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The cycle of preference: Long-term dynamics of aesthetic appreciation

Claus-Christian Carbon *

Chair General Psychology and Methodology, Department of Psychology, University of Bamberg, Markusplatz 3, D-96047 Bamberg, Germany

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ABSTRACT

According to evolutionary psychology people prefer curved objects. We provide evidence that preferences for curved objects might be biologically motivated, but can also be, at least partly, modulated by fashion, trends or Zeitgeist effects. In four studies, participants ($n1 = 38$, $n2 = 40$, $n3 = 38$, $n4 = 38$) rated the curvature and appreciation of car models for ten 5-y periods (1950–1999). A parabolic function of curvature, with the lowest curvature for 1980s designs, was documented. Further, appreciation followed this parabolic trend. We revealed adaptation effects as plausible candidates for triggering such changes in preference. In sum, as appreciation of curvature changes dynamically over time, any study aiming to find static and general principles of liking regarding curvature is confounded with Zeitgeist effects.

1. Introduction

Humankind is on a long journey to fundamental, universal and stable properties of beauty and the associated psychological concepts of liking and appreciation of and preference for objects with such properties. Fechner was probably the first to approach this topic in his famous "Vorschule der Ästhetik" (Fechner, 1876) within a psychophysical context by systematically analyzing the physical properties of simple stimuli and aesthetic appreciation. His pioneering research on proportions, such as the golden section, was later unveiled as originating from familiarization effects (Hekkert, 1995). Others have documented systematic deviations from the golden section (Russell, 2000), further questioning fixed and static ratios that lead to high degrees of preference in general. Further notions of fixed properties of general aesthetic value range from color attributes, balance and proportion factors, contrast and intensity of a stimulus to form properties. The latter were recently investigated in studies comparing straight (angular) and curved (round) car interior designs (Leder & Carbon, 2005) and pairs of real objects with the same semantic meaning and general appearance, but differing in curvature and contour (Bar & Neta, 2006). Only recently, Silvia and Barona (2009) demonstrated specific liking of curved forms in the preference for balance test (Exp. 1) and a test with parallelized angular and rounded random polygons (Exp. 2). All the three studies clearly revealed the participants' preferences for curved designs.

Bar and Neta (2006) presented a plausible explanation for preferences of curved designs based on an evolutionary-psychological approach. As visual objects are processed very fast on a cognitive (Carbon & Leder, 2005b) and affective basis (Bar, Neta, & Linz, 2006), such processes must be founded on visual primitives, for instance the overall curvature of an object, or highly sophisticated and over-learned cognitive processing. According to Bar and Neta, sharp transitions in contour are often indications of possible life threats (e.g., the sharp contours of the teeth of a shark or the pointy shape of the overall appearance of a shark) and are associated with potential injuries (e.g., thorn of a rose) (see Fig. 1). Thus, angular forms seem like ideal candidates for simply communicating danger and evoking threats (Aronoff, Woike, & Hyman, 1992). Bar and Neta (2007) indeed showed in a subsequent fMRI study the higher activation of the Amygdala, a brain structure particularly activated by fear-inducing stimuli, when objects were shown with sharp design properties compared to curved ones.

Bar and Neta (2006) tested their hypothesis by presenting individual pictures from 140 matched pairs of real objects for a brief

* Tel.: +49 951 863 1860.
E-mail address: ccc@experimental-psychology.com

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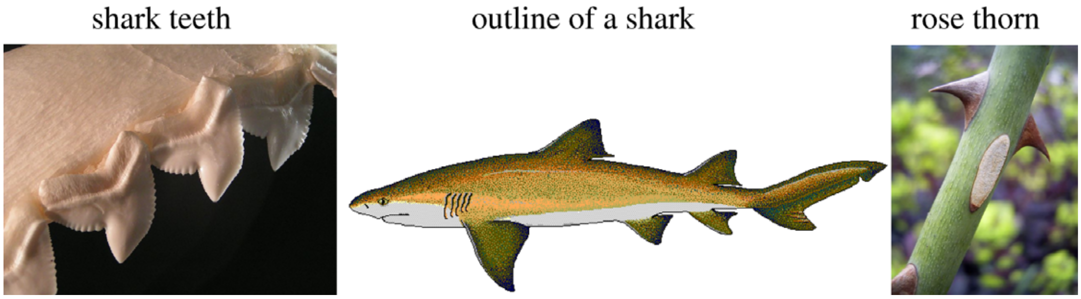

Fig. 1. Natural sharp transitions in contour indicating possible life threats ((a) shark teeth, (b) outline of a shark, (c) rose thorn) or potential injuries.

period of 84 ms. Their study revealed higher liking ratings for curved objects than for angular objects or control objects with mixed forms, which is fully compatible with their predictions derived from their evolutionary-based approach.

Despite Bar and Neta's clear and convincing data pattern, there are some critical points regarding their approach which should be addressed further. It is questionable whether preferences for curved forms can indeed be demonstrated in all domains and for all times, especially when we take artificial, human-made objects into account. Does the processing of such objects also follow evolutionary-shaped programs or does it follow alternative rules? If we extensively observe preferences in everyday life, indeed some important deviations from the general preference pattern including preferences for curved objects are detectable. Such deviations can be found for (a) natural objects and (b) artificial objects.

First, there are certain natural properties that are strongly preferred, if they have angular contours or sharp attributes. For instance, male humans with high sexual-dimorphism, expressed by larger jawbones, prominent and angular cheekbones, sharp contours and straight eyebrows (Enlow, 1990), are preferred by potential partners of the opposite sex (Thornhill & Gangestad, 1999).

Second, many artificial products need to be shaped a certain way in order to be produced successfully. For instance, pottery has been produced for a long time very easily and solidly by using a potter's wheel from which round forms inherently emerge. The same is true for the original method of glass production via blow forming. By pressing air through a nozzle, the melting glass expands constantly to all three dimensions generating more or less perfect spheres. This technique was transferred to many other domains such as blow molding of hollow plastic parts. Other examples of production-based round forms are coins or plates. There are, however, also angular forms that naturally emerge as a result of the production process, such as furniture which is assembled from easy-to-cut straight basic forms, windows and doors which need frames of simple but solid structures and sheets of paper which have to optimize the required space for the printed letters. According to the prototype and fluency theories, such material, which is quite prototypical—as it is the most natural way to perceive them—should be preferred, regardless of its specific appearance (see Winkielman, Halberstadt, Fazendeiro, & Catty, 2006).

Third, and foremost, we encounter myriads of new, different designs within a lifetime that are not uniquely shaped or structured, but demonstrate immense varieties. Personal taste accounts for part of this effect, but fashion has an even stronger impact (Sproles, 1981). In a historic context it is quite clear that humans have changed their preferences towards specific outward appearances within many different classes of objects. Fashion clothing changes its vocabulary of forms every now and then. Even the way we want to encounter natural artifacts such as the layout of trees, bushes or watercourses in public parks and gardens has changed essentially over time. While people in the baroque era sought to experience gardens of planned geometric and symmetric lines, thereby restricting natural growth to a minimum, people in later periods broke this canon by introducing natural-appealing gardens, rejecting symmetry as value on its own.

The potential of changing appearances has been intensively and explicitly used by the consumer product industry. As design aspects of consumer products are constantly increasing in importance (Carbon & Leder, 2005a; Carbon, Michael, & Leder, 2008), changing the products' form is one instrument to stimulate market success due to novelty and innovativeness aspects (Hirschman, 1980; Kreuzbauer & Malter, 2005). According to the Most Advanced Yet Acceptable (MAYA) design principle, such a change should not be abrupt, as beholders prefer designs that are advanced (novel, innovative), but also familiar enough to still be manageable (Hekkert, Snelders, & van Wieringen, 2003).

2. The present study

In the present paper, we want to extend the view that "humans prefer curved visual objects" (Bar & Neta, 2006) by confronting the participants with the images of car exteriors spanning a long period of time. The specific usage of historic views of design-oriented objects such as cars should provide a sensitive test of how the design vocabulary (German: "Formensprache") has changed over the last 50 years. We decided to use cars in this study because cars are (a) very long-lasting products which can (b) be clearly assigned to specific series, such as the "BMW 7-series" and which are (c) produced for many model generations. This helps to reduce the confounding effects of prestige, pricing, degree of luxury, functionality, etc. as long-term changes in the design are directly compared from one to another model generation. In Study 1, we ask the participants how they like the cars without providing any cue of the historic context. We further ask for key variables for design appreciation, such as curvature, complexity, quality, innovativeness and security to control the influences for the participants' appreciation of the cars. To control for Zeitgeist-dependent effects, Study 2 provides additional historic knowledge by telling the participants from which era the respective cars originated. If the Zeitgeist is taken into account, we expect less pronounced time-dependent responses to the designs. Most importantly, in Studies 3 and 4 we reveal plausible mechanisms underlying Zeitgeist-dependent appreciation effects. We used adaptation paradigms which are known to be able to change long-term representations (Carbon & Ditye, 2010; Carbon & Leder, 2006) and liking (Carbon, Ditye, & Leder, 2006a; Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003). When, the participants are first exposed to cars with very innovative (Study 3) and angular (Study 4) design concepts, we want to simulate everyday exposure to highly innovative and design-specific material. Such exposure can be experienced day by day through passive viewing of salient design exemplars in the market or through presentations of concept studies in the media. After exposure to the specifically designed cars which were innovative or angular, we expected to find a decrease in liking for recent more curved designs typically being highly preferred. This would be in accordance with the recent findings from the adaptation literature of high vision, where strong adaptation of preferences was found for a variety of natural categories, for instance, for faces (Rhodes et al., 2003). In an appended control study, we further investigated the relationship of curvature and liking in a historic context by comparing the production numbers of the car industry with curvature and liking ratings in Study 1. This will help us to understand whether curved designs sold better than angular designs. Such a statistic is important to reveal any *general* preference for any form of language, be it curved or angular in shape.

3. Study 1: evaluating car exteriors without explicit instruction

Study 1 aimed to reveal the dynamic changes in design aspects of car exteriors over a time period of 50 years. The participants had to evaluate several properties known to be essential for the appreciation of car designs. If there is a general trend over the years, evaluations of images depicting car series of several car brands should follow a unique, concordant trend.

3.1. Method

3.1.1. Participants

Thirty-eight undergraduate students from the University of Vienna, between the ages of 18 and 37 years ($M = 22.6$; $SD = 3.5$; 32 females), volunteered to participate in the study. They received course credit for participation. All the participants had normal or corrected-to-normal vision (assured as in all other studies by standard vision tests), had not taken part in any of the other studies and were naïve to the aim of the experimental procedure. None of them, as in all subsequent studies, was identified as having special expertise in cars in general and car design in particular.

3.1.2. Apparatus and stimuli

For stimulus material grayscale photographs of car exteriors of six major car brands in Germany (Audi, BMW, Ford, Opel, Mercedes-Benz and Volkswagen) were used. To compare different model generations over the years, only models were selected whose respective class was continuously produced from 1950 to 1999. Examples include the VW compact class represented first by the VW Beetle and then the subsequent VW Golf (Rabbit) generations, or the standard limousine class of Mercedes-Benz (represented inter alia by the "stroke-8", "W123", "W124", "W210" model lines). For each brand and each 'lustrum' (five-year period, starting from 1950 to 1954) one picture was selected yielding a total of 6 [brands] $\times$ 10 [lustra] = 60 images. The stimuli, being about 500×250 pixels large, were retouched to cover all direct signs of the brands, such as logos and lettering. They were presented on a 17-in. CRT eMac monitor with a screen resolution of 1024×768 pixels at 89 Hz.

3.1.3. Procedure

The participants were tested individually. They sat approximately 70 cm in front of the computer monitor, in a constantly lit room. For every image, six ratings were asked. First the participants had to rate how much they liked the car exterior shown in the picture on a 7-point-Likert scale (from '1': "very weak", up to '7': "very strong"). As soon as they had made their decision, the scale, shown at the bottom of the screen, was removed, and the next scale was shown. To alert the participant that a new scale had to be rated, the subsequent scale was always shown 32 pixels lower than the previous one. The ratings assessed included liking, curvature, complexity, quality, innovativeness and safety. The or-

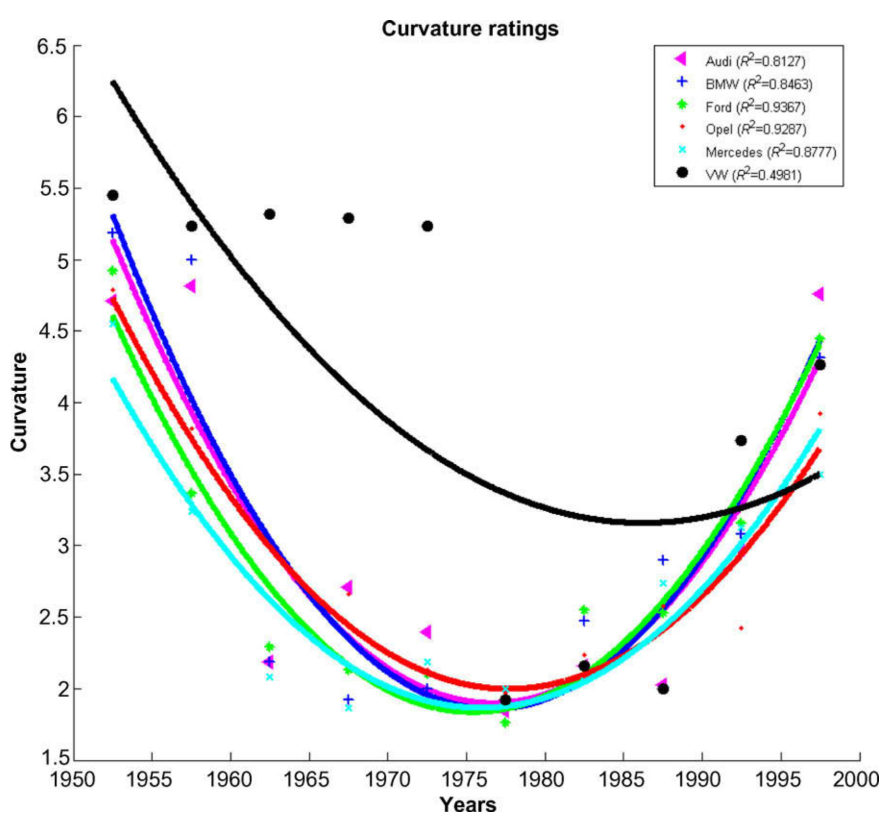

Fig. 2. Mean ratings (Study 1) for curvature evaluations for each car brand modeled with two degree polynomials. Fittings indicated by the determination coefficient R^2 are shown in the legend.

der of the stimuli was fully randomized. The whole procedure lasted approximately 15 min.

3.2. Results and discussion

We will first concentrate on the curvature ratings to analyze how the overall design vocabulary of car interiors has changed over the past 50 years. Of particular importance will be the congruence of changes across different brands to test for general design trends. Additional analyses of the residuary ratings, particularly of liking, will be conducted, to test for preferences for different design aspects over the years.

3.3. Curvature ratings

First, the mean ratings for curvature evaluations were inspected (Fig. 2).

The overall curvature of all the brands but VW followed a clear u-shaped trend with maximum curvature ratings for the first (1950–1955) and last lustrum (1995–1999) and with a minimum around the period of 1970–1980. Two degree polynomial fittings showed high to very high fittings, with R^2s between .81 and .94. Evaluations for VW did not follow this trend indicating a special historic case. Since we used as stimulus material for VW the compact car sector, the historic series of generations contained the Volkswagen Beetle, a model engineered in the 1930s, which ultimately became the longest running and most-produced automobile with a unique design (in fact the production continued in Mexico until 2003 with an approximately total number of 21 million produced units). The few changes in design from 1950 until the lustrum of 1970–1974, when the Beetle was last produced in Germany and consequently included in the present statistic, were minor and did not significantly change the overall Beetle-like (=curved) Gestalt. In fact, the Beetle was also the most curved design of all the designs rated in the present study.

To exclude the specific properties of the Volkswagen brand, in all the following analyses the data were analyzed without the data for VW. Mean curvature data for each participant were submitted to a two-way repeated measurement ANOVA with *lustrum* (1950–1954, 1955–1959, etc.) and *brand* (Audi, BMW, Ford, Mercedes, Opel) as within-subjects factors (see Fig. 3). The factor *lustrum* showed a large effect, $F_{9,333} = 101.2$, $p < .0001$, $\eta^2_p = .732$, and *brand* a weak one, $F_{4,148} = 7.1$, $p < .0001$, $\eta^2_p = .161$. Both effects were further characterized by a weak effect of interaction between them, $F_{36,1332} = 6.6$, $p < .0001$, $\eta^2_p = .151$ indicating only weak individual trends of the different brands, but a strong general trend.

Overall, the results of the regression and ANOVA revealed a clear, nearly universal, parabolic trend of curvature over the span of 50 years, further demonstrated by high correlations between the different brands (.828 < Rs < .926; Cronbach's $\alpha = .969$). Importantly, the variation of curvature was substantial, with the lowest curvature ratings being less than 2 on a 7-point scale for the period of ca. 1970–1980, while the highest curvature ratings, being more than 5, were recorded for the 1950s, and ratings of higher than 4 were observed for 1995–1999.

3.4. Liking and ratings of design property

According to Bar and Neta (2006), humans prefer curved designs. To directly test this hypothesis, we compared the liking of car exteriors over time. Again, a clear u-shaped trend over time was revealed—concordantly with the related curvature ratings (see Fig. 3).

In fact, the correlation between aggregated curvature and aggregated liking ratings was very high, $R = .911$. When taking all the variables into account, a stepwise multiple linear regression (as for all subsequent regression analyses, only the main variables but no interaction between these variables were used as independent variables) showed that curvature was the only predictor which significantly explained a participant's liking, $R^2 = .830$, $\beta = .911$, $F(1, 8) = 39.2$, $p = .0002$. See Table 1 for an overview of all regression analyses.

The analyses conducted in Study 1 clearly demonstrated the close relationship between curvature and liking across different brands. Nevertheless, as we have assessed all the evaluations in a specific time period—the present—when designs are very much curved (see data for the lustrum 1995–1999 in Fig. 2), this close relationship could also be explained by effects of contemporary taste. This would mean that at the beginning of the 21st century, at a time when curved design is very much appreciated, low-curved designs, whether presented as historic or brand-new cars, should be relatively unpopular. As it is not possible to evaluate the given cars within the original time context including the simulation of specific fashion and Zeitgeist ideas of the respective

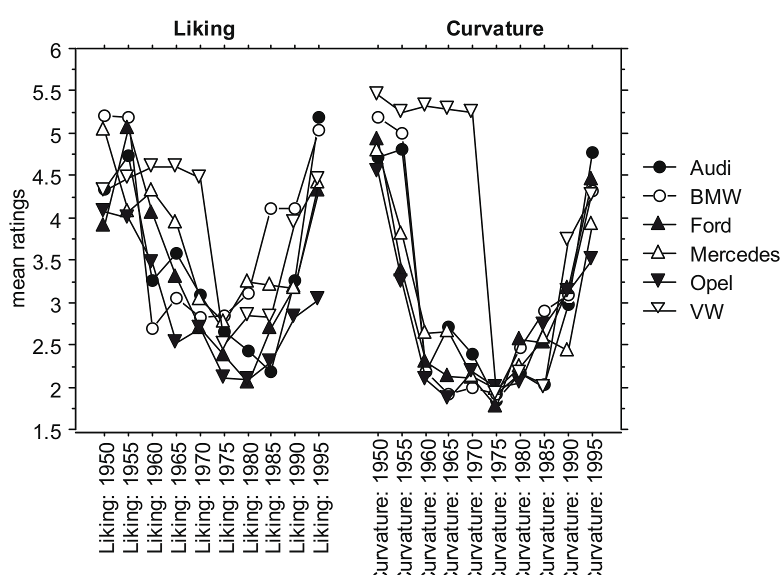

Fig. 3. Mean ratings (Study 1) for liking and curvature in comparison.

Table 1
Overview of the stepwise multiple linear regression models for all studies.

Predictor	β	t-Value	p-Value
Study 1 (evaluating car exteriors without explicit instruction; base rate)			
Model *curvature*, $F(1, 8) = 39.2$, $p = .0002$, $R^2 = .830$			
Curvature	.911	6.3	.0002
Study 2 (evaluating car exteriors with explicit historic instruction)			
Model *innovativeness*, $F(1, 8) = 170.5$, $p < .0001$, $R^2 = .955$			
Innovativeness	.977	13.1	<.0001
Study 3 (evaluating car exteriors after adaptation to innovative cars)			
Model *curvature*, $F(1, 8) = 24.1$, $p = .0012$, $R^2 = .750$			
Curvature	.866	4.9	.0012
Study 4 (evaluating car exteriors after adaptation to innovative cars)			
Model *innovativeness* and *complexity*, $F(2, 7) = 174.2$, $p < .0001$, $R^2 = .980$			
Innovativeness	1.511	7.2	.0002
Complexity	−.549	−2.6	.0347
Model *innovativeness*, $F(1, 8) = 196.0$, $p < .0001$, $R^2 = .961$			
Innovativeness	.980	14.0	<.0001

era, we worked out two auxiliary strategies. (1) In the control study appended to Studies 1–4, we have analyzed historic production figures of the given brands to investigate whether any indications of a drop in production are observable for periods when designs low in curvature were produced. (2) In Study 2, we replicated Study 1, while providing extra information about the historic context of the presented cars, and we instructed the participants to evaluate on the basis of this context. If the participants can abstract from their current taste, no designs should be specifically preferred, as the respective design was probably liked in those days to the same degree as today's design. In contrast, if the participants cannot abstract from their appreciation, comparable data patterns as in Study 1 should be obtained.

4. Study 2: evaluating car exteriors with explicit historic instruction

Study 2 addressed a subsequent question raised by the previous study. Study 1 revealed clear dynamic changes in design properties and design appreciation over time. Specifically, the degree of curvature changed dramatically between 1950 and 1999, from very curved in the 1950s–1960s to ultra-angular in the 1970s and 1980s, back to a pronounced curved form in the late 1990s. Concordant with the degree of curvature, liking data also followed such a parabolic trend. As curved forms are still *en vogue* these days, the tight relationship between curvature and liking can be a Zeitgeist-dependent effect. If so, and if we cannot abstract from these Zeitgeist-dependent effects, adding information about the historic context of the cars should not bias this relationship. We, therefore, presented stimuli of each lustrum blockwise and provided extra information about the historic context of the cars. The main analyses will, consequently, be conducted through comparisons of results from Studies 1 and 2.

4.1. Method

4.1.1. Participants

Forty undergraduate students from the University of Vienna, between the ages of 18 and 28 years ($M = 20.7$; $SD = 2.0$; 31 females), volunteered to participate in the study. They received course credit for participation. Again, all the participants had normal or corrected-to-normal vision, had not taken part in any of the other studies and were naïve to the aim of the experimental procedure.

4.1.2. Apparatus and stimuli

The apparatus and stimuli were the same as in Study 1.

4.1.3. Procedure

The procedure was very similar to Study 1, with two exceptions. (1) The participants were explicitly informed about the time when the given models were available on the market and they had to evaluate all the ratings based on this knowledge. To facilitate this procedure, they were instructed to act as if they perceived the cars from the historic perspective. (2) To further facilitate the perspective change, the entire stimuli were presented blockwise, for instance, all the models from the 1970–1974 lustrum were shown consecutively (with full randomization within each of the blocks). The order of the lustra blocks was randomized across participants.

4.2. Results and discussion

Fig. 4 shows the mean evaluations of all ratings in comparison with Study 1. The general trends of both data patterns were very similar, again following u-shaped distributions. The correlation of innovativeness ratings between Study 1 and Study 2 was quite high ($R_{\text{innovativeness}} = .739$), but much lower than that for the remaining scales ($R_{\text{liking}} = .947$, $R_{\text{curvature}} = .992$, $R_{\text{complexity}} = .888$, $R_{\text{quality}} = .931$, $R_{\text{safety}} = .955$). Besides these general concordances in the shape of the functions, the participants in Study 2 showed higher evaluations within a very limited range of values. This

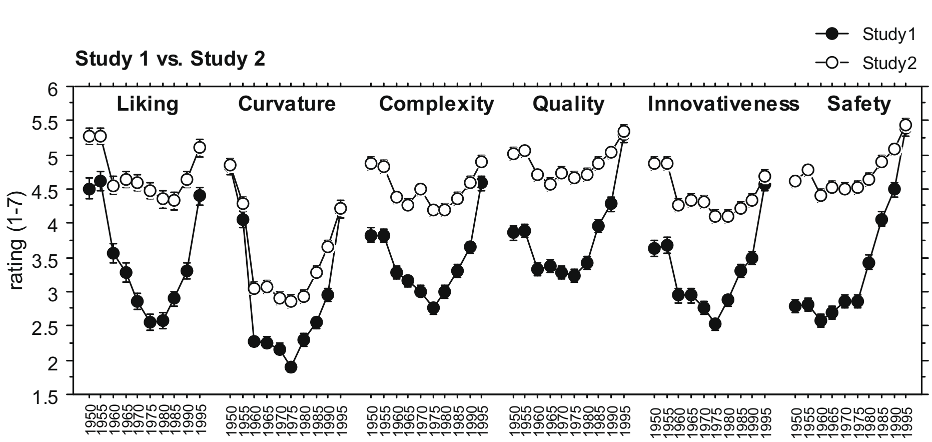

Fig. 4. Comparison of mean evaluations of Studies 1 and 2 sampled over brands. Error bars show one standard error of the mean.

indicates that the instructions from Study 2 were partly effective, although the participants' ratings were neither far from being unique nor randomly distributed across the lustra.

When looking for the major predictors for liking via stepwise regression (with liking as dependent and all other variables as independent variables), only one predictor was identified: innovativeness, $\beta = .977$, $F(1, 8) = 170.5$, $p < .0001$, with a total amount of explained variance of $R^2 = .955$. Obviously, the participants followed a different strategy to evaluate the liking of the given cars compared with Study 1. While the participants based their liking ratings mainly on curvature in Study 1, the participants of Study 2, equipped with the historic information of the cars, based their liking ratings on innovativeness. Innovativeness was also identified as the major factor in design appreciation in other studies (e.g., Carbon & Leder, 2005a; Carbon et al., 2008; Hekkert et al., 2003) and was probably used as a basis only in Study 2 as the participants tried to imagine what essential properties of historic designs were important for liking at that time. As curvature changes dynamically over time (as demonstrated in Study 1), reliance on an alternative factor such as innovativeness, which is relevant in any design era, makes sense. This indicates, at least a partially effective, possibility of abstraction from the current Zeitgeist. In Study 3, we wanted to reveal the possible mechanisms that trigger the changes of the Formensprache and the change of preferences for such designs.

5. Study 3: evaluating car exteriors after adaptation to innovative cars

Study 3 was realized as a direct control for Study 1 to reveal the potential cognitive mechanisms underlying dynamic changes in preference. In particular, this study addresses the important question whether adaptation towards new stimuli can trigger such dynamic changes. Adaptation has been revealed as a very important mechanism to change mental representations (for long-term effects see Carbon et al. (2007); for short-term effects see Webster, Kaping, Mizokami, and Duhamel (2004)) and preferences for specific material (for fashion Carbon et al. (2006a); for faces Rhodes et al. (2003)). Following the ideas from the adaptation literature, the participants were first exposed to new, highly innovative concept cars, which represent future design philosophies of a variety of car brands. The aim of this adaptation phase was to simulate everyday life experiences with new and highly innovative designs, typically presented via media or direct experiences with such prototypes, concept cars or brand-new cars at motor shows or via ordinary road traffic. If adaptation mechanisms are influencing the aesthetic judgment of already known designs, we should register the changes for key design variables such as the innovativeness or the quality of design, known to be modulating design appreciation (Leder & Carbon, 2005). When new, highly innovative car designs are introduced, familiar designs should start to fade in innovativeness or perceived quality—they should begin to "look old", out-dated and old-fashioned. The evaluation of mere physical characteristics such as curvature, though, should not be biased by such an adaptation routine as the assessment of curvature seems rather context independent. If adaptation is not a valid candidate for changing the overall appreciation of a car and thus the basis of triggering dynamics in preferences, we should find no substantial change in the overall pattern of design evaluations through the adaptation procedure. This will be tested by a comparison of the data between Study 1 and Study 3.

5.1. Method

5.1.1. Participants

Thirty-eight undergraduate students from the University of Vienna, between the ages of 19 and 28 years ($M = 21.3$; $SD = 2.2$; 30 females), volunteered to participate in the experiment. They received course credit for participation. Again, all the participants had normal or corrected-to-normal vision, had not taken part in any of the other studies and were naïve to the aim of the experimental procedure.

5.1.2. Apparatus and stimuli

The apparatus and stimuli of the test phase were the same as in Studies 1 and 2. Before the test phase started, however, an adaptation phase took place. Here, 12 concept cars were shown with two pictures of each, one from a front view, the other from a rear view (see an exemplar for each view in Fig. 5).

The concept cars had been obtained from a diverse group of automobile manufacturers such as Audi, BMW, Honda, and Mercedes-Benz. They all depicted futuristic car concepts of which parts and ideas of the designs will usually be realized in future days; thus, they give an impression of possible cars in the near future. The examples chosen were highly innovative and futuristic. All logos or direct cues for brand recognition were retouched in order not to link them with concrete brands. The 12 [concept cars] × 2 [views] = 24 stimuli, being about 500 × 250 pixels large, were presented on a 17-in. CRT eMac monitor with a screen resolution of 1024 × 768 pixels at 89 Hz.

5.1.3. Procedure

The procedure was the same as in Study 1, but prior to the test phase, an adaptation phase was conducted. The adaptation phase was a cover task where the participants were instructed to decide as fast as possible whether the car shown is seen from the front or the rear. To intensify the adaptation procedure, the participants were not able to directly stop the exposure to the stimulus by pressing an answer button ('x' or 'm' for front or rear; assignment of buttons was counter-balanced across participants), but had to wait for a duration of 1, 2 or 3 s before a beep announced the readiness of the system to record the participant's response. Then, the stimulus was erased for 1 s and appeared again for one more second at the same location. To increase the attention demands, the target location of the stimulus was varied across the trials on five possible areas across the screen. The same general procedure was used in a gender-decision cover task for face adaptation elsewhere

Fig. 5. Illustration of the two examples of the futuristic adaptation stimulus set used in Study 3: on the left side, a front view of a Honda concept car, on the right side, a rear view of a BMW concept car.

(Carbon et al., 2007) and was shown to be highly effective in producing adaptation to stimuli. The whole procedure consisting of the adaptation phase and the test phase lasted approximately 15 + 15 = 30 min.

5.2. Results and discussion

Parallel to the results section of Study 1, we will first concentrate on curvature ratings, which we will compare with Study 1 to test for any adaptation effects. Additionally, analyses of the residuary ratings will further help to understand the complex interplay between design properties and liking across a wide time span.

5.3. Curvature ratings

First, mean ratings for curvature evaluations were inspected (Fig. 6), revealing a trend highly similar to that of Study 1 (across the lustra: $R = .997$, $N = 10$, $p < .0001$). Indeed a mixed design ANOVA with *adaptation* (Study 1: no adaptation vs. Study 3: adaptation) as between-subjects factor and *lustrum* as within-subjects factor revealed only a large effect of *lustrum*, $F_{9,666} = 176.5$, $p < .0001$, $\eta_p^2 = .705$, but neither an effect of *adaptation*, $F_{1,74} < 1$, $p = .9050$, *n.s.*, nor an interaction between *adaptation* and *lustrum*, $F_{9,666} < 1$, $p = .9770$, *n.s.* Curvature was, as hypothesized due to its physical nature, not affected by the adaptation routine used.

5.4. Liking and ratings on design property

We again found a close relationship between curvature and liking ($R = .866$). In fact, a stepwise multiple linear regression identified curvature as the only predictor for liking with an explained variance of this model with $R^2 = .750$, $\beta = .866$, $F(1, 8) = 24.1$, $p < .0001$, which was much lower than that of the model identified in Study 1. Clearly, adaptation towards futuristic designs did change the ultimate role of curvature for assessment of liking, but still, curvature was the most important predictor for liking.

To further analyze the impact of the adaptation routine of Study 3, we employed a mixed design multivariate ANOVA with the dependent measures *complexity*, *quality*, *innovativeness* and *safety* and the independent measures *adaptation* (between-subjects) and *lustrum* (within-subjects). We revealed a main effect of *lustrum*, $F_{36,2664} = 28.2$, $p < .0001$, $\eta_p^2 = .276$, but not *adaptation*, $F_{1,74} < 1$, $p = .7340$, *n.s.* We also detected an interaction between *adaptation* and *lustrum*, $F_{36,2664} = 2.2$, $p < .0001$, $\eta_p^2 = .028$. Further univariate analyses of the individual measures revealed significant interaction effects between *adaptation* and *lustrum* for *complexity* ($p = .0181$), *innovativeness* ($p < .0001$) and *safety* ($p < .0001$), but only a marginal interaction effect for *quality* ($p = .0555$, *n.s.*). Deeper analyses for simple main effects of *adaptation* on all levels of *lustrum* showed, besides other changes, important decreases of liking and innovativeness ratings from Study 1 to Study 3 for the more recent time periods (see Fig. 6). In summary, the adaptation to highly innovative and futuristic designs showed very specific effects on ratings of car models. While the evaluation of mere physical properties such as curvature and quality was hardly affected, the evaluated liking, innovativeness and safety of car exteriors from the last 15 years were negatively affected. As innovativeness is an important predictor for liking of cars (Leder & Carbon, 2005), any exposure to brand new and highly innovative car models might decrease the level of innovativeness of recent and present car models. With the adaptation procedure employed in Study 3, we have realized such an extreme exposure as only highly innovative cars were shown. Interestingly, older car models were hardly affected by this procedure. Older models dating back to the 1950s–1980s are perhaps categorized as being historic car models which are not susceptible to any further fashion or adaptation effects any more. They are no longer in everyday use. They are part of museums now, not of everyday phenomena. Consequently, they are stable in terms of preferences for them and major design characteristics assigned to them, with the exception of safety. After having been exposed to futuristic car exteriors, cars stemming from older periods were evaluated safer than without adaptation. This could indicate that massive exposure to futuristic cars changes the heuristic for assessing safety from the simple principle "the newer, the safer", to "new cars are safer but familiar cars are not so unsafe after all."

As we are specifically interested in the relationship between curvature of design and its liking, we conducted a second adaptation study (Study 4), which used highly angular designs as adaptors. If adaptation towards angular design occurs, it should lead to a reduction of attractiveness for recent designs which were highly preferred in Study 1. Further, if adaptation towards geometric forms realized by repeated exposure to angular car exteriors is successful, this should also change the pattern of predictive variables by reducing the impact of curvature.

6. Study 4: evaluating car exteriors after adaptation to innovative design

Study 4 was used as extension of Study 3 to gain deeper insights into the adaptability of aesthetic appreciation. In particular, this

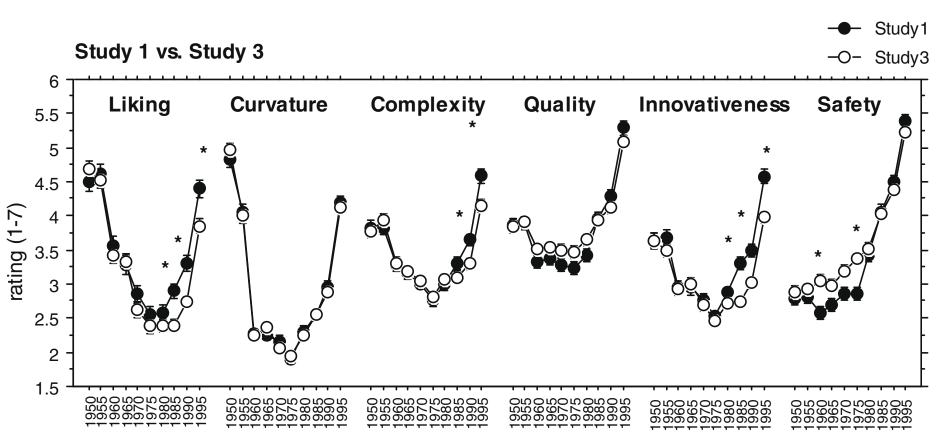

Fig. 6. Comparison of the mean evaluations of Studies 1 and 3 sampled over brands. Asterisks (*) indicate significant simple main effects between Study 1 and Study 3. Error bars show one standard error of the mean.

study addresses the important question whether adaptation towards angular stimuli can change the overall pattern of liking for curved forms. When highly angular car designs are used as stimuli in the adaptation phase, adaptation, if occurring, should lead to reduction of liking of recent designs which were found in Study 1 as being preferred, particularly because liking was mainly related to curvature.

6.1. Method

6.1.1. Participants

Thirty-eight volunteers, between the ages of 19 and 60 years ($M = 27.7$; $SD = 11.9$; 30 females), participated in the experiment. Most of them, who were undergraduate students studying psychology at the University of Bamberg, received course credit for participation, while others were recruited on a voluntary basis without receiving course credit. Again, all the participants had normal or corrected-to-normal vision, had not taken part in any of the other studies and were naïve to the aim of the experimental procedure.

6.1.2. Apparatus and stimuli

The apparatus and stimuli of the test phase were the same as in Study 3 with the exception that 12 historic cars being highly angular in shape were shown using two pictures of each, one from a front view and the other from a rear view (see a sample image for each view in Fig. 7).

The cars originated from a diverse group of automobile manufacturers such as Alfa Romeo, BMW, Lamborghini, Lancia, Lotus, Maserati, and Mercedes-Benz. They all depicted historic car models that differed from the models presented in the test phase and which had been manufactured in the 1970s, 1980s and the beginning of the 1990s. The examples chosen were highly angular. All logos or direct cues for brand recognition were retouched in order not to link them with the existing brands. The 12 [angular cars] × 2 [views] = 24 stimuli, being about 500 × 250 pixels large, were presented on an integrated 17-in. TFT PowerPC monitor with a screen resolution of 1440 × 900 pixels at 60 Hz.

6.1.3. Procedure

The procedure was the same as in Study 3.

6.2. Results and discussion

As we did with Study 3, we will first concentrate on curvature ratings, which we will compare with that of Study 3 to test for any differential adaptation effects. Additionally, analyses of the residuary ratings will further help to understand the complex interplay between design properties and liking across a wide time span.

6.3. Curvature ratings

Curvature ratings for the lustra were highly concordant with Study 1 ($R = .998$, $N = 10$, $p < .0001$). This was further validated by a mixed design ANOVA with *adaptation* (Study 3: adaptation with futuristic designs vs. Study 4: adaptation with angular designs) as between-subjects factor and *lustrum* as within-subjects factor revealing only a large effect of *lustrum*, $F_{9,666} = 241.5$, $p < .0001$, $\eta^2_p = .765$, but neither an effect of *adaptation*, $F_{1,74} < 1$, $p = .5064$, *n.s.*, nor an interaction between *adaptation* and *lustrum*, $F_{9,666} < 1$, $p = .9833$, *n.s*. Curvature was, as in the former adaptation study, not affected by the adaptation routine used. Note that the participants were recruited from another subject pool with different demographics: whereas in Study 1 (and Studies 2 and 3) the participants were exclusively undergraduates studying psychology at the University of Vienna, Austria, we recruited a variety of persons for Study 4, all from the Bamberg area, Germany, and many of them were not students. The high correlation of curvature ratings between both studies demonstrates a highly reliable and stable assessment of physical properties such as curvature.

6.4. Liking and ratings on design property

In contrast to Study 3, a stepwise multiple linear regression identified *innovativeness* and *complexity* as the best predictors for liking with a very high amount of explained variance of this 2-variable-model, $R^2 = .980$, β(innovativeness) = .980, β(complexity) = −.540, $F(2, 7) = 174.2$, $p < .0001$. It is important to note that although adding *complexity* to the regression still increased the overall quality of the model, *innovativeness* alone already explained the lion's share of variance with $R^2 = .961$, $F(1, 8) = 196.0$, $p < .0001$. Moreover, *complexity* was related with liking in a negative way. Adaptation towards specific geometric forms, here towards singular shapes of historic car exteriors, indeed changed the set of predictive variables. Curvature, identified as the ultimate predictor for liking in Studies 1 and 3 was no longer of predictive quality.

The impact of the adaptation routine of Study 4 was tested in comparison with Study 1 by a mixed design multivariate ANOVA with the dependent measures *complexity*, *quality*, *innovativeness* and *safety* and the independent measures *adaptation* (between-subjects: Study 1 vs. 4) and *lustrum* (within-subjects). We revealed only a main effect of *lustrum*, $F_{36,2664} = 29.7$, $p < .0001$, $\eta^2_p = .286$, and an interaction between *adaptation* and *lustrum*, $F_{36,2664} = 1.5$, $p = .0245$, $\eta^2_p = .020$, but no main effect of *adaptation*, $F_{1,74} < 1$, $p = .9051$, *n.s.* Further univariate analyses of the individual measures revealed significant interaction effects between *adaptation* and *lustrum* for *complexity* ($p = .0118$), *quality* ($p = .0111$), *innovativeness* ($p = .0391$) and *safety* ($p = .0278$).

To further analyze the impact of the adaptation routine of Study 4 in comparison with the alternative adaptation material of Study 3, we employed a mixed design multivariate ANOVA with the dependent measures *complexity*, *quality*, *innovativeness* and *safety* and the independent measures *adaptation* (between-subjects:

Fig. 7. Illustration of the two exemplars of the adaptation stimulus set used in Study 4: on the left side, a front view of a very angular-designed historic car (Alfa Romeo 75, manufactured from 1985 to 1992), on the right side, a rear view of the same car.

Study 3 vs. 4) and *lustrum* (within-subjects). We revealed only a main effect of *lustrum*, $F_{36,2664} = 30.0$, $p < .0001$, $\eta_p^2 = .288$, but neither one of the *adaptation*, $F_{1,74} < 1$, $p = .9051$, *n.s.*, nor an interaction between *adaptation* and *lustrum*, $F_{36,2664} < 1$, $p = .9530$, *n.s.* Further univariate analyses of the individual measures were not conducted due to non-existing main or interactive effects of *adaptation*.

With the adaptation procedure of showing highly angular designs in Study 4, we have induced adaptive effects quite comparable to those in Study 3 where futuristic cars were used as adaptors. Analyzing the adaptation material of Study 3 deeper, it is clear that those cars were also quite angular in shape. This might indicate that futuristic cars in the years when this research was conducted (2008–2010) are mainly angularly shaped as fashion trends follow more and more angular forms—at least in the automobile industry.

Nevertheless, it is quite interesting that very future-oriented concept cars and historic angularly shaped cars show very similar impacts as adaptors in the given experimental framework. The intense and repeated inspection of both groups of designs let essential predictors for liking of cars change very similarly indicating common mechanisms. At least with this framework, the essential quality of both groups was not being futuristic vs. being historic, but being rather angular. This might be interpreted as a supremacy of form and shape in comparison with other important design qualities such as familiarity and novelty (Hekkert et al., 2003) when it comes to adaptability of the Formensprache.

After having shown with adaptation effects in Studies 3 and 4 plausible mechanisms that trigger changes in preference, we were further interested in the analysis of historic data of preferences for cars. As no empirical study is available which investigated people's preferences for current car models in a longitudinal design, we referred to historic car production numbers. If curved cars were also more preferred at a time when the Formensprache was quite angular, we should find a drop in sales for the period when these cars were produced (see Study 1). Therefore, we compared curvature and liking ratings with the specific production numbers of the used car manufacturer.

7. Control study: investigating the relationship of curvature and liking in a historic context

The idea behind this control study was to analyze historic data of preferences for cars. Although we have found clear preferences for curved car designs in Study 1, we questioned whether this effect is based on general preferences for curved objects, or whether this effect is based on specific time-dependent mechanisms. As we have asked people for their preferences at a time when curved design is still *en vogue*, there is a serious confounding of Zeitgeist preferences and assumed general preferences. We therefore compared the production numbers of the given car brands with curvature and liking ratings from Study 1. With the combination of both data sets we can test for the generality of preferences for curved objects with the following rationale: if the preference for curved objects is a general one, we should detect a drop in the production numbers in times when angular design was popular (e.g., the 1980s; cf. Study 1).

7.1. Method

7.1.1. Material

The production numbers of all six car manufacturers from which the car models in the previous empirical studies were used were retrieved from the yearbooks 1950–1999 of the VDA (Verband der Automobilindustrie e.V.), the most influential German interest group of the German automobile industry.

7.2. Results and discussion

We aggregated all the production numbers per car manufacturer for each lustrum utilized in Study 1. Fig. 8a documents the production numbers from the 1950s until 2000 which increased in a nearly linear pattern. When residuals of the linear fit were analyzed (Fig. 8b), we observed that the highest production figures were obtained in the years when pronouncedly angular designs were produced. In fact, the residuals of the production figures correlated *negatively* with curvature, $R = -.566$. However, such correlations should be carefully interpreted, as we cannot assess all the factors influencing the production of cars, for instance, exchange rates, production costs, export barriers, political constraints, technical innovations and flops, or the financial situation at a given time period. It is, however, clear that we could not find any drop in the production numbers for cars which had angular shapes. Interpreting this with great caution, we can conclude that angular designs, at least, does not necessarily lead to rejection of products, operationalized here by the production numbers of cars.

8. General discussion

In the present studies, we investigated long-term dynamics of design properties. To be able to assess a long time period, we used

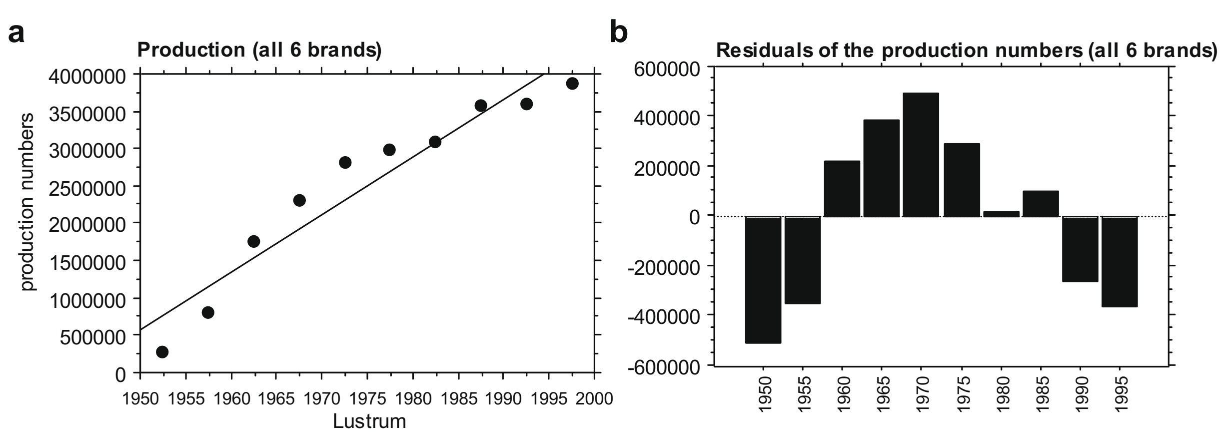

Fig. 8. (a) Mean production numbers of the brands targeted in the present studies plus linear fit with the data, $R^2 = .916$. (b) Residual production numbers (after being regressed with the linear function) across the different lustra (5-year periods).

historic designs of car exteriors, which we evaluated in terms of liking, curvature, complexity, quality, innovativeness and safety. This was done by (a) directly asking the participants to evaluate the cars, without providing specific information about the historic context (Study 1) and (b) by assessing the same scales after giving the participants information about the date of design and instructing them to evaluate on the basis of this knowledge (Study 2). We found dynamic changes of design properties over time. Car designs in the 1950s and 1990s were rather curved, 1970s and 1980s designs, however, were extremely angular shaped. We also found a positive relationship between the degree of curvature and liking. Obviously, our participants who had arrived at their evaluations in recent times prefer curved objects. Nonetheless, we cannot differentiate between general or time-specific preferential patterns induced by current taste. Consequently, in Studies 3 and 4 we tried to identify a potential and plausible mechanism which can trigger changes of preference. By employing an adaptation procedure where the participants were intensively exposed to highly innovative, futuristic car concept designs, we could demonstrate changes in the overall evaluation pattern of design properties such as innovativeness. After having been adapted towards futuristic car exteriors, present and recent car designs from the last 15 years were evaluated as less innovative. Concordantly with the decrease in innovativeness, the liking ratings also went down. Study 4 extended Study 3's finding by employing very angular car exteriors from the historic context of the 1970s–1990s as adaptors. Again, the overall evaluation pattern of design properties changed, most significantly, curvature was no longer the only predictor for liking as found in Studies 1 and 3. Now, innovativeness predicted liking most accurately. In the subsequent control study, subjective curvature and liking ratings were linked with objective production numbers of the automobile industry to test the negative effects of angular designs on the production outcome. We could not find evidence for such negative effects in the objective data basis.

Only recently, Bar and Neta (2006) hypothesized that the participants generally prefer curved visual objects. In accordance with this hypothesis we could demonstrate in Study 1 a close relationship between curvature and liking in a historic sample of car models. Interestingly, the design of car exteriors has changed dramatically in many respects over the last 50 years. Most obviously, the degree of curvature changed from very curved forms in the 1950s to very angular designs in the 1970s and 1980s. In recent years, curvedness of designs has increased again, nearly reaching the level of curvedness of the early 1950s. Accordingly, the participants of today preferred designs from the 1950s and 1990s, while rejecting the 1970s and 1980s styles. In Study 1 we also found that curvature is the major predictor for liking even when other potential design properties are included in a regression analysis: complexity, quality, innovativeness and safety.

It is important for proper interpretation of these results that all the studies which demonstrated preferences for curved designs, such as car interiors (Carbon & Leder, 2005a; Leder & Carbon, 2005) and natural and artificial objects (Bar & Neta, 2006; Silvia & Barona, 2009), were conducted in the last few years, a period where curved designs have been used quite frequently. This is rather problematic as this specific setting creates a confounding factor with probable time-specific (fashion, Zeitgeist) preferences inherently combined with conclusions regarding general preferences. As a first step, we changed the instruction for the participants in Study 2 by providing them with information on the production time of the respective car models and asking them to evaluate them on the basis of the historic context of that time. The participants indeed used this additional information which led to a reduction of the relationship between curvature and liking—the major predictor for liking became the innovativeness of the given designs. As curvature is a perpetually changing design property, the participants who have to take the historic context of design into account cannot validly rely on curvature as a major predictor for preference any more. Apparently, evaluation of innovativeness is much easier to assess in such a context.

In Studies 3 and 4, we wanted to uncover a potential cause of dynamic changes of preference for different design properties. In Study 3, we used an adaptation paradigm to simulate everyday life experiences with highly innovative, futuristic car exteriors of so-called 'concept cars'. Everyday life experiences tell us that when we are exposed to new designs we become familiar with them and after a while we get used to not only the new ones, but also the older models "feel old"—they seem out-dated. Indeed, the participants who were adapted towards highly innovative, futuristic car designs showed a different evaluation pattern of the car stimuli compared to the base rate (Study 1). They evaluated cars from the last 15 years as being less innovative. At the same time, their liking data for these models decreased significantly. Other aspects, more physical in nature, such as the curvature of the stimuli, were not affected by the adaptation routine. Importantly, older car stimuli were not rated differently indicating fashion or Zeitgeist effects as being most effective for more recent products. Perhaps, older cars are interpreted as being historic items which are not susceptible to dynamics any more. Study 4, which used very angular, historic car designs as adaptors, extended these findings. Most importantly, curvature was no longer the most important predictor for liking revealed by stepwise multiple linear regressions. In a 1-predictor-model solution, innovativeness, in a 2-predictors-model solution, innovativeness and, negatively related, complexity were identified as the sole predictors for liking. When exposed to and forced to evaluate the design of futuristic cars in the adaptation phase, the participants use innovativeness instead of curvature as the basis of their preferences. We experience similar cognitive processes when coming back from influential international motor shows in Frankfurt, Tokyo or Detroit or after having studied innovative car concepts: being massively affected by highly innovative designs, we seek innovative design solutions, which might be but do not necessarily need to be related to a specific curvature type.

The subsequent control study further investigated the generality of preferences for curved objects. We certainly cannot turn back the clock, but we can investigate market acceptance in historic contexts. If there is a general preference for curved forms independent of Zeitgeist factors, we should find a drop of market acceptance in the periods where angular designs were prominent, e.g., for the 1980s in the car manufacturer sector (see Study 1). We compared the production numbers of the six car brands used in the present studies with curvature ratings of the Study 1. Although in the current study we cannot control for other factors influencing production volume, we found no indication for a drop in the production for periods when very angular designs were on the market. On the contrary, we only found indications for particularly strong production figures in the 1980s, the peak of angular and boxed designs in the automobile industry. Caution for interpretation of such data is advisable, as we cannot control for additional factors such as exchange rates, production costs, export barriers, political constraints, technical innovations and flops, or the financial situation of the given time period, which are all known to have an influence on production rates. We could, however, demonstrate that angular design does not necessarily lead to rejection of products, operationalized here by the production numbers of cars. On the basis of these data we should not speak of general preferences for curved objects in all time periods.

This also indicates that every era has its shape, its fashion, Zeitgeist, and last but not the least *taste*—the 1980s developed the specific taste to prefer angular designs, while a clear preference for curved designs evolved from the experiences made in the last 10–15 years. Fig. 9 shows for example that the Volkswagen

Fig. 9. Illustration of the change of curvature over time within one specific class of cars, here the Volkswagen compact class (Beetle and Golf) is used.

compact class had a very round shape in the first decades. Having always been a best-selling car, the change of shape was seemingly adequate for the target group.

Anecdotal descriptions tell us, people loved the form of such cars, particularly the Beetle-like form. The 1970s and 1980s were dominated by a completely different design vocabulary (German: "Formensprache") described as clear-cut, angular, square-cut and polygonal. And yet, people loved it—once again. People, moreover, probably preferred it because it was the style of the time, and closely related to this, it reflected the taste of the time. Again, ten to twenty years later, designers predominantly used curved designs, more and more also mixed with angular artifacts. Again, people showed a preference for the new designs. Seen from a longer range perspective, it seems that people's taste changed in a cyclical way. A new kind of Formensprache substitutes the previous one, where "old forms" are labeled as "old-fashioned" and "out-dated".

After careful consideration of everyday phenomena and an analysis of historic developments, it is clear that we encounter complex dynamics of our Formensprache throughout a lifetime. From a cognitive psychological perspective, it is of relevance which specific processes such dynamics might trigger.

First of all, from the data basis provided by Study 1, we recognize long-term cycles of design properties such as curvature. Evidently, general forms, such as curved vs. angular designs, show cyclical appearances. A closer inspection of such designs, however, reveals that a specific design is not merely copied in the future. For instance, the case of "retro style" only imitates or is influenced by, but does not fully copy a predecessor. Copied old designs would not be appreciated much due to technical, security or legal issues.

Second, a design becomes out-dated by the introduction of a new one. Often, new designs are in discordance with our "visual habits" at first sight (Carbon & Leder, 2005a)—the reason why we often reject new and unusual designs. After a while, we adapt to the new designs (Carbon & Leder, 2006; Carbon et al., 2006a)—we "fit the mind to the world" (Rhodes et al., 2003). With more frequently observed new designs, we increase the rate of mere exposure to them, thus increasing their liking (Zajonc, 1968). Such an adaptation mechanism was also shown in Studies 3 and 4, demonstrating that pure adaptation to trend-setting designs could be a simple and plausible explanation of how such cycles might emerge. This is in accordance with Cutting's (2006) idea that we prefer canonical pictures of, for instance, artists, because we have been exposed to them more often than to non-canonical examples. After a longer period of exposure to and elaboration with the new designs, we integrate the new appearances into our "visual habits" (Carbon & Leder, 2005a). Carbon and Leder have recently developed a simple technique to simulate such everyday phenomena of getting familiarized with new material. Their "repeated evaluation technique" (RET, Carbon & Leder, 2005a) explicitly prompts deep elaboration of any given material by the participants. Although the participants typically reject innovative designs, while preferring familiar and more conservative designs before the RET elaboration phase, this evaluation pattern reverses after the RET. Thus, the RET can trigger dynamics of aesthetic appreciation and can demonstrate changes in taste within a very short period of time as proved by behavioral (Carbon & Leder, 2005a) as well as psychophysiological measures (Carbon, Hutzler, & Minge, 2006b; Carbon et al., 2008).

General preferences for visual objects might be based on evolutionary-shaped processes, such as heuristics that tell us where more or less danger is to be expected. Angular forms might provide such cues for danger, but angular forms might also increase our arousal, which could trigger appreciation (Berlyne, 1974)—just look at the "W.W. Stool" designed by Philippe Starck for film director Wim Wenders: it obviously resembles a dangerous object which could easily hurt you. Nevertheless, it is highly appreciated, fancy, and pleasing. We also know from biological research that angular forms are preferred in some cases, for instance, for selecting human males (Thornhill & Gangestad, 1999). Furthermore, humankind has created some products that are usually designed very angular due to production constraints or production methods. These products are, though, preferred to curved designs, probably due to their prototypical appearance (Winkielman et al., 2006).

Considering all the aforementioned facts, although humans might generally be pre-shaped by evolution to prefer specific properties preventing them from danger, they are specifically shaped to explore innovative and challenging properties. The experience of the dynamics arising from the interaction of both antipodes and the continuous pursuit of a counter-balance between them might provide an explanation why human nature is so successful in designing objects and adapting to them.

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