	0.210
50%	30	5.733	1.078	0.196
75%	30	5.146	1.409	0.257

Table 7. ANOVA for relationships between white space groups and perceived attractiveness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5.555	2	2.777	1.863	.161
Within Groups	129.729	87	1.491		
Total	135.284	89			

Table 8. Tukey test for relationships between white space groups and perceived attractiveness

White space	Mean difference	Error	Sig.
25% → 50%	0.153	0.315	0.878
25% → 75%	0.433	0.315	0.359
50% → 75%	0.586	0.315	0.156

The second hypothesis stated that *“The more the utilized space approaches half of the total area of the Web pages of a website, the greater the perceived efficiency of the website will be.”* ANOVA test results offer support to this hypothesis (table 10).

According to the Tukey test results (table 11), there seems to be a significant negative effect on perceived efficiency when white space increases from 50% to 75%

($p = 0.007$), and from 25% to 75% ($p = 0.010$). On the contrary no significant difference occurs when the white space drops from 50% to 25% ($p = 0.986$). It seems that the users have adapted the currents trends of travel agency website design is of a high level. The vast majority of such websites utilize a minimal amount of white space, thus users seem to be used to that trend and perceive less white space as efficient.

Table 9. Perceived efficiency rankings between groups

White space used	N	Mean	Std. Dev.	Error
25%	30	6.075	0.924	0.168
50%	30	6.133	0.962	0.175
75%	30	4.975	2.087	0.381

Table 10. ANOVA for relationships between white space groups and perceived efficiency

	Sum of Squares	df	Mean Sq.	F	Sig.
Between Groups	25.551	2	12.776	6.243	.003
Within Groups	178.029	87	2.046		
Total	203.581	89			

Table 11. Tukey test for relationships between white space groups and perceived efficiency

White space	Mean difference	Error	Sig.
25% → 50%	0.583	0.369	0.986
25% → 75%	1.100	0.369	0.010
50% → 75%	1.158	0.369	0.007

The third hypothesis stated that *“The more the utilized space approaches half of the total area of the Web pages of a website, the greater the perceived effectiveness of the website will be.”* ANOVA test results offer support to this hypothesis by giving a p value of 0.004 (table 13). After running a Tukey test, (table 12), there seems to a significant negative effect on perceived effectiveness when white space increases from 50% to 75% ($p = 0.015$). On the contrary, no significant difference occurs when the white space drops from 50% to 25% ($p=0.925$). Once again, a negative effect seems to occur, when white space increases over the optimal point.

Table 12. Perceived effectiveness rankings between groups

White space used	N	Mean	Std. Dev.	Error
25%	30	5.916	1.358	0.248
50%	30	5.816	1.511	0.275
75%	30	4.483	2.387	0.435

Table 13. ANOVA for relationships between White space groups and perceived effectiveness

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	38.422	2	19.211	5.864	.004
Within Groups	285.025	87	3.276		
Total	323.447	89			

Table 14. Tukey test for relationships between white space groups and perceived effectiveness

White space	Mean difference	Error	Sig.
25% → 50%	0.100	0.467	0.975
25% → 75%	1.433	0.467	0.008
50% → 75%	1.333	0.467	0.015

The fourth hypothesis stated that *“The more the utilized space approaches half of the total area of the Web pages of a website, the greater the perceived satisfaction of the website will be.”* ANOVA test results also offer support to this hypothesis (table 13).

Comparing the means of the three groups with Tukey’s test (table 14), there seems to a significant negative effect on perceived satisfaction when white space increases from 50% to 75% ($p = 0.007$) and from 25% to 75% ($p = 0.006$). On the contrary, no significant difference occurs when the white space drops from 50% to 25% ($p = 0.997$).

Therefore, a pattern seems to be emerging regarding a higher than 50% white space usage in terms of perceived usability. The users seem to prefer lesser amounts of white space (always in the context of e-commerce website designs, and specifically online travel agencies).

Table 15. Perceived satisfaction rankings between groups

White space used	N	Mean	Std. Dev.	Error
25%	30	5.433	1.090	0.199
50%	30	5.408	1.188	0.216
75%	30	4.283	1.823	0.332

Table 16. ANOVA for relationships between White space groups and perceived satisfaction

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	25.888	2	12.944	6.551	.002
Within Groups	171.894	87	1.976		
Total	197.781	89			

Table 17. Tukey test for relationships between white space groups and perceived satisfaction

White space	Mean difference	Error	Sig.
25% → 50%	0.025	0.362	0.997
25% → 75%	1.150	0.362	0.006
50% → 75%	1.125	0.362	0.007

The fifth, sixth and seventh hypotheses stated “*The greater the level of perceived attractiveness of a website is, the greater its perceived efficiency, effectiveness and satisfaction will be.*” A regression analysis was run to identify potential connections between perceived website attractiveness and perceived website usability. Table 18 shows the Pearson correlations between perceived attractiveness and each of the usability constructs. An array of potential connections among perceived attractiveness and perceived usability seem to emerge. All three usability constructs appear to be correlated with how perceptually attractive the website was, according to the subjects.

Table 18. Pearson’s correlations between perceived attractiveness and perceived usability

	R	R²
Efficiency	0.657	0.432
Effectiveness	0.620	0.385
Satisfaction	0.709	0.505

The R squares indicate that in this study, 43.2% of the variance in Efficiency, 38.5% of variance in Effectiveness and 50.5% of variance in Satisfaction were explained by perceived attractiveness. While the 5th and 6th hypothesis (p. efficiency and p. effectiveness) were not statistically supported, there was strong support regarding the relationship between perceived attractiveness and perceived satisfaction. Therefore, it is found, that perceived attractiveness may explain to a large extent variance in perceived usability of a website, particularly in terms of user satisfaction.

An ANOVA test was run to ensure the significance of the regression model (table 19). In addition, the Table 20 presents in more details the results of the regression analysis.

Table 19. ANOVA for the significance of the regression model

	Sum of Squares	df	Mean Square	F	Sig.
Regression	58.385	1	58.385	66.814	.000 ^a
Residual	76.899	88	0.874		
Total	135.284	89			

Table 20. Regression analysis model between perceived attractiveness and usability

		B	Error	Beta	t	Sig.
H5	Attractive → Efficient	0.149	0.121	0.182	1.229	0.222
H6	Attractive → Effective	0.057	0.088	0.088	0.644	0.521
H7	Attractive → Satisfactory	0.406	0.116	0.491	3.489	0.001

Lastly, a regression analysis was run, to identify the relationships among the constructs of usability. The results indicate that almost 72 percent of the variance in satisfaction was explained by perceived effectiveness and efficiency (R^2 .719). Findings (shown in Table 21), support existing literature (Coursaris, 2005) by showing a strong linear relationship between perceived efficiency and satisfaction, and also between perceived effectiveness and satisfaction.

Table 21. Regression analysis model between perceived efficiency, effectiveness and satisfaction

	B	Error	Beta	t	Sig.
Efficiency → Satisfaction	0.537	0.095	0.544	5.625	.000
Effectiveness → Satisfaction	0.269	0.076	0.345	3.560	.001

Discussion

The findings of this present study extend prior research in HCI concerning the role of aesthetics in User Experience and particularly in usability (Tarasevich 2001, Lavie and Tractinsky 2004, Nakarada and Lobb 2005, Coursaris 2008). This study examined the role of white space utilization in website design by testing three different versions of a website. Across the three versions, white space was manipulated to occupy 25, 50 and 75 percent of the total area of the pages, respectively.

This study presents a series of findings showing that variations in white space usage could impact the perceived usability of websites. The empirical evaluation showed that deviation from the optimal point (50% white space) as stated from the literature (Harrington et al. 2004) is able to alter the users' perceptions of usability. The greatest negative impact seems to be when the white space increases to occupy 75% of the total area of the pages. In this case, the analysis indicated that all three usability constructs were affected. Perceived satisfaction appeared to experience the greatest negative effect due to white space amplification. Perceived efficiency and effectiveness followed a similar pattern of decline, when white space was increasing.

On the contrary, there was no significant alteration in terms of perceived usability when the usage of white space decreased under the optimal point. It seems that the users' adaptability to the current trends of website design is high. The website genre tested (travel agency) in this study, is characterized by its minimal usage of white space. The vast majority of such websites tend to utilize a minimum amount of white space, in order to condense and include a maximum amount of content. So it could be argued that users seem to perceive lower amounts of white space more usable than higher ones.

That could be explained, when considering the context of use. Users seek detailed information for effective decision making regarding their potential bookings or purchases. When that amount of information is decreased in favor of white space and other principles interconnected with white space such as clarity and cleanliness, the users do not appear to perceive it favorably. Thus, it is suggested that context of use is critical when considering web aesthetics. It could also be argued that the impact of aesthetics will differ significantly across different contexts.

In addition, findings of this study offer further support to existing research regarding the relationship between perceived attractiveness and perceived usability. An array of potential connections among perceived attractiveness and perceived satisfaction emerge. Perceived satisfaction appeared to be correlated with how perceptually attractive the website was, according to the subjects' self-reported evaluations. Findings indicated that perceived attractiveness considerations are able to influence judgments regarding the perceived satisfaction with a website.

Furthermore, the results did not indicate any significance between perceived efficiency, perceived effectiveness, and perceived attractiveness. It could be argued that perceived attractiveness, which mainly deals with the hedonic aspect of user experience, does not influence the utility (efficiency/effectiveness).

While other studies found effects of aesthetics on the perceived attractiveness of websites (Lavie and Tractinsky 2004, Coursaris 2008), this study did not offer statistical support about the proposed relationship between white space and perceived attractiveness. At first glance, it seems that manipulation of white space did not have a significant impact on the perceived attractiveness of the website. However, it became

apparent that despite the absence of statistical significance, the directionality of the study followed the pattern illustrated in the theory from Harrington et al. (2004). Therefore, within the context of travel agency websites, white space did not appear to have a significant impact of how attractive the design was perceived. Nevertheless, the perceived aesthetic appeal seems to decrease once the usage of white space deviates from the optimal point. Thus, this study argues that differences may occur as the white space is drastically increased, although the statistical analysis does not offer significant support. Another plausible explanation for this observation is that aesthetics, both classical and expressive, are always applied in combinations, thereby creating cohesive visual units throughout the pages. In this case, the combinations might function in favor of white space, thus no significant alteration in terms of perceived attractiveness seemed to emerge. These current findings yield to a need for a more in-depth exploration of the manipulation of white space, especially in an era that users seem to adapt current design trends, which are characterized by a higher concentration of information and a lower usage of white space.

In closing, this study pursued the extension of the findings of previous studies (Lavie and Tractinsky 2004, Brandy and Phillips 2003, Coursaris 2008, Cai 2008, Hartmann et al. 2007, Lindgaard et al. 2007), about the understanding of how the manipulation of visual design elements may impact users' perceptions of usability and perceived attractiveness.

Chapter 5 – Contributions and limitations of this research

Contributions of this research

A user's given impression (or more precisely a first impression) of a website design is heavily dependent on aesthetics. Aesthetics can generate positive emotions, which can impact a user's mood and consequently his/her perception of the website. Recently, a few theoretical frameworks have emerged out of research into the effects of emotions created by artifacts. For example, Tractinsky (2004) cites Norman et al. (2002) who suggest a three-level theory of human behavior that integrates two information-processing systems, namely the affective and the cognitive. In each level, the world is being evaluated (affect) and interpreted (cognition). The lowest level processes take place at the intuitive level that surveys the environment and quickly communicates affective signals to the higher levels. The behavioral level is where most of a person's learned behavior occurs. Lastly, the reflection level is where the highest-level processes take place.

Current efforts in HCI research are differentiated from previous ones, where human decisions were assumed to be consequents of strictly cognitive processes. Since initial aesthetic impressions are affective, they are formed quickly at a low level and therefore influence cognitive processes (Tractinsky 2004). Hence, the immediate affective reactions can potentially control successive cognitive processes (Duckworth et al. 2002). Early judgments influenced by beauty may lead to later perceptions about deeper characteristics of the system (Tractinsky 2004). Fernandes et al. (2003) found that evaluations of Websites' attractiveness to which users were exposed for only five 0.5 second were highly similar to those of users who were exposed to Websites for longer

time periods. Thus, sufficient evidence is provided for the importance of affect in the context of usable interactive systems. By considering the emerged research framework, affect becomes a critical factor and complements the ergonomic considerations that typically drive the design decisions of telecommunication products. This study calls for the integration of aesthetics in usability engineering and in particular prototyping. Feedback sessions should probe for affective outcomes as well as performance-related considerations typical of usability evaluations. Current subjective usability measures capture user attitudes of working with systems by evaluation satisfaction, acceptability and comfort (Gleiss et al. 2004). A natural extension to these dimensions would be the inclusion of aesthetic appeal in the usability evaluation process.

There is sufficient evidence to suggest a relationship between aesthetics and usability. This study suggests that successful combinations of visual elements, which obey basic rules of aesthetics, can enhance the usability of a website along with its intended message. It seems that beauty plays a critical role in users' perceptions of a system both before and after using it.

There will be significant implications for theory, as the traditional scope of utilitarian usability will be expanded to include hedonic dimensions emerging from the realm of aesthetics. A clearer understanding of the relationship between aesthetics and usability is emerging, as increasingly more studies contribute in this area of HCI.

This study presents a set of findings regarding the effects of white space that may be used in future research that seeks to empirically validate the effects of aesthetic dimensions on usability. Implications to practice also emerge, starting with those on User Experience Design (UXD). Our understanding of UXD and all of the related fields such

as User Interface Design (UI) and Interaction Design (IxD) is expected to shift by heightening the role of aesthetic dimensions in contextual design. Furthermore, implications for practice are also found in the context of improving Marketing Communications by advancing the effectiveness of organizations' website designs.

Limitations of this research

As it has been mentioned several times thus far, this study involves users' perception. The study was conducted exclusively online in the form of a task completion and a post-experiment survey that measured various subjective perceived evaluations of the users' perceptions. Many factors could not be controlled, such as different browsers and connection speeds. A potential transfer of this study into a lab setting may generate more accurate results in terms of the white space effects on perceived attractiveness and usability.

A critical limitation for this study and also for other similar studies conducted, is that the User Experience in the context of websites does not consist only of usability and aesthetics. Other factors may influence it and put the aesthetic considerations aside. Factors such as connection speeds, servers' errors, content quality, writing, advertising, and several others may influence the overall experience and do not allow any margins for aesthetic explorations. This study assumes that the studied websites met many of these standards expected by their potential users. It is given that factors such as functionality and accessibility are greater concerns. When a website does not function properly or when it is not sufficiently accessible to its audiences, aesthetics may play a less significant role.

Also the scope and purpose of different Websites could be critical factors when it comes to assessing and evaluating Web aesthetics. When the need of transferring important and “raw” information over the Internet is the number one priority, it is greatly possible that aesthetics would not even be considered.

Culture is another limitation of this study. The Internet has enabled numerous corporations and institutions to expand their target audiences across the globe. At his first study, Tractinsky (1997) expanded the study of Kurosu and Kashimura (1995) regarding aesthetics and usability in the context of ATM machines. Although, the study occurred in a different cultural context than the previous one, the results were similar. Nevertheless, conclusions could not be made reliably since websites are more complicated than just ATM interfaces. Designing across cultures may be complex since many factors should be under varied consideration and interpreted, such as color combination, symbols, alignment styles, and many others.

APPENDIX 1

Questionnaire:

Demographics

1. What is your gender? (Male) (Female)

2. What is your age?

3. What is your highest level of education?

High school

Some College / University

College / University Graduate

Graduate Degree

Other

Likert 7-point from I strongly agree to strongly disagree

Perceived Attractiveness:

My perception of this websites is that it is...

clean

clear

aesthetic

pleasant

symmetrical

organized

Effectiveness:

My perception of this websites is that...

I was able to complete all the tasks on the web site successfully.

I was able to complete all the tasks on the web site accurately.

Efficiency:

My perception of this website is that

It was easy to learn how to use it

It was easy to use

It was fast.

It was user friendly.

Satisfaction:

My perception of this websites is that...

I feel satisfied with my use of the website.

I feel pleased with my use of the website.

I feel contended with my use of the website.

I feel happy with my use of the website.

APPENDIX 2

Website:

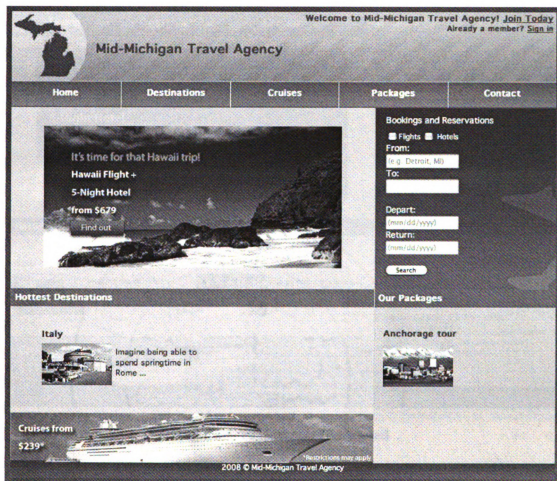


Figure 4. 75% White Space used



Figure 5. 50% White space used



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Figure 6. 25% White space used

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