

Opinion

# Why and How Should Cognitive Science Care about Aesthetics?

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**Empirical aesthetics has found its way into mainstream cognitive science. Until now, most research has focused either on identifying the internal processes that underlie a perceiver's aesthetic experience or on identifying the stimulus features that lead to a specific type of aesthetic experience. To progress, empirical aesthetics must integrate these approaches into a unified paradigm that encourages researchers to think in terms of temporal dynamics and interactions between: (i) the stimulus and the perceiver; (ii) different systems within the perceiver; and (iii) different layers of the stimulus. At this critical moment, empirical aesthetics must also clearly identify and define its key concepts, sketch out its agenda, and specify its approach to grow into a coherent and distinct discipline.**

## Entering the Mainstream

Aesthetic processing has a profound impact on our everyday lives. It influences our choices regarding romantic partners, where we wish to live, how we dress, which objects we surround ourselves with, and the activities we pursue in our leisure time [1–4]. Aesthetic considerations affect health, productivity, and learning, and participation in cultural activities is positively related to wellbeing [5–9]. The desire to recognize the principles underlying aesthetic processing has played a dominant role in the history of human thought, particularly in the Western philosophical tradition. By contrast, empirical approaches to aesthetics – as first advocated in mid-19th century psychology by Fechner [10] and later by Berlyne [11] – have not found any major, sustained representation at universities and are only now on the verge of becoming accepted as a mainstream field in the cognitive neurosciences.

Over the past two decades, research in empirical aesthetics has been propelled strongly by advances in neuroscientific methods, giving rise to the subfield of neuroaesthetics (pioneering studies include [12–14]; for reviews see [15,16]). The use of artworks provided insights into general brain functioning, including reward, motor control, neuroplasticity, learning, and embodiment [17,18]. At the same time, there is overall little agreement regarding the general conceptualization of empirical aesthetics as a distinct research field, the identification and definition of its key concepts, and a methodological framework for its future advancement. What actually is the agenda and what are the main goals of empirical aesthetics? Does it need novel constructs to describe specific phenomena? What characterizes **aesthetic experiences** (see [Glossary](#))? Why is it important to study them, and how? This programmatic opinion article aims to provide conceptual clarity, a road map, and an integration of empirical aesthetics into a broader picture of the academic landscape.

## The Arts and Aesthetics Are Not Coextensive

From an anthropological perspective, the ability to create artworks and artful decorations is well accepted as a defining feature of the human species, along with the use of complex symbolic communication systems, the formation of complex societies, and the manufacture of complex

### Highlights

For more than two millennia, theoretical reflections on aesthetic perception and the creation of aesthetically appealing objects have been an important domain of humanist scholarship.

Empirical aesthetics complements this tradition by adopting scientific methodology and providing evidence-based, reproducible answers to both longstanding and recently arisen questions.

While empirical aesthetics has largely remained marginal since its foundation by Fechner in the mid-19th century, it is now about to be more broadly acknowledged as an important subfield of scientific research.

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tools [19–23]. What remains subject to debate, however, is the age and origin of this ability, as well as its potential continuity with animal behaviors [23–25]. According to the current state of knowledge, the oldest cave paintings produced by our species date back 44 000 years [26], the first musical instruments 40 000 years [27], and the earliest body ornaments 100 000 years [28,29]. Additionally, archeological records include elaborate decorations of everyday objects, such as engravings on arms or paintings on vessels, which do not modify the functional purpose of a given tool [30,31]. Finally, ethnological research has reported refined practices of singing and dancing across a broad range of older and more recent cultures [32,33].

In their entirety, these data support the assumption that the human senses and the human mind have evolved to be able to evaluate not just bodies, movements, vocalizations of conspecifics and other animals, landscapes, and other natural events, but also culturally produced objects and performances aesthetically (i.e., for their sensory and perceptual qualities). Such evaluation occurs additionally to, and sometimes regardless of, the pragmatic functions (e.g., demonstration of social status, mate choice, consolidation of group cohesion) that these objects and performances may serve, on top of providing inherent processing pleasure.

First introduced by Baumgarten in 1735 [34], the discipline of ‘aesthetics’ became widely accepted as a third branch of philosophy complementing the ‘theoretical’ and ‘practical’ branches. Rather than distinguishing true from false statements and moral from amoral acts/attitudes, this faculty of the mind was defined by its function to evaluate the phenomenal appearance of objects and performances on a number of qualitative dimensions (e.g., ‘beautiful’, ‘sublime’, ‘grotesque’), with a special emphasis on the hedonic value of these perceptual qualities. Notwithstanding this initially broad framing, the general meaning of ‘aesthetics’ has over time been narrowed to apply exclusively to the fine arts and therein to the perceptual quality of ‘beauty’. The legacy of this development, which we are still faced with today, prevents aesthetics from accounting for the richness and pervasiveness of aesthetic processing.

To arrive at a comprehensive understanding of aesthetic processing it is, therefore, important to broaden our perspective beyond institutionalized artistic contexts of the modern era, such as concert halls and art galleries, and include stimulation from everyday objects, creatures, and natural phenomena. At the same time, it is equally important to study specific factors that an artistic context might introduce. Thus, it is a perennial question ever since Aristotle’s *Poetics* [35] why we are fascinated by the depiction of a decaying corpse on a painting or the display of someone’s suffering on stage, when both experiences would be highly undesirable if encountered *in vivo*. In a similar vein, why do we appreciate nonidiomatic, ambiguous, and difficult language use in poetry? Why do we enjoy the emotional ups and downs of a feature-length film? Why do we take pleasure in uncertainty in suspenseful narratives? These examples also illustrate that aesthetic experiences go far beyond beauty, which is only one dimension of aesthetic appreciation, and have distinct capacities to integrate negative emotions into an overall enjoyable affective response.

Over the past 2500 years, important efforts have been made in the humanities to provide answers to such questions. Unsurprisingly, different scholars have proposed competing and sometimes contradictory explanations and predictions. As a result, the humanist tradition offers an abundance of explanatory models and testable hypotheses. The emergence of empirical aesthetics holds the promise of identifying which of these explanations and predictions are accurate as well as drafting entirely new models informed by the latest insights into human brain functioning. Thus, empirical aesthetics does not aim to replace traditional humanist disciplines but to facilitate collaboration between scientists, artists, and humanist scholars.

## Glossary

**Aesthetic distancing:** cognitive processing mode operating primarily in artistic contexts and, more generally, in witness positions; characterized by a psychological disconnection from any short-term pragmatic concerns and urgencies to respond to an eliciting stimulus; does not necessarily imply reduced intensity of affect and (dis)pleasure; prerequisite for negatively valenced emotions to be integrated into an overall enjoyable aesthetic experience.

**Aesthetic emotion:** class of emotions functionally specialized in evaluating sensory and perceptual qualities of stimuli (aesthetic qualities); necessary part of a genuine aesthetic experience, emerging from a sufficient degree of salience of an aesthetic quality; subject to hedonic evaluation and therefore a predictor of both felt (dis)pleasure and future approach–avoidance behavior.

**Aesthetic evaluation:** cognitive process characterized by the detection, internal representation, and integration of distinct stimulus properties that are diagnostic for a specific aesthetic quality; operates spontaneously, continuously, and independent of the perceiver’s awareness (always-on hypothesis); however, once a sufficient degree of congruency with an internally stored property profile of an aesthetic quality is reached, the detected aesthetic quality becomes salient to the perceiver, along with an emotional and a hedonic component (amounting to an aesthetic experience).

**Aesthetic experience:** emotionally and hedonically engaging, conscious experience of an aesthetic quality of a stimulus; specifically, episodes of aesthetic experiences entail awareness of the triad of (i) the stimulus’s aesthetic quality, (ii) the aesthetic emotion, and (iii) the hedonic quality of (i) and (ii); leads to an explicit aesthetic judgment.

**Aesthetic judgment:** explicit (verbal) expression of a perceived aesthetic quality; often implies an appraisal of the stimulus’s capability to provide aesthetic pleasure (e.g., speaking of a ‘moving piece of music’ implies the notion that the power to move us is an achievement of this stimulus, which ultimately provides aesthetic pleasure).

**Aesthetic labeling:** appraisal of an aesthetic quality resulting from an aesthetic evaluation, memory, or top-down knowledge, but in the absence of

## Feature-Based versus Constructivist Perspectives

The body of literature in empirical aesthetics can be assigned to two major categories: the subject-oriented and the stimulus-oriented approach, portrayed in [Boxes 1](#) and [2](#), respectively.

The stimulus-oriented approach is influenced by the longstanding idea (originating in antiquity) that aesthetic experiences can be traced back to, and therefore be predicted by, the compositional make-up of a stimulus. The tradition advocating this idea seeks to identify the sensory features that support specific aesthetic effects and to provide guidance on how to create and combine certain elements in the stimulus to arouse a specific effect in the perceiver. Historically,

the conscious experience of an emotional or a hedonic component (i.e., without a genuine aesthetic experience).

### Aesthetic pleasure/displeasure:

hedonic component of an aesthetic experience, arising from both the perception of an aesthetic quality and the feeling of the accompanying aesthetic emotion; ultimate currency of aesthetic processing.

**Aesthetic quality:** class of attributes referring to aspects of the phenomenal appearance of perceived objects (e.g., beautiful, elegant, sexy, kitschy, sublime, ugly, grotesque, fascinating, harmonious, grooving, moving, touching, suspenseful); arises from perception and further processing of distinct stimulus properties (monochromy, slenderness, streamlined contours, smoothness of movements) as well as their integration into more complex semantic concepts (lightness, efficiency), which are diagnostic for a certain aesthetic quality (elegance); detected within the process of aesthetic evaluation; implies a hedonic valence; pleasurable aesthetic qualities are referred to as aesthetic appeal; verbalized as aesthetic judgment.

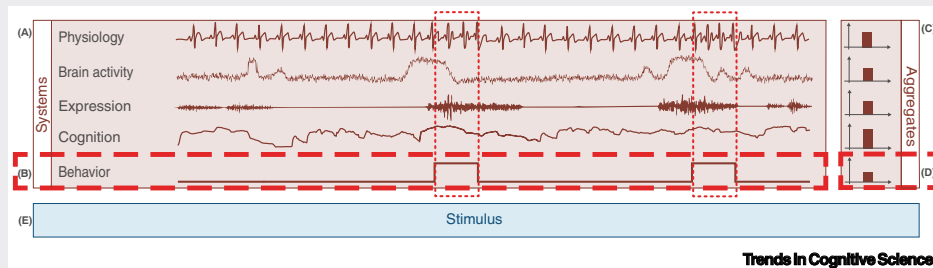
### Box 1. Subject-Oriented Approach

The primary goal of this approach is to elucidate the general cognitive, emotional, and neurophysiological foundations underlying aesthetic experiences, including their structural and temporal organization in the brain, their subjective feeling (over time), and their functions in, and consequences for, our psychological lives. This approach is less concerned with how a stimulus elicits a specific aesthetic response. Rather, it focuses entirely on specific processes triggered in recipients. A prototypical example here is research on art-elicited chills. Usually, participants are asked to provide chill-eliciting stimuli (e.g., songs) of their own choosing [93–96].

Figure 1 illustrates this approach with an elementary building block of a data set (i.e., a participant being exposed to a stimulus). One variable – here, button presses – is chosen to be the signal of interest (B). Therein, frames of interest (chill episodes) can be defined (vertical broken-lined rectangles) and contrasted with other frames of interest (e.g., time periods preceding chills, periods without chills). This framework can be further extended by having multiple signals of interest (e.g., subjectively felt chills indicated by button presses, goosebumps measured objectively by a video-recording device).

Examination of the physiological and neural activity in these moments reveals the brain structures that orchestrate the anticipation and the experience of chills [47,93], their temporal choreography over time and interaction with other neural circuits [97,98], how the autonomic nervous system is involved [94,99–101], and how participants subjectively feel during these moments [101,102].

The search for general mechanisms underlying aesthetic experiences is complemented by the study of individual differences in aesthetic preferences and their systematic relation to other variables of the perceiver, such as personality dispositions, personal history, expertise, gender, educational/cultural background, and biological differences. This approach can be called ‘differential empirical aesthetics’. Constructivist positions, as discussed in the main text, represent an extreme version of this strand, calling into question interindividually shared properties and lawful prediction of aesthetic experiences across individuals.



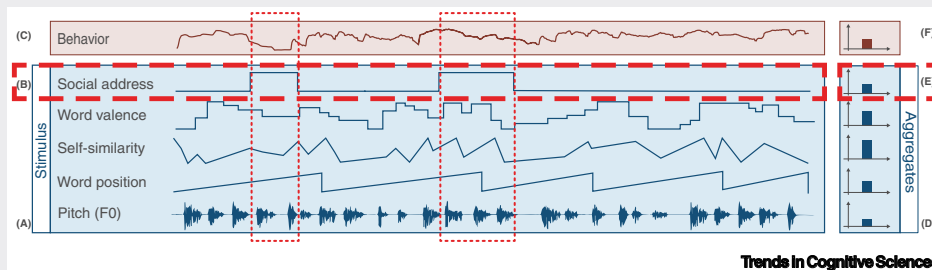
**Figure 1. Subject-Oriented Approach.** Area (A) shows time-logged data simulated for a participant exposed to a stimulus (E). The layers in (A) represent different measurement systems of the person, with respective examples. The number and choice of specific measurement systems depends on the research question. Here, peripheral physiology is illustrated with electrocardiography (ECG), brain activity with percentage blood-oxygen level-dependent (BOLD) signal change for a subcortical nucleus, expression with facial electromyography (EMG) for the corrugator muscle, cognition with a continuous rating of the vividness of mental imagery, and behavioral self-report with button presses of the participant indicating chill experiences. Areas (C,D) represent stimulus-logged aggregates (e.g., accumulated frequencies, central tendencies) that can be computed from the continuous measures in (A,B). Notably, many studies, particularly those without a physiological focus, start already on the aggregated level by collecting, for instance, post-stimulus self-reports on mental imagery or the number of experienced chills over entire stimuli. Note that (E) is not further subdivided or specified, as this approach is not interested in how the specific properties of a stimulus lead to signal changes in areas (A,B).

### Box 2. Stimulus-Oriented Approach

The stimulus-oriented approach focuses on the properties and elicitation mechanisms on the part of the stimulus that lead to specific effects in the recipient. The main question here is: how, or by virtue of which properties, is a specific effect elicited by a stimulus? An example of this is a study of the effects of parallelistic patterning in poetic language (i.e., repetitive structures; e.g., rhyme, meter) on the emotional processing and appreciation of recited poems [103]. Specifically, the main hypothesis predicted that a stepwise experimental removal of such parallelistic features from original poems – while maintaining their semantic contents – would reduce emotional involvement with, and the liking of, these different poem versions. Note that despite the focus on objective properties of specific stimuli (i.e., parallelistic patterns), stimulus-oriented research can readily include (average) rating responses from participants, as in this example.

Stimulus-oriented research may also, however, focus entirely on stimulus analysis and/or historical data, as in the case of corpus studies for instance. To illustrate, in one study [104], an objective measure for the melodiousness of poetic language was developed (based on autocorrelations of sound sequences) and applied to a corpus of classical poems. The resulting objective melodiousness values were then used as predictors for the likelihood of a poem to be set to music by professional composers in subsequent times.

The stimulus-oriented approach is illustrated in Figure 1. The object of examination comprises the distinctive properties of a given stimulus. Depending on the domain, these properties will vary considerably, ranging from objectively measurable to psychologically informed variables. Here, the exemplary stimulus is a recited poem.



**Figure 1. Stimulus-Oriented Approach.** The exemplary stimulus is a recited poem with five illustrative property layers (A). Social address designates text passages in which one character is directly addressing another character (i.e., direct speech). Word valence represents the affective valence of single words, as indicated, for instance, by the Berlin Affective Word List [105]. Self-similarity is a syllable-based index expressing parallelistic patterning in (poetic) language [103]. Word position is the relative position of words in five stanzas [47]. The oscillogram represents the sound parameters of the reciting voice; for example, the fundamental frequency F0 (i.e., pitch). Note that in the stimulus-oriented approach, measures obtained from perceivers (usually self-report ratings) can be incorporated (C). However, the signal of interest (B) is chosen from the list of stimulus properties, as the aim is to elucidate the working principles of the stimulus. Hence, in this example the correlates of direct speech passages (frames of interest designated by vertical broken-lined rectangles) are examined and can be compared with other passages. (D,E,F) represent stimulus-logged aggregated measures.

this quest to decipher the (hidden) sources of aesthetic appreciation and artistic success led to the emergence of poetics [35], rhetoric [36], the doctrine of affections in music [37], montage theory in filmmaking [38], method acting in the dramatic arts [39], the hero's journey in storytelling [40], and other catalogs of production rules.

This feature-based approach is challenged by constructivist positions, which argue against a universal causal link between stimulus properties and aesthetic experiences. Rather, in explaining the emergence of aesthetic experiences, they focus on the active construction of the experience by an individual perceiver, who is influenced by personality dispositions, personal history, personal relevance, idiosyncratic meaning making, and context. The properties of the stimulus are thought to play a secondary role in this process, if any [41–43]. The key message of this position is captured by the much-quoted dictum 'beauty lies in the eye of the beholder'.

The tension between these two strands is reflected in research attempting to distinguish between shared and private tastes [44–46]. These efforts have shown that, to a certain degree, the

discrepancy can be mitigated by findings demonstrating a stronger shared taste for natural stimuli (e.g., faces, landscapes) and greater variability in responses to cultural artifacts. However, even regarding the latter, a growing number of studies provides evidence for a lawful prediction of aesthetic experiences across individuals based on constituent stimulus features. For instance, the time points of peak-pleasure experiences of art-elicited chills in response to recited poetry have been shown to obey the law of cadence, (i.e., clustering towards the ends of lines, stanzas, and entire poems) [47]. Thus, closing word positions predict chills across individuals. Furthermore, using machine-learning algorithms, a large study in the visual domain demonstrated on both computational and neural levels that aesthetic preferences can be described and lawfully predicted across individuals from the physical features of paintings and photographs [48]. Seminal work on statistical image properties in visual arts has been conducted by Redies and colleagues [49,50]. Similar efforts have been made in architecture [51] and music [52].

In light of advances in the development of computational tools, artificial intelligence, and data collection from ever-larger sample sizes, we expect a significant increase of further evidence attesting to the value of feature-based approaches and their power to explain substantial amounts of variance in aesthetic experiences. Importantly, this still leaves room for variance that is bound to interindividual differences due to personality dispositions, personal history, and idiosyncratic weighting of particular stimulus features [4,48]. Moreover, the particular cognitive framing of an object (e.g., fiction versus documentary) can readily trigger top-down control mechanisms and modify aesthetic processing [53]. The location of a performance (concert hall versus metro station [54]) and the social context (being alone, with friends, or strangers [55]) are further situational factors to be considered, to explain as much variance as possible in aesthetic experiences.

### Key Concepts and Ideas

In recent empirical work on aesthetics, terms such as aesthetic experience, **aesthetic evaluation**, **aesthetic pleasure**, **aesthetic judgment**, aesthetic appeal, and **aesthetic emotions** appear frequently. Usually these concepts are barely or only vaguely defined, both as individual concepts and with regard to their relations to one another. Here, we propose a taxonomy that integrates all terms into one conceptual space.

The most fundamental aspect of aesthetic processing is aesthetic evaluation. It can be regarded as a detection mechanism for specific properties that are diagnostic for a specific aesthetic quality of a stimulus. Monochromy, for instance, is a stimulus feature that has relevance for the quality of 'elegance'. Other diagnostic features predictive of this attribution include slenderness, streamlined contours, and smoothness of movements, as well as higher-order properties such as lightness and efficiency [56]. Although the latter higher-order properties can still be traced back to the stimulus's physical make-up, they result from an internal integration of basic features into more complex semantic concepts.

The greater the perceived distinctness and clarity of stimulus features and the more they conform with a person's stored profile of elegance-relevant properties, the more salient does this aesthetic quality become in the perceiver's mind and the more likely it is for the stimulus to be explicitly judged as elegant (aesthetic judgment). Other aesthetic qualities will have a property profile that either overlaps with that of elegance, as in the case of 'beauty', or diverges from it, as in the case of 'kitsch' [57] or the 'sublime' [58]. Moreover, while the properties included on a specific profile may vary between individuals as well as due to historical or educational influences, we advocate the idea that a specific aesthetic quality has shared and stable core properties due to biological or cultural origins [59–61]. For facial attractiveness, for instance, symmetry, averageness,

and sexual dimorphism have been argued to represent a biologically based property triad that is particularly relevant for this aesthetic quality across sexes, cultures, and history [62]. For an example of a culturally shaped aesthetic quality, we might refer again to elegance, which has long been closely associated with (features signifying) higher social status, wealth, and cultural refinement [56].

Importantly, neither all the stimulus properties that prime a certain aesthetic judgment nor the accompanying processes they trigger in the brain (e.g., engagement of the motor system [63–65]) have to be consciously accessible to the observer. This is why we can readily experience something as moving, fascinating, or attractive without necessarily understanding how this impression came about – similar to recognizing an emotional state from a facial expression or vocal prosody without being able to pinpoint all of the diagnostic features that led to this impression.

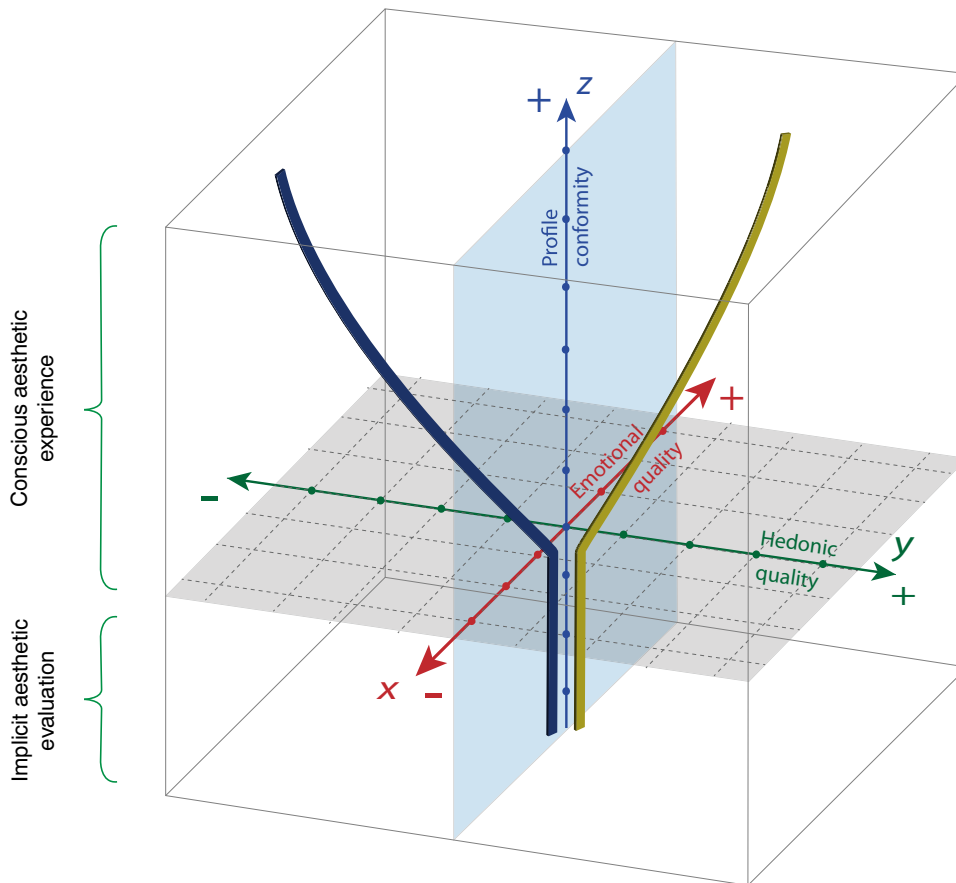
### The Always-On Hypothesis

Several studies have shown that the process of aesthetic evaluation might operate spontaneously and continuously, even in the absence of our conscious awareness (for faces see [66–68], for language see [69]). We call this the always-on hypothesis. An ongoing readiness for aesthetic evaluation can be seen in light of evolutionary advantages for the individual not to miss a mating partner or a resource-rich habitat. It does not, however, imply that the individual has a continuous aesthetic experience. For a genuine episode of an aesthetic experience to occur, the evaluation process has to be imbued with: (i) an emotional component; and (ii) a sense of pleasure or displeasure. This is typically the case when the aesthetically relevant stimulus features have high distinctiveness and hence are perceived with great clarity, thus overlapping highly with a certain property profile and rendering the respective aesthetic quality particularly salient and intense (Figure 1). Critically, with the emergence of these two additional aspects, the immediate experience surfaces in our awareness and the elicitor is singled out of the stream of the incoming sensory input to allow the executive system to take action towards the elicitor (e.g., focusing on it, prolonging the exposure, approaching it physically) [70].

For empirical research, it is important to note that it is possible to provide ratings on an aesthetic quality even in the absence of a genuine aesthetic experience. For instance, when asked to provide a kitsch rating for a stimulus, the participant will (implicitly) assess to what degree the stimulus exhibits the features diagnostic of this aesthetic quality and report the perceived overlap with the cognitively stored profile as a rating. However, this will not guarantee that the participant arrives at this rating by having an aesthetic experience, for which the additional two conditions (experiences of both emotional and hedonic components) must be in place. Thus, research aimed at genuine aesthetic experiences should entail provisions for these additional factors (e.g., by collecting supplementary ratings on felt pleasure and felt emotion). To set apart an aesthetic judgment that is based not on an aesthetic experience but solely on aesthetic evaluation, we refer to it by the term **aesthetic labeling**.

### The Emotionally Engaging Nature of Aesthetic Experiences

Both the representation and the elicitation of emotions are essential across all artistic domains. Accordingly, films and music are often used for mood regulation [71], on both an individual and a collective level. The key role of an aesthetic emotion for an aesthetic experience means that this component serves the perceiver as a second, purely internal, criterion that primes an aesthetic judgment, in addition to the diagnostic stimulus properties of an aesthetic quality. In other words, if, due to the perception and further processing of specific stimulus features, a stimulus makes us feel a certain way – say, emotionally moved – we will project our emotional



## Trends in Cognitive Sciences

**Figure 1. Interplay of Aesthetic Evaluation, Hedonic Value, and Aesthetic Emotion.** The z-axis represents the perceptual salience and conformity of the perceived stimulus features with an internally stored profile of diagnostic properties for a specific aesthetic quality. For instance, among other features, a stimulus can be perceived to display in a pronounced way monochromy, slenderness, streamlined contours, and smooth motion sequences and thus to conform highly to the profile of elegance. This detection, inner representation, and integration mechanism is essential to aesthetic evaluation and is assumed to operate spontaneously, continuously (always-on hypothesis), and without the need for the person's conscious awareness (i.e., as an unconscious implicit aesthetic evaluation). However, once a sufficient degree of conformity with the property profile is reached (the intersection of the axes), the perceiver becomes aware of the aesthetic quality, along with a hedonic component (e.g., pleasure), represented on the y-axis, and an emotional component (e.g., feeling of elegance), represented on the x-axis. This amounts to a consciously felt aesthetic experience and gives salience to both the experience and the elicitor. The emotional and hedonic components each have a positive and a negative valence, with the respective intensities increasing to the peripheries. The yellow and blue functions represent two prototypical variants of aesthetic processing: pleasurable approach-related (yellow) and unpleasant avoidance-related (blue) processing. Note that for aesthetic processes with mixed affective states (e.g., as in being moved), the functions' values on the x- and y-axes represent integrated affect and pleasure (i.e., being overall on either the positive or the negative side of the axes).

response onto the stimulus itself and call it 'moving'. A number of aesthetic qualities, including 'moving', 'touching', 'awe inspiring', or 'suspenseful' are strongly informed by the emotional aspect of the aesthetic experience, whereas the related aesthetic judgments are used as expressions of appreciation (e.g., a moving performance, a touching speech, an awe inspiring vista, a suspenseful film) [72,73]. For aesthetic qualities that do not imply the emotional dimension already in their name (e.g., beauty, grace, kitsch), Kant introduced the strategy of adding the preceding expression 'the feeling of' to the object-focused terms [74].

Importantly, not all emotions that are elicited by a given stimulus are aesthetic emotions, but only those that are: (i) responsive to the stimulus's aesthetic qualities; and predictive of (ii) aesthetic (dis)pleasure and (iii) approach–avoidance behavior. To give a negative example, consider the case of sadness or fear elicited by a film scene. We might call these art-elicited, but not aesthetic, emotions because, on their own, they lack the power to directly predict aesthetic pleasure (usually operationalized as liking) and motivational tendencies. Rather, these negative basic emotions only indirectly contribute to aesthetic liking by fueling the overall desirable states of being moved (in the case of sadness) and suspense (in the case of fear), which indeed do fulfill all three criteria for aesthetic emotions (studies demonstrating this mediation effect are [72,75–77]).

Particularly in the arts, negatively valenced emotions are often drawn on as catalysts for aesthetic emotions [78,79]. In this process, negative emotions can still exert their strong grip on attention, emotional involvement, and memory, yet in a way that is disconnected from any real-life danger or urgency to respond to the eliciting stimulus. This disconnection in artistic contexts (e.g., theater, film, music) and more generally in witness positions (e.g., observing a predator or the eruption of a volcano from a safe position) is called 'cognitive distancing' in aesthetic processing [78] or **aesthetic distancing** (for a related concept, 'liberated embodied simulation', see [80,81]).

### The Hedonically Engaging Nature of Aesthetic Experiences

While the involvement of emotions is a pivotal ingredient of aesthetic experiences, the sense of aesthetic pleasure or displeasure is the ultimate currency of aesthetic processing altogether. Importantly, the hedonic evaluation is to be distinguished from the emotional experience, as the latter is subject to the former. In other words, the felt emotional experience elicited by a stimulus's aesthetic quality is evaluated on how pleasurable the emotion feels – its hedonic value.

All processes discussed so far are coordinated around an evaluation of the hedonic quality of both the stimulus – as manifesting a certain aesthetic quality – and the elicited emotion (which includes the interoception of physiological, expressive, and subjective-feeling changes). The fundamental role of pleasure in aesthetic processing is the ultimate reason for an overrepresentation of positively valenced emotions in the context of aesthetics (positivity bias), which is in stark contrast to the prominence of negative emotions in adaptive contexts (negativity bias) [78].

In explanatory accounts of aesthetic pleasure, we often encounter references to evolutionary biology. For instance, in choosing a sexual partner the preference for symmetry (which is indicative of genetic quality [62]) is thought to provide evolutionary advantages for offspring, who will eventually inherit this aesthetic preference. Although compelling in this case, evolutionary explanations reach their limit when it comes to explaining pleasures derived from cognitive mastering, unpredictability, or experiences that include negative emotions. To account for these cases, the explanatory framework needs to be broadened to include the self-rewarding nature of aesthetic processing [9] (e.g., 'savoring' a felt emotional state) [73,78], the exploitation of the brain's predictive coding system (especially in time-based stimuli with regular elements; e.g., music, poetry) [82–84], reference to social cohesion (as aesthetic experiences are often made in social contexts) [85,86], and developmental, emotional, and health-related benefits [87,88].

### Conducting Research in Empirical Aesthetics

#### Scope and Agenda

Empirical aesthetics is a multidisciplinary, evidence-based discipline aimed at understanding the elicitation mechanisms and the constituent processes of aesthetic experiences. Aesthetic experiences arise from: (i) an aesthetic evaluation (i.e., the perception and higher-order processing of stimulus properties that are diagnostic of an aesthetic quality); (ii) a felt emotional component; and



(iii) felt aesthetic (dis)pleasure. A vital goal for understanding the basics of aesthetic processing is to identify the core constituents of interindividually shared property profiles of aesthetic qualities and the respective thresholds at which (ii) and (iii) come into play, as well as the neural organization and the temporal choreography of (i), (ii), and (iii). Based on a mechanistic understanding of these fundamental processes, the study of their consequences and functions for both the individual and the social environment is central to the discipline. Additionally, it is important to provide models that explain variance that is not covered by general models but is rather bound to interindividual and intercultural differences, contextual regulation, and top-down processes.

### Multidisciplinarity

To perform this kind of research successfully, it is necessary to overcome the boundaries of the established disciplines (Box 3). Due to the central role of the senses, evaluation, emotion, and pleasure at the recipient's end, such research requires expertise in the established psychological/neurocognitive domains: perception, attention, emotion, decision making, reward, and motivation. Study of the stimulus, by contrast, calls for expertise in relevant fields such as face perception, music, poetry, fashion, cinematography, dance, etc. Finally, philosophical theories are valuable for drawing explanatory models and planning experimental designs. In this sense, empirical aesthetics uniquely combines different fields, with psychology, neurosciences, arts/art-related disciplines, and philosophy at its core and with disciplines such as anthropology, ethnology, sociology, and linguistics as valuable extensions.

### Interactionist Approach

Until now, most studies in empirical aesthetics have been either subject oriented or stimulus oriented. Further, the great majority of these studies have relied on data accumulated over time, whether by aggregating data over predefined periods – usually entire stimuli – or by collecting post-stimulus summary ratings. Both aspects imply considerable limitations for our progress in understanding aesthetic processing and for the development of mechanistic models of aesthetic experiences, which unfold over time and in an ongoing interaction with the stimulus [89–92].

Even if the properties of the stimulus are static, as in the case of a painting, a chair, or a building, it is important to locate them in the time-logged framework due to their dynamic processing in the brain, the time-bound perceptual navigation through the stimulus, and the active, explorative behavior of the perceiver.

We propose a research framework that encourages researchers to think both in terms of temporal dynamics and in terms of interaction between: (i) the stimulus and the perceiver; (ii) different systems within the perceiver; and (iii) different layers of the stimulus. This approach can be either exploratory or hypothesis driven. In Box 3, we illustrate this interactionist approach with a hypothesis-driven example.

### Concluding Remarks and Future Directions

Why should we care about aesthetics? Aesthetic processing permeates and influences all aspects of human cognition, emotion, reward, and motivation. As a consequence, a great number of our everyday life decisions, our psychological wellbeing (including healthy brain development), our social cohesion, and the appearance of our environment depend on aesthetic processing. A thorough scientific understanding of the mechanisms and the elicitation principles underlying aesthetic experiences would do justice to this important aspect of human life. Moreover, insights into aesthetic processing will benefit not only the fields of empirical aesthetics and neuroaesthetics but general research on neurobiology, cognition, and emotion as well. This would allow an informed application of aesthetically salient stimuli in scientific studies, therapy,

### Outstanding Questions

What are the evolutionary origins of aesthetic experiences and how can we study them today?

Are there differences between the aesthetic processing of natural stimuli and of artifacts of human culture? What are these and how can we explain them?

How does an artistic context modulate the default aesthetic processing? We already pointed to aesthetic distancing as one mechanism and prerequisite to make negative emotions compatible with aesthetic pleasure. Are there more mechanisms of this sort?

What are the interindividually shared properties on the internally stored profiles of aesthetic qualities? Which of these properties are culturally independent and probably evolutionarily inherited?

Several aesthetic qualities are applied across different domains. Elegance, for instance, is often applied to visual objects but is also very common in mathematics, programming ('elegant code'), writing, and poetic language. What are the common stimulus properties among all of these domains? Most likely these properties will be higher-order semantic concepts, such as lightness or efficiency (in solving difficult tasks) in the case of elegance. So far, there is, however, little empirical work on aesthetic qualities across domains.

Aesthetic pleasures involve the primary reward circuitry, yet in their subjective experience participants report them to be markedly different from primary rewards such as food and sex. Which additional mechanisms explain the subjectively felt qualities of aesthetic pleasures?

Which aesthetic qualities are influenced by socially and culturally shaped ideals and moral values?

Which negative emotions (other than sadness and fear) can function as catalysts for aesthetic emotions?

Which aspects of aesthetic processing can be used purposefully and put into practice in health-related, developmental, pedagogical, therapeutic, architectonic, and design-related contexts?

**Box 3. Illustrative Example of a Multidisciplinary, Interactionist Approach**

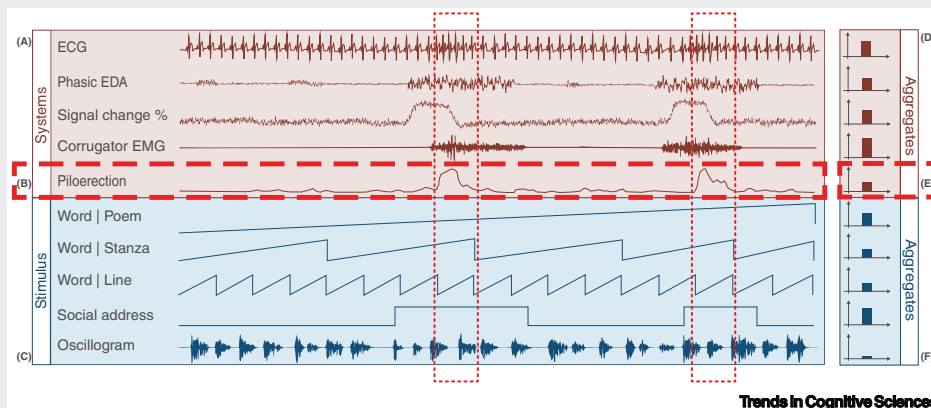
A recent study drew inspiration from the fields of cognitive neuroscience, poetry, and philosophy [47]. As a point of departure, we adopted Friedrich Schiller’s philosophical definition of being moved as a ‘mixed sentiment of suffering and pleasure’ [106]. A second hypothesis from the field of psychophysiology predicted peak moments of being moved to be marked by emotional goosebumps (piloerection) [100]. A third hypothesis from experimental psychology associated states of being moved with the presence of a prosocial component in the stimulus [102,107–109]. Finally, a fourth hypothesis from the realms of poetics and rhetoric anticipated elicitors of being moved to be located at closures or cadences (i.e., the ends of lines, stanzas, and entire poems [36]). In short:

- H1: being moved is a mixed state including negative affect and pleasure;
- H2: peak moments of being moved are marked by goosebumps;
- H3: being moved is related to the evocation of pro-social values;
- H4: particularly moving moments are located at closing positions.

Note that H1 and H2 are aimed at subject-oriented processes whereas H3 and H4 make stimulus-oriented predictions. If accurate, all hypotheses should interrelate with one another. For instance, coactivation of negative affect and pleasure (H1) is expected to be particularly visible in goosebump periods (H2), which in turn should cluster for passages with prosocial contents (H3) and at closing positions (H4).

We first validated H2 [75]. To not interfere with the participants’ experience of the recited poems, goosebumps were recorded objectively by a camera [110]. ‘Suffering’ was operationalized as electromyographic contraction of the facial corrugator muscle and ‘pleasure’ as heightened activity in the reward-related nucleus accumbens. When tracing the words that participants heard when goosebumps appeared in the camera, we expected an overrepresentation of words at closing positions and assumed that prosocial behavior would be particularly pronounced in direct speech acts. These passages represent a simulation of a direct personal communication and social interaction, in which prosocial elements are more likely to occur. Specifically, direct speech passages in an overall emotionally moving context are typically highly compatible with prosocial norms and conjure social ideals such as selflessness, courage, and generosity.

Figure I summarizes schematically our findings in an interactionist framework. The core idea of this framework is a time-logged juxtaposition of concurrent signals in the systems of the perceiver and the different layers of the stimulus.



**Figure I. Interactionist Approach.** The signal of interest chosen is piloerection (i.e., goosebump formation), computed from video recordings. The frames of interest define two goosebump episodes. On the part of the perceiver, these periods are marked by increased activity in the nucleus accumbens and electromyographic contraction of the corrugator, corroborating H1. These moments are further characterized by general physiological arousal, as evidenced by increased heartbeat frequency in the electrocardiogram (ECG), and heightened phasic electrodermal activity (EDA). On the part of the stimulus (i.e., a poem represented by its oscillogram), goosebump episodes lie within segments of direct speech (corroborating H3), begin at the ends of lines and at the ends of stanzas, and accumulate towards the end of the poem (corroborating H4). (D,E,F) represent aggregated measures. Although certain research questions may be answered on the stimulus level, in this case operating on an aggregated level would fail to capture essential compositional aspects of the peak aesthetic experience on either side of the juxtaposition. Abbreviation: EMG, electromyography.

pedagogy, adult education, urban development, human engineering, etc. (see Outstanding Questions).

How should we care about aesthetics? Crucially, future progress in our understanding of aesthetic processing will depend on having well-defined key concepts along with the grasp of their interrelation, a clear road map of an agenda, a drawing of mechanistic models that are based on the integration of stimulus- and subject-oriented approaches in a unified interactionist framework, and a strong focus on the temporal course of aesthetic processing.

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### Declaration of Interests

The authors have no interests to declare.

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