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Trust and distrust on the web:
User experiences and website Characteristics

Mirjam Seckler, Klaus Opwis & Alexandre N. Tuch
University of Basel, Department of Psychology, Center for Cognitive Psychology & Methodology,
Missionsstr. 62a, 4055 Basel, Switzerland

Correspondence should be addressed to:
Mirjam Seckler
University of Basel,
Department of Psychology,
Center for Cognitive Psychology and Methodology,
Missionsstrasse 62a,
CH-4055 Basel,
Switzerland.

Tel.: +41 (0) 61 267 06 17
E-mail: mirjam.seckler(at)unibas.ch
Linking objective design factors with subjective aesthetics: An experimental study on how structure and color of websites affect the facets of users’ visual aesthetic perception

ABSTRACT

The present study examines how objective design factors of a website are linked to different facets of subjective aesthetic perception. Five online experiments based upon the screenshots of real-existing websites with a total of $N = 194$ participants were conducted to isolate and analyze the effects of two objective structural factors (vertical symmetry, visual complexity) and three objective color factors (hue, saturation, brightness) on the different facets of subjective aesthetic perception (simplicity, diversity, colorfulness, craftsmanship) measured with the Visual Aesthetics of Website Inventory (Moshagen & Thielsch, 2010). Although all investigated factors are apparent features in website design, their effects on different facets of subjective aesthetic perception are not yet well understood. Our results show that websites of high symmetry, low complexity, blue hue, medium brightness or medium and high saturation received the highest overall aesthetics ratings. Furthermore, data reveal that structural factors compared to color factors have a manifold and greater impact on the different facets of subjective aesthetic perception than the color factors. Both structural factors have a great impact on simplicity, diversity and craftsmanship whereas the color factors have a great impact especially on colorfulness. Only complexity affects all facets of subjective aesthetic perception. The other objective design factors had effects on specific facets. Our findings shed light on the relationship between objective and subjective factors of aesthetic perception and may help designers to systematically target specific facets of visual aesthetics.

Keywords:
Aesthetics measures; Aesthetic perception; Web-design factors; VisAWI; Visual aesthetics
INTRODUCTION

Within the field of human-computer interaction (HCI) and especially in the context of user experience research, the aesthetics of user interfaces has become a topic of major interest. Aesthetic factors beyond traditional usability are increasingly recognized as contributing to the overall user satisfaction (Hartmann, Sutcliffe, & De Angeli, 2007; Schenkman & Jonsson, 2000; Tractinsky, Katz, & Ikar, 2000) and overall success of a product or system (Green & Jordan, 2001; Norman, 2004). Furthermore, numerous studies show the influence of aesthetics on perception of usability (e.g., Phillips & Chapparro, 2009; Thüring & Mahlke, 2007), on usability testing (Sonderegger & Sauer, 2010), on trust and credibility (Karvonen, 2000; Robins & Holmes, 2008), on intention to revisit (Mahlke, 2002; Yoo & Donthu, 2001), and on fun and enjoyment (Mathwick, Malhotra, & Rigdon, 2001).

Previous studies point out that there are two different approaches to measuring visual aesthetics of user interfaces: One is an objective screen-design-based approach and the other a subjective questionnaire-based approach (Altaboli & Lin, 2011a; Mõttus, Pajusalu, Lamas, & Torres, 2013; Tractinsky, Cokhavi, Kirschenbaum, & Sharfi, 2006). The first approach assumes that specific features such as structure and color factors in the interface’s design trigger users’ perception of aesthetics of the interface. This approach therefore corresponds to the concept of “beauty in the observed object” (Altaboli & Lin, 2011a). An example of this approach is the study of Bauerly and Liu (2006) in which they use computational aesthetic quantification algorithms based on symmetry, balance and quantity of elements of websites and subsequently relate them to subjective aesthetic ratings. The second approach argues that the analysis of aesthetics should view beauty within the subject and not in the object and focuses therefore on the users’ subjective perception of aesthetics. As an example for this approach, Lavie and Tractinsky (2004) developed a questionnaire to measure the visual aesthetics of websites. They were able to show that users’ subjective aesthetic perception of websites consists of two main aesthetic facets, which they termed “classical” and “expressive” aesthetics.

Although highly relevant for web design, there has been little effort in systematically combining the two approaches. Many studies only investigated a single objective design factor on its influence on multiple subjective facets (e.g. Cai and Xu, 2011; Michailidou et al., 2008; Tuch, Bargas-Avila, & Opwis, 2010) or multiple objective design factors on a global aesthetic dimension or a single aesthetic facet (e.g., Purchase, Freeman, & Hamer, 2012; Reinecke, Yeh, Miratrix, Mardiko, Zhao, Liu, & Gajos, 2013; Reinecke & Gajos, 2014; Wu, Chen, Li, & Hu, 2011). The few studies that assessed multiple objective screen-based measurements of websites (e.g., symmetry) and correlated them to different dimensions of users’ subjective aesthetic perception did not find consistent results (Altaboli & Lin, 2011a, 2011b; Mõttus et al., 2013). Previous research, furthermore, lacks experimental studies that ensure that the investigated design factors are not confounded with other factors. There are several studies who applied computational modeling with a high number of stimuli and participants to predict the aesthetics of a
website (e.g., Ivory and Sinha, 2001; Reinecke & Gajos, 2014; Reinecke et al. 2013), however, these studies are only correlational and potential confounding variables are not identifiable. Consequently, how different objective design factors affect different facets of subjective aesthetic perception is not well understood.

We conducted five experimental online studies in which we systematically manipulated five different objective design factors on 25 different websites and measured their effects on different facets of users’ subjective aesthetics perception. The five factors included structural elements (symmetry and complexity) as well as color characteristics (hue, saturation and brightness). With our study we make the following two contributions: (1) By combining the objective factors with different facets of subjective aesthetic perception, we achieve a better understanding about how well qualified the objective screen-design-based approach is for assessing users' perception of interface aesthetics. In doing so, we gain insight into how the subjective facets of aesthetics are formed by different objective factors. (2) From a practical point of view, our findings may help interface designers to find better layout and color solutions by systematically targeting specific facets of visual aesthetics.

THEORETICAL BACKGROUND

2.1 Measurement approaches to studying aesthetic perception

There are two measurement approaches to studying aesthetic perception, as laid out in the Introduction. First, the objective screen-design-based approach relates screen design factors and layout elements to the users' perception of visual aesthetics (e.g., Kim, Lee, & Choi, 2003; Tuch, Bargas-Avila, & Opwis, 2010). Early attempts to identify attributes of objects that may critically influence aesthetics (e.g., Berlyne, 1960; Birkhoff, 1933; Eysenck, 1941) were inspired by the objectivist perspective on aesthetics (Moshagen & Thielsch, 2010). Measurement methods for this approach use simple numerical counts of visual features on the screen (e.g., number of words or images) or more complex mathematical formulas (e.g., complexity or symmetry). Michailidou, Harper, and Bechhofer (2008) used the structural elements (such as text, tables, links, and images) of a web page and their characteristics (such as color and size) to determine its visual presentation and complexity level. Ngo and Byrne (2001) developed 14 objective measures of screen aesthetics such as symmetry, simplicity and order. Bauerly and Liu (2006) also objectively quantified symmetry and balance of web pages to investigate their effects on subjective aesthetic perception.

Second, there is the subjective approach that uses questionnaire-based instruments to measure users' perception of visual aesthetics (e.g., Lavie & Tractinsky, 2004; Moshagen, & Thielsch, 2010). Due to the complexity and inter-relationships among screen design elements, this approach argues that the analysis of aesthetics should view beauty within the subject and not in the object (Lavie & Tractinsky,
Two widely accepted measurement methods from this approach are the classical and expressive aesthetic scales (Lavie & Tractinsky, 2004) and the visual aesthetics of websites inventory (VisAWI; Moshagen & Thielsch, 2010).

Lavie and Tractinsky (2004) found two dimensions of perceived website aesthetics, termed “classical aesthetics” and “expressive aesthetics”. The authors conducted multiple studies where participants evaluated websites on different adjectives. Adjectives such as clear, organized and pleasant showed high loading in exploratory factor analysis for the classical dimension. Adjectives such creative, colorful, original are linked to the expressive aesthetics dimension and show the designers’ creativity and originality and to the ability to break design conventions.

Moshagen and Thielsch (2010) developed a new measure covering broader aspects of perceived interface aesthetics. Their instrument has 18 items and captures four different facets of the user’s subjective visual aesthetic perception. The facet “simplicity” is strongly correlated to the “classical aesthetics” and the facet “diversity” is strongly correlated to the dimension “expressive aesthetics” from Lavie and Tractinsky (2004). Beside these, Moshagen and Thielsch (2010) postulate “colorfulness” and “craftsmanship” as new, discrete facets. “Colorfulness” comprises items related to the evaluation of individual colors and their composition and “Craftsmanship” reflects whether the site has a harmonious design and uses modern technologies (Moshagen & Thielsch, 2010).

**2.2 Linking objective web-design factors to facets of subjective aesthetic perception**

Although there is a considerable amount of research into objective design factors and subjective facets, there are only a few studies combining these approaches (see table 1 for an overview). On one hand, many studies only investigated a single design factor. Michailidou et al. (2008) found a negative correlation between visual complexity and classical and expressive aesthetics. Tuch, Bargas-Avila, and Opwis (2010) could show in an experimental study that the perception of classical and expressive aesthetics is also affected by vertical symmetry. Coursaris, Swierenga and Watrall (2008) as well as Cai and Xu (2011), furthermore, focused on how color factors influence subjective aesthetic perception. Both studies found an effect of color on expressive aesthetics. However, Coursaris et al. (2008) could not find an effect on classical aesthetics. On the other hand, there are authors who investigated multiple objective design factors but used only one subjective aesthetic measure such as a single-item scale or a general aesthetic score (e.g., Purchase et al. 2012; Reinecke et al. 2013; Reinecke & Gajos, 2014; Wu et al. 2011).

Altaboli and Lin (2011b) made a first attempt by systematically investigating the effect of multiple different objective web-design factors (balance, unity and sequence) on facets of subjective aesthetic perception. They were able to show that the objective factors affected users’ perception of classical and expressive aesthetics as well as the four facets of the VisAWI in different ways. The validity of these
### Table 1
Summary of publications combining objective design factors with subjective aesthetic facets

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Objective Factor(s)</th>
<th>Subjective Facet(s)</th>
<th>N*</th>
<th>Main results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Website Color Research</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Couris et al. (2008)</td>
<td>Experimental</td>
<td>Cool vs. warm colors for primary (e.g., navigation) and secondary elements (e.g., image borders)</td>
<td>CA &amp; EA</td>
<td>Np = 328; Nw = 4</td>
<td>-Color temperature affected EA, but not CA.</td>
</tr>
<tr>
<td>Mos-hagen (2010) Study, 6</td>
<td>Experimental</td>
<td>Combination of colors (either aesthetically pleasing or distorted)</td>
<td>VisAWI</td>
<td>Np = 87; Nw = 1</td>
<td>-Effect of color on colorfulness, -No effect on other facets of the VisAWI</td>
</tr>
<tr>
<td>Cai et al. (2011)</td>
<td>Experimental</td>
<td>Color (background, table border, and font) e.g. white vs. grey</td>
<td>EA</td>
<td>Np = 44; Nw = 4</td>
<td>-Effect of color on expressive aesthetics</td>
</tr>
<tr>
<td><strong>Website Structure Research</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Michailidou et al. (2008)</td>
<td>Correlational</td>
<td>Complexity (totally 5 items)</td>
<td>CA &amp; EA</td>
<td>Np = 55; Nw = 30</td>
<td>-Negative correlation between visual complexity and items from both, classical and expressive aesthetics: clean, organized, clear and beautiful. -Clearness has the strongest relation with visual complexity.</td>
</tr>
<tr>
<td>Tuch, et al. (2010)</td>
<td>Experimental</td>
<td>Vertical symmetry</td>
<td>CA &amp; EA</td>
<td>Np = 60; Nw = 40</td>
<td>-Vertical symmetry has an impact on classical and expressive aesthetics</td>
</tr>
<tr>
<td>Altaboli &amp; Lin (2011a)</td>
<td>Correlational</td>
<td>Symmetry; balance; unity; sequence; simplicity; density; economy; rhythm; No of objects; No of different sizes of objects; JPEG file size; No of different font types; No of images</td>
<td>CA &amp; EA VisAWI</td>
<td>Np = 512; Nw = 42</td>
<td>-Positive correlation between classical aesthetics and unity, simplicity, economy -No sign. correlation between expressive aesthetics and any of the objective measures -Positive correlation between the simplicity facet and unity, simplicity, economy, No. of objects and No. of different sizes of objects -Positive correlation between the diversity facet and economy, No. of different sizes of objects and No. of different font types -No sign. correlation between colorfulness facet and any of the objective measures -Positive sign. correlation between the craftsmanship facet and unity, simplicity, economy, No. of objects and No. of different sizes of objects</td>
</tr>
<tr>
<td>Altaboli &amp; Lin (2011b)</td>
<td>Correlational</td>
<td>Balance; unity; sequence</td>
<td>CA &amp; EA VisAWI</td>
<td>Np = 512; Nw = 42</td>
<td>-Only unity highly correlates with the questionnaire measures. -No significant correlations were found between balance and sequences and the questionnaire measures.</td>
</tr>
<tr>
<td>Möttus et al. (2013)</td>
<td>Correlational</td>
<td>Balance; rhythm equilibrium; symmetry; sequence cohesion; unity; proportion; simplicity; density; regularity; economy; harmony</td>
<td>CA &amp; EA VisAWI</td>
<td>Np = 41; Nw = 8</td>
<td>-No significant correlations for any of the factors with classical and expressive aesthetics or VisAWI facets</td>
</tr>
</tbody>
</table>

*Note. CA = classical aesthetic ; EA = expressive aesthetics ; VisAWI = Visual Aesthetics of Website Inventory; Np = N participants; Nw = N websites*
findings, however, is somewhat unclear because the study had only a correlational design. In a further study, the same authors assessed eight different objective screen-based measurements (e.g., symmetry, balance, rhythm) and correlated them to the same subjective measurements as in their previous study (Altaboli & Lin, 2011a). Again, they were able to show significant correlations between many of the objective screen-based measures and subjective questionnaire-based measures. For instance, they found a positive correlation between the objective measures of unity, simplicity and economy and the simplicity facet, between number of different fonts as well as number of different sizes of objects and the diversity facet as well as between unity, simplicity and economy and the craftsmanship facet. These findings nicely illustrate how specific objective design factors map onto different facets of users’ subjective aesthetic perception. Nevertheless, this is only a first step in understanding the inter-relationship between objective and subjective aesthetic measurements. The authors themselves acknowledged that there are further objective factors, such as color (e.g., Reinecke, 2013), that need to be investigated and that there is a need for experimental studies that back-up the findings from the correlational studies.

In a more recent study by Mõttus et al. (2013), however, the findings of Altaboli and Lin (2011a, 2011b) could not be affirmed. Mõttus et al. (2013) evaluated eight websites of different art museums with the same objective (plus five more) and subjective measurements as in Altaboli and Lin (2011b) and could not find any significant correlations. To sum up, although highly relevant for web design, there has been little effort in systematically combining the two approaches. Moreover, previous research lacks experimental studies and results from different authors are not consistent.

### 2.3. Objective screen-design factors

Two apparent objective factors that contribute to the visual aesthetic impression of an interface are its structure and color. Both have been repeatedly found to be significant predictors for users’ aesthetic perception of websites (e.g., Bi, Fan, & Liu, 2011; Cyr, Head, & Larios, 2010). In the following, we will briefly review previous studies on two well-established structural design factors (i.e., vertical symmetry and visual complexity) and three color-related design factors (i.e., hue, saturation, and brightness). We chose to focus on these factors because there are numerous studies in the field of psychology (and to a lesser extent in the field of HCI) that show their relevance in the context of aesthetic perception.

#### 2.3.1 Structural factors

Two of the most salient design factors at first sight are complexity and symmetry (Leder, Belke, Oeberst, & Augustin, 2004). There are also several studies that report the influence of these factors on website perception (e.g., Bauerly & Liu, 2008; Bi et al., 2011; Lai, Chen, Shih, Liu, & Hong, 2010; Michailidou et al., 2008; Nadkarni & Gupta, 2007). In the following, we introduce these two structural factors:
The role of symmetry for visual aesthetics has long been recognized by the Gestalt theory of perceptual organization (Arneheim, 1974, Koffka, 1935). There are several empirical studies from classical experimental psychology stating the positive influence of symmetry on perceived attractiveness of human faces (e.g., Zaidel, Aarde, & Baig, 2005), on plants, and on animals as well as on cultural artefacts (O’Mara & Owens, 1996). In the realm of biological beauty, symmetry is associated with stable development and health (Leder, 2013). There are also several studies from the field of HCI that report the influence of symmetry on website perception (e.g., Bauerly & Liu, 2008; Bi et al., 2011; Lai et al., 2010; Ngo & Byrne, 2001; Tuch et al., 2010; Wilson & Chatterjee, 2005). According to Bauerly and Liu (2008) symmetry helps to establish a regular structure and meaningful form on the interface and thus allow the viewer to better structure the content.

Similar to symmetry, visual complexity is a topic of major interest in aesthetic research. It can be dated back to the work from Birkhoff (1933) and Eysenck (1941) who suggested that aesthetics of an object depends on the two factors “simplicity” and “complexity”. Although the term “complexity” has proven to be difficult to define, there are many attempts in the existing literature as observed by Xing and Manning (2005). Berlyne defined complexity as “the amount of variety or diversity in a stimulus pattern” (Berlyne, 1960, p. 38). Several other authors defined visual complexity by the perceptual dimensions of quantity of objects, clutter, openness, symmetry, organization, and variety of colors (Michailidou, Harper, & Bechhofer, 2008; Nadkarni & Gupta, 2007; Oliva, Mack, Shrestha, & Peeper, 2004). Many studies from HCI found a negative linear correlation between visual complexity and aesthetic perception; high visual complexity is perceived as less aesthetic than low visual complexity (e.g., Michailidou et al., 2008; Pandir & Knight, 2006; Tuch, Presslaber, Stöcklin, Opwis, & Bargas-Avila, 2012).

2.3.2 Color

Beside the two structural factors symmetry and complexity, color has been repeatedly found to be the most noticeable design characteristics at first sight (Cyr, Head, & Larios, 2010; Reinecke et al., 2013). The Hue-Saturation-Brightness (HSB) model is a common method of color entry for computer-based applications (Fortmann-Roe, 2011) and contains three main properties (Martin, Carlson, & Buskist, 2007): (1) hue, the pure spectral color such as blue, red and yellow, (2) saturation, the intensity of a color, and (3) brightness, the visually perceived luminance of a color. Colors and their composition have been repeatedly found to influence the aesthetic appraisal in general (Arneheim, 1974; Kawabata & Zeki, 2004; Moon & Spencer, 1944; Schloss & Palmer, 2011) and with respect to the design of websites in particular (Cyr et al., 2010; Hall & Hanna, 2004; Papachristos, Tselios, & Avouris, 2005). However, there is relatively little research regarding color in online, Internet-based environments (Cyr et al., 2010; Pelet & Papadopoulou, 2010). In the follow we will briefly review previous research on the role of hue, saturation, and brightness in aesthetic perception:
Most studies investigating color preference for single colors focused on the colors’ hue (Ou, Luo, Woodcock, & Wright, 2004). In general, studies found that blue hues were most favorable, whereas yellow and yellow-green hues were least favorable (e.g., Fortmann-Roe, 2011; Ou et al., 2004; Palmer & Schloss, 2013). In the web environment, the findings are comparable. Cyr et al. (2010) could show that there is a global tendency to dislike yellow colored websites, while blue and grey sites were liked the best. Nevertheless, Valdez and Mehrabian (1994) noted that much of the research on color and affect is limited on several grounds due to (1) insufficient controls of color stimuli (e.g., absence of controls for saturation and brightness while investigating effects of hue) and use of nonstandard or unspecified lighting conditions and (2) insufficient reliable, valid or comprehensive measures of emotional responses to color stimuli.

Only a few studies investigated saturation independently from hue and brightness. Palmer and Schloss (2010) concluded that Western adults generally prefer colors of higher saturation to those of lower saturation for context-free patches of color. Lindgaard, Dudek, Sen, Sumegi and Noonan (2011) conducted a study with 50 real websites and found the highest aesthetic ratings for homepages with a quite bright background. Also, in a controlled laboratory setting and using image sets consisting of colored rectangles as stimuli, Camgöz, Yener, and Güvenc (2002) showed that colors having maximum saturation were most preferred. However, Fortmann-Roe (2011) analyzed over 600,000 Twitter accounts to find color preferences. They did not find that brighter and more saturated colors were preferable. The mean saturation and brightness in their study hovered around 50%. The authors concluded that this difference illustrates the difference between laboratory experiments where subjects might be attracted to powerful stimuli and real-world color choices where intense colors can be overbearing or distracting.

Like saturation, brightness is not well investigated in relation to aesthetics. In a laboratory study with \( N = 46 \) experienced Internet users, Papachristos et al. (2005) presented eight different color schemes of a website. Results of their research suggest that the design attribute with the strongest effect on the Website’s attractiveness is the brightness of the dominant color. Hue, a color’s saturation, number of colors and contrasts between hues were less important. Palmer and Schloss (2010) conducted a study with different color sets consisting of colored rectangles and found a preference for higher brightness. The study from Lindgaard et al. (2011) could further support this finding; their results showed that websites with a high brightness in the background were rated as most appealing.

### 2.3.3 Other objective design factors

Besides those reviewed above, there are further objective design factors documented in the literature (for an overview see Moshagen & Thielsch, 2010). For instance, Ngo and Byrne (2001) investigated the effects of objective structural design factors such as homogeneity, order, balance, and simplicity. In the
present study we decided to focus on visual complexity and symmetry for the following reasons: (1) Based on a review of the literature we think that visual complexity and symmetry are well-established design factors, which can be clearly defined. (2) Other objective factors such as balance, sequence, cohesion, regularity, and homogeneity are very similar to symmetry and not clearly distinguishable from the concept of symmetry; for instance, low balance implies low symmetry (Wilson & Chatterjee, 2005). Similarly, visual complexity is basically the same concept as simplicity as defined in Ngo and Byrne (2001). (3) The operationalization of many of the objective structural design factors are not precisely defined as interfaces can have wide range of complex layouts such as text areas with unclear borders and animations (Mõttus et al., 2013).

2.4. Facets of subjective aesthetic perception

The subjective questionnaire-based approach provides operational definitions of facets or dimensions of perceived visual aesthetics of websites. As mentioned earlier, two widely accepted measurement methods for this approach are the questionnaires from Lavie and Tractinsky (2004) and Moshagen and Thielsch (2010). For the present study we decided to use the latter as it measures visual aesthetics in more detailed manner and is more sensitive to color-related design aspects of aesthetic perception. The VisAWI captures four different facets of users’ aesthetic perception (i.e., simplicity, diversity, colorfulness, and craftsmanship), whereas the questionnaire by Lavie and Tractinsky (2004) only measures two dimensions (classical and expressive aesthetics). Previous studies have shown that the facet simplicity is highly correlated with classical aesthetics and that the facet diversity is highly correlated with expressive aesthetics (Altaboli & Lin, 2011a; Moshagen & Thielsch, 2010). Moreover, the VisAWI has the facet colorfulness, which captures color-related aspects of the users’ aesthetic impression of a website. In contrast, neither the classical nor expressive aesthetics contains a single color-related single item. In the following we expand on the four facets of the VisAWI:

Simplicity has already been recognized as a central factor in early approaches to aesthetic perception (Birkhoff, 1933; Winckelmann, 1759). It has been identified as one of the major design factors influencing perceived visual aesthetics (e.g., Choi & Lee, 2012). The simplicity facet as conceptualized in the VisAWI (Moshagen & Thielsch, 2010) relates to the Gestalt psychologists’ figural goodness concept (Arnheim, 1974; Pomerantz & Kubovy, 1986) and includes aspects that facilitate perception and the processing of a layout, such as clarity, homogeneity and orderliness (Moshagen & Thielsch, 2010).

Diversity reflects aspects related to dynamics, variety, visual richness, creativity, interest, and novelty (Moshagen & Thielsch, 2013) and is therefore closely related to visual complexity (Hekkert, Snelders, & van Wieringen, 2003; Moshagen & Thielsch, 2010).

Colorfulness comprises items related to the evaluation of individual colors and their composition, as well as their selection, placement, and combination (Moshagen & Thielsch, 2010). There is wide
agreement that colorfulness is one of the most noticeable design characteristics at first sight in HCI (Cyr et al., 2010; Zheng, Chakraborty, Lin, & Rauschenberger, 2009). 

Craftsmanship relates to the skillful and coherent integration of all relevant design dimensions and therefore reflects whether the site has a harmonious design and uses modern technologies (Moshagen & Thielsch, 2010).

The four facets of the VisAWI are interrelated and jointly reflect the overall subjective aesthetic perception (called general factor in study from Moshagen & Thielsch, 2010). Moshagen and Thielsch (2010) were able to show that each facet is of similar importance for the overall subjective aesthetic perception.

2.5. Aim of the study and hypotheses

The present study aims to investigate how objective screen-design factors impact users’ subjective visual aesthetic perception of websites (see figure 1). Based on previous findings, we expected that all objective factors will have a significant effect on the overall subjective aesthetic of the VisAWI (e.g., Leder et al., 2004; Reinecke et al., 2013). Furthermore, we expect that the three objective color factors (hue, saturation, brightness) will only have a significant effect on colorfulness, whereas the two objective structural factors (vertical symmetry, visual complexity) will have a significant effect on one or more other facets of the VisAWI (Moshagen & Thielsch, 2010). Regarding the subjective aesthetic preferences for each objective factor, it is expected that websites with a high symmetry, low complexity, blue hue, high saturation and high brightness will be perceived as most beautiful (e.g., Bauerly & Liu, 2008; Palmer & Schloss, 2010; Tuch et al., 2012).

![Figure 1. How do objective design factors influence the differences facets of subjective aesthetic perception?](image-url)
Method

3.1 Experimental design
In order to study the effects of objective design factors on the facets of subjective aesthetic perception, five online experiments were conducted, each with a within-subject design. The independent variables were symmetry (symmetric vs. asymmetric), complexity (high vs. low), hue (red = 0; yellow = 60; green = 150; blue = 210; violet = 300 on the HSB scale), saturation (low = 10% vs. medium = 40% vs. high = 70%), and brightness (low = 60% vs. medium = 79% vs. high = 98%). For reasons of practicality, design factors were manipulated independently of each other. Therefore possible interactions between the design factors are not taken into account. As dependent variables, the subscales (facets) of the VisAWI (Moshagen & Thielsch, 2010) were used.

3.2 Participants
Participants were recruited through the University of Basel’s recruiting database, containing the data of people interested in attending studies. Two Apple TVs were raffled among all participants as an incentive. The participants were contacted by e-mail containing a link to one of the five experiments. A total of 337 participants started the experiments (52-95 per experiment), of which 120 aborted the study (17-38 per experiment). Most of these participants dropped out after the first (introduction) or the second page (demography). This leads to a drop-out rate of 35.6% (28.8% - 40.4% per experiment). A total of N = 194 participants (32-54 per experiment) were included in the analysis (37.8% male, 61.0% female, 1.2% did not indicate their gender). The total mean age was 29.3 years (SD per experiment = 7.7 - 11.8; total range: 17 - 71). The average self-rated web design experience on a scale of 1 to 7 (1 = no experience; 6 = expert) was 2.5 (SD per experiment = 1.3 - 1.5). Participants with color impairment and missing data were excluded from the analysis. See table 2 for values per experiment.

3.3 Manipulation of objective screen-based design factors
Because websites are very heterogeneous stimuli, we decided to focus on a specific category of websites to select our stimuli. For their study on mental models, Roth, Schmutz, Pauwels, Bargas-Avila and Opwis (2010) extracted six different categories of websites from the 100 most visited websites of the USA, Germany, Austria and Switzerland: (1) company websites, (2) social networking sites, (3) online newspapers and news portals, (4) online shops, (5) search engines, and (6) various types. The category company websites was identified as being the largest one and their results showed that users have a consistent mental model of these sites. Therefore, we decided to only include company websites by applying the following exclusion criteria: (1) a contentless intro page, (2) a shopping basket, (3) advertisement (banners), (4) an archive or (5) a content language other than English or German. These exclusion criteria were already applied by Tuch et al. (2012) and are based on the findings of Roth et al.
(2010), who showed which website-elements are typical for company sites. Moreover, we only included websites that were unlikely to be familiar to our participants to reduce branding effects. We took screenshots of existing websites from the World Wide Web and manipulated them according to our objective design factors. We used real websites to ensure a high ecological validity of the experiment. The websites were manipulated with Photoshop CS 3 according to the levels of each objective design factor. In total we manipulated 48 websites (10 for complexity, 10 for symmetry, 10 for hue, 9 for brightness and 9 for saturation), resulting in 144 manipulated versions of the initial screenshots (20 for complexity, 20 for symmetry, 50 for hue, 27 for brightness, and 27 for saturation). The screenshots were then validated by means of several online studies with a total $N = 280$ participants. Based on the results of these studies, we selected the stimuli for our five main studies: five sets of website screenshots for each design factor. Each set consisted of several manipulated versions of the same website according to the different levels of the factors. All websites had the same size (490 x 368 pixels) in order that two websites could be placed on one screen with common screen size and without scrolling being necessary so that participants could directly compare the different design versions.

3.3.1 Manipulation of symmetry: We looked for websites with a low symmetry and manipulated the sites to achieve a higher symmetry by centering the layout and by adding the same background color to the right side as was on the left. This procedure should further ensure high ecological validity, because for a designer it is more difficult to enhance the beauty of a site by adding symmetry than to downgrade a good design. This process should further ensure high ecological validity, as it would be easier to downgrade a good design. The symmetry was calculated by a pixel-to-pixel comparison along the vertical axis in the middle of the screen (see table 3 in the appendix for details). There are authors from the image processing research area (Koostra, de Boer, & Schomaker, 2011; Loy & Eklundh, 2006) who proposed more complex methods of symmetry estimation; however, we decide to use a method that can

Figure 2. Example of a symmetry set. Copy of the original Schuh™ website (right) and the more symmetrical version (left).
be easily applied by any web designer. On average, high symmetric websites were 61% symmetric; whereas low symmetric websites were 48% symmetric (100% would be perfect symmetry). In total there were five different sets of websites, each set consisting of a high and a low symmetric version of the website (see Figure 2 for an example).

3.3.2 Manipulation of visual complexity: We looked for websites with a high complexity and manipulated the sites to reduce the complexity. Again, this process should further ensure high ecological validity, as it would be easier to downgrade a good design (e.g., to clutter a website). More complex websites contained more text and navigation links. Forsythe, Nadal, Sheehy, Cela-Conde, and Sawey (2011) and Riglis (1998) found evidence that the technical compression rate is an appropriate measure of a stimulus complexity. The size of a gif or a jpg file obtained after compression is strongly correlated to the subjective perception of complexity and so that a larger file size may be considered more complex. Our websites of high complexity had an average file size of 521 KB, whereas site of low complexity 434 KB (see table 4 in the appendix for details). Figure 3 shows an example set of a high and low complexity stimulus.

Figure 3. Example of a complexity set. Copy of the original SNL Financial™ website (right) and the less complex version (left).

3.3.3 Manipulation of hue: We manipulated the stimuli by adapting the hue of the colored elements of the websites. Based on the HSB color model we used the following hue values: red = 0; yellow = 60; green = 150; blue = 210; violet = 300. Figure 4 shows an example of a manipulated set.
3.3.4 Manipulation of saturation: We manipulated the websites to achieve the following average saturation values per screenshot: low = 10% vs. medium = 40% vs. high = 70% on the HSB scale (see Figure 5).

3.3.5 Manipulation of brightness: Similarly to the manipulation of saturation we adjusted the average brightness level of the websites to following values: low = 60% vs. medium = 79% vs. high = 98% on the HSB scale. See Figure 6 for an example set.
3.4 Measuring facets of subjective aesthetic perception

To measure facets of subjective visual aesthetic perception, we applied a short version of the Visual Aesthetics of Website Inventory (VisAWI) by Moshagen and Thielsch (2010). The VisAWI is a valid questionnaire that allows for a precise and reliable assessment of perceived visual aesthetics of websites. It distinguishes between four interrelated facets: simplicity, diversity, colorfulness and craftsmanship. These facets jointly describe perceived visual aesthetics, but are still distinguishable from each other. The overall subjective aesthetic perception was determined by computing the total score of all items of the VisAWI. Participants were asked to indicate their level of agreement to each item on a 7-point Likert scale ranging from 1 (“strongly disagree”) to 7 (“strongly agree”). High ratings show positive values, for example, a high rating on the diversity facet does not necessarily imply that the design of the website is exceedingly dynamic or creative, but merely that the realized degree of diversity is positively valued by a given perceiver (Moshagen & Thielsch, 2010).

3.5 Procedure

For each objective design factor we conducted a separate online study with the survey tool Unipark EFS survey (Version 8.1). The basic procedure was the same for all five studies: Starting from an introduction page, participants first answered some demographic questions. Then they were presented with the different versions of the website screenshots and were ask to rate them on the VisAWI facets.

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1 We did not use the full questionnaire as the experiment would have taken too long. The authors sent us their shorter version with nine items (see table 5 in the appendix for list of items). This list was an interim version and is five items longer than the one published later in Moshagen and Thielsch (2013).
Before evaluating each screenshot of a set separately, the participants were presented with an overview, where they could see the different design variations (see Figure 7). We used this overview that participants learn about the small differences between the designs and that they do not think that they see the same design again and again. This procedure was repeated for all sets. The presentation order of all the sets as well as the order of the screenshots within each set was randomized. On average, each study lasted for five to ten minutes.

![Set overview ➔ VisAWI ratings for each website](image)

Figure 7. Study procedure.

### 3.6 Data preparation

#### 3.6.1 Reliability of the VisAWI

In general, the internal consistency of the VisAWI was high. The Cronbach’s alpha estimates for the subscales were good (M = .82, SD = .07), with a range from = .70 (acceptable) to .92 (excellent); only the craftsmanship facet of the complexity condition is questionable (M = .68) (Kline, 1999). Overall, the reliability of the nine-item scale that we used is comparable to the findings reported by the authors of the VisAWI with a Cronbach’s alpha lying between the full VisAWI (Moshagen & Thielsch, 2010) and the shorter VisAWI-S (Moshagen & Thielsch, 2013).

#### 3.6.2 Inter-subject agreement

In order to estimate the inter-rater agreement of the subjective facets on the objective factors, we calculated the interclass correlation (ICC) for each objective factor separately. The average ICC coefficient was remarkably high for visual complexity (ICC=.88; SD=.05), vertical symmetry (ICC=.86; SD=.04) and hue (ICC=.86; SD=.04), and of medium size for the other two color factors, saturation (ICC=.74; SD=.10) and brightness (ICC=.68; SD=.13), suggesting a medium to high agreement between the participants.

#### 3.6.3 Data aggregation

In order to analyze the effects of objective factors on the subjective facets, we aggregated the ratings of the individual screenshots so that we had one value per facet, condition and participant. Before aggregating the ratings, we checked whether the design factors affected the users’ ratings in a similar way
across the different websites. To do so, we conducted for each VisAWI facet an ANOVA with objective
design factors as within-subject factor and the different websites as between-subject factor. A disordinal
interaction between websites and design factor suggests that aggregating across the websites might be
problematic for statements regarding the subjective aesthetic preferences for each objective factor.
There were no significant disordinal interactions for symmetry, complexity and brightness, which means
that design factors had similar effects across all websites. Therefore aggregating across the websites is
unproblematic. Disordinal interactions were found for hue and saturation (see table 6 in the appendix).
Certain conditions for hue and saturation affected the users’ ratings in a different way across the
different websites. We therefore calculated contrasts to test trends (see table 7 in the appendix) and we
will give a description of these results in the results section.

For the subsequent analyses (i.e., testing whether objective screen-design factors have an impact on the
subjective visual aesthetic perception of websites), we aggregated the ratings in each experimental
condition to account for degrees of freedom inflation. Such an inflation would give the illusion of
having a more powerful test than the data support and boosts the rejection of a potentially true null
hypothesis (type I error) (see Picquelle & Mier, 2011).

RESULTS
We begin this section by (1) presenting an overview of the descriptive data for all objective factors. In
the second part of this section, (2) we focus on the effects on overall subjective aesthetic perception. In
the next part (3), we provide a detailed analysis for the two structural factors vertical symmetry and
visual complexity followed by (4) a detailed analysis for the three color factors hue, saturation and
brightness.

4.1 Overview
Descriptive data for the four VisAWI facets and for the overall subjective aesthetic perception for each
of the five objective factors can be found in table 8. In the following, we used repeated measure
ANOVAs to analyze the effect of the objective design factors on the subjective facets. For all statistical
tests an alpha level of .05 was used. Furthermore, all data were checked to ensure that they met the
required conditions for the statistical tests. We corrected the degrees of freedom according the more
conservative Greenhouse Geisser when appropriate.
Table 8
Mean and standard deviation of the VisAWI facets

<table>
<thead>
<tr>
<th>VisAWI facets M (SD)</th>
<th>Overall subjective aesthetic perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity</td>
<td>Diversity</td>
</tr>
<tr>
<td>Structural factors</td>
<td></td>
</tr>
<tr>
<td><strong>Symmetry</strong> (n = 33)</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>4.5 (1.1)</td>
</tr>
<tr>
<td>low</td>
<td>4.0 (1.0)</td>
</tr>
<tr>
<td><strong>Complexity</strong> (n = 54)</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>3.9 (1.0)</td>
</tr>
<tr>
<td>low</td>
<td>4.7 (1.0)</td>
</tr>
<tr>
<td>Color factors</td>
<td></td>
</tr>
<tr>
<td><strong>Hue</strong> (n = 41)</td>
<td></td>
</tr>
<tr>
<td>red</td>
<td>4.8 (0.9)</td>
</tr>
<tr>
<td>yellow</td>
<td>4.7 (0.9)</td>
</tr>
<tr>
<td>green</td>
<td>4.7 (1.0)</td>
</tr>
<tr>
<td>blue</td>
<td>5.0 (0.9)</td>
</tr>
<tr>
<td>violet</td>
<td>4.6 (0.9)</td>
</tr>
<tr>
<td><strong>Saturation</strong> (n = 34)</td>
<td></td>
</tr>
<tr>
<td>low</td>
<td>4.3 (0.8)</td>
</tr>
<tr>
<td>medium</td>
<td>4.4 (0.8)</td>
</tr>
<tr>
<td>high</td>
<td>4.5 (0.9)</td>
</tr>
<tr>
<td><strong>Brightness</strong> (n = 32)</td>
<td></td>
</tr>
<tr>
<td>low</td>
<td>4.5 (0.9)</td>
</tr>
<tr>
<td>medium</td>
<td>4.6 (0.9)</td>
</tr>
<tr>
<td>high</td>
<td>4.4 (1.0)</td>
</tr>
</tbody>
</table>

Note. All values were aggregated over the five websites. Min = 1; Max = 7.

4.2 Effects on overall subjective aesthetic perception

As expected, results show that all objective design factors had a significant effect on overall subjective aesthetic perception. The two structural factors symmetry and complexity had the largest effect (symmetry: $F(1, 32) = 19.20, p < .001, n^2 = .38$; complexity: $F(1, 53) = 25.36, p < .001, n^2 = .32$). In contrast, the three color factors (hue, saturation and brightness) showed comparatively less pronounced effects that were still of medium or large effect size (hue: $F(4, 160) = 8.73, p < .001, n^2 = .11$; saturation: $F(1.36, 44.81) = 3.93, p < .021, n^2 = .11$; brightness: $F(1.58, 49.05) = 3.55, p = .023, n^2 = .10$).

4.3 Detailed analysis for structural factors

Our results show that different objective design factors correspond with different facets of visual aesthetics (see table 9). In the following, we present a detailed analysis of structural and color factors and their effects on different facets.
Table 9
Overview of the explained variance in the facets of the VisAWI (Moshagen & Thielsch, 2010) by the objective design factors

<table>
<thead>
<tr>
<th>Objective Factors</th>
<th>Simplicity</th>
<th>Diversity</th>
<th>Colorfulness</th>
<th>Craftsmanship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symmetry</td>
<td>.30**</td>
<td>.28**</td>
<td>.09</td>
<td>.28**</td>
</tr>
<tr>
<td>Complexity</td>
<td>.48**</td>
<td>.19**</td>
<td>.25**</td>
<td>.17*</td>
</tr>
<tr>
<td>Color</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hue</td>
<td>.10*</td>
<td>.01</td>
<td>.21**</td>
<td>.12*</td>
</tr>
<tr>
<td>Saturation</td>
<td>.05</td>
<td>.07</td>
<td>.17*</td>
<td>.02</td>
</tr>
<tr>
<td>Brightness</td>
<td>.11*</td>
<td>.06</td>
<td>.11*</td>
<td>.02</td>
</tr>
</tbody>
</table>

Note. Values represent effect sizes from the ANOVAs ($n^2$). Effect sizes are independent of each other as they stem from different studies. ** $p < .001$, * $p < .05$.

4.3.1 Vertical Symmetry

Vertical symmetry had an effect on three of the four facets of the VisAWI. The largest effect was found for the simplicity facet ($F(1, 32) = 13.40, p < .001, n^2 = .30$). Moreover, craftsmanship ($F(1, 32) = 12.29, p < .001, n^2 = .28$) and diversity ($F(1, 32) = 12.57, p < .001, n^2 = .28$) also showed a large effect that is only slightly lower than of the simplicity facet. Colorfulness was not influenced by the symmetry factor, ($F(1, 32) = 3.04, p = .091, n^2 = .09$). For all three facets, symmetric websites were preferred over asymmetric ones (see Figure 8 for simplicity as an example).

![Figure 8. Simplicity ratings for websites of low and high vertical symmetry.](image-url)
4.3.2 Visual Complexity

Visual complexity had a significant influence on all aesthetic facets, generally showing that less complex websites were perceived as being more appealing than websites of greater complexity. The largest effect was found for the simplicity facet ($F(1, 53) = 49.80, p < .001, n^2 = .48$). There was also an effect of complexity on the colorfulness facet ($F(1, 53) = 17.36, p < .001, n^2 = .25$) and on the diversity facet, $F(1, 53) = 12.05, p < .001, n^2 = .19$. The lowest but still large effect showed the craftsmanship facet, $F(1, 53) = 10.48, p < .05, n^2 = .17$. Descriptive data revealed, as expected, that the less complex websites were all rated better than the more complex websites (see Figure 9 for simplicity as an example).

![Figure 9. Simplicity ratings for websites of low and high visual complexity.](image)

4.4 Detailed analysis for color factors

4.4.1 Hue

As expected, the hue of a website had a strong influence on the colorfulness facet, $F(4, 160) = 10.82, p < .001, n^2 = .21$. Unexpectedly, hue also affected the perception of craftsmanship ($F(3.08, 123.03) = 5.26, p < .05, n^2 = .12$) and simplicity ($F(4, 160) = 4.56, p < .05, n^2 = .10$). No significant effect was found for the diversity facet, $F(4, 160) = 0.61, p = .330, n^2 = .01$.

It appears that users in general favored the blue versions of the websites over the other colored versions. The violet colored versions usually received the lowest ratings. The results for the remaining colors (i.e., green, yellow and red) seem less clear. More detailed analyses at the level of the individual websites (instead of aggregating the ratings per condition first) that included website as a factor into the ANOVA illustrate the complexity of the results. There were significant website x hue interactions for colorfulness and simplicity, meaning that color preference varies from website to website. As depicted in Figure 10 the blue versions of the websites were mostly evaluated best and the violet versions worst but no clear pattern emerged for the red, yellow and green versions.
4.4.2 Saturation

The only facet influenced by saturation was colorfulness, $F(2, 66) = 6.82, p < .05, \eta^2 = .17$. No significant main effects were found for the simplicity facet $F(1.52, 50.14) = 1.77, p = .187, \eta^2 = .05$, the diversity facet $F(1.47, 48.35) = 2.47, p = .055, \eta^2 = .07$, and the craftsmanship facet $F(1.42, 46.88) = 0.51, p = .540, \eta^2 = .02$.

Descriptive data show that low saturated websites were rated the lowest, whereas highly saturated websites received the highest ratings. However, this pattern was not observed within all website sets; significant saturation*website interactions were found for colorfulness (see table 6 in the appendix). As depicted in Figure 11 the low saturated websites were rated significantly lower than the medium and high saturated websites. However, there is no significant difference between the medium and the high saturated sites (see table 7 in the appendix).

Figure 10. Colorfulness ratings for all websites and different hues.

Figure 11. Colorfulness ratings for all websites and different saturation conditions.
4.4.3 Brightness

Brightness had a significant effect on the colorfulness facet, $F(2, 62) = 3.95, p < .05, n^2 = .11$, and on the simplicity facet $F(1.55, 48.04) = 3.90, p < .05, n^2 = .11$. No significant effects were found for diversity, $F(2, 62) = 1.82, p = .086, n^2 = .06$, and craftsmanship, $F(2, 62) = 0.59, p = .560, n^2 = .02$.

Websites with a medium level of brightness were evaluated best followed by websites with a low level (see Figure 12 for the colorfulness facet as an example). Website with a high brightness received the lowest ratings. Post-hoc tests with Bonferroni correction showed that there was only a significant difference between the medium and the high brightness level (colorfulness: $p = .020$; simplicity: $p = .035$).

![Figure 12. Colorfulness ratings for all websites and different brightness conditions.](image)

DISCUSSION

First, our results show that the all investigated objective screen design factors affected subjective visual aesthetics. Second, we show that each of our objective design factors affected the users’ subjective aesthetic perception differently. Each factor stimulated a different pattern of the visual aesthetics facets.

In sum, our study suggests that objective layout-based measures can be used to assess generally the overall visual aesthetics of websites and particularly the aesthetic aspects related to the VisAWI facets of website aesthetics. Altogether, structural factors (e.g., visual complexity) had a greater impact on overall aesthetic perception than color factors (e.g., hue). Our results show that only complexity influenced each facet of visual aesthetics. Symmetry, however, had the largest effect on the overall subjective aesthetic perception of all factors but only had an influence on three facets. Of the color factors, hue showed an influence on three facets as well, saturation on two, and brightness on one facet.
5.1 Structural objective design factors as predictors for aesthetic judgments

As expected and in line with previous research, visual complexity and vertical symmetry (Bauerly & Liu, 2008; Michailidou et al., 2008), are strong predictors for aesthetic judgments in general. Particularly noticeable was the large effect of visual complexity on simplicity ($n^2 = .48$). Our findings partially contradict results from other studies. Findings from Altaboli and Lin (2011a) did not show a significant correlation between symmetry and any of the VisAWI facets. This is even more surprising because in our study, of all objective design factors, symmetry had the largest effect for the diversity and craftsmanship facets and on the overall subjective aesthetic perception. Results from Bi et al. (2011) also revealed a significant correlation between symmetry and aesthetic ratings. However, the authors could not find an effect of complexity whereas in our study complexity had a strong effect on all facets as well as on the overall subjective aesthetic perception. On a first glance it seems puzzling that complexity also influences the perception of colorfulness. However, already Nadkarni and Gupta (2007) postulated a relation between complexity and colorfulness. The more graphics and colors are used in a website, the more complex and the more colorful it becomes. This in turn affects the subjective perception of colorfulness. In the present study, the websites reduced in complexity, automatically had more blank space, which probably made them appear less colorful. As shown by Reinecke et al. (2014), Swiss prefer less colorful websites and therefore rated the colorfulness facet (attractiveness of color composition) for websites of low complexity higher. In agreement with previous research (e.g., Bauerly & Liu, 2008; Tuch et al., 2012), we found higher aesthetic ratings for websites with a high symmetry and low complexity.

5.2 Color factors as predictors for aesthetic judgments

Reinecke et al. (2013) noted that in the context of aesthetic perception of websites visual complexity is a more salient feature than color because complexity already partly accounts for the influence of colors. The authors argued that visual complexity cannot be measured by the amount of text or the number of images on the interface alone, but that other metrics, such as a largely colorful interface, are thought to additionally contribute to visual complexity. Therefore, the authors concluded that colors alone would only play a minor role in people’s first impression of appeal. In line with this finding, our results revealed that color factors had a less pronounced effect on visual aesthetics than structural factors. However, by systematically manipulating the different facets independently, our study could show that color factors were still of large or medium effect size.

Our expectation concerning the influence of color factors on the VisAWI facet was only partially supported. Moshagen and Thielsch (2010) found that the color of a website selectively affected ratings on the colorfulness facet and did not affect the remaining facets. In contrast, in our study only color saturation exclusively affected colorfulness whereas color hue also affected the simplicity and craftsmanship facets and color brightness the simplicity facet. It might be possible that websites with a
high brightness were perceived as too bright and striking making it more difficult to grasp the rest of the site, which also influenced the simplicity facet. But these additional effects were less pronounced than those on colorfulness. Moreover, an effect on diversity was not found for any of the color facets.

These results highlight the importance of manipulating hue, saturation and brightness independently as they did not show the same effects on different facets of subjective aesthetic perception. In contrast to the results from Palmer and Schloss (2013), we found violet, not yellow, to be least favorable hue. In their study, however, color was being dealt with in isolation and not applied to a context. It could be possible that the gray beige of the web browser lead to a more positive evaluation of the yellow hue than in previous studies. Another possible explanation is provided by the so-called mere exposure effect, which refers to the phenomenon in which repeated unreinforced exposure to an item increases the probability that it will be preferred over new items. According to Hupbach, Melzer and Hardt, (2006), the color of an item can also evoke a mere exposure effect. In our case, this means that more common colors on websites are preferred. While there is barely any website in the one hundred most visited websites in the US (Alexa.com, 2015) that is mainly yellow, yellow seem to be a more common website hue in Switzerland. The e-banking service “postfinance.ch”, the Swiss national postal service “post.ch” and the translation service “leo.org” are three well-known websites in Switzerland for example that are mainly yellow. Our results support Palmer and Schloss (2013) finding that blue hues were perceived as the most favorable.

In line with Lindgaard (2011), high saturated websites were perceived as more beautiful, although we found no significant difference between the medium and the high saturated sites. However, our results do not support Lindgaard et al.’s (2011) finding that participants also identify websites with a high brightness to be more beautiful. Reinecke and Gajos (2014) showed that colors can have strong cultural associations. Their results showed that a preference for different levels of colorfulness is highly influenced by a person’s country of residence. While countries like Switzerland and Germany prefer websites with a low colorfulness score, participants from, for example, the United States, prefer more colorful websites. This might explain why less bright colors were perceived as more beautiful in our study.

### 5.3 Theoretical implications

By linking the two approaches, we achieved a better understanding about how well qualified the objective design factors are for assessing users' perception of interface aesthetics. In contrast to previous research, the present study used real websites instead of artificial stimuli to achieve a higher ecological validity. Furthermore, we used an experimental design that allows for controlled statements about how strongly each factor influences the overall subjective aesthetics and its different facets. Finally, we included color factors that previous studies had overlooked. As Bauerly and Liu (2008) stated, interface design is a complex process and experimental studies become all the more important. Only a controlled
experiment with carefully manipulated design characteristics can ensure that not a confounding variable cause an effect. Our study, furthermore, provided additional support for the facets of the Visual Aesthetics of Website Inventory (Moshagen & Thielsch, 2010). We could show that objective factors can also be linked to the colorfulness and craftsmanship facets that had been overlooked by Lavie and Tractinsky (2004).

5.4 Practical implications

As for practical implications, the findings of this research provide a better understanding of how objective factors influence the different facets of visual aesthetics. This can help website managers and designers to develop websites that are able to evoke the desired aesthetic responses of users by systematically targeting the specific facets of visual aesthetics. Users weigh design attributes of websites differently depending on the type of product or service offered by those sites (Zhang et al., 2001). Addressing the simplicity facet can therefore be useful for web shops with convenience goods (Tractinsky and Lowengart, 2007) or banks websites where it is more important to evoke a clean and competent design. Our study shows that to achieve a higher rating of the aesthetic facet “simplicity”, not only the site’s complexity but also its symmetry, its hue and its brightness should be manipulated. However, if the layout should evoke higher inventiveness (diversity), our results suggest manipulating the complexity and symmetry and none of the color factors. Targeting ‘diversity’ for example might be desirable for webshops with specialty goods to show its uniqueness (Tractinsky and Lowengart, 2007). Furthermore, our findings can be helpful in early stages of a design process by eliciting design alternatives. Moreover, they can reduce the number of prototypes that will encounter tests with human users in later stages of design (Altaboli & Lin, 2011a). Thielsch, Spiet, Jahn, Hirschfeld and Koller (2014) present some examples how the VisAWI can be applied in practice for website redesigns or benchmark studies for companies. Our findings can provide additional insights into practical studies’ results in the future. However, our findings about website preferences (high symmetry, low complexity, blue hue, medium brightness or medium and high saturation had the highest preferences) should not be blindly used as a recipe when designing websites. For a successful web presence many other aspects such as brand recognition and content fit should be considered too. Therefore the theoretical contribution of this research is probably stronger than the practical implications.

5.5 Limitations and future research

Several issues still need to be considered when interpreting the findings of this study. (1) Website sample: A limitation of our study is that our website sample may not represent a random sample drawn from the web. Although we carefully constructed this dataset to be as representative as possible, we cannot affirm that it catches the same aesthetic variety as found on the web. Furthermore, our website sample only consist of business websites; studies showed a high correlation between the
content and the type of a website and the aesthetic perception (Aladwani & Palvia, 2002). It is also possible that the content of the business sites in the present study affected the perception of the facets of users’ visual aesthetic perception (see also Zhang et al., 2001). Further studies with larger datasets will be necessary to validate our results with other type of websites. Moreover, it would be worth investigating a larger sample of websites and examining how well a model including our objective factors may predict subjective aesthetic ratings. In the future, experimental designs and computational modeling approaches should be combined.

(2) Passive viewing: The results we present are from a classical picture perception task, not interactive websites. In real life, when users are browsing the web, their interactions will have a major influence on how the overall user experience is shaped. Nevertheless, the paradigm used enables us to look into the initial process of aesthetic judgment formation. For further studies, it would be interesting to know whether the use of interactive websites leads to different results.

(3) Manipulation of objective factors: The different conditions of the objective design factors were chosen randomly. We therefore cannot affirm that a linear effect exists. Reinecke and Gajos (2014), for example, found an inverted U-shape relation between complexity and aesthetic perception.

(4) Manipulation of single factors: In the present study, we manipulated one factor per site only and did not include combinations of objective factors. More experimental studies investigating interaction effects between objective design factors are needed.

(5) Cross-cultural differences: Cultural aspects of aesthetics in website design are disregarded. Our results were obtained with young, educated, predominantly female, Swiss sample. Other authors (Palmer & Schloss, 2013; Reinecke & Gajos, 2014) could show that users from different countries prefer different complex websites and also different levels of hue, saturation and brightness.

(6) Changes over time: Website design is permanently changing and developing (Ntoulas, Cho & Olsten, 2004) and people’s perception and taste may change over time.

CONCLUSION

This study suggests a new perspective on website design research that extends the traditional studies that focus on either an objective or a subjective approach of visual aesthetics. In sum, our study shows that each design factor affects the facets of the Visual Aesthetics of Website Inventory (Moshagen & Thielsch, 2010) in a different way. Our findings shed light on the relationship between the objective and subjective factors of aesthetic perception and may help designers to systematically target specific facets of visual aesthetics.
LITERATURE


Reinecke, K., & Gajos, K. Z. (2014, April). Quantifying visual preferences around the world. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems* (pp. 11-20). ACM.


APPENDIX

Table 2
Demographic data per study

<table>
<thead>
<tr>
<th>Structural factors</th>
<th>gender</th>
<th>age</th>
<th>web design experience</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetry n = 33</td>
<td>20 (60.6)</td>
<td>29.8 (10.6; 17-62)</td>
<td>2.6 (1.5)</td>
</tr>
<tr>
<td>Complexity n = 54</td>
<td>32 (59.3)</td>
<td>33.1 (12.3; 18-62)</td>
<td>2.4 (1.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color factors</th>
<th>hue n = 41</th>
<th>Saturation n = 34</th>
<th>Brightness n = 32</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25 (61.0)</td>
<td>23 (67.6)</td>
<td>18 (56.3)</td>
</tr>
<tr>
<td></td>
<td>28.9 (11.8; 18-71)</td>
<td>25.8 (7.7; 17-48)</td>
<td>29.0 (11.2; 19-61)</td>
</tr>
<tr>
<td></td>
<td>2.5 (1.3)</td>
<td>2.3 (1.4)</td>
<td>2.8 (1.5)</td>
</tr>
</tbody>
</table>

Table 3
Objective measures for the symmetry stimuli

<table>
<thead>
<tr>
<th>Website</th>
<th>high</th>
<th>low</th>
</tr>
</thead>
<tbody>
<tr>
<td>105</td>
<td>59.4</td>
<td>47.0</td>
</tr>
<tr>
<td>136</td>
<td>72.4</td>
<td>63.1</td>
</tr>
<tr>
<td>318</td>
<td>71.6</td>
<td>64.5</td>
</tr>
<tr>
<td>348</td>
<td>48.7</td>
<td>30.7</td>
</tr>
<tr>
<td>401</td>
<td>51.3</td>
<td>35.7</td>
</tr>
</tbody>
</table>

Code (C# .NET) for symmetry calculations

```csharp
using System;
using System.Drawing;
using System.Windows.Forms;
namespace Symetrietest
{
    public partial class Form1 : Form
    {
        public Form1()
        {
            InitializeComponent();
        }
        private void button1_Click(object sender, EventArgs e)
        {
            compareBitmap(new Bitmap("d:\105a.jpg"));
            compareBitmap(new Bitmap("d:\105b.jpg"));
        }
        private void compareBitmap(Bitmap img)
        {
            int anzMatch = 0;
            for (int y = 0; y < img.Height; y++)
            {
                for (int x = 0; x < img.Width / 2; x++)
                {
                    if (ComparePixel(img.GetPixel(x, y), img.GetPixel(img.Width - x - 1, y)))
                        anzMatch++;
                }
            }
        }
    }
```
double anzTests = img.Height * img.Width / 2;
MessageBox.Show(string.Format("anzMatch {0}; Verhältnis {1}", anzMatch,
((double)anzMatch) / anzTests));
}
private bool ComparePixel(Color color1, Color color2)
{
    int treshhold = 10;
    if (Math.Abs(color1.R - color2.R) < treshhold &&
        return true;
    return false;
}

Table 4
Objective measures for the complexity stimuli

<table>
<thead>
<tr>
<th>Website</th>
<th>JPG File Size (KB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VC high</td>
</tr>
<tr>
<td>166</td>
<td>679</td>
</tr>
<tr>
<td>27</td>
<td>637</td>
</tr>
<tr>
<td>256</td>
<td>448</td>
</tr>
<tr>
<td>107</td>
<td>444</td>
</tr>
<tr>
<td>122</td>
<td>396</td>
</tr>
</tbody>
</table>

Note. Higher values represent more complex layouts

Table 5
Items and facets of the VisAWI

<table>
<thead>
<tr>
<th>No</th>
<th>Facet</th>
<th>English translation</th>
<th>German original</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Simplicity</td>
<td>The layout is easy to grasp.</td>
<td>Das Layout ist gut zu erfasen.</td>
</tr>
<tr>
<td>2</td>
<td>Simplicity</td>
<td>Everything goes together on this site.</td>
<td>Auf der Seite passt alles zusammen.</td>
</tr>
<tr>
<td>3</td>
<td>Diversity</td>
<td>The layout is inventive.</td>
<td>Das Layout ist originell.</td>
</tr>
<tr>
<td>4</td>
<td>Diversity</td>
<td>The layout is pleasantly varied.</td>
<td>Die Seite ist angenehm vielseitig.</td>
</tr>
<tr>
<td>5</td>
<td>Colorfulness</td>
<td>The color composition is attractive.</td>
<td>Die farbliche Gesamtgestaltung wirkt attraktiv.</td>
</tr>
<tr>
<td>6</td>
<td>Colorfulness</td>
<td>The colors do not match.</td>
<td>Der Farbeinsatz ist nicht gelungen.</td>
</tr>
<tr>
<td>7</td>
<td>Craftsmanship</td>
<td>The layout appears professionally designed</td>
<td>Das Layout ist professionell.</td>
</tr>
<tr>
<td>8</td>
<td>Craftsmanship</td>
<td>The layout is not up-to-date.</td>
<td>Das Layout ist nicht zeitgemäss.</td>
</tr>
<tr>
<td>9</td>
<td>Craftsmanship</td>
<td>The site is designed with care.</td>
<td>Die Seite erscheint mit Sorgfalt gemacht.</td>
</tr>
</tbody>
</table>

Table 6
Overview of significant interactions website*design factor for disordinal interactions

<table>
<thead>
<tr>
<th>Design Factor</th>
<th>Facet</th>
<th>p</th>
<th>n^2_p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hue</td>
<td>colorfulness</td>
<td>&lt; .001</td>
<td>10</td>
</tr>
<tr>
<td>Hue</td>
<td>simplicity</td>
<td>.014</td>
<td>.06</td>
</tr>
<tr>
<td>Saturation</td>
<td>colorfulness</td>
<td>.002</td>
<td>.09</td>
</tr>
</tbody>
</table>
Table 7
Contrast results for disordinal interactions

<table>
<thead>
<tr>
<th>Design Factor</th>
<th>Facet</th>
<th>Contrast for</th>
<th>p</th>
<th>$n_p'$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hue</td>
<td>colorfulness</td>
<td>blue vs. others</td>
<td>&lt; .001</td>
<td>.41</td>
</tr>
<tr>
<td>Hue</td>
<td>colorfulness</td>
<td>violet vs. others</td>
<td>&lt; .001</td>
<td>.42</td>
</tr>
<tr>
<td>Hue</td>
<td>simplicity</td>
<td>blue vs. others</td>
<td>.001</td>
<td>.23</td>
</tr>
<tr>
<td>Hue</td>
<td>simplicity</td>
<td>violet vs. others</td>
<td>.009</td>
<td>.16</td>
</tr>
<tr>
<td>Saturation</td>
<td>colorfulness</td>
<td>low vs. others</td>
<td>.004</td>
<td>.23</td>
</tr>
<tr>
<td>Saturation</td>
<td>colorfulness</td>
<td>medium vs. high</td>
<td>.068</td>
<td>.10</td>
</tr>
</tbody>
</table>