DISSERTATION

Titel der Dissertation

Visual Features, Aesthetic Judgments, and Modulating Factors

Verfasser

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Abstract

The act of making aesthetic judgments of objects in the environment involves a complex interplay of numerous factors that are present during any given aesthetic episode (Leder, Belke, Oeberst, & Augustin, 2004). Since Fechner (1876), empirical aesthetics has had a tradition of examining the influence of visual features on aesthetic judgments. However, the influence of modulating factors on the relationship between visual features and aesthetic judgments remains largely unexplored. This dissertation addressed this shortcoming. It investigated the effects of visual features, such as symmetry and complexity, on aesthetic judgments and how these effects are influenced by modulating factors, such as familiarity and stimulus-inherent emotional valence. The project was multifaceted, and examined several factors known to influence aesthetic judgments. A wide range of stimuli, behavioral and psychophysiological methodologies, and traditional and newly developed paradigms were employed.

Leder et al.'s (2004) *information processing model of aesthetic experiences and aesthetic judgments* was used as a framework for contextualizing the investigations. The model consists of five stages that can be mapped into two broad levels of processing: automatic, implicit processing; and deliberate, explicit processing. This dissertation addressed both levels. First, it examined the effects of symmetry, complexity, and familiarization on aesthetic judgments of basic patterns and faces (Tinio & Leder, 2009a; Tinio, Gerger, & Leder, 2010), and showed that the effects of symmetry and complexity were generally robust. It also showed how massive familiarization to a particular type of stimulus resulted in specific modulation of the effects. Second, it examined emotion as a modulating factor in the preference for curved objects (Leder, Tinio, & Bar, 2010). Results showed that the preference for curved objects was found only in objects with neutral and positive emotional valence. Negative emotional valence associated with some objects had overridden the positive influence of curvature. Third, the dissertation investigated the influence of image quality degradations on aesthetic judgments of images of natural and human-made scenes (Tinio & Leder, 2009b; Tinio, Leder, & Strasser, in press). The results demonstrated that people preferred images of natural over human-made scenes, and that this preference was modulated by image quality. Finally, several investigations focused on the behavioral consequences of attractiveness in real-world scenes and how they are modulated by situational demands (Leder, Tinio, Fuchs, & Bohrn, in press). Results indicated that attractive faces received longer looks, although responses to attractiveness depended on specific situational demands.

Each set of studies presented in this dissertation is prefaced by an introduction to the main theoretical and empirical issues addressed, and copies of the original manuscripts are

provided. In addition, the implications of the results on the field of empirical aesthetics and psychology in general are discussed. Finally, a discussion of the current state and future directions of each research topic is provided.

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1.

General Introduction

Aesthetic judgments are involved in many of the decisions that we make in everyday life, from judging the attractiveness of a face in a crowd or choosing between two consumer products, to deciding whether to invest time looking at a work of art in a museum. Previous research has shown that aesthetic judgments are made in a matter of seconds, and there is evidence showing that aesthetic experiences, even in contexts as complex as art museums, transpire quickly (Smith & Smith, 2001; Smith, Bousquet, Chang, & Smith, 2006). This is remarkable in light of evidence indicating that numerous factors influence the outcome of such judgments (see Leder, Belke, Oeberst, & Augustin, 2004).

The aim of this dissertation was to examine the nature of the effects of such factors on the aesthetic judgments of stimuli varying in their levels of visual and semantic complexity. Low-level factors consist of *stimulus-inherent visual features* such as stimulus symmetry, complexity, and contrast. For this dissertation, aesthetic judgments are broadly defined as decisions that reflect approach- or hedonic-related responses (and their corresponding inverses). Such responses reflect a person's orientation towards a certain stimulus or aspects of it. Aesthetic judgments are described by terms such as preference, liking, and interest. Favorable aesthetic judgments are generally associated with a positive state of affairs whether cognitive, affective, or physiological in character.

Although aesthetics has deep philosophical roots (e.g., Baumgarten, 1758; Baumgarten, 1779/1969; Kant, 1790/1952), the investigations in this dissertation were based on the empirical aesthetics tradition. The founding of empirical aesthetics is attributed to Gustav Theodor Fechner. Fechner's (1876) early work has served as a foundation for empirical aesthetics as we know it today—characterized by quantitative investigations and analyses, and the idea that aesthetic responses are closely related to hedonic experiences (Leder, et al., 2004). This focus on hedonics is reflected in the numerous studies that have used dependent measures involving liking, interest, and pleasantness. Fechner also introduced the concept of aesthetics from below, a bottom-up conceptualization of aesthetics phenomena. This concept has had a tremendous influence on the aesthetics research that followed, especially those studies that focused on the effects of low-level visual features on perception and aesthetic judgments.

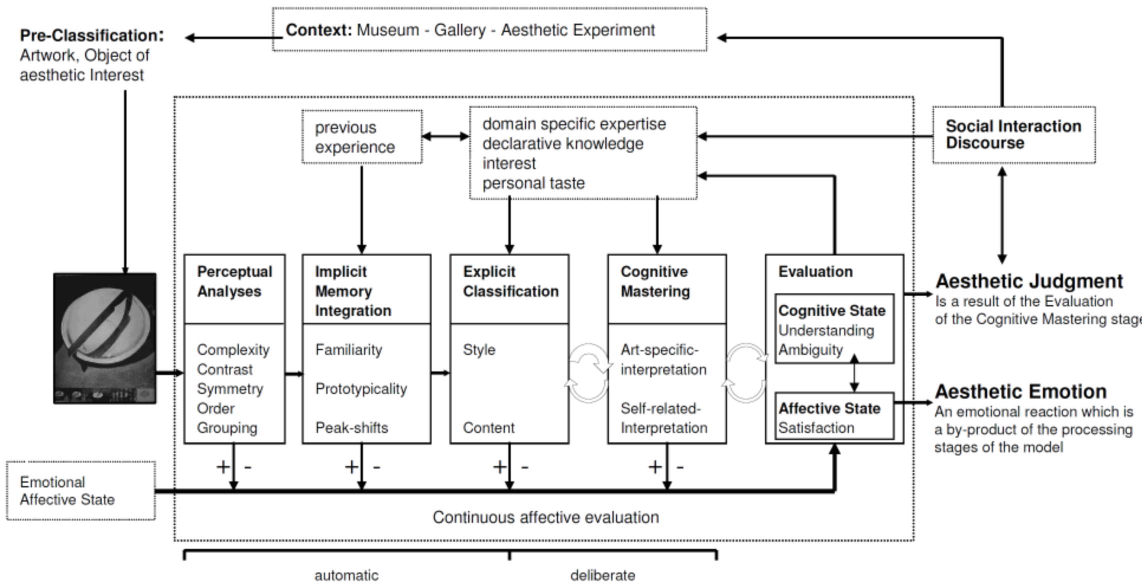
Fechner's (1876) influence on the field of empirical aesthetics is evident in the work of Birkhoff (1932), a mathematician who proposed that the aesthetic value of an object is based on the relationship between complexity and order that is inherent in the object. Eysenck (1941) also based his formulation of aesthetic appreciation on these two factors, although in a different manner. Many other approaches were founded on the idea that the visual properties of objects somehow determine aesthetic appreciation (Arnheim, 1966, 1974). For example, Berlyne's (1970, 1971, 1974) work was comprised of studies of how properties such as complexity, symmetry, and novelty—which he referred to as *collative variables*—are related to aesthetic appreciation. This dissertation was influenced by the approach of Fechner and those scholars that followed him. It primarily examined the relationship between variations in specific features of visual stimuli and how the stimuli were judged aesthetically.

Certain characteristics of visual stimuli have been shown to strongly influence aesthetic judgments. These include factors such as prototypicality (Martindale & Moore, 1988; Martindale, Moore, & Borkum, 1990; Martindale, Moore, West, 1988), familiarity (Zajonc, 1968), organization of compositional elements (Arnheim, 1988; Höge, 1995; Locher, 2003; Locher, 2006; Locher, Gray, & Nodine, 1996; Nodine, Locher, & Krupinski, 1993; Wilson & Chatterjee, 2005), and features that are associated with the composition and visual structure of stimuli. Regarding the latter features, studies have shown that people prefer symmetrical over non-symmetrical objects (e.g., Eisenman & Gellens, 1968; Humphrey, 1997; Jacobsen & Höfel, 2001, 2002, 2003; Jacobsen, Schubotz, Höfel, and van Cramon, 2006; Washburn, 2006; Washburn & Humphrey, 2002), complex over simple objects (Jacobsen, 2004), and curved over sharp objects (Bar & Neta, 2006, 2007; Silvia & Barona, 2009). This dissertation had two main objectives. The first was to assess the effects of variations in stimulus-inherent visual features on aesthetic judgments. The second was to investigate how the effects of such features are modulated by factors such as stimulus familiarity.

The investigations were contextualized within Leder et al.'s (2004; see Figure 1) *information processing model of aesthetic experience and aesthetic judgments*. This multi-stage model was initially proposed to account for cognitive processes involved in aesthetic experiences of visual art. However, the model has been applied in other domains, such as music (Brattico & Jacobsen, 2009; Roose, 2008) and the performing arts (Calvo-Merino, Jola, Glaser, & Haggard, 2008). Cognitive, affective, contextual, and perceiver-related variables are integrated within the five stages of the model. In *perceptual analysis*, the first stage, basic visual features such as symmetry, complexity, and contrast are perceptually analyzed, with the analysis taking place quickly and without the perceiver's conscious awareness. A "call to memory" begins during the *implicit memory integration* stage. Here, familiarity, prototypicality, and peak-shift effects regarding the stimulus are influential to the aesthetic experience. Access to the perceiver's memory occurs during *explicit classification*. At this stage, the perceiver's knowledge base allows for the deliberate processing of content. The next two stages of *cognitive mastering* and *evaluation* are linked as they form a continuous feedback loop. Through the feedback loop, the perceiver is able to test hypotheses regarding interpretations related to the stimulus. The cognitive mastering stage may result in increased understanding or changes in ambiguity levels, which are then evaluated for success. If these processes are unsuccessful, information processing may revert to an earlier stage. A positive state of affairs results from successful processing. For example, an art novice may successfully relate a painting to a previous experience. Similarly, an art expert may have been able to associate a painting or elements of it to a specific art concept or style. During each stage of aesthetic processing, there are changes in the perceiver's affective state. Two outputs result from information processing: aesthetic emotion and aesthetic judgment. Aesthetic emotion could be positive or negative depending on the outcome of the processing occurring at each stage. Aesthetic judgment is based on the outcome of the cognitive mastering stage.

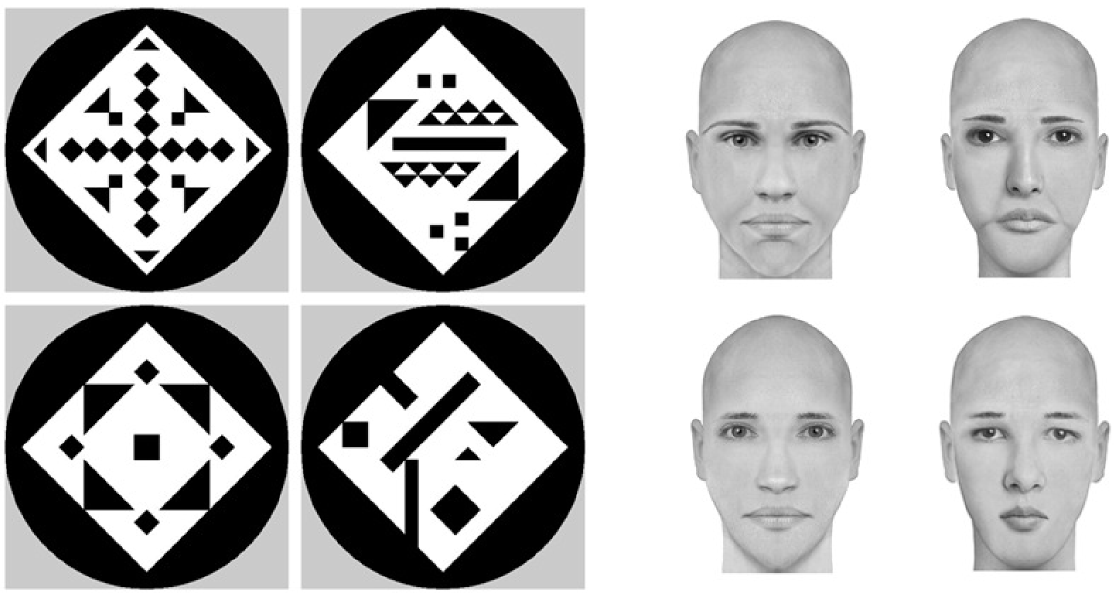
The five stages of the model (see Figure 1) can conceptually be mapped into two broad levels of information processing: automatic, implicit processing; and deliberate, explicit processing. Stimulus features are processed automatically and implicitly during the first two stages, and processing during the last three stages takes place consciously (Leder et al. 2004). The main investigations conducted for the dissertation were focused on the early stages of the aesthetic experience, according to which visual features are most influential to aesthetic judgments. Several studies were, however, also focused on the later stages. This two-pronged approach is consistent with the model's proposal of an interaction between bottom-up and top-down influences on the aesthetic experience. Thus, within the dissertation, the topic of aesthetics was treated in a broad sense. Multiple aspects of the aesthetic experience were addressed, and deeper understanding of each individual topic was sought. Consistent with this multifaceted approach, was the wide range of experimental methodologies used, from basic behavioral measures to eye movement tracking. Additionally, the hypotheses were examined using different stimuli ranging from abstract patterns that are devoid of semantic meaning, faces, which have high biological and social significance, and photographs of objects and various real world scenes, which have high ecological validity.

Figure 1. Model of aesthetic appreciation and aesthetic judgments (Leder, Belke, Oeberst, & Augustin, 2004)



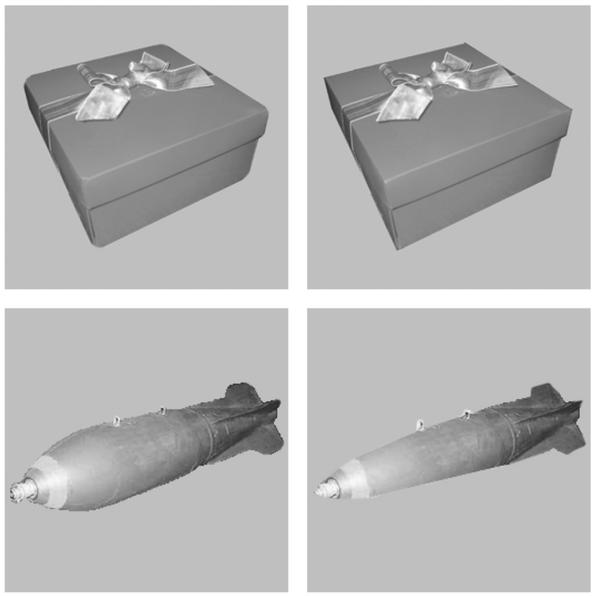
The first set of studies, reported in Chapters 2 and 3 examined the combined effects of symmetry and complexity on aesthetic judgments, and how familiarity moderated these effects. The effects of symmetry and complexity have been shown to be robust. These studies aimed to challenge that robustness with familiarization, especially massive familiarization, and to address classic theories (e.g., mere-exposure effect; Zajonc, 1968) and conceptualize them in a new light. Two categories of stimuli were employed in these studies: abstract patterns and composite faces (see Figure 2). The use of these two categories was somewhat analogous to a common distinction between two categories of artworks: abstract and representational (e.g., Cupchik & Gebotys, 1988). Results showed that although the effects of symmetry and complexity were generally robust, the effects were modulated by massive familiarization. In addition, the modulating effects of familiarity were different for the abstract patterns and composite faces.

Figure 2. Examples of the abstract patterns (Tinio & Leder, 2009a) and composite faces (Tinio, Gerger, & Leder, 2010): for each set of patterns and faces—complex-symmetrical (upper-left), complex-non-symmetrical (upper-right), simple-symmetrical (lower-left), and simple-non-symmetrical (lower-right).



The experiments reported in Chapter 4 examined the modulating role of stimulus-inherent emotional valence on the effects of curvature on aesthetic judgments. Similar to symmetry and complexity, curvature has been shown to positively influence aesthetic judgments (Bar & Neta, 2006, 2007; Silvia & Barona, 2009). According to these previous studies, the influence of contour—whether curved or sharp—occurs during the early stages of aesthetic processing. However, it has not yet been shown if stimulus-inherent emotional valence (see Figure 3) mediates the effects of contour. In terms of Leder et al.'s model (2004), these experiments addressed both the early and late processing stages. Additionally, and perhaps more importantly, they explored the idea that the results of the processing during the early stages of the aesthetic experience may be overridden by the explicit processing of the stimuli. It was shown that the curvature preference was found only in objects with neutral or positive emotional valence, and not in objects with negative emotional valence. For the latter objects, the negative emotional valence appeared to have overridden the effects of curvature.

Figure 3. Stimuli used in Leder, Tinio, and Bar (2010): round-positive (upper-left), sharp-positive (upper-right), round-negative (lower-left), and sharp-negative (lower-right).



The third set of studies, reported in Chapters 5 and 6, focused on the influence of image quality on aesthetic judgments of complex real-world scenes. Previous studies have repeatedly shown that people prefer images of natural scenes over images of human-made scenes (e.g., Biederman & Vessel, 2006; Kaplan, 1992; Kaplan & Kaplan, 1989). In those studies, photographs of such scenes were used as stimuli. In Chapter 5, we report on a study that examined the impact of image quality on aesthetic judgments of images of natural and human-made scenes (see Figure 4). We also proposed the *taxonomy of image manipulation procedures*, which conceptualized the similarities and differences among various image manipulation techniques. Also discussed were the effects of specific manipulations on aesthetic judgments. We extended this research in another set of studies, reported in Chapter 6, in which we investigated the individual, paired, and fully combined effects of contrast, sharpness, and grain degradations on aesthetic judgments of images. These were the first studies to examine these basic building blocks of image quality in a systematic manner. Taken together, the findings from these studies showed that people prefer natural over human-made scenes, and that image quality has a strong influence on such preference. However, certain image quality degradations were more influential than others. The findings also demonstrated that the impact of the degradations was additive.

Figure 4. Illustration of the image manipulation procedure used in Tinio and Leder (2009b) and Tinio, Leder, and Strasser (in press) with original (left) and degraded (right) versions.

Chapter 7 addressed how the aesthetic response guides visual exploration of the environment. The results of two experiments using eye tracking methodology are reported. The studies examined whether attractive faces in real-world scenes demand longer looks, as indicated by mean fixation, mean first fixation, and total fixation durations (see Figure 5 for a sample stimulus). Results showed that attractive faces received longer fixations than less attractive faces, and that fixations were longest to female faces, and by female perceivers. Additionally, the results showed that the effects varied depending on whether the viewing context was positive or negative.

Figure 5. Illustration test scene used in Leder, Tinio, Fuchs, and Bohrn (in press) showing an attractive and a less attractive face (here, faces used in the actual study were replaced by example faces).

The following chapters contain brief introductions to the main elements of the research and a discussion of implications of the results for the field of experimental aesthetics and psychology in general. Also provided are corresponding manuscripts. The dissertation concludes with a general discussion integrating the main themes and a post commentary about the current state and future direction of each research area.

2.

Symmetry, Complexity, and the Jaws of Massive Familiarization

2.1. Introduction

The article was published in *Acta Psychologica*, and aspects of the data were presented at “Means and Devices of Art,” an Invited Session at the *2008 Conference of the International Association of Empirical Aesthetics*, Chicago, U.S.A.

It examined the combined effects of symmetry and complexity on the aesthetic judgments of basic patterns. According to Leder et al.’s (2004) model, the effects of these two factors are most salient during the early stages of processing, which take place automatically and quickly. The categorization of the stimuli into complex-symmetrical, complex-nonsymmetrical, simple-symmetrical, and simple-nonsymmetrical categories extended previous studies that have used the same stimuli to assess the effects of symmetry and complexity (e.g., Jacobsen & Höfel, 2001). We confirmed the results of such studies, and showed that symmetry and complexity are powerful determinants of aesthetic judgments, and that their effects are additive.

We also examined whether familiarization (see Bornstein, 1989 for a comprehensive review) would modulate the combined effects of symmetry and complexity on the aesthetic judgments of the patterns. We directed our analyses on several possible outcomes based on previous work on familiarization effects by Zajonc (1968), Berlyne (1970), and Biederman and Vessel (2006). We also examined structural mere-exposure effects (Gordon & Holyoak, 1983; Manza & Bornstein, 1995; Monahan, Murphy, & Zajonc, 2000; Newell & Bright, 2001; Zizak & Reber, 2004), according to which familiarization to one type of stimulus leads to generalization of the effects to new but similar stimuli. Results showed that familiarization was indeed influential as a moderating factor. Participants familiarized to complex-nonsymmetrical patterns rated simple patterns more beautiful than participants familiarized to simple-symmetrical patterns. Participants familiarized to simple-symmetrical patterns rated complex patterns more beautiful than participants familiarized to complex-nonsymmetrical patterns. It is important to note that these results were obtained through massive familiarization. Participants who were only moderately familiarized (one-fourth the amount of the massive familiarization conditions) to one of the four types of patterns did not show contrast effects.

2.2. Original Manuscript

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Just how stable are stable aesthetic features? Symmetry, complexity, and the jaws of massive familiarization

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Using both group- and individual-level analyses, we explored the complex and dynamic effects of basic visual features on aesthetic judgment. Specifically, the mediating influence of familiarization on the combined effects of complexity and symmetry on aesthetic judgment was examined. Experiment 1 showed that symmetry and complexity are indeed powerful determinants of aesthetic judgment. Experiment 2 demonstrated that massive familiarization generated contrast effects for complexity: participants familiarized to simple stimuli subsequently judged complex stimuli more beautiful and participants familiarized to complex stimuli subsequently judged simple stimuli more beautiful. In contrast, moderate familiarization in Experiment 3 did not elicit the above effects. Group-level analyses were augmented with judgment analyses of individual response patterns resulting in a more comprehensive assessment of aesthetic judgment.

The aesthetic response is generally sensitive to certain visual features that are perceived as hedonically pleasing. As a result, the field of empirical aesthetics is rich in investigations of the relationship between visual features and aesthetic judgment. For example, it has been shown that people prefer large over small objects (Silvera, Josephs, & Giesler, 2002), and curved over sharp objects (Bar & Neta, 2006, 2007; Silvia & Barona, 2009). However, the nature of the effects of such features on aesthetic judgment is complex and dynamic, and the stability of the effects against specific conditions such as familiarity is unclear. Moreover, with the exception of a few approaches (e.g., Augustin & Leder, 2006; Jacobsen & Höfel, 2002; Silvia, 2006), the majority of previous work is based primarily on group-level analyses, which generally results in the loss of valuable information regarding individual variation in judgments. We attempted to address these limitations by examining the combined effects of two visual features – symmetry and complexity – on aesthetic judgment (Experiment 1), and by assessing the mediating effects of the dynamic condition of familiarity (Experiments 2 and 3). Using massive familiarization, we showed how even the seemingly stable effects of symmetry and complexity on aesthetic judgment can be altered. In addition, to shed light on the judgment patterns of the participants, group-level analyses were augmented with judgment analyses (e.g., Jacobsen, 2004) of individual responses.

Symmetry is a salient feature in the environment, and can be found in symbol systems and graphic depictions across various cultures and time periods. For example, symmetrical patterns and depictions are found in ancient Chinese pottery, Mesopotamian decorations, and 20th century Western artworks (see Darvas, 2007). Interestingly, the penchant for symmetry appears early in human life as research has demonstrated that infants show preference for symmetry (e.g., Humphrey & Humphrey, 1989). Symmetry also appears to be perceptually salient (see van der Helm & Leeuwenberg, 1996; Wagemans, 1995, 1997, 1999), and there is existing evidence that symmetry detection occurs preattentively (e.g., Locher & Wagemans, 1993). In addition, the ability to detect symmetry appears to be flexible and robust (Barlow & Reeves, 1979; Locher & Smets, 1992; Wagemans, 1993; Wagemans, van Gool, & d'Ydewalle, 1992; Wenderoth, 1997). Generally, in terms of empirical aesthetics research, symmetrical visual stimuli are judged more positively than those that are non-symmetrical. This effect has been demonstrated extensively using faces (e.g., Cardenas & Harris, 2006; Perrett et al., 1999; Rhodes, Proffitt, Grady, & Sumich, 1998), wherein preference for symmetry is commonly explained using a biological advantage perspective; symmetrical faces signal good health and thus, reproductive fitness (e.g., Jones et al., 2001; Rhodes et al., 2001; Thornhill & Gangestad, 2006). Preference for

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symmetry has also been shown in aesthetic judgments of the human body (e.g., Concar, 1995; Thornhill & Gangestad, 1994) and abstract designs (Cardenas & Harris, 2006). In a number of studies employing basic shapes or abstract patterns, Jacobsen and Höfel (2001, 2002, 2003) and Jacobsen, Schubotz, Höfel, and van Cramon (2006) found symmetry as the strongest predictor of beauty judgments, with participants finding symmetrical stimuli more beautiful than non-symmetrical stimuli.

In the studies by Jacobsen and his colleagues (e.g., Jacobsen, 2004), it was also found that another variable that strongly influenced aesthetic judgment was complexity. With complexity defined as the number of individual elements that composed each stimulus, participants considered complex stimuli more beautiful than simple stimuli. The effects of complexity have also been demonstrated using other types of stimuli. For example, Imamoglu (2000) found a preference for complexity using schematic drawings of building facades. For common facades, participants preferred drawings that were more complex. Several other studies have demonstrated that complexity is an important factor in predicting aesthetic judgment (e.g., Cox & Cox, 2002).

Thus, according to previous studies, complexity and symmetry characteristics (e.g., Eisenman & Gellens, 1968; Jacobsen, 2004) somehow predict aesthetic judgment of visual stimuli. The relationship between these two factors and the aesthetic response has been explored since the early days of aesthetics research (e.g., Birkhoff, 1932; Eysenck, 1941). The effects of complexity and symmetry appear to be quite stable, and may point to biologically related responses to such visual features. In fact, Washburn (1999) has suggested that the prominence of symmetrical representations suggests a special manner in which humans interact with their surroundings. For the present study, this stability was challenged by the use of a familiarization phase in Experiments 2 and 3 with the aim of eliciting dynamic changes such as an adaptation to a particular aspect of the stimuli. Recently, dynamic changes in aesthetic judgment have been shown for stimuli such as artworks (Carbon & Leder, 2006) and innovative consumer products (Carbon & Leder, 2005). Thus, we attempted to test whether the effects of symmetry and complexity on aesthetic judgments are stable or whether they are susceptible to changes brought about by familiarization. In order to explicitly identify such changes, the stimuli were systematically classified into four groups with each group representing a unique combination of symmetry and complexity.

The combined effects of symmetry and complexity were examined in Experiment 1. We employed stimuli previously used by Jacobsen and Höfel (2001, 2002, 2003) and Jacobsen et al. (2006). The stimuli were initially intended to vary mainly on symmetry and complexity. There has been considerable research on the salience of symmetry and how it is perceived (for comprehensive reviews, see Van der Helm & Leeuwenberg, 1996; Wagemans, 1995, 1997, 1999). Although the present study was designed primarily to assess beauty judgments, it is important to consider the results of studies on symmetry detection, especially regarding the number and orientation of symmetry axes. Such studies typically used detection reaction times and error rates as dependent measures.

The number of symmetry axes within a given stimulus is a crucial factor in how the stimulus is processed. There is strong evidence that the presence of multiple symmetries in a stimulus facilitates its processing. Palmer and Hemenway (1978) found that stimuli with quadruple symmetry had a processing advantage over stimuli with double symmetry, which in turn had a processing advantage over stimuli with single symmetry. The general advantage of quadruple symmetry was also found by Royer (1981). Moreover, Wagemans, van Gool, and d'Ydewalle (1991) showed that stimuli with quadruple symmetry were more resistant to the effects of symmetry perturbation through a skewing transformation, as compared to stimuli with single or double symmetry. It is important to note that in their study, stimuli with double symmetry were affected less by skewing than stimuli with single symmetry. In the present study, most of the symmetrical stimuli had quadruple symmetry (see Section 1.1.2 for details). Thus, judging from the results of previous studies, in terms of symmetry, the symmetrical stimuli in this study could be considered perceptually very salient. However, this idea could be qualified by previous studies that have shown that the experimental design and the characteristics of the complete set of stimuli (both symmetrical and non-symmetrical) could influence the salience of quadruple symmetry (Wenderoth, 1997; Wenderoth & Welsh, 1998).

Another important factor regarding symmetry is the orientation of the symmetry axes – whether the orientation is vertical (V), horizontal (H), left diagonal (LD), right diagonal (RD), or along any other axis between these main axes. Evidence suggests that vertical symmetry is easiest to be detect (Corballis & Roldan, 1975; Palmer & Hemenway, 1978; Wagemans et al., 1992). However, results do not converge on whether horizontal or diagonal symmetry is perceptually better (based on reaction times and error rates): Royer (1981) and Palmer and Hemenway (1978) found that horizontal symmetry was better than diagonal symmetry, while Corballis and Roldan (1975) found the opposite. Wenderoth (1994) conducted three experiments that examined not only the main axes (i.e., vertical, horizontal, and diagonals) but also the intermediate axes. He found that the advantage for a particular axis could be modulated by attentional and scanning strategies. Furthermore, Locher and Wagemans (1993) suggested that the conflicting results regarding the effects of axis orientation are due to the characteristics of the symmetry detection task and the set of stimuli specific to each study. In the present study, the majority of the symmetrical stimuli were symmetrical at all the main axes – vertical, horizontal, and both diagonals (see Section 1.1.2 for details).

The stimuli were classified into the following subsets: complex-symmetrical (CoSy), complex-non-symmetrical (CoNs), simple-symmetrical (SiSy), and simple-non-symmetrical (SiNs). The classification – in contrast to an ex post facto approach – and strict delineation of the stimuli into the four subsets, was an extension of the investigations by Jacobsen and his colleagues. The results of Experiment 1 were used as comparison data for assessing the mediating influence of familiarization on the effects of complexity and symmetry on beauty judgments. We predicted that people would provide the highest beauty ratings to CoSy, followed in decreasing order by SiSy, CoNs, and SiNs stimuli. These predictions were based on previous findings indicating that symmetry is a stronger predictor of aesthetic judgment than complexity. Hence, Experiment 1 was conducted to confirm previous findings regarding the effects of complexity and symmetry. In addition, findings from Experiment 1 were employed in subsequent experiments to assess the changes in the order of liking judgments resulting from different levels of familiarization.

Several important issues regarding stimulus familiarity had to be considered, which is a factor also deemed important in understanding general aesthetic preferences. The influence of familiarization on aesthetic judgment was first systematically assessed by Zajonc (1968) using nonsense words, Chinese ideographs, and photographs of faces. Through a series of correlational studies and experiments, he demonstrated that repeated exposure to various stimuli generally resulted in more positive affect. This mere-exposure effect has been replicated in numerous studies, and meta-analyses have revealed several variables that can facilitate or hinder mere-exposure effects (see Bornstein, 1989; Stang, 1974). For example, mere-exposure effects are greater for complex than for simple stimuli (e.g., Oskamp & Scalpone, 1975; Saegert & Jellison, 1970).

The relationship between stimulus complexity and familiarity (or novelty) was addressed by Berlyne (1970, 1971) in several experiments employing colored patterns and paintings that varied in complexity and figurativeness. Results revealed an interaction between complexity and novelty with more positive judgments for complex stimuli and less positive judgments for simple stimuli through increasing exposure. Berlyne (1970) explained these results using the *arousal potential* concept, wherein stimuli with moderate levels of arousal potential are judged more favorably. Specifically, upon initial presentation, stimuli that are novel and simple possess moderate arousal potential levels. With repeated exposure, these stimuli lose arousal potential and are subsequently judged less positively. Such dynamics may account for the *boredom* phenomenon. In contrast, complex stimuli will initially be judged less positively since they elicit feelings of uncertainty. However, with further exposure, conflicting elements are assimilated. Thus, complex stimuli progress from initially having excessively high arousal potential to having moderate arousal potential, which is the optimum level for aesthetic judgments.

Recently, the role of novelty as opposed to familiarity was investigated by Biederman and Vessel (2006) in an fMRI study using photographs of natural and human-made scenes. They found that signals from areas of the brain that are assumed to be associated with pleasure decreased with repeated exposure to the photographs. The authors suggested that people prefer stimuli that provide the possibility for interpretation. As people try to interpret a stimulus, there is increased pleasure with repeated exposure. This pleasure peaks upon comprehension of the stimulus, whereby the brain is able to make rich connections with stored information. Subsequently, habituation and decline in preference occurs. Like those of Berlyne (1970), these findings contradict the mere-exposure hypothesis (Zajonc, 1968). Biederman and Vessel added that the mere-exposure effect is seemingly confined to the early rising portion of an inverted U-shaped function that they proposed as describing the time course of experiencing perceptual and cognitive pleasure. Although they employed complex scenes as stimuli in contrast to simple novel patterns, their findings indicate the possibility that people prefer the novel to the familiar.

Concerning the present study, on the one hand, the mere-exposure paradigm (Zajonc, 1968) would predict that when the patterns that participants are familiarized to are intermixed with novel patterns of different symmetry and complexity structure, the familiar patterns would be rated as more beautiful. On the other hand, according to the arousal potential concept (Berlyne, 1970) – setting symmetry aside – familiar simple patterns as compared to the other patterns would be judged as least beautiful, while familiar complex patterns, as compared to the other patterns, would be judged as most beautiful.

An additional issue concerns the possible transfer effects of familiarization to one type of stimulus to other similar but novel stimuli. Exposure to a particular stimulus has been shown to produce generalization effects to new but similar stimuli (Gordon & Holyoak, 1983; Manza & Bornstein, 1995; Monahan, Murphy, & Zajonc, 2000), a phenomenon referred to as *structural mere exposure* (Newell & Bright, 2001; Zizak & Reber, 2004). In structural mere-exposure studies, traditional mere exposure (Zajonc, 1968) and implicit learning (Reber, 1967) approaches are coupled within one experimental procedure. The procedure essentially involves a learning and a testing phase. In the learning phase, participants learn stimuli such as letter strings possessing inherent grammatical structure. The testing phase involves affective judgments of the previously learned letter strings in addition to new letter strings that are grammatically consistent with the previously learned letter strings, and letter strings that are not grammatically consistent with the previously learned letter strings (Zizak & Reber, 2004). Experiments 2 and 3 of the present study are somehow consistent with the structural mere-exposure approach of presenting – in the testing phase – stimuli that were viewed in the familiarization phase and new stimuli that are similar or dissimilar in structure to the familiar stimuli. However, the fundamental difference between their study and the present study lies in the structure of the stimuli used. Analysis in structural mere-exposure studies focus on a transfer of "grammar" from familiar to unfamiliar stimuli. In the present study, analyses were directed towards positive or negative transfer of the effects of visual structure – complexity and symmetry – from familiar to unfamiliar stimuli. In other words, the focus here was not on some type of grammatical rule but rather on *structural generalization* or *structural contrast* of specific, traditionally aesthetic properties – features known to influence aesthetic judgments.

From a conceptual perspective, it is apparent that the crossing of symmetry and complexity within a set of stimuli could reveal important aspects of familiarization effects, especially those that relate to the visual structure of stimuli. Previous studies have shown that people prefer symmetrical stimuli (e.g., Jacobsen & Höfel, 2001), that familiarization leads to liking (e.g., Zajonc, 1968), that complexity interacts with familiarization (e.g., Berlyne, 1970; see also Lévy, MacRae, & Köster, 2006, in the context of food preference), and that familiarization to a stimulus leads to a transfer of effects to novel stimuli (e.g., Gordon & Holyoak, 1983; Manza & Bornstein, 1995). In Experiment 2, extensive familiarization to a particular combination of complexity and symmetry (i.e., CoSy, CoNs, SiSy, or SiNs) was employed. Participants subsequently rated (for beauty) the familiar stimuli along with novel stimuli from the three other stimulus classes.

We hypothesized that if mere-exposure effects (Zajonc, 1968) are elicited, participants would provide an overall higher beauty judgment to the familiar stimuli; otherwise, a contrast effect would result with participants providing higher ratings to structurally "opposite" stimuli. If arousal potential effects are elicited (Berlyne, 1970), the more specific effects would be expected such that: familiar simple patterns as compared to the other patterns would be judged lowest in terms of beauty, while familiar complex patterns, as compared to the other patterns, would be judged most favorably. Participants familiarized to symmetrical patterns could prefer symmetrical over non-symmetrical patterns in the rating phase. Similarly, participants familiarized to non-symmetrical patterns could subsequently prefer non-symmetrical over symmetrical patterns. However, provided that symmetry has been shown to be a powerful predictor of aesthetic judgment across various types of stimuli (e.g., faces and artworks), and given that familiarization effects on symmetry are at the present unknown, it stood to reason that familiarization may not change the effects of symmetry on beauty judgments. In other words, contrast or generalization effects would not be expected. Thus, symmetrical stimuli should be rated more beautiful than non-symmetrical stimuli in the rating phase regardless of which stimulus class participants are familiarized to. In order to test these possible outcomes in a manner that is more consistent with the traditional mere-exposure paradigm, moderate familiarization was employed in Experiment 3. Affect change through familiarization has been shown to be optimally evoked using a small number of exposures, with some studies demonstrating that massive exposure leads to an eventual downturn in affective ratings or effects approaching an asymptote (see Bornstein, 1989). Thus, the mere-exposure effect was addressed in Experiment 3 by employing a familiarization phase considerably more moderate than that used in Experiment 2.

The conceptualization of these outcomes appears overly straightforward given that the effects of interest are the combined effects of symmetry and complexity on beauty judgments. However, such an approach was necessary for two reasons. First, from a theoretical standpoint, the approach facilitates an examination of the stability of the effects of complexity and symmetry on aesthetic judgment. Second, from a practical standpoint, an approach based on transfer effects enables the derivation of informative yet straightforward analyses of the crucial aspects of the data and how they relate to previous findings. In the case of Experiments 2 and 3, statistical analyses were focused on planned comparisons of ratings of each stimulus type as a function of familiarization condition, and judgment analyses of response patterns of individual participants (e.g., Jacobsen, 2004).

1. Experiment 1: The combined effects of complexity and symmetry on beauty judgments

The purpose of Experiment 1 was to systematically assess the combined effects of complexity and symmetry on beauty judgments of novel, abstract patterns.

1.1. Method

1.1.1. Participants

Sixteen psychology students from the University of Vienna participated in the study. All the students were female ranging in age from 19 to 29 with a mean age of 23.5. All participants had normal or corrected-to-normal vision.

1.1.2. Materials

The stimuli consisted of 160 basic patterns employed in previous studies (Jacobsen & Höfel, 2001, 2002, 2003; see Fig. 1 for examples). The patterns were selected from the set of 252 patterns used by Jacobsen and his colleagues. Pre-ratings for beauty were used as a baseline for selecting the subset from the larger set; the 40 highest rated patterns for each stimulus type (i.e., CoSy, CoNs, SiSy, and SiNs) were selected. Selection was also based on creating a stimulus set that was clearly delineated in terms of two levels of complexity, as will be discussed below. Each pattern was originally created using 86–88 small graphic elements, which were grouped into larger elements. The patterns were 8.0 centimeters in diameter and composed of the following visual elements arranged within a rhombic shape: oblique bars; large oblique bars; small oblique bars; triangles; large triangles; small triangles; squares; large squares; small squares; rhombi; large rhombi; small rhombi; regular composition; horizontal or vertical bars; large horizontal or vertical bars; and small horizontal or vertical bars. For the purpose of the present study, the patterns were systematically sorted, according to symmetry and complexity characteristics (e.g., Eisenman & Gellens, 1968), into the following category sets (with 40 patterns in each set): complex-symmetrical (CoSy), complex-non-symmetrical (CoNs), simple-symmetrical (SiSy), and simple-non-symmetrical (SiNs). An additional 20 patterns (5 for each category) not included in the main trials were used in the practice trials. The patterns were highly standardized in visual characteristics such as size, brightness, and contrast.

A given pattern was classified as symmetrical when symmetry was present along at least one axis (e.g., vertical, horizontal, and diagonals). The numbers of symmetry axes for the two symmetry categories were: CoSy: 36 quadruple and 4 single; SiSy: 33 quadru-

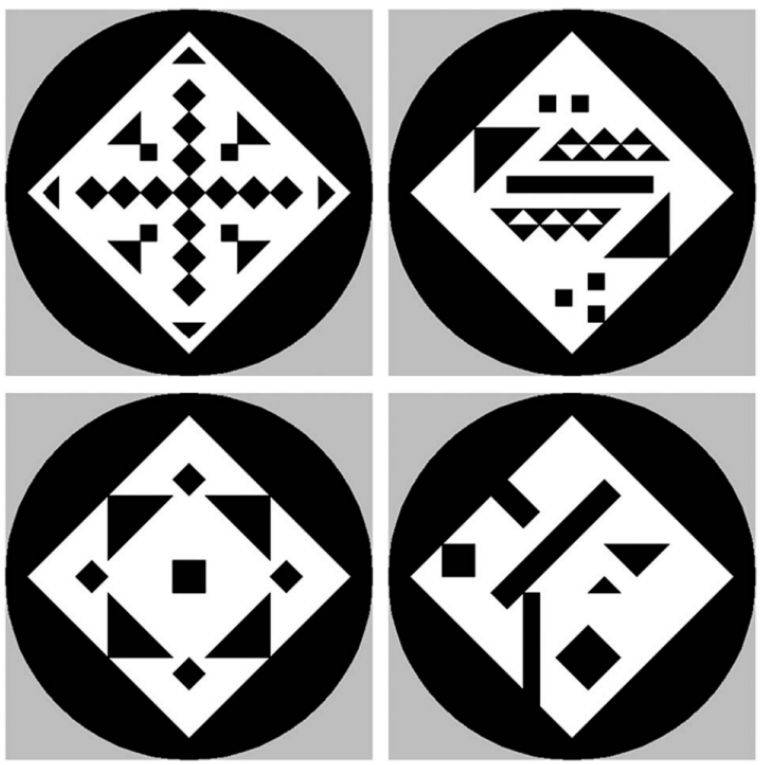

Fig. 1. Examples of the stimuli (from Jacobsen & Höfel, 2001, 2002, 2003; Jacobsen et al., 2006): Complex-symmetrical (upper-left), complex-non-symmetrical (upper-right), simple-symmetrical (lower-left), and simple-non-symmetrical (lower-right).

ple and 7 single. Furthermore, for the CoSy patterns, the distribution of types of axis orientations was: V, H, LD and RD for the patterns with quadruple symmetry; and V for the patterns with single symmetry. For the SiSy patterns, the distribution of types of axis orientations was: V, H, LD and RD for the patterns with quadruple symmetry; four V, two H, and one RD for the patterns with single symmetry.

A given pattern was classified as complex when it was composed of more than 10 individual elements (e.g., triangles and bars). The range and mean values (in parentheses) of individual elements for the patterns in each category were as follows: CoSy: 12–42 (20.3); CoNs: 11–44 (21.8); SiSy: 3–10 (7.23); and SiNs: 3–10 (6.49). Two points must be noted regarding these values. First, the two levels of complexity generally diverged in terms of average number of elements. Second, within each level of complexity, the two groups (i.e., CoSy and CoNs; and SiSy and SiNs) were approximately equal in the number of elements that composed the patterns.

Regarding the two main factors, it is important to note that there is evidence that symmetry could moderate complexity. Specifically, symmetry and complexity may interact in such a way that the presence of symmetry in a particular stimulus could reduce the amount of perceived complexity in that stimulus (e.g., Chipman, 1977; Chipman & Mendelson, 1979). To address this issue, we conducted a study to validate the appropriateness of the classification of the stimuli into the simple and complex categories. Ten undergraduate students (mean age: 21.5; 4 males) participated in the study. The 160 patterns were presented in random order for 3.0 s each, following a 200 ms fixation cross. Participants rated each pattern for "complexity" using a seven-point scale with "1" indicating "less complex" and "7" indicating "more complex." Participants were not provided explicit instructions regarding how to evaluate the patterns for complexity. Thus, participants were free to use their own criteria.

The mean complexity ratings for the patterns were sampled across participants for each stimulus type and were as follows: CoSy, 4.82 (SD = 0.83); CoNs, 5.14 (SD = 0.73); SiSy, 2.66 (SD = 0.42); and SiNs, 2.87 (SD = 0.64). An analysis of variance with symmetry and complexity as within-subject factors and complexity ratings as the dependent variable revealed a significant main effect of Complexity, $F(1, 9) = 98.44$, $p < 0.001$, $\eta_p^2 = 0.92$. The main effect of Symmetry and the interaction between symmetry and complexity were not significant ($p = 0.25$ and $p = 0.34$, respectively). Kayaert and Wagemans (in press), using a delayed matching task and novel shapes, also did not find an interaction between symmetry and complexity. These results provide support for the appropriateness of the classification of the patterns into the two categories of complexity. However, generalization of the results beyond the present study may not be appropriate, as the interaction between complexity and symmetry may depend on context-specific factors.

1.1.3. Procedure

The patterns were presented using Presentation software (version 10.3). Each trial consisted of presenting the following sequence of stimulus events: a cue "How beautiful is this pattern?" for 2.0 s; a fixation cross for 200 ms; the stimulus for 3.0 s; and an inter-trial interval for 2.5 s. The general structure of the experiment was as follows (in order of presentation): instructions; practice trials; instructions; and main trials. In order to become familiar with the trial structure, participants were given 20 practice trials (5 CoSy, 5 CoNs, 5 SiSy, and 5 SiNs patterns), which were identical in structure to the main trials.

Participants provided their responses during the time interval in which the patterns were presented on the screen in order to encourage spontaneous ratings and also to maintain consistent trial durations throughout the experiment. Participants rated each of the 160 patterns for beauty using a seven-point scale with "1" indicating "least beautiful" and "7" indicating "most beautiful." If participants provided a response after the pattern had already been cleared from the screen, they were given a warning message instructing them to respond while the pattern was on the screen. Participants were tested individually, and the presentation of the patterns was randomized.

1.2. Results and discussion

The mean beauty ratings for the patterns were sampled across participants for each stimulus type and were as follows: CoSy, 4.62 (SD = 1.23); SiSy, 3.86 (SD = 0.91); CoNs, 3.31 (SD = 1.01); and SiNs, 2.38 (SD = 0.98). An analysis of variance with symmetry and complexity as within-subjects factors revealed significant main effects of: Complexity, $F(1, 15) = 12.27$, $p < 0.01$, $\eta_p^2 = 0.45$; and Symmetry, $F(1, 15) = 13.62$, $p < 0.01$, $\eta_p^2 = 0.48$. The interaction between symmetry and complexity was not significant ($p = 0.37$). All planned comparisons between mean ratings of each pattern type were significant ($p < 0.01$) with the exception of SiSy vs. CoNs ($p = 0.17$).

The results of Experiment 1 confirmed the predictions that symmetry is a stronger predictor of beauty judgments than complexity. Furthermore, the results support the concept of a combined effect of the two factors with participants providing the highest beauty ratings to CoSy, followed in decreasing order by SiSy, CoNs, and SiNs patterns. In order to further explore these results, judgment analyses of individual response patterns were conducted.

2. Judgment analysis

Judgment analyses of each individual participant's responses were performed to reveal differences in visual cue use for the judgments of the patterns, especially with regard to the main factors: complexity and symmetry. The judgment analysis process employed was consistent with that used by Jacobsen and Höfel (2002) and Jacobsen (2004). Although the focus of the present analyses was on the two factors of symmetry and complexity, specific elements that comprise the patterns were included in the analyses, resulting in a comprehensive assessment of the contribution of each aspect of the patterns to beauty judgments. Thus, for each participant, the following predictors were entered in a multiple regression analysis with beauty ratings as the criterion variable: oblique bars; large oblique bars; small oblique bars; triangles; large triangles; small triangles; squares; large squares; small squares; rhombi; large rhombi; small rhombi; regular composition; horizontal or vertical bars; large horizontal or vertical bars; small horizontal or vertical bars; number of elements; symmetry along one axis; and symmetry along four axes. Cue entry was conducted in a stepwise fashion provided that entering cues exceeded the $p < 0.001$ entry criterion and that their correlation with already entered cues was $r < 0.25$.

2.1. Results and discussion

A judgment analysis could not be performed for one participant as none of the criterion variables met the entry criterion. Results of the judgment analysis across all participants confirmed previous findings (e.g., Jacobsen & Höfel, 2002) with symmetry as the strongest predictor of beauty judgments (80% of participants). Complexity (13% of participants) and *regular composition* (7% of participants) were the second and third strongest predictors. It is important to note that patterns that are regular in composition are typically symmetrical and highly complex. Therefore, caution must be placed in interpreting the *regular composition* factor. Interestingly, two participants had symmetrical at four axes as a negative predictor, thus showing that although symmetry positively affects aesthetic judgments for most participants, others may consider it a negative visual cue.

These results, along with previous findings, indicate the stability or robustness of the effects of symmetry and complexity on aesthetic judgments. Therefore, Experiment 1 results served as comparison data for Experiments 2 and 3, which examined the stability of symmetry and complexity effects following familiarization to one of the four types of patterns. Familiarization was employed as a means of eliciting dynamic changes in the combined effects of symmetry and complexity. Of particular interest to this research was whether the order of mean beauty ratings of the four stimulus types would change as a result of familiarization.

3. Experiment 2: Familiarization and the combined effects of symmetry and complexity on beauty judgments

Experiment 2 addressed the question of whether generalization and contrast effects could be produced by extensive familiarization to CoSy, CoNs, SiSy, or SiNs patterns.

3.1. Method

3.1.1. Participants

Forty psychology students (38 females) from the University of Vienna participated in Experiment 2. Their age ranged from 19 to 29 with a mean age of 21.05. All participants had normal or corrected-to-normal vision.

3.1.2. Materials

The stimuli consisted of the same 160 basic patterns used in Experiment 1.

3.1.3. Procedure

The experiment consisted of two phases. The first phase involved a familiarization procedure, in which participants were familiarized to one of the four possible sets of patterns (i.e., CoSy, CoNs, SiSy, or SiNs) using a matching task that involved same/different judgments of two pseudo-randomly paired and simultaneously presented patterns belonging to the same stimulus set (e.g., both CoSy patterns). This phase consisted of 160 same and 160 different pairs trials for a total of 320 trials. The matching task was employed because it produced an extensive amount of familiarization to the particular stimulus type, in terms of both number of exposures and amount of processing. Moreover, in a pilot study that included a debriefing interview, participants found the task to be challenging and interesting enough to hold their interest for the entire duration of the familiarization phase. An additional five pairs of patterns not included in the main trials were used in practice trials for the matching task. The second phase involved the same beauty ratings as in Experiment 1, where participants were presented the set (i.e., CoSy, CoNs, SiSy, or SiNs) that they were familiarized to in the familiarization phase, as well as the remaining three stimulus sets for a total of 160 rating trials. Experiment 2 lasted for approximately one hour. The assignment of participants into one of the four familiarization groups and the presentation order of stimuli was randomized.

3.2. Results and discussion

Table 1 provides the mean ratings and standard deviations sampled across participants. A mixed analysis of variance with symmetry and complexity as within-subjects factors and familiarization group as between subjects factor revealed significant main effects of Symmetry, $F(1, 36) = 77.90$, $p < 0.001$, $\eta_p^2 = 0.68$ and Complexity, $F(1, 36) = 37.91$, ($p < 0.001$), $\eta_p^2 = 0.51$. In addition, the interaction between Complexity and Familiarization was significant, $F(3, 36) = 5.20$, $p < 0.01$, $\eta_p^2 = 0.30$. There were no other significant interactions. In general, the order of mean beauty ratings for the four pattern types resembles those from Experiment 1. However, as will be shown, massive familiarization resulted in specific influences on the relationship between the two main factors (complexity and symmetry) and beauty judgments (see Fig. 2). Because the focus of this study was on generalization and contrast effects, planned comparisons of the ratings of each stimulus type were conducted. Specifically, differences in ratings of each stimulus type were examined as a function of familiarization condition. Emphasis was placed on significant differences in beauty ratings for each stimulus type. For the sake of conciseness and clarity of presentation, results are organized according to ratings by familiarization condition.

3.2.1. Simple-symmetrical condition

Participants familiarized to simple-symmetrical patterns rated complex-symmetrical patterns significantly more beautiful than participants familiarized to simple-non-symmetrical patterns ($p < 0.05$). Simple-symmetrical familiarized participants rated complex-non-symmetrical patterns significantly more beautiful than did both complex-non-symmetrical ($p < 0.05$) and simple-non-symmetrical ($p < 0.05$) familiarized participants.

3.2.2. Complex-non-symmetrical condition

Participants familiarized to complex-non-symmetrical patterns rated simple-symmetrical patterns significantly more beautiful than participants familiarized to simple-symmetrical ($p < 0.05$), complex-symmetrical ($p < 0.05$), and simple-non-symmetrical ($p < 0.01$) patterns. Participants familiarized to complex-non-symmetrical patterns also rated simple-non-symmetrical patterns significantly more beautiful than participants familiarized to simple-non-symmetrical patterns ($p < 0.05$).

3.2.3. Complex-symmetrical and simple-non-symmetrical conditions

Participants familiarized to complex-symmetrical and simple-non-symmetrical patterns did not show significantly higher beauty judgments of particular stimulus types than the other familiarization groups.

It appears that familiarization effects were more pronounced for the simple-symmetrical and complex-non-symmetrical familiarization conditions. It is important to note that of the four stimulus types, the simple-symmetrical and complex-non-symmetrical patterns had the distinct quality of a fully crossed positive (complex and symmetrical) and negative (simple and non-symmetrical) stimulus characteristics. These two groups were isolated and compared in a mixed analysis of variance. There were significant main effects of Symmetry ($p < 0.001$) and Complexity ($p < 0.001$). In addition, the interaction between Complexity and Familiarization was significant ($p < 0.001$). Fig. 3 provides a graphic depiction of these results.

Closer inspection of the results reveals that participants familiarized to simple-symmetrical patterns found complex-symmetrical ($p < 0.05$) and complex-non-symmetrical ($p < 0.05$) patterns significantly more beautiful than participants familiarized to complex-non-symmetrical patterns. Furthermore, participants familiarized to complex-non-symmetrical patterns found simple-symmetrical ($p < 0.05$) and simple-non-symmetrical ($p < 0.05$) patterns significantly more beautiful than participants familiarized to simple-symmetrical patterns.

The effects of familiarization were found in the beauty ratings of participants familiarized to simple-symmetrical and complex-non-symmetrical patterns. This is reflected in the significant Complexity × Familiarization interactions in the two- and four-group mixed ANOVAs. A direct comparison of these two groups showed that familiarization to simple-symmetrical patterns produced a contrast effect in which novel complex patterns – whether symmetrical or non-symmetrical – are judged as being more beautiful. Moreover, familiarization to complex-non-symmetrical patterns also produced a contrast effect wherein unfamiliar simple patterns – whether symmetrical or non-symmetrical – were evaluated as being more beautiful. To explore these effects further, analyses beyond the group level were necessary to investigate individual participants' use of specific stimulus characteristics in their judgments of beauty. Thus, judgment analyses of individual participants' responses were performed.

4. Judgment analysis

Judgment analyses were performed for Experiment 2 using the same procedure as in Experiment 1. Cue entry was again conducted in a stepwise fashion provided that entering cues exceeded the $p < 0.001$ entry criterion and that their correlation with already entered cues was $r < 0.25$. Particular focus was placed on between-group differences as a function of familiarization to either CoSy, SiSy, CoNs, or SiNs patterns.

4.1. Results and discussion

Judgment analyses could not be performed for three participants as none of the criterion variables met the entry criterion. Most of the participants had symmetry (57%) and complexity (32%) as the main predictors of beauty judgments. For the reasons discussed above, the discussion of the results will focus on these two factors. Results of the judgment analyses across all participants and familiarization groups confirmed Experiment 1 findings with symmetry as the strongest and complexity as the second strongest predictor of beauty judgments.

The judgment analyses also revealed distinct response patterns of the familiarization groups. Seven participants familiarized to CoNs, five to CoSy, five to SiNs, and four to SiSy patterns had symmetry as the most important predictor of beauty ratings. Five participants familiarized to SiSy, three to CoSy, and three to SiNs had complexity as the main predictor. Interestingly, only one participant familiarized to CoNs had complexity as the most important predictor. One of each of the three CoSy and three SiNs familiarized participants demonstrated an inverse use of the complexity factor – preferring less complex patterns.

The results of the group-level analysis showed that participants familiarized to simple-symmetrical patterns come to prefer complex patterns. The judgment analysis confirms and clarifies this finding by showing that those participants indeed found complex patterns more beautiful regardless of symmetry; five participants had complexity as the most important predictor. The group-level analysis also showed that participants familiarized to complex-non-symmetrical patterns come to prefer simple patterns. Only one of these participants had complexity as a primary predictor.

Several issues related to these results must be considered. First, according to the arousal potential concept (Berlyne, 1970), a contrast effect for complexity is expected for participants familiarized to simple patterns. The finding that participants familiarized to complex patterns judge simple patterns more positively in a subsequent rating phase contradicts this expectation. Second, from the standpoint of classic mere-exposure (Zajonc, 1968), patterns previously seen should have been judged most favorably by the participants. The results do not support this as none of the groups showed a positive bias towards the patterns that they were familiarized to. In fact, it can be argued that participants subsequently judged patterns that were "structurally" opposite to those that they were familiarized to as more beautiful, thus resulting in the contrast effects. In other words, participants may have liked what

Table 1
Experiment 2 and Experiment 3 mean beauty ratings and standard deviations (in parentheses) of patterns by familiarization group. Means that share a common letter subscript differ at $p < 0.05$.

Fam. group	CoSy	SiSy	CoNs	SiNs
Experiment 2				
Pattern type				
CoSy fam.	5.02 (*1.37*)	3.96 (*0.79*)$_b$	3.29 (*1.11*)	2.41 (*0.99*)
SiSy fam.	5.57 (*0.87*)$_a$	3.84 (*1.03*)$_c$	3.84 (*0.72*)$_{e,f}$	1.99 (*0.48*)
CoNs fam.	4.76 (*0.70*)	4.67 (*0.57*)$_{b,c,d}$	3.11 (*0.49*)$_e$	2.81 (*0.88*)$_g$
SiNs fam.	4.39 (*1.18*)$_a$	3.71 (*0.52*)$_d$	2.97 (*0.64*)$_f$	2.31 (*0.73*)$_g$
Experiment 3				
Pattern type				
CoSy fam.	4.95 (*1.10*)	3.67 (*0.86*)	3.50 (*1.06*)	2.44 (*1.08*)
SiSy fam.	4.18 (*1.33*)$_h$	3.45 (*1.28*)	3.05 (*1.27*)	2.30 (*1.06*)
CoNs fam.	5.16 (*0.51*)$_h$	3.95 (*0.93*)	3.73 (*1.04*)	2.10 (*0.81*)
SiNs fam.	4.75 (*1.34*)	3.75 (*1.07*)	3.23 (*0.91*)	2.00 (*0.74*)

Note: CoSy = complex-symmetrical; SiSy = simple-symmetrical; CoNs = complex-non-symmetrical; SiNs = simple-non-symmetrical. CoSy fam = familiarized to complex-symmetrical; SiSy fam = familiarized to simple-symmetrical; CoNs fam = familiarized to complex-non-symmetrical; SiNs fam = familiarized to simple-non-symmetrical stimuli.

was different following familiarization. It is also possible that the familiarization was so extensive that the classic exposure effects were "washed out." Biederman and Vessel (2006) suggested that mere-exposure effects only represent the early aspect of the familiarity-liking function, and are thus only sensitive for few repetitions. Furthermore, Bornstein's (1989) comprehensive meta-analysis suggests that when it comes to familiarization, less is more, in that moderate familiarization is more likely to induce affect change in subsequent ratings of stimuli. In order to explore this issue, Experiment 3 involved moderate familiarization involving the same matching task used in Experiment 2, though with only 80 trials.

5. Experiment 3: Moderate familiarization and the combined effects of symmetry and complexity on beauty judgments

Experiment 3 employed a familiarization phase that provided less extensive exposure to one of the four stimulus types. It was more consistent with the classic mere-exposure paradigm (Zajonc, 1968) as discussed above. The familiarization phase in Experiment 3 consisted of only a fourth of the number of trials included in Experiment 2.

5.1. Method

5.1.1. Participants

Forty-eight psychology students (36 females) from the University of Vienna participated in Experiment 2. Their age ranged from 18 to 29 with a mean age of 20.9. All participants had normal or corrected-to-normal vision.

5.1.2. Materials

The stimulus set consisted of the same 160 basic patterns used in Experiments 1 and 2.

5.1.3. Procedure

The same 160 patterns (40 of each type of pattern) employed in the previous two experiments were used. As in Experiment 2, two phases were involved: a familiarization phase to one of the four possible sets of stimuli using a matching task that included 80 trials (consisting of 40 same and 40 different, pseudo-randomly paired, and simultaneously presented stimuli of the same type); and a judgment phase in which participants rated the set that they were familiarized to in phase one, as well as the remaining three

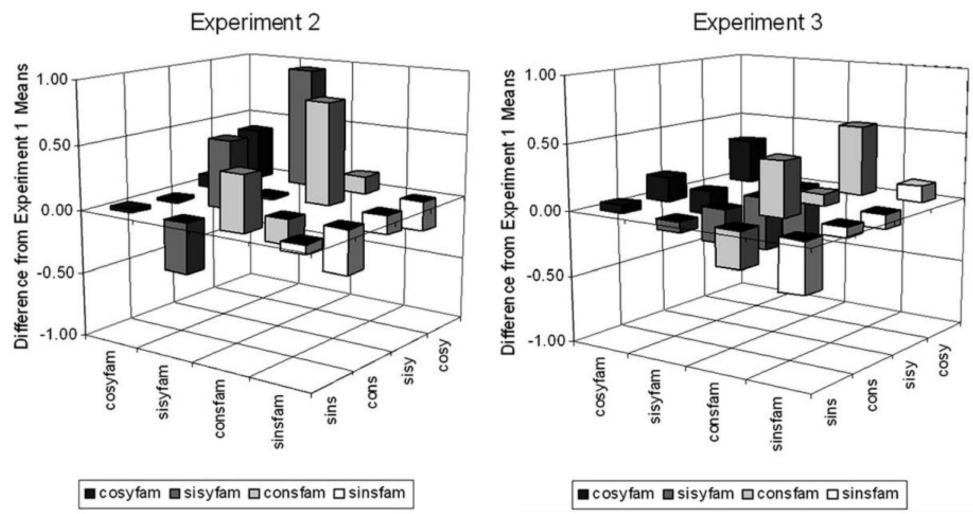

Fig. 2. Differences from Experiment 1 means as a function of familiarization condition. CoSy fam = familiarized to complex-symmetrical; SiSy fam = familiarized to simple-symmetrical; CoNs fam = familiarized to complex-non-symmetrical; SiNs fam = familiarized to simple-non-symmetrical stimuli.

stimulus sets for beauty using the same rating procedure as in the two previous experiments. Experiment 3 lasted for approximately 30 min, with the familiarization phase a quarter less extensive than in Experiment 2. The assignment of participants into one of the four familiarization groups and the presentation order of stimuli were randomized.

5.2. Results and discussion

Table 1 also provides the mean ratings and standard deviations sampled across participants for Experiment 3. A mixed analysis of variance with symmetry and complexity as within-subjects factors and familiarization group as between subjects factor revealed significant main effects of Symmetry, F (1, 44) = 60.35, $p < 0.001$, $\eta_p^2 = 0.58$, and Complexity, F (1, 44) = 57.49, $p < 0.001$, $\eta_p^2 = 0.57$. In contrast to Experiment 2, there were no significant interactions with Familiarization (see Fig. 2). As with Experiment 2, differences in ratings of each stimulus type were examined as a function of familiarization condition. Participants familiarized to CoNs patterns judged CoSy patterns significantly more beautiful than participants familiarized to SiSy patterns ($p < 0.05$). There were no other significant effects.

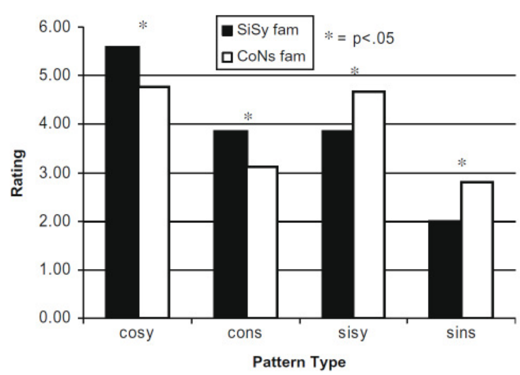

Fig. 3. Mean beauty ratings of patterns by SiSy and CoNs familiarized groups.

Symmetry and complexity appear to influence beauty judgments following moderate familiarization to one stimulus type. Planned comparisons revealed only one effect, that of CoNs familiarized participants finding CoSy patterns more beautiful than SiSy familiarized participants. Isolating the CoNS familiarized and SiSy familiarized groups in a two-group analysis confirmed this finding ($p < 0.05$). However, there were no other significant effects (except main effects for symmetry and complexity) similar to those found in Experiment 2. With the absence of other findings, this single effect is difficult to interpret. Hence, judgment analyses were performed to further explore the data, especially at the level of individual judgments.

6. Judgment analysis

Judgment analyses were also performed for Experiment 3 using the same procedure as in Experiments 1 and 2. Cue entry was conducted in a stepwise fashion provided that entering cues exceeded the $p < 0.001$ entry criterion and that their correlations with already entered cues were $r < 0.25$.

6.1. Results and discussion

Most of the participants had symmetry (60%) and complexity (23%) as the most important predictors of beauty judgment. Results of the judgment analysis across all participants and familiarization groups confirmed the previous findings with symmetry as the strongest and complexity as the second strongest predictor of beauty judgments. The judgment analyses revealed distinct response patterns of the familiarization groups. Nine participants familiarized to CoSy, seven to CoNs, seven to SiNs, and six to SiSy stimuli had symmetry as the most important predictor. One participant familiarized to CoSy, two to SiNs, and three to CoNs had complexity as the most important predictor. In contrast, five participants familiarized to SiSy employed complexity as the most significant predictor with one of the five demonstrating an inverse use of the cue – preferring fewer numbers of elements.

It is apparent that judgment analyses of individual response patterns can help in exploring the general findings derived from group-level analyses. The finding in Experiment 3 that participants familiarized to CoNs stimuli found CoSy patterns more beautiful than participants familiarized to SiSy stimuli may be due to the three CoNs familiarized participants who had complexity as the most important predictor of their judgments. This is in contrast to one participant who was familiarized to CoNs stimuli having complexity as the primary predictor in Experiment 2. However, such an interpretation may not suffice to completely explain the responses of participants familiarized to CoNs stimuli in Experiment 3.

7. General discussion

In this research, we examined the stability of the effects of symmetry and complexity on aesthetic judgment. We also critically explored the results by employing judgment analyses of participants' individual response patterns. Experiment 1 confirmed previous findings (e.g., Eisenman & Gellens, 1968; Jacobsen & Höfel, 2001) that symmetry and complexity are strong predictors of aesthetic judgment. The categorization of the patterns into four stimulus sets clearly delineated the combined effects of the two features, thus extending what is known from previous studies. Based on the findings, it is apt to conclude that the effects of symmetry and complexity on aesthetic judgment are quite robust, even when assessing their effects using different stimuli, participants, and testing contexts. The stability of the effects of visual features on aesthetic judgment seems fitting, given the human need to efficiently deal with the constantly changing aspects of the environment. However, Experiment 2 revealed that even seemingly stable effects are susceptible to changes brought about by massive familiarization. What resulted is a kind of "craving for novelty," which is consistent with Biederman and Vessel's (2006) finding that following familiarization, people come to prefer the novel, and is inconsistent with results from traditional mere-exposure studies (e.g., Bornstein, 1989; Zajonc, 1968).

What is particularly interesting is that massive familiarization did not merely result in a general decrease in ratings, a pattern associated with a boredom-related response. The contrast effects found in Experiment 2 suggest that massive exposure to stimuli could result in higher judgments of beauty for structurally opposite stimuli, which is in contrast to the idea of structural generalization effects (Gordon & Holyoak, 1983; Manza & Bornstein, 1995).

It also appears that the effects of some features are more stable than others. In the case of Experiment 2, the effects of complexity on aesthetic judgment were sensitive to familiarization, while the effects of symmetry were not – at least when assessed at the group level. Familiarization generated contrast effects for complexity. Specifically, participants familiarized to simple patterns subsequently found complex patterns more beautiful than simple patterns; and participants familiarized to complex patterns subsequently found simple patterns more beautiful than complex patterns. Such dynamic changes are consistent with results of previous studies using methodologies that were more elaborated (e.g., Carbon & Leder, 2005, 2006) than those used in traditional exposure studies (e.g., Zajonc, 1968).

The moderate familiarization employed in Experiment 3 was not sufficient to generate contrast effects, even with the slightly larger sample used. It seems that extensive familiarization was necessary. This suggests that the effects of complexity in most contexts are rather stable and that its stability is challenged only by extreme experimental manipulations. Future studies should be directed towards specifying the exact amount of familiarization necessary to generate contrast effects by providing different levels of familiarization.

Future studies should also directly examine – as primary research questions – the effects of massive familiarization on the aesthetic judgment of specific aspects of symmetry, in a manner similar to previous work on symmetry detection (for comprehensive reviews, see e.g., Van der Helm & Leeuwenberg, 1996; Wagemans, 1995, 1997, 1999). Using these studies as a foundation, it would be fruitful to examine the relationship between massive familiarization and aesthetic judgment of stimuli in terms of varying numbers of symmetry axes (e.g., Wagemans et al., 1991); different symmetry orientations (e.g., Wenderoth, 1994); types of symmetry – bilateral, rotational, and translational (see Corballis & Roldan, 1974; Darvas, 2007; Wagemans, 1995; Wagemans, van Gool, Swinnen, & van Horebeek, 1993); clustering or grouping of stimulus elements (e.g., Locher & Wagemans, 1993; Strother & Kubovy, 2003; Wenderoth, 1996); and, as suggested by Locher and Wagemans (1993), the interaction between element type and grouping. The latter question could shed further light on the finding of the present study that some participants had visual features, in addition to the two main factors, as the primary predictors of their judgments. Such interaction may help explain why some people are sensitive to less salient features. Future studies should also examine the questions explored in the present study using more meaningful stimuli such as faces or artworks.

The results of this study are limited in terms of their ability to explain the influence of number of symmetry axes on aesthetic judgment, because levels of this factor were not equally balanced across each set of symmetrical patterns. Related to this issue is the question of whether the same results would have been obtained if analyses were focused only on the patterns with quadruple symmetry, which represents most of the symmetrical patterns used in the study. To address this question, we performed a re-analysis of the data for all three experiments with the data points from non-quadruple symmetrical patterns removed for each participant. The results of the re-analysis for all three experiments were similar (in terms of decisions for the hypotheses tests and direction of effects) to those of the original analyses. For Experiment 1, the main effects, interaction, and pairwise comparisons were identical to the results of the original analyses. For Experiment 2, the main effects, interactions, and specific comparisons among the four familiarization groups were identical to those of the original analyses. The focused analysis involving the SiSy and CoNs familiarized groups also remained unchanged. Finally, for Experiment 3, the main effects, interactions, and specific pairwise comparisons were also identical to those of the original analyses.

The use of judgment analyses to explore participants' response patterns was successful in two aspects. First, analysis at the individual level supported and augmented the results of the group level analyses. In general, the judgment analyses indicated that the most influential visual features were symmetry and complexity. Second, the richness concerning the differences in participants' responses was made more salient by the judgment analyses. The analyses showed, in detail, that several participants actually had symmetry and complexity as negative predictors of their aesthetic judgments. Thus, we recommend that future studies in aesthetics employ judgment analyses to augment group-level analyses.

People's interactions with the environment may demand automatic and consistent responses. However, when conditions go above and beyond those in typical contexts – such as massive exposure to an object – responses could be altered. In this respect, the present study shows how preferences are generally a complex combination of automatic responses and adaptable processes for dealing with dynamic aspects of the environment. Taken together, the present findings shed light on the complexities of aesthetic judgment by having subjected visual features assumed to be stable to the intense and dynamic "jaws" of massive familiarization, and by having examined the intricacies of aesthetic judgment through the systematic assessment of individual response patterns.

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2.3. Discussion

The studies examined the modulating influence of familiarization on the combined effects of complexity and symmetry on aesthetic judgments of abstract patterns. Results revealed that the effects of symmetry and complexity on aesthetic judgments were robust, although the effects of symmetry appeared more robust that those of complexity. Massive familiarization was able to generate contrast effects for complexity, although generalization effects consistent with structural mere-exposure (e.g., Gordon & Holyoak, 1983) were not found. The robustness of the responses to certain visual features may reflect the human need for automatic and consistent reactions to common elements of everyday environments. However, typical responses could be altered when contextualized within more unusual or extreme circumstances.

The results of these experiments effectively extended the literature in several respects. First, it focused on massive familiarization, going above and beyond the typical level of familiarization used in mere-exposure studies. This approach points to the importance of examining psychological phenomena using experimental manipulations that exceed the usual levels used in previous studies. In this case, the increase in the strength of the experimental manipulations allowed for a more extensive assessment of the range of responses. Second, this research revealed a new type of contrast effect. It has previously been shown (e.g., Berlyne, 1970) that people familiarized to simple stimuli subsequently respond more favorably to complex stimuli. However, the present study was the first to show the inverse effect, with participants familiarized to complex stimuli later judging simple stimuli more beautiful. Third, the group-level statistical analyses were augmented by a judgment analysis of each participant's responses according to Jacobsen (2004) and Jacobsen and Höfel's (2002) approach. The results confirmed and extended their work, and indicated the importance of assessing effects at the level of individual research participants.

The next chapter describes an extension of these experiments in which composite faces were used. As compared to the abstract patterns, the faces were associated with greater semantic complexity and ecological validity.

3.

Symmetry, Complexity, Familiarization, and the Attractiveness of Faces

3.1. Introduction

The article discussed in this chapter is in preparation. Aspects of the data were presented at the *2009 Copenhagen Neuroaesthetics Conference*, Copenhagen, Denmark; and will be presented at the *2010 Annual Meeting of Experimental Psychologists* (TeaP), Saarbrücken, Germany.

It develops on the studies reported in the previous chapter and also addresses the early stages of Leder et al.'s (2004) model of aesthetic experiences and aesthetic judgments. In these studies, we used faces as stimuli. The shift from using abstract patterns to faces parallels the distinction between abstract and representational art as discussed by Leder et al. In general, faces have greater biological and social significance than the simple and abstract patterns used in the previous studies. There is evidence that faces constitute a special class of objects, as they are perceived and processed differently from other objects (Leder & Bruce, 2000). They also have been shown to capture (Fletcher-Watson, Findlay, Leekan, & Benson, 2008) and bind attention (Bindemann, Burton, Hooge, Jenkins, & de Haan, 2005). Moreover, special brain regions for face perception (Kanwisher, McDermott, & Chun, 1997) have been identified.

We sought to capitalize on this distinct quality of faces as visual stimuli by testing new hypotheses concerning the effects of visual features on aesthetic judgments. People are accustomed to looking at, and evaluating faces. Faces are also more likely than abstract patterns to tap into long-term memory, and thus be associated to perceivers' previous experiences. In the experiments discussed in Chapter 2, contrast effects were found for complexity but not for symmetry, even after massive familiarization. In the studies discussed in this chapter, we focused on face-specific generalization and contrast effects involving complexity and symmetry.

Unlike facial symmetry, for which there is extensive research available, little is known about the effects of complexity on the aesthetic evaluation of faces. Our operational definition of facial complexity involved higher numbers of facial elements for the complex faces than the simple faces. The two levels of complexity (simple and complex) were crossed with the two levels of symmetry (symmetrical and nonsymmetrical) resulting in four types of stimuli just as in our previous studies using abstract patterns. It is important to note that the complexity manipulation led to an increase in the negative valence of complex faces.

Results of three experiments confirmed the hypothesis that simple-symmetrical faces would be judged as most attractive, followed in decreasing order of attractiveness by simple-nonsymmetrical, complex-symmetrical, and complex-non-symmetrical faces. These results are consistent with the results found in the studies reported in the previous chapter. Both studies demonstrated that the effects of the main factors on aesthetic judgments were additive. In the present experiments, participants' ratings of the emotionality of the faces confirmed the more negative valence of complex faces as compared to simple faces. In general, symmetrical faces were rated as more attractive than nonsymmetrical faces, and simple faces were rated as more attractive than complex faces. As with the studies reported in Chapter 2, we assessed the modulating influence of familiarization on the effects of symmetry and complexity on the aesthetic judgments of faces. Based on the special status of faces as visual stimuli, as discussed above, we explored the possibility that generalization effects of complexity and symmetry—after familiarization—would be found for the faces. But because symmetry, and to a lesser extent complexity, is robust in their effects, we also hypothesized that effects would only be apparent through massive familiarization. We showed that familiarization can indeed modulate the effects of symmetry and complexity, but only if familiarization is extensive, and that the effects were not due to a change in perceived emotion.

3.2. Original Manuscript

Running Head: SYMMETRY, COMPLEXITY, AND FAMILIARITY EFFECTS

Symmetry, Complexity, Familiarization, and the Attractiveness of Faces

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Symmetry, Complexity, Familiarization, and the Attractiveness of Faces

Introduction

The influence of low-level visual features on aesthetic responses to visual stimuli has been examined since Fechner's (1876) early studies on aesthetics. There is an extensive body of evidence showing that the presence of certain visual features, such as curvature in objects (e.g., Bar & Neta, 2006, 2007, 2008; Silvia & Barona, 2009), increases the object's aesthetic value. Studies have also shown that the effects of certain visual features are robust, and that extreme manipulations are necessary to modulate their effects. Tinio and Leder (2009) have demonstrated the robustness of the effects of symmetry and complexity on the aesthetic judgments of abstract patterns. However, the study also showed that when participants were subjected to massive familiarization to certain categories of stimuli, contrast effects were found. In this paper, we report on studies that examined the effects of symmetry and complexity on the aesthetic judgments of faces, and how familiarization modulates these effects. We capitalized on the greater biological and social significance of faces as compared to the abstract patterns that have been used in previous studies.

The perception and aesthetic evaluation of faces as compared to other objects are unique. Studies have shown that faces capture visual attention (Fletcher-Watson, Findlay, Leekan, & Benson, 2008), and this has also been found in brain damaged individuals (Vuilleumier, 2000). Moreover, once attention is captured, faces also seem to bind that attention, regardless of whether the faces have been seen previously or not (Bindemann, Burton, Hooge, Jenkins, & de Haan, 2005). The attentional advantage of faces could be attributed to how they are processed, as it is widely believed that faces are processed in a unique manner (Leder & Bruce, 2000; Ro, Russell, & Lavie, 2001). Research has also identified special brain regions that are recruited for face processing (e.g., Allison, Puce, Spencer, & McCarthy, 1999; Kanwisher, 2000; Kanwisher, McDermott, & Chun, 1997).

Aesthetic responses to faces also appear to involve specific neural patterns (O'Doherty et al., 2003; Winston, O'Doherty, Kilner, Perrett, & Dolan, 2007). This has been shown regardless of whether the faces were explicitly or inexplicitly evaluated for attractiveness, suggesting that aesthetic responses to faces are automatic and transpire pre-attentively (Chatterjee, Thomas, Smith, & Aguirre, 2009; Susac, Ilmoniemi, Pihko, Nurminen, Supek, & 2009). Thus, there is extensive evidence indicating that aesthetic responses to faces are different from aesthetic responses to other stimuli. We premised our research on this seemingly special status of faces.

In the studies presented here, we examined the influence of symmetry on aesthetic judgments of faces. Symmetry is salient both in natural objects such as crystals and in human artifacts such as artworks (Darvas, 2007; Weyl, 1983). There seems to be a visual bias towards symmetry. Symmetry is visually salient (van der Helm & Leeuwenberg, 1996; Wagemans, 1995, 1997, 1999), it can be detected pre-attentively (Chatterjee, 2004; Locher & Wagemans, 1993), and its detection is robust against such factors as slight symmetry perturbations (Barlow & Reeves, 1979; Locher & Smets, 1992; Wagemans, 1993; Wagemans, van Gool, & d'Ydewalle, 1992; Wenderoth, 1997). The manner in which stimuli can be visually explored is also influenced by the presence of symmetry (Locher & Nodine, 1973, 1987). Moreover, symmetry has been shown to facilitate short-term recognition memory for basic shapes (Kayaert & Wagemans, 2009).

In terms of aesthetic judgments, symmetrical stimuli such as abstract designs (Cardenas & Harris, 2006) and patterns (Jacobsen & Höfel, 2001, 2002, 2003; Jacobsen, Schubotz, Höfel, & van Cramon, 2006; Tinio & Leder, 2009) are judged more positively than their nonsymmetrical counterparts. The positive influence of symmetry on aesthetic judgments is especially evident in evaluations of human faces. Symmetrical faces are judged as more attractive than nonsymmetrical faces (e.g., Cardenas & Harris, 2006; Grammer & Thornhill, 1994; Little, Jones, DeBruine, & Feinberg, 2008; Mealey, Bridgstock, & Townsend, 1999; Perrett et al., 1999; Rhodes, Proffitt, Grady, & Sumich, 1998). There is also evidence that the preference for symmetry in faces is present in all cultures, and is a deep feature of human biology (Little, Apicella, & Marlowe, 2007**;** Little, Jones, Waitt, et al., 2008; Rhodes, Yoshikawa, et al., 2001). It has been suggested that symmetry in faces and bodies signal successful adaptation to various environmental pressures, and genetic and reproductive fitness (Jones et al., 2001; Rhodes, Zebrowitz, et al., 2001; Singh, 1995; Thornhill & Gangestad, 1999, 2006). Symmetry has also been shown to be an important characteristic even for non-human species (Moller & Thornhill, 1998; Thornhill & Moller, 1998).

Two factors associated with symmetry perception have been addressed extensively in previous studies. The first factor is the number of symmetry axes in a stimulus. Symmetry contributes to the processing of stimuli, and stimuli with greater numbers of symmetry axes have a processing advantage over stimuli with less (Palmer & Hemenway, 1978; Royer, 1981; Wagemans, van Gool, & d'Ydewalle, 1991). The second factor involves the orientation of symmetry axes. Axes orientation could be vertical, horizontal, diagonal, or any other orientations between these axes. Detection of symmetry is easiest when it is on the vertical axis (Corballis & Roldan, 1975; Wagemans et al., 1992). The stimuli used in the present study consisted of faces that were bilaterally symmetrical. Thus, there was only one axis of symmetry, and this occurred on the vertical axis. We assumed, based on the seemingly special status of faces and the salience of vertical symmetry, that symmetry in face stimuli are particularly salient. Such salience was further enhanced by the presentation environment in this study, which involved the central presentation of the faces on the screen resulting in the placement of the vertical symmetry axis directly at fixation point. Previous research has shown that symmetry is most salient when it is presented at or near fixation point (Barlow & Reeves, 1979; Locher & Nodine, 1989).

Complexity is another visual feature found to be highly influential to aesthetic judgments. Since the early days of empirical research on aesthetics, complexity has been considered as an important factor in aesthetic judgments. For example, in Eysenck's (1941) formulation of an aesthetic measure, complexity contributed positively to the aesthetic value of an object. Other studies have shown that complex abstract patterns (e.g., Jacobsen & Höfel, 2002; Tinio & Leder, 2009), artworks (Osborne & Farley, 1970), schematic renditions of building facades (Imamoglu, 2000), and graphic advertisements (Cox & Cox, 2002) were preferred over their corresponding simple versions.

Regrettably, there is a general lack of research on the influence of complexity on the aesthetic judgments of faces. Therefore, it is not known whether complexity in faces has a positive or a negative influence in how they are judged aesthetically. There are also no standard practices regarding how complexity in face stimuli should be operationally defined. Existing approaches to defining complexity are mainly concerned with basic shapes and patterns (e.g., Berlyne, 1963, 1970). We based our approach on previous studies that have used stimuli that simultaneously varied in both symmetry and complexity (e.g., Eisenman & Gellens, 1968; Jacobsen & Höfel, 2001; Tinio & Leder, 2009). In those studies, complexity was defined in terms of the number of distinct elements that comprised a stimulus. This way of defining complexity is considered direct given the existing evidence that even at an early age, responses to the complexity of visual stimuli are based largely on the number of elements (Chevrier & Delorme, 1980), and given the approach that we employed to produce the face stimuli. We used a face composition program to create composite faces that systematically varied in the number of facial features. Thus, we operationally defined complexity as the number of additional facial features added to a face template. The simple faces were comprised of the following seven features: forehead contour, overall face contour, jaw contour, eyes, eyebrows, nose, and mouth. For the complex faces, forehead lines, cheek lines, and mouth lines were included in addition to the previous seven features.

In Experiment 1, the combined effects of symmetry and complexity on aesthetic judgments were examined using four categories of faces with each set corresponding to a particular combination of the two factors. The categories were the following: simple-symmetrical (SiSy), simple-nonsymmetrical SiNs, complex-symmetrical (CoSy), and complex-nonsymmetrical (CoNs). Participants rated the faces for attractiveness. It is important to note that the use of the three additional features to create the complex faces led to a change in the emotional valence of the faces. In general, complex faces appeared to have more negative emotional expressions than the simple faces. To account for this in our analyses and interpretations, participants also rated the faces for their emotional valence. Moreover, participants rated the faces for distinctiveness to verify that there was no difference between simple and complex faces in this factor.

We hypothesized that participants would judge the SiSy faces as most attractive, followed in decreasing order of attractiveness by SiNs, CoSy, and CoNs faces. We based these hypotheses on previous studies that have shown the positive influence of symmetry on aesthetic judgments (e.g., Grammer & Thornhill, 1994; Jacobsen & Höfel, 2001), and on the two levels of emotional valence that resulted from the complexity manipulation. Thus, symmetrical faces should be judged more attractive than nonsymmetrical faces, and simple faces should be judged more attractive than complex faces.

Experiments 2 and 3 assessed the modulating influence of familiarization on the effects of symmetry and complexity on the aesthetic judgments of the faces. While symmetry and complexity are strong predictors of aesthetic judgment of various stimuli (e.g., Eisenman & Gellens, 1968), recent studies have shown that dynamic factors could modulate the effects of visual features on aesthetic judgments (e.g., Carbon & Leder, 2005, 2006; Tinio & Leder, 2009). In Experiments 2 and 3, participants were familiarized to one of the four types of faces. Following familiarization, they rated the faces to which they were familiarized and the other three sets of faces for attractiveness.

Familiarization effects were first examined by Zajonc (1968) in a series of correlational and experimental studies using stimuli such as nonsense words and photographs of faces. He showed that repeated exposure to a certain stimulus resulted in more positive affect for that stimulus. Zajonc's *mere-exposure* effect has received considerable attention from researchers (for comprehensive reviews, see Bornstein, 1989; Stang, 1974). According to the mere-exposure concept, participants in the present study should judge the faces to which they were familiarized as more attractive than the novel faces.

In our analysis, we placed emphasis on generalization effects that may be elicited by familiarization. This is consistent with the *structural mere exposure* phenomena, which is a concept that is similar to mere-exposure. Structural mere exposure refers to the transfer of effects from a familiar stimulus to a similar but novel stimulus (Gordon & Holyoak, 1983; Manza & Bornstein, 1995; Monahan, Murphy, & Zajonc, 2000; Newell & Bright, 2001; Zizak & Reber, 2004). Structural mere exposure studies typically focus on the transfer of artificial grammatical structures from a familiar to an unfamiliar but similar stimulus. Thus, traditional mere exposure assumes positive affect towards familiar stimuli, while structural mere exposure assumes positive affect towards familiar structures in stimuli. In the present study, we focused on the transfer of the effects of facial structures—mainly the effects of symmetry and complexity—from familiar to unfamiliar but similar faces. This is a type of *structural generalization*, which Tinio and Leder (2009) have previously discussed.

We also examined the possibility of contrast effects, especially in relation to the interaction between familiarization and complexity. According to Berlyne's (1970, 1971) *arousal potential* theory, stimuli with high complexity are evaluated more positively than stimuli with low complexity through increasing exposure. This is consistent with the idea that people prefer a moderate level of arousal. Thus, upon initial presentation, low complexity stimuli possess moderate levels of arousal potential, which decreases through increasing exposure. In contrast, high complexity stimuli upon initial presentation have undesirably high levels of arousal potential. However, through increasing exposure, the arousal potential decreases to moderate levels, which results in subsequent liking of the complex stimuli.

Tinio and Leder (2009), using abstract patterns, found *structural contrast* effects for the complexity factor following a massive familiarization phase. Participants familiarized to complex patterns subsequently rated simple patterns more beautiful than complex patterns. Likewise, participants familiarized to simple patterns subsequently rated complex patterns more beautiful than simple patterns. In the present study, we predicted that generalization effects of symmetry and complexity were likely to occur because facial stimuli have biological and social significance, and because they are visually dynamic. We also predicted that such effects would only be found following massive familiarization (Experiment 2) to a particular type of face, and that moderate familiarization (Experiment 3) would not be sufficient. In terms of the emotional valence of the faces resulting from the complexity manipulation, we expected similar patterns in the emotional valence ratings of the faces between the moderate and massive familiarization conditions. This expectation is based on recent studies that have shown that familiarization has little effect on the processing of emotional stimuli (e.g., Schupp, et al., 2006).

Experiment 1

Method

Participants

Eighteen undergraduate students (15 females; mean age: 21.57; range: 19-26) from the University of Vienna, Department of Psychology participated in the experiment for partial course credit. The nature of the procedures was explained to, and informed consent was obtained from, each participant prior to data collection. All participants had normal or corrected-to-normal vision and none were aware of the purpose of the experiment.

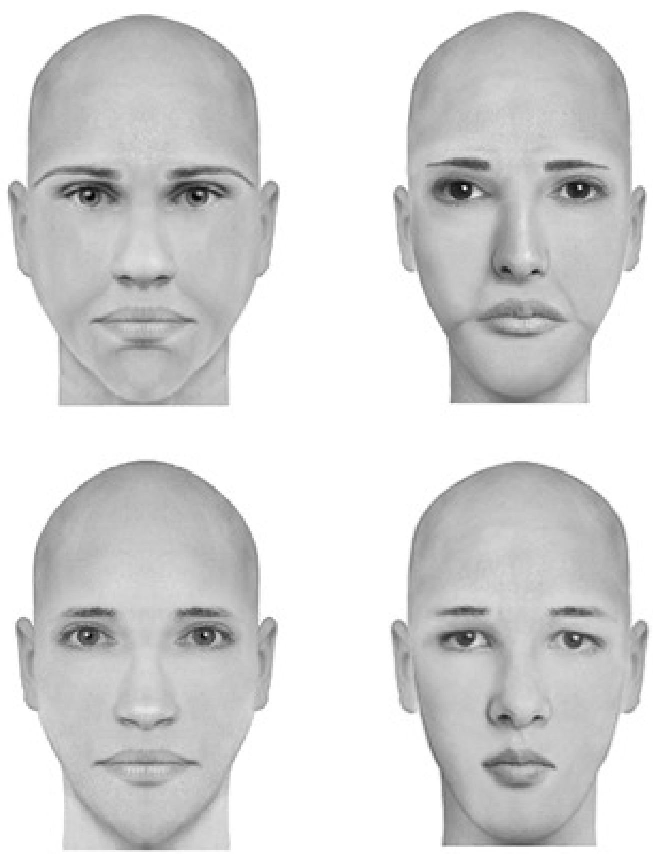
Stimuli

The stimuli were created using a face composition software that enabled combinations of various facial features. The software contained a database of various facial features, and there were numerous individual exemplars of each feature. Consequently, there was a high number of different possible facial configurations. The use of composite faces helped to address experimental control issues typically associated with photographs of real faces. These include issues related to varying image quality, lighting, head orientation, hair styles, and differences in skin complexion.

We created 160 composite male faces. Eighty of these faces were simple and were comprised of the following seven facial features: forehead contour, overall face contour, jaw contour, eyes, eyebrows, nose, and mouth. The other 80 faces were complex and were composed of the previous seven features plus forehead frown lines, cheek lines, and mouth lines. In producing the faces, differences among the faces were emphasized in order to maximize the likelihood of having distinct looking faces in the set. This was achieved by minimizing the inclusion of a particular feature exemplar in too many faces.

One-half of the simple faces were symmetrical and the other half were nonsymmetrical. Similarly, one-half of the complex faces were symmetrical and the other half were nonsymmetrical. The symmetrical faces were created by locating the vertical midline of a face and performing a bilateral reflection on one side of the midline, which resulted in bilateral symmetry. The side of the face that was bilaterally reflected was roughly counterbalanced across the 160 faces. The approach of directly bilaterally reflecting at the midline of faces has been used previously on symmetry studies involving biological images (e.g., Evans, Wenderoth, & Cheng, 2000). The original faces contained slight nonsymmetry. To increase the difference between symmetrical and nonsymmetrical versions, minor shifts were made to facial features in these nonsymmetrical faces. Thus, the entire set of face stimuli consisted of the following four types of faces (see Figure 1): 40 simple-symmetrical; 40 complex-symmetrical; 40 simple-nonsymmetrical; and 40 complex-nonsymmetrical faces.

Figure 1. Examples of the composite faces: complex-symmetrical (upper-left), complex-non-symmetrical (upper-right), simple-symmetrical (lower-left), and simple-non-symmetrical (lower-right).



Procedure

In order to prevent anchor effects in the ratings and to optimize the ratings' reliability (Grammer & Thornhill, 1994), the experiment began with an eight-second preview phase that included four faces. Each face representing one of the four face types. These preview faces were not included as stimuli in the main experiments. The experiment consisted of the following three rating blocks: attractiveness—"how attractive is this face?"; emotional valence—"how would you interpret the emotional expression of this face?"; and distinctiveness—"how distinct is this face?". The ratings were provided using seven-point

Likert-type scales, with 1 indicating less attractive, negative, or less distinct and 7 indicating more attractive, positive, or more distinct, for the attractiveness, emotionality, and distinctiveness scales, respectively. All participants performed the attractiveness block first, as this was the primary dependent measure. Then, the order of the emotionality and distinctiveness blocks was fully counterbalanced across participants.

All stimuli (approximately 9.5 cm x 6.5 cm) were presented in greyscale on a white (RGB: 255, 255, 255) background. Each trial consisted of the following sequence of stimulus events: a fixation cross for 200 milliseconds; the stimulus for 1500 milliseconds; the rating scale with a response-dependent duration (responses were self-paced). An inter-trial interval of 1000 milliseconds was presented following each response, after which the next trial began. In order to become familiar with the trial structure, participants were given 8 practice trials (2 simple-symmetrical, 2 complex-symmetrical, 2 simple-nonsymmetrical, and 2 complex-nonsymmetrical faces). The faces used in the practice trials were not included in the main experiment. The participants were instructed to provide their ratings spontaneously, base their judgments on their initial reactions, and try to use the entire rating scale. They were tested individually and the presentation order of the faces was randomized.

Results and Discussion

Mean attractiveness, emotional valence, and distinctiveness ratings were sampled across participants for each type of face. Our hypothesis regarding the attractiveness ratings of the four types of faces was confirmed. Participants judged the SiSy faces (3.82) as most attractive, followed in decreasing order of attractiveness by SiNs (3.62), CoSy (2.74), and CoNs (2.55) faces. A repeated measures analysis of variance was performed with complexity (simple and complex) and symmetry (symmetrical and nonsymmetrical) as within-subject factors and attractiveness ratings as dependent variable. Results showed that simple faces were rated as more attractive than complex faces, $F\ (1, 17) = 153.42$, $p < .001$, $\eta_p^2 = .90$, and symmetrical faces were rated as more attractive than nonsymmetrical faces, $F\ (1, 17) = 10.12$, $p = .005$, $\eta_p^2 = .37$. The interaction between complexity and symmetry was not significant ($p = .97$).

A repeated measures analysis of variance was also performed with emotional valence ratings as dependent variable and complexity (simple and complex) and symmetry (symmetrical and nonsymmetrical) as within-subject factors. These results verified the influence of the additional facial features of complex faces on ratings of emotional valence. Complex faces were rated as more negative in emotional valence than simple faces, $F\ (1, 17) = 166.50$, $p < .001$, $\eta_p^2 = .91$. There was no main effect of symmetry ($p =.32$) and no interaction between complexity and symmetry ($p = .82$).

Finally, a repeated measures analysis of variance was performed with complexity (simple and complex) and symmetry (symmetrical and nonsymmetrical) as within-subject factors and distinctiveness ratings as dependent variable. The main effect of complexity only approached significance ($p = .05$). There was no main effect of symmetry ($p = .38$) and no interaction ($p = .10$).

The results of Experiment 1 confirmed our hypothesis that participants would judge the SiSy faces as most attractive, followed in decreasing order of attractiveness by SiNs, CoSy, and CoNs faces. The results illustrate the additive nature of the effects of symmetry and complexity. Participants' emotional valence ratings indicated that the complexity manipulation performed on the faces resulted in a shift towards more negative valence for the complex faces. As a manipulation check, distinctiveness ratings were also collected. The results did not indicate that the faces differed significantly on this dimension. For the subsequent experiments, the main dependent measures were attractiveness and emotional valence ratings as these were directly related to the research questions. Experiments 2 and 3 examined the modulating influence of familiarization on the effects of symmetry and complexity on the aesthetic judgments of the faces.

Experiment 2

Method

Participants

Forty undergraduate students (32 females; mean age: 21.50; range: 19-29) from the University of Vienna, Department of Psychology participated in the experiment for partial course credit. The nature of the procedures was explained to, and informed consent was obtained from, each participant prior to data collection. All participants had normal or corrected-to-normal vision, none were aware of the purpose of the experiment, and none had participated in any of the other experiments reported here.

Stimuli

The stimuli consisted of the same 160 faces used in Experiment 1.

Procedure

The experiment consisted of a familiarization phase and a rating phase. The familiarization phase was based on the procedure used previously by Tinio and Leder (2009). It involved a matching task in which participants were simultaneously presented two pseudo-randomly paired faces belonging to the same stimulus group (i.e., simple-symmetrical, complex-symmetrical, simple-nonsymmetrical, or complex-nonsymmetrical faces). Participants were randomly assigned to one of the four groups. In each trial, same/different evaluations on the two faces were made. This familiarization phase included 160 same and 160 different pairs resulting in 320 total trials, and lasted for approximately 30 minutes. Following the familiarization phase, participants were presented, in random order, the faces from the set that they were familiarized to and the faces from the other three sets. In this rating phase, all 160 faces were rated for beauty in the same manner as in Experiment 1. Following the attractiveness ratings, participants rated all of the faces for emotional valence, also in the same manner as in Experiment 1. The orders of presentation of the face pairs in the familiarization phase and the individual faces in the rating phase were fully randomized.

Results and Discussion

Mean attractiveness ratings were sampled across participants for each type of face. A repeated measures analysis of variance was performed with complexity (simple and complex) and symmetry (symmetrical and nonsymmetrical) as within-subject factors, the? familiarization condition as a between-subjects factor, and attractiveness ratings as dependent variable. Results showed that symmetrical faces were rated as more attractive than nonsymmetrical faces, F (1, 36) = 43.95, p <.001, η_p^2 = .55, and simple faces were rated as more attractive than complex faces, F (1, 36) = 285.27, p <.001, η_p^2 = .89. These results are consistent with those found in Experiment 1. However, in contrast to Experiment 1, there was a significant interaction between complexity and symmetry, F (1, 36) = 16.55, p <.001, η_p^2 = .32, with greater differences between ratings of symmetrical and nonsymmetrical faces in simple than complex faces.

The results indicated that massive familiarization had a strong influence on the attractiveness ratings. There was a significant interaction between complexity and familiarization condition, F (3, 36) = 15.93, p <.001, η_p^2 = .57, which reflects the greater differences in ratings between simple and complex faces for participants familiarized to simple faces (cosyfam and sisyfam). There was also a significant interaction between symmetry and condition, F (3, 36) = 3.85, p <.05, η_p^2 = .24, which is based on greater differences in ratings between symmetrical and nonsymmetrical faces for participants familiarized to symmetrical faces. Finally, there was a significant interaction among complexity, symmetry, and condition, F (3, 36) = 3.82, p <.05, η_p^2 = .24. This three-way interaction reflected specific patterns in the data, especially effects that were related to familiarization condition. Participants familiarized to complex-nonsymmetrical faces rated complex-nonsymmetrical faces more beautiful than participants familiarized to complex-symmetrical (p < .05) and simple-symmetrical (p < .05) faces. Participants familiarized to simple-symmetrical faces rated simple-symmetrical faces more beautiful than participants familiarized to complex-symmetrical faces (p < .05).

Participants familiarized to simple-nonsymmetrical faces rated simple-nonsymmetrical faces more beautiful than participants familiarized to complex-symmetrical faces ($p < .01$).

Table 1

Experiment 2 and Experiment 3 mean attractiveness ratings and standard deviations (in parentheses) of patterns by familiarization group. Means that share a common letter subscript differ at p < .05.

	Experiment 2			
	Pattern type			
Fam. group	SiSy	SiNs	CoSy	CoNs
SiSy fam.	4.15 (*0.87*)$_a$	3.30 (*0.72*)	2.45 (*0.65*)	1.96 (*0.59*)$_c$
SiNs fam.	4.00 (*0.94*)	3.75 (*0.82*)$_b$	2.48 (*0.60*)	2.31 (*0.53*)
CoSy fam.	3.26 (*0.99*)$_a$	2.66 (*0.82*)$_b$	2.61 (*0.90*)	2.01 (*0.63*)$_d$
CoNs fam.	3.44 (*0.70*)	3.11 (*0.64*)	2.71 (*0.59*)	2.63 (*0.60*)$_{cd}$

	Experiment 3			
	Pattern type			
Fam. group	SiSy	SiNs	CoSy	CoNs
SiSy fam.	3.76 (*0.85*)	3.13 (*0.88*)	2.56 (*0.86*)	2.20 (*0.98*)
SiNs fam.	3.12 (*1.07*)	3.13 (*0.87*)	2.23 (*0.52*)	2.45 (*0.93*)
CoSy fam.	3.50 (*1.17*)	3.08 (*0.64*)	3.14 (*0.79*)	2.71 (*0.69*)
CoNs fam.	3.28 (*0.92*)	3.12 (*0.59*)	2.68 (*0.75*)	2.87 (*1.17*)

Note. CoSy = complex-symmetrical; SiSy = simple-symmetrical; CoNs = complex-nonsymmetrical; SiNs = simple-nonsymmetrical. CoSy fam = familiarized to complex-symmetrical; SiSy fam = familiarized to simple-symmetrical; CoNs fam = familiarized to complex-nonsymmetrical; SiNs fam = familiarized to simple-nonsymmetrical stimuli.

A repeated measures analysis of variance of the emotional valence ratings was performed with complexity and symmetry as within-subject factors, and familiarization condition as a between-subjects factor. As with Experiment 1, complex faces, as compared to simple faces, were rated as more negative in emotional valence, $F\,(1, 36) = 234.74$, $p < .001$, $\eta_p^2 = .87$, and there was no effect of symmetry ($p = .47$). There was a significant interaction between complexity and symmetry, $F\,(1, 36) = 6.28$, $p < .05$, $\eta_p^2 = .15$. There were no interactions between complexity and familiarization condition ($p = .18$), symmetry and familiarization condition (p = .94), and among complexity, symmetry, and familiarization condition ($p = .98$).

Experiment 2 demonstrated the modulating influence of massive familiarization on the attractiveness ratings. There was a trend towards familiar faces being rated more attractive than unfamiliar faces, which is illustrated by the mean values on the cross-diagonal in Table 1. These descriptive results, when put together with the three significant interactions, seem to suggest generalization effects following massive familiarization to one type of face. The differences in attractiveness ratings between simple and complex faces were greater for participants familiarized to simple as compared to those familiarized to complex faces. Similarly, the differences in attractiveness ratings between symmetrical and nonsymmetrical faces were greater for participants familiarized to symmetrical faces as compared to those familiarized to nonsymmetrical faces. In addition, emotional valence ratings were generally similar to those found in Experiment 1, with no interactions involving familiarization condition. Experiment 3 examined whether similar effects would be found using a less extensive familiarization phase. All aspects of the methods used in Experiment 2 were kept constant.

Experiment 3

Method

Participants

Forty undergraduate students (24 females; mean age: 22.23; range: 19-39) from the University of Vienna, Department of Psychology participated in the experiment for partial course credit. Prior to data collection, the nature of the procedures was explained to, and informed consent was obtained from, each participant. All participants had normal or corrected-to-normal vision, none were aware of the purpose of the experiment, and none had participated in Experiments 1 or 2.

Stimuli

The stimuli consisted of the same 160 faces used in Experiments 1 and 2.

Procedure

As with Experiment 2, there was a familiarization phase and a rating phase. The familiarization phase involved the same matching task used in Experiment 2. Participants were simultaneously presented two pseudo-randomly paired faces belonging to the same stimulus group (i.e., simple-symmetrical, complex-symmetrical, simple-nonsymmetrical, or complex-nonsymmetrical faces). However, familiarization was more moderate in this experiment, with only a fourth of the number of trials used in Experiment 2. Thus, there were 40 same and 40 different matching pairs for a total of 80 trials. Participants were randomly assigned to one of the four familiarization groups. Following the familiarization phase, participants were presented the faces from the set that they were familiarized to and the faces from the other three sets. In this rating phase, all 160 faces were rated for beauty and emotional valence as in Experiments 1 and 2. The presentation of the faces was fully randomized.

Results and Discussion

Mean attractiveness ratings were sampled across participants for each of the four types of face. A repeated measures analysis of variance was performed with complexity (simple and complex) and symmetry (symmetrical and nonsymmetrical) as within-subject factors, familiarization condition as a between-subjects factor, and attractiveness ratings as dependent variable. Symmetrical faces were rated more attractive than nonsymmetrical faces, F (1, 36) = 4.35, p <.05, $\eta_p^2 = .11$, and simple faces were rated more attractive than complex faces, F (1, 36) =14.40, p <.01, $\eta_p^2 = .29$. Additionally, there was a significant interaction between complexity and symmetry, F (3, 36) =, p <.8.90, $\eta_p^2 = .20$, which reflected a significant difference between ratings of symmetrical and nonsymmetrical faces in simple ($p < .01$) but not in complex ($p = .27$) faces.

We performed a repeated measures analysis of variance with emotional valence ratings as dependent variable and complexity and symmetry as within-subject factors, and familiarization condition as a between-subjects factor. The results were similar to those of Experiment 2. Complex faces were rated as more negative in emotional valence than simple faces, F (1, 36) = 12.51, $p < .01$, $\eta_p^2 = .26$, and there was no effect of symmetry ($p = .64$). There was also a significant interaction between complexity and symmetry, F (1, 36) = 4.31, $p < .05$, $\eta_p^2 = .11$. Moreover, as with Experiment 2, there were no interactions between complexity and familiarization condition ($p = .91$), symmetry and familiarization condition ($p = .18$), and among complexity, symmetry, and familiarization condition ($p = .43$).

The pattern of effects concerning the effects of symmetry and complexity that were found in this experiment was the same as the pattern of effects found in Experiment 2. At the descriptive level, there was also a trend towards familiar faces being rated higher on attractiveness than unfamiliar faces (see Table 1). However, unlike Experiment 2, none of the interactions involving familiarization were significant.

General Discussion

We examined the effects of symmetry and complexity on the aesthetic judgments of faces and how familiarization modulated these effects. Experiment 1 showed that the influence of symmetry and complexity was additive. We hypothesized a specific ordering of attractiveness ratings for the four types of faces. This ordering was premised on previous findings that symmetrical stimuli are judged more positively than nonsymmetrical stimuli (e.g., Jacobsen & Höfel, 2001; Tinio & Leder, 2009) and that simple faces, because of their neutral valence, would be judged more positively than complex faces. As predicted, participants rated simple-symmetrical faces as most attractive, followed in decreasing order by simple-nonsymmetrical, complex-symmetrical, and complex-nonsymmetrical faces.

The results of Experiments 2 and 3 were, to an extent, consistent with findings from mere-exposure studies (Zajonc, 1968), wherein familiar stimuli were shown to be evaluated more favorably than novel stimuli. The findings of Experiment 3 clearly illustrate that the approach of using moderate familiarization, which is typical of mere-exposure studies, may not fully capture the possible range of responses. Following massive familiarization, participants appeared to have generalized visual structures from familiar faces to new but similarly structured faces. This type of *structural generalization* (Tinio & Leder, 2009) was found for both symmetry and complexity.

Structural generalization effects are analogous to *structural mere exposure* effects (Gordon & Holyoak, 1983; Manza & Bornstein, 1995; Monahan, Murphy, & Zajonc, 2000; Newell & Bright, 2001; Zizak & Reber, 2004). The latter involves a transfer of artificial grammatical structures from familiar stimuli to similar but new stimuli. In this study, structure involved variations in symmetry and complexity in the facial stimuli.

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3.3. Discussion

The results extended previous research in general (e.g., Jacobsen & Höfel, 2001) and our previous studies in particular. The shift from using abstract patterns to using stimuli with more semantic complexity and ecological validity enabled the examination of additional hypotheses related to emotional valence. To our knowledge, this was the first experiment to show the direct relationship among symmetry, complexity, and emotional valence in facial stimuli. Following extensive familiarization, there was a change in the effects of the visual features on aesthetic judgments, while perceived emotion remained constant.

The results also validated the general robustness and additive nature of symmetry and complexity effects, even with stimuli with which people are very familiar. The finding that emotion seems to take over the effects of visual features is interesting especially from an evolutionary point of view. Emotional valence might take precedence over the visual characteristics of stimuli in situations in which a harmful object in the environment produces negative emotions, which necessitate an avoidance-related response. Thus, the immediate avoidance of a potentially harmful object has higher priority in terms of requiring a response than a feature-based evaluation of the object. This idea is explored in the next chapter, which deals directly with visual features and emotional valence.

4.

Emotional Valence Modulates the Preference for Curved Objects

4.1. Introduction

The article is in preparation. Aspects of the data were presented at “Facing Future: New Voices in Aesthetics, Creativity, and the Arts,” an Invited Session at the *2008 Conference of the American Psychological Association*, Boston, U.S.A.

Previous studies on the relationship between contour and the aesthetic response have mainly used stimuli with neutral emotional valence (Bar & Neta, 2006, 2007; Hevner, 1935; Silvia & Barona, 2009). Consequently, it is not known whether stimulus-inherent emotional valence influences aesthetic evaluations. In this study, we first replicated Bar and Neta’s (2006) study to validate that the effects that they found would hold in a different context (laboratory and test participants). We then used objects with positive and negative valence to examine the potential impact of emotional valence on evaluations of curved and sharp objects.

Results showed that the curved versions of the objects were generally liked more than their sharp version counterparts. This confirmed Bar and Neta’s (2006, 2007) findings. However, the effects were only obtained for objects with neutral and positive emotional valence. This contour-based liking bias was not found for objects that were clearly negative in emotional valence. We proposed a prioritization model based on these results. According to the model, when a perceiver is confronted with a negative object, the semantically-based affective value of that object is prioritized, in terms of responses, over the basic visual features inherent in the object.

4.2. Original Manuscript

Running Head: EMOTIONAL VALENCE AND CONTOUR PREFERENCE

Emotional Valence Modulates the Preference for Curved Objects

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Abstract

Previous studies have shown that people like objects with curved contours more than objects with sharp contours. However, those studies used stimuli that were mainly neutral in terms of emotional valence. In this study, we used positive and negative stimuli to examine whether emotional valence modulates the bias for liking curved objects through a response prioritization mechanism. We found that people liked the curved versions of objects as compared with the sharp versions of the same objects, only if the objects were neutral or positive in emotional valence. There was no difference in liking for objects with negative emotional valence, thus, providing evidence for the prioritization of valence over contour in negative objects.

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Valence Modulates the Preference for Curved Objects

The human mind is equipped to deal with different aspects of the environment that vary in their demands for specific responses. These demands require corresponding response mechanisms, which have been subjected to adaptive refinement during the course of human evolutionary history. One basic mechanism of the human visual system responds to low-level stimulus features. Such stimulus features somehow influence approach-avoidance reactions, such as those characteristic of aesthetic responses. For example, it has been shown that people like stimuli that are symmetrical rather than asymmetrical (e.g., Jacobsen & Höfel, 2001; Tinio & Leder, 2008), complex rather than simple (e.g., Imamoglu, 2000), and large rather than small (Silvera, Josephs, & Giesler, 2002). It has also been demonstrated that contour, whether curved or sharp, influences how objects are perceived and liked (Leder & Carbon, 2005; Bar & Neta 2006; 2007). In the area of product design, there has been a recent trend towards designing objects that are generally more rounded, compared with the designs of approximately three decades ago. Objects such as cars, furniture, and electronic devices have become more curved in their appearance. This trend has been paralleled by research supporting the positive bias in preference towards stimuli with curved contours. For example, it has been shown that people prefer car interiors with curved rather than sharp elements (Leder & Carbon, 2005). Several recent studies (Bar & Neta, 2006, 2007; Silvia & Barona, in press) using various types of stimuli have supported and expanded our understanding of this preference.

Bar and Neta (2006, 2007, 2008) suggested that the reason why sharp objects are liked less is that they potentially appear as threatening. They further posited that the difference in preference judgments between curved and sharp objects might stem from an increased arousal in response to sharp objects. Bar and Neta explored this hypothesis using functional magnetic resonance imaging (fMRI) to examine differential activations in the brain as a function of exposure to curved or sharp objects. Results of their study indeed demonstrated greater activation in the amygdala (Bar & Neta, 2007), an area of the brain linked to the fear response and general arousal (e.g., Adolphs, 2002; Adolphs et al., 1999; Whalen, 1998).

The stimuli used in past research on the relationship between contour and preference consisted of basic shapes such as circles (Hevner, 1935) and polygons (Silvia & Barona, in press), but also real-world objects such as furniture and other household goods (Bar & Neta, 2006, 2007). Importantly, those stimuli were characteristically neutral in emotional valence. In the present paper, we report a study in which the influence of emotional valence on the preference for curvature was examined directly, using stimuli that varied in valence. We specifically examined the possibility that people would only show preference for objects with curved contours if the objects are associated with *semantically* non-threatening information. Our prediction was that preference for curvature should be present for stimuli with neutral or positive valence. However, when people encounter objects with negative valence, semantically threatening information becomes prominent and subsequently overcomes the influence of contour. This would be the case if the objects with negative valence, which are perceived as threatening, elicit a conscious aversive response. This explicit response subsequently overrides the more unconscious effects of visual features such as contour.

Because of the influx of environmental cues available at any given moment, different mechanisms may be simultaneously activated, and in some circumstances, such mechanisms might compete for priority (e.g., Tooby & Cosmides, 2005). Thus, if a particular situation demands several simultaneous responses, it is crucial that priority is placed on producing the response for the most pressing—in terms of threat—of demands. Thus, in terms of behavioral responses that are directed towards survival and other more specific adaptive problems, objects that are associated with a positive affective value should be approached and those associated with negative past experiences avoided. However, what happens if two sources that effect preference—semantic and contour—conflict? Will preference depend on the bias dictated by the inherent properties of the contour, or the higher-level semantic affective value?

This study consisted of two parts. The aim of Experiment 1 was to establish the effects found by Bar and Neta (2006, 2007) that people like curved objects more than sharp objects, for objects with neutral valence. This experiment was conducted to ensure that the effects would be found in a different context—in terms of physical setting, language (instructions in German), and some modified aspects of the procedure (e.g., slight differences in timing). With effects established, the same participants took part in Experiment 2, which was aimed at directly assessing response prioritization in situations where there is competition in responses between affect determined by semantic information (e.g., snake vs. lollipop) and the liking bias elicited by contour (i.e., sharp vs. curved) . In addition to liking ratings, we collected valence ratings to better characterize the emotional valence factor, and arousal ratings, as there is some evidence that negative emotions generate higher levels of arousal than positive emotions (Ekman, Levenson, & Friesen, 1983).

Experiment 1: Replication Using Stimuli with Neutral Valence

Method

Participants. Twenty-one psychology students (15 female) from the University of Vienna participated in both Experiments 1 and 2. Their age ranged from 18 to 27 with mean age of 21.67. All participants had normal or corrected-to-normal vision.

Materials. The stimuli consisted of three sets of stimuli with neutral emotional valence previously used by Bar and Neta (2006, 2007). The first set included 140 pairs of real objects, with each pair consisting of a curved- and a sharp-contoured version. The second set included 140 pairs of abstract patterns, with each pair consisting of a curved- and a sharp-contoured version. The third set was a control set of real objects (e.g., table, hammer, lantern, and leaf) that were also neutral in valence, and consisted of 80 objects with approximately equal numbers of curved- and sharp-contoured objects.

Procedure. All stimuli (9.03cm x 9.03cm) were presented in grey scale on a grey (193,193,193) background using Presentation software (version 10.3, www.neurobs.com). The general structure of the experiment was as follows (in order of presentation): instructions; practice trials; main trials. Each trial consisted of the following sequence of stimulus events: a fixation cross for 500 milliseconds; the stimulus for 84 milliseconds; a cue for 1916 milliseconds; and an inter-trial interval for 2000 milliseconds. In order to become familiar with the trial structure, participants were given 60 practice trials (10 round real objects; 10 sharp real objects; 10 round abstract objects; 10 sharp abstract objects; and 20 control objects), which were identical in structure to the main trials. The stimuli used in the practice trials were not included in the main trials. For the main trials, each participant viewed one member of each pair (either round or sharp counterbalanced across subjects) and all the control objects.

Participants provided their response during the time interval in which the cue "Like? or Dislike?" was presented on the screen. Two buttons on the keyboard corresponded to the two response choices. The participants were instructed to provide their ratings spontaneously. In addition, they were tested individually and the presentation of the objects was randomized.

Results and Discussion

The dependent measure was based on the calculation of the proportion of like responses to the total number of responses. The results indicated that people prefer curve-contoured over sharp-contoured visual objects. Specifically, curved real objects were liked more than sharp real objects, $t\ (20) = 2.08$, $p < .05$. Curved abstract objects were liked more than sharp abstract objects, $t\ (20) = 2.38$, $p < .05$. Overall, curved objects were liked more than sharp objects, $t\ (20) = 2.56$, $p < .05$. An analysis of variance with Contour and Object Type as within-subjects factors revealed significant main effects of Contour, $F\ (1, 20) = 6.47$, $p < .05$; and Object Type, $F\ (1, 20) = 36.81$, $p < .001$. The interaction between Contour and Object Type was not significant ($p = .11$).

Thus, the results of Experiment 1 confirmed previous findings (Bar & Neta, 2006, 2007; Silvia & Barona, in press) that curved objects are liked more than sharp objects. This effect was observed both for real objects and abstract patterns, with both sets of stimuli possessing inherent neutral valence. In Experiment 2, we examined whether the preference for curved contour will be elicited if the stimuli possessed non-neutral emotional valence. Using two sets of stimuli that varied in their emotional valence, we aimed to directly examine semantic valence as mediators between competing responses. Consequently, analysis was focused on the differences in participants' liking judgments between curved and round objects for both positive and negative stimulus sets.

Experiment 2: Extension Using Stimuli with Positive and Negative Valence

The aim of Experiment 2 was to directly compare the effects of contour on preference judgments for objects that had positive and negative emotional valence. In addition to measuring liking ratings, we also measured valence and arousal ratings.

Method

Participants. The same group of participants who took part in Experiment 1 served as the participants for Experiment 2.

Materials. A new set of objects (see Figure 1 for examples) was produced for Experiment 2. The visual characteristics (e.g., size, brightness, contrast, and background color) of these stimuli were standardized to match the set used in Experiment 1A. However, in contrast to the previous set, the objects in the new set were chosen because they were objects commonly known to have strong positive (e.g., slice of cake, chocolates) or strong negative (e.g., snake, battle ax, bomb) emotional valence.

The stimuli consisted of 20 pairs of real objects with positive valence, with each pair consisting of a round and a sharp version; and 20 pairs of real objects with negative valence, with each pair consisting of a round and a sharp version. Thus, there were four groups of objects: 10 round positive; 10 round negative; 10 sharp positive; and 10 sharp negative real objects.

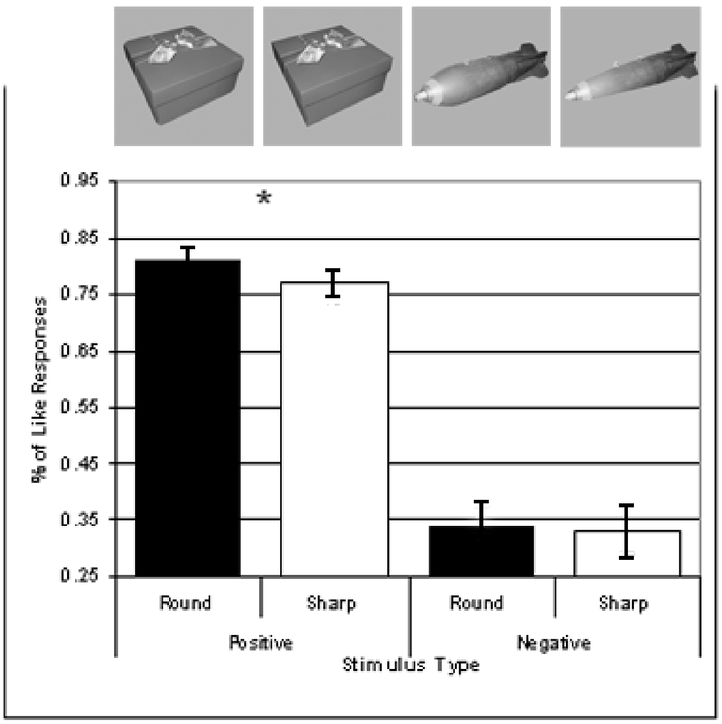
Procedure. Experiment 2 consisted of 3 blocks. The first block involved liking ratings of the stimuli in the same manner as in Experiment 1. The second block involved forced-choice "pleasant" or "unpleasant" valence ratings. Finally, the third block consisted of arousal ratings on a seven-point scale with "1" indicating "calm" and "7" indicating "exciting." All participants performed the liking block first. Then, the order of the second and third blocks—the valence and arousal ratings—was fully balanced across participants.

The general structure of the experiment and the sequence and timing characteristics of the stimulus events for the liking and valence ratings were the same as in Experiment 1. To provide the participants with sufficient time to use the 1-7 scale for the arousal ratings, the response window was increased to 2916 milliseconds. In order to become familiar with the trial structure, participants were given 12 practice trials (3 round positive; 3 round negative; 3 sharp positive; and 3 sharp negative objects), which were identical in structure to the main trials. The number of practice trials (12) in Experiment 2 was much less than the number of practice trials (60) in Experiment 1. This lower number was chosen because it was commensurate with the lower number of stimuli in Experiment 2. The stimuli used in the practice trials were not included in the main trials. For the main trials, each participant viewed one member of each pair (either round or sharp counterbalanced across subjects). Consequently, for each participant, the same set of objects was used for all three blocks.

Results and Discussion

For the liking judgments, an analysis of variance with Contour and Valence as within-subjects factors and proportion of like responses sampled over participants as the dependent variable revealed a significant main effect of Valence, F (1, 20) = 48.81, $p < .001$ (See Figure 1). The positive objects were liked more than the negative objects. There were no other significant effects. To examine differential effects as a function of object valence, we performed planned t-tests comparing curved and sharp objects separately for the positive and the negative stimulus sets. Results showed that round positive objects were liked more than sharp positive objects, t (20) = 2.44, $p < .05$, but there was no difference in liking between round negative and sharp negative objects ($p = .82$).

Figure 1. Proportion of “like” responses by stimulus type. * is statistically significant at p < .05.



An analysis of variance with Contour and Valence as within-subjects factors and valence ratings as the dependent variable revealed a significant main effect of Valence, F (1, 20) = 126.60, $p < .001$. The participants found the positive stimuli more pleasant than negative stimuli, irrespective of contour. There were no other significant effects. Planned t-tests did not reveal significant differences in valence ratings between round positive and sharp positive objects, and between round negative and sharp negative objects ($p = .10$ and $p = .68$, respectively). In addition, an analysis of variance with Contour and Valence as within-subjects factors and arousal ratings as the dependent variable revealed a significant main effect of Valence, F (1, 20) = 31.12, $p < .001$. Participants found the negative objects more arousing than the positive objects. There were no other significant effects. Planned t-tests also did not reveal significant differences in arousal ratings between round positive and sharp positive objects, and between round negative and sharp negative objects ($p = .46$ and $p = .38$, respectively). These results support the idea that negative emotions produce higher arousal than positive emotions (Ekman, Levenson, & Friesen, 1983).

The findings of Experiment 2 provide clear evidence that contour modulates judgments only for objects that are positive but not negative in emotional valence.

General Discussion

Objects that were neutral and positive in emotional valence revealed clear effects based on contour characteristics, such that objects in their curved version were liked more than the same objects in their sharp version, replicating previous findings. However, this contour-based liking bias was not found for objects that were clearly negative in emotional valence. This is particularly noteworthy in light of the finding that participants rated the negative stimuli as more arousing than the positive stimuli. The affective evaluation system thus involves some sort of prioritization scheme: when confronted with negative objects, inherent basic visual features are not considered for the response as highly as the semantically-based affective value of those objects. As consistent with assumptions by theories of aesthetics, the pleasantness of a visual stimulus is restricted to non-threatening, positive, or at least neutral objects (see Leder, Belke, Oeberst & Augustin, 2004). It remains to be shown what underlying mechanisms are involved in moderating the effect. It is possible that positive valence leads to an interaction with objects in a manner in which basic stimulus features are considered. In contrast, negative valence might lead to a general avoidance response wherein object features are not considered. Whether such processes are moderated by levels of consciousness should also be examined. To summarize, we have shown that curved objects are preferred when objects are characteristically neutral or positive, but when objects are inherently negative in emotional valence, the attractiveness of curvature cannot fool the threatened perceiver.

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4.3. Discussion

We explained these results in terms of a response prioritization mechanism. Various situational demands activate different response mechanisms, and these mechanisms may compete for priority (e.g., Holmes, Bradley, Nielsen, & Mogg, 2009; Tooby & Cosmides, 2005). The effects of visual features may be more dominant in neutral situations. However, when confronted with threatening objects, the effects of features such as curvature are relegated to a secondary position; the semantically-based affective value of those objects takes precedence.

The results are consistent with those reported in the previous chapter in which negative emotional valence in the faces had overridden the positive effects of symmetry on the aesthetic judgment of the faces. In this case, curvature effects were overridden by negative emotional valence inherent in the objects. According to Leder et al.'s model, in order for aesthetic experiences to transpire, they should be situated at the very least within neutral contexts (see Leder, et al., 2004). The results of this study are also consistent with this claim. The present study confirmed previous findings (e.g., Bar & Neta, 2006) regarding the effects of contour. It also demonstrated for the first time that the preference for curved contours is context-dependent, in this case on emotions. This is consistent with fMRI evidence that areas of the brain implicated in emotional responses (Adolphs, 2002; Adolphs et al., 1999)—mainly the amygdala—are activated during the viewing of threatening objects (Bar & Neta, 2007). It is also in accordance with the idea that bottom-up and top-down factors are highly interactive (Cupchik, Vartanian, Crawley, & Mikulis, 2009).

The previous three chapters described experiments that addressed the influence of visual features on aesthetic judgments. The visual features—symmetry, complexity, and contour—were structural in character. In the next two chapters, we describe experiments that examined the relationship between image quality and aesthetic judgments. In contrast to a feature such as symmetry, elements of image quality (e.g., image grain or noise) are intrinsic to the *surface* rather than the *structure* of visual stimuli.

5.

Natural Scenes Are Indeed Preferred, But Image Quality Might Have the Last Word

5.1. Introduction

The article was published in *Psychology of Aesthetics, Creativity, and the Arts*. It examined the influence of image quality on the aesthetic judgment of photographs of natural and human-made scenes. As with symmetry, complexity, and contour, the effects of image quality are associated with the early stages of Leder et al.'s (2004) model, as aspects of image quality such as clarity (Leder, 2002; Reber, Winkielmann, & Schwarz, 1998) are processed early and quickly. Although numerous studies have demonstrated people's preference for natural scenes, such as forests, over human-made scenes, such as cities (e.g., Biederman & Vessel, 2006; Kaplan, 1992; Kaplan & Kaplan, 1989; Kaplan, Kaplan, & Wendt, 1972; Ulrich, 1981), the effects of image quality on this preference have not been explored. Based on previous studies, we predicted that natural scenes would be preferred over human-made scenes and that high quality scenes would be preferred over degraded scenes. We also expected that high quality images of human-made scenes would be preferred over low quality images of natural scenes, which would serve as evidence for the crucial role of image quality and the need to control for image quality in studies that use photographic stimuli. In addition to collecting liking ratings, familiarity ratings of the scenes were collected to explore whether people find one type of image more familiar than other types, and to examine the possibility that scenes that are preferred are of the type that is familiar, which Monin (2003) referred to as the *warm glow heuristic*. Finally, we addressed the claims that natural scenes are preferred over human-made scenes because they elicit pleasure, promote physical and cognitive well-being, and represent the type of environment in which humans evolved. If these claims were valid, we expected natural scenes to be categorized faster than human-made scenes in a rapid, two-alternative forced-choice task (natural vs. human-made).

Results showed that images of natural scenes were preferred over images of human-made scenes, and high quality images were preferred over low quality images, thus confirming our hypotheses. Importantly, as we predicted, high quality images of human-made scenes were preferred over low quality images of natural scenes, which is evidence that image quality could modulate the preference for images of natural scenes. Regarding familiarity ratings, high quality images were evaluated as more familiar than low quality images. Results of the two-alternative forced-choice task indicated higher classification durations for human-made scenes as compared to natural scenes, but only for degraded images.

5.2. Original Manuscript

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Natural Scenes Are Indeed Preferred, but Image Quality Might Have the Last Word

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Numerous studies have shown that people prefer natural scenes over human-made scenes. Evolutionarily and neurologically based explanations for this preference have been proposed. This study examined the impact that image quality has on the preference for natural scenes. The authors also explored the influence of image quality on familiarity ratings and on how scenes are classified in a rapid, two-alternative, forced-choice task. Finally, the authors propose a framework for conceptualizing the nature of different image manipulation procedures, and how they influence aesthetic experiences.

Keywords: aesthetics, image quality, image manipulation, natural scenes, photography

Research in environmental psychology and visual aesthetics have repeatedly shown that people prefer images of natural scenes over images of human-made scenes (e.g., Biederman & Vessel, 2006; Kaplan, 1992; Kaplan & Kaplan, 1989; Kaplan, Kaplan, & Wendt, 1972; Ulrich, 1981). Three explanations have been proposed to account for this preference. First, natural scenes are the type of environment that humans evolved in and that they are well adapted to (e.g., Kaplan & Kaplan, 1989; Orians & Heerwagen, 1992). Second, being in or looking at nature has restorative effects on physical and mental health (e.g., Hartig, Mang, & Evans, 1991; Ulrich, 1984; van den Berg, Hartig, & Staats, 2007). Third, natural scenes activate association areas in the brain that have a high concentration of mu-opioid receptors, which have been linked to the experience of pleasure (Biederman & Vessel, 2006; Yue, Vessel, & Biederman, 2007).

In this paper, we report on a study that directly and systematically examined the impact that image quality has on the robust preference for natural scenes. As the studies cited above suggest, there has been a considerable amount of research directed toward examining why people prefer natural scenes. As many of those studies employed photographic images, consideration of image quality as a methodological element is crucial. We expected to support previous findings (e.g., Biederman & Vessel, 2006) that people prefer natural scenes over human-made scenes. In addition, we predicted image quality to have an impact on the preference for natural scenes. Specifically, and of main interest to our research, was whether human-made scenes of high image quality would be preferred over natural scenes of low image quality.

Why would image quality influence scene preference? One explanation is based on the concept of *perceptual fluency*, wherein stimuli that are high in perceptual fluency are liked more. Image quality (e.g., based on contrast) has previously been shown to influence perceptual fluency (e.g., Reber, Schwarz, & Winkielman, 2004). Another possible explanation is that image quality corresponds to photographic quality. In this sense, people are aware that a photograph of a scene is a mere graphic depiction of the scene. Thus, photographs of scenes with high image quality could be liked more because they possess high photographic (and artistic) value.

We also explored whether people exhibit greater familiarity for a particular type of scene. Monin (2003) proposed that stimuli that are liked are perceived as more familiar, a concept he referred to as the *warm glow heuristic*. Thus, high-quality images may be higher in perceptual fluency, which could lead to higher judgments of liking (e.g., Reber et al., 2004), which in turn could induce the warm glow heuristic. As a result, high-quality images may be judged as more familiar.

If natural scenes are indeed preferred because they are familiar in an evolutionary sense, or because they promote well-being, or because they elicit pleasure, then it is appropriate to expect that natural scenes would be faster and more accurate to classify than human-made scenes. To examine this prediction, we used a rapid, two-alternative, forced-choice classification task wherein participants had to classify each image into natural or human-made. A short presentation duration of 100 ms was used in order to promote spontaneous responses. It has been shown that people are able to grasp the "gist" of a complex scene quickly (e.g., Oliva & Torralba, 2006) even with short presentation durations (e.g., Potter, 1975; Thorpe, Fize, & Marlot, 1996). In addition, affective evaluation of environmental scenes occurs rapidly (e.g., Hietanen, Klemettilä, Kettunen, & Korpela, 2007). Because of the short presentation duration used, careful attention was placed on creating sets of stimuli that clearly belonged to the two scene categories.

Image Manipulation Procedure and Category Validation Pre-Study

The original set of stimuli consisted of 50 high-quality color photographs of natural scenes and 50 high-quality color photo-

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graphs of human-made scenes. The natural scene photographs depicted scenes such as mountain ranges, prairie fields, desert landscapes, canyons, and forests. The human-made scene photographs depicted scenes such as city skylines, bridges, road systems, and housing complexes. The latter set of scenes did not include any indoor scenes; it has been shown that different cortical areas of the brain are activated in response to outdoor and indoor scenes (Henderson & Larson, 2007). The presence and visual dominance of other aspects of the environment (e.g., water) that may be present in both types of scenes were roughly equated.

Using Adobe Photoshop CS2 (version 9.0, www.adobe.com), a degraded version of each photograph was produced by manipulations on the following image properties: sharpness (decrease); noise and grain (increase); contrast (decrease); color fidelity (toward less accurate); and color saturation (decrease). Figure 1 shows an example of the results of the image manipulation procedure. All of the manipulations were performed globally—linearly, across the entire image area—for each photograph, with the restriction that the changes be moderate enough so that the content of the photograph was retained, thus avoiding unnatural or artificial looking images. The final stimulus set consisted of 50 natural-normal scenes, 50 natural-degraded scenes, 50 human-made-normal scenes, and 50 human-made-degraded scenes.

An initial category validation prestudy involving four participants (2 females, 2 males; mean age of 24.00) was conducted to validate the authors' initial classification of the scenes into the natural and human-made categories. The scenes (approx. 8.5in. × 11in. in size) were presented in random order with a response-dependent presentation duration. This self-paced procedure was employed in order to simulate a manual sorting study.

The results of the prestudy indicated that the initial classification of the scenes was accurate. The performances of the participants in percent accuracy were as follows: 100%, 96%, 100%, and 99%. It was important that there was no particular scene for which the participants consistently made errors regarding its classification into its respective category.

Method

Participants

Sixteen psychology students (14 females, 2 males; mean age of 21.05) from the University of Vienna participated in the main experiment. None of these participants took part in the category validation prestudy.

Materials

The stimuli consisted of the same four sets used in the prestudy.

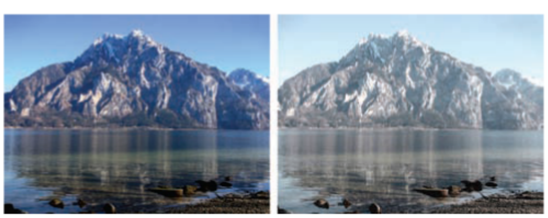

Figure 1. Illustration of the image manipulation procedure, with original (left) and degraded (right) versions.

Procedure

The experiment consisted of three blocks. The first block involved liking ratings of the stimuli using a Likert-type scale with 1 indicating "dislike" and 7 indicating "like." The second block consisted of familiarity ratings also using a Likert-type scale with 1 indicating "unfamiliar" and 7 indicating "familiar." The third block consisted of a forced-choice classification of the stimuli as either natural or human-made. However, for this block, a short presentation duration was used in order to elicit spontaneous responses. All participants completed the liking block first, as this was the dependent measure that was most closely tied to the main research question. The order of the familiarity and classification blocks was counterbalanced across participants.

Trials for the three blocks consisted of the following sequence of stimulus events: a fixation cross for 200 ms; the stimulus for 1500 ms (100 ms for the classification block); a cue for 2000 ms; and an intertrial interval for 2000 ms. Participants provided their responses while the cue was on the screen, and were instructed to provide their responses as quickly as possible based on their initial "gut" feeling. For each block, participants completed 12 practice trials (using three of each type of stimuli not included in the main trials), which were identical in structure to the main trials. Each participant viewed only one version of each scene, either normal or degraded, counterbalanced across participants. The presentation order of the stimuli was fully randomized.

Results

Liking

See Figure 2 for graphic depictions of the results from the three blocks. The mean liking ratings for the scenes sampled across participants for each scene type were: natural-normal, 5.47 (SD = 0.67); natural-degraded, 3.64 (SD = 0.88); human-made normal, 4.82 (SD = 0.86); and human-made degraded, 3.09 (SD = 0.66). An analysis of variance with scene type (natural and human-made) and image quality (normal and degraded) as within-subjects factors yielded significant main effects of: scene type, $F(1, 15) = 10.66$, $p < .01$, $\eta_p^2 = 0.42$; and image quality, $F(1, 15) = 89.80$, $p < .001$, $\eta_p^2 = 0.86$. The interaction between scene type and image quality was not significant ($p = .46$). These results confirm previous findings that, in general, natural scenes are liked more than human-made scenes. Of primary interest to our study was whether image quality could influence the relationship between scene type and preference judgments. The planned comparison of human-made normal versus natural-degraded was significant, with human-made normal scenes being liked more than natural-degraded scenes, $t(15) = 3.74$, $p < .01$.

In order to test whether perceptual fluency (e.g., Reber et al., 2004) was involved in the liking judgments, response latencies were analyzed. An analysis of variance with scene type and image quality as the within-subjects factors and response latency for the liking ratings as the dependent variable yielded a significant main effect of scene type, $F(1, 15) = 7.52$, $p < .05$, $\eta_p^2 = 0.33$. In general, latencies for human-made scenes were higher than natural scenes. There were no other significant effects. The paired comparison between response latencies for natural-degraded (2357.20 ms) and human-made normal (2407.95 ms) scenes was not significant ($p = .07$).

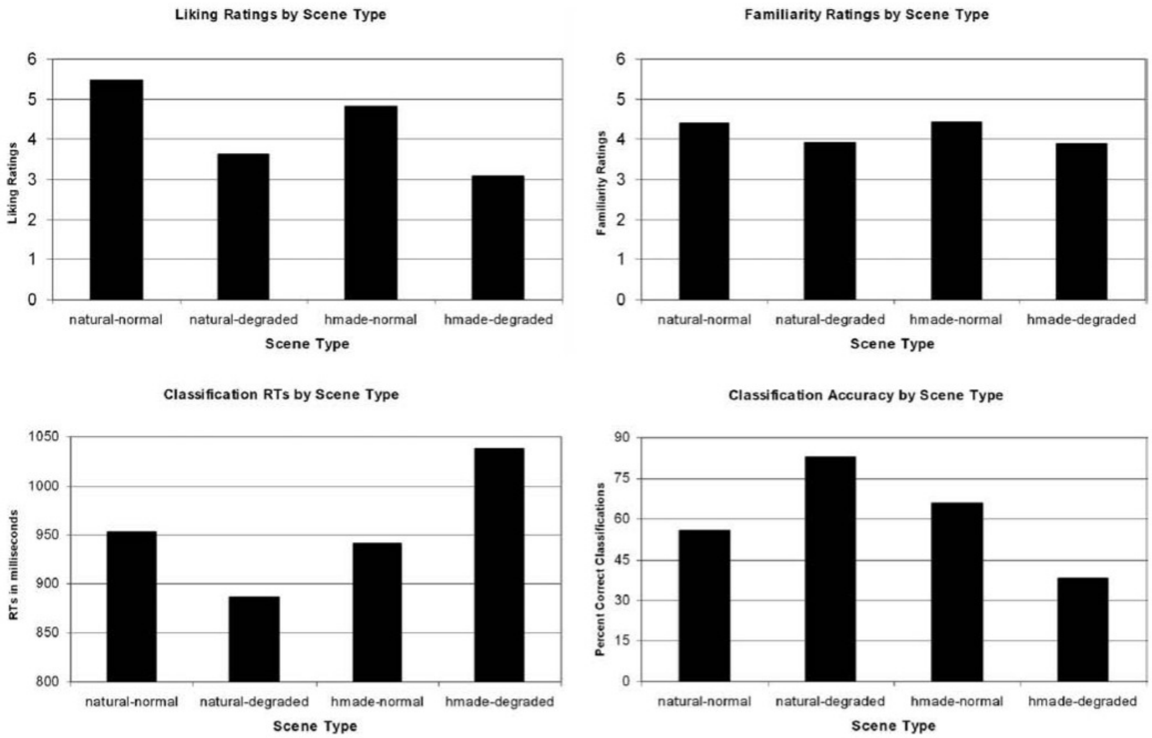

Figure 2. Mean liking ratings, familiarity ratings, classification response times, and classification accuracy by scene type.

Familiarity

As with the liking ratings, the mean familiarity ratings for the scenes were sampled across participants for each scene type and were: natural-normal, 4.42 (SD = 0.94); natural-degraded, 3.94 (SD = 0.76); human-made normal, 4.44 (SD = 1.00); and human-made degraded, 3.90 (SD = 0.79). An analysis of variance with scene type (natural and human-made) and image quality (normal and degraded) as within-subjects factors revealed a significant main effect of image quality, $F(1, 15) = 5.91$, $p < .05$, $\eta_p^2 = 0.28$. There were no other significant effects. Overall, the high-quality scenes were judged as more familiar than the degraded scenes.

Classification Into Natural or Human-Made

The principle measures of interest in this block were reaction time and response accuracy *for correct classifications*. The mean reaction times sampled across participants for each scene type were as follows: natural-normal, 953.63 ms (SD = 154.69); natural-degraded, 886.55 ms (SD = 157.08); human-made normal, 941.14 (SD = 226.69); and human-made degraded, 1038.04 (SD = 232.37). The main effects of scene type and image quality were not significant, p = .07 and p = .58, respectively. An analysis of variance with scene type (natural and human-made) and image quality (normal and degraded) as within-subjects factors revealed a significant interaction, $F(1, 15) = 10.73$, $p < .01$, $\eta_p^2 = 0.42$. For the natural scenes, classification times were significantly higher for normal than for degraded versions, $t(15) = 3.27$, $p < .01$. For the human-made scenes, the difference in classification times between degraded and normal images only approached significance (p = .06). For nondegraded scenes, there was no difference in reaction times between natural and human-made scenes (p = .78). However, for degraded scenes, classification times for human-made scenes were significantly higher than for natural scenes, $t(15) = 3.45$, $p < .01$.

A notable finding in this task was that the classification accuracy was highest for the natural-degraded scenes (83%), followed in decreasing order by human-made normal (66%), natural-normal (56%), and human-made degraded (38%) scenes. These findings are especially noteworthy in light of the results of the prestudy, which showed that participants were very good at classifying images when the task was self-paced in both viewing of the scenes and in providing responses. Such high error rates make the interpretation of the reaction times complex.

Discussion

Previous studies would undoubtedly have attempted to control for the quality of the stimuli; however, the extent of such control is not clear. While these results confirmed previous findings (e.g., Biederman & Vessel, 2006) that in general, natural scenes are liked more than human-made scenes, the results also showed that the image quality of the scenes could influence preference judgments. Specifically, human-made scenes of high image quality were liked more than natural scenes of low image quality. Furthermore, perceptual fluency (e.g., Reber et al., 2004) did not seem to influence the results. Thus, it seems that the photographic (or artistic) value of high-quality images could explain why high-quality images are preferred. Several studies designed to further test this idea are planned.

In addition to the liking ratings—the traditional dependent measure for scene preference studies—we examined familiarity ratings. Overall, participants found the original high-quality images more familiar than the degraded images. Participants also generally liked high-quality images more than degraded images. Thus, a possible interpretation of these effects is that people judged what they liked as more familiar, which is consistent with Monin's (2003) proposal of the warm glow heuristic.

The classification task was aimed at examining the prediction that people should be faster and more accurate at classifying natural scenes because doing so would be adaptive, as natural environments possess elements that are necessary for survival. The results indicated an interaction between scene type and image quality with classification times for human-made scenes significantly higher than natural scenes, but only for degraded images. At first glance, it may seem that people's ability to classify scenes is more tolerant to degradation for natural than for human-made scenes. However, this interpretation could be disputed by the fact that for the natural scene category, classification times were significantly higher for the normal than for the degraded images. Furthermore, accuracy was negatively related to response times. Specifically, classification was fastest for natural-degraded scenes, which were the scenes most correctly classified; classification was slowest for human-made degraded scenes, which were the scenes most incorrectly classified. The complex data that resulted from the classification task is difficult to interpret, although upon closer examination, the results indicated that participants may have been biased toward judging scenes as belonging to the natural scene category when the presentation duration was short. The question that beckons is why were the natural-degraded scenes the fastest and most accurate to classify? Further studies are required to examine this specific question and to explore the relationship between reaction times and classification accuracy when judging scenes.

While it is true that we tend to like trees and forests more than concrete roads, the quality of the image is important. Image quality also has an influence on what scenes we find familiar, and how those are classified. Our findings reiterate the importance of having a controlled set of stimuli, especially for studies fundamentally based on evaluations of visual representations. If image quality is not systematically controlled, it could become an artifact of the experimental context.

Taxonomy of Image Manipulation Procedures

In light of the results of this study, we would like to present a taxonomy of image manipulation procedures that is especially relevant for aesthetics research. In proposing this taxonomy, we do not intend to oversimplify the many variations and combinations of image manipulation procedures. Instead, we hope that it could serve as a starting point for conceptualizing how different techniques vary and are related to each other, and how they subsequently influence aesthetic experiences.

For this study, the manipulations performed on the original set of images were basic (albeit powerful) *surface-level manipulations*. These consisted of transformations in terms of sharpness, noise, grain, contrast, color fidelity, and color saturation. Manipulations were performed globally for each image. In general, surface-level manipulations could be performed easily, efficiently, and in a direct manner, thus possessing *high manipulability*. It is interesting that such manipulations are often subtle enough that people cannot readily identify that certain image properties were changed. In terms of experimental studies in psychological aesthetics, surface-level changes lend themselves well to studies such as those reported in this paper—those that involve short presentation durations, fast judgment, and dependent variables such as response latencies.

Surface-level manipulations are in stark contrast to *composition-level manipulations*, wherein changes are made on structural aspects of images. An example of such a manipulation is a change in the cropping of an image. In cropping, the external borders of the image are manipulated, which results in changes in the image's complexity, symmetry, and balance. Compared to surface-level manipulations, composition-level manipulations are less direct, and typically involve both local and global changes. Thus, they possess *moderate manipulability*.

Finally, *semantic-level manipulations* consist of changes to local image areas. Typically, such manipulations require direct manipulations of image content (the actual referent) such as adding or removing elements in an image, or altering the positions of different elements. Semantic-level manipulations are not as easy to perform as surface-or composition-level manipulations; the former type of manipulations generally involve local changes. Thus, semantic-level manipulations have *low manipulability*. Changes to the image using semantic-level manipulations could be more easily identified by perceivers than surface level or composition level manipulations.

In terms of aesthetic appreciation, this taxonomy is congruent with Leder, Belke, Oeberst, and Augustin's (2004) model of aesthetic appreciation. The influence of surface- and composition-level manipulations occurs during the initial perceptual analysis of an image and during subsequent implicit integration into memory, which both occur automatically. In contrast, semantic-level manipulations are directed toward the image content, and are therefore closely related to the generally deliberate explicit classification stage as outlined in the model of aesthetic appreciation. Simultaneous consideration of both the taxonomy presented here and Leder et al.'s model is an approach that could help researchers to conceptualize how stimulus manipulations performed on photographic images impact how the images are perceived aesthetically.

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5.3. Discussion

Our results illustrated the impact of image quality on the aesthetic judgments of images. Although natural scenes were indeed preferred over human-made scenes, the opposite result was obtained when human-made scenes had higher image quality than natural scenes. The results of this study not only contribute theoretically to aesthetics literature, but also directly address a fundamental methodological issue—control of stimulus features. Failure to control for the quality of images used in experiments could be detrimental to the entire research process.

In the article, we proposed the *taxonomy of image manipulation procedures*, the first model of its kind to formally conceptualize the differences and similarities of various image manipulation techniques. The taxonomy was directly related to Leder et al.'s (2004) model, especially in terms of the stages of information processing at which specific manipulations show their influence. In examining image quality, we employed an approach similar to what we used for structural visual features as reported in Chapters 2 to 4. This approach involves an evolution of concepts, ideas, and hypotheses from one study to the next. The next chapter describes experiments that further explore image quality effects.

6.

Image Quality and the Aesthetic Judgment of Photographs:
Contrast, Sharpness, and Grain Teased Apart and Put Together

6.1. Introduction

The article is in press in *Psychology of Aesthetics, Creativity, and the Arts.* Aspects of the data will be presented at the *2010 Conference of the International Association of Empirical Aesthetics*, Dresden, Germany.

It builds on the findings and ideas presented in the previous chapter. Although several studies (e.g., Calabria & Fairchild, 2003) have examined specific aspects of image quality, none has done so in a systematic manner. Therefore, we examined the individual, paired, and fully combined effects of contrast, sharpness, and grain degradations on the aesthetic judgments of images. These three degradations could be considered the building blocks of image quality. In addition, we performed a comparative analysis across the three main experiments to examine if the effects of the three degradations are additive.

Results showed that images of natural scenes were liked more than images of human-made scenes, and that normal high quality images were liked more than degraded images. These results confirmed our previous findings. There was also evidence that degradations that involved contrast have the greatest impact on aesthetic judgments.

As an additional analysis, we used the results from the three experiments to assess whether image degradations were additive. This would be reflected in a decrease in liking ratings through increasing numbers of degradations. The results of this analysis confirmed the previous findings. Images of natural scenes were liked more than images of human-made scenes. Moreover, high quality images were liked more than degraded images. Importantly, results indicated that liking ratings decreased as the number of degradations increased, and this effect was found in ratings of both natural and human-made scenes. This is evidence that the effects of image quality degradations are additive. One additional noteworthy finding is that liking ratings of the high quality natural and human-made images increased as the degraded images were subjected to increasing numbers of degradation manipulations, suggesting a contrast effect in which the more the degraded images were disliked, the more the high quality images were liked.

6.2. Original Manuscript

Image Quality and the Aesthetic Judgment of Photographs: Contrast, Sharpness, and Grain Teased Apart and Put Together

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Abstract

We examined the individual and combined effects of contrast, sharpness, and grain degradations on the aesthetic judgments of photographs depicting natural and human-made scenes. Our systematic approach demonstrated that certain degradations, and their combinations, had more impact on aesthetic judgments than others, and that the effects varied depending on the type of scene. We also showed that the degradations were additive in that the more degradations to which an image was subjected, the less it was liked. Finally, we found evidence for a contrast effect in which the aesthetic judgments of high quality images were more positive as the images they were presented with were more degraded.

KEYWORDS: aesthetics, image quality, image manipulation, contrast, sharpness, grain, photography

Image Quality and the Aesthetic Judgment of Photographs: Contrast, Sharpness, and Grain Teased Apart and Put Together

Introduction

Photographs dominate our visual lives. They are on billboards, websites, consumer products, and in magazines. They are exhibited in museums and galleries, and many are considered to be valuable works of art. Almost everyone makes photographs in one form or another. And making a "good" photograph is important to those who take the activity seriously. Consequently, there has been extensive dialogue about what constitutes a good photograph. Many books have been written, many classes have been taught, and many technological innovations have been made (e.g., fine grain film) to optimize image quality. Surprisingly, there have been few empirical studies on photography (Axelsson, 2007a, 2007b; Tinio & Leder, 2009a) and therefore, not much is known about how specific aspects of image quality impact the perception and aesthetic experience of photographs. This paper details our attempt to understand the effects of image quality on the aesthetic judgments of photographs.

There have been few previous attempts to study image quality, and only a handful of those used a direct aesthetic measure. Moreover, the majority of past research had the disadvantage of being carried out in a piecemeal manner, often involving only one element of image quality such as contrast (e.g., Gershoni & Kobayashi, 2006). In addition, past studies typically used a few (e.g., Calabria & Fairchild, 2003) or even one image (e.g., Stulz & Zweig, 1962), and did not control for factors such as image size and image orientation. To address these limitations and to better understand the relationship between image quality and aesthetic judgments, we directly and systematically compared the individual and combined effects of several elements within one investigation using a large set of high quality photographs. We report on three experiments in which we directly compared responses to degradations of three important image elements: image contrast, sharpness, and grain.

Early studies of photographic image quality were consistent with traditional psychophysics approaches. For example, Jones and Higgins (1945, 1947) investigated people's perception of grain in various photographic materials. Regarding sharpness, Wolfe and Eisen (1953) attempted to find a physical or objective correlate of the subjective concept of sharpness. Furthermore, Higgins and Wolfe (1955) examined the effects of sharpness and resolution on the evaluation of image definition (i.e., general appearance of detail).

Stultz and Zweig (1962) extended those earlier studies (Higgins & Wolfe, 1955; Wolfe & Eisen, 1953) by investigating how variations in sharpness and grain influenced evaluations of image definition and quality. The latter judgment was employed as an indirect measure of aesthetic evaluation. The stimuli used in Stultz and Zwieg's study consisted of only one original scene (used previously by Wolfe & Eisen) with the following variations: five-step variations in grain; four-step variations in sharpness; and one version with medium grain and moderate sharpness. Results showed that the influence of sharpness and grain depended on whether the images were judged for definition or quality. Specifically, when judging in terms of image quality, sharpness and grain had approximately equal influence on the evaluations. However, when judging in terms of definition, sharpness correlated higher with the evaluations than grain.

The studies described previously (e.g., Higgins & Wolfe, 1955) did not include an *explicit* measure of aesthetic judgment such as liking or preference. Although Stultz and Zweig (1962) included the word "prefer" in the instructions, it was mentioned in the context of the primary measure "picture quality." More recently, Calabria and Fairchild (2003) explicitly used an aesthetic measure. They assessed the independent effects of image lightness, chroma (related to color saturation), and sharpness on perceived image contrast and image preference. Their stimuli consisted of six images that varied in size, and depicted the following: brainscan, pyramid building, wakeboarder, heterosexual couple, still-life with fruits and vegetables, and dinner table. In four psychophysical experiments, it was shown that in general, perceived image contrast and image preference were effectively predicted (i.e., scalable) by variations in levels of image lightness, chroma, and sharpness. The effects were generally independent of type of image, although there was a difference in image preference between the brainscan image and the other five images. Moreover, expertise (limited vs. extensive experience in the field of imaging) did not influence the results. Finally, the relationship between preference and perceived contrast was described by an inverted-u-shaped function—a moderate amount of contrast was preferred.

Several aspects of Calabria and Fairchild's (2003) study deserve note. First, the stimuli were not standardized according to variables such as presentation orientation (vertical or horizontal) and image size. It has been previously demonstrated that size has a significant influence on aesthetic judgments of stimuli (Silvera, Josephs, & Giesler, 2002). Second, the effects of lightness, chroma, and sharpness were assessed only in terms of how they interacted with contrast—lightness-contrast, chroma-contrast, and sharpness-contrast. Thus, the independent (e.g., the effects of sharpness only) and combined effects of the various image elements were not fully assessed. Third, the stimuli used were few in number; it is therefore possible that the results were heavily influenced by a salient image feature such as complexity or symmetry (e.g., Jacobsen & Höfel, 2002; Tinio & Leder, 2009b). A larger set of stimuli would have balanced out such effects.

Gershoni and Kobayashi (2005; Experiments 2 and 3) also focused on the effects of variations in contrast on discrimination performance with photographs. They extended their initial psychophysical investigations by incorporating aesthetic measures in a related set of studies (Gershoni & Kobayashi, 2006). Their stimuli consisted of eight grayscale photographs by Ansel Adams (three landscapes, three portraits, and two architectural). Fifteen versions of each photograph were created by crossing the factors image area (shadow, midtone, and highlight) and contrast increment (2%, 4%, 6%, 8%, and 10%). The participants rated—for liking—the manipulated versions of the photographs, along with the originals. Results showed that overall, preference was highest for the original versions of the photographs, and preference decreased linearly with each increment in contrast. Furthermore, the preference for the original versions was independent of image category or image region.

Gershoni and Kobayashi's (2006) study effectively demonstrated that the photographer's choices regarding contrast corresponded highly with observer preference. Several features of their study are directly relevant to the present study and should be noted. First, the images used were created by one artist; and although they differed in content, the style was nonetheless similar. This was especially the case regarding the tonal range and contrast in the images. Stylistic features have been shown to strongly influence aesthetic judgments (Leder, Belke, Oeberst, & Augustin, 2004). Second, the images were by the well-known photographer Ansel Adams. In fact, the authors stated that 46 percent of their participants reported that they were either familiar with the photographer, or they have previously seen the photographs. There is evidence that people tend to like things that are familiar (e.g., Zajonc, 1968; see Bornstein, 1989 for an overview). Third, the contrast manipulations were made using an imaging software function that enabled the input of specific contrast increment values. Although this approach allows the same numerical contrast value across the entire set of images, how the changes in contrast are perceived actually depends on the image (Calabria & Fairchild, 2003). For example, a two-percent increase in contrast is perceived differently in dark as opposed to light images (e.g., Gershoni & Kobayashi). Thus, it cannot be assumed that a two-percent increase in contrast is perceived in the same way across the eight images used. Finally, Gershoni and Kobayashi investigated the effects of *increasing* contrast in specific tonal areas (i.e., shadow, midtone, and highlights) of the photographs. However, problems with image quality in everyday settings are generally related to *low* contrast resulting in a "muddy" look. Therefore, in terms of aesthetics, it seems more appropriate to investigate degradation in image quality as a result of the lowering of contrast (Tinio & Leder, 2009a).

More recently, Tinio and Leder (2009a) examined the effects of image degradation on the aesthetic judgment of photographs. Specifically, they assessed whether image quality could mediate the preference for natural scenes over human-made scenes (e.g., Biederman & Vessel, 2006; Kaplan, 1992; Kaplan & Kaplan, 1989; Kaplan, Kaplan, & Wendt, 1972; Ulrich, 1981) such that high quality human-made scenes will be preferred over low quality natural scenes. The stimuli consisted of photographs depicting 50 natural and 50 human-made scenes, with high quality and degraded versions of each photograph. Image degradation involved a decrease in sharpness, increase in grain, decrease in contrast, and decrease in color saturation. All of the manipulations were performed globally on each image. The results showed that participants generally preferred the natural scenes over the human-made scenes, and the high quality scenes over the degraded scenes. However, they preferred the high quality human-made scenes over the degraded natural scenes (Tinio & Leder, 2009a).

Tinio and Leder (2009a) demonstrated that image quality has a great influence on the evaluation of photographs. Furthermore, failure to control for image quality in investigations that use photographs as stimuli could lead to confounded results. The image degradation process used by Tinio and Leder involved the simultaneous manipulation of several elements of image quality. Consequently, the magnitude and direction of the effects of each individual element were not assessed.

The investigations reported here aimed to build upon previous studies by assessing the individual, paired, and overall combined influence of contrast, sharpness, and grain degradations on the aesthetic judgment of photographs. Contrast, sharpness, and grain were selected for manipulation because they are the most researched elements of image quality, as suggested by the review above. In addition, manipulations along these elements could be made in a straightforward manner; graphics editing programs such as Adobe Photoshop, Corel Draw, Aperture, and Adobe Lightroom provide special tools (e.g., histograms and curves tools in Photoshop) that are dedicated to such manipulations. Manipulations on these elements are also standard practice during the post processing stages in traditional analog photography. For example, for black and white analog images, contrast can be manipulated by using contrast filters during the print enlarging process, sharpness can be manipulated by the focusing of the enlarger, and grain may be influenced by the type of film or enlarging paper used. Contrast, sharpness, and grain may be jointly considered as the most essential building blocks of image quality, and are therefore the focus of this research.

Why and how would image quality influence aesthetic judgments? One possibility is that the effects of image quality are somehow mediated by *perceptual fluency* (Reber, Schwarz,

& Winkielman, 2004). According to this concept, the reason why high quality images are judged more positively than low quality images is because the former are easier to process. The visual characteristics of stimuli that are high in perceptual fluency are easier to see. Previous studies have shown that stimuli high in figure-ground contrast are judged more positively than stimuli low in figure-ground contrast, presumably because high contrast stimuli are higher in perceptual fluency (Reber & Schwarz, 2001; Reber, Winkielman, & Schwarz, 1998). It is important to note that studies that have looked at contrast as facilitating perceptual fluency have focused specifically on figure-ground contrast and not global contrast (or global sharpness and grain). In addition, these studies used basic shapes (e.g., circles) as stimuli. However, looking at the possible effects of perceptual fluency on aesthetic judgments is important to the present study. Thus, we assessed perceptual fluency by analyzing the response latencies associated with participants' judgments. Response latencies were considered as being indicative of the relative ease of processing of stimuli (e.g., Reber, Wurtz, & Zimmerman, 2004). Participants were explicitly instructed to respond as fast as possible and to base their responses on their initial impressions. If image degradation influences perceptual fluency in a negative way by hindering processing, then response latencies to degraded images should be significantly higher than response latencies to high quality images.

Although a direct comparison of contrast, sharpness, and grain degradations has not been systematically conducted, we expected the three degradations to have varying effects on aesthetic judgments. This may occur if the visual system adapts differently to various types of degradation. Previous studies have demonstrated adaptations to contrast (Gardner et al., 2005; Heinrich & Bach, 2001; Kohn, 2007), noise (Fairchild & Johnson, 2007), and blur (Wang, Ciuffreda, & Vasudevan, 2006; Webster, Georgeson, & Webster, 2002). Differences in the effects of contrast, sharpness, and grain degradations on aesthetic judgments may reflect differences in the nature and time course of visual adaptation to the degradations.

The individual effects of contrast, sharpness, and grain were examined in Experiment 1. We predicted natural scenes to be liked more than human-made scenes, which would be consistent with previous research (e.g., Kaplan & Kaplan, 1989; Biederman & Vessel, 2006) and with theories that claim perceptual and processing biases toward natural scenes (Field, 1987; Field & Brady, 1997). We also predicted that, in general, high quality images would be liked more than degraded images, both for natural and human-made scenes. This would be in accordance with the fluency perspective (e.g., Reber et al., 2004). Assessing the effects of the three degradation types within one experimental study and using a large and controlled set of stimuli allows the examination of differential effects specific to each degradation type.

Regarding the interaction between image class and image manipulation type, it was possible that the effects of the manipulations would be different for natural and human-made scenes, although Gershoni and Kobayashi (2006) and Calabria and Fairchild (2003) found that the effects of contrast variations on aesthetic judgments were independent of image class. The paired effects of the degradations on aesthetic judgments were investigated in Experiment 2, in which contrast-sharpness, contrast-grain, and sharpness-grain degraded combinations were presented along with the high quality images. This experiment addressed the question of whether certain combinations of degradations are evaluated more positively than others, and whether image class would play a role. Finally, the overall combined effects of contrast, sharpness, and grain degradations were examined in Experiment 3. Response latencies were analyzed in each of the three experiments in order to examine possible fluency effects on the participants' judgments.

Additionally, we performed a comparative analysis of the results of the three experiments. We addressed the idea that the influence of image degradations on aesthetic judgments is additive. The additive effects of visual features on aesthetic judgments have been previously demonstrated (e.g., Tinio & Leder, 2009b with symmetry and complexity). We hypothesized that liking ratings for scenes would decrease with an increase in the number of degradations made on the images. Specifically, overall liking ratings for degraded images would decrease from Experiment 1 to Experiment 2 to Experiment 3. In order to compare the results of the three experiments, composite ratings were calculated for Experiments 1 and 2, as both included three degraded conditions (Experiment 3 had one degraded condition). Composite values were calculated by averaging ratings for the three degraded conditions resulting in one degraded condition value for each of the two experiments. In doing so, it was possible to perform an analysis that combined the results of all three experiments. To further augment this analysis, all three experiments had the same number of participants (n = 20), and used the same set of high quality (non-degraded) images. Finally, all aspects of the procedures were held constant across the three experiments.

Image Manipulation Procedure and Degradation Validation Pre-Studies

The original set of stimuli consisted of 200 high quality color photographs of natural scenes and 200 high quality color photographs of human-made scenes. The natural category consisted of scenes such as forests, deserts, and mountains, while the human-made category consisted of scenes such as roads, city skylines, and bridges. Using similar stimuli, Tinio and Leder (2009a) showed that people were very accurate (with near ceiling performance) at categorizing scenes as either natural or human-made. The set of human-made scenes did not include any indoor scenes as it has been demonstrated that specific cortical areas of the brain are activated when viewing such scenes (Henderson, Larson, & Zhu, 2007). In addition, there were no people visible in any of the scenes, as there is evidence that attention is biased towards people in scenes (Fletcher-Watson, Findlay, Leekam, & Benson, 2008). The visual dominance of water elements and ambient lighting (e.g., sunset or sunrise) were approximately equated between the two sets of images.

The image manipulation procedure was consistent with Tinio and Leder's (2009a) approach. First, all images were sized to 800 x 600 pixels (all horizontally oriented). Second, three degraded versions were created from each original photograph: reduced contrast, reduced sharpness, and increased grain. The amount of degradation in each version was restricted so as to avoid unnatural or artificial-looking images. As an initial degradation validation check, one of the authors and two research assistants independently examined the degraded versions for consistency in terms of the amount of degradations applied to the images. Disagreements were discussed and any necessary changes were made. The final set of scenes consisted of contrast, sharpness, and grain degraded versions of the original 200 natural and 200 human-made images. Thus, the entire set of stimuli consisted of 400 normal, 400 contrast degraded, 400 sharpness degraded, and 400 grain degraded images (see Figure 1a). The high number of images used helped assure that effects are robust across different image types.

Figure 1a. Illustration images, Experiment 1

Figure 1b. Illustration images, Experiments 2 and 3

Three pre-studies were conducted to formally validate the consistency of the contrast, sharpness, and grain degradations across the entire set of images. This step also helped to ensure that any differences found between the natural and human-made categories could not simply be due to differences in the amount of degradation. In addition, the initial amount of degradation served as the basis for manipulations for Experiments 2 and 3 in which the different types of degradations were systematically combined. Finally, the validation studies served to identify whether a particular scene was manipulated too little or too much.

Eighteen undergraduate students from the University of Vienna participated in the three pre-studies ($n = 6$ for each pre-study) for partial course credit. None of these participants were involved in the main experiments. Depending on the condition—whether contrast, sharpness, or grain—participants rated the amount of degradation in each of the 200 natural and 200 human-made degraded images using a Likert-type scale with 1 indicating "low contrast," "low sharpness," or "low grain" degradation and 7 indicating "high contrast," "high sharpness," or "high grain" degradation. Each participant was assigned to only one type of degradation condition and was tested individually. At the beginning of the study, participants were shown examples of natural and human-made scenes with a range of possible degradations, from minimally perceptible degradation, moderate degradation, to high level degradation. Participants were instructed to use the entire 7-point scale in rating the images.

The mean degradation ratings were sampled across participants for each type of degradation condition, separately for natural and human-made scenes, and were as follows: natural contrast-degraded, 4.20 ($SD = .72$); human-made contrast-degraded, 3.96 ($SD = .66$); natural sharpness-degraded, 3.73 ($SD = .51$); human-made sharpness-degraded, 3.76 ($SD= .28$); natural grain-degraded, 4.20 ($SD = .90$); and human-made grain-degraded, 3.92 ($SD = .57$). Overall, the ratings ranged from 3.73 to 4.20 ($MD = .47$) on a 1 to 7 scale. According to these results, the amount of degradations was consistent across image types. A formal analysis of the ratings was also conducted. It is important to note that this analysis was only meant to augment the results found at the descriptive level, and that statistical power was limited because of the small sample size. A repeated measures analysis of variance was performed with image class (i.e., natural and human-made) as a within-subjects factor and degradation type (i.e., contrast, sharpness, and grain) as a between-subjects factor, with degradation ratings as the dependent variable. Results did not reveal a significant difference in the amount of degradation between natural and human-made scenes ($p = .50$), and among the three types of degradations ($p = .44$). In addition, there was no interaction between image class and type of degradation ($p = .82$). Finally, there was no particular image that was manipulated too little or too much.

Experiment 1: Individual Effects of Contrast, Sharpness, and Grain Degradations

Method

Participants

Twenty undergraduate psychology students (18 females; mean age: 21.70; SD = 2.60) from the University of Vienna participated in the experiment for partial course credit. None of these participants were involved in any of the other experiments. Prior to data collection, the nature of the procedures was explained to, and informed consent was obtained from, each participant. All participants had normal or corrected-to-normal vision and none were aware of the purpose of the experiment.

Stimuli

The set of stimuli was the same set used in the pre-studies (see Figure 1a). To avoid familiarity effects associated with previous exposure to a particular stimulus (Zajonc, 1968), each participant viewed only one version of each scene, counterbalanced across participants. Thus, for each participant, 50 stimuli representing each type of image were randomly selected from the larger sets of images used in the pre-studies. The stimuli were the following (50 each): natural-normal, natural contrast-degraded, natural sharpness-degraded, natural grain-degraded, human-made normal, human-made contrast-degraded, human-made sharpness-degraded, and human-made grain-degraded.

Procedure

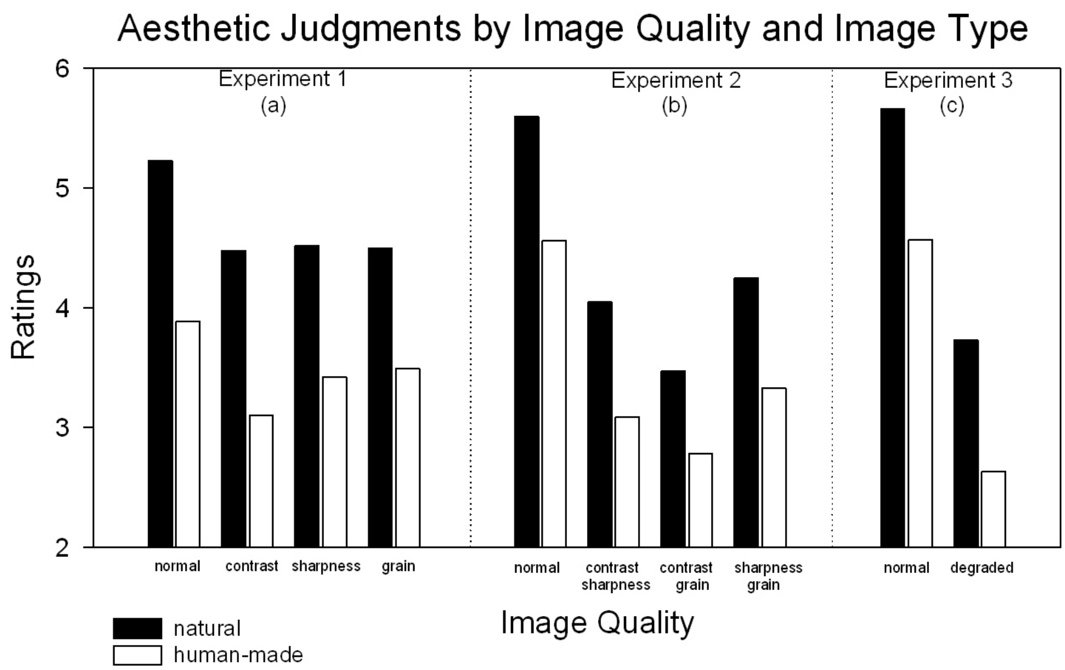
Each trial consisted of the following sequence of stimulus events: a fixation cross for 200 ms; the stimulus for 1.5 s; the question for 2.0 s; and an inter-trial interval for 2.0 s. To familiarize participants to the structure of the trials, they were given 24 practice trials, which consisted of three each of the eight types of stimuli. These stimuli were not included in the main trials. The practice trials had the same structure as the main trials. Each participant viewed only one version of each scene in order to prevent familiarity effects due to repeated exposure (e.g., Bornstein, 1989; Zajonc, 1968); counterbalancing was therefore performed. This resulted in 424 trials (50 for each image type and 24 practice trials) for each participant.

The images were randomly presented using Presentation software (version 10.3). Each image was rated for liking on a seven-point Likert-type scale with “1” indicating “like least” and “7” indicating “like most.” Participants were instructed to base their responses on their “gut” feeling and to respond as quickly as possible. In order to encourage spontaneous ratings and to keep trial durations constant during the course of the experiment, participants provided their responses while the question was on the screen. If participants provided a response before or after the question had already been cleared from the screen, they were shown a message reminding them to respond while the question was on the screen.

Results

The mean liking ratings were sampled across participants for each type of stimulus (see Table 1 and Figure 2a). A repeated measures analysis of variance was performed with image class (i.e., natural and human-made) and image quality (i.e., normal, contrast-degraded, sharpness-degraded, and grain-degraded) as within-subject factors, and liking ratings as dependent variable. Results showed that natural scenes were liked more than human-made scenes, F (1, 19) = 23.01, $p < .001$, $\eta_p{}^2 = .55$, and normal scenes were liked more than degraded scenes, F (3, 17) =16.01, $p < .001$, $\eta_p{}^2 = .74$. There was a significant interaction between image class and degradation type, F (3, 17) = 3.56, $p = .04$, $\eta_p{}^2 = .39$. The interaction showed that on the one hand, there were no significant differences between ratings of natural contrast-degraded and natural sharpness-degraded images ($p = .74$); natural contrast-degraded and natural grain-degraded images ($p = .92$); and natural sharpness-degraded images and natural grain-degraded images ($p = .82$). On the other hand, the human-made contrast-degraded images were significantly liked less than both the human-made sharpness-degraded images, t (19) = -3.57, $p = .002$, $d = .41$ and the human-made grain-degraded images t (1, 19) = -2.61, $p = .017$, $d = .50$. This finding is especially interesting in light of the results of the contrast validation study where there was no significant difference in the amount of perceived contrast degradation between the natural and human-made scenes (p = .33). There was no significant difference between the human-made sharpness-degraded and the human-made grain-degraded images ($p = .58$).

Figure 2. Mean liking ratings for Experiments 1 (a), 2 (b), and 3 (c) by image quality and scene type.



In order to examine the possible effects of fluency, response latencies were analyzed. Mean response latencies were sampled across participants for each type of stimulus (see Table 1). A repeated measures analysis of variance with image class and degradation type as within-subject factors, and response latencies as dependent variable did not indicate significant differences in response latencies between natural and human-made scenes (p = .59) and among degradation types (p = .57). In addition, the interaction between image type and degradation type was not significant (p = .18).

Table 1. Experiment 1: mean liking ratings, mean response latencies (RL), and corresponding standard deviations (in parentheses)

	Experiment 1			
	Image Quality			
	normal	contrast	sharpness	grain
natural	5.23 (*0.66*)	4.48 (*0.81*)	4.52 (*0.77*)	4.50 (*0.93*)
human-made	3.89 (*0.87*)	3.10 (*0.81*)	3.42 (*0.71*)	3.49 (*0.73*)
natural (RL)	2155.85 (*437.56*)	2142.36 (*422.11*)	2154.38 (*422.61*)	2130.51 (*410.93*)
human-made (RL)	2168.23 (*447.76*)	2140.76 (*424.31*)	2142.42 (*454.36*)	2167.85 (*450.36*)

Experiment 1 showed that individual degradations have different effects on aesthetic judgments, although this was apparent only when assessed along the two different image classes. Analysis of response latencies did not indicate fluency effects. The question that arises is whether pairwise combinations of the degradations would also show differential effects within and between image classes. Experiment 2 was designed to address this question.

Experiment 2: Paired Effects of Contrast, Sharpness, and Grain Degradations

Method

Participants

Twenty undergraduate psychology students (17 females; mean age: 21.65; SD = 1.95) from the University of Vienna participated in the experiment for partial course credit. None of these participants were involved in any of the other experiments. Prior to data collection, the nature of the procedures was explained to, and informed consent was obtained from, each participant. All participants had normal or corrected-to-normal vision and none were aware of the purpose of the experiment.

Stimuli

The same set of 200 natural and 200 human-made normal high quality images from the validation pre-studies and Experiment 1 was used to create the three sets of degraded stimuli for Experiment 2. The following three degradation combinations were created from each normal image: reduced contrast and reduced sharpness; reduced contrast and increased grain; and reduced sharpness and increased grain. For this experiment, new degradations were made on the normal images. However, the amount of each manipulation applied to the images was consistent with the amount used in the validation studies. It is important to note that the *order* of manipulations was an important factor for the versions that involved an increase in grain. Image grain, as compared to contrast and sharpness, consists of actual discrete grain structures on the image surface. It was crucial that grain was added after the contrast and sharpness manipulations were made. This ensured that the added grain structure would not be changed by the contrast and sharpness manipulations, as would have been the case if grain was added first. Furthermore, this approach also increased the similarity in the amount and character of the grain across the different experiments. The final set of scenes consisted of: normal high quality, contrast-sharpness, contrast-grain, and sharpness-grain degraded versions of the normal 200 natural and 200 human-made scenes. Thus, the entire set of stimuli consisted of 400 normal, 400 contrast-sharpness degraded, 400 contrast-grain degraded, and 400 sharpness-grain degraded images (see Figure 1b).

Procedure

Aspects of the testing procedure, including trial and experiment structure, stimuli selection, number of trials, and counterbalancing were the same as in Experiment 1.

Results

The mean liking ratings were sampled across participants for each type of stimulus (see Table 2 and Figure 2b). A repeated measures analysis of variance was performed with image class and degradation type as within-subject factors, and liking ratings as dependent variable. Results showed that natural scenes were liked more than human-made scenes, F (1, 19) = 20.43, $p < .001$, $\eta_p^2 = .52$, and normal scenes were liked more than degraded scenes, F (3, 17) = 18.74, $p < .001$, $\eta_p^2 = .77$. The interaction between image class and degradation type only approached significance ($p = .11$).

Planned comparisons were conducted to further explore the results. The sharpness-grain-degraded images were liked significantly more than the contrast-grain-degraded images, for natural, t (1, 19) = -6.03, $p < .001$, $d = .69$, and human-made scenes, t (1, 19) = -5.02, $p < .001$, $d = .61$. In addition, the contrast-sharpness degraded images were liked significantly more than the contrast-grain-degraded images for natural, t (1, 19) = 3.46, $p < .01$, $d = .52$ and human-made scenes, t (1, 19) = 2.98, $p < .01$, $d = .35$. There was no significant difference between contrast-sharpness-degraded and sharpness-grain-degraded images for both natural (p = .18) and human-made (p = .12) scenes. It seems that of the degraded scenes, those that included some form of contrast degradation were in general liked least.

Mean response latencies were sampled across participants for each type of stimulus (see Table 2). A repeated measures analysis of variance with image class and degradation type as within-subject factors, and response latencies as dependent variable revealed that response latencies were higher for human-made than natural scenes, F (1, 19) = 8.25, $p < .05$, $\eta_p{}^2 = .30$. This finding is consistent with that found by Tinio and Leder (2009a). There was no main effect of degradation type ($p = .34$) and no interaction ($p =.15$).

Table 2. Experiment 2: mean liking ratings, mean response latencies (RL), and corresponding standard deviations (in parentheses)

	Experiment 2			
	Image Quality			
	normal	contrast sharpness	contrast grain	sharpness grain
natural	5.60 (*0.79*)	4.05 (*0.96*)	3.47 (*1.16*)	4.25 (*1.04*)
human-made	4.56 (*1.07*)	3.09 (*0.84*)	2.78 (*0.92*)	3.33 (*0.87*)
natural (RL)	2236.60 (*199.44*)	2239.91 (*178.63*)	2228.73 (*148.75*)	2249.80 (*165.52*)
human-made (RL)	2329.04 (*195.22*)	2275.81 (*135.42*)	2259.23 (*157.26*)	2272.56 (*133.45*)

Experiment 1 demonstrated that evaluations of human-made images degraded in contrast were different as compared to human-made images degraded in sharpness and grain. Experiment 2 provided evidence suggesting that regardless of image class, aesthetic judgments of images that are degraded in contrast are evaluated least positively. These two findings appear compatible as they both suggest that of the three elements of image quality, contrast is the most influential to aesthetic judgments of photographs. Results of Experiment 2 also indicated that image class was not a significant factor for judgments of images with paired degradations; although ratings of human-made scenes were, in general, lower than those of natural scenes, the pattern of effects were similar for the two types of scenes, which is illustrated by the parallel nature of the bars in Figure 2b.

Experiment 3 was designed to assess the fully combined effects of contrast, sharpness, and grain degradations on aesthetic judgments.

Experiment 3: Fully Combined Effects of Contrast, Sharpness, and Grain Degradations

Method

Participants

Twenty undergraduate psychology students (17 female; mean age: 21.55; SD = 1.79) from the University of Vienna participated in the experiment for partial course credit. None of these participants were involved in any of the other experiments. The nature of the procedures was explained to, and informed consent was obtained from, each participant. All participants had normal or corrected-to-normal vision and none were aware of the purpose of the experiment.

Stimuli

The same set of 200 natural and 200 human-made normal high quality images from the validation pre-studies and Experiment 1 was used to create the set of degraded stimuli for Experiment 3. For each normal photograph, one degraded version was created by simultaneously reducing contrast and sharpness, and increasing grain. For this experiment, new degradations were made on the normal images. However, the amount of each manipulation applied to the images was consistent with the amount used in the validation studies. The final set of scenes consisted of normal and fully degraded versions of the original 200 natural and 200 human-made scenes. Thus, the entire set of stimuli consisted of 400 normal and 400 degraded images (see Figure 1b).

Procedure

All aspects of the testing procedure, including trial and experiment structure, stimuli selection, number of trials, and counterbalancing were the same as in Experiments 1 and 2.

Results

The mean liking ratings were sampled across participants for each type of stimulus (see Table 3 and Figure 2c). A repeated measures analysis of variance was performed with image class (i.e., natural and human-made) and degradation type (i.e., normal and degraded) as within-subject factors, and liking ratings as dependent variable. Results showed that natural scenes were liked more than human-made scenes, F (1, 19) = 16.51, $p < .01$, $\eta_p^2 = .47$; and normal images were liked more than degraded images, F (1, 19) = 33.82, $p < .001$, $\eta_p^2 = .64$. The interaction between image class and degradation type was not significant ($p = .98$).

Mean response latencies were sampled across participants for each stimulus type (see Table 3). A repeated measures analysis of variance with image class and degradation type as within-subject factors, and response latencies as dependent variable showed a main effect of image class, F (1, 19) = 6.06, $p < .05$, $\eta_p^2 = .24$, and an interaction between image class and image quality, F (1, 19) = 7.45, $p < .05$, $\eta_p^2 = .28$. The interaction reflected higher response latencies for human-made scenes than natural scenes for normal images, t (1, 19) = 3.01, $p <$ .01, d = .46, but no significant difference in response latencies between the two types of scenes for degraded images (p = .13).

Table 3. Experiment 3: mean liking ratings, mean response latencies (RL), and corresponding standard deviations (in parentheses)

	Experiment 3	
	Image Quality	
	normal	degraded
natural	5.66 (*1.21*)	3.73 (*1.25*)
human-made	4.57 (*1.20*)	2.63 (*0.82*)
natural (RL)	2221.05 (*296.74*)	2301.45 (*327.73*)
human-made (RL)	2379.50 (*370.64*)	2247.67 (*293.93*)

The results of Experiment 3 were consistent with those of Experiments 1 and 2; natural scenes were liked more than human-made scenes, and high quality images were liked more than degraded images. The results of the three experiments were used to examine whether the image degradations were additive in their effects on aesthetic judgments.

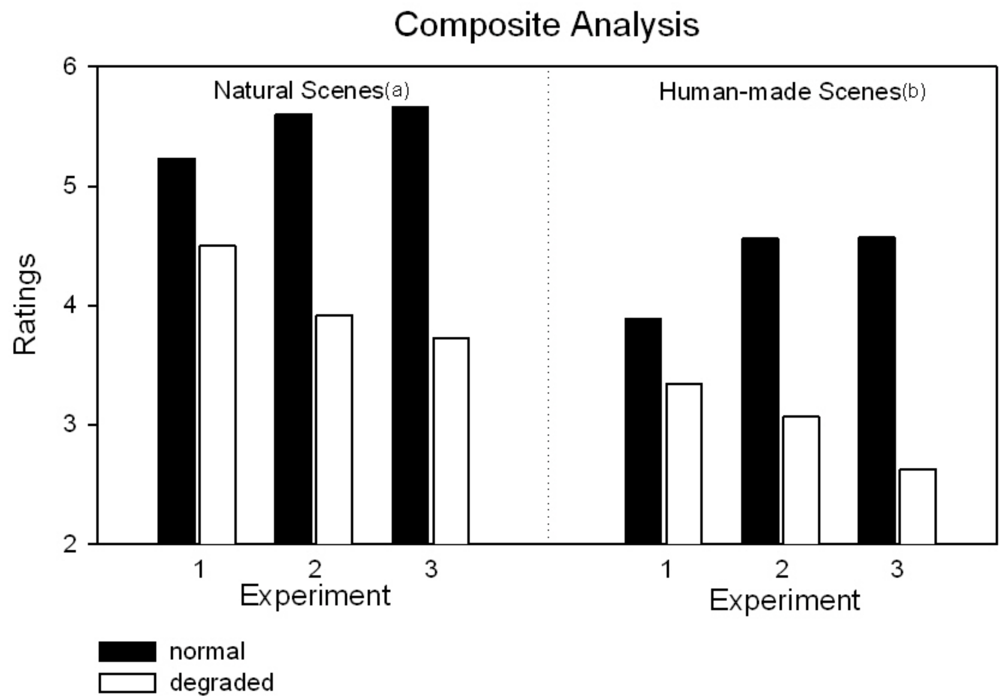
A Comparative Analysis of Experiments 1, 2, and 3

In order to examine whether the influence of image degradation on aesthetic judgments is additive, data from the three experiments were combined within one analysis. We hypothesized that liking ratings would decrease as the number of degradations performed on the images increase. Thus, liking ratings of the degraded images should decrease from Experiments 1 to 3. As compared to the degraded images used in Experiment 3, which used only one type of degraded image (i.e., simultaneous degradations in contrast, sharpness, and grain), three types of degraded images were used in each of Experiments 1 and 2—individual contrast, sharpness, and grain degradations in the former, and paired combinations of the degradations in the latter. To carry out the analysis, composite values were calculated for Experiments 1 and 2 by averaging ratings across the three types of degraded images. Consequently, participants (n = 60) from the three experiments each had an average rating for natural-normal, natural-degraded, human-made-normal, and human-made-degraded images.

The overall pattern of mean values for both types of scenes supported the hypothesis (see Figures 3a and 3b). Of the degraded images, those from Experiment 1 were liked the most, followed by images from Experiment 2; images from Experiment 3, which had the most individual degradations, were liked the least. The data were analyzed with a mixed model repeated measures analysis of variance, with image class (natural and human-made) and image quality (normal and degraded) as within-subjects factors, and experiment (Experiments 1, 2, and 3) as a between-subjects factor. Confirming the previous analyses, images of natural scenes were liked more than images of human-made scenes, $F\ (1, 57) = 61.58$, $p < .001$, $\eta_p^2 = .52$, and high quality images were liked more than degraded images, $F\ (1, 57) = 105.63$, $p < .001$, $\eta_p^2 = .65$. In addition, there was a significant interaction between image quality and experiment, $F\ (2, 57) = 8.15$, $p < .01$, $\eta_p^2 = .22$. The interaction is based on an overall decrease in mean liking ratings with increasing number of degradations for both natural and human-made scenes. This suggests that the different aspects of image quality are additive in their influence on aesthetic judgment.

The significant interaction between image quality and experiment reflected an additional noteworthy, albeit unexpected, pattern of results. The mean liking ratings of the normal high quality images increased from Experiments 1 to 3. This was found in both natural and human-made scenes. Although the increase in liking was less than the corresponding amount of decrease in liking for the degraded images across experiments, it nonetheless suggests a possible contrast effect. Specifically, it appears that the more the degraded images were disliked, the more the normal images were liked. Therefore, the interaction may reflect a type of *contrast effect* in which evaluations of one type of stimulus is influenced by the evaluations of other stimuli within the same stimulus set.

Figure 3. Results of comparative analysis plotted by experiment for natural (a) and human-made (b) scenes.



General Discussion

We aimed to understand the effects of image quality on aesthetic judgments of photographs. In three experiments, high-quality images were degraded in contrast, sharpness, and grain. We investigated the individual, paired, and combined effects of the degradations on natural and human-made scenes. In addition, we examined if the effects of image degradation are additive, whether aesthetic judgments become more negative as more degradations are made on the images.

In directly comparing the individual degradations with each other using different image classes, we found evidence that degradations in contrast impact judgments of photographs of human-made scenes more than those of natural scenes. This contradicts previous findings that the effects of image degradations are similar across various image types (Calabria and Fairchild, 2003; Gershoni and Kobayashi, 2006). One possible explanation for this difference is that natural scenes are more robust or tolerant to contrast degradation than human-made scenes because humans evolved in and are well adapted to natural environments (e.g., Orians & Heerwagen, 1992). From this perspective, it follows that the human visual system may be more tolerant to degraded images of natural scenes as compared to degraded images of human-made scenes. This would be consistent with theories claiming a processing bias towards natural scenes (Field, 1987; Field & Brady, 1997). This processing bias is, to an extent, compatible with the robust finding that people prefer natural over human-made scenes (e.g., Kaplan & Kaplan, 1989), and that viewing natural scenes is beneficial to physical and mental health (e.g., Berman, Jonides, & Kaplan, 2008; Hartig, Mang, & Evans, 1991; Ulrich, 1984; van den Berg, Hartig, & Staats, 2007; van den Berg, Koole, & van der Wulp, 2003). It is also consistent with studies that have shown distinct neural response patterns when looking at natural scenes (Biederman & Vessel, 2006; Felsen, Touryan, Han, & Dan, 2005; Yue, Vessel, & Biederman, 2007).

The results of Experiments 1 and 2 both showed that degradations in contrast appeared more influential to aesthetic judgments than degradations in grain or sharpness. This could be related to the human ability to adapt visually to changes in the perceptual environment in order to maintain perceptual constancy. Previous studies have demonstrated adaptations to contrast (e.g., Kohn, 2007), noise (Fairchild & Johnson, 2007), and blur (e.g., Wang, Ciuffreda, & Vasudevan, 2006). The nature and time-course of visual adaptation may be specific to each type of degradation, thus resulting in differences in the effects on aesthetic judgments. Although visual adaptation may explain these differences, it is important to note that most studies in visual adaptation were based on long exposure durations to the adaptation stimuli, which stands in stark contrast to the relatively short presentation durations and to the absence of an adaptation phase used in the present studies. However, if adaptation is a factor in this study, it would likely have occurred on a trial-by-trial basis during the course of the entire study. The present study also differs from adaptation studies in that the amount of degradation made on each image was more restricted than image degradations on typical visual adaptation stimuli.

It is also possible that contrast, grain, and sharpness degradations are different in their saliency. If so, degradations in contrast may be more salient than degradations in grain and sharpness, thereby having the greatest influence on aesthetic judgments. Tinio and Leder (2009a) have proposed a *taxonomy of image manipulation procedures* that conceptualized how different image manipulations impact aesthetic judgments. The taxonomy consists of three levels of manipulation: surface-level, composition-level, and semantic-level manipulations. The contrast, sharpness, and grain degradations used in the present studies were surface-level manipulations because each manipulation was performed globally (the entire image area) for every image. The essence of surface-level manipulations is that changes that result from them are difficult to identify because they are typically subtle. However, *within* this level of manipulation, it is nonetheless possible that there are micro-variations in how the manipulations are visually perceived and evaluated.

Overall, analyses of the response latencies did not indicate that perceptual fluency systematically mediated the effects of the degradations on aesthetic judgments. Although it is possible that the manner in which image quality and perceptual fluency are related is different for contrast, sharpness, and grain manipulations, analysis of response latencies in Experiment 1 did not reveal differences among the three degradation types. It is important to note that past studies that have found a relationship between perceptual fluency and contrast were based mainly on figure-ground contrast (Reber & Schwarz, 2001; Reber, Winkielman, & Schwarz, 1998; Willems & van der Linden, 2006), which differs from the global contrast manipulation used in the present studies. Further studies are needed to explore the link between perceptual fluency and contrast, sharpness, and grain, and whether fluency effects would be apparent in response conditions more demanding (e.g., two-alternative forced choice tasks) than those in the present experiments.

We also found evidence that the effects of degradations are additive. The more degradation an image is subjected to, the less it is liked. This finding is consistent with studies that have shown the combined effects of basic visual features on aesthetic judgments (e.g., Tinio & Leder, 2009b). Although this issue of additive degradations was not the main focus of our investigations, it would be fruitful to assess the interaction among the effects of the degradation manipulations. For example, a reduction in sharpness may result in a reduction in contrast (e.g., Sprawls, 1993). However, the exact nature of the interactions among the different degradations is unknown. Thus, a more focused investigation with an approach similar to that used in Experiment 2 is warranted.

Our study found descriptive evidence for a contrast effect for images of both natural and human-made scenes. The evaluations of high quality images were more positive as the images they were presented with were more degraded. In this sense, the entire stimulus set within each experiment acted as an evaluative context. This contrast effect has been shown previously in attractiveness (Cash, Cash, & Butters, 1983; Kowner & Ogawa, 1993) and taste judgments (Sakai, Kataoka, & Imada, 2001). It appears that contrast effects are based on adaptation to characteristics of the stimulus set. Thus, within each experiment, the set of degraded images served as a baseline of comparison against the high quality images. Adaptation to the baseline set occurred after repeated exposure to, and evaluation of, the stimuli, resulting in an increase in contrast effects through increasing degradations. This becomes more compelling in light of the fact that although the sets of degraded images were different in each experiment, the same set of high quality images were used in the three experiments.

According to all measures in this study, degraded images were liked less than their high quality counterparts. A paradox arises when photographs are considered within the general framework of art history and photographic theory. There have been many instances where image quality—in the sense of image clarity, definition, and accuracy in depiction—has not been considered as being tantamount to aesthetic quality. Cases in point were the photographs that were consistent with the Pictorialism photography movement during the late 1800s and early 1900s. Photographs associated with this movement were characterized by a painterly feel, and often looked out of focus (Rosenblum, 2008). Another example is the popularity of the film look, which is characterized by soft, grainy, and blurry images (Manovich, 1995). The introduction of grain into an image could result in an artistic effect (Zakia, 2007). Why then would people in this study show strong preference for high quality images, when in an artistic sense, high quality images may not have the highest aesthetic value? One possibility is that only certain images do not suffer and might even benefit from the application of degradations. Another possibility is that degradation needs to be applied in a certain manner by an expert image maker in order for it to positively influence the aesthetic value of the image. It is also possible that the level of expertise of a perceiver has a role in the preference for certain images. The participants in the present studies consisted of undergraduate students who may not have had high level expertise in photography. Photography experts could be included as participants in future studies to determine if they would prefer degraded images, perhaps because such images are challenging, more demanding, and complex (Axelsson, 2007a).

Although the present results were based on tightly controlled experiments, their implications in applied settings could be surmised. For example, in applying degradations to an image for the purpose of making it more aesthetically pleasing, one must consider that the amount and combination of degradations should be carefully modulated. The effects of the degradations might also be specific to a particular type of image. The issue of set effects is another important consideration when displaying photographs. Photography curators place great emphasis on the selection and order of presentation of photographs. The present studies suggest that in addition to content, the surface qualities of photographs could potentially impact the presentation context.

The straightforward characterization of the photographic image is that it is a mere depiction of reality, that it is a direct representation—of an object, a person, or a scene. However, since its inception, photography had at its core both representational and aesthetic capacities. Although the former is clear, the latter has been debated throughout photography's history. Our results shed light on the idea that photography cannot simply be equated to mechanical reproduction because its essence is not entirely based on depicted content alone (Sontag, 1973). "…we *regard* the photograph, the picture on our wall, as the object itself (the man, landscape, and so on) depicted there. This need not have been so," (Wittgenstein, 1953, p. 205) as we have shown that surface qualities do matter.

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6.3. Discussion

These investigations comprise the most systematic analysis of the effects of image quality on aesthetic judgments of photographic images. The results contribute to contemporary debates in several areas of psychology, such as evolutionary theory Orians & Heerwagen, 1992), environmental psychology (Hartig, Mang, & Evans, 1991; Ulrich, 1984), visual adaptation (Fairchild & Johnson, 2007; Kohn, 2007; Wang, Ciuffreda, & Vasudevan, 2006), processing fluency (Reber & Schwarz, 2001; Reber, Winkielman, & Schwarz, 1998; Willems & van der Linden, 2006), contrast effects (Cash, Cash, & Butters, 1983; Kowner & Ogawa, 1993), and photography theory (Manovich, 1995; Rosenblum, 2008; Sontag, 1973; Zakia, 2007).

The finding showing that the effects of the image degradations are additive is consistent with results of the studies reported in Chapters 2 and 3. Those studies showed that the effects of symmetry and complexity were also additive for both abstract patterns and faces.

7.

When Attractiveness Demands Longer Looks: The Effects of Situation and Gender

7.1. Introduction

The article is in press in the *Quarterly Journal of Experimental Psychology*. We used eye tracking methodology to examine whether attractive faces would receive longer looks than less attractive faces, and if contextual demands would modulate the effects. Participants viewed photographs of real-world scenes with embedded attractive and less attractive faces. We employed classic eye movement measures—mean fixation, mean first fixation, and total fixation durations (Duchowski, 2007). We considered gaze behavior as overt manifestations of cognitive processes (Henderson, 2003), and regarded longer fixation durations on attractive faces to reflect the idea that the aesthetic response functions to orient people towards the pleasing and rewarding features of the environment.

Results showed that mean fixation, mean first fixation, and total fixation durations were longer to attractive faces than less attractive faces. In addition, fixations were longest to female faces and by female perceivers. We also examined if the aesthetic response may function in an adaptive manner to orient people to certain aspects of their environment depending on the situation that they are in. We specifically tested if the advantages of attractiveness in terms of attracting longer looks might be modulated by specific situational demands. Prior to the viewing phase, participants were subjected to a threat or social approach manipulation. Results showed that participants' gaze responses depended on the manipulation condition to which they were assigned.

7.2. Original Manuscript

Running Head: ATTRACTIVENESS IN COMPLEX SCENES

When Attractiveness Demands Longer Looks: The Effects of Situation and Gender

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Abstract

We investigated how aesthetics guides our exploration of the environment. We embedded attractive and nonattractive faces into complex, real world scenes, and measured eye movements during scene viewing. We examined whether attractive faces would elicit longer looks, which would suggest that the aesthetic response orients people toward the rewarding and pleasing aspects of the environment. Experiment 1 showed that mean fixation, mean first fixation, and total fixation durations were longer to attractive faces, and fixations were longest to female faces and by female perceivers. In Experiment 2, we examined whether these effects of attractiveness are sensitive to situational factors. When perceivers were subjected to a threat or social approach manipulation prior to viewing the scenes, we confirmed specific hypotheses concerning the two manipulations. In accordance with the hypothesis that males have higher aggression potential than females, there were no differences in fixation durations between attractive and nonattractive male faces in the threat condition. On the other hand, in the social approach condition, both female and male attractive faces received longer looks. These results suggest that the aesthetic response orients people not only to the pleasing aspects of their environment, but also to those features that are adaptively relevant.

Keywords: attractiveness, aesthetics, threat, social approach, eye movements

When Attractiveness Demands Longer Looks: The Effects of Situation and Gender

Attractiveness and nonattractiveness lie at each end of a dimension that is at the heart of aesthetic evaluations of objects in our environment (Darwin, 1874). It is apparent that people in most situations are able to judge whether something is beautiful or not, and which of two objects they prefer aesthetically. Such evaluations are a product of the human aesthetic response, which has been previously conceptualized as an adaptive behavior with survival value for dealing with various aspects of the environment (Dissanayake, 2007). In this paper, we report on research that examined specific behavioral manifestations associated with the aesthetic response, especially with regard to approach and avoidance responses. We employed a novel approach in which we measured gaze behavior to ecologically-relevant stimuli consisting of attractive and nonattractive faces embedded within complex scenes. We also assessed whether the aesthetic sense is adaptively sensitive to situational demands such as the presence of threat. This approach is consistent with current models of situated cognition wherein behavior is contextualized within the actual situation in which they occur (e.g., Schwarz, 2007; Smith & Semin, 2004).

What are the possible functions of the aesthetic response? Consistent with the Darwinian perspective, aesthetic appreciation has been considered as “an adaptive behavior that promotes selective attention and positive emotional response to components of the environment that lead to ‘good’ (adaptive) decisions and problem solving” (Dissanayake, 2007, p. 4). In this sense, aesthetic appreciation may function to orient people towards positive aspects of their surroundings—an approach response—, and that being drawn to such things is rewarding and pleasing, and has adaptive value. For example, the aesthetic sense may be sensitive to attractive people because attractiveness signals reproductive fitness (Etcoff, 1999; Grammer & Thornhill, 1994; Symons, 1979; Thornhill & Gangestad, 1999). As such, attention is directed towards attractive people because doing so could lead to adaptive mating decisions. Furthermore, looking at attractive people may also lead to rewarding and pleasing experiences (Dissanayake, 2007; Hayden, Parikh, Deaner, & Platt, 2007). Aesthetic appreciation might also function in an adaptive way to draw people to aspects of their environment depending on the situation that they are in. For instance, being in a threatened state could lead to sensitivity to certain types of people presumably because they pose as a threat (Anderson, Christoff, Panitz, De Rosa, & Gabrieli, 2003). In the present study, we operationalized the consequences of the aesthetic response by measuring gaze behavior. Gaze behavior can be considered as overt manifestations of visual and cognitive processes (Henderson, 2003). In Experiment 1, participants viewed real world scenes with attractive and nonattractive faces within a neutral context. In Experiment 2, participants viewed the same scenes and faces following a threat or social approach manipulation.

We used face stimuli that were either “attractive” or “nonattractive.” The concept of attractiveness as a biologically-determined feature and an evaluative category is well-established in psychological literature. It is also associated less with ambiguities and philosophical issues as compared to other terms in aesthetics (e.g., beauty). For faces, there are clear-cut differences in levels of attractiveness.

Faces are particularly suited for such an examination because they are associated with a biologically-determined sense of beauty. There is abundant evidence that faces somehow capture visual attention. For example, Fletcher-Watson, Findlay, Leekam, and Benson (2008) found that participants had the tendency to look at scenes with people, and that they were inclined to attend to the face region within those scenes. Once faces have captured attention, they also seem to bind it, as was shown by Bindemann, Burton, Hooge, Jenkins, and de Haan (2005). They found an *attention retention bias* for faces as compared to non-face objects. There is also evidence that faces are processed in a special manner (Leder & Bruce, 2000; Ro, Russell, & Lavie, 2001), in that the brain recruits a special region for face processing (e.g., Kanwisher, McDermott, & Chun, 1997), and facial attractiveness, in particular, elicits a specific neural response pattern (Chatterjee, Thomas, Smith, & Aguirre, 2009; O’Doherty et al., 2003; Winston, O’Doherty, Kilner, Perrett, & Dolan, 2007). Finally, the distinction between an attractive and a nonattractive face is often clear-cut (Etcoff, 1999), so simultaneously presenting two faces that clearly differ in attractiveness should allow for a direct assessment of the aesthetic response to attractiveness.

Thus, a careful selection of faces as stimuli allows the examination of the behavioral consequences of the aesthetic response. Differences in facial attractiveness may be due to variation on features such as symmetry (e.g., Perrett et al., 1999; Rhodes, Proffitt, Grady, & Sumich, 1998) and averageness (e.g. Langlois & Roggman, 1990). Although these features are subjects of debates (Fink & Penton-Voak, 2002), their effects on attractiveness judgments are reliably found (Etcoff, 1999). Nevertheless, individual differences have also been shown with regard to aesthetic evaluations (Hönekopp, 2006). In this sense, aesthetic responses are a result of a combination of object features and characteristics of the perceivers such as gender. Such aesthetic responses should be stable across various contexts. Consistent with this are previous studies that have shown differential aesthetic responses to female and male faces (e.g., Aharon et al., 2001), and that faces are processed differently by male and female perceivers (Levy et al., 2008; McBain, Norton, & Chen, 2009). Therefore, we included two additional variables in our design: gender of perceived face and gender of perceiver. Inclusion of these gender variables also allowed the examination of additional hypotheses in Experiment 2, which were concerned with the moderating influence of gender and situational demands.

For the purpose of our study, it was important to systematically vary the presence and location of attractiveness in complex scenes. We wanted to ascertain how attractiveness influences visual exploratory behavior as indicated by eye movements. Thus, we digitally embedded attractive and nonattractive female and male faces into everyday scenes (Figure 1a) and measured participants' eye movements. The embedding procedure, which was undetected to the participants, enabled the use of complex, realistic urban scenes while also allowing the control of important stimulus variables such as the location and orientation of faces in the scenes.

Previous studies that have examined the relationship between judgments of attractiveness and gaze have presented faces in isolation (e.g, Shimojo, Simion, Shimojo, & Scheier, 2003). Such an approach has made it difficult to conceptualize results in terms of how attractiveness influences *natural* gaze behavior or how it affects passive viewing of real-world scenes. Here, we assumed the perspective of situated cognition wherein behavior is considered in its natural context, one rich in physical artifacts and situational cues (see Smith & Semin, 2004). The processing of objects is known to be enhanced by the presentation of associated situational information (Chaigneau, Barsalou, & Zamani, 2009). To our knowledge, there has been no study that has looked at the relationship between attractiveness and gaze in the context of complex real world scenes. Here, we used scenes consisting of various urban street environments photographed from a normal pedestrian perspective. To further examine gaze behavior as it naturally occurs in everyday situations, participants freely viewed the scenes without having to perform a specific task.

In Experiment 1, we analyzed eye movements to explore if attractive faces could receive longer fixations because doing so would be adaptive (e.g., informative to mating decisions), and pleasing and rewarding (Dissanayake, 2007; Hayden et al., 2007). This is consistent with Santayana's (1896) claim that, "There must therefore be in our nature a very radical and wide-spread tendency to observe beauty, and to value it" (p. 1). Alternatively, nonattractive faces could receive longer fixations because they may be adaptively more informative, thus demanding more attention and longer looks, as Rhodes, Geddes, Jeffery, Dziurawiec and Clark (2002) found with young children. Accordingly, once a face is deemed beautiful, it allows the release of perceptual resources to other aspects of the environment. This would be a negative version of the beautiful-is-good heuristic, according to which beauty is associated with positive personal characteristics (Dion, Berscheid, & Walster, 1972; Eagly, Makhijani, Ashmore, & Longo, 1991).

The function of aesthetics may be deeper and more fundamental than is typically considered. It could serve to integrate and account for the dynamic aspects and changing situational demands of the environment. If this is the case, then manipulating the context by emphasizing threat or social approach should lead to changes in the behavioral consequences of looking at attractiveness. This should particularly be evident with regard to gender. There is evidence that aggression potential is higher in males than females in humans and other species (Wrangham & Peterson, 1996). This difference may have evolutionary origins. Pinker (2002) has claimed that aggression developed as a strategy used during competitive contexts that often involved males. As a result, males are generally more aggressive than females. Consistent with this is the higher rate of violent behavior such as rape perpetrated by males (see Thornhill & Palmer, 2000). According to the *Supplementary Homicide Reports* of the Bureau of Justice Statistics of the United States Department of Justice, males are eight times more likely to commit murder than females (www.ojp.usdoj.gov/bjs/homicide/gender.htm). The Law Library states that, “Gender is the single best predictor of criminal behavior: men commit more crime, and women commit less. This distinction holds throughout history, for all societies, for all groups, and for nearly every crime category. The universality of this fact is really quite remarkable, even though many tend to take it for granted.” (http://law.jrank.org/pages/1256/Gender-Crime.html).

There may also be different effects with regard to gender in contexts in which social approach and partnership is emphasized. Attractiveness is more important to males than females (Buss, 1995; Feingold, 1990). Thus, under conditions in which social partnership is stressed, the effects of attractiveness should be more apparent in male than female perceivers.

In Experiment 2, participants viewed the same scenes and faces in a similar manner as in Experiment 1. However, prior to viewing, participants were subjected to either a threat or a social approach manipulation. If attending to attractive faces is a positive and rewarding experience, and if it is related to adaptive mating decisions, then participants in the social approach condition should look longer at the attractive faces, and this might be more elaborated for male perceivers. In contrast, under conditions of threat, situation-specific behavior may take precedence over the effects of attractiveness, particularly for male faces.

Figure 1. (a) Test scene, showing an attractive and a nonattractive face (here, faces used in the actual study were replaced by example faces). (b) Filler scene. (c) Test scene analyzed by an automatic saliency detection system.

Experiment 1

Experiment 1 examined two competing hypotheses: people will look longer at attractive than nonattractive male and female faces because doing so is adaptively beneficial; alternatively, people could look longer at nonattractive faces because attractive faces release perceptual resources to other, potentially more informative aspects of the environment.

Method

Participants

Forty-four undergraduate students (half female; mean age: 21.8) from the University of Vienna participated for course credit. Prior to data collection, the nature of the procedures was explained to, and informed consent was obtained from each participant. All participants had normal or corrected-to-normal vision.

Materials

The stimuli consisted of the following two types of street scenes: 18 test scenes with embedded, pre-rated attractive and nonattractive neutral expression faces; and 18 filler scenes (Figure 1b), which were similar to the test scenes, although without people. These scenes were included as distractor stimuli. Their inclusion also aided in establishing an experimental scenario that resembled a realistic sequence of street scenes. Each test scene depicted two people of the same gender resulting in nine male and nine female pairs. The left-right face positions were fully counterbalanced across participants. The embedded faces were taken from our in-house face database and various internet websites, and were all in frontal view.

Categorization into attractive and nonattractive was based on a pre-study (n = 10) in which a set of 88 faces was rated for attractiveness. This rating step ensured that the attractive and nonattractive faces were clearly on the opposite ends of the attractiveness scale. The selected faces were digitally embedded into the scenes, completely replacing the original faces. The scenes were subsequently equalized in luminance and contrast, converted to grayscale, and sized to 800 x 600 pixels.

To examine the potential influence of the embedding manipulation on low-level image features, specifically in the areas around the faces, all test scenes were analyzed with an automatic saliency detection system, which is based on low-level visual features analyses (Itti, Koch, & Niebur, 1998). This system simulated the first five fixations for each scene. Figure 1c depicts an example of an output of the analysis. Thus, there were a total of 180 possible fixations (18 scenes x 2 versions x 5 fixations). We expected an unbiased distribution of fixations across the images. Of the 180 fixations, only five fixations (2.8%) landed on the faces, and of these, three (1.7%) were on attractive and two (1.1%) were on nonattractive faces. Thus, the images and the faces within them did not systematically differ in low-level visual features.

Apparatus

Eye movements were recorded (left eye) with an iView X Hi-Speed video-based eye tracker (SensoMotoric Instruments) at 240 Hz frequency. Participants sat at a distance of 59 cm from the monitor, and their positions were stabilized with head and chin rests. The experiment was controlled by Presentation software (Neurobehavioral Systems).

Procedure

The experiment consisted of a viewing and a rating phase. At the beginning of the viewing phase, the signal was verified with a 5-point calibration. This was followed by the instructions. Each trial began with a "Blink Now" message allowing the participant to blink. A fixation cross followed and remained on the screen until the participant fixated on it. Each scene was presented (screen size: 8.33 x 11.11 inches) for 10 seconds while eye movements were recorded. Participants were not given a specific task, but were merely told to freely view the scenes. The scenes were presented in random order.

After all of the scenes were presented in the viewing phase, new instructions were provided for the rating phase. The same scenes were subsequently shown for three seconds. For each scene, participants provided three 7-point Likert-type scale ratings: attractiveness ratings, one for each of the two faces; and an interestingness rating of the actual scene. This latter question was included as a distractor, and was used for both types of scenes. Data associated with the distractors were not analyzed.

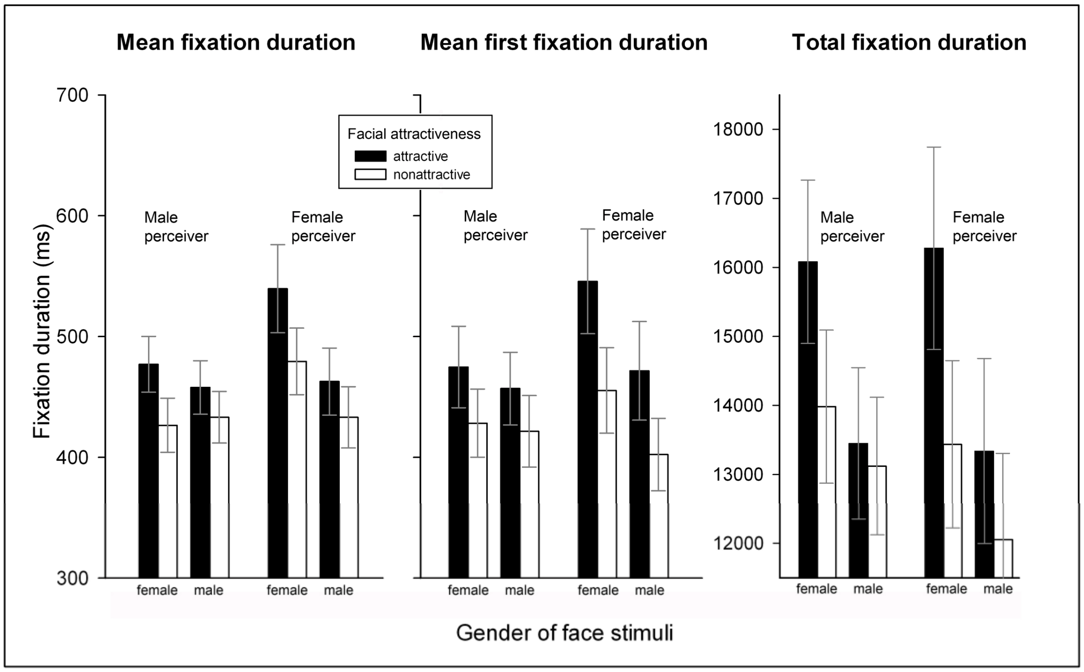
Eye Movement Data Analysis

Raw eye movement output files were filtered using Matlab (version 7.1) to derive the fixations. Blinks and saccades were not included in the analyses. Two areas of interest (AOIs) consisting of the areas of the two faces were defined for each scene. The sizes of the AOIs were equal for all faces and across all scenes. Fixations within the AOIs were analyzed along the main factors (i.e., attractiveness, gender of face, and gender of perceiver) for the following dependent variables: mean fixation duration (MF), mean first fixation duration (MFF), and total fixation duration (TF; see Duchowski, 2007 for a discussion of these traditional objective eye tracking metrics). MFs within AOIs were sampled across participants for each face category. MFFs consisted of the average initial fixations sampled across participants for each face category. Finally, TFs were the average total (sum) fxation durations sampled across participants for each face category.

Results

The MFs, MFFs, and TFs were sampled across participants for the attractive and nonattractive faces. Repeated measures ANOVAs of gaze data (Figure 2), with attractiveness and gender of face as within-subject factors and gender of perceiver as between-subjects factor, showed that the MFFs were longer for the attractive than the nonattractive faces, $F\ (1, 42) = 15.40$, $p < .01$, $\eta_p^2 = .27$, with durations being generally longer for female faces, $F\ (1, 42) = 5.62$, $p = .02$, $\eta_p^2 = .12$. MFs showed a similar pattern with durations longer for attractive faces than nonattractive faces, $F\ (1, 42) = 18.99$, $p < .01$, $\eta_p^2 = .31$, and durations longer for female faces $F\ (1, 42) =10.08$, $p < .01$, $\eta_p^2 = .19$. Moreover, there was a significant interaction for MFs between gender of perceiver and gender of face, $F\ (1, 42) = 6.70$, $p < .01$, $\eta_p^2 = .14$. This indicates that female perceivers looked longer than male perceivers at female, ($p = .07$), but not male faces ($p = .93$). Analysis of TFs indicated longer TFs for attractive than nonattractive faces, $F\ (1, 42) = 14.20$, $p < .01$, $\eta_p^2 = .25$, and for female than male faces $F\ (1, 42) = 18.70$, $p < .01$, $\eta_p^2 = .30$. Finally, there was a significant interaction between attractiveness and gender of face, $F\ (1, 42) = 6.13$, $p <.05$, $\eta_p^2 = .13$, indicating that the difference between attractive and nonattractive faces was larger for female, ($p < .01$), than male faces ($p = .13$). There were no other significant results.

Figure 2. Experiment 1. Mean fixation, mean first fixation, and total fixation durations ± SE plotted separately for male and female perceivers.



Results of the behavioral data were analyzed in a repeated measures ANOVA with attractiveness and gender of face as within-subject factors and gender of perceiver as between-subjects factor. The analysis revealed that the attractive faces were indeed rated as more attractive (means: 4.31 vs. 2.85), F (1, 42) = 172.43, $p < .01$, $\eta_p^2 = .80$, validating the initial classification of the faces according to attractiveness. Furthermore, female faces were rated more attractive than male faces (means: 3.86 vs. 3.30), F (1, 42) = 37.07, $p < .01$, $\eta_p^2 = .47$. There was a significant interaction between attractiveness and gender of face, F (1, 42) = 12.55, $p < .01$, $\eta_p^2 = .23$, with the difference in ratings between attractive and nonattractive faces larger for female (mean difference: 1.67) than male faces (mean difference: 1.24). Moreover, there was a significant interaction between attractiveness and gender of perceiver, F (1, 42) = 4.12, $p < .05$, $\eta_p^2 = .09$, indicating that female perceivers provided higher ratings than male perceivers to attractive ($p = .05$) but not nonattractive ($p = .53$) faces. There were no other significant results. Overall, this pattern of results was similar to the gaze data. These analyses reveal that the differences in attractiveness were highly salient, but that female faces were more attractive, and that the gender of the perceiver is marginally influential. For the present analyses, the first finding is crucial as it allows an interpretation in terms of exploratory behavior to faces differing in attractiveness.

Moreover, results of post-experiment interviews indicated that participants were unaware of the manipulations made on the images. Finally, although the faces within the scenes may have been fixated before other elements of the scenes because the faces were near central fixation and because faces generally tend to attract gaze (Fletcher-Watson et al., 2008), the direction of first fixations were equally likely (no differences) to attractive and nonattractive faces, for both male (p = .50) and female (p = .63) faces. This suggests that the response to facial attractiveness is determined by higher-level cognitive functions, and is consistent with the results of the visual saliency detection analysis. In Experiment 2, we tested whether the advantages of attractive faces in terms of fixation durations could be moderated by the situational context.

Experiment 2

In Experiment 2, we examined participants' gaze behavior under threat and social approach conditions. We explored the possibility that the aesthetic sense may bias the perceptual and cognitive systems in order to take account of the demands of specific contexts. In threatening situations, the advantages of attractiveness in terms of attracting gaze might disappear because of the presence of other situational demands.

Method

Participants

Forty undergraduate students (half female; mean age: 21.9) from the University of Vienna participated for course credit. The nature of the procedures was explained to, and informed consent was obtained from each participant prior to the experiment. All participants had normal or corrected-to-normal vision, and none had participated in Experiment 1.

Materials

The stimuli consisted of the same 18 test scenes with embedded faces and 18 filler scenes.

Apparatus

The same iView X Hi-Speed video-based eye tracker system and software was used as in Experiment 1.

Procedure

The viewing and rating phases comprising the main experiment were conducted in the same manner as in Experiment 1. However, prior to the main eye tracking experiment, participants were randomly assigned to one of two conditions (each with 10 male and 10 female participants): threat or social approach manipulation. They were then told that they will complete three different tasks. In the first task, they had to complete six matrices within two minutes. This task was included as a distractor task. The second task was presented as a memory task, although it actually involved the threat or social approach manipulation, depending on which condition the participant was assigned. Participants were instructed that they should carefully read a short text for one minute, and that they will be asked to reproduce the text after reading it. The threat manipulation text described the city of Vienna with emphasis on crime rates and other crime-related information. The social approach manipulation text described Vienna with focus on being a single person, and the positive elements of urban life as related to partnerships. The texts were approximately the same length, and written in a similar style. After reading the text, all participants performed the same task; they were instructed to summarize the text in a few sentences, and were asked to characterize the content of the text using three keywords. To verify the effectiveness of the manipulations, three independent judges individually rated each text summary on a 5-point Likert-type scale for correspondence to a positive or negative valence (depending on the condition). They rated on a 5-point Likert-type scale with 1 indicating low correspondence and 5 high correspondence. The ratings showed that the manipulations were effective with an average rating of 4.65 (range: 3.67-5.00).

Following the manipulation, the study then proceeded as in Experiment 1 with the viewing and rating phases. After these, participants were again asked to summarize the text that they read and to characterize it using three keywords. This final task was included as a control to verify that the effects of the manipulation persisted after the main experiment. The same three judges also rated each of the second text summaries for consistency with the corresponding *first* text summaries. They used a 5-point Likert-type scale with 1 indicating low persistence and 5 high persistence. The ratings indicated high persistence due to the manipulation, with an average rating of 4.60 (range: 4.00 – 5.00).

Data Analysis

Data analyses for both attractiveness ratings and eye movements were performed in the same manner as in Experiment 1. For the eye movement data, fixations within the AOIs were analyzed along the main factors (i.e., attractiveness, gender of face, and gender of perceiver) for mean fixation, mean first fixation, and total fixation durations.

Results

MFs, MFFs, and TFs were sampled over participants for the attractive and nonattractive faces. Repeated measures ANOVAs of gaze data, with attractiveness and gender of face as within-subject factors, gender of perceiver and condition (threat and social approach) as between-subjects factors, and MFs as dependent variable revealed longer fixation durations for attractive faces, $F\ (1, 36) = 25.37$, $p < .01$, $\eta_p^2 = .41$, with durations generally longer for female faces, F (1, 36) = 14.62, $p < .01$, $\eta_p^2 = .29$. The difference in fixation durations between attractive and nonattractive faces was larger for female than male faces, F (1, 36) = 6.93, $p < .05$, $\eta_p^2 = .16$. Importantly, there was a significant interaction among attractiveness, gender of face, and condition, F (1, 36) = 7.69, $p < .01$, $\eta_p^2 = .18$. This effect was based on longer fixation durations for attractive female faces in the threat ($p < .01$) and social approach conditions, ($p < .05$), and longer durations for attractive male faces in the social approach condition, ($p < .01$). However, there was no difference in MFs for attractive and nonattractive male faces in the threat condition ($p = .49$).

The pattern of effects was similar for the MFF data. MFFs were longer for attractive than nonattractive faces, F (1, 36) = 25.42, $p < .01$, $\eta_p^2 = .41$, and longer for female than male faces, F (1, 36) = 6.25, $p < .05$, $\eta_p^2 = .15$. The difference in MFFs between attractive and nonattractive faces was larger for female than male faces, F (1, 36) = 9.24, $p < .01$, $\eta_p^2 = .20$. There was also a significant interaction among attractiveness, gender of face, and condition, F (1, 36) = 11.90, $p < .01$, $\eta_p^2 = .25$. This interaction reflected longer MFFs for attractive male faces in the social approach condition, ($p < .05$), and attractive female faces in the threat condition, ($p < .01$). There was no difference in MFFs between attractive and nonattractive male faces in the threat condition ($p = .60$), and between attractive and nonattractive female faces in the social approach condition ($p = .16$).

Analyses of TFs showed similar findings, with longer TFs for attractive than nonattractive faces, F (1, 36) = 19.98, $p < .01$, $\eta_p^2 = .36$, and longer TFs for female than male faces, F (1, 36) = 16.92, $p < .01$, $\eta_p^2 = .32$. The difference in TFs between attractive and nonattractive faces was larger for female than male faces, F (1, 36) = 27.11, $p < .01$, $\eta_p^2 = .43$. The interaction among attractiveness, gender of face, and condition was significant, F (1, 36) = 5.76, $p < .05$, $\eta_p^2 = .14$. TFs were longer for attractive than nonattractive female faces in both the threat, ($p < .01$), and social approach, ($p < .05$) conditions. There were no differences in TFs between attractive and nonattractive male faces in the threat ($p = .79$), and social approach ($p = .11$) conditions. There were no other significant results.

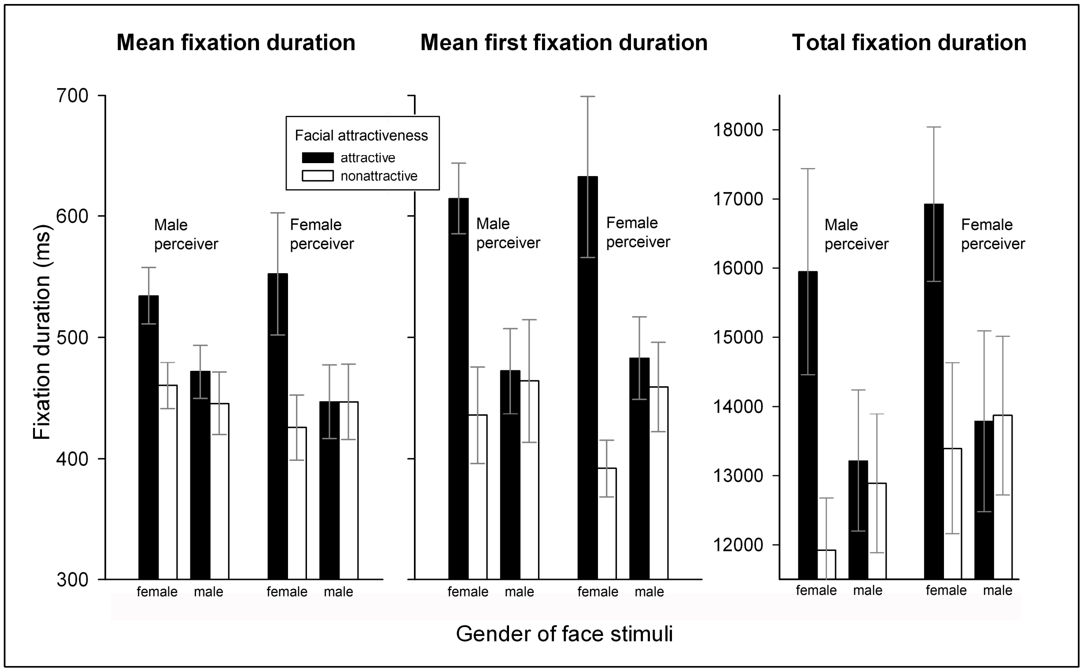
Participants' behavioral ratings of the faces were analyzed in a repeated measures ANOVA with attractiveness and gender of face as within-subject factors and gender of perceiver and condition as between-subjects factors. As with Experiment 1, the analysis revealed that the beautiful faces were indeed rated as more beautiful (means: 4.04 vs. 2.55), F (1, 36) = 274.06, $p < .01$, $\eta_p^2 = .88$, and female faces were rated more beautiful than male faces (means: 3.60 vs. 2.55), F (1, 36) = 50.78, $p < .01$, $\eta_p^2 = .59$. There was a significant interaction between attractiveness and gender of face, F (1, 36) = 11.48, $p < .01$, $\eta_p^2 = .24$, which was based on greater differences in ratings between attractive and nonattractive faces for female (mean difference: 1.69) than male (mean difference: 1.29) faces. There were no other significant effects. Finally, results of post-experiment interviews indicated that participants were unaware of the manipulations made on the images.

Separate analyses (see Figures 3 and 4) were performed on the eye movement data for the threat and social approach conditions to more directly address the effects of situational demands on fixation durations to attractive and nonattractive faces. Within each condition, emphasis was placed on exploring the effects in terms of the gender of the perceiver.

Threat Condition

Attractive faces were looked at longer than nonattractive faces overall, as indicated by MFs, $F\ (1, 18) = 11.49$, $p < .01$, $\eta_p^2 = .39$, MFFs, $F\ (1, 18) = 18.02$, $p < .01$, $\eta_p^2 = .50$, and TFs, $F\ (1, 18) = 12.88$, $p < .01$, $\eta_p^2 = .42$. In addition, female faces were looked at longer than male faces, as revealed by MFs, $F\ (1, 18) = 8.32$, $p < .05$, $\eta_p^2 = .32$, and MFFs, $F\ (1, 18) = 4.84$, $p < .05$, $\eta_p^2 = .21$; this effect approached significance for TFs, $F\ (1, 18) = 4.37$, $p = .05$, $\eta_p^2 = .20$. There were significant interactions between attractiveness and gender of face for MFs, $F\ (1, 18) = 17.15$, $p < .01$, $\eta_p^2 = .49$, MFFs, $F\ (1, 18) = 24.19$, $p < .01$, $\eta_p^2 = .57$, and TFs, $F\ (1, 18) = 36.79$, $p < .01$, $\eta_p^2 = .67$. This interaction is based on significant differences between attractive and nonattractive faces for female, (all p's $< .01$), but not male faces (all p's $> .49$). In other words, under threat, the attractiveness advantage remains for female faces but disappears for male faces. This is consistent with the idea that males have a higher aggression potential than females. There were no other significant results.

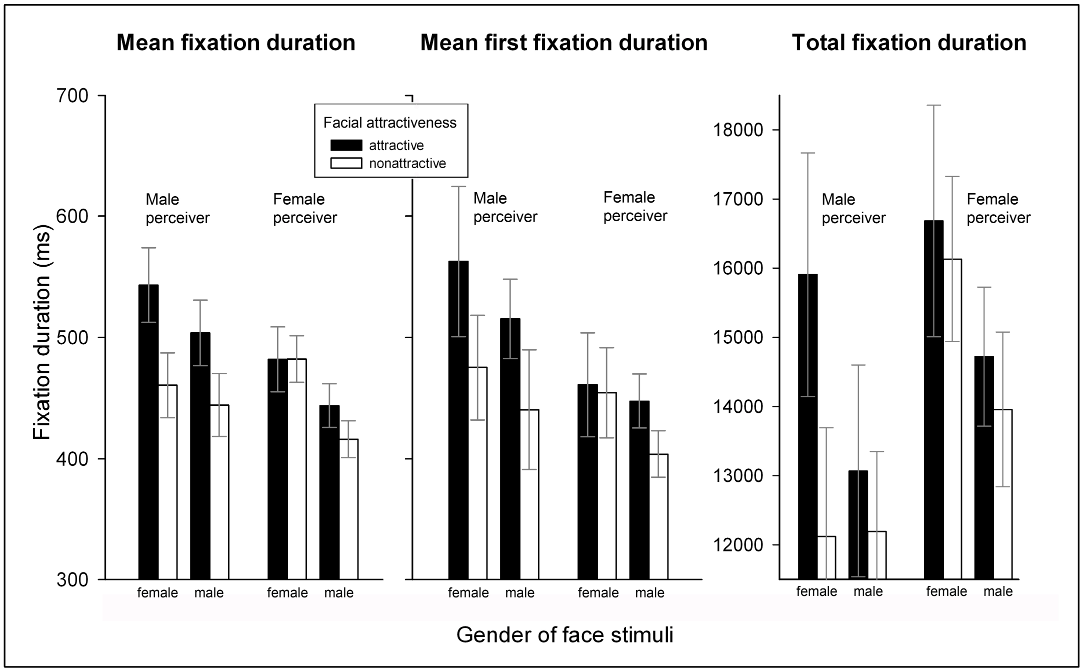
Figure 3. Experiment 2 – threat condition. Mean fixation, mean first fixation, and total fixation durations ± SE plotted separately for male and female perceivers.



Social Approach Condition

Attractive faces in the social approach condition were looked at longer than nonattractive faces for MFs, F (1, 18) = 16.76, $p < .01$, $\eta_p^2 = .48$, MFFs, F (1, 18) = 7.49, $p < .05$, $\eta_p^2 = .29$, and TFs, F (1, 18) = 7.48, $p < .05$, $\eta_p^2 = .29$. Female faces were looked at longer than male faces for MFs, F (1, 18) = 6.50, $p < .05$, $\eta_p^2 = .27$ and TFs, F (1, 18) = 15.39, $p < .01$, $\eta_p^2 = .46$. This effect was not found in MFFs, ($p = .18$). There was a significant interaction between attractiveness and gender of perceiver in MFs, F (1, 18) = 7.68, $p < .05$, $\eta_p^2 = .30$, which reflects a difference between attractive and nonattractive faces for male ($p < .01$) but not for female ($p = .35$) perceivers. Although this finding is consistent with Buss (1995) and Feingold (1990), the effects of gender of perceiver were marginal. There were no other significant interactions.

Figure 4. Experiment 2 – social approach condition. Mean fixation, mean first fixation, and total fixation durations ± SE plotted separately for male and female perceivers.



General Discussion

In this study, we investigated the function of aesthetics in human experience. Aesthetics could be examined using various measures. Traditionally, it has been examined using behavioral judgments such as preference or ratings of attractiveness. However, visual exploratory behaviors are more direct indicators of approach and avoidance behaviors (Henderson, 2003). We therefore looked at eye movements to examine the function of aesthetics.

There are different positions concerning its possible functions. It could function to signal a positive feature of an object. For example, when beauty and attractiveness signal general health, reproductive fitness, and overall mating value (e.g., Grammer & Thornhill, 1994), then attractiveness would attract visual behavior. If such effects are a feature of the objects, then they would be stable and independent of transient situational variations. This would be consistent with studies that have shown agreement in judging facial attractiveness (Etcoff, 1999), and in preferences for natural scenes (Kaplan, 1992). However, some studies have also shown inconsistencies that are attributed to individual differences with regard to taste (Hönekopp, 2006). According to such a position, aesthetics reflect the outcome of evaluations based on both object features and the perceiver's characteristics. Consequently, although not everyone will evaluate the same objects as attractive, behavioral consequences in terms of exploratory visual behavior will remain stable, and would be reflected in longer looks at the attractive objects. Shimojo et al.'s (2003) finding that attractive faces received longer looks support this position. Thus, aesthetic responses could be based on both object features and individual differences, and are stable across different contexts in terms of behavioral consequences. However, aesthetics may have a deeper, more fundamental function that goes beyond stable responses. Aesthetics could be an adaptive mechanism that integrates and takes into account the dynamic aspects of situations. This enables a flexible response to the richness of human experience. Behavioral consequences in this sense would change depending on situational demands.

In order to distinguish among these different positions, we assessed the consequences of attractiveness by directly comparing visual exploratory behavior to attractive and nonattractive faces in real world scenes. In Experiment 1, all measures indicated that attractive faces were judged as more attractive and were looked at longer than nonattractive faces. This is clearly in accordance with the first position. While these data suggest a direct relationship between attractiveness and behavioral consequences, results of Experiment 2 clearly showed a more differentiated picture.

When perceivers in Experiment 2 were subjected to either a threat or social approach manipulation, then exploratory behavior differed predictably depending on the situation. In the social approach condition, male perceivers had longer mean fixation durations at attractive than nonattractive faces while female perceivers did not. Moreover, under the threat condition, attractive male faces no longer received longer looks, which was expected given the higher aggression potential associated with males. Taken together, the two experiments clearly showed that the behavioral consequences of attractiveness systematically varied with regard to the situation. Thus, aesthetics adaptively guides visual exploration in response to the changing demands of the environment.

In the present studies, we employed a new approach in which we compared eye movements to attractive and nonattractive faces in complex scenes. The studies revealed the effects of the situation in terms of visual exploratory behavior, but not in terms of the attractiveness ratings. These findings attest to our approach of measuring eye movement behavior. Future research could reveal more regarding the processes that moderate these effects.

Attractive faces may be looked at longer because they are rewarding and they produce positive emotions (Hayden, et al., 2007). However, as was shown in Experiment 2, the situation of threat extinguished the longer fixations for attractive male faces. Threat seemed to have overridden the pleasing and attention-binding aspects of attractiveness. On the other hand, in the social approach condition, the effects of attractiveness appeared to have been strengthened.

Concerning a more general framework of aesthetics, it remains to be seen whether using the approach used in the present study will result in similar findings with other stimuli such as artworks. There is a long history of using artworks in aesthetics research. However, artworks are not as biologically-related, as are faces. Thus, the aesthetic response to artworks may not depend so much on attractiveness and a sense of beauty. This is particularly the case for modern and contemporary art in which beauty has been deemphasized. Aesthetic responses to such artworks seem to rely more on the perceivers' past experiences and art expertise than on the attractiveness or beauty of the artworks (Augustin & Leder, 2006). Recent approaches to modern or contemporary art (Leder et al., 2004) stress the rewarding and positive emotional consequences of aesthetic experiences of art. In this regard, future research could expand on the present findings.

While we found predicted situations in which attractive faces were not looked at longer, attractive faces demanded longer looks in the majority of experimental conditions. It appears that unless a specific situational demand is present, attractiveness is most influential in shaping the way we perceive the world. The context dependency of the aesthetic response may also be reflected in the special environments in which aesthetic experiences usually take place. Examples of these include opera houses and the "white cube" as a prototype for the art museum. The specific effects of these environments on the aesthetic response are fascinating topics for future research.

To conclude, the present studies have revealed important aspects of aesthetics much in the sense of Baumgarten (1779), who first proposed the concept of aesthetics. He believed that aesthetics is a non-analytical and integrative way to access the world around us. Our results are consistent with such a holistic approach as we have shown that object features, individual factors, and situational demands determine our aesthetic response.

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7.3. Discussion

This was the first study to examine eye movement behavior as being directly related to attractiveness in real-world scenes. Eye movements were taken as indicators of cognitive processing (Henderson, 2003). The studies were also the first to provide direct evidence of the possible function of aesthetics; the aesthetic response guides people towards the pleasing and rewarding aspects of their environment, and that it adaptively constrains visual behavior to account for the changing demands of the environment. This adds to the current debates regarding beauty (Etcoff, 1999) and to issues in evolutionary theory related to the function of aesthetics (Dissanayake, 2007). It also contributes to the expanding literature regarding the relationship between bottom-up and top-down factors during aesthetic experiences (Cupchik, et al., 2009; Kirk, Skov, Hulme, Christensen, & Zeki, 2009). Finally, the process of embedding attractive and less attractive faces in real world scenes proved to be a valuable paradigm for investigating aesthetics phenomena.

8.

General Discussion

This dissertation had two objectives: to examine the effects of visual features on aesthetic judgments and to assess how these effects are modulated by factors such as familiarization and stimulus-inherent emotional valence. Taken together, the studies we have presented demonstrated the various ways that visual features can influence aesthetic judgments of a wide range of stimuli, including abstract patterns, composite faces, photographs of common objects, and photographs of natural and human-made scenes. Leder et al.'s (2004) information processing model of aesthetic experience and aesthetic judgments served to frame and integrate the various aspects of this dissertation. The results confirmed the findings of past studies (e.g., Bar & Neta, 2006, 2007; Jacobsen & Höfel, 2001) and extended research literature by testing theoretical claims (e.g., Berlyne, 1970, 1972; Zajonc, 1968), examining new hypotheses (e.g., regarding additive effects of degradations), using new experimental manipulations (e.g., embedding faces in real world scenes), and proposing novel concepts and ideas concerning various topics in experimental aesthetics (e.g., the taxonomy of image manipulation procedures).

The results of the studies reported in Chapters 2, 3, 5, and 6 demonstrated that the effects of visual features were additive—given the concurrent presence of two factors known to influence aesthetic judgments, the effects of one factor is built up on the effects of the other. This was found for structural (e.g., symmetry) and surface-level (e.g., image grain) visual features, and for abstract patterns, faces, and photographs of real world scenes.

The experiments in Chapters 3 and 4 demonstrated that emotional valence overrides the usually positive effects of certain visual features, which makes for an important contribution to the research literature because it shows that aesthetic responses are based on a complex interaction of lower-level and higher-order factors. This effect appears robust as it was found in experiments using different stimuli and experimental procedures. A similar effect was also shown in the eye tracking experiments discussed in Chapter 7 where participants were subjected to a threat or a social approach manipulation prior to the free viewing task. Although differences in fixation durations were found in the social approach condition, no differences in fixation durations were found between attractive and less attractive male faces in the threat condition. One interpretation of this is that the threat manipulation resulted in the activation of a threat-related response heuristic, which subsequently influenced visual exploratory behavior. In this case, the negative situation created by the manipulation took precedence over the visual elements that would normally bias fixations towards attractive faces. Referring to Leder et al.'s (2004) model, the effects of visual features during the early stages of processing were modulated by what transpired in the later stages of processing. Although the model makes the assumption that information processing generally proceeds from the perceptual analyses stage to the cognitive mastering and evaluation stages, the flow of information is not necessarily serial, but instead depends on the type of processing that occurs during each stage. In this sense, we found that later processes modulated earlier processes, which is in accordance with recent findings regarding the interaction between bottom-up and top-down processes during aesthetic episodes (Cupchik et al., 2009; Kirk et al., 2009).

The studies presented in Chapters 5 and 6 were aimed at addressing an important issue in the field of empirical aesthetics—the lack of research on the psychology of photography. This issue is critical because although photographs are used as stimuli in a significant amount of aesthetics research, little is known about how photographs themselves, not just what they depict, influence people's responses. Our studies addressed this by focusing on image quality, an aspect of photographic stimuli that varies tremendously both within one stimulus set and across different studies. Interestingly, image quality is rarely mentioned as an important variable in most studies. Our results clearly demonstrate the need for greater control of image quality elements. The research presented in Chapters 5 and 6 not only sought to contribute to the literature on the aesthetics of photography. It was also a serious attempt to stimulate further debates and research on the topic of image quality and other aspects of photography, such as the relationship between the material photograph and what it is depicting in the real world.

In Chapter 7, we showed that in general, attractive faces received longer looks. Importantly, the results clearly showed that context played a role. The approach of assessing the influence of context on aesthetic judgments is in accordance with the situated cognition approach (Schwarz, 2007; Smith & Semin, 2004). The relationship between aesthetic judgments and aspects of the context in which they occur remains a promising area of research.

As one of the oldest branches of psychology, empirical aesthetics has traditionally focused on low-level cognitive processes. This focus stems largely from Fechner's (1876) initial push for empirical research of aesthetics phenomena, which is reflected in his approach of "aesthetics from below." This dissertation aimed to develop on past research by not only investigating low-level visual features, but also the effects of modulating factors. In essence, it sought to examine the various factors—both bottom-up and top-down factors—within a comprehensive, yet integrated and systematic project, and to do so using both traditional experimental paradigms and state-of-the-art methodologies.

9.

Post Commentary

This entire endeavor continues beyond the partial fulfillment of an academic requirement. Each research topic described in the chapters above is being sustained with continued research, both active and forthcoming. To cite some examples, the research on symmetry, complexity, and aesthetic judgments has recently been extended using electromyography (EMG) measures. We are also planning future studies that will pinpoint what specific psychological mechanisms cause the difference in effects between abstract patterns and composite faces.

Experiments are also being conducted to further examine why attractive faces embedded in real world scenes demand longer looks. These experiments involve variations in the number of persons within the scenes. In addition, we are planning to extend the approach of embedding various objects into scenes to investigate other aesthetics issues.

Research on image quality is currently active. The effects of image quality degradations on the speed of aesthetic judgments are being examined. Also being explored are the interesting response latency patterns found in several of the experiments reported in Chapters 5 and 6. Why were response latencies generally higher for normal high-quality images of human-made scenes?

The push for photography research continues with studies investigating other aspects of photography. Presently, the focus is on examining compositional techniques long believed to have a positive influence on a photograph's balance, aesthetic appeal, artistic quality, and impact on the viewer. In this case, eye movement tracking seems to be an appropriate weapon of choice.

Models of aesthetic experiences explicitly describe cognitive processes involved during aesthetic episodes and factors that influence them (e.g., Chatterjee, 2003; Jacobsen, 2006; Leder et al., 2004). What is not explicitly addressed in those models is that prior to aesthetic episodes, perceivers must first *choose* to engage an object aesthetically (Cupchik, et al., 2009) or to shift attention to another object or to another activity altogether. Studies are being conducted that explore this choice to engage an object aesthetically. In those studies, the objects consist of high quality reproductions of artworks presented in large format. The project develops on previous research (Smith & Smith, 2001; Tinio, Smith, & Potts, 2010) and touches upon several of the main themes addressed in this dissertation, including visual features and contextual demands.

For each of these lines of research, we will continue to scrutinize previously found effects, while at the same time generating new hypotheses. One of the main goals is to maintain a multifaceted research program that sustainably advances the various areas of study.

10.

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11.

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East Stroudsburg University, Department of Early Childhood and Elementary Education
Instructor (Spring 2004)
- Child Growth and Development in Education: 1 Section

Kean University, Psychology Department
Instructor (Spring 2004)
- Life-Span Developmental Psychology

Union County College, Department of Psychology and Sociology
Instructor (Spring 2004)

- General Psychology (English as a Second Language Course)

Union County College, Department of Psychology and Sociology
Instructor (Fall 2003)

- Child Psychology: 2 sections
- General Psychology: 3 sections

Kean University, Psychology Department
Instructor (Fall 2003)

- First Year Seminar: Academic Success Course

Media and Arts Workshop: Red Bank Regional High School/Middle School
Lecturer (2002-2006)

- Worked with a team of writers and photojournalists to conduct arts and media workshops for media-track high school students

Various Publication Agencies, (National, International)
Photographer (1998-2003)

- Researched and produced person-centered photo essays exploring personal issues, interpersonal relations, and the interactions between people and their environment
- Conducted photographic coverage for news and magazine publications.
- Works published in Asbury Park Press, TRI Inc., YES Magazine, *Psychology of Aesthetics, Creativity and the Arts* (cover photo) and City News

Beyond The Cover Magazine
Chief Photography Editor (2000-2002)

- Directed the Photography Department
- Liaised with all departments for various projects
- Organized and conducted photo shoots involving entertainers, politicians, professional athletes, and key public figures

PUBLICATIONS

- Tinio, P. P. L., & Leder, H. (2009). Just how stable are stable aesthetic features? Symmetry, complexity, and the jaws of massive familiarization. *Acta Psychologica*, *130*, 241-250.

- Tinio, P. P. L., & Leder, H. (2009). Natural scenes are indeed preferred, but image quality might have the last word. *Psychology of Aesthetics, Creativity, and the Arts*, *3*, 52-56.

- Tinio, P. P. L., Leder, H., & Strasser, M. (in press). Image quality and the aesthetic judgment of photographs: Contrast, sharpness, and grain teased apart and put together. *Psychology of Aesthetics, Creativity, and the Arts*.

- Leder, H., Tinio, P. P. L., Fuchs, I., & Bohrn, I. (in press). When attractiveness demands longer looks: The effects of situation and gender. *Quarterly Journal of Experimental Psychology*.

- Tinio, P. P. L., Smith, J. K., & Potts, K. (2010). The object and the mirror: The nature and dynamics of museum tours. Manuscript submitted for publication.

- Gerger, G., Leder, H., Schacht, A., & Tinio, P. P. L. (2009). Do I smile or do I frown? Facial EMG as an indicator of affective reactions to attractiveness judgments of faces and patterns. Manuscript submitted for publication.

- Smith, J. K., & Tinio, P. P. L. (2008). Audibly engaged: Talking the walk. In L. Tallon, & K. Walker (Eds.), *Digital Technologies and the Museum Experience*. Lanham, MD: AltaMira Press.

- Tinio, P. P. L., & Leder, H. (2008). Optimal interface between artworks and the information processing system. In V. M. Petrov, & A. V. Kharuto (Eds.), *Information Theory and Art Studies*. Moscow: KomKniga, 144-149.

- Tinio, P. P. L., & Leder, H. (2008). One of many bridges: From basic visual stimulus features to formal elements in artworks. *Proceedings of the 20th Congress of the International Association of Empirical Aesthetics*, 409-411.

IN PREPARATION

- Tinio, P. P. L., Gerger, G., & Leder, H. (in preparation). Symmetry, complexity, familiarization, and the attractiveness of faces. Manuscript in preparation.

- Leder, H., Tinio, P. P. L., & Bar, M. (2009). Emotional valence modulates the preference for curved objects. Manuscript in preparation.

- Tinio, P. P. L., O'Donnell, A., & Smith, J. K. (in preparation). Creative mutual facilitation in groups.

- Tinio, P. P. L., Smith, J. K., Paul, M. A., Leder, H., & John, B. (in preparation). Spending time on art: An experimental study.

PUBLISHED ABSTRACTS

- Tinio, P. P. L., & Leder H. (2009). The robustness of symmetry and complexity against familiarization. Abstract. *The Copenhagen Neuroaesthetics Conference*. http://naconference.ikk.ku.dk

- Tinio P. L., & Leder H, (2007). Visual stimulus familiarity and generalization effects: An experimental examination of mediating factors. *Perception, 36*, ECVP Abstract Supplement.

- Tinio, P. L., & Leder, H. (2007). Optimal interface between artworks and the information processing system. Abstract. *Conference on New Methods in Studies of Artistic Creativity* and *International Symposium on Information Approach in Studies of Art and Culture.*

- Smith, J. K., Tinio, P. L., & Potts, K. (2005). The museum tour: Visitors, guide, interactivity. Abstract. *Museum Education Monitor*.

OTHER PUBLICATIONS

- Tinio, P. L. (2005). The museum tour: Visitors, guide, and interactivity. Unpublished report. New York City: The Whitney Museum of American Art.

- Tinio, P. L. (2003). The effects of environmental ergonomics on perceived work stress. Masters Thesis for the Degree of Master of Arts in Behavioral Science, Kean University. Advised by Dr. Lisa F. Smith.

- Tinio, P. L. (2000). The graphic development of children. Senior Thesis for the Degrees of Bachelor of Science in Psychology and Minor in Biology, Kean University. Advised by Dr. Aaron Kaplowitz.

PRESENTATIONS

INVITED PRESENTATIONS

- Tinio, P. P. L., & Leder, H. (2008). Emotional valence and the preference for curved contours. In Facing Future: New Voices in Aesthetics, Creativity, and the Arts. An Invited Session of the *2008 Conference of the American Psychological Association*, Boston, U.S.A.

- Tinio, P. P. L., & Leder, H. (2008). An experimental examination of familiarity, basic visual features, beauty judgments. In Means and Devices of Art. An Invited Session of the *2008 Conference of the International Association of Empirical Aesthetics*, Chicago, U.S.A.

- "Arts and the media." *Guest Speaker*, 2003 Arts and Media Forum, Red Bank Regional School, Redbank, New Jersey, U.S.A.

OTHER PRESENTATIONS

- Tinio, P. P. L. (2009). The effects of symmetry, complexity, and massive familiarization on the perception and evaluation of basic patterns and faces. Poster presented at the *2009 Copenhagen Neuroaesthetics Conference*, Copenhagen, Denmark.

- Strasser, M., Tinio, P. P. L., & Leder, H. (2009). The influence of image quality on scene preference. Poster presented at the *2009 Vienna Aesthetics Symposium*, Vienna, Austria.

- Tinio, P. L., & Leder, H. (2007). Mediating factors in visual stimulus familiarity effects: An experimental examination of stimulus characteristics. Poster presented at the *2007 European Conference on Visual Perception*, Arezzo, Italy.

- Tinio, P. L. (2006). The museum tour: Visitors, guide, and interactivity. Presented at the *Graduate School of Education Poster Session*, Rutgers University.

SERVICE, PROFESSIONAL ACTIVITIES, AND AFFILIATIONS

- Current International Representative to the Executive Committee of the American Psychological Association, Division 10: Society for the Psychology of Aesthetics, Creativity, and the Arts

- Co-Organizer of the 2009 Vienna Aesthetics Symposium: Eye Movements in Art Perception; and the 2010 Vienna Aesthetics Symposium: Art Appreciation, Emotions, and Research Methods
- Listserve Administrator (2005-2008) - American Psychological Association Division 10: Society for the Psychology of Aesthetics, Creativity, and the Arts
- Program Committee Member for 2008 Conference of the American Psychological Association
- Psychology of Aesthetics, Creativity, and the Arts (APA Publication) – Student Board Member
- Lecture Series Chairperson - Rutgers University, Graduate School of Education (2006-2007)

REVIEW WORK

- Psychology of Aesthetics, Creativity, and the Arts (active)
- Advances in Cognitive Psychology (ad hoc)
- European Journal of Cognitive Psychology (ad hoc)
- Optical Engineering and Photonic Technology International Symposium, 2009 (ad hoc)