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REVIEW

Beauty and the brain: culture, history and individual differences in aesthetic appreciation

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Abstract

Human aesthetic processing entails the sensation-based evaluation of an entity with respect to concepts like beauty, harmony or well-formedness. Aesthetic appreciation has many determinants ranging from evolutionary, anatomical or physiological constraints to influences of culture, history and individual differences. There are a vast number of dynamically configured neural networks underlying these multifaceted processes of aesthetic appreciation. In the current challenge of successfully bridging art and science, aesthetics and neuroanatomy, the neuro-cognitive psychology of aesthetics can approach this complex topic using a framework that postulates several perspectives, which are not mutually exclusive. In this empirical approach, objective physiological data from event-related brain potentials and functional magnetic resonance imaging are combined with subjective, individual self-reports.

Key words aesthetics; cognitive neuroscience of aesthetics; empirical aesthetics; experimental aesthetics; experimental psychology of aesthetics; neuroaesthetics.

Introduction

Humans appreciate a wide range of entities aesthetically: painting, sculpture, music, opera, theatre, literature, design and buildings but also faces, flowers, landscapes, food, machinery, habitats and various objects of everyday life. The mental processing that underlies aesthetic appreciation or production is highly complex, so the topic as a whole involves a wide range of issues that challenge attempts to undertake a unified approach. This article will briefly review work showing that aesthetic processing, i.e. the evaluation or production of beauty, ugliness, prettiness, harmony, elegance, shapeliness or charm, is governed by a host of factors such as stimulus symmetry, complexity, novelty, familiarity, artistic style, appeal to social status and individual preferences. Evolutionary psychologists have identified universal, biological aspects of beauty that may be reshaped by cultural and historical influences (e.g. Perrett et al. 1999; Tomasello, 2000). Cultures differ, however, in what is considered beautiful and within cultures people differ; moreover, the degree of agreement between individuals differs between content domains. Therefore, aesthetic processing can be usefully considered from multiple perspectives including evolutionary, historical, cultural, educational, cognitive, (neuro)biological, individual, personality, emotional and situational (Jacobsen, 2006). Hence, any attempt at understanding the cognitive processes underlying human aesthetics, as a whole, is best approached from a number of different perspectives at several different levels of analysis, always bearing in mind the need to relate these approaches to the human brain architecture that underpins and accommodates all facets of aesthetic experience and behaviour.

Psychology of aesthetics

In 1876, Gustav Theodor Fechner published his major work on psychological aesthetics in the 'Vorschule der Aesthetik'. That year marks the beginning of the second oldest branch of experimental psychology, following Fechner's psychophysics. In contrast to most of the very popular philosophical aesthetics of his days, he argued for an empirical 'aesthetics from below' that assembles pieces of objective, empirical knowledge. Today's psychology of aesthetics still follows Fechner's tradition. It often establishes transformational relations between objective observations from a third person perspective, on the one hand, and participants' reports based on individual, inherently subjective experience, on the other. In the neuro-cognitive psychology of

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aesthetics, the objective observations comprise measures such as electroencephalography, event-related brain potentials (ERPs), magnetoencephalography, functional magnetic resonance imaging (fMRI) or positron emission tomography. In contrast, the subjective reports are irreducible because they constitute the access to the phenomenological, qualitative side of mental aesthetic processing. In taking this approach, the discipline constitutes one aspect of inner psychophysics, the science relating body-internal physiological measures to experience.

When considering the history of experimental aesthetics, a few major trends can be identified. Following Fechner's seminal writings, a number of contributions stand out as seminal. 'Gestalt' psychology had a strong influence on the psychology of art and aesthetics. In this context, the work of Arnheim (1974) represents an important application of gestalt laws of perception to art and aesthetics. The quality of a perceptual gestalt affects aesthetic processing of that stimulus. Berlyne (1971, 1974) advocated a psycho-biological approach and succeeded in reviving experimental aesthetics on a large scale after a period of neglect. He emphasized the importance of physiological arousal and suggested inverted U-shaped relations between so-called 'collative' variables (complexity, novelty, etc.) and aesthetic appreciation. Eysenck (1983 and references therein), an eminent theorist in personality structure research, contributed a great number of mostly comparative and psychometric publications to experimental aesthetics. Another milestone is the cognitive theory of Martindale (1988), which put particular emphasis on the determining role of a person's cognitive representations, the structure of knowledge, to aesthetic processes.

The meaning of the word 'aesthetics' is multilayered and has changed over time. Two main clusters of meaning can be identified. The first is related to processes of sensation, as illustrated by its derivatives 'anaesthetic', the absence of sensation, and 'synaesthetic', involuntary co-sensation. The second cluster is related to the meaning of aesthetics as discussed in the humanities, philosophy and art history. In a recent study of German college students, a bipolar beautiful/ugly dimension clearly appeared to be the primary and prototypical descriptive dimension used to address the aesthetics of objects (Jacobsen et al. 2004). This result, of course, converges with the main conceptualization of aesthetics in philosophical and psychological aesthetics: 'beauty'. At a secondary level, there is a conceptual system entailing a larger number of concepts, e.g. elegant, harmonious, shapely, small, big, round and coloured. The descriptive approach of such a study yields information about a given state without negating potential change due to historical, educational, cultural and other influences. The study showed that, in contemporary Western culture, the second range of meanings of the word 'aesthetics' dominates. The first meaning, related to sensation, however, is inherent in that a sensory component is mandatory for aesthetic processing. For instance, an aesthetic judgement of beauty requires sensory processes, whereas a memory-based judgement of beauty does not. Consequently, aesthetic processing is sensation-based evaluation of an entity with respect to the above conceptual system, primarily the beauty dimension. The sensory sub-components of aesthetic processing can be mentally simulated using imagination. Throughout this text, the word 'aesthetics' will be understood as referring to beauty, the arts, shapeliness, elegance, harmony and the like, rather than as referring to the study of perception *per se*.

Human aesthetic appreciation

Many determinants of aesthetic experience and behaviour have been identified (Fechner, 1876; Berlyne, 1971, 1974; Arnheim, 1974). It has been reported that aesthetic experience and judgements are affected by the symmetry or asymmetry of an object (Fechner, 1876; Berlyne, 1971; Jacobsen & Höfel, 2002), complexity or simplicity (Berlyne, 1970, 1971), novelty or familiarity (Berlyne, 1970, 1971), proportion or composition (Höge, 1995; Locher, 2003), semantic content as opposed to formal qualities of design (Martindale, 1988), prototypicality of an object (Hekkert & van Wieringen, 1990; Hekkert et al. 2003) and the significance or mere exposure of a stimulus (Leder et al. 2004). In addition, many factors are known to influence aesthetic judgements, including aspects of a person's emotional state (Konecni, 1979), interestingness of a stimulus (Berlyne, 1971), appeal to social status or financial interest (Konecni, 1979; Ritterfeld, 2002), education and historical, cultural or economical background in general (Konecni, 1979; Jacobsen, 2002; Ritterfeld, 2002). Various situational aspects play a role, e.g. we might appreciate the same object differently in a museum compared with a supermarket. In addition, aesthetic judgement is also determined by inter-individual differences (Fechner, 1876; Berlyne, 1971; Whitfield, 1984; Martindale, 1988; Jacobsen, 2002, 2004a; Jacobsen & Höfel, 2002). These and other factors illustrate the fact that aesthetic experiences and behaviour are subject to a complex network of stimulus-, person- and situation-related influences.

As a 21st century subject, the psychology of aesthetics is characterized by a mosaic of empirical approaches. The inherent problems that have to be faced today are, however, the same as in the past, e.g. the conflict between the degree of experimental control, on the one hand, and the extent of the generalisability of the findings, on the other. The logic of the experiment calls for clearly defined conditions that, preferably, are varied only in regard to one or a few well-defined factors, whereas the others remain constant. This methodological background applied to the study of aesthetics often implies a sacrifice of stimulus complexity for the sake of maximum experimental control. In the scope of these experiments, participants are asked to judge the beauty of geometrical shapes or just simple lines. But can individuals make genuine aesthetic judgements about such simple forms? Usually, individuals are more comfortable making an aesthetic judgement about paintings, sculptures, buildings or melodies, which are much more complex. These, however, mostly combine variations of a multitude of stimulus dimensions that hamper adequate experimental control or even render it impossible. For this reason, researchers often restrict themselves to simple, easy-to-control stimuli, even though they are then very much restricted in their statements about combinatory effects and interactions between the facets investigated. In the worst case, it is impossible to come to any conclusions about the objects of interest. However, there is virtually nothing that cannot be appreciated aesthetically, including simple shapes.

All of the qualitatively different multifaceted processes of aesthetic perception are supported by dynamically configured neural networks. Therefore, it is absolutely mandatory to experimentally constrain the complexity of mental processing in order to be able to generate informative data. The fact that there are a vast number of dynamically configured neural networks underlying these multifaceted processes of aesthetic appreciation may also account for the bulk of differences in results between neuroscientific studies that have been reported to date (e.g. Kawabata & Zeki, 2004; Vartanian & Goel, 2004; Chatterjee, 2004; Zaidel, 2005; see also Zaidel, 2010, this issue). This is the current challenge – a challenge of successfully bridging art and science, aesthetics and neuroanatomy.

The framework for the psychological study of aesthetics proposed by Jacobsen (2006) adopts seven vantage points related to aesthetic processing (Jacobsen, 2006). Each vantage point can have different levels of analysis, which are not mutually exclusive. They are concerned with the processing of aesthetics, although approaching it in a multifaceted manner from different angles, covering a broad range of partly inter-related topics. These seven perspective pillars are: mind, body (these two are at the heart of neuroaesthetics), content, person, situation, diachronia and ipsichronia (see Fig. 1).

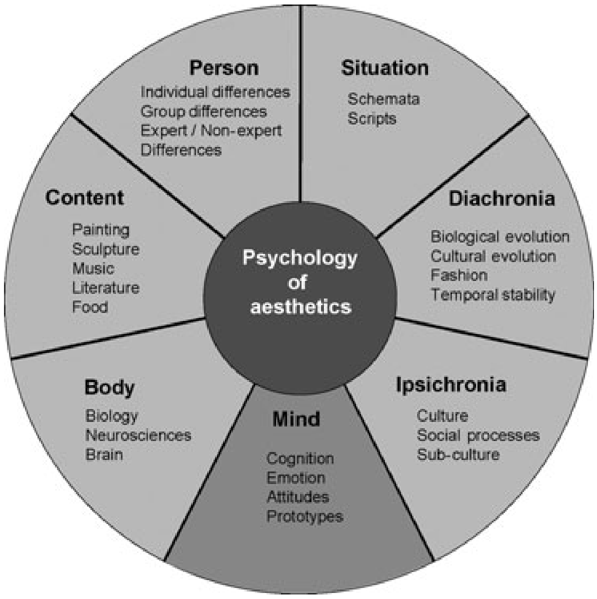

Fig. 1 An illustration of a framework for the Psychology of Aesthetics (from Jacobsen, 2006). The topic is viewed from seven different vantage points, which are not mutually exclusive. These are called: diachronia, ipsichronia, mind, body, content, person and situation. Eventually, this work can converge on a unified theory of processing aesthetics. Diachronia is the perspective that takes change over time into account. Ipsichronia is the vantage point focusing on comparisons within a given time slice, i.e. comparisons between cultures, sub-cultures or social systems.

In a recent study, aesthetic judgements of the beauty of 49 novel, formal graphic patterns were collected from non-artist participants (Jacobsen, 2004a). The data were subjected to individual analyses resulting in models reflecting the individual's strategy of aesthetic judgement. In such an idiographic approach, individual case modelling provides the means of capturing these inter-individual differences. The study also derived a group model based on averaged data. This model, however, could sufficiently account for only half of the participants' strategies, whereas the individual models provided a much more precise account. It therefore seems reasonable to assume that some nomothetic studies, i.e. studies seeking to postulate general principles, may have camouflaged marked individual differences by using data averaging. Hence one may debate the justification of mere nomothetic approaches given such a data pattern. Thus, it was argued that the idiographic approach should be additionally adopted, if such an equivocal empirical situation is encountered (Jacobsen, 2004a). In that sense, there is (no) accounting for taste, indeed.

Some differences between individuals are, however, reasonably well accounted for at the level of group differences. Experts and non-experts, laymen or novices differ in regard to their abilities and skills. Experts are equipped with a specific, structured knowledge of their area of expertise. Knowledge systems show different degrees of complexity. These different cognitive systems, in turn, can lead to different aesthetic processing. These principles are illustrated by studies that contrast the performance of groups of experienced judges with the performance of groups of naive or inexperienced judges (e.g. Nodine et al. 1993). There is also a considerable literature based on personality structure research (e.g. Eysenck, 1983). In addition to inter-individual and inter-group differences, cultural differences are an important perspective.

The preference-for-prototype model, for example, holds that prototypical exemplars of a given category will be preferred over less typical ones (Hekkert & van Wieringen, 1990). This demonstrates the applicability of a very influential cognitive model (Rosch, 1975) to the psychological study of aesthetic processing (see also Reber et al. 2004 for the application of a general fluency concept to the study of mental aesthetic processing). In this vein, there are also more theoretical concepts in cognitive psychology that would be applicable to the study of aesthetic processing. The systematic transfer of contemporary psychological concepts, however, has yet to be carried out.

Our attitude towards a work of art, an object or an event, as it is stored in memory, may determine its evaluation (see e.g. Petty et al. 1997 for a review on attitudes). This is also often the case for aesthetic evaluations. This link has only been elaborated for limited content domains, such as furniture (Ritterfeld, 2002). In addition, cognitive social psychology has developed a theoretical inventory that could be used more intensely for research into the psychology of aesthetics.

Diachronia, the perspective that takes change over time into account, can be pursued at different levels of analysis, e.g. the perspective of evolutionary biology/anthropology addresses the substantial changes from non-human to human primates. The focus of attention here concerns the origins of, and reasons for, human aesthetic behaviour. Why do individuals produce splendid and elaborate tools and weapons if they are not intended for use (e.g. Miller, 2000; Dutton, 2009)? Why do faces have to show a certain degree of symmetry to be perceived as beautiful? What is the contribution of evolution to the development of our aesthetic faculties and skills (Wundt, 1900–1920)? These questions lead to a classical complex of questions in psychology, the nature–nurture debate.

Diachronia is also concerned with the other side of the nature–nurture question, cultural development (or cultural evolution, Tomasello, 2000), which underlies the main variance of aesthetic processing today. Despite the fact that evolution and our biological design play a major role in aesthetics (see Zaidel, 2010, this issue), many aspects of aesthetic appreciation are obviously culture-relative, i.e. culturally determined. This holds, for instance, for the design of urban space (Weber et al. 2008), the design of school environments (Jacobsen et al. 2008) and bleaching procedures in cosmetic dentistry (Höfel et al. 2007).

Another perspective of psychological aesthetics is the historical one, especially related to the history of civilization. Aesthetic judgements and preferences change over time (Jacobsen, 2002; Höfel & Jacobsen, 2003). Aesthetic usage is changed by the availability of tools, the development and availability of materials, and production techniques. For instance, the development of Kandinsky's colour-form assignment, and its transformation into an icon for the Bauhaus school of design as a whole, was a mulitfaceted historical process that involved technical development as well as simplification and the setting down of examples as critical stages (Jacobsen, 2002, 2004b; Jacobsen & Wolsdorff, 2007; see Fig. 2 for an illustration).

Ipsichronia is the vantage point focusing on comparisons within a given time slice. Together with diachronia, it also covers the entire realm of aesthetic processing. A wide range of entities of aesthetic processing is subjected to cultural and social processes. Hence, the effects of culture and influences of social roles, social status or cultural differences are taken into consideration (Baldwin, 1992; Ritterfeld, 2002).

The comparison of cultures can be a very informative method (Wundt, 1900–1920). Contrasting the main cultural tendencies and their predominant ideals of beauty with those adopted by sub-cultures is becoming an increasingly important research endeavour. A systematic survey of the cultural influences on aesthetic tendencies that are assumed to be universal would be an interesting facet of an interdisciplinary approach. There are numerous examples of aesthetic preferences that are contingent on a given culture or sub-culture, like tattoos, (facial) piercings, dress codes or hair styles. Research into the psychology of aesthetics can benefit from research in other disciplines on cultural specificities in order to avoid the proposition of psychological models that are culture-dependent and therefore not general.

Neuro-cognitive psychology of aesthetics: neuroaesthetics

In our laboratory we undertook a cognitive neuroscience approach to the study of aesthetic judgement. To this end, we constructed new stimulus material that enabled us to control for the factors influencing aesthetic judgement that were introduced above (Jacobsen & Höfel, 2002; Höfel & Jacobsen, 2003; Jacobsen, 2004a; Fig. 3). Symmetry and complexity were varied in the material. Other factors were adequately controlled.

The first ERP data reflecting human aesthetic judgement were presented in 2000 (Jacobsen & Höfel, 2000, 2003; Fig. 4). The results showed a double dissociation in temporal course as well as neural sources between an evaluative aesthetic judgement task and a descriptive symmetry judgement task, both using identical stimuli and task structure. A frontal negativity was elicited under the aesthetic judgement task and a posterior sustained negativity was elicited under the symmetry judgement task. Effects were observed for the contrasts non-aesthetic minus aesthetic in the time window between 300 and 400 ms for the frontal negativity, and for symmetrical minus non-symmetrical in the time window between 600 and 1100 ms after stimulus onset (see Fig. 4). Since the original study, these findings have been repeatedly replicated and extended (see Höfel & Jacobsen, 2007a,b; Roye et al. 2008).

In a subsequent ERP study, participants were asked to judge the beauty of male and female faces. As a second task, in different trials, they were also asked to judge whether the shape of a shown face was oval or round. The latter descriptive judgement task was contrasted with the evaluative aesthetic beauty judgement task. ERPs indicated that initial perception, including specific face processing (as indexed by the N170 ERP component), probably did not differ between the judgement conditions. Later, at around

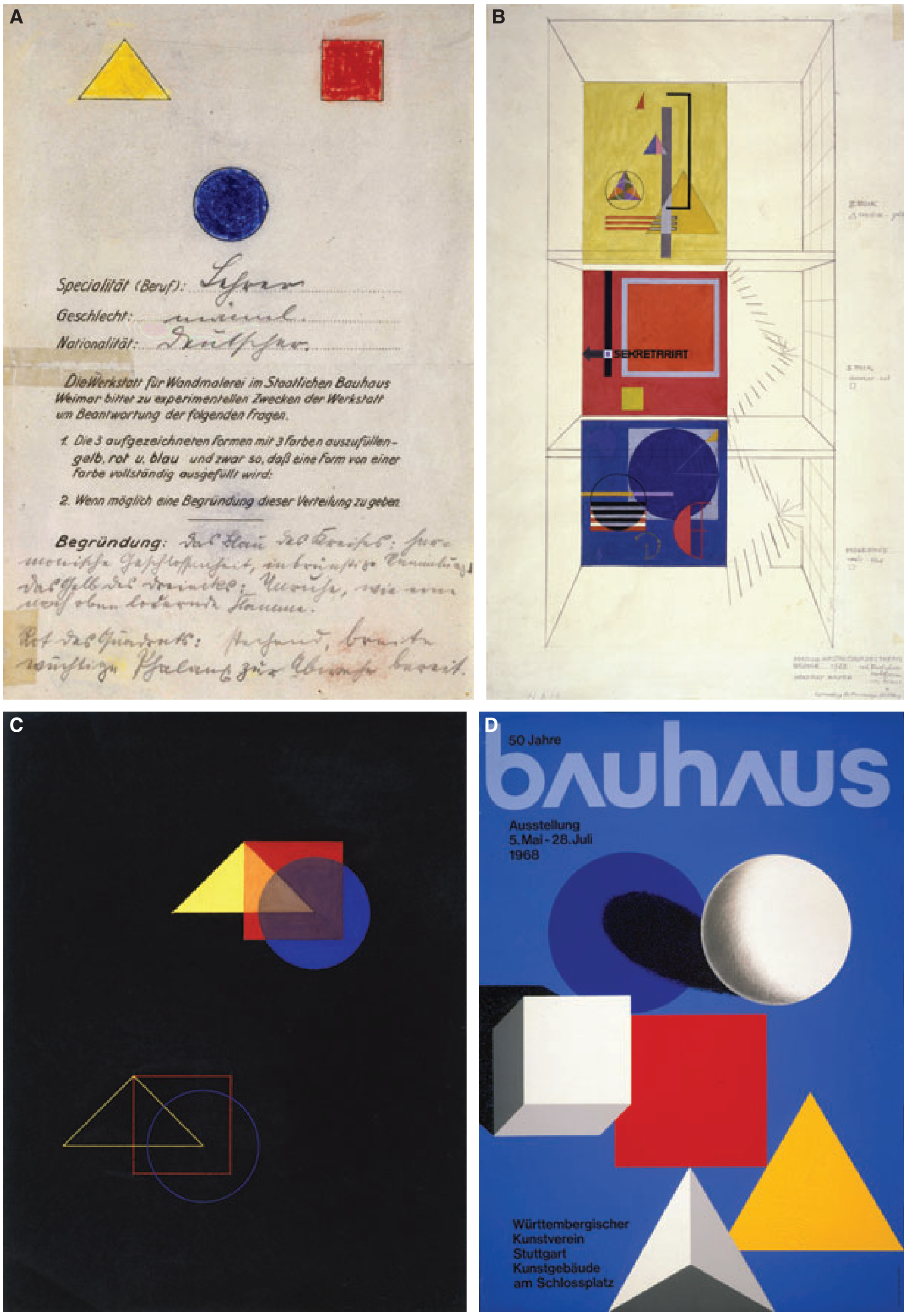

Fig. 2 (A) Original questionnaire of the wallpainting workshop designed by Kandinsky at the Bauhaus to investigate the correspondence of basic colours and forms, 1923 (Bauhaus-Archiv, Berlin, Germany). Filled in using the Kandinsky colour-form assignment by an unknown member of the Bauhaus. Two copies of the original questionnaire (one filled in, one blank) that still exist today are frequently used for illustrative purposes in publications about the Bauhaus. A third, filled-in copy was recently discovered (http://www.bauhaus.de). (B) Herbert Bayer: design of the colour scheme in the staircase leading up to the exhibition spaces of the Bauhaus exhibition at the Bauhaus in Weimar, 1923. Gouache on paper, 66 × 40 cm (Bauhaus-Archiv, Berlin, Germany; http://www.bauhaus.de). (C) Fritz Tschaschnig: Exercise work from Kandinsky's teaching, 'Räumliche Wirkung von Farben und Formen', 1929–1930. Tempera and pencil on black cardboard, 42.4 × 33.2 cm (Bauhaus-Archiv, Berlin, Germany; http://www.bauhaus.de). (D) Advertisement poster for the Bauhaus exhibition in Stuttgart in 1968 created by Herbert Bayer who used the combinations of colours and forms as in the illustration (Bauhaus-Archiv, Berlin, Germany; http://www.bauhaus.de).

400 ms after the onset of the stimulus presentation, ERPs differed reflecting the aesthetic evaluation of the face stimuli. Moreover, the ERPs also revealed stimulus-dependent gender differences in aesthetic judgement. Surprisingly, both men and women took less time to judge male faces than female faces. This is likely to be due to the judgements having been made on the basis of a coarser set of cues. Female faces, however, required a longer time to be evaluated and were judged taking a larger number of cues into consideration.

Focusing on neuroanatomical questions, fMRI was used to investigate the neural correlates of aesthetic judgements of the beauty of geometrical shapes. Participants performed evaluative aesthetic judgements (beautiful or not?) and descriptive symmetry judgements (symmetric or not?) on the same stimulus material. Symmetry was employed because aesthetic judgements are known to be often guided by criteria of symmetry. Novel, abstract graphic patterns were presented to minimize influences of attitudes or memory-related processes and to test the effects of stimulus symmetry and complexity.

Behavioural results confirmed the influence of stimulus symmetry and complexity on aesthetic judgements. Direct fMRI contrasts showed specific activations for aesthetic judgements in the frontomedial cortex [Brodmann Area (BA) 9/10)], bilateral prefrontal (BA 45/47) and posterior cingulate, left temporal pole, and the temporoparietal junction (Fig. 5). In contrast, symmetry judgements elicited specific activations in parietal and premotor areas subserving spatial processing. Interestingly, beautiful judgements enhanced the blood oxygenation level-dependent signals not only in the frontomedial cortex but also in the left intraparietal sulcus of the symmetry network. Moreover, stimulus complexity caused differential effects for each of the two judgement types.

The findings indicated that aesthetic judgements of beauty rely on a network that partially overlaps with the network underlying evaluative judgements on social and moral cues. This neural overlap was taken to reflect the neural underpinnings of domain-general processes of self-reflective, subjective evaluation. The findings of the study also substantiate the significance of symmetry and complexity for our judgement of beauty.

In a very recent fMRI study, Kornysheva et al. (2009) investigated individual aesthetic preferences for rhythmical structures. Participants were asked to either perform aesthetic judgements or tempo judgement on short pieces of rhythmic music. The fMRI blood oxygenation level-dependent contrasts revealed a specific network sub-serving both judgement processes. On the one hand, there was a further replication of earlier structural findings by Jacobsen et al. (2006) in that the fronto-medial cortex (BA 9/10) showed stronger activations for the aesthetic judgement task compared with the tempo judgement task. Domain specificity of the musical rhythm stimuli, on the other hand, was

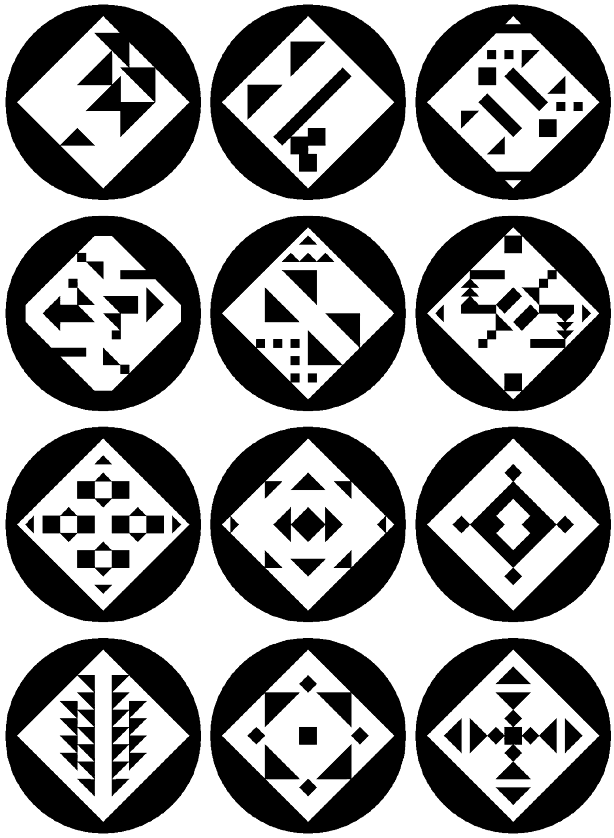

Fig. 3 Stimulus examples from Jacobsen & Höfel (2002, 2003), Höfel & Jacobsen (2007a,b) and Jacobsen et al. (2006). The graphic patterns in rows 1 and 2 are not symmetric, ranging from not beautiful to beautiful (line by line). Patterns in rows 3 and 4 are symmetric, also ranging from not beautiful to beautiful.

indicated by an involvement of the premotor cortex component of the network. This divergence in structural recruitment, as compared with the stimuli from the visual domain, indicated that sequencing was an integral constituent of this task. Assessing the temporal relations between sounds was mandatory in both tasks in this experiment. Tuning in to the beat, however, as reflected by stronger ventral premotor cortex activation, was observed only for more beautiful rhythms. Therefore, this study is a good example of the investigation of the dynamically configured brain networks sub-serving aesthetic appreciation and its domain specificity.

Neuroaesthetics integrally deals with the body/brain and mind vantage points introduced above. The other five perspectives also contribute to making predictions about mental processing, behavioral performance and the dynamic configurations of underlying brain networks. Neuroaesthetics, in its correlational approach, constructs transformational relations between irreducibly and individually subjective mental processes and states, on the one hand, and their objectively, externally observed neural underpinnings, on the other. Therefore, the study of neuroaesthetics follows the tradition initiated by Fecherns, not only from his experi-

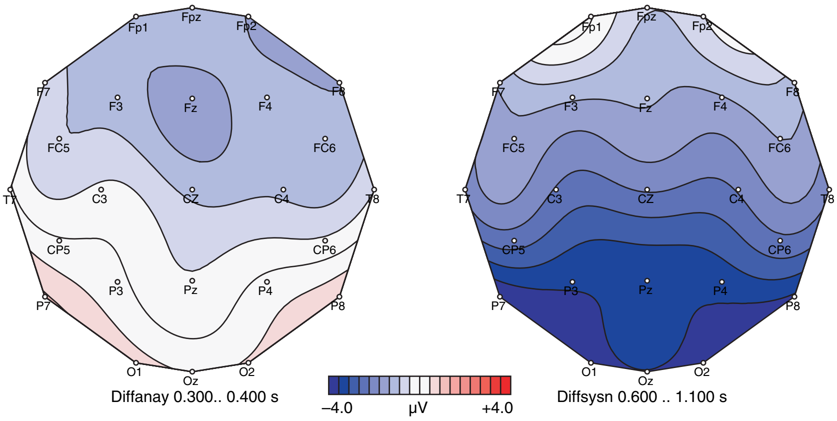

Fig. 4 ERP data from Jacobsen & Höfel (2000, 2003). Maps of electrical potentials are shown in a view from above (frontal areas at top of the figure). Standardized electrode sites are indicated by small circles. Frontal negativity elicited under the aesthetic judgement task (left panel) and posterior sustained negativity elicited under the symmetry judgement task (right panel). Mean difference potentials were plotted. The not-aesthetic minus aesthetic is shown in the time window between 300 and 400 ms for the frontal negativity and the symmetrical minus non-symmetrical contrast is shown in the time window between 600 and 1100 ms after stimulus onset (see Höfel & Jacobsen, 2007a,b; Jacobsen et al. 2001; Roye et al. 2008, for further information).

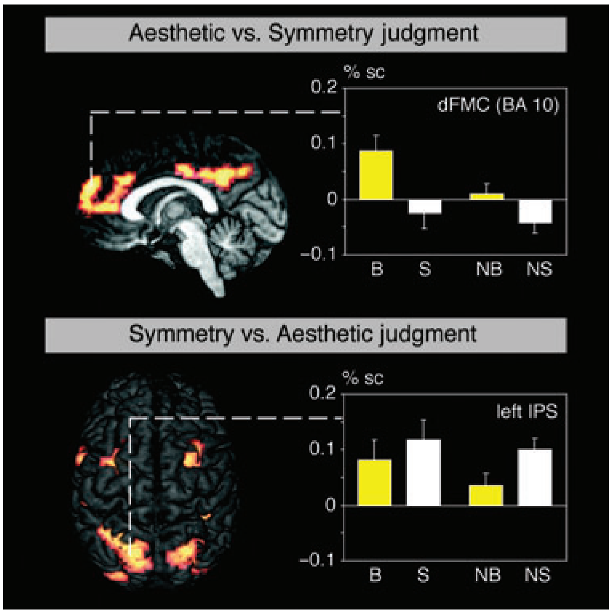

Fig. 5 FMRI results from Jacobsen et al. (2006). Group-averaged (n = 15) statistical maps of significantly activated areas for aesthetic judgements as opposed to symmetry judgements (upper panel) and for symmetry as opposed to aesthetic judgements (lower panel). Z-maps were thresholded at z = 3.09 (P < 0.05 corrected). Bar charts show percentage signal changes in two regions of interest [dorsal frontomedial cortex (dFMC) and intraparietal sulcus (IPS)] as measured during the judgements 'beautiful' (B), 'symmetric' (S), 'not beautiful' (NB) and 'not symmetric' (NS); $\%_{SC}$, percent signal change.

mental aesthetics but also, and more centrally, because it is a brilliant example of modern psychophysics. Today, inner psychophysics has come a long way due to the availability of modern neuroscientific methods. The basic methodological approach, however, is the same. In a pragmatically dualistic approach, subjective experience and external observation (electroencephalography, ERP, magnetoencephalography, fMRI, positron emission tomography, etc.) are correlated or, when possible and ethically feasible, causal relationships are established (neuropsychology and transcranial magnetic stimulation).

All of the factors introduced above, known to affect aesthetic processes, are very likely also to exert an effect on neuroscientific measures. The science of neuroaesthetics has set out to take on an exciting and vastly complex challenge.

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