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# DISSERTATION

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**Affective and Cognitive Aspects of Aesthetic  
Evaluations in Design, Art, Faces and Abstract  
Patterns**

Verfasser

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## **Abstract**

Humans have a sense of aesthetics which can be applied to a wide variety of natural categories like faces, and also to artificial categories such as artwork, design, and abstract patterns. Making aesthetics evaluations for such object categories involves a complex interplay of numerous factors and processes involving emotional and cognitive aspects (Leder, Belke, Oeberst, & Augustin, 2004). Thus, studying aesthetic evaluations can contribute to a deeper understanding of how the complex interplay of cognition and emotion forms human attitudes and experiences. In order to better understand different aspects of aesthetic evaluations and their dependence on different classes of objects (faces, abstract patterns, visual artworks and consumer product designs – car interiors), a wide range of different methods were employed in this dissertation: psychophysiological (facial EMG) or behavioral, and recently developed paradigms like massive familiarization (Tinio & Leder, 2009a) and repeated evaluation technique – (RET, Carbon & Leder, 2005).

Seven articles are reported which can be divided in three partially overlapping strands – 1) studying physiological aspects of aesthetic evaluations, addressing emotional consequences of aesthetic evaluations (Gerger, Leder, Schacht, & Tinio, submitted, chapter 2), – 2) studying dynamic changes of aesthetic evaluations due to familiarization (Tinio, Gerger, & Leder, 2010, chapter 3) and repeated evaluations (Gerger, Leder, Faerber, & Carbon, in press, chapter 4.2; Leder, Faerber, Gerger, Forster & Carbon, 2010, chapter 4.3; Gerger, Leder, Faerber, & Carbon, 2010, chapter 4.4; Faerber, Leder, Gerger, & Carbon, 2010, chapter 4.5) and – 3), studying the interplay of emotional and cognitive variables on aesthetic evaluations (Gerger et al., 2010, chapter 4.4; Leder, Gerger, Dressler, & Schabman, in press, chapter 5).

Gerger et al. (submitted) showed that there are differences and similarities in the aesthetic evaluations between natural and artificial categories when physiological consequences of aesthetic evaluations were measured by facial EMG. In Tinio et al. (2010) it was demonstrated that the stimulus dimension of complexity and symmetry in faces was generally robust but significantly modulated by massive familiarization. Moreover, in relation to an earlier study (Tinio & Leder, 2009a) different effects emerged for natural (faces, this study) and artificial (abstract patterns, Tinio & Leder, 2009a) categories. Results of these studies suggest that there are differences in how natural and artificial categories are aesthetically evaluated. The studies in chapters 4.2 – 4.5 likewise studied how the stimulus dimension innovativeness, which is characterised by some novelty, contributes to aesthetic

evaluations and dynamic changes in aesthetic evaluations of design products (car interiors). A novel paradigm was employed in these studies – the RET (Carbon & Leder, 2005). Results demonstrated that stimulus context (chapter 4.2), situational context (chapter 4.3) and evaluative context during initial stimulus exposure (chapter 4.5) influenced appreciation and the dynamic aspects of the appreciation of innovativeness. Moreover, the study in chapter 4.4, investigating the interplay of emotional and cognitive variables, showed that emotional variables are one of the main contributors to aesthetic evaluations. This was also demonstrated by Leder et al. (in press) by studying emotional and cognitive variables influencing aesthetic evaluations of artworks. Emotional valence was the strongest predictor of aesthetic evaluations for artworks. However, type of artwork (abstract, modern and classic) and expertise modulated these effects.

Each set of studies is introduced with the main empirical questions in brief, along with the original manuscripts. Additionally, articles are discussed with regard to the specific field of empirical aesthetics as well as to empirical psychology in general. The dissertation closes with a general discussion and with an outlook for future developments.



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# 1 General Introduction

Humans have a sense for aesthetics, which might be deeply embedded in our evolutionary history and unique to humans (Dissanayake, 2007). We are fascinated by the aesthetics of natural objects such as landscapes (Kaplan, Kaplan, & Wendt, 1972) and faces (Etcoff, 1999; Thornhill & Gangestad, 1999) but also by human made objects such as pieces of art (Leder, Belke, Oeberst, & Augustin, 2004), music (Blood & Zatorre, 2001; Koelsch, Fritz, Von Cramon, Muller, & Friederici, 2006; Vitouch, 2003), architecture (Maderthaner & Schmidt, 1989) and design (Carbon & Leder, 2005; Hekkert & Leder, 2008). However, attractive aspects in our environment not only fascinate us, but influence a wide variety of our decisions – simple decisions such as which piece of art to look at longer and which music to listen to, more complex decisions such as which product to buy and really important decisions such as the choosing of one's mate. Although aesthetic evaluations show some stability there is also evidence from everyday life and from psychological research that, indeed, there are some dynamics in aesthetic evaluations. Aesthetic evaluations change for example due to fashion (Carbon, 2010), familiarization and habituation (Tinio & Leder, 2009a; Zajonc, 1968), expertise (Kirk, Skov, Christensen, & Nygaard, 2009) or by active use and repeated evaluations (Carbon & Leder, 2005). Several variables are known to affect aesthetic evaluations, often classified as affective or cognitive (Leder, et al., 2004). Due to the complex interplay of several variables, studying aesthetic evaluations can therefore contribute to a deeper understanding of the interplay of cognition and emotion in forming human attitudes and experiences.

In order to answer open questions regarding the complex interplay of cognitive and emotional factors, and their dependence on different classes of objects, the current dissertation project covered a broad range of behavioral and physiological studies. The studies can be roughly divided into three partially overlapping strands – studies regarding the physiological aspects of aesthetic evaluations (chapter 2), which address the emotional consequences of beauty, studies regarding dynamical aspects of aesthetic evaluations (chapters 3, 4.2, 4.3, 4.4, 4.5), which measure changes due to familiarization (Zajonc, 1968) or repeated evaluation (Carbon & Leder, 2005), and studies regarding the relationship between cognitive and emotional variables and how they contribute to aesthetic evaluations (chapters 4.4, 5).

Although some scholars and philosophers see aesthetic evaluations only with regard to the evaluation of high art, experimental aesthetics conceives aesthetic evaluations more

widely in the context of general evaluations of natural objects, such as faces and scenes, and artificial objects, human made artefacts, well controlled visual stimuli, real or artificial “artworks” (for an overview, see Allesch, 2006). This rather wide conception of aesthetic evaluations as general evaluations dates back to the 18<sup>th</sup> century philosopher, Alexander Baumgarten, (Baumgarten, 2007) who defined the term aesthetics as perception by means of the senses. Therefore a variety of stimuli were used in the present studies – faces (as in Schacht, Werheid, & Sommer, 2008) as a biologically and ecologically highly relevant category, abstract patterns highly controlled for their visual features (as in Jacobsen & Höfel, 2001), visual art and car interiors (as in Carbon & Leder, 2005).

Aesthetic evaluations are intimately connected to hedonic qualities as hedonically positive or negative. Asking lay people how they conceive aesthetics, they describe aesthetic evaluations mostly in terms of beauty and ugliness (Jacobsen, Buchta, Kohler, & Schröger, 2004). Thus, they equate aesthetic evaluations with the hedonic qualities accompanying it. The present studies are based on this conception of aesthetic evaluations as an evaluation indicating hedonic, aesthetic quality of various natural or artificial categories as either positive or negative. In this, they are part of the tradition of experimental aesthetics in psychology.

## **1.1 A Brief History of Psychological Aesthetics**

The studies contributing to the dissertation are based on a long experimental psychology tradition of aesthetics. Previously, Fechner (1876) tried to formulate general laws of aesthetics which were based on basic stimulus dimensions – for example, he studied the impact of proportions (e.g. golden section) on aesthetic evaluations. In addition, he distinguished an aesthetics from below and an aesthetics from above, which means, Fechner anticipated that not only bottom up – or stimulus driven processes – but also top down – or knowledge driven processes - are important for understanding aesthetic evaluations. This duality of bottom up and top down processes influencing aesthetic evaluations is consistently found in later theories. However, these theories more or less emphasized either bottom up or top down mechanisms (e.g. Arnheim, 1954; Berlyne, 1970a, 1970b; Birkhoff, 1932; Eysenck, 1940, 1941; Kreitler & Kreitler, 1972; Leder, et al., 2004; Martindale, 1988).

Fechner’s ideas inspired the work of Birkhoff (1932). He tried to find a formula by which aesthetic value is the ratio of order and complexity within a stimulus, which means that higher order increases attractiveness while higher complexity reduces it. Based on his theory

simple perceptual dimensions like simplicity, clarity of detail, contrast, and symmetry are important dimensions of aesthetic evaluations (and factors like symmetry, order, contrast and the like have indeed been identified as influential contributors to aesthetic evaluations; e.g. Arnheim, 1954; Garner, 1970; Höfel & Jacobsen, 2005; Humphrey, 1997; Jacobsen & Höfel, 2001, 2002; Locher, 2003; Tinio & Leder, 2009a; Tinio & Leder, 2009b).

Very similar to Birkhoff's theory, Eysencks (1940, 1941) postulated that aesthetic evaluations are determined by two factors: a general factor and a bipolar factor. The general factor represents a stable perceptual factor independent of learning, teaching and cultural backgrounds, and is similar to Birkhoff's order factor. The bipolar factor represents a distinction between liking more or less complex stimuli and affects, for example, the appreciation of formal and representational art. It can be influenced by the perceiver's personality and learning history. Thus, Fechner's conception of stimulus-driven bottom up and cognitive top down processes influencing aesthetic evaluations was also made by Eysenck (1940, 1941). In contrast to Birkhoff, however, Eysenck's theory considers the aesthetic value of a stimulus as the product of the two factors, instead of the ratio between them (Birkhoff, 1932). Thus, people will prefer stimuli with both high perceptual saliency or order and high complexity.

About half a century later the psychobiological theory of aesthetic evaluations became influential (Berlyne, 1970a, 1970b). Berlyne defined collative stimulus properties that refer to complexity, novelty and surprise as one of the most important contributors to aesthetic evaluations. The main characteristic of collative variables is that they involve comparison processes. That is, aesthetic evaluation therefore depends on the relation of the stimulus with other contextual stimuli (or stimulus elements) which may be presented together or at different times and thus, includes basic memory processes. That basic memory processes influence aesthetic evaluations was repeatedly demonstrated in the mere exposure effect – familiarization through repeated (mere) exposure increases appreciation (Zajonc, 1968; for an extensive review, see Bornstein, 1989).

The impact of these earlier studies can be seen in more recent work, as well. For example, factors linked to the visual characteristics like prototypicality (Halberstadt, 2006; Martindale & Moore, 1988; Winkielman, Halberstadt, Fazendeiro, & Catty, 2006) or visual rightness (Krupinski & Locher, 1988; Locher, 2003) were identified as important contributors to aesthetic evaluations. Recently Reber, Schwarz, and Winkielman (2004) attempted to explain the preference for such factors as prototypicality, familiarity, contrast, symmetry, order and the like in terms of general processing mechanisms of the brain. According to Reber

et. al.'s (2004) theory, high values in these factors (e.g. high prototypicality or high familiarity) enhances the stimulus processing, makes it faster, easier, less resource - demanding and consequently more efficient – which is summarized under the term “fluency of processing”. Fluency in turn increases positive affect, resulting in positive aesthetic evaluations. This idea, that our aesthetic evaluations are rooted in basic perceptual mechanisms of how our brain perceives the world can also be found by Zeki (1999), Ramachandran and Hirstein (1999) and Chatterjee (2003).

Recent studies have also focused more on complex top down processes such as attitudes, meaning and explicit knowledge (e.g. Kreitler & Kreitler, 1972; Leder, Carbon, & Ripsas, 2006; Martindale, 1988; Millis, 2001; P. A. Russel, 2003), and on the impact of complex appraisal processes linked to the emotional consequences of aesthetic evaluations (Scherer, 2005; Silvia, 2005a). These complex top down and appraisal processes can influence aesthetic processing beyond the mechanisms outlined above. In order to unify these diverse bottom-up and top-down accounts Leder et al. (2004) developed a model of aesthetic evaluations that attempted to combine some of these previous works on aesthetics.

## 1.2 A Model of Aesthetic Experiences as a Framework

Leder et al. (2004) developed a model of aesthetic evaluations (see Figure 1, p. 5) which divides aesthetic evaluations into five consecutive sub-processing stages. The input of the model is a stimulus to be aesthetically evaluated. Usually aesthetic evaluations require some pre-classification and/or context to warrant aesthetic processing. Seeing a work of art in a museum or exhibition or being asked to aesthetically evaluate a stimulus in the laboratory are such contexts to reliably trigger aesthetic processing. Thus, aesthetic processing in relation to ordinary stimulus processing is characterised by the context in which a stimulus is evaluated.

In the first processing stage the stimulus is analyzed along its *perceptual characteristics*. Visual factors like contrast (Reber, Winkielman, & Schwarz, 1998; Tinio & Leder, 2009b), symmetry (Garner, 1970; Jacobsen & Höfel, 2001), “Gestalt” phenomena such as order and grouping (Arnheim, 1954), and complexity (Berlyne, 1970a; Martindale, Moore, & Borkum, 1990; Tinio & Leder, 2009a) govern aesthetic processing at this stage. Perception of these factors happens automatically and implicitly without the need of conscious awareness. The next processing stage – *the implicit memory integration* – comprises

**Pre-Classification:**  
Artwork, Object of aesthetic Interest

**Context:** Museum - Gallery - Aesthetic Experiment

**Social Interaction Discourse**

**Aesthetic Judgment**  
Is a result of the Evaluation of the Cognitive Mastering stage

**Aesthetic Emotion**  
An emotional reaction which is a by-product of the processing stages of the model

**Automatic Stage:**

- Perceptual Analyses**
  - Complexity
  - Contrast
  - Symmetry
  - Order
  - Grouping
- Implicit Memory Integration**
  - Familiarity
  - Prototypicality
  - Peak-shifts

**Deliberate Stage:**

- Explicit Classification**
  - Style
  - Content
- Cognitive Mastering**
  - Art-specific-interpretation
  - Self-related-Interpretation
- Evaluation**
  - Cognitive State**
    - Understanding
    - Ambiguity
  - Affective State**
    - Satisfaction

**Continuous affective evaluation**

**Emotional Affective State**

**Automatic**      **Deliberate**

Content and style related information are represented at this stage (Augustin, Leder, Hutzler, & Carbon, 2008; Leder, et al., 2004). Knowledge and expertise may play a specific role at this stage as well as in the later stages. For example, when someone with little experience in art sees Duchamp's "fountain" he might classify it as what it depicts - a urinal - and aesthetic processing might stop at this stage. An art expert might classify it as one of the first ready made sculptures and an important artwork. Such a classification might be self rewarding.

The next two stages - *cognitive mastering* and *evaluation* - are closely connected because they also form feedback loops with the former stage. At these stages, understanding, interpretation and coping with ambiguity takes place. A feeling of understanding (Millis, 2001) and coping with ambiguity (Jakesch & Leder, 2009) are presumably also accompanied by positive affective states. For example, elaborating the context under which Duchamp's

fountain was produced and what the artist intended to convey with this particular piece of art might contribute to the positive evaluation of the stimulus through understanding. Such effects were reported by Millis (2001). He found that adding elaborative titles to representational artworks increased their aesthetic appreciation compared to descriptive titles which presumably did not provide enough additional information to enhance understanding. Moreover, domain specific knowledge, interest and personal tastes contribute to the evaluation on these later stages.

Although the model is formulated in a serial order with information flowing from the first to the later processing stages it is important to note that this order constitutes a relative hierarchy. Processing can potentially refer to earlier stages forming feedback loops. This is particularly important for the later explicit processing stages when ambiguities emerge, which need to be reduced in order to increase cognitive mastering and understanding.

Along with these cognitive processing stages, the affective processing is closely connected and vice versa. According to the model the affective state is permanently updated. Thus, each of the stages can either increase or decrease the affective states resulting in continuous changes in the affective processing. For example, an initially affective negative reaction to Duchamp's urinal could be attenuated by successfully classifying it as a sculpture and through embedding it in the correct art historical context. Thus, affective reactions to the stimuli are shaped by the appraisals processes involved in evaluating the stimulus (Scherer, 1984, 2005; Silvia, 2005a).

Leder et al., (2004) distinguishes two outputs of the model: an aesthetic evaluation (Leder, et al., 2004) and an aesthetic emotion (Leder, et al., 2004; Scherer, 2005). While the aesthetic emotion captures affective responses due to whole processing of the stimulus as hedonically positive or negative, the aesthetic judgment goes beyond such a simple positive/negative evaluation and somehow combines both, cognitive as well as affective factors. For example, perceiving a painting as affectively positive due to the aesthetic emotions it triggers does not mean that the same painting necessarily is evaluated as high in the aesthetic evaluation, because the painting might be considered a particularly poor example of the painter's work (Leder et al., 2004, p. 502).

Although the model was initially mainly conceptualized to explain cognitive and affective processes during aesthetic evaluations in 20th century modern visual art - which is characterized by its "need for cognition" due to its conceptual and innovative character, often foregoing beauty - the described processes and mechanisms are also transferable to more general aesthetic experiences. The model has already been applied more widely to other fields



like, for example, performing arts (Calvo-Merino, Jola, Glaser, & Haggard, 2008) and music (Brattico & Jacobsen, 2009; Istok, et al., 2009). In the present thesis, it was used as a conceptual framework for the different studies. In the following section it will be explained in brief how each of the studies relates to this framework.

### 1.3 Open Questions

In the first study reported, we directly addressed the consequences of one of the output stages – the aesthetic emotion. Aesthetic emotion depends on how a stimulus is appraised during perception (Leder, et al., 2004; Scherer, 1984; Scherer & Ellgring, 2007a, 2007b). There is evidence that experiencing attractive music, art and faces leads to positive affect, indicated by activity in reward related areas in the brain (e.g. Aharon, et al., 2001; Blood & Zatorre, 2001; Kawabati & Zeki, 2004; Menon & Levitin, 2005; O'Doherty, et al., 2003), which may explain people's fascination with attractiveness (Etcoff, 1999). However, it is unclear whether attractiveness evaluations and resulting affective output differ between natural and artificial stimuli (Kaplan, 1992; Kaplan, et al., 1972; Olson & Marshuetz, 2005; Tinio & Leder, 2009b). Consequently, we compared faces (as in Schacht, et al., 2008, see Figure 2, p. 8) and abstract patterns (as in Jacobsen & Höfel, 2001, see Figure 2, p. 8) to represent natural and artificial categories, respectively, and measured people's facial electromyographic (EMG) responses to the attractiveness of these stimuli. EMG allows the measurement of subtle differences in affective responses to stimuli (Cacioppo, Petty, Losch, & Kim, 1986; Dimberg, Thunberg, & Elmehed, 2000; Lang, Greenwald, Bradley, & Hamm, 1993; Topolinsky, Likowski, Weyers, & Strack, 2008).

The appraisal of facial attractiveness depends on physical stimulus characteristics such as symmetry, averageness, and youthfulness (Etcoff, 1999; Rhodes, 2006); however, due to the high biological, social, and socio-sexual relevance of faces (Ekman, Friesen, & Ancoli, 1980; Kampe, Frith, Dolan, & Frith, 2001; Thornhill & Gangestad, 1999), personal tastes (Hönekopp, 2006), cultural background (Cunningham, Barbee, & Philhower, 2002) and the social situation (Kampe, et al., 2001; Müser, Grau, Sussman, & Rosen, 1984) are also relevant. Abstract patterns, on the other hand, do not have this high social, biological, and socio-sexual relevance. Therefore, appraisals of attractiveness and its accompanying physiological states might differ between these two categories (Scherer & Ellgring, 2007a). In order to further explore differences between these two categories, perceptual fluency through

different stimulus presentation durations was manipulated (Reber, et al., 2004; Winkielman & Cacioppo, 2001)



*Figure 2.* Examples of the abstract patterns (left, Gerger et al., submitted; Tinio et al., 2010) faces (middle, Gerger et al.), and composite faces (right, Tinio et al.) used in the studies in chapters 2 and 3. The abstract patterns and the composite faces systematically varied in complexity and symmetry – complex symmetrical (upper left), complex non-symmetrical (upper right), simple symmetrical (lower left) and simple non-symmetrical (lower right). Note: The photographed faces were presented in color during the study.

The other output stage – the aesthetic evaluation – was addressed in the studies reported in chapters 3, 4 and 5. Aesthetic evaluations in these studies were broadly measured by attractiveness, liking and related constructs, for example, interest, arousal, and boredom. The first set of studies in chapter 3 and chapter 4 were all considered with dynamic effects of the aesthetic evaluation. The model (Leder et al., 2004) depicts processing stages and assumes changes in one of the processing stages causes changes in the overall aesthetic evaluation. Accordingly, a change in familiarity and habituation, or active experience results in a change of the aesthetic evaluation. Thus, the model predicts dynamic changes in aesthetic evaluations. Regarding familiarization, which can be seen as a cognitive process, since the seminal studies of Zajonc (1968) it is known that familiarization leads to dynamic changes in attractiveness evaluations – it was often found to increase attractiveness (for an extensive review see Bornstein, 1989). The study in chapter 3 extended the familiarization paradigm and tested whether massive or moderate familiarization (Tinio & Leder, 2009a) changed the seemingly rather stable impact of the factors of complexity (Berlyne, 1970b; Martindale, et al., 1990) and symmetry (Fink, Neave, Manning, & Grammer, 2006; Garner, 1970; Jacobsen

& Höfel, 2001; Perrett, et al., 1999). The experiments were based on a study by Tinio and Leder (2009a) in which the impact of massive or moderate familiarization was measured by employing abstract stimuli highly controlled in their complexity and symmetry (the same stimuli as in the previous study). In order to again compare (as in chapter 2) natural and artificial objects, we used faces in our study. Complexity and symmetry were controlled by artificially created faces which were produced for this experiment (see Figure 2, p. 8). This study therefore extends the question posed in the previous study as to whether aesthetic evaluations of natural and artificial categories differ.

Tinio, Gerger and Leder (2010) studied dynamic changes due to massive familiarization. The studies in chapters 4.2, 4.3, 4.4 and 4.5 similarly address dynamic changes but, notably, in a more applied way. In real life contexts, dynamic changes in aesthetic evaluations occur in fashion, music, art, and design (Carbon, 2010; Leder, et al., 2004; Moulson & Sproles, 2000). In such contexts familiarization does not typically involve only massive exposure, but rather exposure with elaboration through repeated evaluations of stimuli.

For example, when a new and innovative car design is introduced to the market you are not only passively seeing it in print advertisements and on TV, but you will also actively engage with it by possibly reading an article about this particularly innovative car design, or by talking to your friends, family or working colleagues about it. As common as these experiences are in our everyday lives, very few studies have been conducted on the topic, even though it relates to innovativeness, an aspect of consumer products that can make or break product success (Moulson & Sproles, 2000).

We employed a recently developed experimental paradigm, the repeated evaluation technique – RET (Carbon & Leder, 2005), which simulates real-world experiences with consumer products by repeatedly evaluating the stimulus materials on various scales. Thus, these studies examine how dynamic changes in aesthetic evaluations for innovative stimuli, namely car interiors (see Figure 3, p. 11), are influenced by familiarization and evaluation. In previous studies it has been shown that repeated evaluation triggers dynamics for innovative stimuli. Innovativeness is characterised by some novelty, however, innovativeness in contrast to novelty is supposed to have a longer time perspective. While novelty quickly diminishes with exposure, innovativeness remains somewhat stable (Carbon & Leder, 2005).

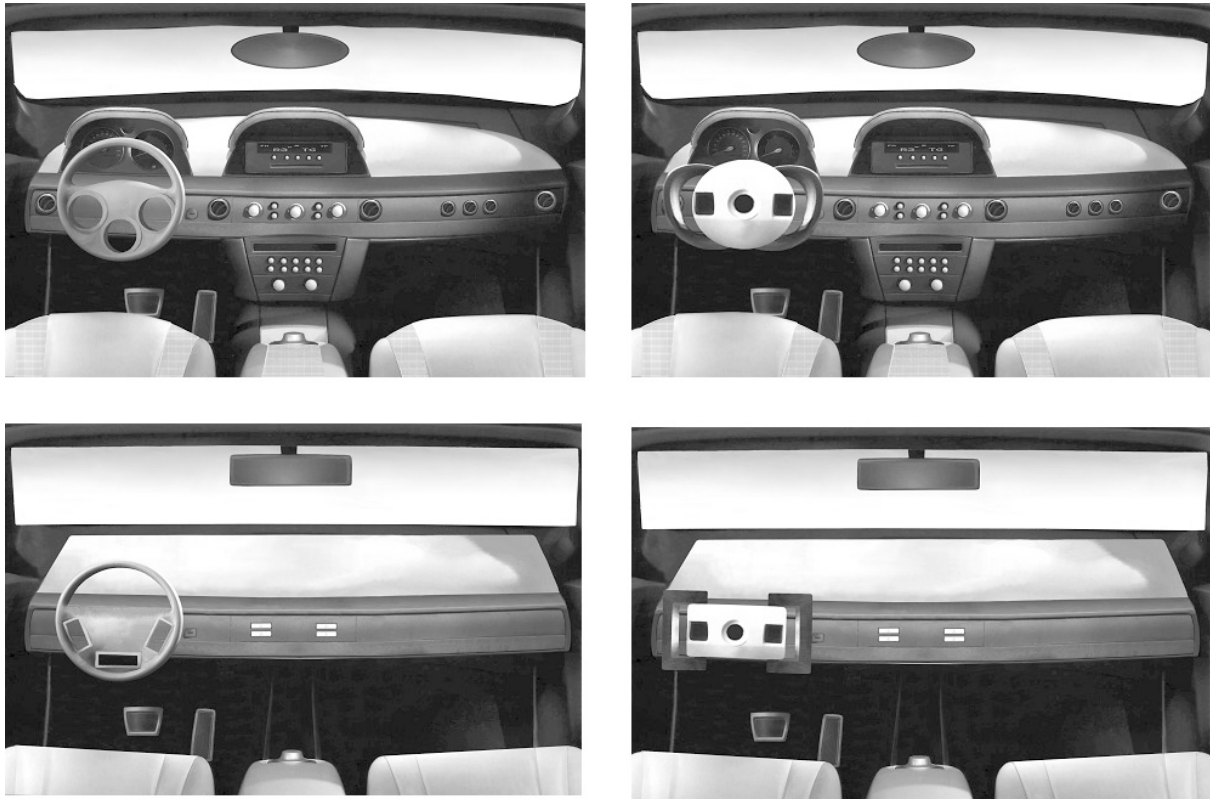
Initially, innovative materials are often disliked, but repeated evaluation of such materials increases their liking (Carbon, Hutzler, & Minge, 2006; Carbon & Leder, 2005). It must be emphasized that although these studies are conceptualized within a seemingly quite

narrow range of innovative consumer design evaluations, studying innovativeness illuminates the more general mechanisms in how our aesthetic sense adapts to novel but generally manageable materials. Thus, these studies fuel the debate whether, and indeed how, familiarity (Bornstein, 1989; Carbon, et al., 2006; Zajonc, 1968, 2001) or novelty (Berlyne, 1970b; Biederman & Vessel, 2006) contribute to aesthetic evaluations. The experimental RET paradigm and the stimuli used are introduced in more detail in chapter 4.1. Because the same experimental paradigm was employed in the following four studies, these are reported in the subsections of chapter 4 (chapters 4.2 – 4.5).

Two studies systematically varied contextual factors that accentuated or mitigated the apparent innovativeness of the stimuli to be judged, researching its impact on the dynamics on attractiveness. Specifically, the study in chapter 4.2 systematically varied context in terms of the stimulus sets used while the study in chapter 4.3 systematically varied the situational context by two types of elaboration used during the repeated evaluation phase.

The studies in chapter 4.4 and chapter 4.5 conceptualised the construct of aesthetic evaluations more widely by testing six variables derived from literature (e.g. Berlyne, 1970b; Carbon & Leder, 2005; Cox & Cox, 2002; Leder, et al., 2006; Zajonc, Crandall, Kail, & Swap, 1974) and theory (Leder, et al., 2004) as connected to aesthetic evaluations: arousal, boringness, positivity, interestingness, innovativeness and attractiveness. In the study in chapter 4.4 we researched how arousal, boringness, positivity, interestingness and innovativeness evaluations of the stimuli generally relate to attractiveness evaluations of the stimuli and its dynamics by performing a correlational study. Additionally, the impact of the boringness was varied as a situational variable because it might generally influence the evaluations (Perkins & Hill, 1985).

By systematically varying the aesthetic construct by either employing an exhaustive evaluation set consisting of all six variables or specifically reduced sets, research was carried out as to whether the aesthetic construct itself, that is, whether the evaluative context during initial stimulus exposures, triggers dynamic changes in aesthetic evaluations. See studies in chapter 4.5. All of these studies were conducted within the FWF project: Psychological Aesthetics: The dynamics of innovativeness and appreciation over time (P18910).



*Figure 3.* Examples of the car interiors used in the studies in chapter 4. Interiors systematically varied in innovativeness – low (left row) vs. highly innovative (right row). Furthermore, designs systematically varied in curvature and complexity - examples for high degrees in complexity and curvature are shown in the top row, examples for low degrees in complexity and curvature are shown in the bottom row.

The joint effects of cognitive and emotional factors contributing to aesthetic evaluations of pieces of art, was studied by Leder, Gerger, Dressler & Schabmann (in press) and are reported in the last study in chapter 5. According to Leder et al. (2004), variables of the perceiver, the object and the situation jointly determine the aesthetic evaluation of art. Here it was tested how variables, relevant to aesthetic evaluations of the object (an artwork), elicited emotion (Silvia, 2005a; Zentner, Grandjean, & Scherer, 2008), arousal (Berlyne, 1970a; Martindale, et al., 1990) and comprehension (Leder, et al., 2006; Millis, 2001), relate to the aesthetic evaluations of three kinds of artwork – abstract, modern, and classic. Additionally, it was studied how perceiver characteristics operationalized by relative expertise (Hekkert & VanWieringen, 1996a, 1996b; Leder, et al., 2004; Locher, Smith, & Smith, 2001) influence the aesthetic evaluations. In order to uncover the complex interplay of these variables, structural equation modelling (SEM, Byrne, 2001; MacCallum & Austin, 2000) was applied. SEM allows for determining the relative weights of different variables contributing to

the aesthetic evaluation. Moreover, SEM modelling can help to uncover the complex interplay of the various factors affecting aesthetic evaluations testing assumptions of the Leder et al. (2004) model.

In the following chapters all studies are briefly introduced in each of the research topics. The aim is to summarize the main operationalizations and research decisions. Subsequently in each chapter, the respective manuscripts are presented. Each chapter concludes with a summary and outlook of how these results relate to the field of experimental aesthetics specifically, and to empirical psychology in general. The dissertation concludes with a general discussion of the results.



## 2 Faces vs. Patterns: Exploring Aesthetic Reactions Using Facial EMG

### 2.1 Introduction

This chapter is based on an article, which is submitted to *Psychology of Aesthetics, Creativity and the Arts*. It includes suggestions by reviewers of a previous version of this article. The research question of this paper is based on a long-standing issue in experimental aesthetics: whether aesthetic evaluations differ between natural and artificial categories (Biederman & Vessel, 2006; Kaplan, 1992; Kaplan, et al., 1972; Olson & Marshuetz, 2005; Tinio & Leder, 2009b). Faces (as in Schacht & Wehrheid, 2008) were chosen to represent natural category and abstract patterns (as in Jacobsen & Höfel, 2001) to represent an artificial category for this study. Although aesthetic evaluations for both categories are linked to positive states - measured behaviorally by higher attractiveness, liking, preference evaluations and the like, or measured physiologically - both categories activate reward related structures in the brain when they are found attractive (Blood & Zatorre, 2001; Cloutier, Heatherton, Whalen, & Kelley, 2008; Kawabati & Zeki, 2004; O'Doherty, et al., 2003), there might be subtle differences between the categories during aesthetic evaluations. According to the Leder et al. (2004) model the output of the aesthetic evaluation, comprising an aesthetic emotion and an aesthetic evaluation, is as a consequence of the appraisal processes which occur during the processing of the stimulus. This appraisal processing (Scherer, 1984; Scherer & Ellgring, 2007a) might differ between faces and the abstract patterns due to the higher social, biological and socio-sexual relevance of faces (Cunningham, et al., 2002; Ekman, et al., 1980; Ekman & Rosenberg, 1997; Grammer & Thornhill, 1994; Kampe, et al., 2001; Müser, et al., 1984; Parkinson, 2005). In this research we concentrated on measuring the consequences of one of the output stages - the aesthetic emotion. Affective processing is linked to physiological changes (Scherer, 2005). We inferred physiological changes from affective processing by measuring facial EMG (Fridlund & Cacioppo, 1986).

Facial EMG seems to be particularly suitable for measuring subtle differences in the affective impact of the aesthetic evaluations. It allows the measurement of differences in affective responses to stimuli (Cacioppo, et al., 1986; Dimberg, et al., 2000; Lang, et al., 1993; Topolinsky, et al., 2008). Positive valence is indicated by increased *M. zygomaticus major* activations, a muscle which is active in genuine smiling (Ekman, et al., 1980; Surakka



& Hietanen, 1998). Negative valence on the other hand manifests itself in increased activity of the “frowning” muscle - *M. corrugator supercilii* (Dimberg, 1990; Lang, et al., 1993). Moreover, Scherer and Ellgring (2007a) suggest that activation patterns of these muscles are dynamically driven by the underlying appraisal processes for the stimuli. Thus, differences in the appraisal of attractiveness between faces and the patterns might be uncovered by measuring facial EMG. The method of measuring facial EMG was implemented in the laboratory for these studies. In order to further explore differences between the categories fluency related effects were studied (Reber, et al., 2004; Winkielman & Cacioppo, 2001), as well. Fluency refers to how easily or effortlessly a stimulus can be processed and increases positive affect. Fluency of processing was manipulated by employing a shorter and a longer presentation duration of the stimuli.

Results corroborated the utility of using facial EMG for studying the affective consequences during attractiveness evaluations. Attractive stimuli (faces and patterns) produced relatively stronger activations of the *M. zygomaticus major*, which is an indicator of positive affect, and relatively weaker activations of the *M. corrugator supercilii*, a muscle which is an indicator of negative affect (Ekman, et al., 1980; Izard, 1971). However, a fluency related effect indicated by a stronger activation of the *M. zygomaticus major* in the longer presentation duration was only found for the abstract patterns. Moreover, the overall facial activation patterns for the abstract patterns seemed to be clearer compared to the activation patterns for faces. These differences in physiological patterns were interpreted in terms of differences in the underlying appraisal processes of the stimuli – faces comprise more complex appraisal processes than the abstract patterns.

## **2.2 Original Manuscript**

Running head: FACIAL ACTIVATION PATTERNS FOR ATTRACTIVENESS

Faces vs. Patterns: Exploring aesthetic reactions using facial EMG

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## Abstract

We used facial EMG to examine reactions to the attractiveness of natural (faces) and artificial (abstract patterns) stimuli under long and short presentation durations. Attractive faces and patterns both produced strong activations of the *M. zygomaticus major* muscle, indicating positive affective reactions; and unattractive faces and patterns both produced strong activations of the *M. corrugator supercili* muscle, indicating negative affective reactions. Time-related fluency effects, indicated by stronger activations of the *M. zygomaticus major* in the long than in the short presentation duration were, however, only found for the patterns. Moreover, the patterns were also associated with more consistent activations over time than the faces, suggesting differences in how faces and patterns are evaluated. We discuss these results in terms of differences in appraisal processes between the two classes of stimuli—the greater biological, social, and socio-sexual significance of faces trigger more complex appraisals than the abstract patterns.

## Faces vs. Patterns: Exploring aesthetic reactions using facial EMG

The aesthetic response is a complex human behavior directed towards various aspects of the environment. Aesthetic responses typically involve evaluations that are associated with beauty or attractiveness—how attractive is something or someone. It seems that attractiveness is appealing because it elicits positive affect. Numerous studies, both behavioral and physiological, have shown this to be the case with natural objects such as faces (Aharon et al., 2001; Cloutier, Heatherton, Whalen, & Kelley, 2008; O'Doherty et al., 2003) and artificial objects such as artworks (Kawabati & Zeki, 2004; Vartanian & Goel, 2004). What remains relatively unexamined, however, is how aesthetic responses differ between natural and artificial objects. In this study, we examined this question using facial electromyography, a measure that is sensitive to subtle differences in affective reactions. As stimuli, we used faces and abstract patterns to represent the natural and artificial categories, respectively. Moreover, we used either a short or relatively long presentation duration to further explore differences in perceptual and aesthetic processes associated with the two categories of stimuli.

Different cognitive and affective processes may be involved in attractiveness evaluations of natural and artificial objects. We chose faces and abstract patterns to represent these two categories because attractiveness judgments have been shown to be consistent for both stimuli (faces: Etcoff, 1999; Rhodes, 2006; patterns: Jacobsen & Höfel, 2001; Tinio & Leder, 2009). Regarding faces, there is strong evidence that they comprise a special category (Farah, Wilson, Drain, & Tanaka, 1998; Leder & Bruce, 2000); faces attract (Ro, Russel, & Lavie, 2001) and bind attention (Bindemann, Burton, Hooge, Jenkins, 2005). Newborns react to face-like stimuli more intensely than non-face-like stimuli (Goren, Satu, & Wu, 1975; Simion, Valenza, Cassia, Turati, & Umiltà, 2002).

The processing of faces has also been shown to be very efficient. Ro et al., (2001) reported that in a change detection paradigm changes in face stimuli in comparison to non-face stimuli were spotted more accurately and rapidly. Similarly Finkbeiner and Palermo (2009) found differences in the processing of face and non-face stimuli. Facial primes presented for 50 ms enhanced a categorisation task regardless of whether attention was directed spatially towards the prime or not. For non-face stimuli, attention had to be directed towards the prime to have an influence on the categorisation task. These processing benefits of faces might be based on either unique (McKone, Kanwisher, & Duchaine, 2007) or highly specialised neural networks that have evolved through life-long learning and training (Bukach, Guthrie, & Tarr, 2006). It could also be based on the higher biological and social

relevance of faces as compared to other objects (e.g., Haxby, Hoffmann & Gobbini, 2002; Johnson, 2005; Thornhill & Gangestad, 1999).

Importantly for this study, it is not only the perception of faces that seems to be special but also the perception of their attractiveness. The perception of the attractiveness of a face might be related to survival issues—in terms of the search for potential mates and of reproduction (Thornhill & Gangstead, 1999; Etcoff, 1999). Attractive faces have been shown to attract attention (Leder, Tinio, Fuchs, & Bohrn, in press; Sui & Liu, 2009, Duncan et al., 2007) and could be perceived under constrained viewing conditions. Ohlson and Marshuetz (2005) demonstrated that facial attractiveness could be appraised even when faces were only shown for 13 ms. Although the participants in their study could not accurately report seeing the faces, they were still able to evaluate their attractiveness. Neural activities related to the perception of attractive faces are engaged even when participants are not asked to explicitly judge attractiveness (e.g., Aharon et al., 2001; Johnston, & Oliver-Rodriguez, 1997; Winston, O’Doherty, Kilner, Perrett, & Dolan, 2007). Similarly, physiological responses measured by skin conductance levels are detectable even when no explicit attractiveness evaluations are required (McDonald, Slater, & Longmore, 2008). These findings suggest that facial attractiveness is appraised rather automatically. However, Schacht, Wehrheid, and Sommer’s (2008) study involving event-related potentials showed that the effects of attractiveness were enhanced with explicit processing.

The perception of the attractiveness of non-face objects may not be as efficient as that of faces. Olson and Marshuetz (2005) examined this difference using faces and images of houses as stimuli. They showed that attractive faces were able to influence cognitive processing even under very constrained viewing conditions. Specifically, affectively positive words (e.g. “laughter”) primed by attractive faces (flashed for only 13 ms) were classified faster than when primed by unattractive faces. This suggests that participants may have sensed a “gist of attractiveness” that facilitated the processing of positive words. In contrast, when participants were primed by attractive or unattractive images of houses, such effects of attractiveness on cognitive processing were not found.

What factors determine attractiveness? They are averageness, symmetry, sexual dimorphic characteristics, and youthfulness for faces (Etcoff, 1999; Rhodes, 2006). Interestingly, attractiveness ratings are highly consistent across different people and different cultures (Jones & Hill, 1993; Perrett, May, & Yoshikawa, 1994). This, along with the finding that newborns attend to attractive as compared to non-attractive faces more intently (Slater et

al., 1998), suggests that the perception of facial attractiveness is deeply embedded in our cognitive system and biology.

In addition to basic physical features, the perception of the attractiveness of faces is also influenced by factors such as a person's cultural background (Cunningham, Barbee, & Philhower, 2002), personal learning history, individual preference (Hönekopp, 2006), personality (Duncan et al., 2007), and immediate constraints of the evaluative context (Leder et al., in press). Facial mimicry and expressions are also influential (Kampe, Frith, Dolan, & Frith, 2001; Müser, Brau, Sussmann, & Rosen, 1984). For example, faces signalling affiliation behavior through positive expressions are rated attractive (Müser et al., 1984). Even subtle gaze behavior can attenuate attractiveness-related neural activations. Kampe et al. (2001) found greater reward-related neural activity when attractive faces looked at the perceiver (thus signalling affiliation) than when they looked away from the perceiver. Thus, judgments of facial attractiveness involve factors beyond low-level physical features (e.g. symmetry, averageness).

Compared to faces, abstract patterns do not have biological, evolutionary, and social relevance. For example, in seeing an attractive face, socially-relevant information (Frith, 2009; Kampe et al., 2001; Kleinke, 1986) or mate quality (Duncan et al., 2007; Thornhill & Gangestad, 1999) may be inferred. Abstract patterns, however, do not elicit such inferences. The perceived attractiveness of abstract patterns depends largely on visual features. The patterns (from Jacobsen & Höfel, 2001) used in the present study varied systematically in symmetry and complexity. Both symmetry (Garner, 1970; Humphrey, 1997; Jacobsen, Schubotz, Höfel, & Von Cramon, 2006) and complexity (Berlyne, 1970) have relatively stable effects on attractiveness judgments (Tinio & Leder, 2009). Nonetheless, Jacobsen (2004) has also found evidence for individual differences in the attractiveness evaluations of these stimuli.

We classified faces and abstract patterns as attractive and unattractive by using ratings collected by Schacht et al. (2008; faces) and Tinio and Leder (2009; abstract patterns). In order to confirm this pre-classification and to enable analysis of perceived attractiveness at the level of individual participants (Hönekopp, 2006; Jacobsen, 2004), we included blocks in which participants rated all stimuli according to attractiveness.

We assumed that explicit evaluations of attractiveness are linked to positive affective reactions (Kawabati & Zeki, 2004; Vartanian & Goel, 2004; Blood & Zatorre, 2001; Aharon et al., 2001; Cloutier et al., 2008; O'Doherty et al., 2003). Therefore, we employed facial electromyography (EMG) recordings from the *M. corrugator supercilii* and the *M.*

*zygomaticus major* muscles (Fridlund & Cacioppo, 1986). Facial EMG has been shown to detect even subtle changes in affective responses due to positive and negative affective valence of the stimuli (e.g. Cacioppo, Petty, Losch, & Kim, 1986; Dimberg, Thunberg, & Elmehed, 2000; Lang, Greenwald, Bradley, & Hamm, 1993; Topolinski, Likowski, Weyers, & Strack, 2009; Winkielman & Cacioppo, 2001). These studies showed that stimuli with positive valence increase the activity of the *M. zygomaticus major*, a muscle that elevates the corners of the mouth and is active during genuine smiling (Ekman, Friesen, & Davidson, 1990; Surakka & Hietanen, 1998) while stimuli with negative valence (Dimberg, 1990; Lang, Greenwald, Bradley, & Hamm, 1993) on the other hand, increases the activity of the *M. corrugator supercilii*, a muscle responsible for frowning. The latter is also sensitive to cognitive mental load (Lishner, Cooter, & Zald, 2008).

The sensitivity of facial EMG could reveal differences in people's aesthetic evaluations to faces and abstract patterns. According to the *sequential check theory* of emotion, muscle activation patterns of the face reflect ongoing appraisal processes (Scherer & Ellgring, 2007a). Basic stimulus features such as symmetry, complexity, and averageness influence the early appraisal stages, which are generally automatic (e.g., novelty and pleasantness). In contrast, later stages involve higher-order cognitive processes (e.g., relevance and need/goal conduciveness - Scherer, 1984, 2005; Scherer & Ellgring, 2007b). Faces, because of their high social and biological significance, could elicit more complex appraisal processes contributing to the overall aesthetic evaluation; in addition to the influence of physical features such as averageness and symmetry, affiliations or mate quality might also be assessed. Differences in the appraisal processes in aesthetically evaluating faces and abstract patterns would not be detectable by behavioral measures as these reflect only the outcome of these underlying appraisal processes. Facial EMG, however could detect differences between the categories due its sensitivity to the underlying appraisal processes (e.g. Lanctot & Hess, 2007; Scherer & Ellgring, 2007a).

The relative ease that a stimulus can be processed has been shown to influence the aesthetic evaluation of the stimulus. Reber, Schwarz, and Winkielman (2004) referred to this as the fluency effect. Specifically, stimuli that are high in processing fluency are evaluated more positively than stimuli that are low in processing fluency. In this study, differences in appraisals due to fluency were assessed by presenting stimuli for either 400 ms or 47 ms. Longer presentation durations are assumed to enhance fluency. Reber, Winkielman and Schwarz (1998) found higher attractiveness evaluations of abstract patterns presented for 400 ms as compared to 100 ms. Winkielman and Cacioppo (2001) corroborated these results in a

study in which neutral non-face stimuli (houses, birds, and dogs) were evaluated under different presentation durations while facial EMG was recorded from the zygomaticus and corrugator muscles. Behavioral evaluations and physiological measures both increased with longer presentation durations. For the physiological measures, only zygomaticus activity increased. This was interpreted as positive affect due to fluency. Stronger activations of the zygomaticus muscle due to perceptual fluency were also demonstrated using abstract dot patterns as stimuli (Winkielman, Halberstadt, Fazendeiro, & Catty, 2006).

These fluency studies used only artificial or neutral stimuli, which have little or no biological or social relevance. With such stimuli, manipulating perceptually driven processes through the use of a longer presentation duration would presumably have a strong impact on fluency-related effects. Faces, in contrast, because of their high biological and social relevance, could trigger more complex appraisal processes (e.g., regarding partnership, or affiliation), which could reduce fluency-related processing.

Regarding the short presentation duration, several studies have indicated that within 47 ms, stimuli are still consciously perceived, but higher cognitive processes are impaired. For example, famous faces flashed for about 40 ms could not be identified (McDonald et al., 2008). However, elevated skin conductance responses, a measure of sympathetic activity and thus, physiological arousal (Dawson, Schell, & Filion, 2000), revealed that the attractiveness of the faces had an effect even under such short presentation duration. For non-face stimuli, however, Finkbeiner and Palermo (2009) showed that with a 50 ms presentation duration, attention had to be directed towards the stimulus for the stimulus to have an effect on cognitive processing. Under this short presentation duration, we still expected some conscious processing for both stimulus categories; that is, we hypothesized that participants could still provide attractiveness judgments consciously. However, we expected more reliable attractiveness judgments in the 400 ms compared to the 47 ms presentation duration.

To summarize, if the appraisal process is more complex for faces than abstract patterns, we expect differences in affective reactions. Specifically, fluency-related effects due to the different presentation durations—47 or 400 ms—could be higher for the faces than the abstract patterns. In general, we expected attractive faces and patterns to enhance the activity of the *M. zygomaticus major*, which would reflect positive valence; we expected unattractive faces and patterns to enhance the activity of the *M. corrugator supercilii*, which would reflect negative valence.



## Methods

### *Participants*

Twenty-eight participants (all female) from the University of Vienna participated for partial course credit. The mean age of the participants was 22.4 (SD: 2.4). Only female participants were tested because it has been shown that females show more intense, yet qualitatively similar facial mimicry than males (Dimberg & Lundquist, 1990; Lang et al., 1993). One participant had to be excluded because of problems with data recording, and a second participant was excluded because after the pre-processing of the EMG data, only a few (less than six) artifact-free trials were left in several of the conditions.

### *Stimuli*

The abstract patterns were developed by Jacobsen and Höfel (2001). Twenty-eight attractive and 28 unattractive patterns were chosen for this study according to pre-ratings obtained by Tinio and Leder (2009). An equal number of simple-symmetrical, complex-symmetrical, simple-nonsymmetrical, and complex-nonsymmetrical patterns were chosen. The attractive stimuli consisted of the complex-symmetrical and simple-symmetrical patterns, while the unattractive stimuli consisted of the complex-nonsymmetrical and simple-nonsymmetrical patterns. In order to constrain the perceptual persistence of the stimuli in the short presentation duration condition, backwards masking stimuli were produced. For each pattern, this was done by randomly shuffling the picture parts to a size of 2 x 2 pixels using a custom programmed MatLab script. (MatLab 7.1; The Math Works Inc.). This small shuffling resolution was used to avoid the emergence of random patterns within the abstract patterns. The patterns were presented at a size of 227 x 227 pixels at a screen resolution of 1024 x 768. We used fifty-six faces from Schacht et al. (2008). The persons depicted were recruited from modelling agencies. The professionally-produced colour photographs were standardized with regard to view (frontal), gaze direction (frontal), lighting, and facial expression (neutral). Faces were reframed to ensure identical display windows, and were presented on a standard grey background. All faces were rated for attractiveness on a 7-point scale. From this original set, the 14 most and least attractive male and the 14 most and least attractive female faces were selected. For each face, an individual mask was produced at the size of 10 x 10 pixels. The faces and masks were presented at a size of 324 x 252 pixels at a screen resolution of 1024 x 768. All stimuli were presented on a 19-inch Iiyama Vision Master Pro 454 CRT. The screen refresh rate was set to 85 Hz. The grey background colour on which the patterns and faces were presented was kept constant (RGB 240, 240, 240).

*Procedure*

Electrodes were filled with Signa electrode gel (Parker laboratories) shortly before the arrival of the participants. Upon arrival, participants signed a consent form. They were briefed on the EMG electrode attachment procedure. In order to avoid demand characteristics in collecting EMG data, participants were told that skin conductance responses would be recorded (e.g., Dimberg & Thunberg, 1998; Weyers, Muhlberger, Hefele, & Pauli, 2006). Following the application of the electrodes, participants were seated approximately 1 m in front of the monitor. They were instructed to avoid extensive movements, chewing, or talking to themselves (e.g., one participant commented on the pictures during practice trials) because these would disturb the signal.

Presentation of the stimuli was controlled by Presentation software (Neurobehavioral Systems, Inc.). The experimental session consisted of a facial EMG recording block that was followed by a rating block which was performed for two times – participants started either with the faces or the abstract patterns; order was balanced. Participants completed eight practice trials to become familiarized to the experimental design. During the EMG recording block, all 56 stimuli were shown twice: either for 47 ms or 400 ms resulting in 112 experimental trials. Each trial started with a fixation cross (3000 ms) followed by the stimulus (either 47 or 400 ms), and then a mask (5000 ms). After the mask, a question mark on the screen appeared until participants classified the stimulus as either attractive or not via a binary response (yes/ no). This simple dichotomous task was employed to elicit spontaneous responses. Additionally, by asking the participants for an explicit evaluation after each stimulus, evaluations in the context of attractiveness judgments were ensured. A variable inter-stimulus interval (ISI) consisting of a blank screen followed (for 3100 to 4000 ms). The presentation order of the stimuli was random with the following constraints: first, all 56 stimuli were randomly assigned to either the 47 or 400 ms time bin with the constraint that an equal amount of pre-classified attractive/unattractive stimuli was in each time bin. After all 56 stimuli were shown, time bins were switched and the stimulus presentation order was again randomized. Thus, a stimulus that was presented for 47 ms in the first run was presented for 400 ms in the second run, and vice versa. Additionally, to prevent habituation, we ensured that there were at most three stimuli from the same time bin and at most three stimuli from the same attractiveness level presented in sequence.

Immediately following the EMG recording block, participants rated all of the 56 stimuli again in the rating block. Ratings were provided on a seven-point scale anchored with unattractive (1) and attractive (7). The scale was presented below the stimuli. No EMG data

were collected during this block, and participants proceeded at their own pace. Participants were encouraged to use the entire scale for their ratings. The total duration of the experiment was approximately 90 minutes. After participants finished the experiment, they were thanked and debriefed.

### *Facial EMG*

Facial EMG was recorded over the M. zygomaticus major and the M. corrugator supercilii regions of the left side of the face using bipolar placements (Fridlund & Cacioppo, 1986). Ag/AgCl electrodes with 4mm diameter/ 7mm housings (<http://www.easycap.de>) were used. The ground electrode was placed on the right outer quarter of the forehead. Impedances of the electrodes were reduced to less than 10 k $\Omega$  by rubbing the skin with abrasive paste (NuPrep – Weaver). The EMG raw signals were measured with a TMS International (<http://www.tmsi.com/>) Portilab 20-channel amplifier and stored on a disk at a sampling frequency of 2048 Hz. Raw data were filtered online with a 500 Hz low pass filter. Additional filtering was done offline with a 20 Hz high pass filter to attenuate the impact of blinks (Van Boxtel, 2001), and a 50 Hz notch filter to reduce power line artifacts.

### Data Analysis

*Behavioral data.* In order to test participants' ability to recognize the attractiveness of patterns and faces under different presentation durations, the binary answers (attractive vs. unattractive) during the EMG recording block were converted into d-prime ( $d'$ ) measures (Green & Swets, 1966).  $D'$  reflects participants' ability of to discriminate between two different stimulus classes (here defined as attractive vs. unattractive patterns or faces). This measure controls for the tendency to say yes (that is the stimulus is attractive) even though no attractive stimuli is present.  $D'$  values were computed by subtracting the z-transformed scores of the probability of yes responses (this is an attractive face or pattern) when an attractive stimulus was present minus the z-transformed scores of the probability of yes responses when an attractive stimulus was absent. Classification of the stimuli as attractive was based on the pre-classifications of the stimuli (see Stimuli).

Additionally, we calculated  $d'$  where classifications of attractive and unattractive stimuli were based on the individual ratings from the post experiment rating block. Using individual ratings warrants to account for differences in individual preferences of the participants (Hassenzahl, 2008; Hönekopp, 2006; Jacobsen, 2004; Monin & Oppenheimer, 2005). For each participant, a stimulus was defined as unattractive if it received a rating from

1 to 3; a stimulus receiving ratings of 5 to 7 was defined as attractive. As ratings of 4 on a seven-point scale could be considered arbitrary on a seven-point scale of attractiveness, they were excluded. Thus, between two to 16 stimuli were excluded per stimulus class and participant (mean: 8.3 stimuli). We calculated  $d'$  values separately for the short and long presentation durations (47 ms vs. 400 ms), for the two categories (faces vs. abstract patterns), and for the two types of attractiveness classifications (pre-ratings vs. individual ratings). Positive  $d'$  values that are statistically significant from zero indicate that participants are able to discriminate between attractive and unattractive faces or patterns. In order to analyze whether participants were able to discriminate attractiveness,  $d'$  values sampled across participants were tested against zero using t-tests. Moreover, the absolute size of  $d'$  is a measure of how well participants were able to discriminate between patterns and faces under the different presentation durations.

To examine differences in sensitivity to attractiveness under the different presentation durations,  $d'$  values between presentation durations (47 ms vs. 400 ms) were compared within each condition (faces or patterns). Effect sizes (adjusted Cohen's  $d$ ) for these dependent t-tests were calculated according to Dunlap, Cortina, Vaslow, and Burke (1996). The results are reported separately for condition and type of attractiveness classification.

*Facial EMG.* The raw data were screened for movement artifacts online and offline by crosschecking them with video recordings. Signal epochs containing movement artifacts (e.g., biting, chewing, and coughing) were excluded from further analyses. Raw data were then full wave rectified, integrated with a time constant of 125 ms (Topolinski et al., 2009; Weyers et al., 2006), and standardized (to convert them to z-scores) within subjects and muscle sites (Winkielman & Cacioppo, 2001). Activations represented the relative impact of attractiveness on muscle activations for the patterns or faces. EMG activations were expressed in terms of change scores relative to a pre-stimulus baseline one second in duration. For statistical comparisons, EMG data were averaged over trials in the respective conditions. Statistical comparisons were calculated over consecutive one-second intervals for the first five seconds after stimulus onset. All offline data processing steps were computed in Matlab 7.1 (The Math Works Inc.) using EEGLAB toolbox (Delorme & Makeig, 2004). Statistical analyses were performed with SPSS 14 (SPSS GmbH Software). Due to different response strategies and artifacts within participants, between six and 31 trials remained in each condition for calculating the EMG activations.

## Results

### *Analyses of $d'$*

#### *Abstract patterns*

*D' based on the stimulus pre-ratings.*  $D'$  was significantly different from zero in the 47 and 400 ms conditions [ $d'$  (47 ms),  $t(25) = 7.20, p < .01$ ;  $d'$  (400 ms),  $t(25) = 6.28, p < .01$ ], showing that participants perceived attractiveness. In the shorter presentation duration,  $d'$  values were significantly lower [ $t(25) = 2.21, p = .037, d = .22$ ].  $D'$  was 1.2 (SD = 0.82) and 1.4 (SD = 1.15) for the 47 ms and 400 ms conditions, respectively.

*D' based on the post experiment rating phase.* Again,  $d'$  values significantly differed from zero [ $d'$  (47 ms),  $t(25) = 6.97, p < .01$ ;  $d'$  (400 ms),  $t(25) = 8.65, p < .01$ ]. Moreover,  $d'$  values were significantly different between the two presentation durations [ $t(25) = 3.43, p < .01, d = .48$ ;  $d'$  (47 ms) = 1.1 (SD = 0.85) vs.  $d'$  (400 ms) = 1.6 (SD = 0.95)].

#### *Faces*

*D' based on the stimulus pre-ratings.*  $D'$  values were significantly different from zero [ $d'$  (47 ms),  $t(25) = 12.90, p < .01$ ;  $d'$  (400 ms),  $t(25) = 19.32, p < .01$ ]. Moreover,  $d'$  differed significantly between the two presentation durations [ $t(25) = 7.78, p < .01, d = 1.04$ ;  $d'$  (47 ms) = 1.2 (SD = 0.49) vs.  $d'$  (400 ms) = 1.7 (SD = 0.46)].

*D' based on the post experimental rating phase.* Results of the individual attractiveness ratings from the post experimental part corroborated the above findings. Again,  $d'$  values were statistically significant from zero [ $d'$  (47 ms),  $t(25) = 17.90, p < .01$ ;  $d'$  (400 ms),  $t(25) = 20.98, p < .01$ ]. Thus,  $d'$  based on the individual ratings were higher than  $d'$  values based on the pre-ratings. Like above,  $d'$  values were higher under the 400 ms ( $d' = 2.4$ , SD = 0.56) than under the 47 ms ( $d' = 1.5$ , SD = 0.43) presentation duration, [ $t(25) = 8.12, p < .01, d = 1.64$ ].

### *Analyses of Facial EMG activity*

Because the results of the behavioral data suggested that individual ratings were more sensitive at capturing differences in attractiveness, the stimuli were classified as attractive and unattractive according to the individual attractiveness judgments from the post-experiment block. Again the midpoint scale ratings of four were omitted because they could be considered arbitrary on a seven-point scale of attractiveness. Figures 1 and 2 depict the z-transformed *M. zygomaticus major* and *M. corrugator supercilii* activities sampled for consecutive five-second intervals after stimulus onset, separately for the two stimulus

categories. According to the figures, attractive and unattractive stimuli seem to lead to differential activations over the muscle sites: attractive stimuli resulted in stronger activations of the *M. zygomaticus major* and unattractive stimuli resulted in stronger activations of the *M. corrugator supercilii*. These effects of attractiveness were analyzed in a 5 (interval: seconds 1 to 5 after stimulus onset) x 2 (presentation duration: 47 ms vs. 400 ms) x 2 (attractiveness judgment: attractive vs. unattractive) repeated measurement ANOVA, separately for both stimulus categories (faces and patterns) and muscle sites (*M. zygomaticus major* and *M. corrugator supercilii*). Greenhouse-Geisser corrections were applied whenever necessary (which can be seen in the corrected degrees of freedom).

### *Abstract patterns*

*Corrugator supercilii responses.* The results for the corrugator activations are shown in Figure 1a. Unattractive patterns resulted in stronger activations of the *M. corrugator supercilii* [ $F(1,25) = 14.07, p < .001, \eta_p^2 = .36$ ]. Additionally, the overall activity increased as a function of intervals [ $F(2.03,50.73) = 6.78, p < .001, \eta_p^2 = .21$ ]. Separate analyzes for each interval showed that unattractive patterns resulted in stronger corrugator activations in each interval - 1st [ $F(1,25) = 5.46, p = .028, \eta_p^2 = .18$ ], 2nd [ $F(1,25) = 11.81, p < .001, \eta_p^2 = .32$ ], 3rd [ $F(1,25) = 9.15, p < .001, \eta_p^2 = .27$ ], 4th [ $F(1,25) = 10.56, p < .001, \eta_p^2 = .30$ ] and the 5th [ $F(1,25) = 13.13, p < .001, \eta_p^2 = .34$ ] seconds.

*Zygomaticus major responses.* The results of the zygomaticus activations are shown in Figure 1b. Attractive patterns resulted in an overall stronger activity of the *M. zygomaticus major* [ $F(1,25) = 16.19, p < .001, \eta_p^2 = .39$ ]. This effect was qualified by a significant interval x attractiveness interaction [ $F(4,100) = 3.92, p < .01, \eta_p^2 = .14$ ], indicating larger differences between attractive and unattractive patterns in later intervals. The longer presentation duration as compared to the shorter presentation duration also resulted in stronger activations of the *M. zygomaticus major*. [ $F(1,25) = 4.34, p = .048, \eta_p^2 = .15$ ]. Separate analyses based on the intervals showed that attractive patterns resulted in stronger zygomaticus activations in the 2nd [ $F(1,25) = 7.55, p = .011, \eta_p^2 = .23$ ], 3rd [ $F(1,25) = 12.79, p < .001, \eta_p^2 = .34$ ], 4th [ $F(1,25) = 14.61, p < .001, \eta_p^2 = .37$ ] and 5th [ $F(1,25) = 28.68, p < .001, \eta_p^2 = .53$ ] seconds. The longer presentation duration resulted in stronger zygomaticus activations during the 3rd [ $F(1,25) = 4.63, p = .041, \eta_p^2 = .16$ ] and 4th [ $F(1,25) = 6.25, p = .019, \eta_p^2 = .20$ ] seconds.

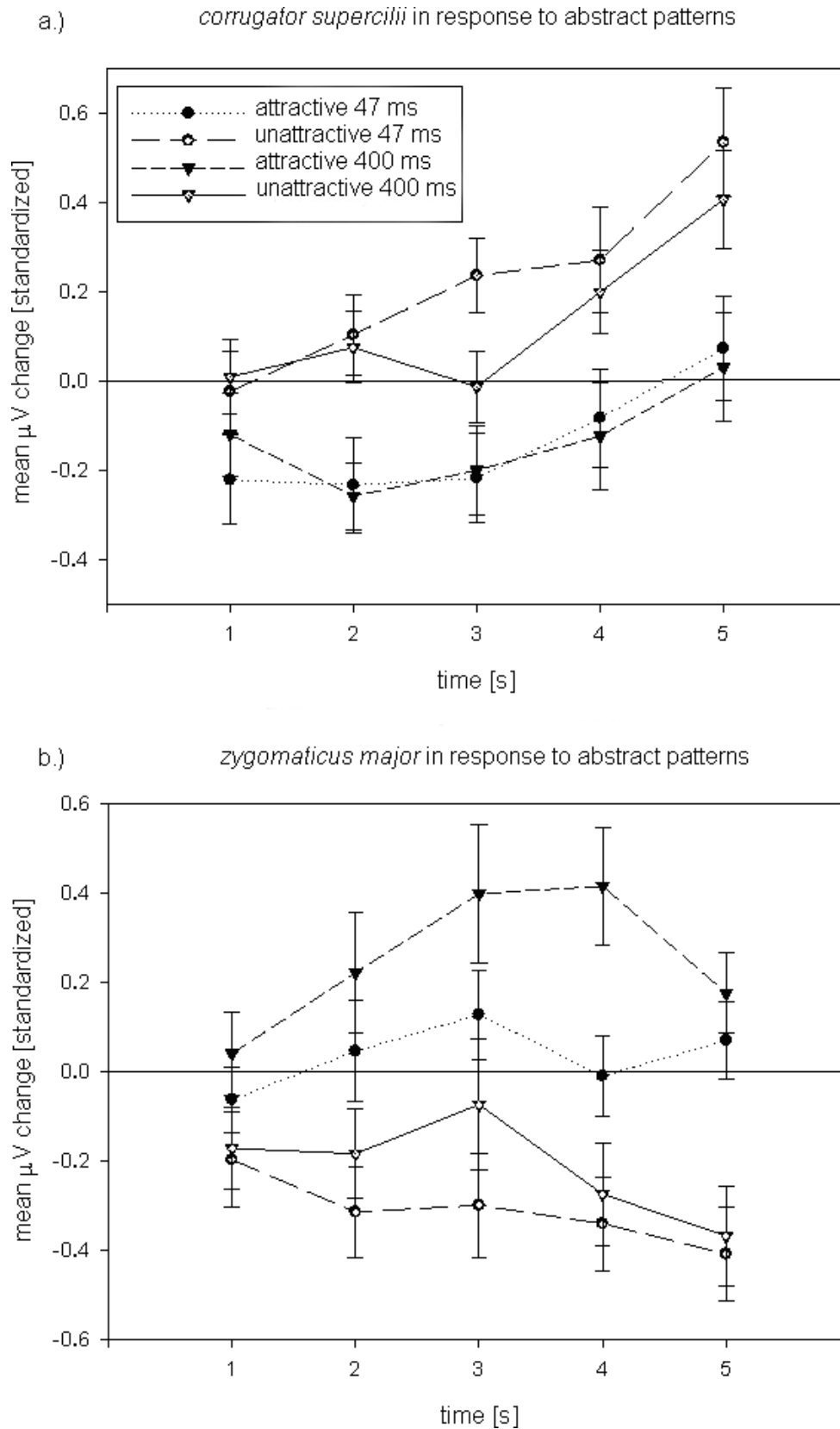


Figure 1: EMG activity in standardized units (mean  $\pm$  1 SE) for *M. corrugator supercilii* (a) and *M. zygomaticus major* (b) in response to abstract patterns for the first five seconds after stimulus presentation.

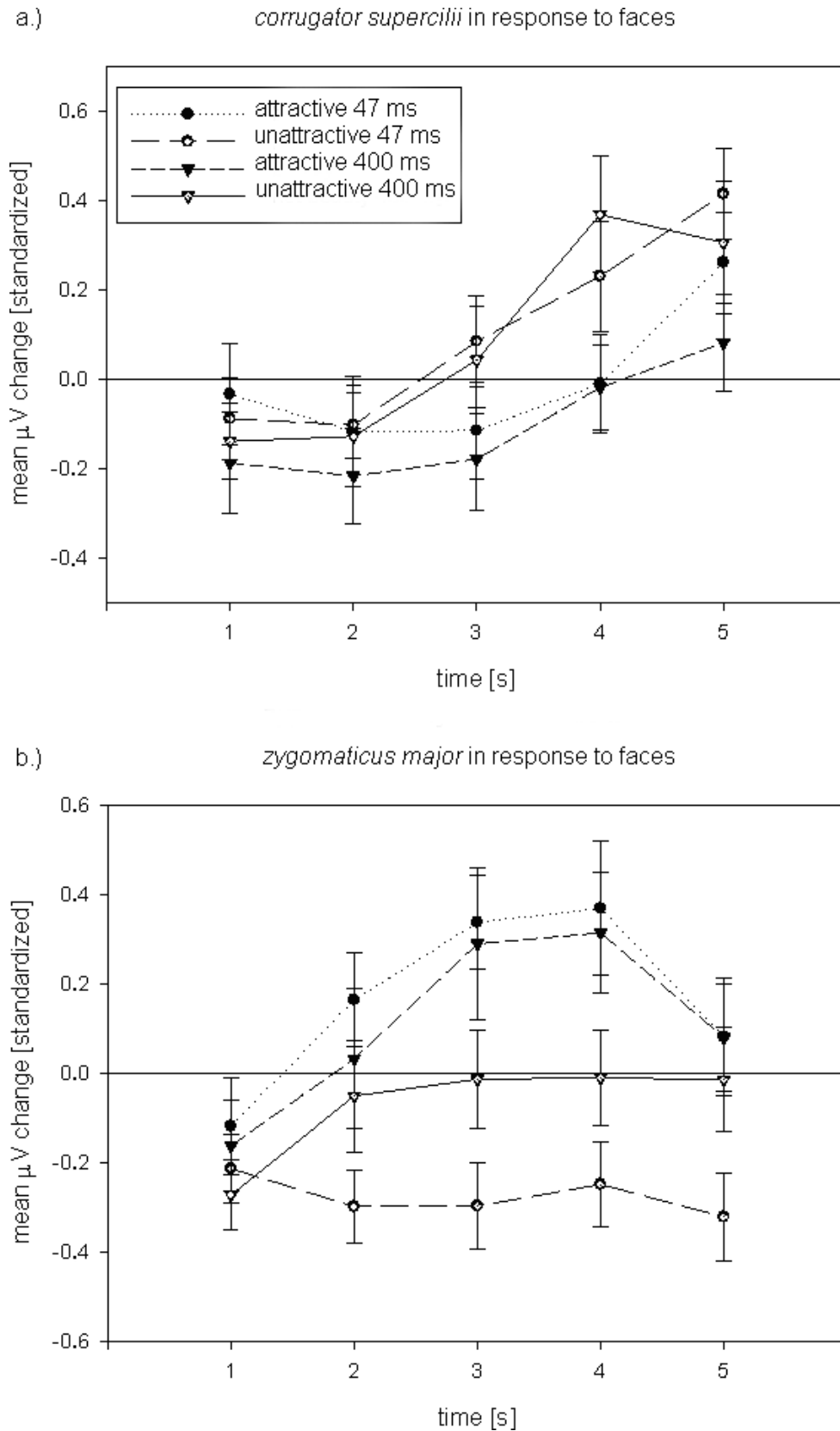


Figure 2: EMG activity in standardized units (mean  $\pm$  1 SE) for *M. corrugator supercilii* (a) and *M. zygomaticus major* (b) in response to faces for the first five seconds after stimulus presentation.



### Faces

*Corrugator supercilii responses.* The results of the corrugator activations are shown in Figure 2a. A significant attractiveness x intervals interaction indicated that unattractive and attractive faces resulted in different corrugator activation patterns [ $F(3.31, 82.83) = 3.21, p = .023, \eta_p^2 = .11$ ]. *M. corrugator supercilii* activities increased over time [ $F(1.94, 48.45) = 8.91, p < .001, \eta_p^2 = .26$ ]. Analyses based on the intervals showed that unattractive as compared to attractive stimuli led to significantly stronger activations during the 4th second [ $F(1, 25) = 5.63, p = .029, \eta_p^2 = .18$ ].

*Zygomaticus major responses.* The results of the zygomaticus activations can be seen in Figure 2b. Attractive faces resulted in stronger zygomaticus activations [ $F(1, 25) = 11.90, p < .001, \eta_p^2 = .32$ ]. *M. zygomaticus major* activities increased over time [ $F(2.10, 52.28) = 3.82, p = .027, \eta_p^2 = .13$ ]. As can be seen in Figure 2b and as was confirmed by the repeated measurement ANOVA, these main effects were qualified by a significant attractiveness x intervals interaction [ $F(2.76, 68.98) = 3.33, p = .028, \eta_p^2 = .12$ ]. Separate analyses of each interval showed that *M. zygomaticus major* activities were stronger for attractive than unattractive faces in the 2nd [ $F(1, 25) = 4.67, p = .04, \eta_p^2 = .16$ ], 3rd [ $F(1, 25) = 16.00, p < .001, \eta_p^2 = .39$ ], and 4th [ $F(1, 25) = 10.29, p < .001, \eta_p^2 = .29$ ] seconds. In the 5th second, zygomaticus activity nearly approached statistical significance [ $F(1, 25) = 4.18, p = .052, \eta_p^2 = .14$ ].

### Discussion

The goal of this study was to assess differences in the attractiveness evaluations of faces and abstract patterns under different presentation conditions. We found that although facial EMG activations and corresponding time courses were quite similar for both types of stimuli—attractive patterns and faces both elicited higher zygomaticus major activations, while unattractive patterns and faces elicited higher corrugator supercilii activations—facial EMG was also sensitive to differences in the attractiveness evaluations of the two types of stimuli. A fluency-related effect was found only for abstract patterns. In accordance with previous studies (Winkielman & Caccioppo, 2001; Winkielman, et al., 2006), the longer presentation duration produced stronger overall zygomaticus activations. Moreover, activation patterns were more consistent for the abstract patterns. Results from the behavioral measures suggest that stimulus processing was impeded under the short presentation duration; the ability to discriminate between attractive and unattractive stimuli was reduced. However,

facial activation patterns still showed a clear difference between attractive and unattractive faces and patterns.

The behavioral data are interesting for several reasons. First, attractiveness in both stimulus categories was perceived under short and long presentation durations. Both  $d'$  measures were larger than zero even when the stimuli were shown for only 47 ms. Regarding faces, these findings are consistent with previous research. Locher, Unger, Sociedade, and Wahl (1993) compared a 100 ms presentation duration to an unrestricted presentation duration and found similar judgments. Their results were consistent with the “attractiveness is good” stereotype. Ohlson and Marshuetz (2005) demonstrated that the gist of attractive faces could be perceived even under a short presentation duration (13 ms). This was not found for images of attractive houses. Compared to faces, there are more complex ways in which different features could define a house and determine what makes it attractive. Thus, the attractiveness of houses might have been more difficult to perceive. In the present study, we used simple abstract patterns that varied along complexity and symmetry. We found that the attractiveness of these patterns was explicitly inferred even when they were shown for only 47 ms. However, for patterns and faces,  $d'$  values in the 47 ms condition were significantly lower than the  $d'$  values in the 400 ms condition. When  $d'$  calculations were based on the individual attractiveness ratings rather than on the stimulus pre-classifications, they were even higher. This demonstrates the importance of individual evaluation strategies in the study of attractiveness judgments (Hönekopp, 2006; Jacobsen, 2004; Monin & Oppenheimer, 2005).

The smaller  $d'$  values under the short presentation duration could be interpreted in different ways. Short presentation durations could influence higher cognitive and evaluative processes. Thus, the conscious report of affective reactions would be impeded. On the other hand, short presentation durations could have restricted early perceptual processes by not allowing the extraction of sufficient detail necessary for more reliable attractiveness judgments. Nonetheless, detailed analysis of a stimulus might not be necessary for reliable attractiveness judgments (Bachmann, 2007; Sadr, Fatke, Massay, & Sinha, 2002).

When the faces and patterns were evaluated for attractiveness, we found differential activations in both corrugator and zygomaticus muscles. Corrugator activations were stronger with unattractive stimuli and zygomaticus activations were stronger with attractive stimuli. This finding is noteworthy given that previous studies have shown that zygomaticus activations are only sensitive to stimuli more extreme in valence than those used in the present study (Dimberg, 1982; Lang et al., 1993; Larsen, Norris, & Cacioppo, 2003).

In a different study, using only mildly evocative stimuli (e.g., mountains), Caccioppo, Bush, and Tassinary (1992) showed that zygomaticus activations did not automatically indicate valence; zygomaticus activations were sensitive to valence only when participants were instructed to amplify their facial mimicry. Corrugator activations, on the other hand, automatically indicated valence and were not influenced by such instructions. Caccioppo et al. concluded that facial activation patterns are governed by automatic affective and explicit communicative factors. Theories considering facial activation patterns as serving social display functions that communicate motives and intentions (Fridlund, 1996; Parkinson, 2005) assume that explicit communicative factors are essential for the emergence of these activation patterns. Thus, the differential zygomaticus activations to mildly evocative stimuli found here may have been elicited by such factors. For example, a person might react positively to seeing an attractive stimulus. This reaction might then be communicated (unintentionally) through a display of positive emotions. The extent to which the communication of motives or genuine affective responses contributed to the facial activation patterns found here cannot be answered with our experimental paradigm. However, because affective processing and social display theories make the same predictions regarding facial activations, facial EMG seems valuable for examining evaluations related to attractiveness.

The EMG data indicated clear differences - due to attractiveness - within the long and the short presentation durations. On a behavioral level, however, the smaller  $d'$  values under the short presentation duration indicated that the perception of attractiveness was impaired. Thus, physiological reactions were more sensitive to attractiveness, and were somehow dissociated from the overt responses.

Although similar activation patterns were found for both categories, there were also differences between the categories. In the early time intervals (1st and 2nd second), significant differences due to attractiveness were found only for abstract patterns. Moreover, in later time intervals, differences due to attractiveness were more consistent for the abstract patterns than the faces. The clearer differences between attractive and unattractive patterns reflect the nature of the stimuli. The patterns had different levels of complexity and symmetry, which are both known to affect attractiveness judgments. Symmetry is a salient perceptual feature (Washburn, 1999). It can be detected quickly (Wagemans, 1997) and preattentively (Locher & Wagemans, 1993), and it has been shown to positively influence aesthetic evaluations (e.g. Humphrey, 1997; Jacobsen & Höfel, 2001; Tinio & Leder, 2009). Complexity is an important factor in Berlyne's (1970) arousal theory. Previous studies using the same patterns have shown that complexity influences aesthetic evaluations (Jacobsen &

Höfel, 2001; Tinio & Leder, 2009). The patterns were also novel and meaningless. Therefore, participants could not have compared them to previous experiences or to fixed cognitive schemata (Mandler, 1982). Additionally, such patterns are less likely to trigger higher-order cognitive processes (Scherer & Ellgring, 2007a).

Regarding faces, perceptual factors such as symmetry (Fink, Neave, Manning, & Grammer, 2006) also contribute to their attractiveness. However, faces are also compared to an internal prototype (Halberstadt & Rhodes, 2003). Previous encounters with faces are meaningful in terms of evaluative dimensions, such as mate quality (Grammer & Thornhill, 1994), and in terms of social display characteristics (Ekman et al., 1980, 1990; Kampe et al., 2001). Thus, facial attractiveness is not only influenced by perceptual factors, but also by experiential, social, and sexual factors. As a result, the appraisal processes for faces might be more complex than those for abstract patterns. Scherer and Ellgring (2007a) have suggested that these differences in appraisal processes could account for the attenuated facial activation patterns, which results in less clear activations for faces.

Appraisal-related differences could also explain why fluency effects due to presentation duration were only found for the abstract patterns. For the abstract patterns, the longer presentation duration resulted in enhanced zygomaticus activity in the 3rd and 4th seconds. This replicates and extends Winkielman and Caccioppo's (2001) and Winkielman et al.'s, (2006) finding that fluency enhances zygomaticus activations. The enhanced zygomaticus activity due to longer presentation duration indicates a general increase in positive affect. However, the more complex appraisal processes involved in judgments of facial attractiveness might have impeded similar fluency effects for the faces.

The present study demonstrated that facial EMG is a valuable tool for understanding affective reactions elicited by the attractiveness evaluations of different stimulus categories. Attractive and unattractive stimuli resulted in clear facial activation patterns. Although short presentation durations restricted explicit attractiveness judgments, physiological responses to the attractiveness of faces and abstract patterns were differentiated. A fluency-related effect was found only in the abstract patterns. This suggests that there are systematic differences between the stimulus categories in the way that attractiveness is appraised. For the abstract patterns, attractiveness appraisals are generally based on perceptual characteristics, such as complexity or symmetry; for faces, attractiveness appraisals might additionally be based on biological, experiential, social, and socio-sexual factors.

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### 2.3 Summary & Outlook

The study showed that facial EMG is a useful tool to infer the affective impact in aesthetic evaluations – stimuli (both faces and abstract patterns) evaluated as attractive resulted in stronger activations of the *M. zygomaticus major* and stimuli judged as unattractive resulted in stronger activations in the *M. corrugator supercilii*. Thus, employing facial EMG studies seems warranted when testing other materials (e.g. artworks). The implementation of this method was an essential part of the dissertation project. It is now used on new research questions in the field of aesthetic evaluations (e.g. testing if expertise changes facial EMG reactions in evaluating artworks for their attractiveness, and measuring subtle differences in design appearance).

Moreover facial EMG was also instrumental in uncovering differences between the categories beyond a simple positive negative distinction; a fluency related effect as indicated by stronger *M. zygomaticus major* activations was found for the abstract patterns but not for the faces. These differences suggest that aesthetic evaluations indeed depend on whether natural or artificial categories are tested (Kaplan, 1992; Kaplan, et al., 1972; Tinio & Leder, 2009b). We argued that different appraisal processes (Scherer & Ellgring, 2007a) contributed to the results because faces might trigger more complex appraisals due to their social, biological and socio-sexual relevance. Such different appraisal processes influencing the affective outcome of aesthetic evaluations are in line with the assumptions of the Leder et al., (2004) model.

Regarding future studies, several issues were raised in the article which could contribute to the debate as to whether aesthetic processing differs between these two stimulus categories. In this study the stimuli have been shown under conscious viewing conditions with a clear evaluative focus by explicitly telling the participants to judge the faces and patterns for their attractiveness. In future studies subliminal viewing conditions (Dehaene, Changeaux, Naccache, Sackur, & Sergent, 2006) could be used to test if aesthetic processing for one or the other stimulus category breaks down under subliminal viewing conditions. Regarding faces, it could be expected that aesthetic processing still takes place under subliminal viewing conditions (Olson & Marshuetz, 2005), however, with aesthetic processing of the abstract patterns, this needs to be explicitly tested. Subliminal viewing could also uncover interesting dissociations between the overt response measured by attractiveness ratings and the physiological reactions. It can be expected that no clear overt attractiveness ratings can be given under subliminal viewing conditions, however, physiological changes in the facial

activation patterns could still be detectable under subliminal viewing conditions (Dimberg, et al., 2000).

Moreover, detecting changes in physiological activation patterns under subliminal viewing conditions could also contribute to the question as to whether attractiveness of a stimulus is automatically processed and perceived. Automaticity of attractiveness perception would also be indicated when changes in the facial activation patterns are detectable without putting a clear evaluative focus on the attractiveness on the stimuli as done in this study (Palermo & Rhodes, 2007).

Such experimental manipulations could additionally contribute to the issue of whether facial activation patterns reflect ongoing affective processes in a direct manner (Ekman, et al., 1980; Ekman, Friesen, & Davidson, 1990; Izard, 1971) or indicate affective processes indirectly (Fridlund, 1996; Parkinson, 2005) as facial activation patterns serve as social display functions that mirror motives and intentions. If a subliminally presented attractive stimulus or if an attractive stimulus is presented without the instruction to explicitly rate the stimulus for attractiveness still results in changes in facial activation patterns, this would then support the former theory that affective processing is directly linked to specific facial activation patterns.

Interestingly, the attractiveness of different stimuli classes still result in measurable and predictable facial activation patterns. This chapter concentrated on the physiological consequences of aesthetic evaluations. In the next chapter, behavioral consequences were studied, examining how learning by familiarization changes aesthetic evaluations by measuring attractiveness ratings.



### **3 Structural Generalization of Facial Symmetry and Complexity Following Massive Familiarization**

#### **3.1 Introduction**

This article is in preparation for submission. This study addressed the impact of early stages on aesthetic evaluations in the Leder et al. (2004) model. It combines the effects of stimulus dimensions which are known to affect aesthetic evaluations – complexity (Berlyne, 1970b; Martindale, et al., 1990) and symmetry (Fink, et al., 2006; Garner, 1970; Jacobsen & Höfel, 2001; Perrett, et al., 1999) – with (massive) familiarization (Tinio & Leder, 2009a; Zajonc, 1968) when faces were used as stimuli. Thus, this research investigates how learning by familiarization changes aesthetic evaluations.

The research in this article was based on Tinio and Leder (2009a). Using abstract patterns highly controlled for their symmetry and complexity (Jacobsen & Höfel, 2001 - the same patterns which were used in chapter 2) - Tinio and Leder (2009a) showed that the salient perceptual dimensions of symmetry and complexity have an additive impact on aesthetic evaluations – complex symmetrical patterns are preferred over simple symmetrical ones which in turn are preferred over complex non-symmetrical ones. Simple non-symmetrical patterns are least preferred. However, massive familiarization changed these preference patterns resulting in a contrast effect. Participants familiarized to complex symmetrical patterns rated simple patterns as more attractive; participants familiarized to simple symmetrical patterns rated complex patterns as more attractive. It is important to note that moderate familiarization did not have an impact on the attractiveness ratings. Thus, the impact of complexity and symmetry on aesthetic evaluations seems to be rather robust. Only massive familiarization was able to generate contrast effects for complexity.

In the current study we sought to extend these findings to the category of faces. Thus, these studies expand the research questions posed in chapter 2 regarding differences in the aesthetic evaluations between natural and artificial categories. However, while the affective consequences were measured by using physiological methods in chapter 2, here the behavioral consequences were measured by employing attractiveness ratings. Compared to the abstract patterns, faces are meaningful in terms of previous exposures and are thus connected to long term memory related processes. Moreover, faces are meaningful in social, biological and socio-sexual terms. Therefore, familiarization could differentially impact the



aesthetic evaluations of the faces. In order to manipulate the same dimensions as in the abstract patterns in Tinio and Leder (2009a) the faces in this study were highly controlled in their symmetry and complexity by producing composite artificial faces (see Figure 2, p. 8). While symmetry is a well known dimension known to influence attractiveness of faces (Fink, et al., 2006; Grammer & Thornhill, 1994; Little & Jones, 2006; Perrett, et al., 1999) little is known about the factor complexity with regard to evaluations of attractiveness of faces. Our manipulation of complexity was based on previous research (e.g. Eisenman & Gellens, 1968; Jacobsen & Höfel, 2001; Tinio & Leder, 2009a) and involved changing the amount of elements (by adding forehead mouth and cheek lines to the face). In accordance with the abstract patterns used in Tinio and Leder (2009) the factors of complexity and symmetry were fully crossed, resulting in sets of simple symmetrical, complex symmetrical and simple non-symmetrical and complex non-symmetrical faces. Importantly, the complexity manipulation influenced the perceived emotionality of the faces – complex faces were rated emotionally more negative. As perceived attractiveness of faces varies with emotionality (Müser, et al., 1984; O'Doherty, et al., 2003) we therefore expected complex faces to be rated less attractive than simple faces.

Results showed the expected patterns. Simple symmetrical faces were rated more attractive than complex symmetrical faces. These in turn were rated more attractive than simple non-symmetrical and complex non-symmetrical were rated as least attractive. These results are in line with Tinio and Leder (2009a) in that the effects of symmetry and complexity are additive in evaluating attractiveness. However, regarding familiarization different effects to the study of Tinio and Leder (2009a) were found. In Tinio and Leder (2009a) a contrast effect emerged after massive familiarization using abstract patterns. In this study the effects were in line with mere exposure effects (Zajonc, 1968). Especially after massive familiarization a structural generalization effect, which is similar to a structural mere exposure effect, was found (Gordon & Holyoak, 1983; Monahan, Murphy, & Zajonc, 2000; Zizak & Reber, 2004). Following massive familiarization participants seemed to have generalized visual structures from familiar to novel faces. Significantly, these effects were not due to changes in perceived emotion.

## **3.2 Original Manuscript**

Running Head: GENERALIZATION OF SYMMETRY AND COMPLEXITY

Structural Generalization of Facial Symmetry and Complexity Following Massive  
Familiarization

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## Structural Generalization of Facial Symmetry and Complexity Following Massive Familiarization

The mind is equipped to respond consistently to the environment. But it can also deal with the unforeseen, adroitly adapting to certain stimuli or conditions to produce the appropriate action. Responses to particular visual features, for instance, are generally robust to changes in context. Tinio and Leder (2009) recently demonstrated this with symmetry and complexity in abstract patterns. The effects of these two factors on aesthetic judgments are positive—people find symmetrical and complex objects aesthetically pleasing, at least in typical contexts; people's responses change, however, in extreme contexts, as when people are massively familiarized to these factors. In this paper, we report on three experiments that examined the effects of symmetry and complexity on the aesthetic judgments of faces. We put emphasis on how such effects are modulated by familiarization, both moderate and massive. We capitalized on the greater biological and social significance of faces (Bruce & Young, 1986) as compared to the abstract patterns that have been used in previous studies.

The perception and aesthetic evaluation of faces are unique. Faces capture visual attention (Fletcher-Watson, Findlay, Leekan, & Benson, 2008; Vuilleumier, 2000); once captured, faces also bind that attention, regardless if 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 uniquely processed (Leder & Bruce, 2000; Ro, Russell, & Lavie, 2001). Research has also identified special brain regions used for face processing (e.g., Allison, Puce, Spencer, & McCarthy, 1999; Kanwisher, 2000; Kanwisher, McDermott, & Chun, 1997). Moreover, event-related brain potentials occurring during early processing have been found to be specific to faces (e.g., Herrmann, et al., 2002). 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 both when the faces were explicitly or implicitly 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.

We examined the influence of symmetry on aesthetic judgments of faces. Symmetry is found 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 presence of symmetry also influences the visual exploration of stimuli. (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 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 environmental pressures, and genetic and reproductive fitness (Jones et al., 2001; Rhodes, Zebrowitz, et al., 2001; Singh, 1995; Thornhill & Gangestad, 1999, 2006). Symmetry has 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 faces in the present study 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 how the stimuli were presented—centrally—which place 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, like symmetry, is highly influential to aesthetic judgments. Since the early days of empirical research on aesthetics, complexity has been considered 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.

Research on the influence of complexity on the aesthetic judgments of faces is lacking. Therefore, it is not known whether complexity has a positive or a negative influence on how faces are judged aesthetically. There are also no standard practices regarding how complexity in faces 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 varied simultaneously in symmetry and complexity (e.g., Eisenman & Gellens, 1968; Jacobsen & Höfel, 2001; Tinio & Leder, 2009). In those studies, complexity was defined by 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.

Experiment 1 examined the combined effects of symmetry and complexity on aesthetic judgments using four categories of faces with each set corresponding to the following combination of the two factors: simple-symmetrical, simple-nonsymmetrical, complex-symmetrical, and complex-nonsymmetrical. Participants rated the attractiveness of

the faces. They also rated the emotional valence of the faces in order to determine if the use of the additional features on the complex faces resulted in a systematic difference in the emotional valence between the complex and simple faces. Moreover, participants rated the distinctiveness of the faces to verify that there was no difference in this factor between simple and complex faces.

Based on the findings of previous studies, we hypothesized that symmetrical faces would be judged more attractive than nonsymmetrical faces (e.g., Grammer & Thornhill, 1994; Jacobsen & Höfel, 2001). We also hypothesized that simple faces would be judged more attractive than complex faces because the additional features on the complex faces may have had a negative impact (e.g., on texture) on the attractiveness of the faces (e.g., Fink, Grammer, & Thornhill, 2001; Jones, Little, Burt, & Perrett, 2004). The addition of these features could also have resulted in a shift towards more negative valence for the complex faces. Either of these reasons would result in simple faces being judged more attractive than complex faces. Finally, based on Tinio and Leder's (2009) finding that the effects of symmetry and complexity on aesthetic judgments are additive, we hypothesized that participants would judge the simple-symmetrical faces as most attractive, followed in decreasing order of attractiveness by simple-nonsymmetrical, complex-symmetrical, and complex-nonsymmetrical 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 judgments 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 (massive familiarization) and 3 (moderate familiarization), 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 towards 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, a concept similar to mere-exposure. Structural mere exposure involves 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—symmetry and complexity—from familiar to unfamiliar but similar faces. This is a type of visual *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 more likely because of the greater biological and social significance of faces. We also predicted that these 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 to generate the effects.

## 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 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.

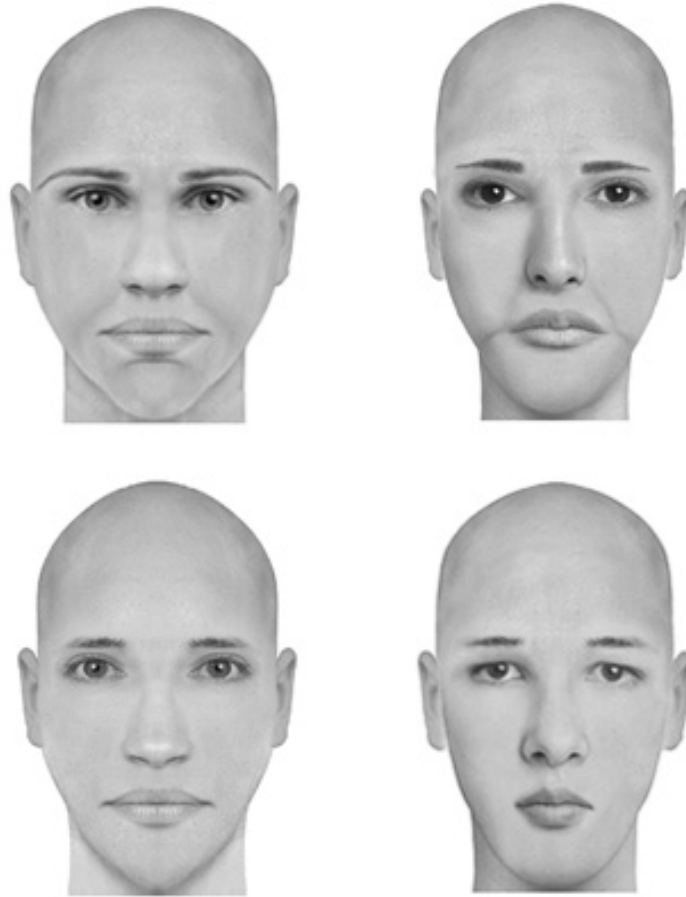


Figure 1: Examples of the composite faces: complex-symmetrical (upper-left), complex-nonsymmetrical (upper-right), simple-symmetrical (lower-left), and simple nonsymmetrical (lower-right)

### *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, with 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 illustrated that the effects of symmetry and complexity on the attractiveness ratings of the faces were additive. 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 attractiveness 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 (see Table 1 and Figure 2). 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. Results showed that symmetrical faces were rated as more attractive than nonsymmetrical faces,  $F(1, 36) = 43.95, p < .001, \eta_p^2 = .55$ , and simple faces were rated as more attractive than complex faces,  $F(1, 36) = 285.27, p < .001, \eta_p^2 = .89$ . 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,  $F(1, 36) = 16.55, p < .001, \eta_p^2 = .32$ , which reflected greater differences between ratings of symmetrical and nonsymmetrical faces in simple (mean difference = .50) than in complex (mean difference = .34) 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,  $F(3, 36) = 15.93, p < .001, \eta_p^2 = .57$ , which reflects the greater

differences in ratings between simple and complex faces for participants familiarized to simple faces (sisyfam = 1.53 and sinsfam = 1.47 vs. cosyfam = .64 and consfam = .61). There was also a significant interaction between symmetry and condition,  $F(3, 36) = 3.85, p < .05, \eta_p^2 = .24$ , which is based on greater differences in ratings between symmetrical and nonsymmetrical faces for participants familiarized to symmetrical faces (sisyfam = .67 and cosyfam = .59 vs. sinsfam = .21 and consfam = .20). Finally, there was a significant interaction among complexity, symmetry, and condition,  $F(3, 36) = 3.82, p < .05, \eta_p^2 = .24$ . 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 ( $p < .01$ ).

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 ( $p = .98$ ).

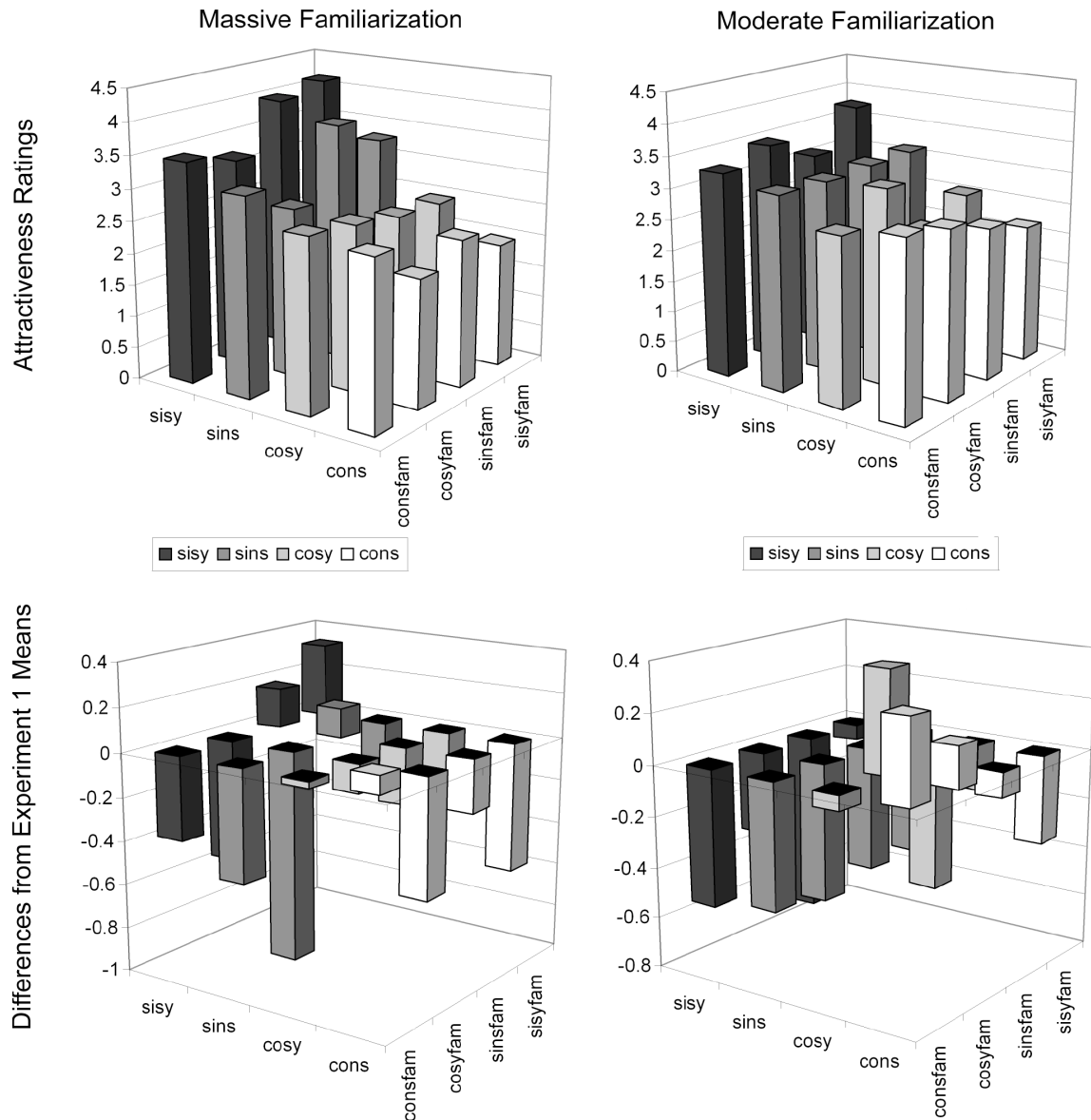
*Table 1.* Experiment 2 and Experiment 3 mean attractiveness ratings and standard deviations (in parentheses) of patterns by familiarization group. Means that share a common letter subscript differ at  $p < .05$ .

Experiment 2				
Pattern type				
Fam. Group	SiSy	SiNs	CoSy	CoNs
SiSy fam.	4.15 (0.87) <sub>a</sub>	3.30 (0.72)	2.45 (0.65)	1.96 (0.59) <sub>c</sub>
SiNs fam.	4.00 (0.94)	3.75 (0.82) <sub>b</sub>	2.48 (0.60)	2.31 (0.53)
CoSy fam.	3.26 (0.99) <sub>a</sub>	2.66 (0.82) <sub>b</sub>	2.61 (0.90)	2.01 (0.63) <sub>d</sub>
CoNs fam.	3.44 (0.70)	3.11 (0.64)	2.71 (0.59)	2.63 (0.60) <sub>cd</sub>

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.



*Figure 2.* Top row: mean attractiveness ratings of faces by face type and familiarization condition; bottom row: differences from Experiment 1 means by face type and familiarization condition; sisy = simple-symmetrical, sins = simple-nonsymmetrical, cosy = complex-symmetrical, and sins = simple-nonsymmetrical, fam = familiarization condition.

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 and Figure 2. 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 (see Table 1 and Figure 2). 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,  $F(3, 36) = 8.90, p < .01, \eta_p^2 = .20$ , which reflected a significant difference between ratings of symmetrical and nonsymmetrical faces in simple ( $p < .01$ ; mean difference = .31) but not in complex ( $p = .27$ ; mean difference = .09) faces. None of the interactions involving familiarization were significant.

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 similarity of results concerning emotional valence between Experiments 2 and 3 is in accordance with recent studies that have shown that familiarization has little effect on the processing of emotion inherent in stimuli (e.g., Schupp, et al., 2006).

Setting the familiarization condition aside, the pattern of data concerning the effects of symmetry and complexity that were found in this experiment was the same as the pattern of data 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. We capitalized on the idea that faces comprise a special class of objects with high social and biological significance (Bruce & Young, 1986). For Experiment 1, 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), and that simple faces would be judged more positively than complex faces. To our knowledge, this is the first study to systematically study the influence of facial complexity on aesthetic judgments. As predicted, Experiment 1 showed that participants rated simple-symmetrical faces as most attractive, followed in decreasing order by simple-nonsymmetrical, complex-symmetrical, and complex-nonsymmetrical faces. These results confirm previous findings (Tinio & Leder, 2009) that the effects of complexity and symmetry on aesthetic judgments are indeed additive.

Experiment 1 also showed that the use of additional features to create the complex faces influenced the emotional valence associated with those faces. Participants judged complex faces as more negative in emotional valence than simple faces. The higher attractiveness ratings of the simple as compared to the complex faces could be attributed to this shift in emotional valence. This explanation would be consistent with the fluency perspective, which states that the more fluent an object is processed, the more positive it will be judged aesthetically (e.g., Reber & Schwarz, 2001; Reber, Schwarz, & Winkielman, 2004; Reber, Winkielman, & Schwarz, 1998). There is evidence of interference in performance in tasks involving faces with negative valence. Note, for instance, Eastwood, Smilek, and Merikle's (2003; using schematic faces) study, which showed that compared to faces with positive or neutral valence, the processing of facial features were disrupted in faces with negative valence. In the present study, disruptions in processing fluency could have lead to the lower attractiveness ratings of faces with negative valence.

Another explanation of why complex faces were judged as less attractive is that the participants may have perceived these faces as threatening, or at least, as signaling threat. There is some evidence that the usually positive effects of attractiveness on aesthetic responses are modulated by the state of the perceiver. For example, Leder, Tinio, Fuchs, and Bohrn (in press) measured eye movements to examine if people look at attractive faces longer than less attractive faces. They found that attractive faces were generally looked at longer. However, when people were in a state of threat, the attractiveness advantage disappeared for

male faces, presumably because males have a higher aggression potential than females. Regarding the present study, complex faces may have been perceived as threatening or signaling threat, and were therefore judged as less attractive than simple faces. The successful recognition of and reaction to a face with negative valence is crucial for survival because such a face could signal a threatening object, person, or predator.

Leder et al.'s (in press) findings also suggests that the effects of top-down processes—such as affect—could override the effects of attractiveness on aesthetic responses. Similarly, the present study found evidence that negative valence in faces—through an increase in complexity—had overridden the effects of symmetry, but only after familiarization. This effect is reflected in the interaction between complexity and symmetry in Experiments 1 and 2. The results of these two experiments illustrate that although symmetrical faces were judged significantly more attractive than nonsymmetrical faces, the differences in attractiveness ratings between symmetrical and nonsymmetrical faces were greater for the simple faces. Thus, the negative valence in the faces had overridden—although not completely—the effects of symmetry on aesthetic judgments. Familiarization, both moderate and massive, may have increased the salience of the negative valence in the faces, and this salience, in turn, may have increased the dominance of the facial valence during the attractiveness ratings of the faces. Indirect evidence for such effect of familiarization comes from studies on the encoding of emotional facial expressions. For example, Halberstadt and Niedenthal (2001) found that when faces—even neutral ones—were accompanied by emotional labels (e.g., happy and sad) during initial encoding, subsequent viewing of those same faces are characterized by an exaggeration of the corresponding emotional labels. For instance, faces encoded as angry were later remembered as angrier than they were upon initial viewing. They also found that the effect was stronger the deeper was the initial encoding. Although participants in the present study did not encode the facial expressions explicitly, the repeated exposures to one type of face may have had a similar effect as explicit encoding. Further studies are required to examine this explanation.

The results of Experiments 2 and 3 were, to an extent, consistent with findings of mere-exposure studies (Zajonc, 1968), wherein familiar stimuli were shown to be evaluated more favorably than novel stimuli. In Experiment 2, the highest attractiveness ratings for a particular type of face were provided by participants familiarized to that type of face. The only exception was that the participants familiarized to complex-symmetrical faces, which were rated second most attractive after complex-nonsymmetrical faces. Similar results were obtained in Experiment 3. Tinio and Leder's (2009) study, which also employed moderate and

massive familiarization to abstract patterns, did not find clear mere-exposure effects. Instead, they found that people seemed to search for novelty following massive familiarization to a specific type of abstract pattern, a finding that is in line with Biederman and Vessel's (2006) recent work. The difference in results between their study and the present study is consistent with Bornstein's (1989) findings, using meta-analysis, that although mere-exposure effects have been found in various classes of stimuli—photographs, words, ideographs, and real people and objects; mere-exposure effects, were not found in the stimulus group consisting of abstract paintings, drawings, and matrices, to which the abstract patterns used by Tinio and Leder belonged.

The differences in findings between Experiments 2 and 3—those related to the interactions with the familiarization condition between-subjects variable—illustrate clearly that the approach of examining only 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 following massive familiarization: simple faces were found to be more attractive than complex faces in all massive familiarization conditions, but the differences in attractiveness between the two faces were greater for participants familiarized to simple faces; similarly, symmetrical faces were found to be more attractive than non-symmetrical faces in all massive familiarization conditions, but the differences in attractiveness between the two faces were greater for participants familiarized to symmetrical faces. These structural generalization effects are similar to *structural mere exposure* effects (Gordon & Holyoak, 1983; Manza & Bornstein, 1995; Monahan, Murphy, & Zajonc, 2000; Newell & Bright, 2001; Zizak & Reber, 2004), although the latter involves a transfer of artificial grammatical structures from familiar stimuli to similar but new stimuli. In this study, structure involved variations in facial symmetry and complexity.

Although structural generalization effects seem to resemble face adaptation effects (e.g., Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003; Webster & MacLin, 1999), the two are different in several ways. Participants in adaptation studies are exposed to distortions in adapting stimuli—such as faces that have been stretched horizontally. Following adaptation, these distorted faces will appear more normal than undistorted faces. If adaptation effects would have occurred in this study, participants familiarized to nonsymmetrical and complex faces might have rated as less attractive the corresponding symmetrical and simple faces—because these latter faces would have become less prototypical following

familiarization (Rhodes, et al., 2003). This was not the case, however, as participants, regardless of familiarization condition, rated symmetrical and simple faces more attractive than their nonsymmetrical and complex counterparts.

The effects of basic visual features on aesthetic judgments are more complex than over a century of research (Fechner, 1876) has shown. We found that the effects of symmetry and complexity were additive. We also found that facial complexity is judged negatively, perhaps because the complexity manipulation resulted in a shift towards negative emotional valence in the faces. Complexity in faces also seemed to have overridden the effects of symmetry. Familiarization had strong modulating effects: moderate familiarization resulted in mere-exposure effects, and massive familiarization resulted in structural generalization effects—people find who they know attractive, and the more they see of them, the more likely they will find attractive others who have similar structural features. This response seems adaptive. We are drawn to familiar people because they are less threatening and more predictable, and communicating with them should be generally easier than communicating with strangers. And as in the adage, “birds of a feather flock together,” we are drawn to people who are similar to those who are very familiar—at least those with familiar features.

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### 3.3 Summary & Outlook

These results extended the findings of previous research regarding the factors of complexity and symmetry (Jacobsen & Höfel, 2001; Tinio & Leder, 2009). Both manipulated visual stimulus dimensions - symmetry and complexity - had a robust impact on attractiveness evaluations in faces. However, in line with results from chapter 2, faces compared with the abstract patterns seem to have a special status regarding aesthetic evaluation. In that chapter it was argued that faces trigger more complex appraisal processes (Scherer & Ellgring, 2007a) which can influence the overall attractiveness evaluations. It's not only perceptual characteristics like symmetry and complexity which influence attractiveness for faces (Müser, et al., 1984; O'Doherty, et al., 2003), but also perceived emotionality. Here, it was shown that emotionality seemed to override the perceptual effects of complexity on attractiveness (complexity was rated more attractive in the Tinio & Leder, 2009a study using abstract patterns). Due to their perceived negative emotionality complex faces were rated as less attractive. Psychophysiological studies suggest that emotionality is an important determinant in facial perception and is inferred early in stimulus processing. Emotional faces, particularly those with negative emotional expressions, influence processing even under subconscious viewing conditions (Dimberg, et al., 2000; Kiss & Eimer, 2008; Whalen, et al., 1998). From an evolutionary point of view, efficient reaction to potentially harmful or negative stimuli is important to survival and this in turn might result in attenuated attractiveness evaluations.

Moreover, familiarization and especially massive familiarization had distinct effects on the attractiveness of the faces. In contrast to abstract patterns (Tinio & Leder, 2009a), where a contrast effect was found, the results of this study were in line with mere exposure effects (Zajonc, 1968). Especially after massive familiarization a structural generalization effect was found. This can be seen as analogous to the structural mere exposure effect (Gordon & Holyoak, 1983; Zizak & Reber, 2004). Following massive familiarization participants seemed to have generalized visual structures from familiar to novel but similarly structured faces. Thus, it seems that under states of high habituation to a stimulus, attractiveness of the meaningless patterns can be explained by craving for novelty of stimulus features (Berlyne, 1970b; Biederman & Vessel, 2006) while familiarity (Zajonc, 1968) of stimulus features is a more important contributor for faces which are meaningful in terms of biological, social and socio-sexual factors. This again supports the assumption of a special role that faces play in perception and aesthetic evaluation. In the following chapters changes in appreciation will be discussed by employing different artificial stimuli – car interior

designs - and a novel experimental paradigm, the repeated evaluation technique (RET, Carbon & Leder, 2005).



## **4 Aesthetic Appreciation and Dynamics of Aesthetic Appreciation of Innovativeness**

### **4.1 Introduction to the Repeated Evaluation Technique – RET**

The previous study investigated changes in the aesthetic evaluation due to (massive) familiarization. Similarly, the next studies investigated dynamic changes in aesthetic evaluations, particularly for innovative objects during design evaluation. Instead of a passive familiarization with the stimuli a rather active paradigm was used where participants repeatedly evaluated the stimuli along different dimensions – the repeated evaluation technique (RET, Carbon & Leder, 2005). These studies employed the RET procedure and investigated the dynamics of the appreciation of innovativeness.

Innovativeness is an important stimulus dimension especially in applied areas such as consumer design, fashion and art. Innovativeness, defined as “originality by virtue of introducing new ideas” (Carbon & Leder, 2005, p. 587) comprises novelty, but the concept of innovativeness might be more far reaching than mere novelty. Carbon and Leder (2005) suggest that innovativeness, when compared to novelty, shows some stability while novelty itself cannot persist. Besides novelty, innovative designs also comprise factors like unexpectedness as they break common visual habits, unusualness and unfamiliarity (Carbon & Leder, 2005). On the positive side a stimulus becomes more distinctive, idiosyncratic and clearly identifiable through these factors, something of special importance in applied areas. For example, in highly competitive industries, like the car industry, it is important to distinguish one’s design from other competitors. This can be ensured by design innovativeness. However, on the negative side innovativeness is often initially disliked (Carbon & Leder, 2005; Leder & Carbon, 2005; Moulson & Sproles, 2000). This negative affect might be due to novelty and unfamiliarity (e.g. Lee, 2001; Robinson & Elias, 2005) or the distinctiveness (Martindale & Moore, 1988; Martindale, Moore, & West, 1988; Rhodes & Tremewan, 1996) inherent in innovative designs. However, innovative designs benefit from a deep evaluation; attractiveness of innovativeness increases over time (Carbon & Leder, 2005).

In Carbon and Leder (2005) this was tested by exposing participants to differently innovative stimuli and repeated stimulus evaluations, the repeated evaluation technique – in short RET. The idea behind RET is to simulate everyday exposures in an ecologically valid way, that is, a mixture of rather active and passive stimulus exposures. For example, in



everyday life we experience novel music, designs or art simply by seeing, discussing or considering it. Thus, the RET procedure extends the classic mere exposure paradigm (Zajonc, 1968) where participants are simply exposed to the stimuli with an active component: the active elaboration and processing of the stimuli. In the RET participants typically first rate attractiveness and innovativeness of the stimuli to obtain base rates for the stimuli. Then a phase of repeated stimulus evaluation follows, where participants repeatedly evaluate the materials on different dimensions. Subsequently attractiveness and innovativeness is tested again. As a result of RET, attractiveness for highly innovative material increased and decreased for the less innovative material. Ratings of innovativeness, however, preserved their initial levels, suggesting that perceived innovativeness is a rather stable feature. These effects were shown in follow-up studies (Carbon, et al., 2006).

With regard to the aesthetic model of Leder et al. (2005) these studies comprise components of the implicit and explicit processing stages – innovativeness can be seen as a perceptual stimulus component, which might influence attractiveness due to its relative novelty, unexpectedness and unfamiliarity. However, familiarization and active elaboration with the stimuli through repeated stimulus evaluation during the RET and explicit classification of the stimuli as innovative or not, might influence the outcome of aesthetic evaluations of such stimuli.

In this chapter, all studies were conceptualized within the RET framework of testing the appreciation of innovative consumer designs – namely car interiors (Carbon, et al., 2006; as in Carbon & Leder, 2005; Carbon, Michael, & Leder, 2008). In contrast to previous studies more photorealistic car interiors (Talker, 2007) were designed specifically for us (see Figure 3, p. 11). Pre-studies confirmed that the stimuli systematically varied along the dimension innovativeness. Additionally, the designs were fully crossed with regard to factors influencing aesthetic evaluations, namely complexity (Berlyne, 1970b; Cox & Cox, 1988) and curvature (Bar & Neta, 2006) - for examples, see Figure 3, p. 11.

Four studies investigated different aspects of the appreciation of innovativeness and its dynamics are reported in the following chapters (chapters 4.2-4.5). Parts of the data had been presented at the 2007 Annual Meeting of Experimental Psychologists (TeaP), Trier, Germany and the 2007 European Conference on Visual Perception (ECVP), Arezzo, Italy.

## **4.2 When the Others Matter - Context-dependent Effects on Changes in Appreciation of Innovativeness**

### **4.2.1 Introduction**

This article is accepted for publication in the *Swiss Journal of Psychology*. In a series of studies by Carbon and Leder (2005), Carbon et al. (2006), and Leder and Carbon (2005) it was repeatedly found that innovativeness is often rejected at first sight. Moreover, appreciation of highly innovative designs increases after repeated stimulus evaluations while it decreases somewhat for low innovative designs (Carbon, et al., 2006; Carbon & Leder, 2005). Critically, in these studies innovativeness was made apparent by testing highly innovative and low innovative stimuli together in one set. Thus, in the context of evaluating highly and low innovative stimuli in one set, participants had the possibility to contrast their evaluations (Berlyne, 1970a; Parducci, 1995; Pol, Hijman, Baare, & van Ree, 1998; Stapel & Winkielman, 1998; Zellner, Rohm, Bassetti, & Parker, 2003) with regard to the apparent innovativeness. This could have influenced the appreciation of innovativeness and its dynamics. In this study we therefore systematically varied the context by applying different stimulus sets, which participants had to evaluate – participants repeatedly evaluated either an homogenous set in innovativeness (only low or only highly innovative stimuli) or heterogeneous (highly and low innovative stimuli together).

When innovativeness of the stimuli was made apparent by testing in a heterogeneous set, the typical dynamics of appreciation were obtained, with initial rejection of highly innovative stimuli and after repeated evaluation preference for those very stimuli. However, using a homogenous set both innovativeness classes were rated similarly on attractiveness and showed the same increase of appreciation over time. This study suggests that innovativeness has to be made apparent to influence aesthetic evaluations and its dynamics.

## 4.2.2 Original Manuscript

Running Head: CONTEXT-DEPENDENT APPRECIATION OF INNOVATIVENESS

When the others matter - Context-dependent effects on changes in appreciation of  
innovativeness

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### Abstract

Although innovativeness is an important variable in product design, we know little about its appreciation. We studied how appreciation of innovativeness and its dynamics depends on the heterogeneity of the context in which it appears. We employed a test-retest design in which appreciation of car interior designs were tested before and after repeated evaluations. We tested heterogeneous (highly and low innovative designs together; Experiment 1) or homogeneous (only highly or only low innovative; Experiment 2) sets. Only for a heterogeneous set the known effect (Carbon & Leder, 2005; Carbon, Hutzler & Minge, 2006) of a selective increase for highly innovative stimuli after repeated evaluations was obtained. In the homogenous sets both highly and low innovative interiors were rated similarly and showed similar dynamics. In Experiment 3, we ruled out differences in experimental design (more ratings and longer duration in Experiment 1) as the cause of the differences by conducting a shorter version of Experiment 1. According to our results, high innovativeness showed a specific increase of attractiveness ratings only when innovativeness was made apparent by presenting stimuli in heterogeneous sets. Thus, awareness of variation in innovativeness as a relevant stimulus dimension is a key feature regarding its effect on appreciation.

### When the others matter - Context-dependent effects on changes in appreciation of innovativeness

Product aesthetics are essential in modern consumer markets (Hekkert & Leder, 2008). For example, Apple's success has been attributed to its intense focus on attractive and innovative product design. Thus, product design that is attractive through innovativeness (Carbon & Leder, 2005; Hekkert, Snelders, & Van Wieringen, 2003) obviously can be a key to distinguish between winners and losers in a market (Liu, 2003; Mairesse & Mohnen, 2002). If innovativeness is not found attractive by customers (Cooper, 2001; Moulson & Sproles, 2000), this would be quite costly for a company. In consequence, innovativeness is often-stressed as being essential in consumer products and a driving force in cultural and industrial progress (see Cox, 2005; and for the arts, Leder, Belke, Oeberst & Augustin, 2004).

Psychologically, innovativeness is not a very well-defined dimension. The specific nature of innovativeness makes it an interesting dimension regarding attitude formation (Schwarz, 2007). Innovativeness can be defined as "originality by virtue of introducing new ideas" (Carbon & Leder, 2005, p. 587). It involves novel and sometimes-unusual stimulus features. Different from novelty, innovativeness remains innovative for some time, while novelty cannot persist (Carbon & Leder, 2005). In design, innovativeness can be extracted from expert knowledge or from concept design studies; however, because what is seen as innovative might differ between perceivers, the effects of innovativeness in empirical studies warrant individual assessment (Carbon & Leder, 2005). In a series of studies using car interiors, systematically varying in innovativeness, Carbon and Leder (2005), Leder and Carbon (2005), and Carbon, Hutzler, and Minge (2006) found that innovativeness was often rejected at first sight. When seen for the first time, low innovative car interiors were appreciated more than highly innovative car interiors. However, after active elaboration through repeated evaluations (Carbon & Leder, 2005; Carbon et al., 2006), attractiveness selectively increased for the highly innovative car interiors. Critically, in these studies because highly and low innovative stimuli were rated together in one set, innovativeness might have been made apparent through the heterogeneity of the evaluated set. Whether an increase of appreciation for highly innovative designs requires explicit awareness of innovativeness as an important dimension, relative to other stimuli, was addressed in the present study. It was tested whether heterogeneity in innovativeness is necessary to selectively increase attractiveness for high innovativeness. For example, the perceived attractiveness of a new, innovative car design depends on the other cars that one knows, or on the other cars that

are presented during the evaluation. Alternatively, innovativeness might also be evaluated independent of either. Understanding under which conditions innovative designs become appreciated would inform about the nature of cognitive-affective evaluations, and how attitudes are formed automatically or are stimulus - context dependent.

In the present study, we used a dynamic test paradigm of repeated evaluations (Carbon & Leder, 2005) and compared homogenous (only highly *or* only low innovative car interiors) and heterogeneous (highly and low innovative car interiors) stimulus sets. Differences would reveal whether appreciation of high innovativeness requires a direct comparison between highly and low innovative stimuli or whether innovativeness, when it is seen, produces effects *per se*, and thus relies on an internal standard of comparison. The latter would be in accordance with effects of an independent, inner standard, similarly to specific responses to stimulus features – such as for example absolute pitch (Takeuchi & Hulse, 1993). The former would be in accordance with effects that depend on differences with other stimuli in the set (Helson, 1948; Parducci, 1995) or, as for example in paradigms of mismatch-negativity, when effects are only measured when suddenly a deviating stimulus appears (Cammann, 1990; Tiitinen, May, Reinikainen & Näätänen, 1994).

We employed a paradigm that utilised a similar paradigm of varying set homogeneity in respect to differentially visually demanding stimuli and repetition (Bornstein, Kale & Cornell, 1990). They found by using two classes of stimuli - visually demanding optical illusions and simple geometrical line drawings- that the effects of stimulus repetition on attractiveness ratings depended on the homogeneity of the stimulus set. Using a between-subjects design where only one homogenous stimulus class was repeatedly shown and then evaluated, they found that attractiveness ratings linearly increased for both classes. Additionally, the attractiveness ratings for both classes of stimuli were similar when seen for the first time. However, when both classes of stimuli were shown together in one set, when evaluated for the first time, the simple figures received lower ratings of attractiveness than the optical illusions. In this heterogeneous set, stimulus repetition resulted in increased attractiveness ratings only for the optical illusions but not for the simple geometric figures. Additionally, after repetitions, both classes of stimuli showed a decrease in attractiveness ratings, which was interpreted as the effect of boredom (Berlyne, 1970b; Stang, 1974). Thus, regarding the dimension of visual demands, only when differences in stimulus features were made apparent by presenting the stimuli together did complexity-dependent changes in attractiveness emerge. Applying a similar design we will test whether effects of innovativeness (as in Carbon & Leder, 2005) also depend on such contexts or set-effects.

Aesthetic appreciation is often studied by measuring attractiveness (Hekkert & Leder, 2008). Attractiveness is a summarizing evaluation representing affective and cognitive aspects (Leder et al., 2004; Leder, Augustin & Belke, 2005) in which a number of related concepts are involved. Regarding the structure of aesthetic evaluations, Faerber, Leder, Gerger and Carbon (2010) showed how the activation of specific attractiveness related concepts produces different effects with regard to aesthetic appreciation. They tested a semantic network approach to aesthetic appreciation by comparing different priming conditions. In these studies, when participants had been primed for innovativeness, changes in attractiveness were observed. However, it is unclear whether these changes depend on the range of innovativeness in the stimulus sets. Different theoretical explanations make different predictions regarding set effects when stimuli are presented in either homogenous or heterogeneous sets.

The following theories propose that appreciation of innovativeness could depend on a kind of internal, already existing comparisons standard; prototype, evolutionary–novelty and two-factor theory. According to prototype theory (e.g. Halberstadt, 2006; Halberstadt & Rhodes, 2003; Rosch, 1978), each stimulus will be matched against an internal prototype (based on previous experiences). Innovative stimuli might be more dissimilar from an internal prototype, because they are more dissimilar from familiar (cf. prototypical) stimuli. Then low prototypicality is not preferred (Halberstadt, 2006). Repeated evaluation increases familiarity, and might cause minor changes in the internal prototype (Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003) towards higher innovativeness (Carbon & Leder, 2005). Therefore, appreciation of highly innovative designs will increase over time. Because stimuli are matched to an already existing internal prototype, one might expect to find similar evaluations and dynamics regardless of whether a homogenous or heterogeneous set is used. However, recent data from the domain of face research have questioned this theory, at least for the process of assessing attractiveness of faces by matching them with an internal prototype (Carbon, Grüter, Grüter, Weber & Lüscho, 2010).

Evolutionary accounts that claim that stimulus novelty (c.f. innovativeness) results in ambiguity or uncertainty (Lee, 2001; Robinson & Elias, 2005) make the same predictions. A perceiver cannot know whether a novel (c.f. innovative) stimulus is potentially harmful. As a consequence approach and avoidance behaviours would both be triggered simultaneously, resulting in attenuated attractiveness judgments. If this initial ambiguity is overcome through repeated evaluations, then attractiveness judgments eventually increase. Regardless of set combination, one might find lower attractiveness ratings for highly innovative than for low

innovative stimuli when rated for the first time. After repeated evaluation, the attractiveness of innovative stimuli would increase.

The two-factor theory of Berlyne (1970b) and Stang (1974) arrives at the same conclusions. According to this theory, the better a stimulus is embedded in our cognitive system, the more positively it will be evaluated until boredom sets in, which then affects evaluations. Embedding occurs through repeated evaluations, and results in positive habituation (Berlyne, 1970b) and increased familiarity (Zajonc, 2001). Moreover, processing fluency of the stimulus also increases (Bornstein & D'Agostini, 1994; Reber, Schwarz, & Winkielman, 2004). All of these factors increase attractiveness evaluations (Carbon, 2010) until boredom sets in, at which point the positive evaluations begin to wane (Berlyne, 1970b; Stang, 1974). Because of their relative novelty, highly innovative stimuli are less well embedded in our cognitive systems than low innovative stimuli. Consequently, the two-factor theory would predict increases for highly but not for low innovative stimuli, regardless of whether innovative stimuli are shown within a heterogeneous or homogenous set.

However, if appreciation of innovativeness depends on a relative comparison standard this would be in accordance with a different rationale of the two-factor model (Berlyne 1970b; Stang, 1974) or arousal theory (Berlyne, 1970a). According to the two-factor theory effects of habituation and boredom on attractiveness ratings could also be *relative* depending on the stimulus set. After repeated evaluations, the highly innovative stimuli might be perceived as relatively less boring in comparison to the low innovative stimuli. However, when only one set is rated, then the boredom effects within the set will be similar and independent of level of innovativeness. Thus, different dynamics might develop when the range of innovativeness is different.

Arousal theories (Berlyne, 1970a) also predict that attractiveness ratings depend on relative differences among the stimuli. They assume that medium levels of arousal will result in the highest attractiveness ratings. Importantly, according to the arousal account, evaluations critically depend on *the relative* arousal level induced by different stimuli. Highly innovative stimuli—because of their novelty, unexpectedness, and unusualness — when seen for the first time, might produce higher suboptimal arousal levels than low innovative stimuli. Through repeated evaluations, this initially high arousal might be reduced to a medium level, while the arousal level of the low innovative stimuli might be reduced to a suboptimal level. Thus, when both innovativeness classes are judged together, arousal differences due to innovativeness might be highly apparent and determine their attractiveness. On the other hand, in a homogeneous set, the arousal levels associated with the stimuli might be similar,



which would result in more similar attractiveness evaluations and dynamics. Evidence for such changes in arousal was also found in Carbon, Michael and Leder (2008), when they measured electro-dermal activity indicative of arousal. Highly innovative material showed physiological effects in accordance with maintaining positive arousal after repeated evaluations.

Thus, the current experiments will distinguish between the following hypotheses: if prototype, novelty, or two-factor explanations account for the effects of innovativeness, then we expect to find similar effects in heterogeneous and homogenous stimulus sets. However, if the appreciation of innovativeness depends on relative differences as suggested by arousal or based on the relative boredom level (according to the two-factor theory), then effects should differ between the conditions.

### Experiment 1

In Experiment 1, a heterogeneous stimulus set was used. Experiment 1 was based on Carbon and Leder's (2005) experimental paradigm, the "Repeated Evaluation Technique" (RET). Car interiors were judged for attractiveness and innovativeness before and after a phase of repeated stimulus evaluations. Thus, Experiment 1 served as a baseline replication of Carbon and Leder (2005) but used photorealistic instead of line-drawing stimuli.

### Method

#### *Participants.*

Twenty-seven participants (19 female, 8 male) enrolled in various introductory psychology courses at the University of Vienna participated for partial course fulfilment. The mean age of the participants was 21.7 years (range: 18 to 28 years).

#### *Stimuli*

Eighteen photorealistic greyscale depictions of car interiors were created in Adobe Photoshop 7. These differed in two level of innovativeness (Carbon & Leder, 2005) as confirmed by pre-tests (for examples, see Figure 1). As in Faerber et al. (2010), the two levels of innovativeness (low, high) were fully crossed with levels of complexity and curvature on 3 x 3 levels (low, medium, high) - for a detailed description of these dimensions see Carbon and Leder, 2005; Leder and Carbon, 2005. Several previous studies ensured equal degrees of complexity and curvature for the two levels of innovativeness using 7-point Likert scales (Carbon & Talker, 2006).



*Figure 1.* Examples of stimuli used: A highly innovative car interior (left) and a low innovative car interior (right).

### *Apparatus*

The experiment was administered using PsyScope PPC 1.25 (Cohen, MacWhinney, Flatt, & Provost, 1993) on Apple eMac computers. Stimuli were centrally presented on a 17" monitor at a size of 678 x 438 pixels with a screen resolution of 1024 x 768 pixels.

### *Procedure*

Experiment 1 consisted of three consecutive parts. In an initial rating phase (Test phase 1: T1), participants first rated all of the car interiors for their attractiveness and then for their innovativeness. In the second part, all stimuli were evaluated on 25 different scales. This repeated exposure phase was used to ensure that participants actively elaborated the stimuli. The stimuli were rated on the following dimensions (as in Carbon & Leder, 2005; German terms in parentheses): disgusting (abschreckend), pleasant (angenehm), appealing (ansprechend), unsophisticated (bieder), carefully designed (durchdacht), inviting (einladend), elegant (elegant), overwhelming (erdrückend), extravagant (extravagant), hippy (flippig), futuristic (futuristisch), solid (gediegen), tasteful (geschmacksvoll), of high quality (hochwertig), kitschy (kitschig), comfortable (komfortabel), conservative (konservativ), luxurious (luxuriös), modern (modern), plain (nüchtern), functional (praktisch), stylish (stilvoll), over-ornate (unübersichtlich), ornamental (verspielt), and overloaded (überladen). The presentation order of these scales was randomized across participants. Finally, the participants rated all of the stimuli again for attractiveness and innovativeness (Test phase 2: T2). All ratings were made on seven-point Likert scales anchored with 1=low (wenig) and 7=high (sehr). The presentation order of the stimuli was randomized within each scale. Participants were not given time constraints for their ratings.

### Results and Discussion

In Experiment 1, participants judged a set of stimuli that were heterogeneous in innovativeness (as in Carbon & Leder, 2005). As can be seen in Table 1, low innovative stimuli were rated higher on attractiveness than highly innovative stimuli at T1. However, after repeated evaluations, only highly innovative stimuli showed an increase in attractiveness at T2 (see Table 1 and Figure 2). Regarding the innovativeness ratings, the data showed a clear pattern (see Table 1). Highly and low innovative stimuli differed at T1 and T2. In order to analyze these effects, we calculated repeated measures ANOVAs with the factors time (T1, T2) and innovativeness (high, low) separately for the attractiveness and innovativeness ratings. Given a sample size of 27 participants an effect of size  $f = 0.36$  (i.e., between a medium,  $f = 0.25$ , and a large,  $f = 0.40$  effect as defined by Cohen, 1988) could be detected with a probability of  $1 - \alpha = .95$  (Faul, Erdfelder, Buchner, & Lang, 2009). For the follow-up dependent t-tests, a-posteriori effect sizes were calculated according to formula 3 in Dunlap, Cortina, Vaslow, and Burke (1996).

*Table 1.* Mean attractiveness and innovativeness ratings for Experiments 1, 2, and 3, separately for T1 and T2. Standard deviations are in brackets.

	Experiment 1		Experiment 2		Experiment 3	
	heterogeneous set - long		homogenous set		heterogeneous set - short	
	Attractiveness					
	T1	T2	T1	T2	T1	T2
low innovative	3.35 (1.00)	3.32 (0.85)	2.96 (1.00)	3.60 (0.80)	3.15 (0.80)	3.47 (0.85)
highly innovative	2.90 (0.72)	3.75 (1.18)	3.26 (1.02)	3.77 (0.80)	3.06 (1.16)	4.98 (1.00)
	Innovativeness					
low innovative	3.11 (0.76)	3.05 (0.69)	3.41 (0.97)	3.62 (0.69)	3.20 (0.91)	3.40 (1.16)
highly innovative	4.44 (1.05)	4.63 (0.94)	3.58 (1.00)	3.84 (1.02)	3.87 (0.90)	4.44 (0.78)

*Attractiveness ratings.* A  $2 \times 2$  (time x innovativeness) repeated measures ANOVA for the attractiveness ratings revealed a significant main effect of time,  $F(1, 26) = 10.99$ ,  $p < .01$ ,  $\eta^2 = 0.30$ . Importantly, the effect of time was qualified by a significant interaction of time and innovativeness,  $F(1, 26) = 10.55$ ,  $p < .01$ ,  $\eta^2 = 0.29$ , reflecting attractiveness dynamics that were dependent on the innovativeness level of the stimuli (see Figure 2). Dependent t-tests showed that this interaction was due to the highly innovative stimuli receiving significantly

higher attractiveness ratings at T2 than at T1,  $t(26) = 4.50$ ,  $p < .01$ ,  $d = 0.81$ ; it was not due to changes in the attractiveness of the low innovative stimuli,  $t(26) = 0.14$ , n.s.,  $d = 0.03$ . The results regarding the attractiveness ratings replicated (using more realistic stimuli) Carbon and Leder's (2005) findings. Highly innovative stimuli were initially rejected, but following repeated evaluations, they were liked more than low innovative stimuli.

*Innovativeness ratings.* A repeated measures ANOVA revealed a significant main effect for innovativeness,  $F(1, 26) = 85.85$ ,  $p < .01$ ,  $\eta^2 = 0.77$ , but no other effect. Thus, innovativeness ratings differed along our pre-classification, and remained stable over time (again as in Carbon & Leder, 2005).

## Experiment 2

In Experiment 2 we tested the critical condition: In order to explore whether innovativeness, when it is not made apparent, influences attractiveness and its dynamics, participants evaluated a set of stimuli that were homogenous in innovativeness (either only low or only highly innovative stimuli).

### Method

#### *Participants*

Fifty-four participants (41 female, 13 male) enrolled in various introductory psychology courses at the University of Vienna participated for partial course fulfilment. The mean age of the participants was 22.5 years (range: 18 to 38 years). Participants were randomly assigned to one of two conditions (Experiment 2a and Experiment 2b), with the restriction that approximately the same amount of men were in each condition (six in Experiment 2a and seven in Experiment 2b).

#### *Stimuli and Apparatus*

The stimuli and apparatus used were the same as in Experiment 1. In Experiment 2a, only the low innovative stimuli (9 stimuli) were presented to the participants; in Experiment 2b, only the highly innovative stimuli (9 stimuli) were presented to the participants.

#### *Procedure*

Again, Experiments 2a and 2b consisted of three consecutive phases (T1, evaluation phase, T2), all ratings were given on seven point Likert scales, and were self-paced.

### *Results and Discussion*

Attractiveness ratings were clearly different from those in Experiment 1. Comparing the results of Experiment 2a and 2b highly innovative stimuli were judged slightly more attractive than low innovative stimuli. Over time, attractiveness ratings increased consistently for both the highly and low innovative stimuli (see Table 1 and Figure 2). Also, innovativeness evaluations did not reveal differences between the two conditions. To analyze these effects, we conducted a 2 x 2 repeated measures ANOVA with innovativeness (high, low) as a between subjects factor and time (T1, T2) as a within subjects factor, separately for the attractiveness and innovativeness ratings. Given the sample size of 54 participants (27 evaluating only the highly innovative, 27 only the low innovative stimuli) we could expect to detect medium sized effects with  $f = .25$  (Cohen, 1988) with a probability of  $1 - \alpha = .95$  (Faul et al., 2009).

*Attractiveness ratings.* A repeated measures ANOVA for attractiveness ratings alone yielded a significant main effect for time,  $F(1,52) = 14.86$ ,  $p < .01$ ,  $\eta^2 = 0.22$ . After the repeated evaluations, attractiveness ratings for both innovativeness classes increased in a concordant manner (see Figure 2). No specific effects for either level of innovativeness were found. Thus, the effects of innovativeness on attractiveness clearly depend on which set combination was evaluated. Only in a heterogeneous set (in Experiment 1) differential effects were found in that highly innovative stimuli gained in attractiveness after repeated stimulus evaluations.

*Innovativeness ratings.* A repeated measures ANOVA for innovativeness ratings revealed no significant effects. However, the factor time showed a trend towards significance:  $F(1,52) = 4.03$ ,  $p = .051$ , n.s.,  $\eta^2 = 0.07$ . Thus, innovativeness of the stimuli did not significantly affect the corresponding innovativeness ratings. So, if the variation on the dimension innovativeness is not made explicit and thus awareness is not specifically raised by showing highly and low innovative stimuli together, then innovativeness does not show a specific effect.

### Experiment 3

Experiments 1 and 2 differed in two respects. First, participants had to provide more ratings in Experiment 1 as compared to Experiment 2. This was due to the different numbers of stimuli (18 in Experiment 1 vs. 9 in Experiment 2). Second, Experiment 1 had a longer total experiment duration. In order to rule out that the different dynamics in attractiveness ratings with a selective gain for highly innovative stimuli in Experiment 1, but not in Experiment 2, was due to the different experimental procedures, Experiment 3 employed the same experimental design as Experiment 1, but used a subset of only four highly and four low

innovative stimuli. This resulted in approximately the same number of evaluations and the same experiment duration as Experiment 2.

## Method

### *Participants*

Twenty-seven participants (24 female, 3 male) from the University of Vienna participated for partial course credit. The mean age of the participants was 22.2 years (range: 19 to 45).

### *Stimuli and Apparatus*

In Experiment 3, only a subset of the stimuli from Experiment 1 was used. Stimuli with medium levels of complexity and curvature were omitted. Thus, the set consisted of four highly and four low innovative stimuli. The apparatus was the same as in Experiments 1 and 2.

### *Procedure*

The same experimental procedure as in Experiments 1 and 2 was used.

### *Results and Discussion*

Experiment 3 was conducted to rule out the possibility that the differences in the results in attractiveness between Experiments 1 and 2 (in Experiment 1 attractiveness ratings selectively increased for highly innovative stimuli, not for low innovative stimuli) were due to different experimental procedures. Descriptively, the results replicated the findings of Experiment 1. At T1, low innovative stimuli were preferred over highly innovative stimuli (although the difference was not as large as in Experiment 1). Importantly, following repeated evaluations, attractiveness ratings for highly innovative stimuli increased more than for low innovative stimuli (see Table 1). As in Experiment 1, innovativeness ratings between highly and low innovative stimuli were clearly different (see Table 1). In order to analyze these effects, we calculated repeated measures ANOVAs with the factors time (T1, T2) and innovativeness (high, low) separately for attractiveness and innovativeness ratings. With a sample size of 27 participants we could expect to detect middle to large effects of  $f = .36$  (Cohen, 1988) with a probability of  $1 - \alpha = .95$ . Effect sizes for the dependent t-tests were calculated according to Formula 3 in Dunlap et al. (1996).

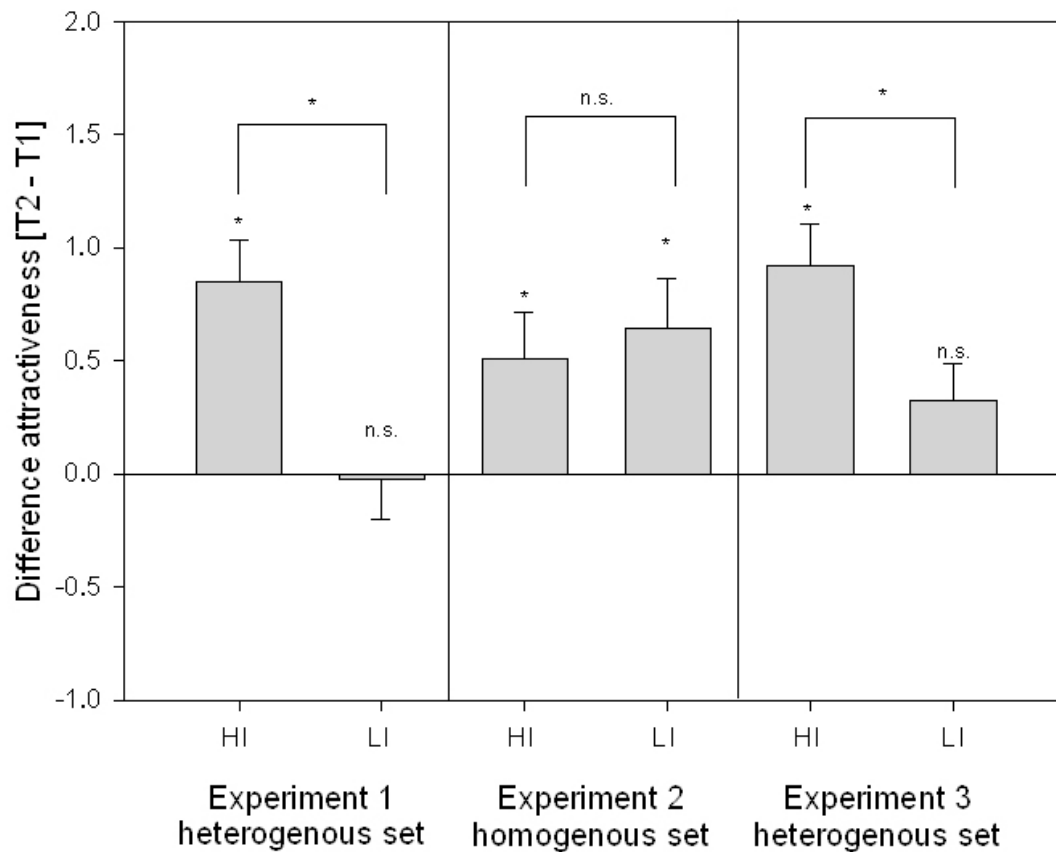
*Attractiveness ratings.* The repeated measures ANOVA for the attractiveness ratings showed a significant main effect for time,  $F(1,26) = 23.72$ ,  $p < .01$ ,  $\eta^2 = 0.48$ , and a significant

interaction of time and innovativeness,  $F(1,26) = 6.03$ ,  $p = .021$ ,  $\eta^2 = 0.18$  (see Figure 2). Follow-up dependent t-tests showed that the attractiveness ratings for the highly innovative stimuli increased significantly from T1 to T2,  $t(26) = 4.90$ ,  $p < .01$ ,  $d = 0.88$ . In contrast, they remained rather stable for the low innovative stimuli,  $t(26) = 2.00$ , n.s.,  $d = 0.41$ . These results replicated Experiment 1 findings, and showed that in a heterogeneous stimulus set, highly in relation to low innovative stimuli showed a greater increase over time. Awareness of innovativeness, resulting from the evaluation of highly and low innovative stimuli within one set, seems to be critical for the appreciation of innovativeness over time.

*Innovativeness ratings.* The repeated measures ANOVA for innovativeness ratings yielded a significant main effect of innovativeness,  $F(1,26) = 21.78$ ,  $p < .01$ ,  $\eta^2 = 0.46$ , and a main effect for time,  $F(1,26) = 6.32$ ,  $p = .018$ ,  $\eta^2 = 0.20$ , which was due to an increase in innovativeness (see Table 1). However, there was no interaction between the two factors. Highly and low innovative stimuli were clearly different with regard to their innovativeness ratings. This suggests that the innovativeness of the stimuli was apparent in this smaller set.

### General Discussion

From previous studies it was known that highly innovative design increase in attractiveness after a series of explicit evaluations, while low innovative design rather loose or stay constant (Carbon & Leder, 2005; Carbon, et al., 2006). Whether innovativeness per se produces the effects or whether these effects depend on the set, thus the variation on this stimulus dimension was tested in the present study. We found that context, in terms of set homogeneity, strongly affected the appreciation of innovativeness. In a set of stimuli with heterogeneous innovativeness including highly and low innovative stimuli (Experiments 1 and 3), we replicated this known effect of innovativeness (see Figure 2). In contrast, when only one level of innovativeness - high or low innovativeness - was repeatedly evaluated (Experiment 2), then attractiveness ratings after repeated evaluations increased for both stimulus classes. Thus, innovativeness affected attractiveness specifically only when both highly and low innovative stimuli were evaluated within one set; that is, when innovativeness was made apparent and was distinctive in the stimulus set. This was reflected in the innovativeness ratings, and suggests that innovativeness was differentially apparent in the different stimulus sets. In Experiments 1 and 3 when heterogeneous sets were used, the innovativeness ratings between the two stimulus classes were clearly and significantly different. This was not the case in Experiment 2.



*Figure 2.* Interaction and main effects of the repeated measures ANOVAs expressed as change scores (T2 minus T1) in the attractiveness ratings of highly innovative (HI) and low innovative stimuli (LI). \* indicates significant differences at a  $p=.05$  level. Error bars depict one standard error of the mean.

Critically one might argue that the lack of differences in the attractiveness and innovativeness ratings for the differently innovative stimuli in Experiment 2 might have been due to differences in scale use of the participants. Participants might have used the whole scale for their ratings in Experiment 2 because they have judged the stimuli relative to each other (Helson, 1948; Parducci, 1995) or they might have felt obliged to use the whole scale for their judgments in order to provide information for the researcher (Schwarz, 1999). These explanations would be confirmed by higher standard deviations in Experiment 2 than in Experiments 1 and 3. However, as revealed in Table 1, the standard deviations were similar across experiments. Thus, we believe that the effects of innovativeness depend on the characteristics of the stimulus set that is being judged. Additionally, different dynamics with



selectively stronger increases in attractiveness for highly innovative stimuli in Experiment 1 and 3 developed only in heterogeneous sets.

In all three experiments innovativeness was evaluated as a dimension also during the first stimulus exposures. The differences in results therefore suggest that effects of innovativeness on attractiveness require a distinctive variation in the stimulus set, not just the awareness that the dimension exists. The effects of innovativeness and attractiveness can also be seen in correlations between attractiveness and innovativeness for the highly innovative stimuli in T1. These (simple Pearson correlations) were  $R = .48$  in Experiment 1 and  $R = .46$  in Experiment 3 but only  $R = .15$  in Experiment 2. These correlations are in accordance with the arousal-theory (Berlyne, 1970a) as well as the two-factor theory (Berlyne, 1970b; Stang, 1974); only when innovativeness is apparent then relative differences in the arousal level (Berlyne, 1970a) or relative differences in boredom (Berlyne, 1970b; Stang, 1974) affect attractiveness ratings and its dynamics. The attractiveness ratings for the low innovative stimuli at T2 in Experiments 1 and 3 are in accordance with an explanation based on boredom. The longer experiment duration and the higher number of ratings in Experiment 1 showed more boredom-like effects (O'Hanlon, 1981). In Experiment 3, attractiveness ratings for low innovative stimuli slightly increased towards T2 while in Experiment 1 their attractiveness slightly decreased. However, these interpretations could be further tested using psycho-physiological measures that are sensitive to arousal and boredom, such as electro-dermal activity (Dawson, Schell, & Fillion, 2000).

### *Conclusions*

The current study demonstrated that the attractiveness and the dynamics of the attractiveness of innovativeness develop only when innovativeness is apparent through the stimulus set and distinct in the stimuli. A mere evaluation of innovativeness alone, as it was explicitly asked for in all experiments in the first phase, could not trigger such specific changes in attractiveness. These findings conform with theories emphasizing the relative nature of evaluations in general (e.g. Helson, 1948) and with theories emphasizing the relative nature of attractiveness evaluations (Berlyne, 1970a,b; Stang 1974). From a basic research perspective our findings emphasize the importance to explicitly consider stimulus dimensions, which affect evaluations. Moreover, they stress that evaluations are made in situations and context, (Smith & Semin, 2004) and – at least as shown for innovativeness here – do not rely on internal, and independent standards.

These finding also have implications for applied contexts, such as for testing the appreciation of innovative product designs that are to be introduced into the market. Our

results suggest that (1) in order to create awareness of the appreciable aspects of innovativeness, innovative designs should be tested together with low innovative designs, and (2) innovativeness profits when evaluated after a phase of repeated evaluations. Testing only once, as often done in single shot marketing studies, might not capture the possible dynamics of attractiveness. This procedure of presenting heterogeneous stimulus sets and using repeated evaluations seems to be a good approximation of processes that occur under real life exposure conditions. For example, seeing an innovative car, one might automatically judge the car in relation to other cars on the streets. Moreover, one might repeatedly see the car in print, in TV advertisements, and in person, and one might talk to friends about it. So, if you want an innovative produced to be liked for its innovativeness, make it experienced with its less innovative competitors!

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### 4.2.3 Summary & Outlook

These studies yielded clear results regarding how innovativeness affects attractiveness and its dynamics. Innovativeness had an influence on the attractiveness evaluations and especially on differential dynamics of attractiveness evaluations, when it was made apparent by presenting highly and low innovative stimuli together in a heterogeneous set. Evaluating only highly or only low innovative stimuli in a homogenous set had no differential effect on the attractiveness ratings, both were rated as similarly attractive and attractiveness evaluations for both increased in a similar manner after repeated evaluations. Thus, innovativeness affects attractiveness only when it is apparent and distinct in the stimuli. The innovativeness ratings support this conclusion, that innovativeness was differently apparent in the stimulus set. Only in a heterogeneous set were the highly and low innovative stimuli rated as differing in their innovativeness; there were no differences in the homogenous sets.

With regard to the model of aesthetic evaluations (Leder, et al., 2004) this research demonstrated the importance of context, manipulated in terms of set composition, influencing the aesthetic evaluations and its dynamics. It is known that contextual stimuli can influence evaluations in general (e.g. Helson, 1948; Pol, et al., 1998; Stapel & Winkielman, 1998) and that relative differences between stimuli might influence attractiveness evaluations in particular (Berlyne, 1970a, 1970b; Stang, 1974). This research demonstrated that appreciation of the factor innovativeness depends on such relative differences within the stimuli. Additionally, this research extended previous findings by showing that set composition not only influenced attractiveness ratings but also dynamic changes in attractiveness due to innovativeness after repeated stimulus evaluations. These findings are important with regard to basic and applied research questions. They demonstrate that relative stimulus differences influence attractiveness evaluations and result in different dynamics due to (active) familiarization (Bornstein, Kale, & Cornell, 1990). In terms of applied contexts, the results imply that testing new and innovative designs should be embedded within already well established designs because only then can innovativeness be considered for attractiveness. Moreover, testing at least twice after repeated evaluations allows for research into dynamic changes in attractiveness which might allow for predicting future preferences. However, as we only assessed changes within one experimental session the question arises as to whether the dynamic changes observed are short or long lasting (the next study partly continues on this issue).



### **4.3 Danger or Fascination? Situated Effects on the Appreciation of Innovation**

#### **4.3.1 Introduction**

This article is in preparation for submission. This study was based on the previous finding that awareness of innovativeness influences the appreciation of innovativeness and its dynamics. However, in this study utilisation of two different situational contexts was used to test specifically whether the quality of the awareness of innovativeness influences the appreciation and its dynamics. Aesthetic evaluations of stimuli are context – specific (Leder, et al., 2004) and can be modulated by the state of the perceiver (Leder, Tinio, Fuchs, & Bohrn, in press). In order to manipulate situational contexts we employed two different evaluation sets during the repeated evaluation phase which were based on the ambiguous qualities of innovativeness. On the one hand innovativeness has potentially fascinating aspects due its novelty; on the other hand it has threatening aspects due its unfamiliarity. These aspects were emphasized in the evaluation sets. Moreover, long term effects of the dynamics of appreciation of innovativeness were studied by employing the RET procedure twice, separated by a one week break. Results showed clear differences between the situational contexts, high-lighting either the fascinating or risky aspects of innovativeness.

Only when fascinating aspects were emphasized did the typical effects of appreciation of innovativeness emerge, with highly innovative stimuli gaining in attractiveness over low innovative stimuli (as in Carbon and Leder, 2005). Testing twice, with a one week break, had little effect on these dynamics. They were similar in the first and second testing session. Stressing the dangerous aspects of innovativeness, however, resulted in quite different dynamics resembling a mere exposure effect. Low innovative stimuli were preferred over highly innovative stimuli while attractiveness ratings for both stimuli increased in parallel over time. This increase was especially notable in the first testing session. During the second session, a week later, no further changes were observed suggesting that a state of saturation had been reached. Taken together, these results clearly support the idea that our aesthetic sense is situation-specific and adaptive.



### 4.3.2 Original Manuscript

Running head: DANGER OF OR FASCINATION FOR INNOVATION

Danger or Fascination? Situated effects on the appreciation of innovation

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### Abstract

Appreciations as attitudes can change over time. In order to show that aesthetic appreciation is adaptive, evidence that object features and situational demands interact in a specific way is required. We studied how the ambiguous quality of innovativeness, being potentially fascinating due to its novelty but also being potentially dangerous due to its unfamiliarity, interacts with changes in appreciation after repeated evaluations (Carbon & Leder, 2005). We varied the specific direction of elaboration towards potential danger of or fascination for differentially innovative car designs. Participants did show specific appreciation for high innovative designs only if they were constrained to elaborate the material on the basis of scales associated with fascinating aspects of the stimuli. The findings clearly underline the adaptive function of aesthetics.

### Danger or Fascination? Situated effects on the appreciation of innovation

Humans have the ability to evaluate their environment on the basis of aesthetics. Evaluations reflect attitudes of certain features in a certain situation. The aesthetic appreciation of object dimensions is somehow context-specific (Leder, Belke, Oeberst, & Augustin, 2004), it is Zeitgeist-dependent (Carbon, 2010), related to expertise (Vogt & Magnussen, 2007), and supposedly, modulated by the state of the perceiver in respect to situational demands (Leder, Tinio, Fuchs, & Bohrn, in press). Aesthetic appreciation involves the expression of attitudes towards objects. For a long time, aesthetics focused on object-inherent features that determine how beautiful or aesthetically pleasing an object is. However, it has become more and more apparent that the more fascinating aspects of such attitudes are the changes that occur depending on the context of evaluations. Regarding adaptation, Schwarz (2007) stated that “to serve action in a given context, any adaptive system of evaluation should be informed by past experiences, but highly sensitive to specifics of the present. Moreover, it should overweight recent experience at the expense of more distant experience”(p. 640). Therefore, in accordance with situational demands, changes in appreciation presumably refer to possible actions.

In order to demonstrate that aesthetic appreciation is adaptive in this sense, we showed how the appreciation of innovativeness as an object feature develops as a function of two different situational demands. We examined the aesthetic appreciation of cars varying in degree of innovativeness, a key factor in product design and potentially an important feature in aesthetic appreciation in general (Leder, Belke, Oeberst, & Augustin, 2004). We examined the impact of two different types of evaluations (Leder & Carbon, 2005), each of which stresses a particular facet of innovation: fascination due to novelty (as in Biederman & Vessel, 2006) and danger due to unfamiliarity.

The adaptive nature of aesthetics was stressed by Dissanayake when she stated that aesthetics is “an adaptive behavior that promotes selective attention and positive emotional responses to components of the environment that lead to ‘good’ decisions and problem solving” (Dissanayake, 2007, p. 4). Consistent with this view is the positive correlation among beauty, appreciation, and positive values. For example, beautiful bodies indicate positive reproductive value, and beautiful faces represent parasite-free and healthy development (Grammer & Thornhill, 1994). The variety of possible evolutionarily fostered functions makes it likely that aesthetic appreciation is sensitive to a complex interplay of perceiver, object, and situation.

But this is not the whole story of aesthetic attributes. Dissanayake (2007) stated that the essential function of aesthetic processing is that it produces relief in a world of uncertainty and threat. In short, that it reduces fear. In this sense, aesthetics also provides a way of dealing with uncertainty. This is particularly the case within the domains of the arts, design, and fashion, in which attributes that are potentially dangerous or threatening are sometimes explicitly used in innovative designs (Carbon, 2010). How can we explain that we can also appreciate things such as artistic objects or products such as cars even though they have much of the innovative essence of being unfamiliar, uncertain or ambiguous? In addition to cognitive and affective factors (Leder et al., 2004), the situational context seems essential for the interpretation of such phenomena. Which and when objects are aesthetically appreciated therefore might depend on an interplay of object features and the attributes of the situation.

To show such influence of situational context on aesthetic appreciation, we used a paradigm that had shown to be sensitive to effects of innovation. In the repeated evaluation technique (RET; Carbon & Leder, 2005), the usual finding that people generally dislike innovative materials (e.g., Leder & Carbon, 2005) was shown to only reflect an initial attitude. Although the disliking of innovative materials may be due to fear of novelty (Bronson, 1968), it is not consistent with people's everyday appreciation of brand new iPods, concept cars at motor shows, or fancy clothes from the latest haute couture collection. The RET compensates the initial dislike of such materials by asking people to explicitly elaborate the materials—evaluate them on different scales. Several studies have shown that following such evaluations, people showed increased appreciation of high innovative designs (Carbon, Hutzler, & Minge, 2006; Carbon, Michael, & Leder, 2008). Moreover, Faerber, Leder, Gerger, and Carbon (2010) showed that the dynamics that favor preference for innovation depend on the kind of aesthetic concept that is primed by dimensions activated by aesthetic evaluations.

In the present study, we systematically changed the situational context by using two different sets of scales within the RET procedure. Innovation is particularly interesting because it somehow bridges the old and the new, the familiar and the unfamiliar, and the present and the future. Innovation means that the elements of an object are somehow fresh, unusual, and unexpected, but without being so new that they would require a new schema. When something appears innovative, it has the potential to challenge habits. Thus, it is particularly fascinating as innovation has two aspects: novelty and uncertainty. In the present study, we used these two aspects of innovation, and consistent with Carbon and Leder's (2005) repeated evaluation technique, we showed how different kinds of evaluations produced

situations in which innovation is differentially appreciated. We addressed the ambiguous nature of innovation, in that the scales used for evaluation were either concerned with the fascinating aspects of or the possible dangers and risks associated with the materials.

Through the different phases, the experiment will show, in accordance with Schwarz (2007), if the first and second aesthetic evaluations will differ in a manner that would be expected if the aesthetic sense were adaptive. If the first evaluation is based on the past experiences, it will rely on existing standards of evaluation and will show the typical positive response to familiar and low innovative materials (Carbon & Leder, 2005; Zajonc, 1968). On the other hand, the second evaluation should be based on recent experience, and would thus depend on the nature of recently performed evaluations.

To obtain a deeper understanding of aesthetic processing within different situational contexts, participants rated the design materials on key variables derived from the literature (e.g., Hekkert & Leder, 2008; Hekkert, Snelders, & van Wieringen, 2003; Leder & Carbon, 2005; Silvia, 2005). Aesthetic appreciation relies on a complex multi-dimensional semantic concept that is comprised of a number of dimensions (Faerber, Leder, Gerger, & Carbon, 2010). To capture changes beyond attractiveness, we also included a measure of interestingness, as interestingness might even be more sensitive to sensitive novel and challenging materials (Jakesch & Leder, 2009; Silvia, 2005). We also used two additional scales that addressed the expression of two additional components related to preference. These two scales are also oriented more towards action. Situational demands might affect an action-related component, which in the case of a consumer products, would be reflected in the wish to own (cf. Kirmani, Sood, & Bridges, 1999; Moreau & Herd, 2010). Thus, in order to include variations of preference measures, we also asked how much participants wish to own a particular design, under the assumption of (a) unlimited resources, or (b) under more realistic restricted conditions. The former refers to judgments without restrictions, and could favor a more aesthetic orientation. In contrast, the latter rather devalues aesthetic orientation.

Moreover, in order to capture long-term adaptations and possible changes in the evaluation structure, we tested all participants in a multiple test-retest design, twice on identical measures with a one-week break. This would reveal whether the effects of the situational context are long lasting, or whether they are more indicative of short-term adaptations. A comparison of the first ratings in both conditions (first and after a week) should indicate the long-term stability of danger- or fascination-related experiences. If the danger-related evaluations elicit fear, and fear is an emotion that consolidates experiences strongly in memory, then evaluations might last a week. Similar effects might also be found in

the fascination condition. Because of the special effects of fear on human memory, changes in aesthetic evaluations in the fascination condition might have less temporal stability.

Therefore, such differences between the two conditions would be evidence that our attitudes are strongly influenced by negative, fear-related experiences; and would be evidence for the special influence of fear on memory (LeBar & Cabeza, 2006; LeDoux, 2000).

## Method

### *Participants*

Fifty-one undergraduate students of the University of Vienna participated for course credit. Twenty-seven (19 women and 8 men; mean age = 22.0) took part in the *Danger* condition, and 24 participants (17 women and 7 men; mean age = 21.6) took part in the *Fascination* condition. All participants had normal or corrected-to-normal vision.

### *Apparatus and Stimuli*

The stimuli consisted of 18 photo-like images of artificial car-interiors sized to 800 x 513 pixels, and presented on a 17-inch Apple eMac CRT monitor with a resolution of 1024 x 768 pixels. The stimuli had been generated using Adobe Photoshop 7.0. According to pre-tests, these varied systematically on innovativeness (low, high). In order to create a sufficiently large sample, they also varied on complexity (low, medium, high), and curvature (low, medium, high). The three dimensions were fully balanced and their different levels were validated by several pre-studies. Importantly, in contrast to the line-drawing versions used in Leder and Carbon (2005), the stimuli used in the present study consisted of grayscale, photographic like versions of car interiors.

### *Procedure*

The experiment consisted of two testing sessions that were separated by a one-week break. Each session consisted of three parts. The three parts were: Test-time 1 (T1), evaluation phase, and Test-time 2 (T2). After one week, there were three additional parts: Test-time 3 (T3), again, an evaluation phase, and Test-time 4 (T4). In T1, the set of stimuli was evaluated block-wise according to the following variables: *attractiveness*, *innovativeness*, *interestingness*, *owning interest unlimited*, and *owning interest limited*. All scales in the study were seven-point Likert scales (1 = least significant, 7 = most significant). For each scale, the stimuli were presented in randomized order, and the rating tasks were self-paced. The initial ratings (T1) were immediately followed by the evaluation phase as in Carbon and Leder (2005). Participants rated the stimuli on 11 different scales (the order was randomized for each participant). The types of scales were specific to each of the conditions, emphasizing

possible dangers and risks, and negative aspects of usability in the *Danger* condition, and emphasizing the fascinating, novel and stimulating aspects of the designs in the *Fascination* condition<sup>1</sup>.

The procedures for T1, T2, T3, and T4 were the same. Participants were instructed to use the full range of the scale if possible, and to respond spontaneously to the questions. Trials were presented using PsyScope 1.25 PPC (Cohen, MacWhinney, Flatt, & Provost, 1993). All participants were tested individually. After a one-week break, participants were tested again using the same procedures as in session 1.

### Results

We examined the effects of variation in the evaluation phase on attractiveness. Attractiveness ratings were sampled over participants separately for highly and low innovative stimuli, with the four different times as within-sample measures, and the two types of evaluations (stressing danger of or fascination for design) as between conditions. Figure 1 shows the effects of changes in attractiveness, sampled over the two levels of innovation at T1 and T2, T3 and T4, for the two different situational conditions, *Danger* (top) or *Fascination* (bottom). Results indicated an interaction between innovativeness level and time but only in the *Fascination* condition.

After the evaluation phase, attractiveness of highly innovative stimuli increased while attractiveness of low innovative stimuli decreased, but was not significantly different from T1. Moreover, the mean ratings of attractiveness in the *Fascination* condition after the one-week break interval showed an interesting pattern: while highly innovative stimuli started at a similar level as in T1, the low innovative stimuli had lost attractiveness from T1 to T3, and were evaluated in T3 as in T2. The pattern of results in the *Danger* condition was very different: while the attractiveness of high and low innovative stimuli differed in T1 as in the *Fascination* condition, after evaluations in T2, attractiveness significantly increased for both levels of innovativeness. This appears to be mere exposure-like effect (Zajonc, 1968), in that repeated evaluations generally increased attractiveness. After a one-week break, both types of stimuli started at similar levels as in T2. However, the second evaluation had no effect on attractiveness at T4, evaluations remained as in T3.

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<sup>1</sup> Scales in the *Danger* condition consisted of the following attributes: dangerous, breakdown probable, error-prone, unsafe, risky, user unfriendly, difficult to get used to, exhausting, unclear, inconvenient, and inexpedient. Scales in the *Fascination* condition were exciting, arousing, thrilling, stimulating, surprising, groundbreaking, progressive, novel, fascinating, ingenious, and terrific.

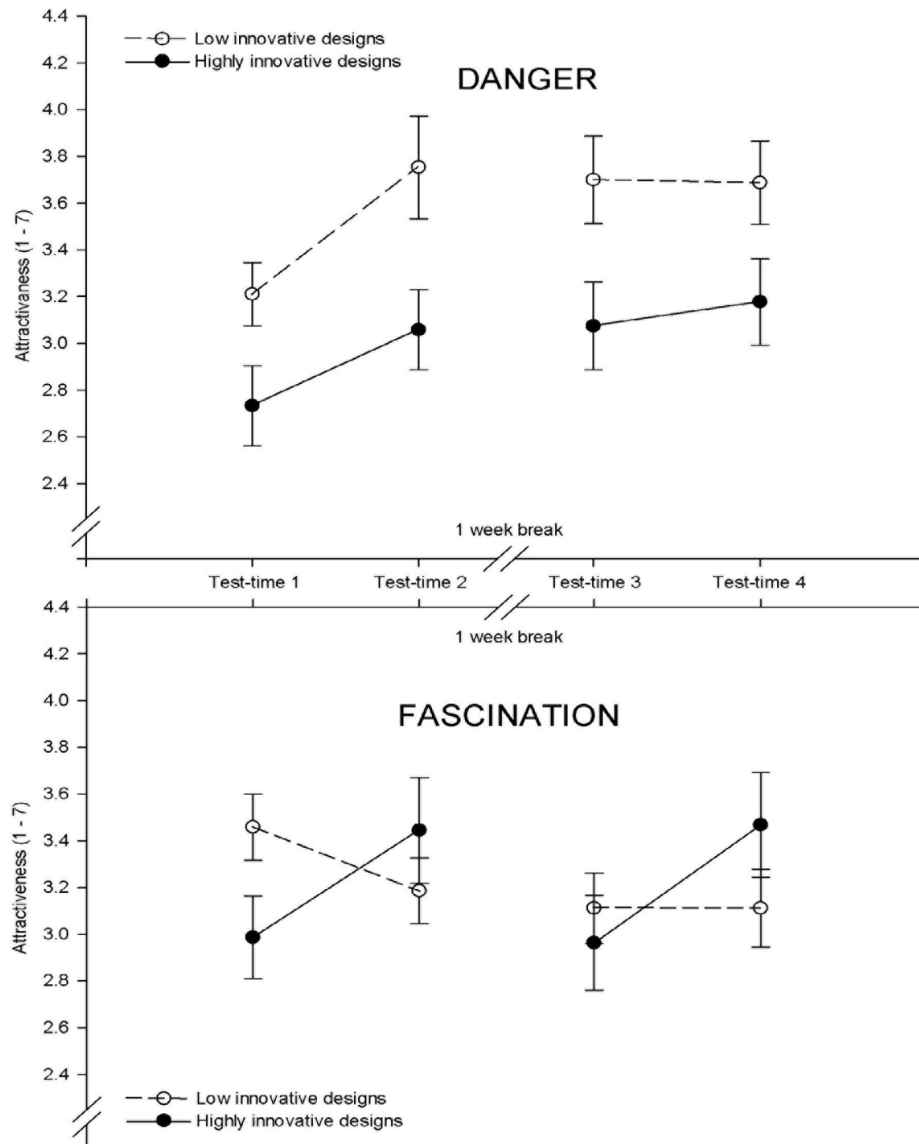


Figure 1. Interaction between Time and Innovativeness for attractiveness ratings at test-time 1 (T1), at T2, T3, and T4: Averaged mean values with one standard error of the mean are indicated for low and highly innovative designs: condition *Danger* (upper) and condition *Fascination* (below).

A mixed-design analysis of variance (ANOVA) was conducted with time (1, 2, 3, and 4) and innovation (low, high) as within-subject factors, condition (*Danger*, *Fascination*) as between-subject factors, and ratings of attractiveness as dependent variable. Results revealed a significant effect of time,  $F(3, 147) = 3.90, p < .05, \eta_p^2 = .07$ . There were significant interactions between time and situational condition,  $F(3, 147) = 3.70, p < .05, \eta_p^2 = .70$ ; and among time, innovation, and condition,  $F(3, 147) = 3.49, p < .05, \eta_p^2 = .67$ . No other effects were significant.



To further explore these interactions, we performed separate analyses for block 1 (T1 and T2) and block 2 (T3 and T4), which were separated by a one-week delay. For the first block, we conducted a mixed-design ANOVA with time (T1 and T2) and innovation (low, high) as within subject factors, condition (*Danger*, *Fascination*) as between-subject factor, and attractiveness as dependent variable. Results showed significant effects of time,  $F(1, 49) = 6.87, p < .05, \eta_p^2 = .12$  and innovation,  $F(1, 49) = 4.59, p < .05, \eta_p^2 = .09$ . There was also a significant three-way interaction among time, innovation and condition,  $F(1, 49) = 5.33, p < .05, \eta_p^2 = .10$ , but no other significant effects. The same analysis for T3 and T4 showed a significant interaction between time and innovation,  $F(1, 49) = 6.11, p < .05, \eta_p^2 = .11$ . As revealed by Figure 1 (lower right), this effect is due to the lack of difference between highly and low innovative materials at T3, but no other significant effects.

Regarding the long-term effects of changes after evaluation we analyzed differences regarding the temporal stability of danger- or fascination-related experiences, a week after T2 at T3. As can be seen in Figure 1, evaluations of high and low innovative designs after a week in the danger condition started at the same level as after the repeated evaluations. The change in appreciation due to the first phase of evaluations remained.

Different results were obtained in the fascination condition. The pattern of results resembles the first evaluation, with low innovative stimuli being slightly higher in attractiveness. However, data in this condition before and after the one-week break looked as if the low innovative designs had temporal stability, while the high innovative designs lost the increase in attractiveness previously gained through repeated evaluations. We confirmed these interpretations with separate analyses for the fascination and danger conditions, in which we separately analyzed T1 and T3, and T2 and T3.

In the danger condition, the comparison between T2 and T3 revealed that there was no effect of time, but as expected, there was an effect of innovation,  $F(1, 26) = 4.39, p < .05, \eta_p^2 = .15$ . In the fascination condition, there was only an effect of time,  $F(1, 23) = 6.89, p < .01, \eta_p^2 = .23$ . No other effect was found. On the other hand, the analyses of T1 and T3 revealed no effect in the fascination condition. However, in accordance with the above interpretation, there was an effect of time,  $F(1, 26) = 6.43, p < .05, \eta_p^2 = .20$ , and innovation,  $F(1, 26) = 7.26, p < .05, \eta_p^2 = .22$ , in the danger condition., but no other effect. These results show that changes were longer lasting in the context of danger.

Concerning the perceived innovativeness, an ANOVA with time (1, 2, 3, and 4) and innovation (low, high) as within-subject factors, and condition (*Danger*, *Fascination*) as between subject-factor revealed a significant effect of innovativeness,  $F(1, 49) = 47.02, p <$

.01,  $\eta_p^2 = .49$ , but no other effects. Thus, innovative designs were seen as significantly more innovative in all conditions, and this did not change over time.

The analysis of interestingness data showed a significant effect of innovativeness,  $F(1, 49) = 31.06, p < .01, \eta_p^2 = .39$ , with highly innovative materials being seen as more interesting. There were no other significant effects. Analysis of the owning interest unlimited data revealed a significant effect of time,  $F(3, 147) = 4.12, p < .01, \eta_p^2 = .08$ , indicating a slight increase over time for the variable. Analysis of the owning interest limited data showed a significant effect of innovativeness,  $F(1, 49) = 30.74, p < .01, \eta_p^2 = .39$ . No other effects were significant.

### Discussion

We investigated aesthetic appreciation's dependence on situational contexts. Using car interior designs of varying levels of innovation, we compared two kinds of situational contexts, stressing either the dangerous or the fascinating aspects of car interior designs. We observed mere exposure-like effects for both stimulus classes in the *Danger* condition over time. In contrast, in the *Fascination* condition, we found cross-over interactions for low versus highly innovative materials in both sessions (T1 vs. T2 and T3 vs. T4). Importantly, the analysis of innovativeness evaluations showed that changes in appreciation were not due to changes in perceived innovativeness.

Previous studies have shown that the appreciation of highly innovative materials increased after explicit evaluations, while the appreciation of low innovative materials decreased (Carbon & Leder, 2005). Our study demonstrated the importance of situational context on such dynamics of aesthetic appreciation. We demonstrated the critical role of the quality of evaluations. In T1, in both conditions, low innovative materials were preferred over highly innovative materials. However, aesthetic appreciation developed differently over time depending on situational context. When the participants evaluated the materials in terms of dangers, risks, and negative aspects of usability, attractiveness ratings for both innovativeness classes developed in a parallel manner from T1 to T4, thus showing a mere exposure effect. We observed the highest increase in attractiveness between T1 and T2. From T3 to T4, the mere exposure effect seemed to have reached a level of saturation, as no further changes were observed. This is consistent with findings that the effects of mere exposure are strongest up to 10 repetitions (Bornstein, 1989). Thus, although participants in the *Danger* condition clearly differentiated between low and highly innovative materials, they did not develop differential

aesthetic appreciation due to the evaluations. Instead, they preferred low innovative materials from the beginning, and this preference persisted over time.

In the *Fascination* condition, low innovative materials were also preferred in T1. However, because the materials were evaluated in terms of fascination, novelty, and stimulation, attractiveness ratings for the two stimulus classes developed very differently, and resulted in two cross-over interactions between innovativeness and time. The appreciation of highly innovative materials increased from T1 to T2, and again from T3 to T4. In contrast, the appreciation of low innovative materials did not change. In T3, again, the highly innovative materials started from about the same level as in T1. This indicated that the increase in the attractiveness of highly innovative materials did not last a week—attractiveness actually decreased. Although we did not directly measure emotional changes due to the different kinds of evaluation, the findings are in accordance with the assumption that fear-related processing yields sustainable effects in memory (LeBar & Cabeza, 2006). On the other hand, when danger and fear are not activated or emphasized, then the positive aspects of innovation show their effects. Thus, some aesthetic experiences benefit from positive, hedonic situations (Leder et al., in press). The differences between the two conditions clearly support the assumption of a situation-sensitive and adaptive aesthetic sense. This finding is consistent with situated cognition approaches, wherein behavior is contextualized within the actual situation in which they occur (Smith & Semin, 2004).

Regarding the temporal stability of changes in aesthetic appreciation, the data also show that attitudes toward innovation endured the one-week break after the danger evaluations. This is in accordance with the assumption that danger- and fear-related processes might have a special role in memory consolidation (LeBar & Cabeza, 2006). Although this is biologically plausible, further research on emotion-based consolidation processes is needed, particularly regarding their role in more applied contexts, where positive emotional states such as joy, interest, and pride are in the fore (Desmet, 2008).

Varying situational context through the use of different evaluation dimensions had strong effects on the attractiveness evaluations over time. Being directed towards the potentially dangerous or fascinating elements of objects might result in the selective consideration of various aspects of the objects. Situational influences are presumably distinct for ambiguous objects, and therefore particularly salient for innovative objects, which could be seen as positive and fascinating, or negative, uncertain, and dangerous. This also has practical implications for the introduction of innovative products: a strong emphasis on the fascinating factors of a product might be an important ingredient for its success. This

emphasis can be accomplished through placing the product into a corresponding context. Marketing strategists should consider these findings.

In the present study, significant changes according to time, level of innovation, and situational contexts were found only for the attractiveness scale, and not for any of the other scales used in the test blocks. While measures of interestingness and owning interest showed sensitivity to innovation, they did not vary with other variables. Thus attractiveness revealed some advantage due to this sensitivity. We found differential effects of repeated evaluation after one week. Future studies should consider extending the time range to those reflecting production cycles that span months or even years (Carbon, 2010; Carbon & Leder, 2007).

Moreover, future studies should investigate if the appreciation of innovativeness is also sensitive to other kinds of situational demands. Innovation is ambiguous, and involves familiarity and novelty. Therefore, its appreciation might be particularly sensitive to other context-inherent features that either favour novel or familiar features. For example, the effect of novelty might generalize and result in particularly strong preferences for innovation in situations when perceivers become tired of repetitive and highly familiar tasks.

To conclude, the present study revealed that the aesthetic appreciation of innovation, which is often seen as a driving force in product design, is sensitive to situational contexts. When the situation demanded caution (*Danger* condition), mere exposure-type effects for both stimulus classes were shown, and the changes were enduring. However, when the situation stressed fascination, challenge, and novelty (*Fascination* condition), there was a cross-over interaction between time and innovativeness for attractiveness ratings. These results explicitly show that aesthetic appreciation is adaptive and context-dependent.

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### 4.3.3 Summary & Outlook

This research demonstrated that aesthetic evaluation and its dynamics are influenced by the situational context. This interpretation is in accordance with situated cognition accounts (Schwarz, 2007; Smith & Semin, 2004) and with the hypothesis from the Leder et al., model (2004). In the model it is hypothesized that aesthetic evaluations usually occur under conditions which indicate safe and emotionally positive environments, and that a change of this context might change the aesthetic evaluations. This was demonstrated here. When car interiors were repeatedly evaluated under conditions which stressed dangerous aspects, then we observed a mere exposure like effect for both stimulus classes, with low innovative stimuli preferred over highly innovative ones. In contrast, when fascinating aspects were stressed differential dynamics developed due to innovativeness – highly innovative stimuli gained in attractiveness while low innovative stimuli remained on the same attractiveness level (as in the previous study and in Carbon & Leder, 2005, Carbon et al., 2007). This shows that the aesthetic evaluation of innovativeness has ambiguous qualities – depending on which aspects of innovativeness were stressed different dynamics of appreciation developed. This extends the findings of the previous research, suggesting that it's not only the awareness of innovativeness which influences the dynamics of appreciation of innovativeness, but the also the quality of the awareness of innovativeness.

Moreover, the situational manipulations also influenced the persistency of the effects of repeated stimulus evaluations. In the danger conditions, the effects of repeated stimulus evaluation were sustained after a one week break, while this was not the case in the fascination condition. Rather, after a one week break the stimuli started at the same attractiveness level as during the first evaluation. Such findings are in line with the assumption that the danger condition triggered emotional processing which enhances memory consolidation (LaBar & Cabeza, 2006) and thus, a long lasting change in the attitudes towards the stimuli emerged. However, as we did not directly infer how and to what extent the repeated evaluations during the danger and fascination condition elicited emotions, this needs further research. Moreover, future research could also vary other situational features. Innovativeness can be seen on an axis comprising novel and familiar aspects. Thus, future study could emphasize the novel versus the familiar properties of the stimuli.





## **4.4 What Changes in Changing Design Appreciation? Dynamic Interplay of Variables Regarding Attractiveness Evaluation over Time**

### **4.4.1 Introduction**

This article is in preparation for submission. It is a revision that includes reviewer comments of a previous version. Attractiveness is only one aspect relevant to aesthetic evaluations. Research in aesthetic evaluations has very often tested related variables of liking, beauty, valence, interestingness, pleasant – unpleasant, boringness, arousal, novelty and the like (e.g. Berlyne, 1970b; Carbon & Leder, 2005; Cox & Cox, 2002; Hekkert, Snelders, & Van Wieringen, 2003; Leder, et al., 2006; Zajonc, et al., 1974). However, how such specific variables correlate and interact with attractiveness and the dynamics of attractiveness was actively researched here. We tested how various cognitive and emotional variables derived from literature and from theoretical consideration, relate to attractiveness evaluation and its dynamics. Specifically, it was measured how the five predictor variables of arousal, boringness, positivity, interestingness and innovativeness relate to attractiveness when the car interior designs were evaluated. Additionally, it was analysed whether these relations remain consistent among participants and indeed if they remain consistent after repeated evaluations. Consistency in the correlational patterns would indicate general relevance of the variables for evaluating attractiveness. Additionally, boredom of the participants was manipulated as a situational variable in two conditions, to test if boredom reduces the correlational patterns (Perkins & Hill, 1985).

Results showed similar correlational patterns for the predictors and attractiveness within and across participants, but also demonstrated higher correlations after the repeated evaluation phase. Interestingly, only innovativeness gained in predictive quality, replicating previous findings that innovativeness influences dynamics of attractiveness. However, one should note, boredom state manipulations did not have any effect on the correlational patterns.

#### **4.4.2 Original Manuscript**

Running head: DYNAMIC INTERPLAY OF VARIABLES DURING DESIGN  
EVALUATION

What changes in changing design appreciation? Dynamic interplay of variables regarding  
attractiveness evaluation over time

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## Abstract

We investigated the dynamic interplay amongst cognitive and emotional variables involved in the evaluation of design objects. We measured how arousal, interestingness, positivity, boringness, and innovativeness relate to attractiveness evaluations. All variables were measured twice, before and after a repeated evaluation phase (Carbon & Leder, 2005), because evaluations might change over time. We also varied the level of boredom as a situational variable. If the correlations among these variables are consistent across participants, then general relations of these variables to attractiveness can be assumed. Results showed similar patterns of correlations for the predictors and attractiveness across participants, but also higher correlations after the evaluation phase, independent of level of boredom. This increasing consistency supports the interpretation that through repeated evaluations, a comparison standard had developed. Moreover, innovativeness gained in predictive power for the attractiveness ratings in the second test phase.

What changes in changing design appreciation? Dynamic interplay of variables regarding attractiveness evaluation over time

Good design is a key element in differentiating between winners and losers in consumer markets (Liu, 2003). This is especially the case in technically advanced industries. For example, in the car industry, the technical quality of a product is often taken for granted, and consumers' decisions are increasingly based on the attractiveness of car designs (Hekkert & Leder, 2008). The attractiveness of a product's design also predicts general user satisfaction (Hassenzahl, 2004).

Attractiveness could change over time as a result of habituation and familiarity (Zajonc, 1968), fashion or Zeitgeist (Carbon, 2010), and the active elaboration and processing of an object (Carbon & Leder, 2005). The latter was found to be important for the appreciation of innovativeness, which is a design dimension that is particularly important in technically-advanced industries such as the car industry (Carbon & Leder, 2005). However, attractiveness judgments rely on more than one dimension and are due to a combination of variables (Carbon, 2010; Faerber, Leder, Gerger, & Carbon, 2010; Hekkert & Leder, 2008). Thus, in terms of marketing strategies, it is important to understand the variables that contribute to attractiveness judgments and how such judgments change over time.

We examined the following five variables related to attractiveness evaluations of car interiors: arousal, boringness, positivity, interestingness, and innovativeness. The manner in which these variables correlate should shed light on the complexities and underlying structure that determine the attractiveness of design. We studied dynamic changes over time by examining all of the variables twice, before and after a phase of repeated stimulus evaluations (as in Carbon & Leder, 2005). Relationships among these variables were analyzed on both individual and group mean levels.

The five variables have been shown to be important predictors of attractiveness (Hekkert & Leder, 2008; Faerber, et al., 2010). Arousal is one of the main variables in Berlyne's (1970a) psychobiological theory of appreciation; he claimed that stimuli with medium levels of arousal are found most attractive (Berlyne, 1970b; Leder, et al., 2004; Saklofske, 1975). Level of arousal is influenced by variables such as novelty, uncertainty, and in particular, complexity. However, empirical studies that examined arousal by varying complexity have shown that high complexity (and presumably high arousal) was found most attractive (Martindale, Moore, & Borkum, 1990; Tinio & Leder, 2009). Interestingness also has a great influence on attractiveness (Bornstein, Kale, & Cornell, 1990; Silvia, 2005).

According to appraisal theories (Silvia, 2005), it is related to engagement and coping (Leder, et al., 2004; Millis, 2001). Positivity represents the valence of a stimulus, which together with arousal, is one of the basic dimensions of emotions (e.g., Osgood, 1966; Russel & Mehrabian, 1977). It has been suggested that the “what is beautiful is good (positive)” stereotype (Dion, Berscheid, & Walster, 1972; Eagly, Makhijani, Ashmore, & Longo, 1991) contributes to a positive correlation between positivity and attractiveness. The fourth variable we measured was innovativeness. Innovativeness is an essential variable in product design, and it is known to affect the dynamics of attractiveness (Carbon & Leder, 2005). Innovativeness, defined as “originality by virtue of introducing new ideas” (Carbon & Leder, 2005, p. 587) can be seen as a subcategory of novelty of a design which, compared to novelty, retains its properties over time (Carbon & Leder, 2005). Perhaps because of their novelty, innovative designs are often initially not liked (Carbon & Leder, 2005; Lee, 2001; Moulson & Sproles, 2000; Robinson & Elias, 2005; Zajonc, 2001). However, following repeated exposure and evaluation, high innovativeness is liked more (Carbon & Leder, 2005; Carbon, Hutzler, Minge, 2006; Faerber et al., 2010). Finally, we evaluated the boringness of the stimuli because boringness might affect the attractiveness evaluations (Bornstein, 1989). Prolonged exposure to a stimulus results in higher boredom, which could reduce attractiveness (Berlyne, 1970a; Leventhal, Martin, Seals, Tapia, & Rehm, 2007; Stang, 1974). Therefore, stimuli perceived as boring could be judged as less attractive.

The aesthetic sense can be directed to all objects, but whether aesthetic appreciation is consistent or varies amongst observers is still not sufficiently understood. In the realm of facial attractiveness, Hönekopp (2006) found that variation in attractiveness could be attributed equally to shared and individual tastes. Regarding the attractiveness of abstract patterns, Jacobsen and Höfel (2002) compared individual and group regressions models and found that only about half of the participants were adequately represented by the group model.

In the present study, we studied the consistency of ratings of car designs in terms of the five variables and attractiveness. In order to determine whether the relationships among these variables are consistent across different perceivers, we performed analyses at both the individual and group levels. If attractiveness judgments are governed by individual and general factors that depend on individual judgment strategies, then correlations with attractiveness should be different amongst perceivers. However, if these correlations turn out to be consistent across perceivers, then it can be concluded that the variables, in general, determine attractiveness. Because consumer products are sold to individuals, it is important to understand the nature of individual judgment strategies. Thus, comparing individual

correlations and group mean correlations should determine whether variables are related to attractiveness generally or individually.

Changes in attractiveness judgments over time occur often in everyday contexts. For example, when the Renault Megane, with its innovative rear end, was introduced to the market in 2002, its design was generally not appreciated. However, after the car had been on the market for some time, its design was eventually appreciated. Understanding the factors that influence such changes is necessary for companies introducing design innovativeness. In order to capture changes in the correlational patterns, we measured all variables twice—before and after a block of repeated evaluations. During this block, participants were required to evaluate the stimuli on various scales. This procedure, the *repeated evaluation technique* (RET), was introduced by Carbon and Leder (2005) to simulate everyday exposures to stimuli in an ecologically valid way. Consider again the Renault Megane; changes in appreciation and sales might have been due to repeated exposures to advertisements on TV and publications. Additionally, because the design was quite innovative, people might have talked to their friends about the design. Carbon and colleagues (2005, see also Carbon, et al., 2006; Faerber et al., 2010) have repeatedly shown that the RET procedure is efficient at capturing changes in design appreciation.

Understanding how patterns of appreciation change and which variables are indicators of such changes over time is essential especially for products with long production cycles, such as cars (Carbon, 2010), because these might help to prevent design failures. Changes in the appreciation due to familiarization may be expected. Thus, in accordance with the mere exposure effect, correlations with positivity could increase over time as a consequence of familiarization (Zajonc, 1968). If boredom reduces attractiveness, then we might find higher correlations between attractiveness and boredom after repeated evaluations. On the other hand, habituation could cause correlations between arousal and attractiveness to become weaker after repeated evaluations (Berlyne, 1970). Regarding innovativeness Carbon and Leder (2005, see also Carbon et al., 2006) found that the appreciation of innovative car interiors increased after repeated evaluations while judgments of innovativeness remained rather stable. Therefore, we expect higher correlations between attractiveness and innovativeness after repeated evaluations. Changes in the correlations between interest and attractiveness may be explained by appraisal processes. Silvia (2005) argued that interest is determined by two sequential appraisal mechanisms: the first appraises something as new, uncertain, complex or ambiguous; the second appraises coping potential. Thus, after having appraised something as new, people try to cope with the stimulus by resolving ambiguity and

assigning meaning. These processes have been assumed to increase aesthetic appreciation (Leder, Belke, Oeberst, & Augustin, 2004; Millis, 2001). Because interestingness reflects the tendency to resolve the ambiguity of new and complex stimuli, the correlations between interestingness and attractiveness ratings should increase if the stimuli become familiar following several evaluations.

Situational factors could also influence the correlations between variables. If individual differences in judgment strategies become more pronounced following repeated evaluations, then we would expect a decrease in the absolute size of correlations across all variables over time. On the other hand, if a common comparison standard for the stimuli develops following repeated evaluations, and as a consequence, judgments become clearer, then the correlations across all variables would increase.

Boredom, as a situational variable, has also been discussed as a general factor that influences cognitive strategies. Little is known about how boredom influences evaluations. Perkins and Hill (1985) hypothesized that a high state of boredom would alter judgment strategies in general because bored participants use limited cognitive strategies and consequently make fewer and less differentiated distinctions among stimuli. This would mean that higher states of boredom would, in general, weaken the correlational patterns across the variables. To test this hypothesis directly, we included boredom not only as an evaluated predictor variable, but also as an independent variable. Prolonged stimulus exposure can increase boredom. Therefore, we employed a short and a long stimulus presentation duration (O'Hanlon, 1981).

Testing all of the variables twice should also reveal which variables over time gain in predictive strength in terms of attractiveness ratings. A relative gain in predictive strength would be indicated if the correlation between a single variable and attractiveness during the first evaluation phase is smaller than with the attractiveness evaluation after the repeated evaluation phase. Such a variable which at the beginning better predicts attractiveness (in the future after extensive evaluations) would be particularly interesting because this would shed light on the factors that cause changes in attractiveness.

To summarize, the correlations should uncover the relationship among the predictor variables and attractiveness on the individual and group levels. By employing a test-retest design, we are able to examine if correlations change dynamically and whether the predictive quality of the variables increases over time. Moreover, a comparison of two levels boredom was conducted.

## Methods

### *Participants*

Forty-eight students (34 female, 14 male) from the University of Vienna participated for partial course credit. The mean age of the participants was 22.4 (range: 19 to 39 years).

### *Stimuli and Apparatus*

Eighteen photorealistic car interiors were used in this study (as in Färber et al., 2010). According to pre-studies, the stimuli systematically varied on two levels of innovativeness. The experiment was run on Macintosh eMac computers using PsyScope 1.25 PPC (Cohen, MacWhinney, Flatt, & Provost, 1993). The stimuli were presented at a size of 500 x 321 pixels with a screen resolution of 1024 x 768 pixels.

### *Procedure*

The experiment consisted of three blocks, first stimuli were evaluated along the five predictor variables (T1) and attractiveness, then a block of repeated evaluations (RET) followed, and then stimuli were evaluated along all predictors and attractiveness again (T2). In order to avoid anchor effects, the experiment began with a preview phase in which nine stimuli were simultaneously presented for six seconds. The experiment then employed Carbon and Leder's (2005) RET design. At T1, participants evaluated all 18 car interior designs individually on six different scales (How attractive, arousing, interesting, positive, boring, innovative - is this design?). The scales presented in this consecutive order. Participants used a 7-point Likert scale (1: least, 7: most) to indicate their ratings.

In the subsequent repeated evaluation phase, participants evaluated all car interiors on 22 different scales. The scales were chosen according to results of a pre-study in which 55 (36 female) participants rated a large number of scales for their arousal and valence. In order to obtain context-specific arousal and valence ratings, participants in the pre-study were instructed to imagine and describe objects typically found in art or design fairs. For the present study scales, which had been rated high on arousal and valence (half positive, half negative) were selected. During the repeated evaluation phase participants judged the designs in terms of how much they were stress inducing (original German term used in the experiment: stressig), disgusting (ekelhaft), repulsive (abstoßend), gruesome (grausig), deterrent (abschreckend), bothersome (nervend), idiotic (idiotisch), daft (bescheuert), ugly (hässlich), damn stupid (saublöde), ridiculous (lächerlich), fantastic (fantastisch), passionate (leidenschaftlich), terrific (grandios), fascinating (faszinierend), revolutionary (revolutionär), desirable (begehrtenswert), outstanding (hervorragend), impressive (beeindruckend), extraordinary (außergewöhnlich), unique (einzigartig) and dynamic (dynamisch). Participants



again used a 7-point Likert scale for their ratings during this phase. The presentation order of the scales was randomized across participants. Following this phase, at T2, all scales used in T1 were again used by the participants. The presentation order of the car interior designs was randomized across all participants and within all rating phases.

To induce two levels of boredom states, half of the participants were assigned to a short condition where the presentation duration was 2.6 seconds. The other half was assigned to a long condition, in which the presentation duration was 5.0 seconds. The short presentation of 2.6 seconds was chosen because participants in previous studies required, on average, 2.6 seconds to evaluate the interior designs (Carbon & Leder, 2005). To validate whether the boredom manipulation was successful, immediately after T2, participants indicated how boring the experiment was. For this rating, they also used a 7-point Likert scale.

### Results

In order to analyze the correlational patterns between the predictors, and differences in the correlational patterns across participants, we calculated Pearson correlations on a subject-basis for the respective test phases—correlations were calculated for each of the predictors (arousing, interesting, positive, boring, and innovative) and attractiveness ratings per person, separately for T1 (T1 predictors x T1 attractive) and T2 (T2 predictors x T2 attractive). To identify the predictors that gain in predictive strength over time, T1 predictors and T2 attractive ratings were correlated. All correlations were Fisher z-transformed for the statistical tests (Bortz, 1993, p. 201). Thus, all mean correlations reported are retransformed Fisher-z values averaged across participants.

#### *Effect of boredom state*

We examined if boredom had an influence on the pattern of correlations. The post-experimental boredom ratings revealed that participants rated the long condition ( $M = 5.8$ ) significantly more boring than the short condition ( $M = 4.3$ );  $t(45) = 3.79$ ,  $p < .01$ ,  $d = 1.13$ . However, this higher state of boredom in the longer condition did not have an effect on the overall correlational pattern. This was revealed by three separate repeated measurement ANOVAS for the respective test phases (T1 predictors x T1 attractive ratings, T2 predictors x T2 attractive ratings, and T1 predictors x T2 attractive ratings) with condition (long, short) as between-subjects variable and correlations of the 5 predictors as within-subjects variable. The analyses revealed neither significant effects for condition nor for the interaction between

condition and correlations (all  $p$ 's > 0.28). Therefore, data for further analyses were collapsed over the short and long conditions.

#### *Analyses of the correlations on individual and group levels*

We analyzed the correlations based on the individual ratings for the T1 and T2 predictor variables and attractiveness ratings. For almost all of the participants (46 out of 48), there was a positive correlation between arousal and attractiveness in T1 and T2. The mean correlation across participants was  $r(48)=.59$  in T1, and increased to  $r(48)=.76$  in T2. Regarding boredom and attractiveness ratings, 36 participants showed the expected negative correlation in T1. This number increased to 39 participants in T2. This was again reflected in the mean correlations with  $r(48)=-.33$  in T1 and  $r(48)=-.56$  in T2. Innovativeness and attractiveness ratings correlated positively for most of the participants in T1 (32 out of 48 participants). However, the mean correlation in T1 -  $r(48)=.21$  - was the smallest compared to the other predictors. Importantly and in accordance with our predictions, the correlations between attractiveness and innovativeness increased in T2  $r(48)=.54$ . In addition, 41 of the 48 participants showed a positive correlation in T2. Interestingness and positivity ratings showed the expected pattern of positive correlations with attractiveness. In T1, 40 participants showed a positive correlation between interestingness and attractiveness ratings; this number increased to 46 participants in T2. The respective mean correlations were  $r(48)=.41$  in T1 and  $r(48)=.66$  in T2. For positivity and attractiveness ratings, 46 participants showed positive correlations in T1 and all 48 participants in T2 [mean  $r(48)=.53$  in T1, and  $r(48)=.75$  in T2].

The descriptive analyses showed a clear pattern. Correlations on both individual and group levels indicate that all predictors were related to attractiveness. Arousal had the highest predictive power (and was most consistent across participants), closely followed by positivity, interestingness, and boringness. Innovativeness had the lowest predictive power. Especially in T2, after all of the stimuli had already been evaluated several times, all correlations became stronger. Thus, the consistency of the pattern of correlations within and across participants suggests that the predictors are indeed involved in attractiveness judgments.

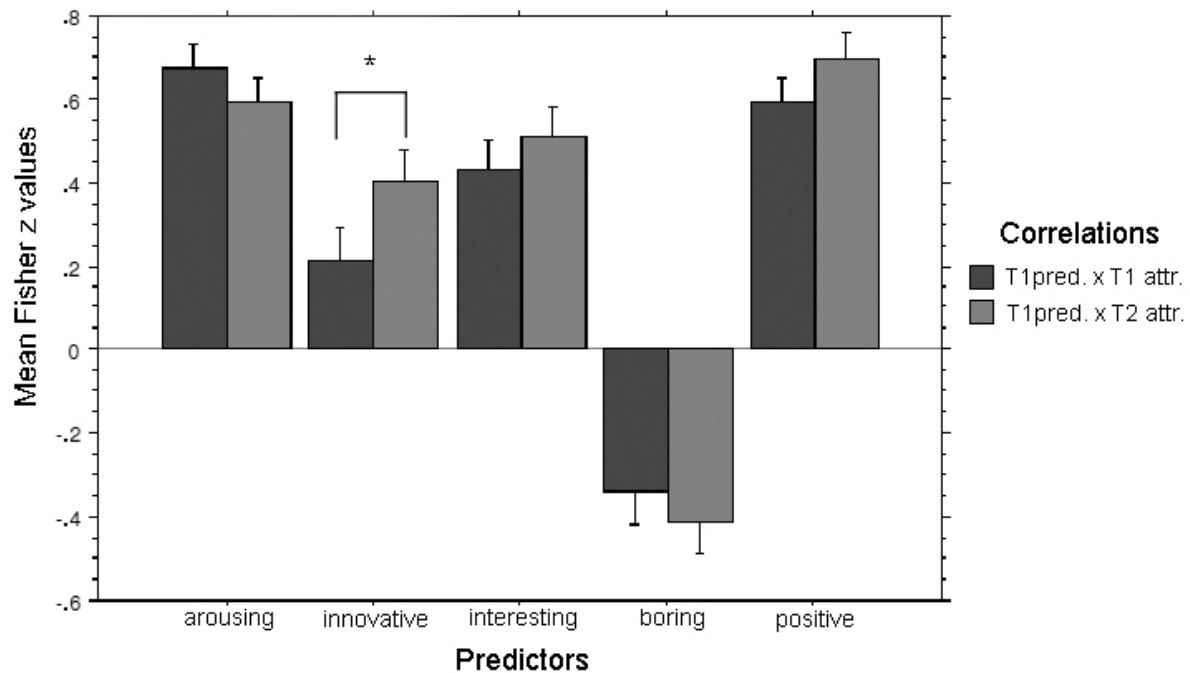
#### *Changes in the pattern of correlations between T1 and T2*

In order to analyze changes over time, we performed a 5 (correlations between boringness, arousal, positivity, innovativeness, interestingness, x attractiveness ratings) x 2 (test phases, T1 and T2) repeated-measurement ANOVA. Greenhouse-Geisser corrections were applied whenever necessary (which can be seen in the corrected degrees of freedom).

Because we were interested in absolute changes in the correlations, the negative signs of the boringness x attractiveness correlations were reversed. This analysis revealed significant main effects for test phase,  $F(1, 47) = 34.8, p < .01, \eta_p^2 = 0.43$ , and predictors,  $F(3.1, 145.9) = 6.2, p < .01, \eta_p^2 = 0.36$ . Regarding test phase, the correlations generally increased from T1 to T2. The main effect of predictors was further explored by post-hoc tests. These revealed significant effects for the arousal and positivity correlations; they were both significantly higher than the correlations of all other predictors (all  $p$ 's  $< 0.01$ ; Bonferroni adjusted). Innovativeness showed the weakest correlations and was also significantly different from the interestingness correlations ( $p < .01$ ). For exploratory reasons, we further analyzed the significant main effect of time separately for each predictor. These dependent t-tests (alpha levels Bonferroni-adjusted) showed that the correlations for each specific predictor increased from T1 to T2, and that the absolute size of the effect depended on the predictors [arousal x attractiveness  $t(47) = 4.2, p < .01, d = 1.08$ ; innovativeness x attractiveness  $t(47) = -5.2, p < .01, d = 0.97$ ; interestingness x attractiveness  $t(47) = -5.1, p < .01, d = 1.09$ ; boringness x attractiveness  $t(47) = 2.7, p < .01, d = 0.69$ ; positivity x attractiveness  $t(47) = -5.6, p < .01, d = 1.29$ ]. The effect sizes (adjusted Cohen's  $d$ ) of the dependent measures were calculated according to Formula 3 in Dunlap, Cortina, Vaslow and Burke (1996).

### *Predictive quality of the variables*

To identify the predictors that were particularly sensitive to indicate changes over time, we analyzed correlations between T1 predictors and T1 attractiveness ratings versus T1 predictors and T2 attractiveness ratings. In this analysis, the T1 correlations served as the baseline for indicating changes in the predictive quality of the predictors. A 5 x 2 repeated measurement ANOVA involving predictor correlations and test phases (T1 versus T2) revealed a main effect of predictors,  $F(1.9, 91.4) = 53.5, p < .01, \eta_p^2 = 0.53$ . The main effect of predictors was qualified by an interaction between predictors and test phase,  $F(2.2, 105.2) = 3.72, p = .023, \eta_p^2 = 0.07$ . To explore this interaction, we conducted follow-up dependent t-tests, separately for each specific predictor (e.g., arousal T1 x attractiveness T1 vs. arousal T1 x attractiveness T2; all alpha-values were Bonferroni-adjusted). Only the innovativeness x attractiveness correlations increased significantly when T1 innovativeness ratings were used to predict T2 attractiveness ratings,  $t(47) = 2.9, p = 0.03, d = 0.51$ ; see Figure 1. None of the other predictors differed significantly.



*Figure 1.* Correlations (Fisher z-transformed values) of T1 predictors x T1 attractiveness ratings and T1 predictors x T2 attractiveness ratings; \* indicates significant differences at a .05 level

### Discussion

We examined the relationship between predictor variables (arousal, boringness, innovativeness, positivity, and interestingness) and attractiveness, and how this relationship changes following a phase of active elaboration. Previous studies have suggested that both shared and common taste contribute to attractiveness judgments (Hönekopp, 2006). We found some consistency in how the predictor variables were related to attractiveness ratings at both the individual and group levels. After repeated evaluations, the relationship became even more stronger and consistent as suggested by the increase of correlations showing in the same direction across participants. This suggests that the predictors generally relate to attractiveness and these relations remain rather constant across participants. However, group level analyses revealed that there were differences in the absolute strength of the correlations of the predictors. The correlations were strongest for the arousal and positivity ratings, weaker for interestingness and boringness ratings, and weakest for innovativeness ratings.

The higher correlations in T2 as compared to T1 suggest the formation of a comparison standard, which developed from the repeated evaluations. In T1, the stimuli were unfamiliar and judgments were therefore based on personal standards rather than on the stimulus set. Through repeated evaluations, participants became accustomed to the stimuli and developed more coherent criteria for evaluating the stimuli. If the formation of a comparison standard caused the higher correlations, then this should be reflected in the effect sizes. Indeed, changes in the correlations between arousal, innovativeness, interestingness, and positivity and attractiveness from T1 to T2 all led to strong effects above 0.8 (Cohen, 1992). Changes in the correlations between the boringness and attractiveness ratings still resulted in a medium effect size of 0.69. Thus, the results support the assumption that a comparison standard developed through the evaluations. The differences in the effect sizes also serve as evidence that each of the predictors had impact on the correlational patterns.

The highest correlations were found for the arousal x attractiveness ratings. This is in accordance with Martindale et al., (1990), but not with Berlyne's (1974) arousal theory; the latter had predicted rather moderate correlations. Correlations for positivity and attractiveness ratings were also high. Positivity ratings correlated positively in T1, and this correlation was even higher in T2. This is in accordance with the above explanation that participants followed a "what is beautiful is good (positive)" stereotype (Dion, et al., 1972; Eagly, et al., 1991). Interestingness ratings correlated moderately positively with attractiveness ratings in T1. Silvia (2005) proposed two appraisal mechanisms for interestingness: novelty-complexity and coping potential. Accordingly, interestingness ratings in T1 were presumably triggered by the novelty of the stimuli. However, repeated evaluations increased the "comprehension" of the designs. As a result, coping potential increased. In T2, much higher correlations were found. These findings thus support explanations based on changes in the appraisal structure of interest. Correlations between boringness and attractiveness were weaker. Boringness ratings correlated negatively in T1, and the correlations increased in T2. This is in line with Berlyne' (1970b) and Stang's (1974) two-factor theory and with previous findings (e.g. Bornstein, et al., 1990; Van den Bergh & Vrana, 1998). According to Stang (1974), two factors determine preference: habituation and tedium (or boredom). Repeated exposure to stimuli will eventually lead to habituation; when boredom sets in, the positive effects of habituation is reduced. Therefore, boredom becomes more important after repeated evaluations. As expected, correlations between innovativeness and attractiveness were weakest at T1, but increased after repeated evaluations. These findings replicates the results of Carbon and Leder (2005) that participants need some time and elaboration to appreciate innovative designs.

Interestingly, the predictability of attractiveness through innovativeness increased over time. The T1 innovativeness ratings correlated higher with the T2 than with the T1 attractiveness ratings. Therefore, innovativeness might be a good candidate as a predictor of the development of attractiveness ratings over time. Predicting future attractiveness ratings is especially important for products with long developmental cycles such as cars. For such products, design failures could be quite costly.

In the present study, the long condition was rated as significantly more boring (mean boredom rating was 5.8 compared to 4.3). However, boredom state had no effect on the pattern of correlations. It could be argued that the effects of boredom might have been present in both conditions because the mean boredom rating was above the midpoint in the short condition (4.3 on a seven point scale). According to Perkins and Hill's (1985) hypothesis higher states of boredom affect cognitive strategies because people use limited and less differentiated strategies and thus, generally lower correlations in T2 than in T1 would have been expected. This was not supported by the data. Boredom's lack of effect is more in line with the assumption of a formation of a comparison standard.

These results have implications for other fields of psychology. Researchers often avoid extensive stimulus familiarization because of the fear that boredom constrains the judgment capabilities of the participants, which is not supported by our data. Thus, the fear of constrained judgments due to massive stimulus exposure seems unwarranted.

The current research demonstrated that arousal, boringness, innovativeness, positivity, and interestingness are related to evaluations of the attractiveness of design objects. The effects of these factors are consistent across and within participants; consistency even increases after repeated evaluations. This increase in correlations suggests that over time and through elaboration, participants formed more stable and reliable judgments. We assume that a comparison standard had been established. Our findings have clear implications for consumer research. If researchers want to understand how novel, innovative and rather unfamiliar consumer products are appreciated, then the RET procedure seems to be an adequate method for obtaining more reliable judgments and capturing evaluation dynamics.

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### 4.4.3 Summary & Outlook

This study was conducted in order to research how specific variables (arousal, boringness, positivity, interestingness and innovativeness) derived from theoretical and empirical considerations, relate to attractiveness under dynamic testing conditions. Furthermore, it was tested whether boringness as a situational variable changed the correlations patterns. Results demonstrated a high consistency in the correlational patterns between the predictors and attractiveness within participants – at least 67 % of the participants and almost all of the participants showed correlations that were going in the same direction – and across participants. This consistency increased after repeated stimulus evaluations, as indicated by an increase of the absolute size of the correlations and the number of participants showing correlations, having the same signs. Although stimulus evaluations depend partly on idiosyncratic judgment strategies (Hönekopp, 2006; Jacobsen, 2004; Tinio & Leder, 2009a) the consistency across the tested variables does suggest that in general they relate to attractiveness. That the correlations increased over time is interpreted by the formation of a comparison standard – through repeated stimulus evaluation the ratings are based to a heavier degree on the relations within the stimulus set; thus judgments became clearer and more coherent. However, manipulation of boringness as a situational variable had no effect on the correlational patterns – rather, the repeated stimulus evaluations supported the formation of a comparison standard, regardless if the experiment was perceived as boring or not. These findings are important for general and applied contexts. When a stimulus material comprises innovativeness, novelty or unfamiliarity then the RET seems to be an adequate method to obtain more reliable ratings. Additionally, length of evaluations and elicited boredom had little effect on the evaluations in general.

Regarding the impact of the various variables tested, we found differences in the absolute strength of the correlations. The predictors with the strongest effects were arousal and positivity ratings; both dimensions are related to emotionality (Osgood, 1966; J. A. Russel & Mehrabian, 1977). This suggests that emotionality is a particularly important predictor for attractiveness ratings. Interestingness, which combines cognitive and emotional aspects suggested by an appraisal structure comprising novelty-complexity and coping potential (Silvia, 2005b), showed slightly weaker effects. For boringness, a dimension important to theories concerning aesthetic evaluations (Berlyne, 1970b; Bornstein, et al., 1990), weaker effects were found. The weakest effects were found for innovativeness, which can be seen as a cognitive dimension. However, innovativeness again showed that it is capable of predicting changes (as in the previous studies and compared to Carbon and Leder,

2005) in attractiveness – the innovativeness ratings during the first evaluation showed higher correlations with the attractiveness ratings after repeated evaluations than with attractiveness during the first evaluations. Taken together these results demonstrate that in accordance with Leder et al. (2004) cognitive and emotional factors contribute to aesthetic evaluations of stimuli and that the specific variables tested here generally relate to attractiveness.



## **4.5 Priming Semantic Concepts Affects the Dynamics of Aesthetic Appreciation**

### **4.5.1 Introduction**

This chapter presents the article by Faerber, Leder, Gerger & Carbon (2010), which is published in *Acta Psychologica*. By means of using theoretical considerations from semantic network theory (c.f. Collins & Loftus, 1975) it was investigated how priming of semantic concepts relevant to the aesthetic evaluation of the stimuli, influence dynamics of aesthetic evaluations of the car interiors. When innovativeness, a dimension highly relevant to the car interiors, was primed then strong dynamics of aesthetic evaluations were observed, especially when an exhaustive concept was used by employing all six variables used in the previous study in chapter 4.4.

This result again demonstrated that the dimension of innovativeness needs to be made apparent to trigger dynamics. However, it's not only the quality of activating the semantic network, by inferring the innovativeness of the stimuli, that influences the development of dynamic changes, but also the quantity, by inferring aesthetically relevant variables.


## 4.5.2 Original Manuscript

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## Priming semantic concepts affects the dynamics of aesthetic appreciation

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## ABSTRACT

Aesthetic appreciation (AA) plays an important role for purchase decisions, for the appreciation of art and even for the selection of potential mates. It is known that AA is highly reliable in single assessments, but over longer periods of time dynamic changes of AA may occur. We measured AA as a construct derived from the literature through attractiveness, arousal, interestingness, valence, boredom and innovativeness. By means of the semantic network theory we investigated how the priming of AA-relevant semantic concepts impacts the dynamics of AA of unfamiliar product designs (car interiors) that are known to be susceptible to triggering such effects. When participants were primed for innovativeness, strong dynamics were observed, especially when the priming involved additional AA-relevant dimensions. This underlines the relevance of priming of specific semantic networks not only for the cognitive processing of visual material in terms of selective perception or specific representation, but also for the affective–cognitive processing in terms of the dynamics of aesthetic processing.

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## 1. Introduction

Have you ever looked at your family photo album thinking, “Oh dear, was I really wearing that back then?” We seem to forget our past preferences, even if sometimes this may be a good thing considering that we could get bewildered looks from others if we wore the same clothes today. Thumbing further through the album, we might also see some objects that we still fancy and would still consider wearing. Obviously, our aesthetic appreciation (AA), and perhaps even our taste, is not static, it changes over time (Carbon, 2010; Cox & Cox, 2002; Moulson & Sproles, 2000; Sproles, 1981).

Most importantly, these changes occur in a rather complex pattern, wherein for one object there may be an increase in appreciation, for another a decrease, and for yet another no changes may occur at all. As most research in the realm of empirical aesthetics focuses on stable properties or relations between key variables of aesthetic experience, we might be misled to believe that aesthetic phenomena operate in a rather static way. This might be an explanation for the divergence that,

on the one hand, we experience strong dynamics in AA in our everyday lives, most prominently when the latest fashion trends are often initially rejected, but are later appreciated after a period of familiarization, while, on the other hand, research continuously reports AA of high reliability e.g., for facial attractiveness with internal consistencies of  $\alpha \geq 0.9$  and inter-rater reliability of  $\alpha \geq 0.9$  (Carbon, Grüter, Grüter, Weber, & Lueschow, 2010), and re-test reliability within short intervals of  $r \geq 0.72$  (Knight & Keith, 2005). A meta analysis (Langlois et al., 2000) revealed inter-rater reliabilities of  $r = 0.90$  for adults,  $r = 0.85$  for children,  $r = 0.88$  for cross-ethnic and  $r = 0.94$  for cross-cultural agreement when evaluating the attractiveness of others.

Although the static or initial view on AA is indeed important for many domains, for instance, the attractiveness of a face at first glance or the first impression of a consumer product, it is essential to understand the dynamics behind it to be able to predict future preferences. Considering that humans base important decisions, such as what product to buy, or even: which partner to choose, on AA, cognitive psychology is interested in understanding the underlying cognitive processes triggering such dynamics.

## 1.1. Measuring aesthetic appreciation (AA)

Research on AA has focused on obtaining insight into associated variables such as attractiveness, beauty, liking, emotional affection,

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interestingness, good–bad, pleasant–unpleasant, boredom and many more (e.g., Carbon & Leder, 2005; Cox & Cox, 2002; Hekkert, Snelders, & van Wieringen, 2003; Leder, Carbon, & Ripsas, 2006). Also the 'affective response' has been measured according to a sample of variables partly in line with the aforementioned ones including liking, arousal, interesting–boring, good–bad, and pleasantness (e.g., Bornstein, Kale, & Cornell, 1990; Redondo, Fraga, Padron, & Pineiro, 2008; Zajonc, Crandall, Kail, &

Swap, 1974). What is particularly interesting for the present study is that some researchers did not focus on one key variable only to assess the attitude towards certain stimuli, but instead measured a combination of variables (see for an overview Table 1).

For instance, Zajonc et al. (1974) pointed out that since the publication of the seminal finding of the mere exposure effect (Zajonc, 1968) the "enhancement of attractiveness" (p. 667) has been observed

**Table 1**

Overview of variables of the construct aesthetic appreciation (AA) as used in related literature implementing more than one scale. This list is not exhaustive, it can only be considered as an excerpt from the literature on measuring the attitude towards objects (RE = repeated exposures: in these studies participants saw the stimulus material more than once before submitting their ratings).

Variable	Actual scale	Operationalisation for	RE	Source
<i>Attractiveness (as well as beauty, and liking)</i>				
	Attractiveness	AA	Yes	Carbon and Leder (2005)
	Attractiveness	AA	Yes	Carbon, Michael, and Leder (2008)
	Unattractive – attractiveness	Aesthetic preferences	Yes	Cox and Cox (2002)
	Attractiveness	AA	No	Leder and Carbon (2005)
	Ugly – beautiful	Aesthetic preference	No	Hekkert, Snelders, and van Wieringen (2003)
	Like – dislike	Attitude	Yes	Bornstein and D'Agostino (1992)
	Like – dislike	Affective response	Yes	Bornstein, Kale, and Cornell (1990)
	Liking	AA	No	Carbon (2010)
	Likable – not likable	Aesthetic preferences	Yes	Cox and Cox (2002)
	Dislike – like	Attitude	Yes	Fang, Singh, and Ahluwalia (2007)
	Liking	AA	No	Leder, Carbon, and Ripsas (2006)
	Like – dislike	Affective response	Yes	Zajonc, Crandall, Kail, and Swap (1974)
<i>Arousal</i>				
	Emotional affection	AA	No	Leder, Carbon, and Ripsas (2006)
	Arousal	Affective response	No	Gomez and Danuser (2004)
	Arousal	Affective response	No	Redondo, Fraga, Padron, and Pineiro (2008)
	Arousal – nonarousal	Affective response	No	Russell and Mehrabian (1977)
<i>Interestingness</i>				
	Interesting – uninteresting	Hedonic value of novelty	Yes	Berlyne (1970)
	Interesting – boring	Affective response	Yes	Bornstein, Kale, and Cornell (1990)
	Interestingness	AA	No	Leder, Carbon, and Ripsas (2006)
	Boring – interesting	Affective response	Yes	Obermiller (1985)
	Interesting – boring	Affective response	Yes	Zajonc, Crandall, Kail, and Swap (1974)
<i>Valence (as well as pleasantness)</i>				
	Bad – good	Aesthetic preferences	Yes	Cox and Cox (2002)
	Good – bad	Affective response	Yes	Brentar, Neuendorf, and Armstrong (1994)
	Bad – good	Attitude	Yes	Fang, Singh, and Ahluwalia (2007)
	Bad – good	Affective response	Yes	Obermiller (1985)
	Good – bad	Affective response	Yes	Zajonc, Crandall, Kail, and Swap (1974)
	Beneficial – harmful	Affective response to novelty	Yes	Zajonc, Crandall, Kail, and Swap (1974)
	Pleasing – displeasing	Hedonic value of novelty	Yes	Berlyne (1970)
	Pleasing – displeasing	Affective response	Yes	Brentar, Neuendorf, and Armstrong (1994)
	Pleasant – unpleasant	Aesthetic preferences	Yes	Cox and Cox (2002)
	Unpleasant – pleasant	Attitude	Yes	Fang, Singh, and Ahluwalia (2007)
	Pleasantness	Affective response	No	Gomez and Danuser (2004)
	Unpleasant – pleasant	Affective response	Yes	Obermiller (1985)
	Pleasantness	Affective response	No	Redondo, Fraga, Padron, and Pineiro (2008)
	Pleasure – displeasure	Affective response	No	Russell and Mehrabian (1977)
<i>Boredom</i>				
	Interesting – boring	Affective response	Yes	Bornstein, Kale, and Cornell (1990)
	Boredom	AA	Yes	Carbon, Michael, and Leder (2008)
	Boring – interesting	Affective response	Yes	Obermiller (1985)
	Interesting – boring	Affective response	Yes	Zajonc, Crandall, Kail, and Swap (1974)
<i>Innovativeness (as well as novelty, originality, and old/new)</i>				
	Imitative – innovative	Subjective novelty	Yes	Brentar, Neuendorf, and Armstrong (1994)
	Innovativeness	Innovativeness	No	Carbon (2010)
	Innovativeness	Innovativeness	Yes	Carbon and Leder (2005)
	Innovativeness	Innovativeness	Yes	Carbon, Michael, and Leder (2008)
	Innovativeness	Innovativeness	No	Leder and Carbon (2005)
	Familiar – novel	Novelty	No	Cox and Cox (2002): Pretest
	Original – unoriginal	Novelty	No	Cox and Cox (2002): Pretest
	Not original – original	Novelty	No	Hekkert, Snelders, and van Wieringen (2003)
	Unusual – common	Novelty	No	Cox and Cox (2002)
	Old – new	Subjective novelty	Yes	Brentar, Neuendorf, and Armstrong (1994)
	Old – new	Recognition	Yes	Bornstein, and D'Agostino (1992)
	New – old	Novelty	No	Cox and Cox (2002): Pretest
	Old – new	Recognition	Yes	Obermiller (1985)

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not just by measuring good–bad scales but was also measured using scales such as interesting–boring, beneficial–harmful, good–bad, and like–dislike. Besides the key variable ‘attractiveness’ research on the enhancement of attractiveness has focused on the variable boredom, since it is seen as a limiting factor for the mere exposure effect (Bornstein et al., 1990). Interestingness, a rather cognitive variable, was identified as an important factor for AA, too. For instance, Zajonc et al. (1974) argued that inanimate stimuli in particular are liked, because they are interesting and Day (1967) showed a complex interplay between interestingness and complexity, both related to preferences for visual objects. Although interestingness and boredom are strongly (inversely) related, interestingness is an activating and engaging characteristic, whereas boredom is not the absence or a low degree of interestingness, but rather a limiting factor for appreciation (Berlyne, 1970). Apparently, boredom is found on a different scale of time perspective. Regarding the dynamics of AA both variables are very promising since interestingness primarily shows short-termed effects while boredom might have a more lasting influence. The variables ‘arousal’ and ‘valence’, on the other hand, are important for assessing the affective response (e.g., Russell & Mehrabian, 1977) and were found to be related to preferences, too (e.g., Berlyne, 1970). Furthermore, a number of authors included scales such as innovativeness, novelty, and originality as important variables for AA (e.g., Brentar, Neuendorf, & Armstrong, 1994; Carbon, Michael, & Leder, 2008; Cox & Cox, 2002), since novelty and subjective familiarity are joint predictors for AA (Heldkert et al., 2003).

To summarise, research on AA reflects a multitude of dimensions which add to the whole construct of AA. Consequently, we assessed AA through the following six key variables derived from the literature: attractiveness, arousal, interestingness, valence, boredom and innovativeness (see for details Table 1). This way we were able to obtain a more comprehensive pattern of the AA than in previous studies simply investigating attractiveness (e.g., Carbon & Leder, 2005), which can only be seen as one, though important, aspect of the complex concept of AA (Leder, Belke, Oeberst, & Augustin, 2004). While we refer to these six variables as the (whole) construct of AA within the context of the present paper, we do note that these six concepts can only be seen as a part of the whole semantic network of AA. Therefore, they cannot be assumed to cover every aspect of aesthetic perception.

### 1.2. Dynamics of aesthetic appreciation (AA)

As mentioned above, aesthetic research mainly focuses on static phenomena. One way to overcome this limitation was Robert Zajonc’s ‘mere exposure’ paradigm, where participants were repeatedly exposed to certain stimuli (Zajonc, 1968). Zajonc and colleagues showed that mere exposure to a stimulus enhances the attitude towards it (Zajonc, 1968), especially when stimuli are presented subliminally (Kunst-Wilson & Zajonc, 1980). In a meta analysis Bornstein (1989) revealed that indeed mere exposure works most efficiently when viewers are not aware of having seen the stimuli. Experiments on mere exposure were particularly fruitful in investigating the connection between cognitive and affective evaluations, but rather limited with respect to higher aesthetic processes involving elaboration, understanding or mastering of a given material. For instance, elaborative processes of artworks through specific entitling (Leder et al., 2006) or effects of ambiguity, and the overcoming of such ambiguity, in portraits such as Leonardo’s Mona Lisa (Bohm, Carbon, & Hutzler, 2010) or long-termed cycles of taste (Carbon, 2010), cannot be adequately explained by the mere exposure approach.

Carbon and Leder (2005) developed a paradigm for elaborating material in a controlled way. By forcing participants to evaluate the given material on a variety of variables participants incidentally elaborated the stimuli in a deep way. Using this *Repeated Evaluation Technique* (RET) they identified the design property ‘innovativeness’ as a key variable for triggering dynamics in appreciation for object evaluation (see Table 1) and defined innovativeness as ‘originality by virtue of introducing new ideas’ (p. 587). As innovative products include highly novel object

properties, or at least an uncommon combination of known properties (Leder & Carbon, 2005), they often break common visual habits. This characteristic is probably the reason why people are often overwhelmed by highly innovative product designs or pieces of art. Without any further familiarization with such material, this often leads to rejection or avoidance of such objects. Moulson and Sproles (2000, p. 47) explicitly speak of a consumer’s ‘inherent conservatism’ toward new styles. Most importantly, the appreciation process does not necessarily stop at this stage. Dealing with innovative products is accompanied by modifications of the processing systems for these product representations and leads to the integration of these new experiences into the perceptual system. At the same time, as the object representations are modified, associative areas of the neural network of perception will register these configurations and will in turn be modified (Versace, Labeye, Badard, & Rose, 2009). Since networks of visual object perception and emotional neuronal networks are closely linked (Pessoa, 2008), this might lead to the aforementioned multidimensional dynamics of AA for innovations in everyday life.

The RET typically consists of three test phases, an initial test phase (T1) where participants are asked to rate the attractiveness of/ liking of/ preference for the material, the repeated evaluation phase (RET phase) where participants have to evaluate the material on a variety of dimensions (e.g., comfortable or stylish) and a final test phase (T2) where the ratings of T1 are repeated. Due to the active elaboration, RET stands in contrast to Zajonc’s (1968) mere exposure approach, where participants are exposed to the material in a rather passive way. Bornstein (1989, Table 1) already noted that mere exposure was rather ineffective when highly complex patterns such as paintings, drawings or matrices were used as stimulus material. One explanation for this is based on the finding that more complex material requires active processing which should be linked to deeper processing according to the ‘levels of processing’ theory (see Craik, 2002; Craik & Lockhart, 1972). In everyday life we indeed experience novel material, for instance, new consumer products or unfamiliar works of art, by testing, using, considering or discussing it—a behaviour which the active elaboration approach of RET aims to simulate in a controlled way. Indeed, by using RET we could demonstrate typical dynamics of AA (Leder & Carbon, 2005) known to take place in real contexts: highly innovative material is often initially rejected and later appreciated, while low innovative, highly familiar material is perceived as boring over time, with the result of being finally rejected. These basic patterns were supported by Carbon and colleagues who investigated eye movements (Carbon, Hutzler, & Minge, 2006) and pupillometry (dilatation of the pupil) (Carbon et al., 2006) and observed changes in electrodermal activity (Carbon et al., 2008) while inspecting the material.

### 1.3. The impact of semantic concept activation

Until now, the question which remains unanswered is what underlying mechanisms trigger such dynamics of AA. According to the spreading-activation theory of semantic networks one could argue that the specific initial phase (T1) of a typical RET experiment, assessing attractiveness and innovativeness—itsself—had an impact on the following repeated elaborations of the stimuli and thus on the dynamics of AA (cf. Collins & Loftus, 1975). In this respect the activation or priming of these nodes or concepts (attractiveness and innovation) would have prepared further elaborations, since activation of a node spreads out along the path of the (semantic) network. During further processing of the target material the networks of the concepts attractiveness and innovativeness might still have been activated and the later processing of the stimuli could therefore have been influenced by these activations. Aside from this automatic spreading of activations, Chwilla, Hagoort, and Brown (1998) described additional mechanisms concerning semantic priming, among them expectations that participants generate. For instance, participants might form expectations after the ratings of attractiveness and innovativeness for the associated topics and therefore further elaborations of the stimulus material will be primed to these two concepts.



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According to this rationale, the initial evaluations of the stimulus material on attractiveness and innovativeness led to priming activations of these concepts which had a determining influence on the subsequent final ratings. As attractiveness is a key variable of AA, we were interested in the impact of the primed semantic concept of attractiveness. The priming of this concept could further lead participants' thoughts, expectations and attention to AA itself. This would keep emotional as well as cognitive networks active during the RET phase and could particularly trigger dynamics of AA. As mentioned above, we know that innovativeness is an influential variable concerning AA and is closely linked to novelty, familiarity and typicality, which was identified as a predictive variable for AA (see also Hekkert et al., 2003). Activating the network of processing innovativeness could lead to awareness of innovative/novel features within the used stimuli and facilitate the integration of novel features into the processing system of these objects. Furthermore, we hypothesised that a combination of concepts such as that of the construct AA (attractiveness, arousal, interestingness, valence, boredom, and innovativeness) could have an even greater impact on the further aesthetic processing than the activation of just one singular concept. Therefore, we assumed that the semantic network of AA integrates different concepts such as attractiveness, arousal, interestingness, valence, boredom, and innovativeness and that priming parts of this network could impact the dynamics of AA. Within this framework we varied the quality and the quantity of the primed parts of the semantic network of AA. Note: Here, we only aim to determine whether there is a difference between qualities, without specifying these qualities in the semantic network of AA. To our knowledge no other study has investigated the impact of priming semantic concepts on the dynamics of AA in a systematic way.

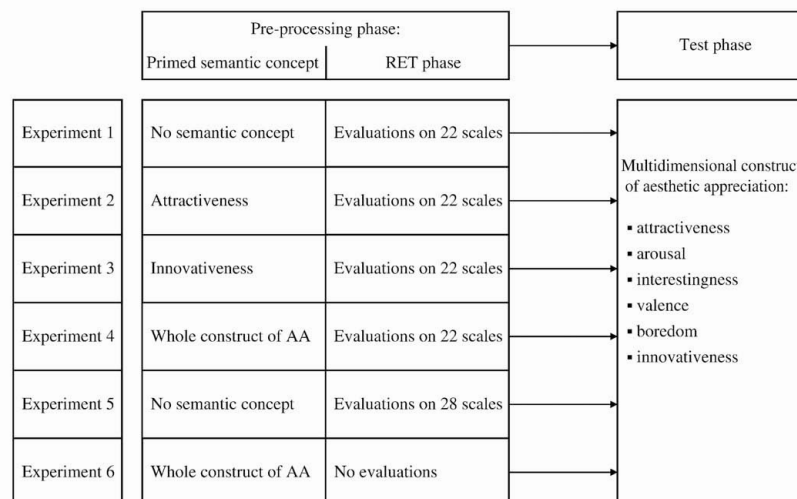
#### 1.4. The present study

In the present study we focused on the influence of primed semantic concepts on the development of dynamics of AA. We hypothesised that depending on the specific primed concepts different degrees of dynamics of AA arise. To ensure the possibility of such dynamics to emerge, we used carefully manipulated material differing in the degree of innovativeness, a variable known to evoke such dynamics (Carbon &

Leder, 2005). We used car interiors as stimulus material for two reasons: (1) they are highly complex visual stimuli which can be plausibly varied on the dimension of "innovativeness", (2) they can be plausibly manipulated on a variety of further design properties in a systematic way: while we were mainly interested in manipulating the stimuli on the dimension innovativeness, we controlled the degree of properties known to influence AA such as complexity (Berlyne, 1970) or curvature (Bar & Neta, 2006; Carbon, 2010). Previous studies (Carbon & Talker, 2006) with the currently used stimulus material indeed revealed clear dynamics as in former experiments using the Repeated Evaluation Technique (RET), namely, an increase in attractiveness for highly innovative car interiors, but a decrease in attractiveness for low innovative car interiors over time.

Our experiments were structured in two phases: (1) the pre-processing phase (priming of the semantic concept and RET phase) and (2) the (final) test phase (rating of the construct AA). Fig. 1 gives an overview of the experimental designs of the whole series of the performed experiments. Altogether, we carried out six experiments varying the priming of semantic concepts before the stimulus material was elaborated with the RET to assess the impact of these activations on the development of the dynamics of AA, which we collected in the final test phase.

To systematically investigate the possible impact of a primed semantic concept we started the experimental series with a procedure where no semantic concept was implemented (Experiment 1). In the second experiment we used the semantic concept "attractiveness", in the third experiment the semantic concept "innovativeness" and in the fourth experiment the above mentioned most complex construct of AA including all six concepts related to AA. Since due to the ratings of six concepts in the fourth experiment the whole pre-processing phase in this experiment inherently provided more opportunities for elaborating the material, a fifth experiment was carried out as a control experiment to investigate whether effects regarding the findings of Experiment 4 were due to a mere longer processing stage of the stimulus material or due to specific priming of semantic concepts. In Experiment 5 again no specific semantic concepts were enforced, although more scales in the RET phase were used to equate the length of the pre-processing phase with Experiment 4. Furthermore, to assess the contribution of the RET to



**Fig. 1.** Experimental designs of the series of six experiments. All experiments consisted of a pre-processing phase and a test phase. The pre-processing phase comprised the specific priming of a varying semantic concept (except for Experiments 1 and 5 where this activation did not occur) and the elaboration of the stimulus material by employing the Repeated Evaluation Technique (RET; except for Experiment 6 where the RET was not used) (Carbon & Leder, 2005). The semantic concept activation occurred through asking the participants to rate the stimulus material on the specific attribute, for example, in Experiment 2 participants rated the stimuli on attractiveness. The test phase included the ratings of the construct aesthetic appreciation (AA; containing the variables attractiveness, arousal, interestingness, valence, boredom and innovativeness).

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**Table 2**  
Description of participants per experiment: total number of participants, number of females, number of males, as well as mean (*M*) and standard deviation (*SD*) of age. For sample information of the base rates see Experiment 6 (as the same sample was used for the base rates and Exp. 6).

	Participants			Age	
	Total	Female	Male	<i>M</i>	<i>SD</i>
Exp.1	24	21	3	22.8	3.9
Exp.2	24	19	5	22.3	3.3
Exp.3	24	21	3	21.8	4.2
Exp.4	24	19	5	22.4	4.7
Exp.5	24	22	2	20.9	2.1
Exp.6	24	20	4	22.1	2.4
Total	144	122	22	22.1	3.5

the results of priming the whole construct of AA in Experiment 4, we implemented a further control experiment (Experiment 6). Here, we used the same design as in Experiment 4 (priming the whole construct of AA), but omitted the entire RET phase, so that the priming was followed immediately by the test phase.

In the context of this paper, we operationalise AA as the attitude towards an object, which is characterised by an integrative nature of AA-relevant affective and cognitive components. As described in detail above, we measure this construct through six variables: attractiveness, arousal, interestingness, valence, boredom, and innovativeness. The dynamics of AA are operationalised by interactions between time and innovativeness as proposed by Carbon and Leder (2005).

2. Method of Experiments 1–6

2.1. Participants

A total of 144 undergraduate students participated for course credit. This sample consisted of 122 women and 22 men with a mean age of

22.1 years (*SD* = 3.5) (for detailed information on the individual experiments see Table 2). All of them had normal or corrected-to-normal vision assured by the standard Snellen Eye test. None of the participants took part in more than one of the reported experiments.

2.2. Apparatus and stimuli

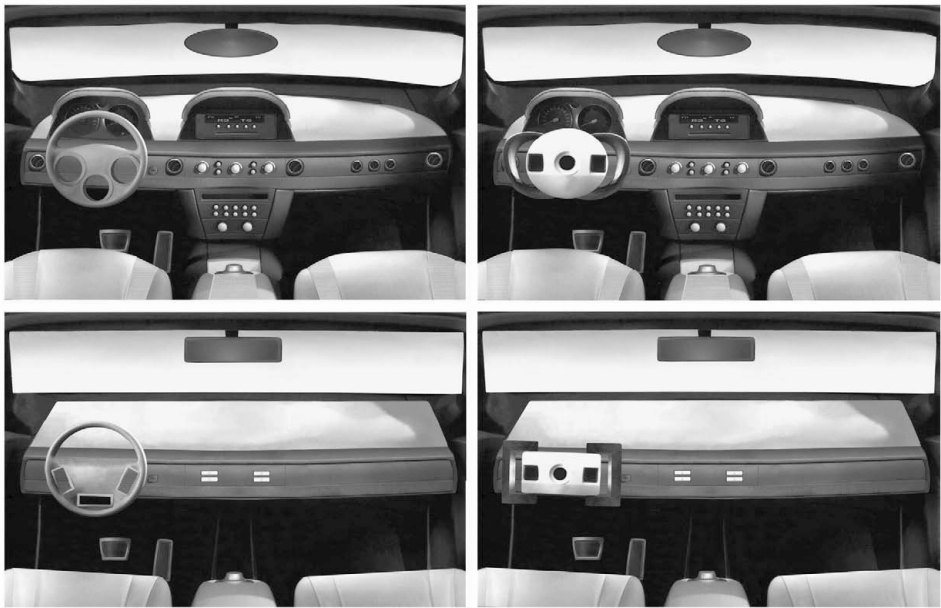
The stimulus material consisted of 18 photo-realistic images of artificial car interiors (see Fig. 2 for exemplary stimuli) with a size of 800 × 513 pixels presented on a 17-inch Apple eMac CRT monitor with a resolution of 1024 × 768 pixels. The stimuli, generated with Adobe Photoshop 7.0, varied on two levels of innovativeness (low, high) and were carefully controlled for further design properties known to affect AA, complexity and curvature. For both levels of innovativeness we systematically varied fully crossed complexity and curvature on 3 × 3 levels (low, medium, high) (for a detailed description of these dimensions see Carbon & Leder, 2005; Leder & Carbon, 2005). Several previous studies were used to ensure equal degrees of complexity and curvature for both levels of innovativeness using 7-point Likert scales (Carbon & Talker, 2006).

2.3. Procedure

The experiments consisted of two phases: the pre-processing phase and the test phase. While the test phase was exactly the same in all experiments, the pre-processing phase varied across the experiments (see Fig. 1 for a graphic overview of the experimental designs).

2.3.1. Pre-processing phase

The pre-processing phase consisted of two parts: the priming of the semantic concept and the RET phase. We implemented the priming of the specific concept(s) by asking the participants to rate the stimuli in terms of the respective specific concept(s) (e.g., attractiveness) on a 7-point Likert scale (1 = “least significant”, 7 = “most significant”). The 18



**Fig. 2.** Examples of the stimulus material, given here by typical low (left) versus highly innovative (right) designs where the levels of curvature and complexity were both fixed to a high degree (above) and a low degree (below), respectively. The stimulus material varied systematically regarding innovativeness, curvature and complexity by alternating elements of the car interiors such as steering wheel, mirrors, dashboard, switches, fresh air nozzles, middle console and seats.

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stimuli were presented one after the other on the screen in randomised order for 2.6 s and rated one after the other by pushing buttons 1–7.

In the RET phase participants rated the stimuli on different scales. These scales met two requirements: (1) they asked for low emotionality and low arousal,<sup>1</sup> thus assessing rather cognitive attributes; (2) none of them were identical with one of the variables included in the construct of AA used here (attractiveness, arousal, interestingness, valence, boredom and innovativeness). We used attributes which rely on shape and form features of the designs and should therefore facilitate the integration of specific design features into the perceptual system through activating the object-selective cortex (Op de Beeck, Torfs, & Wagemans, 2008). The attributes we used were: rectangular (*rechteckig*), oblong (*länglich*), oval (*oval*), continuous (*ebenmäßig*), factual (*sachlich*), uniform (*gleichförmig*), homogenous (*homogen*), anonymous (*anonym*), sober (*nüchtern*), schematic (*schematisch*), angled (*winklig*), minimalist (*schlicht*), concrete (*konkret*), solid (*solide*), regular (*regelmäßig*), formal (*förmlich*), rounded (*abgerundet*), compact (*kompakt*), neat (*ordentlich*), conventional (*konventionell*), classic (*klassisch*) and restrained (*dezent*). The six additional attributes of Experiment 5 were: straight (*geradlinig*), simple (*einfach*), systematic (*systematisch*), purposeful (*zweckmäßig*), precise (*präzise*), and well-arranged (*übersichtlich*). The order of the scales was randomised for each participant. For each scale, all 18 stimuli were presented one after the other for 2.6 s in a randomised order and thereby rated on a 7-point Likert scale (1 = “least significant”, 7 = “most significant”).

In Experiment 1 the pre-processing phase consisted of only the RET phase and no priming was implemented. In Experiment 2 the concept attractiveness was primed. Thus, the pre-processing phase consisted of 23 scales including attractiveness which was presented as the first scale followed by the 22 randomised scales used in Experiment 1. Experiment 3 was identical with Experiment 2, but the concept innovativeness served as a prime. In Experiment 4 we implemented a more extensive semantic concept including the whole construct of AA. Thus, participants first rated the stimuli according to the scales attractiveness, arousal, interestingness, valence, boredom and innovativeness in a fixed order (semantic concept(s) activation) followed by the randomised order of the 22 RET scales. Also, to reduce anchor effects, in this experiment as well as in Experiments 5 and 6 the participants previewed the stimuli (without rating) by simultaneously viewing one half of the items on the screen for 6 s followed by the other half of the items for another 6 s. The positions of the stimuli for the preview phase were pseudo-randomised and held constant for all participants. After that the pre-processing phase and the test phase followed. No concept was primed in Experiment 5, however we implemented a prolonged RET phase with 28 scales (see above). Finally, in Experiment 6, as in Experiment 4, the whole construct of AA served as a prime but we did not apply the RET to rule out the explanation that dynamic effects in Experiment 4 were solely based on the extensively primed concept of AA.

### 2.3.2. Test phase

The test phase followed immediately after the pre-processing phase. Participants rated all stimuli one after the other in randomised

order for each variable of the AA variables presented in the following order: attractiveness (*attraktiv*), arousal (*anregend*), interestingness (*interessant*), valence (*positiv*), boredom (*langweilig*) and innovativeness (*innovativ*). All variables were assessed on 7-point Likert scales (1 = “least significant”, 7 = “most significant”). The presentation duration was again fixed at 2.6 s. The next stimulus appeared automatically after the participant had submitted his/her rating. Participants were instructed to respond to the respective question as spontaneously as possible. Trials for each rating block were fully randomised. All experiments were presented by PsyScope 1.25 PPC (Cohen, Macwhinney, Flatt, & Provost, 1993). All participants were tested individually.

### 2.4. Base rates

In Experiments 1–6 we tested the construct aesthetic appreciation (AA) after the pre-processing phase. To investigate whether dynamics in AA occurred we compared each experiment with base rates of the stimulus material. We collected base rates from the priming phase of Experiment 6. Accordingly, the sample was the same as in Experiment 6. The stimulus material and apparatus were the same as in all experiments. The procedure for collecting the ratings of the AA variables was the same as in the test phase of the experiments. Also, to reduce anchor effects, the participants previewed the stimuli as described above. The participants were tested individually. Results of the descriptive analysis are presented in Fig. 3.

### 2.5. Test of dynamics of aesthetic appreciation

In order to test the hypotheses describing effects of the different semantic concept primes, we concentrated on changes in the ratings for both levels of innovativeness. To investigate whether dynamics in AA occurred we compared the ratings of each experiment with the base rates. We first averaged data over complexity and curvature levels resulting in means of the two levels of innovativeness per variable and per subject. We then conducted a mixed-design analysis of variance (ANOVA) with innovation (low, and highly) as within-subject factor, time (T1: from the base rates; T2: from the final test phase of a given experiment) as between-subject factor, and the ratings as dependent variable. Such an ANOVA was calculated for each experiment and for each variable separately. The subjects needed for collecting the base rates and the ones who participated in Experiment 6 were the same. Nonetheless, we also conducted a mixed-design ANOVA with time as between-subject factor instead of a within-subject factor for Experiment 6 to ensure comparability of statistics across all experiments.

### 2.6. Boredom scale

The scale of the variable *boredom* was reversed for all analyses and illustrations in all figures, since this was the only scale that was negatively correlated with appreciation.

## 3. Results and discussion of Experiments 1–6

### 3.1. Reliability of the construct aesthetic appreciation (AA)

We tested the implemented construct of AA for its reliability using data of the base rates. Inter-rater reliability was assessed separately for each variable using calculations of Cronbach's alpha. Reliability was very high for all variables (attractiveness:  $\alpha = 0.956$ ; arousal:  $\alpha = 0.956$ ; interestingness:  $\alpha = 0.944$ ; valence:  $\alpha = 0.952$ ; boredom:  $\alpha = 0.956$ ; innovativeness:  $\alpha = 0.954$ ) indicating high internal consistency.

### 3.2. Results and discussion

In the following we will first conduct descriptive analyses of the test phases for every single experiment, which are presented in Fig. 3.

<sup>1</sup> In the RET phase of the original paper, where the RET concept was introduced (Carbon & Leder, 2005), participants elaborated the target material on multiple scales including attributes such as futuristic (“futuristisch”) and conservative (“konservativ”). The ratings of the stimuli regarding these attributes might themselves activate networks closely related to innovativeness that we introduced in Experiment 3 as a semantic concept. To rule out such confounding activations in the RET phase and to increase the control over the impacts of the specific semantic concepts, we selected attributes for the RET phase from a pre-study with scales referring to adjectives of neutral valence, low arousal (strength of emotion) and low subjectivity (the degree to which ratings would differ between subjects: highly subjective, e.g., “fascinating”; low subjective, e.g., “rectangular”). The selected scales consisted of rather “cognitive” attributes mostly concerning aspects such as form and shape of the designs. We are indebted to Dave Perrett for providing this idea in a discussion at the ECVF 2005 in La Coruña.

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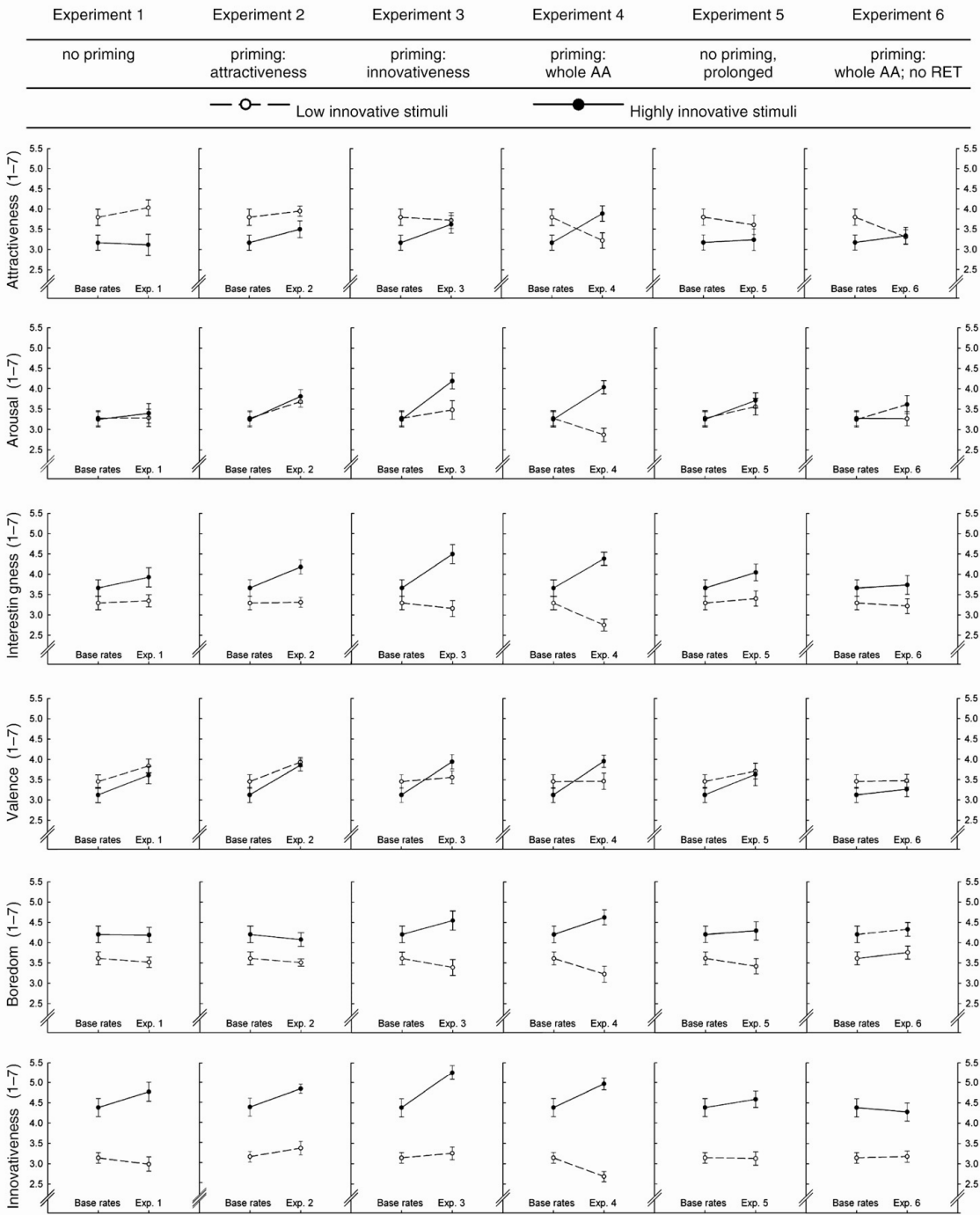


Fig. 3. Comparisons of Experiment 1 (first column from left), 2 (second column from left), 3 (third column from left), 4 (fourth column from left), 5 (fifth column from left) and 6 (sixth column from left) with the base rates: The different AA variables (*attractiveness*, *arousal*, *interestingness*, *valence*, *boredom* and *innovativeness*) are displayed per rows. For each variable and each comparison with the base rates the interaction between time and innovativeness is indicated by mean and standard error of the mean. \*) for reasons of better readability, the scale boredom was inverted to be concordant with the other scales.

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**Table 3**

Test of dynamics of aesthetic appreciation: Comparative analyses of base rates and experiments 1–6 for all variables (VAR): attractiveness (ATT), arousal (ARO), interestingness (INT), valence (VAL), boredom (BOR) and innovativeness (INN). Effects (EFF) for Innovativeness (I) as well as the interactions between innovativeness and time (T1 = base rate; T2 = regarding experiment; I×T) are indicated. Significant interactions between I and T are in bold. Degrees of freedom for all F-tests are 1/46. For a more detailed description, see Section 2.5. *Test of dynamics of aesthetic appreciation.*

VAR	EFF	Base vs. Exp.1 (no priming)				Base vs. Exp.2 (priming: attractiveness)				Base vs. Exp.3 (priming: innovativeness)				Base vs. Exp.4 (priming: whole AA)				Base vs. Exp.5 (control exp. for Exp. 4)				Base vs. Exp.6 (control exp. for Exp. 4)			
		df	F	$\eta_p^2$	p	df	F	$\eta_p^2$	p	df	F	$\eta_p^2$	p	df	F	$\eta_p^2$	p	df	F	$\eta_p^2$	p	df	F	$\eta_p^2$	p
ATT	I	1	15.1	0.25	0.001	1	11.2	0.20	0.002	1	4.4	0.09	0.041	1	<1	0.01	0.919	1	5.7	0.11	0.022	1	3.7	0.07	0.061
	I×T	1	<1	0.01	0.474	1	<1	0.01	0.578	1	2.5	0.05	0.125	1	<b>12.8</b>	<b>0.22</b>	<b>0.001</b>	1	<1	0.01	0.541	1	<b>4.5</b>	<b>0.09</b>	<b>0.039</b>
ARO	I	1	<1	0.01	0.801	1	<1	0.01	0.749	1	3.3	0.07	0.074	1	11.4	0.20	0.002	1	<1	0.01	0.747	1	<1	0.02	0.352
	I×T	1	<1	0.01	0.674	1	<1	0.01	0.621	1	3.9	0.08	0.054	1	<b>12.5</b>	<b>0.21</b>	<b>0.001</b>	1	<1	0.01	0.642	1	1.2	0.03	0.275
INT	I	1	8.4	0.16	0.006	1	15.9	0.26	0.001	1	21.3	0.32	0.001	1	40.0	0.47	0.001	1	8.2	0.15	0.006	1	6.6	0.13	0.014
	I×T	1	<1	0.01	0.527	1	2.6	0.05	0.115	1	<b>6.8</b>	<b>0.13</b>	<b>0.012</b>	1	<b>15.9</b>	<b>0.26</b>	<b>0.001</b>	1	<1	0.01	0.444	1	<1	0.01	0.672
VAL	I	1	2.4	0.05	0.125	1	1.8	0.04	0.189	1	<1	0.01	0.888	1	<1	0.01	0.617	1	<1	0.02	0.381	1	3.2	0.07	0.081
	I×T	1	<1	0.01	0.768	1	<1	0.02	0.401	1	4.0	0.08	0.052	1	<b>6.9</b>	<b>0.13</b>	<b>0.011</b>	1	<1	0.01	0.588	1	<1	0.01	0.696
BOR	I	1	16.9	0.27	0.001	1	13.6	0.23	0.001	1	19.7	0.30	0.001	1	33.6	0.42	0.001	1	11.3	0.20	0.002	1	15.4	0.25	0.001
	I×T	1	<1	0.01	0.799	1	<1	0.01	0.942	1	2.1	0.04	0.159	1	<b>5.5</b>	<b>0.11</b>	<b>0.023</b>	1	<1	0.01	0.521	1	<1	0.01	0.951
INN	I	1	76.9	0.63	0.001	1	89.2	0.66	0.001	1	94.1	0.67	0.001	1	142.8	0.76	0.001	1	92.2	0.67	0.001	1	48.6	0.51	0.001
	I×T	1	2.5	0.05	0.122	1	<1	0.02	0.398	1	<b>5.3</b>	<b>0.10</b>	<b>0.026</b>	1	<b>12.6</b>	<b>0.22</b>	<b>0.001</b>	1	<1	0.01	0.432	1	<1	0.01	0.680

After that we will compare every experiment with the base rates (see method section of Experiment 1, *Test of dynamics of aesthetic appreciation*) to test the occurrences of dynamics of AA. All effects of and interactions with innovativeness are reported in Table 3 (Experiments 1–6). The interaction between time and innovativeness indicates whether changes over time for low and/or highly innovative stimuli, thus dynamics of AA, occurred. Therefore, to increase the readability and to focus on the hypotheses concerning the dynamics of AA, we will only discuss in the following any interactive effects of time and innovativeness for every dependent AA variable. We will not report further possible main effects of the between-subject factor time, since they are not part of our specific research question in this study and no specific hypotheses are stated concerning these effects. The detailed statistics of all the following analyses are presented in Table 3.

The analyses between the base rates and Experiment 1 revealed no significant interaction for time and innovativeness for *attractiveness*, *arousal*, *interestingness*, *valence*, *boredom* and *innovativeness*. We could not detect any difference in aesthetic appreciation after a pre-processing phase consisting of only the RET phase in comparison with the base rates (Fig. 3 (first column from left)). When Experiment 2 was compared with the base rates again no interaction was significant for any AA variables. Thus, priming the semantic concept attractiveness had no significant effect on the development of dynamics in AA either (Fig. 3, second column from left). In Experiment 3 we found significant interactions for time and innovativeness for the variables *interestingness* and *innovativeness* as well as trends for *arousal* and *valence*. No other interaction was significant. So, the priming of the concept innovativeness in the pre-processing phase resulted in dynamics in two of the six AA variables (Fig. 3, third column from the left). After priming the whole construct of AA dynamics (Experiment 4) we found dynamics in all AA variables (Fig. 3, fourth column from the left). Conversely, we found no dynamics of AA after a prolonged RET phase when no concept was primed (Experiment 5; Fig. 3, fifth column from the left). Priming the whole construct of AA (Experiment 6), however, without including an RET phase produced dynamic changes for low and highly innovative material in *attractiveness* (Fig. 3, sixth column from the left).

In sum, we observed no dynamics in Experiments 1, 2, and 5, but we found dynamics in *attractiveness* in Experiment 6 and dynamics in *interestingness* and *innovativeness* as well as trends for *arousal* and *valence* in Experiment 3. Most importantly, we obtained significant dynamics of the whole AA construct in Experiment 4. This indicates that no dynamics of AA were observed when no concept was primed—even with the prolonged RET phase in Experiment 5. Regarding the quality of the primed concept we received different results: while we

found *no* dynamics, indicated by non-existing interactions for time and innovativeness, when attractiveness was primed as the only concept, we *did* observe dynamics for interestingness and innovativeness after priming the concept innovativeness. This indicates that the quality of the primed concepts was important to trigger dynamics of AA. The most extensive dynamics of AA occurred after increasing the quantity of the primed semantic network when the whole construct of AA variables was primed and the RET procedure was implemented. As a result, significant interactions between time and innovativeness were obtained for all variables of AA and, thus, Experiment 4 demonstrated the strongest dynamics in AA. It should be noted that this effect was not due to the longer pre-processing phase, since we did not find any dynamics in Experiment 5 which was created as a control experiment with the same length of the pre-processing phase as in Experiment 4. Neither was it the impact of priming the AA concept(s) alone, because we received less dynamics in Experiment 6 (only in *attractiveness*) with a pre-processing phase consisting only of priming the whole construct of AA, without an RET phase. Therefore, results showed an effect of priming as well as an effect of the RET on the dynamics of AA.

#### 4. General discussion

We investigated the impact of priming semantic concepts related to aesthetic appreciation (AA) in combination with elaborations of the stimulus material (via RET) on the dynamics of AA. We measured AA as a multidimensional construct derived from the literature through *attractiveness*, *arousal*, *interestingness*, *valence*, *boredom* and *innovativeness* (see Table 1) and demonstrated high internal consistency of the multidimensional construct of AA using base rates collected from 24 subjects (initial testing). Possibilities of developing dynamics of AA were realised by using car interior stimuli that varied in the dimension “innovativeness”, which is a key dimension identified for triggering dynamics of appreciation. Thereby, an interaction between time and innovativeness indicated whether dynamics of AA occurred. Our hypothesis that priming of semantic concepts related to AA impacts further processing, thereby triggering the dynamics of AA, was strongly confirmed, since dynamics only occurred when priming of semantic concepts related to AA was implemented. Clear dynamics occurred after having primed the concept innovativeness (Experiment 3) and even stronger dynamics were revealed after having primed the whole construct of AA (Experiment 4). Also we observed weak dynamics, only for attractiveness (Experiment 6) when the whole construct of AA was primed but no RET was conducted. Most importantly, we could show differential impacts of the quality and the quantity of the primed semantic concepts. Concerning the quality,

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when only one single concept related to AA was primed (Exp. 2: attractiveness; Exp. 3: innovativeness) only the concept innovativeness triggered dynamics of AA. Testing the quantity we observed the strongest dynamics in Experiment 4 with the most extensive semantic concept(s) primed including the multidimensional construct of AA.

Concerning the priming of semantic concepts one could argue that it is very important that parts of the semantic networks which are involved in the aesthetic processing are activated during processing to trigger strong dynamics of AA. This conclusion was indeed supported by the comparison between Experiments 4 and 5. With exactly the same number of scales assessed within the pre-processing phase strong dynamics only developed when the complex semantic concept of AA in Experiment 4 was activated. Elaboration of the stimulus material exclusively on the basis of rather cognitive design features such as those concerning form and shape might prevent deeper aesthetic processing. In contrast, after priming semantic concepts strongly (and specifically) related to AA, participants probably had associations and expectations in the direction of the activated semantic networks during further processing, which facilitated dynamics of AA.

We found that the primed semantic concept of innovativeness had a greater impact on the development of the dynamics than that of attractiveness and thus, that the quality of the network is essential. Although both concepts seemed to be promising semantic concepts for triggering further aesthetic processing, innovativeness might be more important for producing dynamics of AA, especially with the stimuli employed. The activation of this semantic concept fosters the awareness of this characteristic in the stimulus material and also promotes the integration of that specific dimension including novel, innovative, and unusual features in the designs. This could lead to an update of object representations which may influence the aesthetic appreciation of the stimulus material. The most successful semantic concept in triggering dynamics of AA combined several concepts related to AA, among others, the concepts attractiveness and innovativeness (Experiment 4). This might indicate that the quantity, thus the extension, of the implemented semantic network had a specific impact, revealed by broader and stronger dynamics than either in Experiment 2 or 3. It could alternatively be interpreted as a qualitative change, too. Only the specific combination of these scales related to AA could generate such pronounced dynamics as observed in Experiment 4. Moreover, these effects were not due to differences in the mere length of the pre-processing phase, nor can they be solely attributed to priming since we found less strong dynamics in Experiment 6. According to Collins and Loftus (1975), this indicates that the spreading activations of the construct AA had further influence on the processing, elaboration and, not to forget, the *appreciation* of the stimuli. This in turn indicates possible expectancies of the participants in the direction of the processing of specific aesthetic dimensions when evaluating the stimuli during the Repeated Evaluation Technique (RET; Carbon & Leder, 2005) phase. As the semantic networks for elaborating the stimulus material regarding cognitive design features such as form and shape, assessed in the RET phase, are connected to those of the processing of AA, a reactivation of the AA-related processing network during the RET phase is also possible. In this sense a possible explanation is that associated networks such as that for emotional processing registered modifications of the processing system (e.g., object representations) during the RET phase (Versace et al., 2009) and thus, that the networks for processing AA (which probably includes parts of the emotional processing network) were modified indirectly. These associated networks required, at least partly, a pre-activation, since we observed clearly reduced, in fact statistically insignificant, dynamics in Experiments 1 and 5, where such priming was not employed.

In sum, our results reflect the plasticity of perception and appreciation. In line with Versace et al.'s (2009) concept of a multimodal, dynamic, functional and situational concept of memory, our appreciation apparatus seems to be constantly modified and adapted to newly processed stimuli, and thus new experiences. Most

importantly, we showed that priming AA-related concepts influenced the AA over time. In line with many studies reported in the priming literature, we showed further evidence that priming affected the re-assessment of given stimuli or, in our case, the aesthetic processing (Experiment 6). But even more interestingly, we found that priming specific concepts had an impact on further processing of the stimuli, thus the following elaborations of the material via RET, which lasted about half an hour, and therefore directly influenced the development of AA over time (Experiments 3 and 4). This could lead to the interpretation that priming affected the reorganization or adaptation of the perceptual system.

However, further research is necessary to define the semantic network of AA in more detail. Also, it would facilitate the interpretation of priming effects if distances between concepts of the semantic network of AA were known. For example, up to now it is unclear why priming innovativeness led to dynamics in the variables innovativeness and interestingness as well as trends in arousal and valence. Varying distances between the concepts used in our study could account for differences in the development of the dynamics. Furthermore, a more detailed knowledge of the semantic network of AA could explain why we found changes due to the priming of innovativeness but not attractiveness.

We did not observe dynamics of AA in Experiments 1 and 5, in which the pre-processing phase *only* consisted of the RET phase, contrary to previous studies also using the RET (Carbon & Leder, 2005). There are two major differences between both approaches: (1) in Carbon and Leder's study participants were asked to rate the stimulus material regarding attractiveness and innovativeness before the RET, which could be interpreted as a priming on two specific semantic networks. (2) In the present series of experiments we purposely used attributes in the RET phase, which were related to rather superficial and shallow aspects of the designs (for more detail on scale qualities see also footnote 1); the original study of Carbon and Leder (2005), however, used a combination of elaborative, cognitive and emotional scales within the RET phase. The authors introduced the RET to simulate everyday life experiences with objects such as consumer products or works of art, which are able to evoke aesthetic experiences. The usage of a variety of scales in the initial study had the disadvantage of losing control of which semantic concepts are specifically primed and which dimensions of cognitive processing are particularly triggered. In the present study, we explicitly used scales related to AA only in a priming phase and excluded all aesthetically relevant scales from the RET phase to be able to minimise confounding factors of priming of aesthetically relevant processing. However, even with the scales used in the present study we found an impact of the RET procedure since we observed clearly reduced dynamics in Experiment 6 (no RET phase) compared to Experiment 4 (with RET phase).

Another critical point for our study concerns the generalization of our findings to other object classes. We used car interiors in this study since we can control a series of aesthetically relevant factors rather easily. It is questionable whether strong dynamics in AA can also be observed with natural material such as faces or nature scenes. Here, more biologically driven programs for assessing the aesthetic value might be at work. It would also be interesting to look at the duration of the dynamics which we obtained in the current study. We know from the face literature that adaptation effects can be quite sustained lasting up to days and weeks (Carbon & Ditye, *in press*), but we also have indications from artificial objects such as car exteriors that dynamics of aesthetic appreciation do occur over periods of several years and decades (Carbon, 2010). Systematic research seems promising to reveal not only the ingredients for dynamics in AA but also their limits and scopes.

It is obvious that the revealed dynamics of AA modulated by the specific usage of priming of semantic networks are not only relevant for cognitive basic research, but offer insight for applied research, too. In the field of market research as well as for the consumer product industry our results highlight the importance of developing tests for the appreciation of new products, which involve deep processing of

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the material. Simple consumer tests with only one presentation of the products which do not give consumers the chance to really understand these products and integrate them into their visual habits seem inadequate. A more dynamic view regarding this key problem of consumer research plus a clear strategy which encourages consumers to engage with the products seems mandatory. One possibility to assess such changes experimentally is to use the Repeated Evaluation Technique (RET) in combination with systematic priming of semantic networks beforehand. This enables intense elaboration of the target material and could lead to deeper insights into what kind of novel features frustrate or overwhelm consumers. As pointed out by Fournier, Dobscha, and Mick (1998) this could help to predict which design innovations will eventually be appreciated, and which products will ultimately be bought.

In our present research we demonstrated the importance of the activation of semantic networks linked to AA for further aesthetic processing of stimuli. We observed differential influences on these dynamics due to the quality and the quantity of the primed semantic networks. It is now important to get further insights into additional variables modulating aesthetic appreciation. The variables in question should focus more on the processing of the stimuli versus the mere properties of the stimuli themselves. Of particular interest of future aesthetic research will be the dynamics underlying these variables to solve questions we never cease to wonder about: what will we like in the future?

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### 4.5.3 Summary & Outlook

This study provides further progress for the understanding of dynamics of aesthetic evaluations. It demonstrates that aesthetic evaluations are highly sensitive to the type of evaluations during first stimulus encounter – the type of evaluations influenced the dynamics of aesthetic evaluations. Strong dynamics developed when dimensions relevant to the stimulus were evaluated, by judging the innovativeness of the stimuli. These dynamics were even enhanced when dimensions relevant to the aesthetic evaluation of the stimulus were additionally evaluated, in terms of attractiveness, arousal, interestingness, positivity and boringness of the stimuli. Such results are in accordance with reasoning derived from spreading activation theories of semantic networks (c.f. Collins & Loftus, 1975). Assessing variables like attractiveness or innovativeness activated nodes or concepts along the path of the (semantic) network which further prepared the processing and elaboration of the stimuli influencing the repeated evaluations and dynamics of aesthetic evaluation. This study replicates and extends findings of the previous studies – awareness of the factor innovativeness by evaluating innovativeness influenced the dynamics of aesthetic appreciation (see chapter 4.2, 4.3) – but dynamics were also enhanced when aesthetically relevant dimensions were additionally evaluated. This is clear evidence that the type of evaluations influences dynamics of aesthetic appreciation.

Concerning future studies, open questions allow for a more detailed analysis of the role of the different variables and their interactions modulating the aesthetic evaluations beyond the mind set, as found here. Specifically, variables could be tested which focus on the processing of the stimulus (such as fluency, excitement, positive emotions eliciting) versus the mere properties of the stimuli (such as curvature, complexity or size).





## 5 How Art is Appreciated

### 5.1 Introduction

This article has been accepted for publication in *Psychology of Aesthetics Creativity and the Arts*. The model of Leder et al., (2004) assumes that variables of the object of evaluation, of the observer and the situation together determine the aesthetic outputs. As outlined in chapter 4.4 the interplay of these various variables on the aesthetic output needs well controlled research. Here, structural equation modelling (SEM - Byrne, 2001; MacCallum & Austin, 2000) was employed as it allows not only to infer the relative contribution of each variable to the aesthetic evaluations, but also reveals the complex interplay of factors affecting the dependent variables. However, SEM analyses require clear definitions regarding the theoretical structure of the model, which was based on the Leder et al. (2004) model.

We measured how variables relevant to processing of an object in aesthetic evaluations – elicited emotion (Silvia, 2005a; Zentner, et al., 2008), arousal (Berlyne, 1970a; Martindale, et al., 1990) and comprehension (Leder, et al., 2006; Millis, 2001) – relate to aesthetic appreciation of three kinds of artworks differing in their representativeness: abstract, modern and classic. According to the Leder et al. (2004) model, representativeness in artworks influences aesthetic processing. For example, classic artworks have clear representational content but abstract artworks are characterised by a lack thereof. Due to this lack of content it is argued that style related processing is particularly important for aesthetically evaluating abstract art. Moreover, it has often been claimed that expertise (Hekkert & VanWieringen, 1996a, 1996b; Leder, et al., 2004; Locher, et al., 2001) changes the way art is perceived – for example, with expertise and knowledge, style related processing is more likely to occur (Augustin & Leder, 2006). Therefore, the relative level of expertise was considered in all analyses.

SEM revealed strong effects of elicited emotion to all three kinds of artworks. The effects of arousal were smaller. Comprehension seemed only to be an important predictor for modern art, presumably because its ambiguous quality fostered a need for understanding (Jakesch & Leder, 2009). Regarding differences which arise due to expertise, it is notable that experts gave higher ratings in general, however, SEM analyses revealed that the inter-correlations between most variables were higher for non-experts. These results indicate that

expertise is concurrent with less constrained, and more differentiated, ratings in art appreciation.

## **5.2 Original Manuscript**

Running head: ART APPRECIATION

How art is appreciated

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### Abstract

Art is a unique feature of human experience. It involves the complex interplay among stimuli, persons and contexts. Using structural equation modeling, we explored this complex interplay by analyzing expertise-related differences in the aesthetic appreciation of classical, abstract and modern artworks. We measured liking, elicited emotions, arousal and comprehension and compared structural equation solutions for two groups of students with higher and lower level of art expertise. Experts and non-experts not only revealed strong effects of emotion in all conditions, but also confirmed that the inter-correlations between emotion and understanding were consistently higher for non-experts. Moreover, experts generally provided higher ratings on nearly all scales. These results reflect experts' greater flexibility and differentiation in art appreciation.

### How modern art is appreciated

Art is a mysterious aspect of human life. Though its direct utility is still the object of recent debates, art is universal and exists in all cultures, and various explanations about its existence have been posited (Dissanayake, 2007). These explanations seek general principles such as the rewarding function of art, or how art fits the way the brain works (Ramachandran & Hirstein, 1999). There is hardly any aspect of our everyday perception that seems more subjective than the human appreciation of art. People differ in the type of art that they prefer. Some people dislike contemporary art, and it elicits very strong negative emotions in others (Silvia & Brown, 2007). People also differ in what they focus on regarding art. Some appreciate craftsmanship, some want to learn about life based on the consumption of art, and others appreciate the amusing and arousing nature of contemporary art. In other words, art appreciation is highly idiosyncratic, and seems to be in the eye of the beholder. Nonetheless, in the present study we showed how analyzing art experiences by means of structural equation modeling allows to systematically analyze the interplay of variables involved in the aesthetic appreciation of art.

There have been several recent psychological approaches that explain art appreciation (e.g., Chatterjee, 2003; Leder, Belke, Oeberst, & Augustin, 2004). A recent stage model of aesthetic experiences of art emphasized higher-order cognitive processes (Leder et al., 2004). The model identified five essential stages of information processing, and a number of variables that affect aesthetic judgments and aesthetic emotions concerning art. The model proposed a perceptual processing stage, which takes place after an object has been classified as art. The next stage represents implicit memory processes, which are based on previous experiences. The explicit classification stage then distinguishes content from style. The fourth processing stage, called cognitive mastering, is concerned with finding meaning, and involves processes such as interpretation and the assignment of meaning. Finally, the results of the previous stages are evaluated resulting in an aesthetic judgment and an aesthetic emotion. All stages of information processing feed into a continuously evaluated emotional state, which is seen as a continuously adapted by-product of the aesthetic processing stages (Leder et al., 2004, p. 502). Thus, according to the model, an interaction between cognitive and emotional processing accounts for the aesthetic experience of and preferences for art. However, the way that these components interact is still unclear.

Some of the model's main assumptions have been supported by the results of empirical studies. For example, Augustin and Leder (2006) confirmed the hypothesis that the

likelihood of style-related processing is greater with increasing expertise. Results of a classification task revealed that experts relied more on the artist's style. In another study, differential sensitivity to explanatory information about the style of abstract artworks was also shown to depend on the level of expertise, but also on a positive emotional state (Belke, Leder, & Augustin, 2006). The interplay of top-down orienting of attention and bottom-up perceptual facilitation was recently supported in a study employing fMRI in art perception (Cupchik, Vartanian, Crawley, & Mikulis, 2009). Evidence for an emotional response, when resolving ambiguity in cubist art, was presented by Kuchinke, Trapp, Leder, and Jacobs (2009). They measured changes in pupil dilation and saw these as indicators of emotion when perceivers suddenly recognized objects that were depicted in cubist paintings. However, the interplay amongst the various features of artworks is still not well understood.

In the present study, we employed a different approach. We measured preferences for different kinds of art as well as evaluations of elicited emotions, arousal and comprehension. We tested a large population of 136 participants and used structural equation modeling (SEM) to simultaneously analyze these features of aesthetic experiences (MacCallum & Austin, 2000). SEM indicates the relative weight of each variable. It also aims to reveal the complex interplay of factors affecting the dependent variables. However, it requires clear assumptions regarding the theoretical structure.

Which variables are considered important in affecting art appreciation? Level of abstractness, from purely abstract to representative, is often discussed. This dimension became an issue a century ago with the "invention" of abstract art by artists such as Kandinski and Malevitch. Since then, abstractness has been a major dimension to distinguish broad classes of artworks. In the model by Leder et al. (2004), various processing demands depend on whether the artwork has a representational content or not. For example, it was argued that the effects of style are particularly dominant in abstract art, for which by definition there is no clear content. Of course, higher-order interpretations such as finding meaning, occur at later stages of information processing and often rather rely on representational content. Consequently, in the present study we measured and analyzed the aesthetic appreciation of three different sets of artworks. The artworks varied in three levels of representativeness and represented a wide variety of styles. The classes of artworks included purely abstract compositions by e.g. Gerhard Richter and Fiona Rae (class called *abstract*); hyper-realistic modern collages by Jeff Koons and expressive depictive works by Baselitz, which contain recognizable objects in surreal contexts (called *modern*); and late 19<sup>th</sup> century classic paintings such as an indoor scene by Adolf von Menzel or impressionist landscapes by Monet

(called *classic*). As it has often been argued that expertise changes the way artworks are perceived (Leder et al., 2004; Locher, Smith & Smith, 2001), and that expertise comes along with greater appreciation of abstract or contemporary art, in the present study relative level of expertise was considered in all analyses.

Moreover, we measured how much artworks elicited emotion, how much they aroused, and how much they were understood. Regarding emotions elicited by art, appraisal theories discuss a wide range of emotions (Zentner, Grandjean & Scherer, 2007) that go far beyond the traditional models (e.g., Wundt, 1896) based on positive and negative emotions. Applying appraisal theory, Silvia and Brown (2007) examined under what conditions negative emotions in art appreciation occur. They presented participants with controversial contemporary artworks and found that in accordance with appraisal theories, anger was associated „with incongruency with one's values and as intentionally offensive, and disgust was associated with appraising a picture as incongruent with one's values and as unpleasant." (p. 100). Recent neuro-psychological studies found that brain regions that are active when people find objects beautiful are different from those that are active when people do find objects not beautiful (Kawabata & Zeki, 2004; Höfel & Jacobsen, 2007; Bar & Neta, 2007; Nadal, Munar, Capó, Rosselló, & Cela-Conde, 2008). However, in modern art, the concept of beauty has generally been abandoned, and the appreciation of modern art might be based on a more complex pattern of influences. Moreover, beyond the above studies, how emotions determine the aesthetic appreciation of modern art (Leder et al., 2004) is still inadequately addressed.

Arousal is closely related to emotion. According to Berlyne (1970), the arousal potential of a stimulus determines both emotional and aesthetic responses. Evidence for the preference for moderate levels of arousal has been weak and inconsistent (see Hekkert, 1995 for a discussion). Thus, predictions regarding the effects of arousal on art appreciation are difficult to make. The more innovative and unusual art is, the more it could arouse. However, arousal might also be closely connected to emotional valence, and therefore affect appreciation in a very similar way. In this case, emotion and arousal would show high interrelations.

According to the Leder et al. model (2004), comprehension and understanding occur in the later stages of information processing. These later stages are concerned with cognitive mastering, e.g. finding meaning and interpretation. In the present study, we conceptualized this aspect of information processing by asking how much perceivers believed that they understood each painting. Artworks that are not meaningful might not be liked. Millis (2001)



showed that titles presented together with artworks not only increased their understanding, but also affected their liking. In a similar study, Leder, Carbon, and Ripsas (2006) showed that while comprehension of abstract artworks depended on the kind of proceeding titles, liking was unaffected. Thus, comprehension might systematically vary with the contents of artworks.

If comprehension is based on explicit classification and ease of cognitive mastering (Leder et al., 2004), then classical art would be understood best, because it often has clear content (a room, river and bridge etc). Abstract art by definition lacks such depictive content. Folk psychology often assumes that abstract art will be seen as an expression of an artist's emotion. However, abstract art's lack of content might actually lead to greater opportunities for subjective interpretation, as it contains ideas, concepts and emotion, as well as art-specific references. This could even result in higher overall values in terms of comprehension. Finally, the artworks in the class of modern art were high in explicit classification, as identifiable objects were depicted. However, they were relatively high in ambiguity and definitely require some interpretation. If the openness to interpretation of the abstract artworks compensates for the lack of content, then the means for comprehension could be similar to those for the modern artworks.

Analyzing how artworks are processed using structural equation models could reveal for which kind of artworks a sense of comprehension is important and important for aesthetic appreciation. Representative, classical art might be understood in a similar way by all perceivers. Abstract art by definition has no depictive content. However, it is unclear whether a sense of understanding is essential for its appreciation. In contrast, the class of modern art, which in the present study consisted of a mixture of representational and abstract elements, might be prone to comprehension because of their ambiguity. Thus, the present study will empirically reveal whether modern or abstract paintings have a stronger need for interpretation (for a discussion, see Gehlen, 1960).

Whether different relationships between emotion and appreciation exist for different kinds of art can be explored by simultaneously analyzing the effects of several factors. In this study, we analyzed the means of ratings on several dimensions with regard to main effects and interactions, and used structural equation models (SEM) to detect more sophisticated relationships. If emotion and comprehension are specific to different classes of artworks, then these will load independently on aesthetic preferences. If aesthetic appeal is a function of a general factor that enables emotion or understanding, then such a mediating factor would be also revealed by the SEM solution.

The aesthetic appreciation of modern and contemporary art is assumed to depend strongly on aspects of cognitive mastering (Leder et al., 2004). Therefore, different levels of expertise, knowledge, experience and interest should determine the outcome of the processing stages involved. Thus, as was argued by Leder et al. (2004), there is strong interdependence between cognitive aesthetic judgments and aesthetic emotions for naïve or rather naïve perceivers. With increasing expertise, aesthetic experience might become more differentiated and the dimensions might be more loosely interconnected. In order to examine the influence of expertise, based on the results of a questionnaire we divided our participants into two levels of expertise. We investigated the aesthetic appreciation of three different classes of artworks: abstract, modern and classic. For each artwork, we measured its emotional valence, emotional arousal and comprehension. We present an approach in which the relationships between several variables and the aesthetic appreciation of art were analyzed using ratings and structural equation model solutions. This latter analysis is a promising step towards establishing a formal psychological model of art appreciation (Leder et al., 2004).

## Method

### *Participants*

One-hundred thirty-six students were recruited from the University of Vienna's Department of Psychology. Twenty-seven were male, and the mean age was 24.2 years (range = 16 to 62 years,  $SD = 7.6$ ). Expertise was measured using a nine-item questionnaire designed by the authors. The questions were concerned with art interest, frequency of museum visitation, retrospective evaluation of art education in school, importance of art in one's life, and interest in reading art-related books.

### *Stimuli*

Three classes of artworks were used: abstract (Hartung, Rae, Richter, van Velde), modern (Baselitz, Dubuffet, Koons, Lüperetz) and classic paintings (Menzel, Monet, Renoir, Signac). Two paintings by each artist were selected resulting in 24 paintings. These paintings and artworks were selected because they somehow had some resemblance in terms of color and general level of complexity. However, they differed in degree of abstraction.

### *Procedure*

All tests were conducted using a custom-made internet based program, Presenter 1. This program allowed the presentation of visual materials and measurement scales on an individually accessed webpage. In each trial, an artwork was presented together with one of the four scales. Participants gave ratings on seven-point Likert scales, ranging from 1 (= not at

all or negative) to 7 (= very much, or very positive). Emotional valence, arousal, feeling of comprehension of the artwork, and liking scales were used for each artwork. The scales were presented block-wise. Thus, in a block, all paintings were evaluated according to one dimension, and the presentation order of artworks within the block was randomized. Following these evaluations, we presented additional tests that were not analyzed for the present study, because we mainly focused on understanding the interplay among the four variables. Finally, participants' art expertise was assessed.

## Results and Discussion

### *Analyzing Evaluations*

All data were analyzed according to relative level of expertise. The responses to the art questionnaire, which consisted of nine scales that were all coded so that low values indicated higher interest and expertise in art, were summed for each participant. Internal consistency was high with a Cronbachs  $\alpha$  of .80. Assignment of participants to high or low expertise groups was based on the median split of this sum. Regarding the sums, the high and low expertise groups differed significantly ( $t(134) = 18.95, p < .001$ ). Sixty-nine participants were assigned to the high expertise group (experts) and sixty-seven were assigned to the low expertise group (non-experts). All data were analyzed according to the mean ratings on all dimensions for the three kinds of artworks, separately for the two levels of expertise. The mean ratings for all dimensions are shown in Table 1.

On all scales (with the exception of arousal ratings of classical paintings), ratings by experts were higher. Thus, expertise resulted in generally higher evaluations of how much artworks were liked, experienced as emotional, comprehended, and to what extent, experienced as arousing. Data in Table 1 show that there were no interactions with expertise. This may be due to the relatively narrow range of expertise tested here. Although schooling and exposure to urban environments may have imparted participants with art knowledge, explicit and elaborated expertise in art is rather limited in a population of psychology students. Therefore, future studies in which real art experts, such as artists, art students, and students of art history, are tested, are necessary. Such studies could show stronger effects.

Concerning the different types of artworks, classical artworks have clear content. They represent semantically meaningful objects, genres and scenes. Not surprisingly, they received high values on comprehension. Modern artworks, which are most ambiguous in terms of depicted content, received much lower values. These results are consistent with Leder et al.'s (2004) hypothesis that comprehension is based on content representation during the explicit

classification stage. Abstract artworks received the lowest values regarding comprehension. Thus, the argument that the lack of depicted, representative content increases the opportunity for subjective interpretations was not supported by the data. In this case, the means for comprehension could have been similar to those of the modern artworks. As can be seen in Table 1, this clearly was not the case.

The emotional valence and arousal dimensions revealed very different effects. Emotional valence was most positive for the classical paintings, and more positive for the abstract than the modern paintings. Arousal, on the other hand, was highest for the abstract paintings, and the modern paintings had higher values than the classical paintings. As revealed by the data in Table 1, the pattern of results of the emotional valence dimensions were most similar to the results of the liking dimension. Thus, concerning comprehension as a representation of the more cognitive part of aesthetic experience, there was no simple interaction such that comprehension was selectively higher for higher levels of expertise. For this dimension, the type of artwork determined the pattern results.

In order to systematically analyze the data, we calculated repeated-measurement ANOVAs separately for the four measures (aesthetic liking, arousal, comprehension and emotion) with art style (modern, abstract and classical) as within subject factors and expertise (experts vs. non experts) as between subjects factor (see Table 2 for exact statistics). For all analyses, main effects for art style were significant, thus indicating differences between art styles.

Regarding liking, participants significantly differed in their liking ratings for abstract (mean liking = 2.80), modern (3.78) and classical (4.27) art ( $ps < .001$  for all pair-wise comparisons, Bonferroni-adjusted). The main effect for expertise was significant, indicating that experts generally liked art more. However, no statistically reliable interaction of art style x expertise was found, indicating that the higher liking was essentially the same for every art style. Arousal was generally lower for classical (mean arousal = 3.22) than for modern (4.09) and abstract (4.38) art ( $ps < .001$  for all pairwise comparisons, Bonferroni adjusted). Although there was no significant main effect for expertise, the interaction of art style x expertise was significant, indicating that non-experts reported a higher degree of arousal than experts when looking at classical paintings, while for modern and abstract art experts reported higher arousal (see Table 1). Analysis of the emotion ratings revealed a significant main effect for art style only, indicating that – as with liking – participants reported a stronger emotional involvement for classical (mean emotion = 4.51) than for abstract (3.72) and modern (3.09) art ( $ps < .001$  for all pairwise comparisons, Bonferroni adjusted). Regarding comprehension,

participants reported a higher level of comprehension for classical (mean comprehension = 5.81) than for modern (3.58) and abstract (2.21) art ( $ps < .001$  for all pairwise comparisons, Bonferroni adjusted). Furthermore, experts generally reported higher values of comprehension than non-experts. However, no significant interaction of art style x expertise was found.

The effects of expertise were small: Participants of higher expertise gave significantly higher ratings on liking and comprehension. Regarding comprehension, these effects are not unexpected – experts can assign meaning to all kind of artworks through their knowledge. Interestingly, as liking ratings in experts were higher as well, this might indicate that higher understanding in experts is somehow linked to liking. These findings are relevant to a long-standing debate in art psychology of whether assigning meaning in artworks brings pleasure (Leder et al., 2006; Millis, 2001). Additionally, arousal revealed an interesting and somehow unexpected interaction effect of art style x expertise. While experts judged abstract and modern art as more arousing than non-experts, classical artworks were found more arousing by the non experts. This finding might refer to an arousal-content link, in that arousal as a positive by-product of identification might be linked to a psychologically controllable level of content.

Interestingly, comprehension varied strongly with the level of abstractness. Representative classic artworks were understood better than modern artworks, which in turn were understood better than abstract artworks. The opposite pattern was found for arousal. Experienced arousal was higher for the abstract artworks. Interestingly, modern art was liked least and elicited the least positive emotions.

These results are very informative. They are in accordance with the general assumption that the emotional aspects of art processing strongly determine aesthetic appreciation. The pattern of emotional judgments closely resembled the means of the liking judgments. However, to better understand these strong effects of emotional valence, we conducted structural equation modeling.

*Table 1.* Mean ratings on all scales split by expertise and type of artwork. *SDs* in brackets.

	Classical		Modern		Abstract	
	Expertise-high	Expertise-low	Expertise-high	Expertise-low	Expertise-high	Expertise-low
Liking	4.48 (1.1)	4.06 (1.3)	2.93 (1.0)	2.68 (1.0)	4.02 (1.2)	3.52 (1.3)
Emotion	4.67 (0.8)	4.36 (1.0)	3.11 (0.8)	3.07 (0.9)	3.82 (1.0)	3.62 (1.0)
Arousal	3.11 (1.0)	3.34 (1.1)	4.22 (0.9)	3.97 (1.1)	4.53 (1.0)	4.22 (1.2)
Comp.	6.00 (0.8)	5.62 (1.0)	3.69 (1.0)	3.47 (1.0)	2.35 (1.0)	2.06 (1.1)

*Table 2.* Analyses of variance for art style (within subjects) x expertise (between subjects) separately for the different dependent measures.

dependent	Art style				Art style x Expertise				Expertise			
	<i>df</i>	<i>F</i>	<i>p</i>	$\eta_p^2$	<i>df</i>	<i>F</i>	<i>p</i>	$\eta_p^2$	<i>df</i>	<i>F</i>	<i>p</i>	$\eta_p^2$
Liking	2, 268	60.76	<.001	.31	2, 268	0.42	n.s.	<.01	1, 134	9.10	<.01	.06
Emotion	2, 268	113.94	<.001	.46	2, 268	1.00	n.s.	<.01	1, 134	2.84	n.s.	.02
Arousal	2, 268	54.10	<.001	.28	2, 268	3.18	.043	.23	1, 134	.82	n.s.	<.01
Comp.	2, 268	542.49	<.001	.80	2, 268	0.28	n.s.	<.01	1, 134	7.41	<.01	.05

*Table 3.* Total effect in the SEM solution, separated for types of artworks and levels of expertise

	Classical		Modern		Abstract	
	Expertise-high	Expertise-low	Expertise-high	Expertise-low	Expertise-high	Expertise-low
Total effects						
<b>Emotion</b>						
Classical	.747	.773	-.011	.096	0	0
Modern	-.052	-.023	.473	.455	0	0
Abstract	0	0	0	0	.734	.786
<b>Comp.</b>						
Modern	-.002	-.035	.405	.448	0	0
<b>Arousal</b>						
Classical	.061	.268	-.106	.212	0	0
Modern	-.19	-.11	0	0	0	0
Abstract	0	0	0	0	.299	.024
<b>R<sup>2</sup></b>	<b>.58</b>	<b>.66</b>	<b>.52</b>	<b>.63</b>	<b>.61</b>	<b>.62</b>

Figure 1. Theoretical (full recursive) SEM model for the analysis of art appreciation

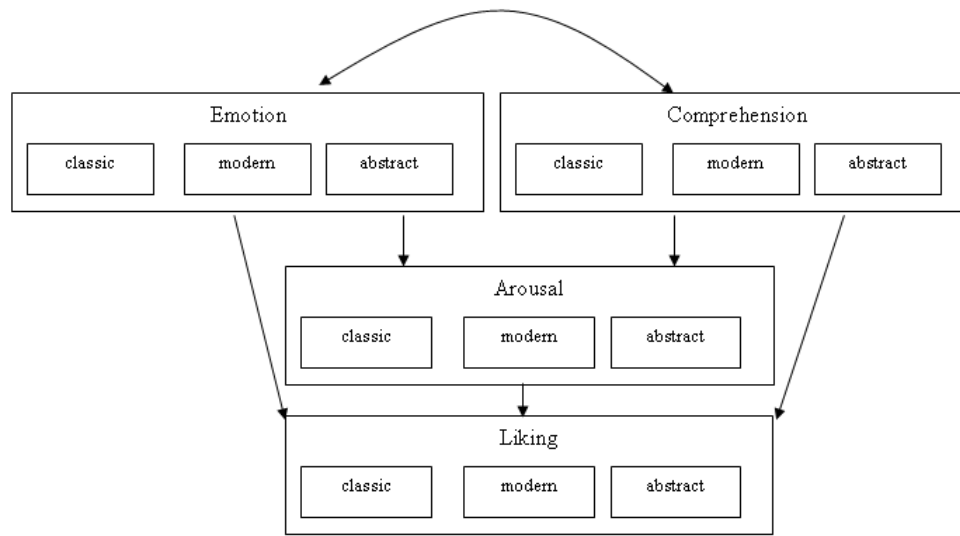
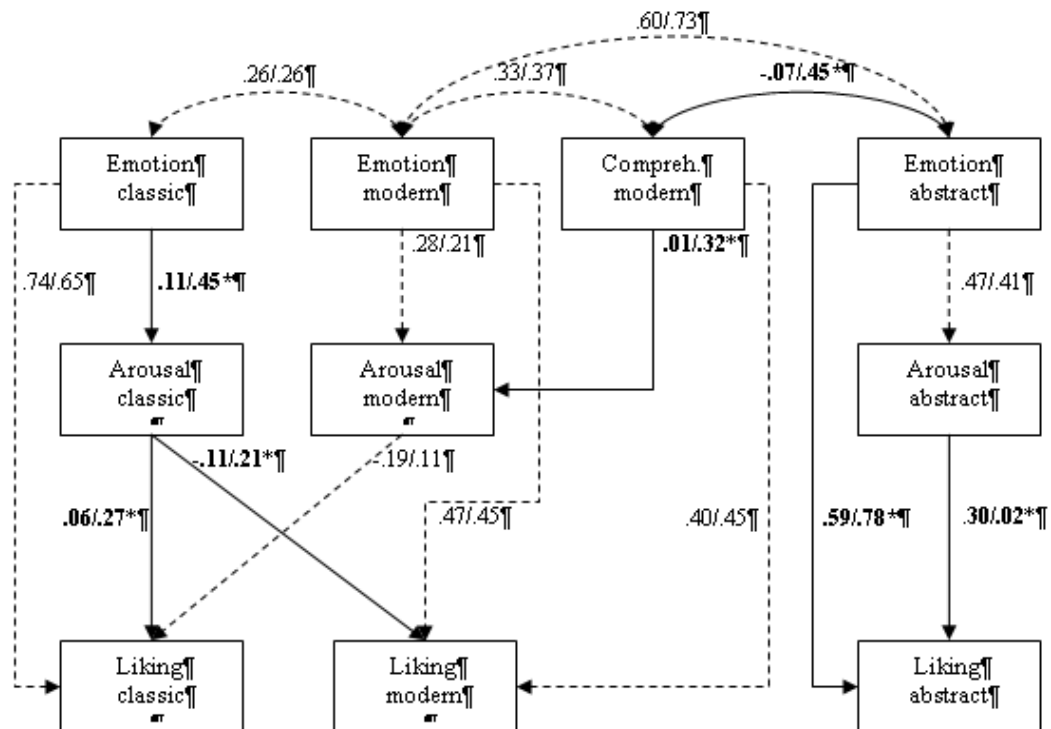


Figure 2. Two-group SEM model (final model; standardized solution) for the explanation of art appreciation. Full lines and \* represent effects that are statistically different for the two levels of expertise, with high-expertise (left parameters) and low-expertise (right parameters). Model FIT:  $\chi^2_{(60)} = 164.5$ ;  $p = .32$ ; GFI = .92; CFI = .99; NFI = .91; RMSEA = .02. Residual correlations ( $r_{\text{arousal classic-arousal abstract}} = -.15/-.25$ ;  $r_{\text{arousal modern-arousal abstract}} = .44/.55$ ) omitted.



*SEM analyses*

To analyze the relative influence of the predictors (emotion, comprehension, arousal) on the liking for art, we conducted a series of two-group (experts, non-experts) structural equation models (SEM). The models were specified in terms of the main assumptions derived from Leder et al.'s (2004) model. According to the model, comprehension represents the outcomes of the cognitive processing stages, and emotion and arousal together represent the outcomes of the affective pathway. Both are thought to contribute to art appreciation measured here in terms of liking. Because this model has not yet been tested using SEM, we first specified a full recursive model in which all parameters were estimated simultaneously for the two groups of expertise but were allowed to differ. This model is shown in Figure 1. Second, all parameters that were equal to zero according to their critical ratios (CR; e.g. Byrne, 2001) were fixed to zero. A predictor was omitted if its effect on all other variables appeared to be zero (regardless of possible correlations with other predictors). This was the case for comprehension of classical and abstract art. This reduced model was rerun, and the remaining parameters of the two groups were compared using the critical ranges for difference ( $CR_{diff}$ ) to see whether they were numerically the same for experts and non-experts. Finally, parameters that appeared numerically equal for both groups were fixed to be equal. This model was compared to the previous model and a full-restricted model in which all parameters were set to be equal for both expertise groups. According to the total model fit, the semi-restricted model (only some parameters different for experts and non-experts) statistically showed the same fit as the unrestricted model (all parameters allowed to differ;  $\Delta\chi^2 = 13.9$ ;  $df = 8$ ;  $p = .08$ ) but a poorer fit than the full-restricted model ( $\Delta\chi^2 = 59.2$ ;  $df = 15$ ;  $p < .01$ ). This indicated that the semi-restricted model was preferable in terms of model fit and parsimony. Figure 2 shows the model, which is the result of the optimization of the modeling process. It shows all the variables that were found to be effective in affecting liking of the artworks. Arrows indicate the direction of effects, with dotted lines representing effects found for both levels of expertise and solid lines representing different effects with respect to expertise.

We also calculated the total effects, which are the contributions of all the different predictors separately in each condition. These values are shown in Table 3. Overall, the model explained about 60% of the variance for all paintings. Given the assumption that art seems to be a very subjective part of human culture, this value is surprisingly high. Thus, it seems that the variables measured here significantly account for the aesthetic appreciation for different types of artworks. As expected, the model's predictive strength is slightly higher for classical



and abstract art. These two types of artworks are rather unambiguous regarding content, as compared with modern art, which by its nature is more ambiguous.

Moreover, we also analyzed zero-order correlations between scales for the different classes of artworks. These are shown in Appendix A. In these zero-order correlations, a comparable but less comprehensive pattern of results was found. Importantly, the results did not contradict the overall model solution. However, the SEM model provides a more complete, complex, and interesting representation of the data.

### *Determinants of Liking for Art*

As Table 3 shows, the overall power of the model was slightly lower for the higher expertise group. This is an interesting finding, which is in accordance with the assumption of a process of differentiation through expertise, in which individual differences (individual preferences and taste) become stronger. Processes of differentiation with increasing expertise were assumed by Leder et al. (2004) and support the notion of increasingly finer distinction as essential in cultural differentiation (Bourdieu, 1979).

Concerning the weight of the predictors, the analyses showed clear results. Emotion was the strongest predictor of liking for all three types of artworks. This was most apparent for the classical and abstract artworks, and to a lesser degree for the modern artworks. This clearly indicates the role of emotion in cases where the results of the explicit classification stage are somewhat clear. For example, classical art has depictive content, so emotional effects determine their processing. Also, emotion determined liking when there was no apparent content in the abstract artworks. The case was different for the more ambiguous modern artworks, which had representative elements without clear semantic representations. Only in these paintings did comprehension play a significant role. This is revealed in Figure 2 by the arrow from “comprehension of modern art” to “liking of modern art” (effect size .40/.45). Liking of modern art was affected to a similar extent by emotion and comprehension. This is clear evidence for the interplay between cognitive and emotional processes as assumed in the model of aesthetic appreciation (Leder et al., 2004). However, the case is restricted to modern art artworks presumably because the need to understand art is greatest when the content is somewhat ambiguous. This is also in accordance with the mean values presented in Table 1. While classical artworks were high in comprehensibility, abstract paintings were not; and modern paintings were moderately comprehensible. The comprehension of modern art directly affected its liking. This is different from Gehlen’s (1960) claim that the need for interpretation should be particularly strong in abstract art. Abstract artworks as a type of art

are now widely established. Thus, the findings for abstract artworks might be due to factors such as educational background and knowledge. This somehow corresponds to some naïve statements concerning the expressive function of abstract art. It seems that the emotional valence elicited by abstract artworks was very similar to their aesthetic appeal.

The SEM solution provides strong support for the hypotheses that emotions are important for aesthetic experiences (Scherer, 2003). However, the findings are not in accordance with arousal models of aesthetics (Berlyne, 1970; 1974). In this study arousal only had small effects. These effects were slightly larger for experts in the case of abstract art, and slightly smaller for non-experts in the case of classical art.

As shown in Figure 2, while abstract artworks somehow appear as a distinctive class, the pattern of results for modern and classical artworks was similar. However, there was also an effect of the comprehension of modern art on emotion of abstract paintings for the non-experts. Non-expert's judgments of the emotionality of abstract art were somehow associated with greater belief that they had an understanding of the modern paintings. Thus, more generally, mastering the cognitive challenge of modern art came along with higher emotions for abstract art.

Most of the effects were consistent with our general framework of predictions. Nonetheless, there was a small effect, which indicated that the amount of arousal for classical and modern art affected the liking of the other class of artworks. Though very small, these effects might reflect some overlap in the processing of meaning; finding modern art arousing affects the liking of classical art, and finding classical art arousing affects the liking of modern art. Interestingly, neither effect of arousal was related to abstract art. Thus, as there is an overlap between the semantic representation of these two classes (classic, and modern), the amount to which these were seen as arousing somehow went along with the other class. Another small effect between the levels of expertise was found between the comprehension of modern artworks and the emotion for abstract artworks. This might be due to non-experts considering abstract and modern art as being more similar than experts. For the latter, both classes of art were clearly different. Whether these explanations hold should be the subject of future studies that investigate what perceptions and processes develop with increasing expertise.

### *Effects of level of Expertise*

The SEM analyses found significant differences regarding level of expertise. The effects of were generally consistent with the means (see Figure 2 and Table 1). The effects

were stronger for non-experts in six out of the seven analyzed comparisons. Only in the arousal for abstract art were the effects stronger for the experts. The effect of emotion was also stronger for this class of artworks. The effects of comprehension suggest a differentiated picture: effects of comprehension on experienced arousal of modern art were only found in non-experts, but the direct link between comprehension and liking of the more ambiguous modern art was similar for both levels of expertise (.40/.45). Thus, the SEM analyses again revealed that the effects of variables assumed to affect art appreciation were greater for non-experts than experts. This was particularly the case for classical art, in which the effects of arousal were generally stronger for naïve participants. For modern art, apart from the exception of comprehension, effects were similar for both levels of expertise. Finally, for non-experts, abstract art arousal effects were weaker but emotional valence had a stronger effect on liking.

#### *Total effects*

Table 3 shows the total effects separately for the three kinds of artworks and levels of expertise. This depiction clearly shows how similar the model solutions are for the classical and abstract artworks. Only the liking of the modern artworks significantly affected emotion and comprehension. Comprehension and emotion had very similar effects. Moreover, although arousal had small effects, these effects were slightly higher for non-experts.

#### Conclusions

How can the findings be summarized? There were surprisingly strong effects of emotion. The effects were even stronger for non-experts. There was also a difference in experienced emotion between modern and abstract artworks. Thus, regarding our hypotheses concerning emotion and comprehension, the findings did not support the presence of one general factor that mediates emotion and understanding. There were specific effects for different classes of artworks. All other effects were of moderate effect size. The findings regarding the modern artworks were most informative. Effects of comprehension were found only in these artworks, and support the conjoint involvement of emotion and cognition.

Moreover, the two methods of analyzing a large set of ratings data revealed an interesting insight regarding art appreciation. Nearly all ratings were higher with higher level of expertise. This means that experts not only liked all artworks more, but also found all artworks more understandable and more emotional than non-experts. This can be interpreted as a general effect of expertise. Thus, while expertise somehow strengthens art related

experiences, SEM analyses revealed that the inter-correlations among most variables were lower with higher level of expertise.

Thus, we see an interesting pattern: expertise increases liking and all contributing factors; but expertise also comes along with a less constrained interplay of variables that determine art appreciation. This seems to be the main finding of the present analyses. It is in accordance with a flexible and idiosyncratic way of processing art, which is a feature of expertise as assumed by Leder et al. (2004). Thus, the present analyses serve as a promising starting point for further explorations of the processes underlying differentiation and specialization in expertise. Moreover, comprehension and liking ratings for the three kinds of artworks mainly showed that comprehension depends on identifiable content. Modern art, which is higher in depictive content than abstract art, was better understood. This is not in accordance with the assumption, that openness to subjective cognitive mastering of the less constrained abstract art, elicited feelings of understanding. The results support the assumption that comprehension is higher when it is being based on depicted content.

In everyday life, expertise is presumably a continuous variable covering a broad range of values. In the present study, the two levels of expertise were defined according to a median split, and the range of expertise was rather limited. In order to better understand the effects of education in art, and changes in the underlying processes that accompany increasing expertise, future studies could use more differentiated groups of participants. For example, they could test experts such as art students, artists, and art historians. Further studies might also more directly address the question of which processes determine experts' liking. Candidates for such processes include processing fluency (Leder, 2003; Reber, Schwarz, & Winkielman, 2004), consideration of familiarity and recognition of authenticity (Leder, 2001), or coping with ambiguity (Jakesch & Leder, 2009).

The methods used in the present study also open a variety of opportunities to answer questions regarding a comprehensive psychology of the arts. For example, differences in personality that affect aesthetic processing, such as levels of sensation seeking (Zuckerman, 1971; Swami, Stieger, Pietschnig & Voracek, 2010) might also be considered. Developmental studies could examine whether the strong emotional component found here develops with age and expertise. Such studies could then assess the components involved in the development of art processing as proposed by Housen (2002).

The artworks used in this study belonged to three categories. In order to test hypotheses concerning the interaction between cognitive and emotional processing (Leder et al., 2004), follow-up studies should consider varying the emotionality of the artworks directly

(Silvia & Brown, 2007). Moreover, if art professionals are tested, more conceptual artworks could be included, which would increase the need for interpretation. The use of such artworks would not have been reasonable in the present study because the participants, in general, did not have elaborated expertise.

The findings also have implications for practitioners. The findings suggest that art education is not merely a luxury that enables social distinction or canon-related refinement; an increase in art interest and expertise is associated with more positive and generally stronger experiences of art. This is a possible function of art, particularly of modern, contemporary art. The findings also provide support for the real-life implications of Leder et al.'s (2004) stage-model of aesthetic experiences of art, which aims to explain why art is so fascinating.

In the present study, art appreciation was based on strong effects of emotion. This applied to all styles of art and was independent of expertise. The inter-correlations between emotion and understanding were consistently higher for non-experts. Expertise was also associated with stronger experiences in nearly all respects. Moreover, expertise was associated with greater differentiation in the interplay of variables affecting aesthetic experiences (Leder et al., 2004). Thus, as often assumed but rarely shown, emotion seems to be the strongest predictor of art appreciation.

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## Appendix A

Zero-order correlations split by style of artworks and levels of expertise.

	Classical			
	Liking	Arousal	Comp.	Emotion
Liking	–	.170/.572***	.279*/.172	.750***/.754***
Arousal		–	.017/.259*	.120/.464***
Comp.			–	.291*/.147°
Emotion				–
	Modern			
	Liking	Arousal	Comp.	Emotion
Liking	–	.286*/.538***	.508***/.683***	.558***/.680***
Arousal		–	.132/.435***	.149/.549***
Comp.			–	.160/.477***
Emotion				–
	Abstract			
	Liking	Arousal	Comp.	Emotion
Liking	–	.559***/.473***	.333**/.612***	.712**/.807***
Arousal		–	.233/.312*	.389**/.552***
Comp.			–	.304*/.618***
Emotion				–

Table Note. Table entries are the two levels of expertise, with high-expertise (left parameter) and low-expertise (right parameter).

\* $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

### 5.3 Summary & Outlook

The findings demonstrate important insights into the appreciation of art. Although art appreciation is often assumed to be highly idiosyncratic the overall result, the SEM explaining approximately 60 % of the variance for all paintings suggests that the variables tested were important and are indeed general contributors of art appreciation. Interestingly, as often assumed, emotional valence turned out to be the strongest predictor (with stronger effects for non-experts) to the aesthetic evaluation for all three kinds of artworks. The effects for the other variables were weaker. The effects for appreciating modern art were very informative. Comprehension became an important predictor solely within this category. Effects of emotionality and comprehension similarly contributed to the liking of modern art, demonstrating the interplay of emotional and cognitive processes for aesthetic evaluations (Leder, et al., 2004). That comprehension was only an important predictor for this category of artwork might be due to the notion that the need for understanding is greatest when the content is somehow ambiguous – modern artworks had representative elements but lacked clear semantic representations; classic artworks had clear content and thus were debatably not ambiguous at all, whereas abstract art had no content and proved highly ambiguous. This finding is in line with the results by Jakesch and Leder (2009) where moderate levels of ambiguity were preferred in appreciating modern art.

Although small in absolute numbers the comparison between experts and non-experts revealed interesting effects: on the one hand, ratings showed a general effect of expertise – experts appreciated the paintings more, found them more understandable and more emotional than non-experts. On the other hand, the SEM analyses revealed that the inter-correlations between most of the variables were weaker, suggesting that experts gave less constrained and more differentiated ratings than non-experts. This is in line with the assumptions of the Leder et al. (2004) model, that expertise comprises more flexible and idiosyncratic ways of aesthetic processing. However, as the range of expertise was rather limited within our sample, as it consisted of psychology students with often limited experience in art, future studies would benefit from using more differentiated groups (by testing e.g. artists, art historians or art students) to explore differences due to a higher level of expertise. Moreover, future studies could examine how the impact of the emotional component develops with age and expertise over time.

The current study replicates the findings of the previous research. In this study, emotional valence was one of the strongest predictor for aesthetic evaluations measured by

attractiveness. This finding is in line with the findings in chapter 3 and in chapter 4.4 using different stimulus classes – faces and car interiors. In both chapters emotional valence of the stimuli also turned out to be an important factor determining attractiveness. Thus, emotional valence seems to be one of the main factors influencing attractiveness evaluations regardless of the type of stimulus evaluated.



## 6 General Discussion and Outlook

This dissertation project studied affective and cognitive aspects of aesthetic evaluations for various classes of objects – artificial patterns, faces, design products, and artworks. In order to uncover mechanisms that determine aesthetic evaluations the studies employed different approaches - studying the physiological aspects of the aesthetic evaluations (chapter 2), systematically studying dynamic changes in aesthetic evaluations due to familiarization (chapter 3) and repeated evaluations (chapter 4), and, finally, studying emotional and cognitive variables influencing aesthetic evaluations (chapters 4.4 and 5). Together the studies demonstrated that aesthetic evaluations are influenced by a complex interplay of many variables – variables of the classes of objects (all chapters), variables comprising contextual aspects (chapter 4.2, 4.3, 4.5), variables of the specific stimulus dimensions in the objects (chapter 3, 4, 5) and variables of the perceiver (chapter 5). In terms of the Leder et al. (2004) model, which served as a framework for the present studies, the results reiterate the importance of considering bottom – up and top – down processes in aesthetic evaluations (Cupchik, Vartanian, Crawley, & Mikulis, 2009; Kirk, Skov, Hulme, Christensen, & Zeki, 2009). The dissertation replicated previous findings (e.g. Carbon & Leder, 2005; Kaplan, et al., 1972; Winkielman & Cacioppo, 2001), tested and extended existing experimental paradigms by employing massive familiarization (Tinio & Leder, 2009a; chapter 3) or the repeated evaluations technique (RET; Carbon & Leder, 2005; chapter 4) and employed a physiological research method (facial EMG, chapter 2) in the Vienna group for the first time.

The studies regarding physiological consequences of aesthetic evaluations (chapter 2) by recording facial EMG, found similarities and differences in the physiological correlates for natural (faces) and artificial categories (abstract patterns). Regarding similarities attractive faces and patterns resulted in stronger zygomaticus activations and unattractive faces in patterns in stronger corrugator activations. However, a fluency related effect, indicated by a stronger zygomaticus activation (Winkielman & Cacioppo, 2001), was observed only for the patterns, and not the faces. These contrasts were interpreted in terms of different appraisal processes contributing to the aesthetic evaluations (Scherer, 1984; Scherer & Ellgring, 2007a) – faces, because of their biological, social and socio-sexual relevance (Ekman & Rosenberg, 1997; Thornhill & Gangestad, 1999) might trigger more complex appraisal processes than the abstract patterns where this biological and social relevance is lacking.

The results of the studies in chapter 3 also support the above finding that there are differences in the aesthetic evaluation between natural and artificial categories. The study in chapter 3 specifically revealed that emotional valence overrode the effect of the stimulus dimension of complexity. While complexity was perceived as aesthetically positive in previous studies (Cox & Cox, 1988; Jacobsen & Höfel, 2001; Martindale, et al., 1990; Tinio & Leder, 2009a) in this study- for faces - it was evaluated as aesthetically negative. This negative evaluation might be due to high complexity in faces being perceived as emotionally negative. Negative emotionality in faces can influence attractiveness evaluations (Müser, et al., 1984).

Moreover, dynamic changes of aesthetical evaluations differed between faces and artificial patterns as a function of massive stimulus exposure. While for faces changes after familiarization were in line with mere exposure (Zajonc, 1968) and with structural generalization effects (Gordon & Holyoak, 1983; Monahan, et al., 2000; Zizak & Reber, 2004) for patterns the opposite, a contrast effect, had been reported (Tinio & Leder, 2009a). Structural generalization effects are in line with explanations that familiar stimuli are preferred (Zajonc, 1968) while the contrast effect for the abstract patterns found can be explained by preference for novelty (Biederman & Vessel, 2006). With regard to the aesthetic model of Leder et al. (2004) these results extend the model by demonstrating that aesthetic evaluations are intimately influenced by the type of stimulus – either artificial, as in the patterns or natural as in the faces. Keeping perceptual factors like complexity and symmetry (chapter 3), stimulus presentation durations (chapter 2) and cognitive factors like familiarization constant, uncovered differences in the aesthetic processing of these stimuli.

The studies in chapter 4 investigated dynamic aspects of aesthetic evaluations of innovative stimulus materials by employing a recently introduced experimental procedure – the repeated evaluation technique (RET; Carbon & Leder, 2005). The studies were embedded in an applied context of testing the dynamic changes of aesthetic evaluations of innovative car interiors. However, conclusions can be extended to more general mechanisms of how our brains adopts to innovative, and somehow novel, material.

In the study in chapter 4.2 it was investigated how context influences the aesthetic evaluations and dynamics of the car interiors in terms of different stimuli sets (sets of stimuli either heterogenous or homogenous in innovativeness) employed. Innovativeness had an effect only when a set heterogenous in innovativeness was used – highly innovative, in contrast to low innovative, stimuli were initially disliked but gained in attractiveness over time (as in Carbon and Leder, 2005). In Berlyne's terms (1970a) innovativeness might thus be

seen as a collative stimulus property in that the appreciation of innovativeness depends on the relation of different stimuli. The semantic priming study in chapter 4.5 extended these findings by showing that the dynamics of appreciation of innovativeness depended on whether innovativeness was explicitly evaluated during the first stimulus encounter, that is, whether the evaluative context during first stimulus exposure influenced the dynamics. Thus, appreciation of innovativeness depends on the awareness and the explicit evaluation of innovativeness.

The studies manipulating situational context in chapter 4.3 demonstrated that appreciation of innovativeness did not only depend on the awareness or the explicit evaluation of innovativeness but also on how innovativeness was evaluated. In this study the quality of the elaborations in the repeated evaluation phase had an impact on the dynamics of innovativeness. Stressing dangerous aspects during repeated evaluations resulted in different dynamics than when stressing fascinating aspects. This clearly demonstrated that not only does familiarization (Zajonc, 2001) or unspecific elaboration (Carbon & Leder, 2005) of the stimuli have an influence on dynamic changes in aesthetic evaluations, but also that aesthetic evaluations depend on the quality of elaboration. As a conclusion, this supports the hypothesis that our aesthetic sense is context dependent. This is in line with situated cognition accounts (Schwarz, 2007; Smith & Semin, 2004) and with the Leder et al. model (2004), as well as recent findings in which visual exploration of beauty was also shown to be sensitive to situational demands (Leder et al., in press). Moreover, this result demonstrates that the RET allows for testing specific manipulations, for example, by employing evaluation sets that promote either positive or negative emotional processing, that go beyond simple stimulus familiarization procedures as in the mere exposure paradigm (Zajonc, 1968). Thus, the RET could be a promising account to further explore the link between affective and cognitive processing on aesthetic evaluations.

The study in chapter 4.4 was aimed at uncovering the relations among cognitive and emotional variables to aesthetic evaluations, thus contributing to one's understanding of which variables are important for aesthetic evaluations. Besides the finding that innovativeness predicted changes in attractiveness as in the previous studies, this study corroborated the importance of emotional factors as one of the main contributors to attractiveness evaluations. Arousal and valence, two main dimensions of emotions (J. A. Russel & Mehrabian, 1977), were the most important predictors in determining attractiveness. This suggests that emotional aspects are core factors in determining aesthetic evaluations measured by attractiveness.

Of course, open questions remain. The generalization to other object classes remains an open issue. Here we used car interior stimuli because the aesthetically relevant dimension can be controlled quite easily within these classes of stimuli. However, it is questionable whether the strong dynamics observed here can be observed within other object classes controlled for similar dimensions like, for example, natural categories like faces or natural scenes. The study in chapter 3 already provided support that the dynamics of aesthetic evaluations differ between natural and artificial categories, for which a strong biological basis of the aesthetic evaluations can be assumed.

In the experiment in chapter 4.3 we found that under specific conditions, when negative aspects of innovativeness were framed, effects of repeated stimulus evaluations persisted over one week. However, in real life context we have evidence that dynamics of aesthetic evaluations for artificial categories (car exteriors) are longer lasting and persist over years (Carbon, 2010). Future research could therefore employ testing paradigms over longer periods of time to uncover which factors contribute to long lasting changes in aesthetic evaluations in the long term.

The last study tested the assumption that emotional and cognitive factors both contribute to the aesthetic evaluations (Leder et al., 2004) of artworks. In order to determine the impact of these factors on aesthetic evaluations, structural equation modelling – SEM (Byrne, 2001) – was used. Emotional factors turned out to be the most important predictors determining aesthetic evaluations for different kind of artworks – classic, abstract and modern. This is another indicator of the importance of emotional valence in the overall aesthetic evaluations (see studies in chapter 2 and chapter 4.3). Cognitive factors were measured by comprehension of the artworks. Comprehension only influenced the aesthetic evaluations for one class of stimuli – the modern artworks, which were ambiguous but somehow interpretable. This means that the type of stimulus influences the balance between affective and cognitive aspects contributing to aesthetic evaluations. Additionally, this study demonstrated that perceiver variables, measured by relative art expertise, influenced aesthetic evaluations. Participants, with higher expertise in art, showed distinctive effects in giving less constrained ratings, as indicated by the contrasting lower effects for participants with higher expertise. However, as the scope of art expertise was limited in the current sample of psychology students, future research seems warranted, employing groups with higher level of expertise (e.g. art historians, artists or the like). This will allow to further test hypotheses regarding the nature and consequences of expertise on aesthetic evaluations (Kirk, et al., 2009).



The studies of this dissertation provided insights and aided progress in understanding the mechanisms of aesthetic evaluations. They demonstrated that aesthetic evaluations are a multifaceted behaviour governed by a complex interplay of both emotional and cognitive aspects and the type of stimulus evaluated. Future research could further explore the issues raised here. For example, further study could focus on which underlying processes specifically contribute to the differences in the aesthetic evaluations between different classes of stimuli. Additionally, studying the emotional aspects of aesthetic processing, by employing different neuro-physiological methods like EEG or fMRI (e.g. Aharon, et al., 2001; Altenmüller, Schurmann, Lim, & Parlitz, 2002; Blood & Zatorre, 2001; Winston, O'Doherty, Kilner, Perrett, & Dolan, 2007) could reveal insight into the temporal (short term) aspects of beauty processing, or provide information about brain structures involved. However, the present studies are a promising step towards the understanding of why we find some objects more attractive than others.



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## I. Appendix

### I.I Zusammenfassung

Menschen haben einen ausgeprägten Sinn für ästhetische Wahrnehmung. Wir können ästhetische Urteile für zahlreiche verschiedene natürliche Kategorien, wie z.B. Gesichter und Landschaften, oder aber auch künstliche Kategorien, wie z.B. Kunstwerke, Design oder abstrakte Muster fällen. Die ästhetische Wahrnehmung für diese verschiedenen Kategorien wird durch ein komplexes Zusammenspiel von verschiedenen Faktoren und Prozessen beeinflusst, die sowohl kognitive als auch emotionale Aspekte umfassen (Leder, Belke, Oeberst, & Augustin, 2004). Das Studium von ästhetischer Wahrnehmung kann daher zu einem tieferen Verständnis beitragen, wie kognitive und emotionale Faktoren generell evaluative Urteile bei Menschen beeinflussen. Um die unterschiedlichen Aspekte ästhetischer Wahrnehmung und deren Abhängigkeit von verschiedenen Stimuluskategorien (Gesichter, abstrakte Muster, Gemälde und Autoinnendesigns) besser zu verstehen, wurden in der vorliegenden Dissertation ein große Bandbreite verschiedener Methoden angewandt: psychophysische (Messung der Reaktion der mimischen Muskulatur) oder behaviorale Messungen, sowie aktuell entwickelte experimentale Methoden wie massive Bekanntmachung (*massive familiarization*, Tinio & Leder, 2009a) und wiederholte Stimulusevaluation (*repeated evaluation technique - RET*, Carbon & Leder, 2005).

Die Dissertation beinhaltet sieben verschiedene Forschungsarbeiten, die grob in drei teilweise überlappende Gruppen, eingeteilt werden können – 1) Studien, die sich mit emotionalen Reaktionen bei ästhetischer Wahrnehmung beschäftigen, indem emotionale Reaktionen mittels physiologischer Methoden gemessen werden (Gerger, Leder, Faerber, & Carbon, eingereicht; Kapitel 2); – 2) Studien, die dynamische Veränderungen von ästhetischer Wahrnehmung durch Bekanntmachungsprozesse (Tinio, Gerger, & Leder, 2010, Kapitel 3) oder mittels RET (Gerger, Leder, Faerber, & Carbon, eingereicht, Kapitel 4.2; Leder, Faerber, Gerger, Forster, & Carbon, 2010, Kapitel 4.3; Gerger, Leder, Faerber, & Carbon, 2010, 4.4; Faerber, Leder, Gerger, & Carbon, 2010) untersuchen und – 3) Studien, die die Interaktion von kognitiven und emotionalen Variablen bei ästhetischer Wahrnehmung untersuchen (Gerger et al., 2010, Kapitel 4.3; Leder, Gerger, Dressler, & Schabmann, in Druck, Kapitel 5).

In der Studie von Gerger et al. (eingereicht) wurde gezeigt, dass es Unterschiede und Gemeinsamkeiten in der ästhetischen Wahrnehmung zwischen künstlichen und natürlichen Kategorien gibt, wenn die dabei ablaufenden physiologischen Reaktionen über

Veränderungen der mimischen Muskulatur, die ein Indikator für emotionale Reaktionen sind, gemessen wurden. Die Studie von Tinio et al. (2010) zeigte, dass die visuellen Stimulusdimensionen Komplexität und Symmetrie einen stabilen Einfluss auf die ästhetische Wahrnehmung von Gesichtern haben, der aber durch massive Bekanntmachungsprozesse beeinflusst wird. Außerdem wurden in dieser Studie im Vergleich zu einer früheren Studie (Tinio & Leder, 2009a) sowie im Vergleich zu der Studie in Kapitel 2 unterschiedliche Effekte für künstliche (abstrakte Muster, Tinio & Leder, 2009a) und natürliche (Gesichter, diese Studie) Kategorien gefunden. Diese Ergebnisse legen nahe, dass es Unterschiede in der ästhetischen Wahrnehmung zwischen künstlichen und natürlichen Kategorien gibt. Die Studien in den Kapiteln 4.2 – 4.5 untersuchten, wie sich die Stimulusdimension Innovation, die durch Neuheit charakterisiert wird, auf ästhetische Wahrnehmung und deren dynamische Veränderung auswirkt, wenn Autoinnendesigns bewertet wurden. In dieser Studie wurde ein vor kurzem eingeführtes experimentelles Paradigma angewandt – das RET (Carbon & Leder, 2005). Die Ergebnisse zeigten, dass Stimuluskontext (Kapitel 4.2), situationaler Kontext (Kapitel 4.3) sowie evaluativer Kontext während der ersten Stimuluseinschätzungen (Kapitel 4.5) die ästhetische Wahrnehmung von Innovation und die Veränderung dieser beeinflusst. Darüber hinaus wurde in der Studie in Kapitel 4.4 das Zusammenspiel von kognitiven und emotionalen Variablen auf die ästhetische Wahrnehmung untersucht. Die Ergebnisse zeigten, dass emotionale Variablen die ästhetische Wahrnehmung am besten voraussagten. Dies wurde auch in der Studie von Leder et al., (in Druck) gefunden. In dieser Studie wurde der Einfluss von kognitiven und emotionalen Variablen auf die ästhetische Wahrnehmung von Gemälden untersucht. Emotionale Valenz war der stärkste Einflussfaktor für die ästhetische Wahrnehmung. Allerdings modulierten der Stil des Gemäldes (abstrakt, modern und klassisch) und die Expertise der Versuchspersonen den Einfluss der kognitiven und emotionalen Variablen auf die ästhetische Wahrnehmung.

Die Studien werden in den jeweiligen Kapiteln durch einen kurzen Einleitungsteil vorgestellt, der die wissenschaftlichen Forschungsfragen expliziert. Die originalen Artikel sind danach beigelegt. Am Ende jedes Kapitels werden die Studien in Relation zu Befunden in der empirischen Ästhetik im Speziellen und zu Befunden in der empirischen Psychologie im Allgemeinen diskutiert. Die Dissertation schließt mit einer allgemeinen Diskussion und einem Ausblick auf zukünftige Studien.





## I.II Curriculum Vitae (abridged)

Mag. rer. nat. Gernot Nikolaus Gerger

born 23.01.1976 in Vorau  
Citizenship: Austria

### Education

- 10/2006 – PhD Studies in Psychology (Dr. rer. nat.), University of Vienna.
- 3/1997 – 3/2000 Studies of Medicine, Medical University of Vienna.  
Erster Studienabschnitt [Preclinical part]
- 10/1995 – 04/2006 Studies of Psychology, University of Vienna.  
Title of thesis: *Evozierte kortikale Potentiale beim inzidentellen Enkodieren von oberflächlich verarbeiteten Wortpaaren in Abhängigkeit des späteren Erinnerungserfolges* [Event related potentials of shallow encoded word pairs in dependence of later memory retrieval]

### Professional Experiences in Academia

- 02/2010 – 08/2010 Researcher in the project: *Der Einfluss von Brillenmerkmalen auf die Gesichtsanziehung und Gesichtswahrnehmung* [The Influence of Glasses on Facial Perception and Appreciation], for Silhouette International Schmied AG, Linz.
- 10/2006 – 12/2009 Researcher in the FWF (Fonds zur Förderung der wissenschaftlichen Forschung – National Austrian Scientific Fund) project P18910: *Psychology of Aesthetics: The Dynamics of Innovativeness and Appreciation over Time*, Faculty of Psychology, University of Vienna.
- Fall 2007, Spring 2008, Fall 2008, Fall 2009 Lecturer for *Proseminar Allgemeine Psychologie* [Proseminar General Psychology], Faculty of Psychology, University of Vienna.
- 04/2005 – 07/2006 Research Assistant at the Sleeping Laboratory, Medical University of Vienna.
- 03/2003 – 02/2006 Student Assistant and Tutor at the Department of Biological Psychology, Faculty of Psychology, University of Vienna.

**Spring Schools/ Summer Schools/ Workshops**

- 03/2008                      Spring School: *Functional Magnetic Resonance Imaging in Psychological Research*, Bender Institute of Neuroimaging, Justus-Liebig-Universität Gießen.
- 03/2008                      Workshop: *Augenbewegungen als Biosignale und Indikatoren psychologischer Konstrukte [Eyemovements as Indicators of Psychological Constructs]*, Universität zu Köln.
- 06/2003                      Workshop: *Low Resolution Brain Electromagnetic Tomography – LORETA*, Institut für Hirnforschung, University of Vienna.

**Publications:**

- Gerger, G., Leder, H., Faerber, S. J., & Carbon, C. C. (in press). When the others matter - Context-dependent effects on changes in appreciation of innovativeness. *Swiss Journal of Psychology*.
- Leder, H., Gerger, G., Dressler, S., & Schabman, A (in press). How art is appreciated. *Psychology of Aesthetics, Creativity, and the Arts, In Press*.
- Faerber, S. J., Leder, H., Gerger, G., & Carbon, C.-C (2010). Priming semantic concepts affects the dynamics of aesthetic appreciation. *Acta Psychologica*. doi: 10.1016/j.actpsy.2010.06.006

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- Gerger, G., Leder, H., Tinio, P. P. L., & Schacht, A. (submitted). Faces vs. Patterns: Exploring aesthetic reactions using facial EMG. *Psychology of Aesthetics, Creativity, and the Arts*.
- Gerger, G., Leder, H., Faerber, S. J., & Carbon, C. C. (2010). What changes in changing design appreciation? Dynamic interplay of variables regarding attractiveness evaluation over time. Manuscript in preparation
- Tinio, P. P. L., Gerger, G., & Leder, H. (2010). Structural generalization of facial symmetry and complexity following massive familiarization. Manuscript in preparation.
- Leder, H., Faerber, S. J., Gerger, G., Forster, M., & Carbon, C. C. (2010). Danger or Fascination? Situated effects on the appreciation of innovation. Manuscript in preparation

**Conference Proceedings and Published Abstracts**

- Gerger, G., Leder, H., & Carbon, C. C. (2007). Contributions of boredom to liking judgments over time. *Perception*, 36, 17-17.

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- Gerger, G., Bauer, H., Fischmeister, F. P. S., & Leodolter, U. (2006). Subsequent memory effects observed during shallow encoding of word pairs. *FENS Forum Abstracts*, 2006, 3
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