

Next Steps in Neuroaesthetics: Which Processes and Processing Stages to Study?

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Aesthetic experiences arise from the interaction among several cognitive and emotional processes. By positing a number of distinctive processing stages, information-processing models have served as fruitful frames for empirical research on the perception of art and aesthetic experiences in general. Such theoretically founded proposals have contributed, among other issues, to our understanding of style-related processing, the time course of early processes, and the relevance of prior experience, including massive familiarization, emotional states, and expertise. Here we examine the implications of recent empirical research for the components of an information-processing model of aesthetic experiences (Leder, Belke, Oeberst & Augustin, 2004). On the one hand, our analysis suggests that the model underestimated the complexity and relevance of emotional processes involved in experiencing art. On the other hand, it has led to new insights into the temporal processes underlying the aesthetic experience and helped clarify issues that will be relevant for future research in experimental aesthetics and neuroaesthetics.

Keywords: aesthetic experience, aesthetic emotion, neuroaesthetics

Art has been the object of empirical study since the very foundation of psychology as a modern science in the second half of the 19th century. Indeed, experimental aesthetics emerged as an early research interest for psychologists (Fechner, 1876). Looking back, Fechner's interest in aesthetics might seem a little opportunistic. At the very least, given how his work capitalized on very fashionable issues at the time, it was a wise tactical decision. The natural sciences were viewed as essential driving forces of technological progress and innovation, and at the same time—closely related with the development of class distinction (see Bourdieu, 1984)—the bourgeois middle class was greatly interested in the cause and function of taste for beauty. An interest in art was a popular, relevant, and admired bourgeois virtue. The appearance of the art societies, the *Kunstvereine* (Grasskamp, 1989), exemplifies this attitude. If the newly emerging empirical psychology was to play a serious role in the canon of modern sciences, what better than to prove the strengths of the most forefront psychological methods to study—and eventually answer—such captivating questions?

Gustav T. Fechner (1801–1887) in Leipzig took this challenge up and provided more than one example of how the nascent science of psychology could address issues pertaining to beauty and art. To this end, the experimental approach he developed

earlier for his psychophysics program was crucial. He addressed general principles of good taste and aesthetics, for instance, by studying people's assessments of the beauty of rectangles with systematically different proportions. His empirical results showed that the proportion representing the often-cited "Golden Section" seemed to be preferred to others. Fechner also published a series of theoretical papers in which he combined historical aspects with aesthetic positions. He also did not pass up a great opportunity to conduct the first field study in experimental aesthetics.¹ In 1871, two nearly identical versions of Holbein's *Madonna* were being shown at a very successful exhibition in Dresden. Taking advantage of the great public expectation created by discussions as to which was the original and which a copy, Fechner studied visitors' responses to both paintings. Although his approach—to examine the role of aesthetics in this "experiment," or historical question, as he called it—was remarkably advanced for his time, it hardly received any public or scientific attention (Schönplflug, 1965). Moreover, Fechner complained that the question of authenticity—different from the intended discussion of aesthetic quality—was erroneously mistaken as the purpose of his study. This example illustrates how the founders of the up-and-coming science of

¹ Original citation by Fechner: "Ein öffentliches ästhetisches Experiment mit dem Vergleiche dieser Exemplare ist von mir bei Gelegenheit der Holbeinausstellung im Jahre 1871 angestellt, worüber in der kleinen Schrift 'Bericht über das auf der Dresdener Holbein-Ausstellung ausgelegte Album' (Lpz. Br. u. H. 1872) berichtet ist." Translation by HL: "In 1871 I conducted a public aesthetic experiment comparing the two exemplars at the occasion of the Holbein exhibition which I describe in the report 'Report on the album displayed at the Dresden Holbein exhibition'" (from <http://www.uni-leipzig.de/~psycho/wundt/opera/fechner/vrschul1/VAesthII.htm>).

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psychology picked up on questions they believed were interesting for their society, and how they used them to showcase psychology's scientific value.

This was certainly a promising start. Nevertheless, experimental or at least empirical aesthetics experienced a surprisingly slow progress during the 20th century. Despite the fact that there were rather few coherent approaches during this period, most theoretical movements and paradigms also made some contributions toward a psychology of the arts. Though mainly at a descriptive level, Gestalt psychologists provided highly insightful principles. Their most renowned contributions include the explanation of artistic composition through the law of Prägnanz, or their conception of entropy as a quality of art (Arnheim, 1987). Most of such principles, incidentally, still await process-based explanations that reveal the underlying cognitive and neurophysiological mechanisms (see Marr, 1982). For example, to explain Gestalt principles, Hummel (2001) studied the binding features that lead to the perception of figures and proposed a neural network—in accordance with his data—that explained how this might be accomplished.

Behaviorism had little to say about aesthetics (see Kreitler & Kreitler, 1972), but the subsequent psychobiological approaches led to fruitful studies in which aesthetics was regarded as a drive for curiosity and modulation of psychophysiological states. In this respect, Berlyne (1976) proposed a comprehensive framework in which arousal-state-modulating aspects of curiosity and art were discussed. Similarly, Kreitler and Kreitler (1972) grounded their approach on a rich combination of cognitive psychology with psychodynamic homeostatic states, where meaning played a crucial role.

Owing to the driving force of perceptual issues, empirical aesthetics has always focused more on the study of receptive than productive processes. Research focusing on perceptual features related with aesthetics, as well as on how they are processed, has been especially influential. Nodine and Locher's (1985; Locher, 2006) studies are good examples of a successful research program aimed at studying how we perceive art. To test various hypotheses relating artistic laws of composition and aesthetic appeal, the authors measured eye movements. In their experiments they typically compared different versions of the same artworks and systematically varied different tasks. This approach lies within the tradition of classical psychophysics, where the effects on experience are studied through systematic variation of stimulus features, preferably along a single well-controlled dimension. Work performed during the last decades has demonstrated that although this approach is strong on the perceptual aspects, a number of methodological improvements are required to achieve a comprehensive account of aesthetic experiences (see, e.g., Locher, 2006). New information technology and the improvement of computer power have allowed empirical aesthetics to make a decisive step forward in the last decade. Several limitations have been overcome, making it possible to handle complex and colorful images in new experimental software packages. Notably, the processing and manipulation of images and artwork reproductions have progressed significantly, owing to increasingly powerful image processing programs. Out of a concern for ecological validity, efforts have been made within aesthetic research to approximate the complexity and resemblance of experimental settings and materials as much as possible to the kinds of situation and objects people naturally associate aesthetic experiences with.

During the last decades researchers in experimental aesthetics have begun to put their findings together to create descriptive models, often following the information processing approach. Nodine, Carmody, and Kundel's (1978) early model describes the components and processing units that control eye-movements in general, but also with a focus on the arts. Jacobsen (2006) presented a classification system of the main levels at which aesthetic appreciation can be—and should be—scientifically studied. Grounded on the neuropsychological literature, Chatterjee (2003) developed a stage model that identified important processes involved in aesthetic experiences, as well as their neurological substrates. Similarly, Leder, Belke, Oeberst and Augustin (2004) assembled and integrated findings from experimental aesthetics into another information-processing model. This “information-processing flow model” was conceived to illustrate the set of factors that enter into play when we experience an artwork, as well as those factors' dynamics. The model identifies a sequence of processing stages that represent different psychologically relevant components of visual, cognitive, and affective processing. Originally, its main aim was to serve as a framework for empirical research and to map the various findings and hypotheses onto corresponding “information-processing stages.” Thus, it could differentiate studies conducted in experimental aesthetics along the different subprocesses in terms of representations. Despite being a descriptive model, it has the potential of being segmented into subcomponents apt for studying specific processes. Therefore, certain parts—or eventually the whole model—could be transformed into a mechanistic version capable of describing how information is transformed from one stage to another.

As shown in Vartanian and Nadal's (2007) comprehensive comparison and discussion of current psychological models of art and aesthetic appreciation, Leder and colleagues' (2004) proposal is well suited to guide psychological research because of its level of resolution. It is specific regarding the processes that are susceptible to the influence of object and perceiver characteristics, as well as regarding the stage-related representations. Also, it postulates processing stages that suggest effects in terms of order and interaction that can be studied empirically. In the present review, this stage model will be used as a directory to discuss the development of recent research on the different processing stages it posits, and to highlight the emerging open questions for neuroaesthetics. Research in neuroaesthetics addresses the neural processes involved in the perception and production of works of art or objects of aesthetic value. Chatterjee (2011) provided a review of neuroaesthetics, focusing on visual aesthetics and the challenges it faces.

Understanding Art Appreciation

Figure 1 presents Leder and colleagues' (2004) model in which some details have been adapted from the original version. These will be discussed in the text and represent changes that emerged since its publication in 2004. A number of studies have referred to the model, either by using it as a general frame of reference in psychology of the arts, or by directly examining the processing stages.

The model is read from left to right. The processes that take place within the perceiver during an aesthetic episode (i.e., the time spent looking at, exploring and thinking about the artwork)

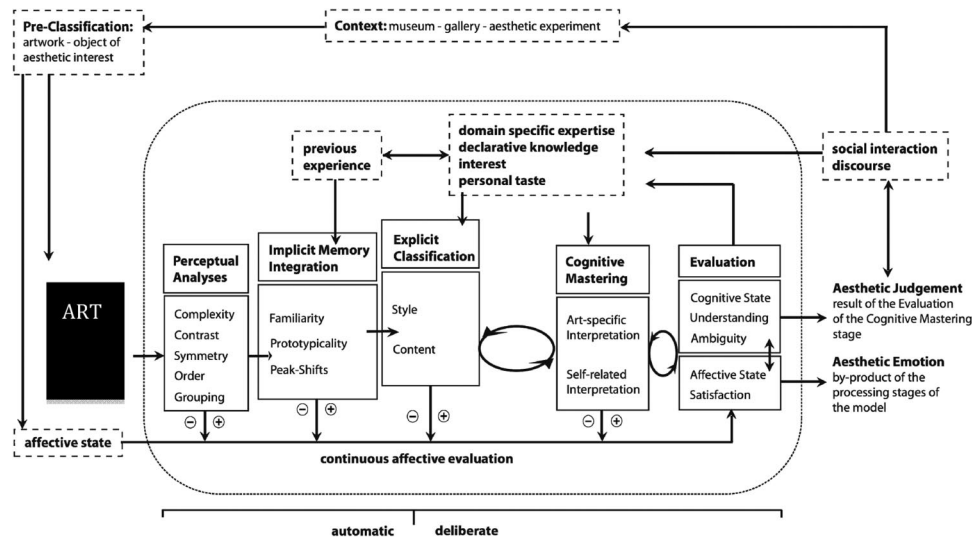


Figure 1. Modified version of the information processing model by Leder, Belke, Oeberst & Augustin (2004). Figure adapted by Elisabeth Schwillle.

are represented within the central finely dotted curved square. The model was originally developed to cover the processes involved in episodes of visual art, mainly modern or contemporary. The model, nonetheless, has also been used as a frame of reference in the realm of aesthetics of everyday objects (Stich, Knaeuper, Eisermann, & Leder, 2007), of design objects (Spendlove, 2008; Reimann, Zaichkowsky, Neumhaus et al., 2010), dance and body perception (Calvo-Merino, Urgesi, Orgs, Aglioti, & Haggard, 2010; Jola, Abedian-Amiri, Kuppusswamy, Pollick & Grosbras, 2012), music (Brattico & Jacobsen, 2009; Istók et al., 2009), and even food (Schifferstein, 2010; Schifferstein, Otten, Thoolen, & Hekkert, 2010). In view of the disparity in the classes of objects that are being studied in aesthetics, as illustrated in the preceding references, it would seem that research in empirical aesthetics might develop into several specific domains. And yet, these references also show how the model can serve as a framework to integrate findings from different specialized areas of experimental aesthetics. For example, the replacement of sensory input by continuously changing patterns of light in film, as opposed to the eminently static nature of painting, poses a challenge to the temporal hypotheses of the model. Indeed, the model's general structure revealed some potential for future adaptation toward different object classes and fields of application with distinctive and specific affordances and processing requirements. Nonetheless, this also raises an important long-term challenge for empirical aesthetics and neuroaesthetics: to produce a comprehensive theory of aesthetics able to cover the full range of aesthetic experiences.

When the Aesthetic Episode Begins: Context

An aesthetic episode begins when a perceiver is exposed to an object that can elicit an aesthetic episode, and when the situation takes place in a context that warrants an aesthetic episode. This is not trivial, as objects that appear very similar can today be found in specifically artistic environments, such as museums or galleries, or in mundane, everyday life settings. Duchamp's ready-mades

constitute the prototypical example. They demonstrate how objects might become art just because of their presentation in the context of an art exhibition. Of course, the essential act of producing this contextual embedding is an artist's decision, and, in consequence, an artist's creation.

A psychological theory of art appreciation should thus be able to ascertain whether objects can indeed be processed differently when seen "as an artwork," and explain what produces this difference. Cupchik, Vartanian, Crawley, and Mikulis (2009) showed that brain activity was different when people viewed paintings with an aesthetic orientation, focusing on their aesthetic experiences, and when they viewed the same paintings merely aiming to obtain information from them, focusing on the depicted content. Whereas the aesthetic orientation was associated with a stronger activation of anterior prefrontal regions, related with cognitive control, the pragmatic orientation toward the paintings was associated with a stronger activation of occipital regions, related with perceptual processing. Thus, an aesthetic attitude leads us to process objects differently than when we approach them with a more casual, everyday attitude.

Top-down classification before the actual episode can also be expected to affect the aesthetic experience by engaging an aesthetic mode or not, leading to an aesthetic episode in one setting but not in another. In addition, top-down classification may regulate the hedonic expectation and thus modulate the intensity of the aesthetic experience. Kirk, Skov, Hulme, Christensen, and Zeki (2009) provided an empirical example of this. They studied the effect of the context in which images were presented on participants' aesthetic valuation of those images and its neural correlates. Participants were told they would see images that were introduced either as artworks from a gallery or computer-generated patterns (nonartworks). Although all the stimuli were computer generated, the classification, which created a semantic context, had a distinct effect on their aesthetic evaluation. Participants gave higher ratings to the same material when it was presented as art, which reveals a

sort of aesthetic status acquired only by the contextual placement. Moreover, analyses of simultaneous brain activity by means of fMRI revealed that the difference in context was correlated with activity in the medial orbitofrontal cortex and the prefrontal cortex, whereas the context, independent of aesthetic value, correlated with bilateral activations of temporal pole and the bilateral entorhinal cortex. The authors concluded that the relevant “prefrontal and orbitofrontal cortices recruited by aesthetic judgments are significantly biased by subjects’ prior expectations about the likely hedonic value of stimuli according to their source” (Kirk et al., 2009, p. 1125).

Using a different methodology, Leder, Tinio, Fuchs, and Bohrn (2010) presented an example of a general context effect that selectively modulates aesthetic preference. Their paradigm built upon Shimojo, Simion, Shimojo, and Scheier’s (2003) finding that perceivers made longer fixations on attractive rather than unattractive faces in a forced-choice beauty selection task. Leder et al. (2010) studied the fixation times for attractive and unattractive faces in images of real-world urban scenes. In a free viewing task in which the scenes with two faces had been intermixed with urban filler scenes without people, the attractive faces were looked at longer, which was in agreement with Shimojo et al.’s (2003) results. In a second experiment, a priming block in which participants read one of two possible texts preceded the free viewing task. One text suggested the possibilities afforded by a city to find partners, marry, and raise a family, whereas the other elicited fear of crime by referring to the criminal dangers in cities. The results showed that the effect of beauty vanished selectively in the latter condition. Although attractive women were still looked at longer, this was not the case with men anymore. Independently of how attractive they were, men—given that they commit most street crimes—were now looked at for about the same time. Thus, it seems that the different contextual priming elicited a specific exploratory behavior that had a strong effect on aesthetics. Eskine, Kacirik and Prinz (2012) also studied the effect of fear on aesthetic evaluation, though in a very different setting. Aiming to disentangle the effects of emotion and arousal on the appreciation of artworks they compared five different conditions: participants either sat normally, were aroused by engaging in 15 or 30 jumping jacks, or saw a happy or a scary—fear inducing—video before rating the artworks. The authors found significantly more positive evaluations of the artworks after participants had seen the scary video, which led them to suggest that “fear uniquely inspires positively valenced aesthetic judgments” (p. 1). To summarize, context seems to have a strong effect on the effectiveness of aesthetic processing. Variations in context and situational demands, therefore, constitute important indicators of the nature of an “aesthetic sense” (Darwin, 1871). The issue of the neural correlates of such adaptation to situational demands remains a question of future research.

Aesthetic Experiences

The first component that the model places within the perceiver encompasses a fairly complex set of processes, summarized as perceptual processing (see Figure 1). The kind of processes included in this box cover what is known as “early and intermediate visual processing” in theories of perception (Chatterjee, 2003; Marr, 1982). Early processes comprise the transformation from

sensory information into visual experiences, as well as those related with perceptual principles that affect aesthetic pleasure. Naturally, the perception of artworks relies on the same processing stages involved in building a representation of our non-art visual environment. The perception of complex images is regarded today as a highly parallel process in which the visual pathways from the retina to the visual areas deliver representations quickly through highly efficient networks. Very early representations sample the distribution of image statistics that allow the coarse classification into different types of scenes, as well as into artistic genres, in a matter of milliseconds. For example, images of landscapes have statistically different distributions than images of forests or urban scenes (Oliva & Torralba, 2001). The combination of ingenious algorithms that identify visually distinctive local features in an image—distinctive colors, areas of high contrast, or high local density of complex elements (Itti, Koch, & Niebur, 1998), for instance—produce depictions of the image with weighted areas that, at least in part, are able to predict early scanning behavior. However, these saliency maps have limitations that become evident when it comes to later stages of extracting meaning and semantic classification (Einhäuser, Spain, & Perona, 2008). Regarding neuroaesthetics, methods that allow fast analyses of brain responses, such as EEG, seem particularly well-suited to understand the temporal order in which brain structures become involved in the very early processes, but also in the subsequent ones (Lengger, Fischmeister, Leder & Bauer, 2007).

Nonetheless, studying artworks along specific values of image statistics can also reveal whether artworks are visually special. For example, Graham and Redies (2010) showed that the power spectra or Fourier analyses differ systematically between different classes of visual stimuli. Their analyses suggest that certain visual features of artworks correspond to the visual coding in the human perceptual system and can inform the way that perception and appreciation might be linked.

This stage of perceptual analyses (see Figure 1) considers the effects of a number of variables that influence images’ aesthetic pleasingness. These include complexity, contrast, symmetry, order, and grouping. *Complexity* has been of interest for a long time, and its role in aesthetic appreciation is still being debated. Nadal and colleagues (Forsythe, Nadal, Sheehy, Cela-Conde, & Sawey, 2011; Nadal, Munar, Capo, Rossello, & Cela-Conde, 2008; Nadal, Munar, Marty, & Cela-Conde, 2010) aimed at resolving the debate concerning the rather ambiguous results of complexity in art appreciation—ambiguous, because some studies found that complexity is preferred, whereas others suggested that simplicity was particularly appreciated. Nadal et al. (2010) combined different methods. First they used a large set of abstract and representational artworks and nonartist images, which were assigned to high, medium, or low levels of complexity based on explicit perceiver evaluations. When participants rated these stimuli for perceived beauty, there was no clear pattern of influences of complexity on aesthetics. Then Nadal et al. (2010) also had a subset of their stimuli classified according to several dimensions that theoretically could determine these levels of complexity, such as the number and variety of elements, aspects of three-dimensionality, symmetry, and so forth. None of these dimensions had a general effect on beauty. The authors concluded that the perceived complexity might have individual causes in different dimensions and that these variations conceal clear effects of complexity on appre-

ciation of artworks. In a related study, Forsythe et al. (2011) concluded that the technical compression rate is a reasonable measure of an artwork's complexity. Moreover, there are attempts to link automatic image analyses with perceived, subjectively assessed complexity, either by level of fractal dimensions (Forsythe et al., 2011) or through the implementation of learning algorithms through neural networks (Gartus & Leder, 2010). The nature of the processes that determine how complexity affects the perception of artworks, however, still remains an interesting topic for future studies.

Contrast

Contrast is one of the main variables that determine the appearance of images. In fact, contrast manipulations are an important mechanism in the art of photography, though they play an important role in the presentation of any kind of image. Reber, Winkielman, and Schwarz (1998) presented findings showing that higher fluency attained through sharper contrast levels could increase aesthetic appreciation. They asked participants to judge circles presented against differentially gray backgrounds that produced different levels of contrast. Under two dimensions of evaluation, participants found higher contrast images prettier and less ugly, which indicates that higher contrast has a generally positive effect on evaluations. Using complex natural images, Tinio and Leder (2009) showed that manipulations in contrast and related parameters regarding image quality could have powerful effects. They found that systematic variation of contrast could even override the well-established preference for landscapes over urban scenes. Although image degradation reduced liking, it did not affect classification speed. Interestingly, in accordance with fluency-familiarity attributions (Monin, 2003), degraded images were also classified as less familiar.

Symmetry

Symmetry is an interesting phenomenon in many real objects. Symmetry can exist along one or several axes, and it is related with the amount of redundancy in a stimulus. Symmetry thus reduces the processing demand required to identify images. Moreover, in the realm of biological beauty, facial symmetry is associated with stable development and health. Although symmetry is often dominant and relevant in abstract patterns, it is less so in artworks, because understanding their compositional structure often requires more sophisticated measures of balance (Locher, Gray, & Nodine, 1996). Tinio and Leder (2009) systematically studied the conjoint effects of familiarity, complexity, and symmetry. They examined how the appreciation of complexity and symmetry was affected by familiarization to a subset of abstract patterns that were either simple or complex, and symmetrical or asymmetrical. In the first block they presented participants with subsets of their stimuli that systematically varied along these two dimensions (Höfel & Jacobsen, 2003). Participants who had been familiarized only with simple patterns later showed an enhanced preference for complex stimuli. Similarly, those participants who were familiarized with complex stimuli later liked simple stimuli more. These effects show that, at least in part, our aesthetic preference depends on recent experiences. Tinio and Leder (2009) found a familiarization-contrast effect, but only after long, massive famil-

iarization. This study also bridges the model separation of an "early perceptual" and a "directly following" stage of implicit memory processing. This stage was posited as a separate one, as it contains what Berlyne (1974) named "collative" variables. These are variables that interact with memory in that the kind of representation they produce is directly related to previous experiences.

Implicit Processing: The Collative Variables

Implicit memory integration relates the representations built during the perceptual processing stage and modifies them with information from previous encounters. Previous encounters with an artwork often create a feeling of familiarity or—if the perceiver knows it to have been seen before—a clear conscious recollection.

Familiarity

The effects of familiarity on liking are well studied, and the most general claim is that familiarity increases liking. Repetition creates positive feelings that can become part of an evaluation, and therefore can also increase aesthetic appeal. Thus, when the mere repetition as a source of positive affective aspects is not too apparent (as was shown by Bornstein & D'Agostino, 1994), it can be informative for an evaluation, for example, an aesthetic judgment. Bornstein and D'Agostino (1994) showed that an evaluative system performs best when it is sensitive to situational demands and it is able to adapt to them. Regarding the relation between evaluation and previous encounters, Schwarz (2007) stated that "To serve action in a given context, any adaptive system of evaluation should be informed by past experience, but highly sensitive to the specifics of the present" (p. 639). Thus, if the aesthetic sense is a kind of specific way of looking at things, in line with Darwin's notion of a "sense" (Darwin, 1871), imbued with an evolutionary founded purpose, then context sensitivity and a flexible relationship with previous experiences should be expected.

Other approaches, which are more complex and move beyond the one-way explanation that familiarity through repetition increases liking, and thereby is a major cause of aesthetic pleasure in art appreciation, have emerged lately. In the tradition of Berlyne (1970), who believed that novelty is an antagonist of familiarity, Biederman and Vessel (2006) developed a hypothesis that not only explains the conditions under which familiarity increases but also those under which liking decreases. They proposed a mechanism based on the distribution of mu-opioid (μ -opioid) receptors in different areas of the brain. This explains why repetition can decrease liking: it weakens the amount of positive stimulation available. This is evidently contrary to a mere exposure explanation *a la* Zajonc (1968) and others. It does, however, provide an explicit mechanism to explain why repetition can modulate pleasure. It should be noted that one critical variable that differs between studies on familiarity and affect is the overall valence of the object: mere exposure effects were often observed for affectively neutral objects, with no intrinsic or acquired positive or negative valence. Biederman and Vessel, on the other hand, considered materials that were clearly liked (landscape photographs) or not (urban scenes or picture of parking lots) from the beginning.

Processing Fluency

The fluency approach constitutes a powerful and very general explanation for simple visual pleasures and rather mild preferences. Reber, Schwarz, and Winkielman (2004, p. 365) summarized this approach's basic principle: "The more fluently the perceiver can process an object, the more positive is his or her aesthetic response." Although fluency itself is not easy to measure, certain features that theoretically increase processing fluency lead to faster, less error-prone processing (see, e.g., the contrast manipulation by Reber et al., 1998). In another example from the same study, when a simple perceptual priming condition was used, perceivers not only liked the primed objects more, but in accordance with an increased ease of processing, were also faster at identifying them. Fluency thus provides a unified explanation for several effects related with liking and preference. For example, it is easier to process symmetrical than asymmetrical stimuli, prototypical objects are easy to classify, and objects that have been primed—either perceptually or conceptually—are processed faster and are liked more. Reber, Schwarz, and Winkielman (2004) provided several examples showing that many phenomena in aesthetics are in accordance with such an explanation. In a particularly fascinating study of the role of motor patterns involved in visual exploration, Topolinski (2010) demonstrated fluency's explanatory power in the realm of aesthetics. After familiarization with a specific pattern of eye movement trajectories he found that images that corresponded to these "trained" motor movements were indeed liked more. Similarly, Leder, Baer and Topolinski (2012) had participants perform different hand movements, concealed from vision behind a screen, either in accordance with hatches, or points, that were corresponding to impressionist or pointillist artworks. Conducting these movements while evaluating artworks of either style positively affected the liking of those artworks in the style corresponding to the hand movement. Thus, it seems that motor components involved in the exploration of visual stimuli can affect aesthetic judgments, presumably because of the more fluent experience they elicit. This argument is in accordance with Taylor, Witt, and Grimaldi's (2012) findings that viewers' cognitive representation of paintings' brushstrokes includes information on the movements necessary to produce them.

Generally speaking, the assumption underlying the fluency explanation is that the brain is somehow lazy, a fact that sounds less conceited when we consider how much energy the brain consumes. Why should effects explained by this energy-based hypothesis produce aesthetic pleasure? This is an intriguing question for future research in neuroaesthetics. It is an important one, as it requires the integration of approaches positing a human drive to satisfy curiosity (Berlyne, 1970) or a human "infovore" nature, which regard humans as beings guided by brains that crave information (Biederman & Vessel, 2006). Moreover, even the authors who have developed the fluency approach see certain limitations regarding its usefulness in understanding aesthetic experiences and art, especially in relation to modern art: "since the emergence of modern art, a piece of art can have aesthetic value without being beautiful" (Reber et al., 2004, p. 365). Modern art often deliberately disrupts fluency, for example when paintings depict scenes in a blurred fashion as in Gerhard Richter's paintings. Leder (2003) therefore postulated a kind of knowledge-based cognitive fluency,

which enables the perceiver to enjoy these produced states of nonfluency.

Explicit Processing: Style and Content

The model's explicit classification level includes processes related with a frequent and substantial difference in how spectators can approach artworks. We distinguished content and style as two fundamental ways of looking at art. In this respect, the representation of the artist's style also marks a first specific processing aspect in which art differs from other everyday objects. The role of style was described this way: "As a result, while the 'what' diminished in significance, the 'how' rose to the fore, causing a large number of individual styles to appear. Now, with a myriad of ways to depict, and with the prominence of abstract art, countless new styles of visually structuring the surface of the canvas developed." (Leder et al., 2004, p. 491). The claim that style-based processing might be a distinctive feature of expertise in art was, however, only partly backed by empirical findings. Augustin, Leder, Hutzler, and Carbon (2008) studied the time course of style and content processing. They asked their participants to indicate the similarity between two artworks that were shown simultaneously (and visually masked) for very brief presentation times of 10, 50, 202, or 3000 ms. The pairs of pictures were examples of modern art, which differed either in terms of content (house, male portrait, tree, flowers) or style (Cezanne, Chagall, Kirchner, van Gogh). When two paintings differed in content, under all presentation times they were judged as dissimilar. Interestingly, when they differed in content and style (they had thus been created by two different painters), they were judged as more dissimilar than two paintings by the same artist, even with 50 ms (but not with 10 ms) presentation time. Thus, viewers are sensitive to stylistic features even with very brief visual experiences. Although these findings support the model's claim for an important role of style in art, a critical test—one that still has not been performed—would be to show that such features have a specific role in art, but less so with respect to non-art.

Ishai, Fairhall, and Pepperell (2007) used an interesting design to explore the effects of form, color, and content. They compared representational artworks, for example, from Michelangelo's Sistine Chapel, with altered versions of the same or very similar paintings created by the painter Pepperell. Though somehow representative in appearance, his painting style makes the depicted objects difficult to identify, so they were well suited to study content accessibility. Ishai et al. (2007) compared identification and affective judgment for the two classes of painters. In the object identification task, participants were requested to indicate whether or not familiar objects were depicted. They were thereafter asked to indicate how much they felt affected by that artwork. The results revealed that in the Pepperell paintings identification of content, in terms of object recognition, took much longer, but that the emotions elicited were not systematically affected by the kind of artworks. In a recognition task, though, performance was much better for the depictions with recognizable objects. The authors concluded the following: "Our results suggest that perception and memory of art depend on semantic aspects, whereas, aesthetic affect depends on formal visual features. The longer latencies associated with indeterminate paintings reflect the underlying cognitive processes that mediate object resolution. Indeterminate art

works therefore comprise a rich set of stimuli with which the neural correlates of visual perception can be investigated” (Ishai et al., 2007, p. 319).

Finding Meaning and Understanding

The model assumes that beyond the initial perception, identification of style and content consists of a processing that aims to achieve understanding, if not a deeper meaning. Though not necessary, it is this kind of ongoing quest that makes art intellectually challenging, often conceptual rather than depictive, and also enables emotionally touching or even transformative aesthetic experiences.

There is still little empirical research regarding these later stages of information processing. Kuchinke, Trapp, Leder, and Jacobs (2009) explored the role of the later stages posited by the model, related with finding meaning and a sense of understanding, by taking advantage of a specific feature of cubist art. These paintings often make it difficult to access the content—“what” is depicted—by the specific device of decomposing objects into geometric elements that, characteristically, are shown simultaneously from different perspectives. In some cases this can delay the process of identification, which usually takes from a fraction of a second to several seconds (Hekkert & Van Wieringen, 1996). In the study by Kuchinke et al. (2009), perceivers were instructed to indicate the moment at which they recognized an artwork’s content. Using an eye-tracker, the authors measured changes in the pupil that are indicative of changes in arousal states. Pupil dilation was greater for those images that were resolved faster, indicating a change of state that happens when something is suddenly recognized.

The finding of higher pupil dilation associated with easy-to-process stimuli is seen as evidence for aspects of aesthetic emotions that follow explicit classification of art stimuli. This of course is an early and very basic level of gathering meaning. Kreitler and Kreitler (1972) considered meaning to be a crucial element of their model of art, and argued that the processing of artworks aims to achieve a state of homeostasis. Forty years ago they wrote the following: “The enormous diversity of meanings attributed as a rule to one and the same work of art by different individuals and in various historical periods also demonstrates that not even on the level of the general meaning of the product of art is a correspondence to be expected between the artist’s possible intention and the spectator’s interpretation” (Kreitler & Kreitler, 1972, page 5). Pelowski and Akiba’s (2011) theory stresses the need for understanding the kinds of situations that disrupt the usual processes of visual understanding and enable states of transformation. They also emphasize the role of emotion in aesthetic processing, which for a long time had been underestimated, although it has received increasing attention from experimental aesthetics and neuroaesthetics.

Emotional Processing: The Underspecified Pathway

Kuchinke and colleagues’ (2009) study illustrates how the emotional aspects of aesthetic processing can be captured by psychophysiological means. There is an ongoing debate over whether art elicits unique emotions or whether these emotions are the same as those elicited by common, everyday situations. Silvia (2005) pro-

vided an insightful analysis of the role that Berlyne’s (1974) influential model. Berlyne conceived arousal as the determinant of aesthetic pleasure. Silvia described how appraisal approaches inform aesthetic processing assumptions. In a study in which he systematically varied the novelty and comprehensibility of artworks (Silvia, 2010), he also demonstrated the strengths of his approach: he showed that confusion, similarly to interest, is the result of specific classifications along those two dimensions, and that appraisal theories can explain this.

Neuroaesthetics will have to deepen the understanding of these emotions, and through comparison of aesthetic and common emotions, either by varying objects, or by comparing different tasks, neuroaesthetics will uncover the underlying responses in the brain. The importance of the emotional response with respect to art was acknowledged by Chatterjee (2011) when noting that given that “the anterior medial temporal lobe, medial and orbitofrontal cortices, and subcortical structures mediate emotions in general, and reward systems in particular” (Chatterjee, 2011, p. 55), these structures and networks constitute crucial elements underlying aesthetic experience. The future of research in experimental aesthetics and emotion will benefit from advances in our understanding of how the brain connectivity is related with affective and emotional information processing and how to approach this study (Sporns, 2010).

Top-Down Processes: Expertise

Silvia argues that appraisal theories are well suited to account for what he regards as knowledge-related states of emotion. One factor that profoundly influences aesthetic experience is expertise. Expertise is more than just implicit knowledge gathered from mere exposure, it is also enriched with declarative knowledge, associations, and explicit references, which create a rich representational structure. There is no doubt that art appreciation cannot be fully understood without reference to culture, knowledge, and the history of the arts (see Cupchik, 2002). Several researchers have also provided evidence showing that the simple distinction between people who have more and less experience with art constitutes a powerful test for some existing theories. For example, the distinction between style and content as two means of approaching and processing art was supported by Augustin and Leder’s (2006) study. They asked art experts and nonexperts to sort artworks into groups of similar items without any restrictions or predefined criteria. When participants were later asked to find descriptions for the distinctions they had made, the experts more often chose style-related terms, whereas nonexperts referred to personal feelings more often. In addition, the study also showed marked similarities between both groups of participants, a finding that we took as evidence for the general characteristics of aesthetic experiences. In an attempt to study whether expertise in art involves specific cognitive adaptations, Belke, Leder, Harsanyi, and Carbon (2010) studied the level of cognitive classification at which experts initially recognize artworks. They found that art experts showed a distinctive downward shift in identification of familiar art, which has also been shown in other domains of expertise. Specifically, the subordinate level, which in the case of Belke and colleagues’ (2010) study was the artist’s name, had a special status for art experts. This was the first classification that came to mind, and the fastest level at which artworks could be classified. These studies

represent the first steps toward understanding the effects of expertise. This goal, however, will require close collaboration between psychologists and neuroscientists. Moreover, unlike studies that link music performance and listening to changes in brain structure, very little is known about the effect of art consumption and expertise on brain development.

Level of Consciousness: Automatic Versus Deliberate Processing?

Another unsolved issue in the appreciation of art is the role of consciousness. In the model there is a vague distinction between “automatic” and “deliberate,” which reflects the transition from the implicit to the explicit processes. As Leder et al. (2004) described, this dimension attempts to account for a commonly observed kind of effect. While processes related merely with perception and implicit memory might often influence appreciation without awareness, the style and content distinction, at least, is accessible to explicit, or at least explicable representations. A number of studies examined the automatic sensitivity to facial beauty. Schacht, Werheid, and Sommer (2008) measured the brain activity of their participants with EEG while they saw or judged beautiful and nonbeautiful faces. Their results showed that after only 150 ms certain components distinguish between the levels of beauty. The authors, however, had some doubts whether facial beauty is processed automatically. Jacobsen and Höfel (2003) found similar effects and suggested that aesthetic orientation by the task may be inevitable. Using facial EMG, a sensitive measure of positive and negative emotions, Gerger, Leder, Tinio, and Schacht (2011) found data that support a very subtle sensitivity to beauty. Future studies will have to refine the methods, but in general terms, comparing overt and covert behavior in combination with neurophysiological methods seems a very promising avenue.

Outlook and Concluding Remarks

We have seen that a model based on processing assumptions and distinctive processing stages can constitute a valuable foundation for a variety of research programs. Nonetheless, empirical studies have also revealed that certain components need refinement, that elements were underspecified, or that some assumptions about processing were not in accordance with data. Some of these findings were surprising. The study by Augustin et al. (2008) revealed that access to style in art occurs very early on. Consequently, the decomposition into content and style might be much faster than the model suggests. In Figure 1 this is addressed by adapting the ordering along the time trajectory. Moreover, concepts such as fluency might be broad enough to affect processing of all components of the model. In this case, the Implicit Memory Integration box might require a different role in the fixed structure of the model. It has also become evident that the notions of sudden insight, delayed object identification, and the emotional states they produce require careful consideration. Also, special attention should be given to defining and distinguishing between these highly related concepts. There are still many open questions regarding the nature of what makes an experience “aesthetic.” With few exceptions, the later stages of information processing, concerned with how knowledge is involved and how meaning is constructed from artworks, have been the focus of little empirical

research. The strong interplay between emotion and affect with certain states of sudden insight, knowledge-based resolution of visual problems, and their associations in the realms of art history also need to be addressed.

The Where and When, Methods of Neuroaesthetic

Neuroaesthetics will likely play an important future role in solving the most interesting questions concerning the neural processes that contribute to the richness of aesthetic episodes. The measurement and analysis of brain activity while people perceive, evaluate, and enjoy art will enable mapping such activity to specific processes, shedding light on the nature of the diverse processes involved. This will allow researchers to address such issues as the impact on the role of certain brain structures depending on whether the task is explicitly related to aesthetics. Functional MRI will also reveal the conditions under which the involvement of structures associated with reward and emotion becomes more prominent. Questions regarding the interplay of style and content can also be addressed using fMRI.

On the other hand, neuroaesthetics also relies on methods that focus on fast early processes, improving our understanding of the time course of activity, rather than the specific brain structures involved. Schacht et al. (2008), for instance, used EEG to ascertain the automaticity and speed of responses to facial beauty. Thus, as the critical components that constitute the emotional, aesthetic, or even art-specific responses become clearer, a variety of questions regarding the time course of aesthetic experiences can be studied using EEG. For example, aiming to study the time course of style and content processing, Augustin, Defranceschi, Fuchs, Carbon, and Hutzler (2011) measured effects in two components of EEG, the Lateralized Readiness Potential (LRP) and the N200. Their results support the claim that processing of style indeed takes place later than processing of content. It is, however, still difficult to isolate effects of specific content, with very few exceptions, such as the fusiform face area (FFA) which seems quite selective for faces.² The study of the genre of portraiture, therefore, seems particularly promising (see, e.g., Leder, 1996). Aesthetic thresholds constitute yet another issue for which such time sensitive methods as EEG are important. The studies by Augustin et al. (2011) have already shown how the use of EEG and very short presentation times might shed light on processes that explain such concepts (Jacobsen, 2006).

Outlook

Some limitations were not apparent when the model was developed, and others were not included because they seemed to be out of its scope. Regarding the former, the role of emotion was clearly underrepresented in the model. Since its publication, the need to reconsider emotional aspects of processing has challenged the traditional cognitivist perspective. New methods, such as EEG, or subtle emotions measured by facial EMG, together with more explicit efforts toward understanding emotion in aesthetics (Zentner, Grandjean, & Scherer, 2008), have become a major topic. Regarding the latter, the scope of experiences that are covered by

² I am grateful to one reviewer who pointed this out and made other helpful comments.

the model has been stretched. For example, Pelowski and Akiba (2011) extended the experiences that are covered by the model to include more emotional, life-relevant, or what they call transformative experiences. Their theory transformed the processing stage of cognitive mastering into a comprehensive idea of how aesthetic experiences result from appraisals, metacognition, self-related but also self-transforming states. In this respect their theory accounts for much stronger art-related experiences that had not been addressed before. However, their model is also more descriptive than formalized. Thus, steps are required to transform existing models into more operative versions that can move beyond the mere description of what can be observed, provide process-based rules of transformations, and quantify what feature of a representation at one stage affects the outcome of a later stage. An attempt to do so was shown by an implementation of parts of the model into a structural-equation model (Leder, Gerger, Dressler, & Schabmann, 2012). The transformation into models with a more neuropsychological orientation is still another important need (see Chatterjee, 2011).

The scope of aesthetics today has become broader than what the model by Leder et al. (2004) intended to cover. Although researchers from different areas of aesthetics have referred to the model, the future of aesthetic response requires further studies, with more systematic variation of aesthetic objects. The interplay of mundane requirements, such as utility, and aesthetic dimensions might be particularly interesting. The same is true for web design (Tuch, Bargas-Avila & Opwis, 2010) and design objects (Spendlove, 2008; Reimann, Zaichkowsky, Neumhaus et al., 2010). More dynamic art forms, such as dance and body perception (Calvo-Merino, Urgesi, Orgs et al. (2010) as well as music (Istók, Brattico, Jacobsen et al., 2010; Koelsch, 2011), will have to come up with models that place special emphasis on temporal order, simultaneity, or aspects of embodiment (Smith & Semin, 2004). The progress in developing new methods and experimental paradigms, together with the openness of neurosciences to address complex questions, will foster these research activities.

In this respect, a model as a framework will have the continuing capacity to integrate findings from different specialized areas of experimental aesthetics. This role is probably more important than ever, because empirical aesthetics is developing into more specialized domains, which reflect the different facets in cultural activities and objects that engage aesthetic experiences, and is in danger of losing its common ground. The long-term goal, therefore, has to be the development of a comprehensive, unified theory of aesthetics and culture. The aesthetic sense and its concern with art and culture make it a candidate for one of the domains that defines and distinguishes our species. In this respect, the future of aesthetics and neuroaesthetics promises to advance our understanding of an essential feature of what make us humans.

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