Mixed Emotional Structure of Paintings

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Abstract

Mixed emotions are strongly linked to aesthetic emotions, which involve both positive and negative emotional experiences. Mixed emotions are aroused as complex emotional reactions to artworks. However, the mixed emotional experiences aroused by paintings have received scant attention in empirical science. This study seeks to quantify the intensity of mixed emotional experiences aroused by paintings and explore their relationships with the emotional and categorical characteristics of the paintings as well as with aesthetic emotion. In online surveys, 948 participants rated 356 paintings across seven emotional scales: three for basic positive emotions (amusement, happiness, and pleasure), three for basic negative emotions (sadness, fear, and disgust), and one for aesthetics (beauty). The strong co-occurrences of aesthetic and basic negative emotions, such as "sad beauty," were demonstrated using data-driven principal component analysis (PCA) and theory-driven quantifications with minimum index (MI). The couplings of basic positive and negative emotions were also quantified using MI and their intensities were associated with the aesthetic emotion, albeit those couplings were relatively weak and not evident in the PCA. Furthermore, both qualitative and quantitative assessments of the paintings revealed that mixed emotional characteristics were distinctive between their negative emotional constituents. The contributions of mixed and negative emotions to aesthetic experiences have been discussed in philosophical aesthetics and art studies. This study provides empirical evidence and sheds new light on these philosophical questions.

Keywords: mixed emotions, painting, valence, beauty

Mixed Emotional Structure of Paintings

Mixed emotions refer to the co-occurrence of emotions in which the constituent emotions have opposing valences (Berrios et al., 2015; Larsen & Green, 2013; Larsen & McGraw, 2011, 2014; Larsen et al., 2001). More broadly, co-occurrences of multiple emotions are termed emotion blends (Berrios et al., 2015; Larsen & McGraw, 2014; Scherer, 1998; Watson & Stanton, 2017). Mixed emotions encompass the special cases of emotion blends, where the co-occurring emotions are opposite in their emotional valences. For example, the subjective experience of nostalgia is often defined as a bittersweet experience combining negatively valenced sadness with positively valenced joy (Johnson-Laird & Oatley, 1989; Trost et al., 2012; Werman, 1977). Like nostalgia, mixed emotional states are strongly linked with "aesthetic emotions" aroused by artworks (Menninghaus et al., 2019). In this study, we investigate the characteristics of mixed emotions aroused by paintings and examine their links to the aesthetic emotion.

Mixed Emotions and Artworks

Mixed emotional experiences—simultaneous blends of positive and negative valence—constitute a defining feature of complex art encounters. For example, engaging with tragic, horror, or suspenseful works often induces co-occurring feelings of sorrow and enjoyment, fear and satisfaction, or disgust and being moved (Menninghaus et al., 2019; Menninghaus et al., 2017a, 2017b). Neurocognitive evidence further shows that these mixed emotions in art—such as "sorrowful beauty" or the sublime—evoke neural activation patterns distinct from those linked to purely positive experiences such as "joyful beauty" (Ishizu & Zeki, 2014, 2017). The field of philosophical aesthetics has seen extensive debates to explain this paradox of mixed emotions in art. Friedrich von Schiller (1792) described tragedy as "artificial misfortune" ("das künstliche

Unglück") that cultivates our capacity to face genuine suffering, while Kivy's (1999) error theory argues that observers misattribute art-represented negative emotions to their own emotional state (Matravers, 2003).

The presence of mixed emotions is exemplified in some forms of artistic stimuli, such as music (Barrett et al., 2010; Brady & Haapala, 2003; Eerola et al., 2018; Hunter et al., 2008, 2010; Ladinig & Glenn Schellenberg, 2012; Larsen & Stastny, 2011; Panksepp, 1995; Taruffi & Koelsch, 2014; Vuoskoski et al., 2012; Weth et al., 2015; Zentner et al., 2008), films (Fong, 2006; Gilman et al., 2017; Hemenover & Schimmack, 2007; Kreibig et al., 2013; Larsen et al., 2001; Larsen & Green, 2013; Mather & Ready, 2021; Murray et al., 2023; Oceja & Carrera, 2009; Samson et al., 2016), and poems (Menninghaus et al., 2017). Mixed emotional studies focus more on temporal (e.g., music, films, and literature) than static (e.g., paintings, photographs, and sculptures) artworks because temporal artworks usually require longer exposure times and thus have greater emotional variations over longer periods than do visually static artworks (Menninghaus et al., 2017b). However, the use of temporal artworks, which require a longer presentation period than static artworks, limits the variation of stimuli, and the obtained results often cannot be replicated/generalized. Regarding static artworks, mixed emotional studies have been conducted using photographic stimuli (Gerger et al., 2014; Hong & Lee, 2010; Müller et al., 2022; Oceja & Carrera, 2009; Schimmack, 2001, 2005; Schimmack & Colcombe, 2007; Veilleux et al., 2013; Wagner et al., 2014). However, these studies usually employ stimuli such as the International Affective Picture System (IAPS) as emotionally arousing material (Lang et al., 1997), with few having examined the mixed emotional states of photographs in the art context. Only two studies with very similar paradigms have addressed the impact of mixed emotions on aesthetic experiences using visual images (Gerger et al., 2014;

Wagner et al., 2014). They showed that negatively arousing photographs, such as those provided by the IAPS, were experienced aesthetically more positively (e.g., higher in liking) when they were provided in an art context (e.g., "This is an artwork") than in a non-art context (e.g., "This is a press photograph"). This highlights the effect of social context on setting a "psychological distance" to the visual images, which allows the impact of negative emotions to empower aesthetic evaluation (Menninghaus et al., 2017a, 2017b). Only a limited study used paintings to examine mixed emotions (Müller et al., 2022), and showed that paintings by one artist evoked emotionally discrepant responses between participants. However, it did not exemplify the mixed emotional states of paintings because the emotional discrepancy between participants does not always correspond to the co-occurrence of oppositely valenced emotions within them. More recently, another study performed a large-scale online survey to collect emotional tags for visual artworks, which included visually static artworks (i.e., paintings) and mixed emotional scales (e.g., feeling moved, nostalgia, and love; Stamkou et al., 2024). However, the authors aimed not to study mixed emotions but to computationally determine the emotional categories aroused by the stimuli, following their study series using facial–bodily expressions (Cowen & Keltner, 2020), vocalizations (Cowen et al., 2019), and video clips (Cowen & Keltner, 2017). Therefore, the authors collected only binary responses (e.g., "Select all the emotions this artwork makes you feel"), which cannot be used to quantify the intensity of mixed emotional experiences. Overall, aesthetic experiences are positive, despite being facilitated by or coupled with negative emotions. With that said, it remains unknown how the balance (i.e., difference in intensity) between positive and negative emotions contributes to mixed emotional experiences and aesthetic emotions. The quantification of mixed emotional intensities and the scoring of their constituent emotions could provide new insights into the structure of mixed and aesthetic emotions. Thus, to

clarify the relationships between the characteristics of the paintings, mixed emotions, and aesthetic emotion, we quantified mixed emotional intensities and comprehensively explored their links to the categorical and emotional features of paintings.

Mixed Emotional Models

Mixed emotions represent a subset of emotion blends (Berrios et al., 2015; Larsen & McGraw, 2014; Scherer, 1998; Watson & Stanton, 2017), broadly defined as the co-occurrence of any two or more same- or opposite-valence emotions. Although the presence of emotion blends is widely accepted in emotional psychology (Diener & Iran-Nejad, 1986; Folkman & Lazarus, 1985; Izard, 1972, 1992; Polivy, 1981; Scherer, 1998; Smith & Ellsworth, 1987), controversies remain regarding the presence of mixed emotions where co-occurring emotional constituents are valenced oppositely ("Can people feel happy and sad at the same time?"; Larsen et al., 2001). Circumplex models of emotions have long dominated in the dimensional approach of emotion studies, which describes the core affect—the most elementary and subjective feelings associated with emotion (Russell, 1980; Russell & Barrett, 1999; Russell & Carroll, 1999; Watson et al., 1999; Watson & Tellegen, 1985). The model sets emotional valence as one of the axes, presuming the bipolarity of positive and negative emotions. In such bipolar models, the two oppositely valenced emotions are usually considered mutually exclusive and cannot be co-activated (Schimmack, 2001); thus, the models cannot assume the presence of mixed emotions. In these classical frameworks, observations of mixed emotional events are ascribed to measurement errors (Berrios et al., 2015; Kreibig et al., 2013). Regarding the art-related experience, a previous study described a feeling of beauty using the circumplex model (Armstrong & Detweiler-Bedell, 2008). However, the approaches based on the circumplex

model cannot presume the mixed emotional state, and therefore an alternative framework is required to comprehend the associations between aesthetic and mixed emotions.

The presence of mixed emotions is supported in alternative frameworks such as bivariate and evaluative space models (ESM; Cacioppo et al., 1999; Cacioppo et al., 2004; Norris et al., 2010), which allow more flexible explanations of mixed emotions. ESM presumes independence of the underlying motivational and neural mechanisms for positive and negative emotions, allowing greater flexibility than classical bipolar models. Furthermore, other studies suggest that mixed emotions differ qualitatively from non-mixed emotions, with new emotional qualities emerging (Kreibig et al., 2013; Murray et al., 2023). The dissociations between frameworks have prevented the comprehension of mixed emotions using classical emotional axes, such as emotional valence and arousal dimensions (Cowen & Keltner, 2017). This is a limitation of the IAPS that assumes the bipolar model of emotional valence, whose midpoint is usually interpreted as "neutral." However, the midpoint may instead reflect the presence of mixed emotions or "emotional ambivalence" (Schneider et al., 2016). It remains unknown whether oppositely valenced emotions cancel out their polarities, which predicts that paintings with higher mixed emotional intensities would receive less extreme (i.e., midpoint) ratings on the bipolarity valence scale or whether the overall affective qualities of mixed emotions are experienced independently from their constituting emotions, which assumes flexible relationships between mixed emotional intensities and the bipolarity valence scale. The present study explores these questions by examining the associations between mixed emotional intensities and emotional valence/arousal scores. The use of valence and arousal spaces contributes to characterizing the mixed emotional experiences aroused by paintings.

Aesthetic and Everyday Emotions

This study examines the links between mixed and aesthetic emotion aroused by paintings. There remain controversies regarding the distinction between aesthetic and ordinary (everyday) emotions and whether aesthetic emotions comprise special characteristics. The arguments and positions are summarized comprehensively in a commentary paper (Skov & Nadal, 2020), which stated that aesthetic studies adopt one of three positions according to the handling of the aesthetic emotions: (a) everyday emotions, (b) everyday emotions in a special presentation, or (c) a wholly distinct class of emotions. For example, a notable study (Christensen, 2017) adopted the second position, which made a distinction between daily pleasurable experience (e.g., food and sex) and aesthetic pleasures elicited by art-related experiences. As mixed emotional art-related experiences lead to aesthetic pleasures, the latter case (i.e., aesthetic pleasure) would encapsulate the mixed emotions. However, fundamental (e.g., food and sex) and higher-order (e.g., monetary and artistic) pleasures share a common hedonic brain system (Berridge & Kringelbach, 2013; Nadal & Skov, 2018). The confliction was collectively reflected in a hybrid model, which subdivided the aesthetic pleasures into two types. The first is associated with physiological desire elicited by biological stimuli (e.g., faces, bodies, and physical spaces), and corresponds to the primary reward system. The second is for internal and social rewards; it takes higher-order stimuli as input (e.g., artworks and mathematical formula), and employs an additional neural circuit, including the orbitofrontal cortex (Ishizu et al., 2023). The study stated that the latter can be accompanied by negatively valenced emotion, indicating that a type of aesthetic emotion can be mixed emotions.

A more recent paper rebutted the notion that the categorization of the three positions was arbitrary and did not apply to the theoretical model (Menninghaus et al., 2020). Instead, they defined aesthetic emotion as full-blown discrete emotion that (1) includes an aesthetic

evaluation/appreciation of objects or events, (2) is tuned to/predictive of a specific type of aesthetic quality (aesthetic appeal), (3) associated with subjectively felt pleasure or displeasure, and (4) an important predictor of liking or disliking. Importantly, they did not conclude that a specific set of emotions plays these roles. According to the definition, any emotions, including ordinary emotions (e.g., joy and anger), can be aesthetic emotions, only when they are used to evaluate and directly predict the aesthetic appeal of objects, which consequently leads to hedonic experiences. This view combines the three perspectives nonparadoxically (Menninghaus et al., 2020). The theoretical paper also mentioned the role of mixed emotions, i.e., that "many overall positive aesthetic emotions encompass negative or mixed emotional ingredients" and the mixed and negative emotions can be integrated as resources to enrich positively valent aesthetic emotions. This view is close to the idea that considers the aesthetic emotion to be a form of emotional complexity (Berrios, 2019), indicating that the aesthetic emotions involve a multiplicity of emotions that are difficult to describe using conventional emotional words (Hosoya et al., 2017; Menninghaus et al., 2019; Ortony et al., 1988). For example, the sublime and awe are often considered a complex mixture of joy and fear (Konečni, 2005; Pelowski et al., 2017), as reflected in the original definition by Burke (1757). This implies that an allowance of co-occurrence of oppositely valent emotions would be one of the characteristics of aesthetic emotions.

Operational Definition of Aesthetic Emotion

In this study, we investigate the characteristics of mixed emotions aroused by paintings, and examine their links to the aesthetic emotion. For this purpose, we operationally define aesthetic emotion as the emotional response evoked by paintings and measure it using a single "feeling of beauty" scale. We adopt this scale because beauty is the preeminent category for

198 evaluating aesthetic qualities (Augustin et al., 2012; Hoshi & Menninghaus, 2018; Jacobsen et
199 al., 2004; Knoop et al., 2016), and consider that it captures the affective component of an
200 aesthetic judgment. While aesthetic experience involves perceptual, cognitive, and other
201 processes, our focus is solely on its emotional dimension and its relation to mixed emotions. This
202 position is similar to that of a previous theoretical paper (Menninghaus et al., 2019); however,
203 the current work differs regarding use of the term "aesthetic emotion" exclusively for the
204 designated scale (i.e., the feeling of beauty) but not for the other emotional scales employed in
205 the present study, namely basic emotions (e.g., amusement and sadness), which could also be
206 encapsulated in the category of aesthetic emotions, by definition (Menninghaus et al., 2019).
207 We operationalize aesthetic emotion via the "feeling of beauty" scale, while also
208 obtaining standard basic-emotion ratings (e.g., amusement, sadness). The basic emotions are a
209 small set of elemental emotions, which are qualitatively discrete and exclusive (Ekman &
210 Cordaro, 2011; Levenson, 2011; Tracy & Randles, 2011). In mixed-emotions studies, basic
211 emotions are often considered the constituents (Larsen et al., 2001; Larsen & Green, 2013;
212 Larsen & McGraw, 2011, 2014). We define the aesthetic emotion as above to operationally
213 distinguish it from basic emotions. This distinction allows us to investigate two types of mixed
214 emotions: (1) the mixtures (co-occurrences) within basic positive and negative emotions and (2)
215 mixtures between basic (negative) and aesthetic emotions.
216 We employ an operational distinction between "aesthetic emotion" and "basic emotions"
217 strictly for the purposes of experimental manipulation and measurement. Here we do not adopt a
218 definitive stance on whether aesthetic emotion constitutes a psychologically distinct category;
219 rather, our use of the term reflects a pragmatic choice. Indeed, many prior investigations of
220 aesthetic response (e.g., Chatterjee & Vartanian, 2014; Ishizu & Zeki, 2011, 2017; Leder et al.,

2004; Silvia, 2005; Vessel et al., 2012) have similarly sidestepped the question of categorical separation by instead referring to "aesthetic experience"—a broad construct encompassing evaluative, emotional, and judgmental components. Thus, while we refer to "aesthetic emotion" throughout the current paper, this label should be understood as an operational convenience rather than an ontological assertion.

The same stance is applied to the "basic emotions," whose psychological validity has been debated in the emotional psychology field for several decades (Russell, 2003; Scarantino & Griffiths, 2011). To select positive and negative emotional categories for experimental purposes, we refer to the previous studies listing "basic emotions," and pick six of those emotions (see "Methods" section for details). Therefore, the set of emotions is naturally termed "basic emotions." This does not indicate a definitive stance on whether basic emotions constitute a psychologically distinct category, or whether specific emotions (e.g., pleasure) are included in such a category.

Scales for Mixed Emotions

To quantify the intensity of mixed emotions within participants, several measurements have been suggested (Berrios et al., 2015; Kreibig & Gross, 2017). For example, mixed emotional intensities are quantified by taking the minimum intensity of paired emotional constituents (minimum index; MI; Priester & Petty, 1996; Schimmack, 2001, 2005) and by adopting scoring paradigms used in emotional ambivalence research (Jonas et al., 2000; Priester & Petty, 1996), such as the ambivalence score (AS; Conner & Sparks, 2002; Thompson & Zanna, 1995) and emotional ambivalence index (EAI; Hong & Lee, 2010; Priester & Petty, 1996; Williams & Aaker, 2002). These paradigms are employed to quantify the intensity of mixed emotions or emotional ambivalence aroused by music (Hunter et al., 2008, 2010), films

(Larsen & McGraw, 2011; Schaefer et al., 2010), the IAPS (Schneider et al., 2016), and non-emotional pictures (Hahn et al., 2024). Among these measures, MI is the most common index for mixed emotions studies. Despite some documented limitations, such as the floor effect (Hamilton & Allard, 2023; Larsen et al., 2017), MI provides a measure of mixed emotional intensity that translates across different stimuli and contexts. Importantly, these measurements are simple algebraic combinations of the constituent emotional scores that quantify the mixed emotional intensities for any stimulus, even when the experiences are very weak or absent. Therefore, they are sensitive to subtle mixed emotional experiences and robust to cases in which one constituting emotion is heavily weighted over the other(s). Owing to the lack of an absolute threshold, the interpretations of the measurements are available only relatively (e.g., between stimuli and conditions), which stands on the theoretical presumption regarding the presence of mixed emotional experience. We introduced an additional data-driven quantification approach using principal component analysis (PCA) to overcome these limitations. We explored the principal components (PCs) that reflect mixed emotional states by capturing the co-occurrence of oppositely valenced or aesthetic and negative emotions.

Study Aim and Design

In this study, we examined the links between the characteristics of paintings, mixed emotions, and aesthetic emotion. The relationships between the emotional (i.e., valence and arousal)/categorical (i.e., content and style) characteristics of paintings and mixed emotions were explored, and the associations between mixed and aesthetic emotions were also examined. Here, we defined mixed emotions broadly in terms of their relationships with aesthetic emotion, which encapsulated both cases: (1) the mixtures (co-occurrences) within basic emotions and (2) mixtures between basic (negative) and aesthetic emotions. In the former scenario, the mixed

emotions correspond to the aesthetic emotions which are constituted by oppositely valenced basic emotions (e.g., sadness and joy). In the latter scenario, mixed emotions are formed by coupling the aesthetic (i.e., the feeling of beauty) with basic negative emotions (e.g., sadness). As the overall aesthetic experiences are positive, the aesthetic emotion would behave similarly to the basic positive emotions while also coupling with basic negative emotions. The constituting emotions comprised six emotions (three positive and three negative) that were selected as aesthetically evaluable emotional qualities of paintings from a list of basic emotions and their candidates (Ekman & Cordaro, 2011; Tracy & Randles, 2011)—amusement, happiness, pleasure, sadness, fear, and disgust—in addition to the aesthetic emotion, namely the feeling of beauty. Subjective ratings for the seven constituent emotions were obtained for the stimuli selected from the Vienna Art Picture System (VAPS), which comprises 999 paintings of varying content and styles (Fekete et al., 2022). We used the VAPS database because the present study employed the content information (i.e., painting category) as target characteristics of the paintings to explore their relationship with mixed emotion; VAPS is superior in its systematic approach to image selection (Fekete et al., 2022). To cover a broad range of paintings, two experiments were performed with an identical design but with different stimulus sets selected from the VAPS, which were analyzed together. Mixed emotional intensities were quantified using data-driven (PCA) and theory-driven (MI) methods, which examined their relationships with the emotional (i.e., valence and arousal)/categorical (i.e., content and style) characteristics of paintings and ratings for the feeling of beauty. An additional purpose of the present study was to supplement the open accessible rating information to the VAPS. This would facilitate the use of the VAPS database, which would consequently encourage the research community to provide comparable results and allow systematic combinations. The prepared rating data would also assist future

studies by potentially allowing them to skip pilot ratings for selecting the stimuli. For this purpose, the average rating data and mixed emotional intensity of each stimulus are provided in the Supplementary Data Sheet. Visually static artwork is frequently used in empirical aesthetic studies, with active discussions being conducted regarding psychological models of aesthetic appreciation (Chatterjee, 2003; Leder & Nadal, 2014; Locher et al., 2010; Menninghaus et al., 2017b; Pelowski et al., 2016, 2017; Pelowski & Akiba, 2011; Silvia, 2005; Wassiliwizky & Menninghaus, 2021). Clarifying the mixed emotional characteristics of paintings could contribute to understanding the significant roles of mixed emotions in aesthetic processing.

Methods

Participants and Ethics

This study recruited 1,017 Japanese participants online and analyzed a dataset from 948 of those persons (432 women, 511 men, four other gender categories, and one unanswered category; mean age = 42.84 ± 0.34 standard error [SE]). Two experiments with an identical design but different stimulus sets were conducted sequentially, involving 465 and 483 participants, respectively; they were analyzed together. Participants were recruited from CrowdWorks (https://crowdworks.jp)—a crowdsourcing platform/online forum used to recruit participants for online experiments. Included were individuals who were in a silent and focused environment that they could maintain until finishing the experiment and those who accessed the website using personal computers but not smartphones (i.e., devices with iOS or Android operating systems). The procedure (e.g., tasks and approximate time to complete), criteria, and experiment requirements were described on the forum. Those willing to participate provided consent and proceeded to the experiment by clicking on a URL to access an online experiment application built on GORILLA (https://gorilla.sc/). The metainformation of the web browser was

then checked, and individuals accessing the website through smartphones were rejected. This study was conducted in accordance with the Declaration of Helsinki and national and international guidelines. The study was approved by the Ethics Committees of Ritsumeikan University (approval number: 衣笠-人-2024-8) and Kansai University (approval number: 266). The participants were paid 500 yen (approximately 3.5 USD) if they finished the experiment.

Stimuli

This study used 180 and 176 paintings for the first and second experiments, respectively. Different stimulus sets were employed for each experiment to cover various types and categories of paintings. The data from the two experiments were analyzed together. Still, the differences between the experiments were not investigated, as we did not have specific assumptions regarding the distinction of the stimulus set, which is beyond the scope of this study. The stimuli were selected from the VAPS database (Fekete et al., 2022), which comprised 999 paintings reflecting various types of content (i.e., scenes, portrait, landscape, still life, and toward abstraction) and styles (e.g., Renaissance and Mannerism, Baroque and Rococo, Surrealistic tendencies, and Abstract expressionistic tendencies; please see the Supplementary Data Sheet for the full list and Table S1 of the Supplementary Material for the summary), accompanied by subjective ratings of emotional valence and emotional arousal (VAPS scores). The stimuli were selected according to their relative positions in the valence–arousal space (VA space) provided in the VAPS (Figure 1). Owing to the dependency between the valence and arousal scores, the paintings in the database exhibited an ellipse-like distribution in the VA space. For the first experiment, following the assumption that stimuli with higher valence and/or arousal would induce emotions for at least one constituent of mixed emotions, paintings located at the edge of the distribution in the VA space (i.e., extreme valence and/or arousal scores) were selected. To

quantify the "extremity" of the paintings in the VA space in consideration of their ellipse-like distribution, we calculated the standardized distance of each painting as follows. First, we fitted an ellipse to the data point of the 999 paintings in the VA space in the least-squares sense, whose tilting angle was used to rotate the data point so that its X and Y coordinates represented axes capturing the maximum variance of the dataset (i.e., the process was equivalent to the varimax rotation). The X and Y coordinates were subsequently normalized so that all data points ranged from 0–1 on each axis. The standardized distance was defined as the Euclidean distance of each data point from the normalized origin of the fitted ellipse. A total of 180 stimuli with the largest standardized distances were used in the first experiment (Figure 1, red dots).

Unlike the first experiment, which used emotionally extreme paintings, the second experiment was performed using non-edge stimuli located relatively in the middle of the VA space (i.e., non-extreme in valence and/or arousal scores). The stimuli were distributed homogeneously in the VA space, as follows: First, we defined a "non-edge" VA space using the stimuli that were unused in the first experiment, ranging between their maximum and minimum valence (X) and arousal (Y) values. Equally distributed points in the non-edge VA space were then defined by breaking the space into an N × N grid whose standardized distances were computed using the aforementioned procedure. The points with a standardized distance smaller than the minimum standardized distance among the 180 stimuli used in the first experiment were counted. This was repeated until the final count was 180 or less, with 1 subtracted from N for every iteration. The iterations yielded 176 equally distributed points with N = 17. For each point, the closest painting (Euclidean distance) was selected from the original VA space, which comprised the 176 stimuli used in the second experiment (Figure 1, blue dots).

For each of the first and second experiments, the stimulus set was divided into six groups (1A–1F for the first, and 2A–2F for the second experiment). The style and content of the stimuli were controlled to ensure they were balanced across the groups. Each group comprised 30 paintings, except for 2C–2F, with 29 paintings.

The Supplementary Data Sheet lists the selected paintings, and Table S1 in the Supplementary Materials summarizes the style and content of the stimuli.

Procedure

An online experiment was conducted using an application built on GORILLA. First, participants were given the option to provide their age and gender. On the next page, they were instructed regarding the task and asked to report the feelings aroused by appreciating the painting as follows: “Paintings will be presented in this task. Please indicate the intensity of *your feelings* expressed by the following words, which are aroused by viewing the paintings.” Linguistically, the word “beauty” belongs to a class of terms that describes objects’ aesthetic quality, whose uses do not directly implicate affective responses (Menninghaus et al., 2019). Therefore, these terms need to be preceded by “the feeling of” to be treated as emotions, such as “the feeling of beauty” (Kant, 1790; Menninghaus et al., 2019). Following this convention, we explicitly instructed participants to indicate their *feelings*. Notably, participants were not asked to indicate the feelings of the person/people depicted in the painting nor the artistic/aesthetic quality of the painting. They responded using a 7-point Likert scale for six basic emotional scores: amusement (楽しい), happiness (幸せな), pleasure (心地よい), sadness (悲しい), fear (怖い), and disgust (嫌悪する), in addition to an aesthetic emotional score: the feeling of beauty (美しい). We selected six (candidates of) basic emotions (Ekman & Cordaro, 2011; Tracy & Randles, 2011) as potential constituents of the mixed emotions aroused by paintings, specifically three positive and

three negative emotions. Basic emotions usually involve more negative emotions (Tracy & Randles, 2011), such as anger and contempt. A previous study compiled a comprehensive list of emotional responses to the visual arts and scrutinized their principal components, which led to the retention of sadness, fear, and disgust as principal negative emotional responses but the dismissal of anger and the exclusion of contempt from the list (Stamkou et al., 2024). Therefore, we concluded that the three basic negative emotional scales (i.e., sadness, fear, and disgust) were suitable for evaluating the emotional state related to the appreciation of paintings. Furthermore, basic emotions frameworks typically list fewer positive states (Tracy & Randles, 2011). Because different positive emotions (e.g., amusement, wonder, pride) may interact uniquely with negative affects in mixed emotion experiences, we supplemented our design with additional positive scales from Ekman and Cordaro's (2011) candidate list. Notably, because the Japanese translation of "amusement" (楽しい) also covers the concept of joy, the scale may capture a broad positive emotional response. Additionally, to capture the aesthetic emotion aroused by paintings, we used the feeling of beauty scale, as described in the Introduction section (Menninghaus et al., 2019). More specifically, the participants were explicitly instructed to indicate their "feelings," and thus we measured "the feeling of beauty" in the literal precise sense (Menninghaus et al., 2019). However, in the following part of the paper, we simply use the "beauty" scale to refer to the measurement for convenience. Subsequently, the participants were instructed to rate each emotional scale independently because the same painting may arouse multiple emotions, as follows: "(with a presentation of a sample painting) For example, you may feel '"amused" as well as "sad" by viewing this painting. As exemplified here, please do not preclude the possibility of feeling sad when amused and vice versa. Instead, please give a rating for each scale independently while assuming your mind may hold multiple feelings at the same

time.” Next, the participants completed a practice trial (i.e., rating) using a painting not utilized in the main task. They were then reminded of the number of trials and approximate completion time, followed by the main task.

For the main task, participants were assigned randomly to the six stimulus sets (1A–1F in the first, and 2A–2F in the second experiment). The main task comprised 29 or 30 trials (paintings), depending on the stimulus set each participant was assigned. The trial order was randomized between participants. A painting was presented at the top of the main task screen, accompanied by seven Likert scales below, which ranged from 1 (I do not feel it at all) to 7 (I feel it very much). The order of the scales (emotions) was randomized across trials within participants, except for the feeling of beauty scale, which was always positioned at the end. Previous studies indicate that the order in which aesthetic and emotional ratings are made inevitably affects responses. Specifically, studies have shown that aesthetic ratings can influence subsequent emotional ones. For example, Brattico et al. (2013) demonstrated that instructing participants to rate music aesthetically enhanced their emotional reactions, such as pleasure and excitement. In turn, emotional ratings have also been found to shape subsequent aesthetic score. For example, Vessel et al. (2023) showed that, when participants related artworks to emotions or memories, their subsequent aesthetic ratings significantly increased. Taken together, these studies have suggested a bidirectional influence between aesthetic and emotional assessments, implying that order effects are an unavoidable consideration in aesthetic and emotional research. To investigate the relationships between rating for the feeling of beauty and mixed emotional intensities, which were constituted by basic emotions, the order needed to be controlled. Therefore, we separated the two; the participants always started the ratings from the basic emotions followed by the feeling of beauty scale in the task, which would be an optimal

arrangement to control the order effect with minimum number of participants. The scales were numbered, and participants were instructed to respond according to the number. Their answers and response times (RTs) were recorded and analyzed.

Data Processing and Analysis

Prior to analysis, unreliable responses were excluded based on two criteria: (1) All responses from participants who provided "straight-line" responses (assigning the same value across all scales in a single trial) in six or more trials were discarded. (2) All responses from participants whose cumulative RTs were located in the bottom and top 2.5% were discarded from each experiment. The second exclusion criteria followed those of our previous study (Fuyama, 2023), with a threshold adjusted from 5% to 2.5%. The adjustment was performed by visually inspecting the evolution of the cumulative RTs across all trials for each participant (Figure S1 in the Supplementary Materials) and sufficiently excluding the participants who showed unexpectedly longer RTs during the evolution (i.e., marked by sudden increases of the cumulative RTs in Figure S1 in the Supplementary Materials). These two criteria led to the discarding of 33 and 36 participants, leaving 465 and 483 participants for the first and second experiments, respectively. Data from the two experiments were analyzed together.

First, to explore the presence of mixed emotional experiences in a data-driven manner, we performed PCA using emotional rating scores. This was repeated twice with different inputs: (1) basic emotional scores (six scales) to explore the PCs capturing the co-occurrences of basic positive and negative emotions (six-component model), and (2) basic and aesthetic emotional scores (seven scales) to explore the PCs capturing the co-occurrences of aesthetic and basic negative emotions (seven-component model). Each time, the component coefficients for each rating and component score for each painting were computed. All PCs were interpreted

according to their component coefficients and visual inspections of paintings that scored the highest and lowest average PCs; those that reflected mixed emotional intensities were identified. Mixed emotional PCs were further scrutinized by comparing their component scores between the categories of paintings and in relation to the valence and arousal scores provided in the VAPS. For each PC capturing mixed emotions, the average and 95% bootstrap confidence intervals (CI; with 5,000 iterations) were calculated for each painting category. The dissociation of CIs is considered a significant difference in PCs between categories. The correlations between mixed emotional PCs and VAPS scores (i.e., valence and arousal) were examined by computing the 95% bootstrap CI (with 5,000 iterations) for Spearman's coefficients for each pair, which were considered significant when the CI did not cross zero.

Subsequently, mixed emotional intensities were quantified using MI (Priester & Petty, 1996; Schimmack, 2001, 2005), which is defined as the minimum score of pairing emotional constituents (e.g., when sadness = 6 and happiness = 2, then MI = min(6,2) = 2). It captures a part of overall affective intensity where the two emotions are potentially co-occurring and leaves remaining intensity as the residual. Theoretically, the MI ranges equally to its constituent scales (from 1 to 7 in the present study). It captures the intensity of emotional mixture alone, but does not necessarily reflect the overall emotional intensity of the paintings. Therefore, it is not comparable to the original rating scores. Among participants, the MI was calculated for each pair of basic positive and negative emotional scores (nine pairs)—sadness × amusement (S×A), sadness × happiness (S×H), sadness × pleasure (S×P), fear × amusement (F×A), fear × happiness (F×H), fear × pleasure (F×P), disgust × amusement (D×A), disgust × happiness (D×H), disgust × pleasure (D×P)—and aesthetic and basic negative emotional scores (three pairs)—sadness × beauty (S×B), fear × beauty (F×B), disgust × beauty (D×B)—as well as for each painting. The

MIs were compared between the categories of paintings and in relation to the valence and arousal scores using the same method employed for the PCs. To investigate the relationships between mixed emotional intensities and aesthetic emotion, the MIs computed for the pairs of basic positive and negative emotions were examined for their correlations with the feeling of beauty scale in each painting category using the aforementioned bootstrapping approach with Spearman's coefficients. Please note that the couplings between the feeling of beauty and basic positive emotions were not considered in the analyses, because they do not fall into the definition of mixed emotions (i.e., the co-occurrence of emotions in which the constituent emotions have opposing valences), although they exemplify the cases of emotion blends (i.e., the co-occurrence of any two or more same- or opposite-valence emotions).

Finally, to examine the validity of quantification methods of mixed emotional intensities (PCA vs. MI), their correlations were examined. As the PC3–5 in the seven-component model captured the mixed emotional intensities, the MIs for corresponding pairs of aesthetic and basic negative emotional scores were examined for their correlations (PC3 and MI for S×B, PC4 and MI for F×B, and PC5 and MI for D×B).

Results

Descriptive Statistics

The present study collected 7-point Likert ratings for six basic emotional scores (amusement, happiness, pleasure, sadness, fear, and disgust) and an aesthetic emotional score (i.e., the feeling of beauty). Descriptive statistics are summarized in Table 1 and Figure 2. Overall distribution showed that the basic positive emotional (amusement, happiness, and pleasure) and disgust scores suffered from the floor effect (Figure 2), with mean scores ranging from 2.60 to 2.98, while the other scores ranged from 3.45 to 3.71 (Table 1).

The ratings were summarized for each painting category (Table 2 and Figure 3). There was a remarkable difference in the rating pattern between landscape and the other categories; compared to the other categories, the landscape category gained higher scores on the basic positive and aesthetic emotional scales but lower scores on the basic negative scales.

Mixed Emotions: PCA

To identify mixed emotional experiences in a data-driven manner, the co-occurrences of emotional ratings were explored using PCA, which was first performed using six basic emotional scales to search for mixed emotions consisting of basic positive and negative emotions (Figure 4 and Table 3). The six-component model showed that the first three PCs had eigenvalues greater than 1.0 (PC1: 10.45, PC2: 3.29, and PC3: 1.55; Table 3), which met the Kaiser criterion (Kaiser, 1960)—the popular cut-out threshold for factor extraction—suggesting that factors with an eigenvalue greater than 1 (>1.0) should be considered primary components. However, the aim of the PCA was to find PCs capturing mixed emotional intensities where basic positive and negative emotions co-occurred, not to select PCs or reduce dimensionality; thus, all PCs were considered for interpretation.

The interpretations of the PCs were made according not only to the directions and sizes of the component coefficients (Figure 4 and Table 3), but also to the visual inspection of the paintings with the highest and lowest average PCs (Figures S2 and S3 in the Supplementary Materials). PC1 had positive coefficients for basic negative emotional scores (sadness: 0.38, fear: 0.52, and disgust: 0.46) and negative coefficients for basic positive emotional scores (amusement: −0.32, happiness: −0.35, and pleasure: −0.38). As such, we named PC1 the "emotional valence" component. PC2 exhibited positive coefficients for all scores (sadness: 0.41, fear: 0.33, disgust: 0.34, amusement: 0.44, happiness: 0.47, and pleasure: 0.45); thus, it captured

519 the emotional intensity aroused by the paintings. Furthermore, the component coefficients were
520 positive for both basic positive and negative emotional scales in PC2, indicating that oppositely
521 valenced scales contributed equally to the PC, where mixed emotional cases were expected.
522 However, the visual inspection of paintings with high/low PC2 suggested that it captured the co-
523 occurrences of same-valenced emotions but did not necessarily reflect oppositely valenced
524 mixed emotional cases. Therefore, we named PC2 the "emotional intensity" component. PC3
525 and 4 contrasted the basic negative emotions while they gained minor contributions by basic
526 positive emotions—PC3 for "sadness versus disgust" (coefficients were 0.79 and −0.49,
527 respectively) and PC4 for "fear versus disgust" (coefficients were 0.73 and −0.66, respectively).
528 Similarly, PC5 and PC6 contrasted the basic positive emotions—PC5 for "amusement versus
529 pleasure" (coefficients were 0.72 and −0.63, respectively) and PC6 for "happiness versus other
530 positive emotions" (coefficients for happiness, amusement, and pleasure were 0.80, −0.34, and
531 −0.49, respectively). The PCs obtained for the six-component model did not capture mixed
532 emotional intensities where basic positive and negative emotions co-occurred.
533 Next, to target mixed emotions consisting of aesthetic and basic negative emotions, PCA
534 was performed using seven scales: the six basic emotional scales and one feeling of beauty scale
535 (Figure 5, Table 4, and Figures S4 and S5 in the Supplementary Materials). The PCs were
536 interpreted while focusing on the feeling of beauty scale. For PC1 and PC2, the feeling of beauty
537 scale showed behavior similar to basic positive emotions, with no mixed emotional intensities
538 implied. Therefore, following the six-component model, the PCs were named the "emotional
539 valence" and "emotional intensity" components, respectively. Importantly, co-occurrences of
540 feeling of beauty and negative emotions were found for PC3–5, which suggested that the PCs
541 captured mixed emotional intensities. PC3 showed positive coefficients for sadness (0.60) and

beauty (0.40), whereas the other scores showed negative coefficients; thus, PC3 represented the "sad beauty" component. Similarly, PC4 captured "fearful beauty" (fear: 0.45, beauty: 0.65) and PC5 captured "disgusting beauty" (disgust: 0.67, beauty: 0.29). PC6 captured a coupling of beauty (0.25) and the basic positive emotion, amusement (0.62), demonstrating the case of emotion blends; therefore, it was named the "amusing beauty" component. PC7 exhibited a biplot similar to that seen for PC6 in the six-component model, with a minor contribution from beauty (0.05); hence, it was named the "happiness versus other positive emotions" component.

PCs 3–5 in the seven-component model, which captured mixed emotional intensities, were further scrutinized for their relationships with painting categories, emotional valence, and arousal. Each PC was characterized by different categories of paintings (Figure 6 and Table 5). The component score of PC3 ("sad beauty") was the highest for landscape paintings (0.35), followed by still life paintings (0.13), whereas the toward abstraction category showed the lowest component score (−0.49). For PC4 ("fearful beauty"), the scenes and portrait paintings showed the highest component scores (0.09), whereas the toward abstraction category showed the lowest score (−0.10), followed by the landscape category (−0.09). PC5 ("disgusting beauty") exhibited the highest component score for the still life category (0.09), followed by the landscape category (0.08). Regarding the relationships between the PCs, valence, and arousal scores in the VAPS, PC3–5 showed different correlational patterns (Figure 7 and Table 6). Low-arousal paintings characterized PC3 ("sad beauty"), whereas PC4 ("fearful beauty") was characterized by high-arousal paintings, which were reflected in the strong negative and positive correlations of arousal scores with PC3 (*rho* = −0.51) and PC4 (*rho* = 0.40). PC5 ("disgusting beauty") also showed a mild negative correlation with arousal score (*rho* = −0.19).

Mixed Emotions: MI

The intensities of mixed emotional experiences were quantified in a theory-driven manner using MI. For each pair of basic positive and negative emotional scores, the average MIs ranged from 1.69 to 1.96, where the differences in the scores were remarkable between their negative constitutes; the sadness-mixing pairs showed the highest (S×A: 1.87, S×H: 1.91, and S×P: 1.96) and the disgust-mixing pairs showed the lowest MIs (D×A: 1.70, D×H: 1.69, and D×P: 1.69; Table 7). We considered the MIs to capture mixed emotional intensities for all pairs reasonably well by visually inspecting the paintings with the highest MIs (Figures 8A–I).

The distributions of MIs were computed for each painting category (Figures 9A–I and Table 8), which demonstrated the categorical characteristics of the paintings for each pair. For the sadness-mixing pairs, the landscape paintings exhibited remarkably high MIs (S×A: 2.04, S×H: 2.16, and S×P: 2.29) compared to the other categories. For the fear-mixing pairs, scenes, portrait, landscape, and toward abstraction categories showed comparable MIs, while the still life category showed the lowest MIs (F×A: 1.76, F×H: 1.80, and F×P: 1.84). For the disgust-mixing pairs, scenes, portrait, and toward abstraction categories showed higher MIs than the landscape and still life categories.

Regarding the relationships between MIs and emotional valence/arousal (Figures 10A–I and Table 9), the MIs for sadness- and fear-mixing pairs exhibited positive correlations with valence (S×A: $rho = 0.57$, S×H: $rho = 0.60$, S×P: $rho = 0.61$, F×A: $rho = 0.28$, F×H: $rho = 0.36$, and F×P: $rho = 0.40$) and negative correlations with arousal (S×A: $rho = -0.23$, S×H: $rho = -0.52$, S×P: $rho = -0.62$, F×H: $rho = -0.15$, and F×P: $rho = -0.31$), except for the positive correlations between F×A and arousal ($rho = 0.21$; Figure 10B). Interestingly, the MIs for disgust-mixing pairs did not exhibit correlations with valence/arousal scores, except for positive correlations between D×A and arousal ($rho = 0.31$; Figure 10C).

588 The MIs computed for the pairs of basic positive and negative emotions were examined
589 for their correlations with aesthetic emotion (i.e., the feeling of beauty scale) for each painting
590 category. The results showed overall positive correlations between MIs and the feeling of beauty
591 scores (Figure 11 and Table 10), except for the landscape category. For the scene painting
592 category, the MIs for all pairs between basic positive and negative emotions were correlated
593 positively with the feeling of beauty score. For the portrait and still life categories, the positive
594 correlations were found for MIs for sadness- and fear-mixing pairs, but not for those of the
595 disgust-mixing pairs. As regards the toward abstraction category, the positive correlations were
596 identified for MIs for sadness-mixing pairs and F×H, but not for those of the others (disgust-
597 mixing, F×A, and F×P). Contrastingly, the landscape category showed negative correlations
598 between MIs for fear- and disgust-mixing pairs and the feeling of beauty score, but not for the
599 sadness-mixing pairs. The distinctive behaviors between landscape and the other categories
600 yielded overall quadratic-like relationships between MIs for fear- and disgust-mixing pairs and
601 the feeling of beauty score (Figures 11B-C, E-F, and H-I).
602 The MIs were also computed for the pairs of aesthetic and basic negative emotional
603 scores. The average MIs ranged from 2.02 to 2.38, which were higher than those computed for
604 pairs of basic positive and negative emotional scores (Table 7). The disgust-mixing pair D×B
605 exhibited a lower MI than the other pairs (2.02). Visual inspection of paintings with the top MIs
606 revealed that the quantification of mixed emotional intensities by MIs provided reasonable
607 selections for all pairs (Figures 8J–L).
608 As regards the categorical differences in paintings (Figures 9J–L and Table 8), the MI for
609 S×B was highest for the landscape category (0.54), followed by the scenes (0.43), and lowest for
610 the toward abstraction category (2.07). The MI for F×B was highest for the scenes category

(2.55), followed by the portrait (2.45), and lowest for the toward abstraction category (2.18). For D×B, the MI was highest for the scenes category (2.21), followed by the portrait (2.10), and lowest for the landscape category (1.75).

Next, the relationships between MIs for beauty-mixing pairs and emotional valence/arousal were examined (Figures 10J–L and Table 9). The MI for S×B showed a negative correlation with arousal (*rho* = −0.24), while those for F×B and D×B showed negative correlations with valence (F×B: *rho* = −0.25; D×B: *rho* = −0.54) and positive correlations with arousal ratings (F×B: *rho* = 0.22; D×B: *rho* = 0.47).

Finally, to examine the validity of methods used to quantify mixed emotional intensities, the correlations between PCs and MIs were examined (Supplementary Figure S6 in the Supplementary Materials). PC3 in the seven-component model and MI for S×B showed a strong positive correlation (*rho* = 0.80, CI = [0.76, 0.84]). PC4 in the seven-component model and MI for F×B also showed a positive correlation (*rho* = 0.58, CI = [0.49, 0.66]). However, PC5 in the seven-component model and MI for D×B showed a mild negative correlation (*rho* = −0.21, CI = [−0.32, −0.08]).

Discussion

The present study explored the links between the characteristics of paintings, mixed emotions, and aesthetic emotion, resulting in four main findings: (1) the aesthetic (i.e., the feeling of beauty) and basic negative emotions (e.g., “sad beauty”) strongly co-occurred, as they were identified using both data-driven (i.e., PCA) and theory-driven (i.e., MIs) approaches; (2) the intensities of co-occurring basic positive and negative emotions were relatively weak, but they can be quantified using the theory-driven approach; (3) mixed emotions showed different characteristics between their negative emotional constituents, regarding their relationships with

painting categories and valence/arousal scores; and (4) mixed emotions between basic positive and negative emotions modulated the aesthetic emotion (i.e., the feeling of beauty) in positive fashion, while the relationships were modulated by the negative ingredient of the mixed emotions and painting category.

Mixtures of Aesthetic and Basic Negative Emotions

We defined mixed emotions broadly in terms of their relationships with aesthetic emotion, which encapsulated both cases: (1) the mixtures (co-occurrences) within basic positive and negative emotions and (2) mixtures between basic (negative) and aesthetic emotions. In this subsection, we discuss the latter case (2); indeed, these mixtures were apparent in the results of both PCA and MI analyses. The mixed emotional intensities of sad beauty (PC3 in the seven-component model and MI for S×B) and fearful beauty (PC4 in the seven-component model and MI for F×B) were correlated positively between the quantification methods, providing strong support for the presence of mixed emotions. The coupling of aesthetic and negative emotions encompasses the enjoyment of negative art, such as tragedy and horror films. In this case, we experience the co-occurrence of aesthetic emotion (i.e., the feeling of beauty) and negative emotions, such as sadness, forming an experience of negative aesthetic emotions, such as sad beauty. Our PCA results showed that mixed emotions of this type could explain emotional variations aroused by paintings. PCA is a data-driven approach that defines the PCs according to the overall covariances of emotional scales. The emergence of PCs capturing mixed emotional characteristics indicates that the behaviors of the seven emotional scales were explained by the underlying mixed emotional experiences aroused by the paintings. Particularly, “sad beauty” and “fearful beauty,” which were captured by PC3 and 4 of the seven-component model, respectively, showed eigenvalues over 1.0 (PC3: 1.71 and PC4: 1.09), suggesting that the

components considerably contributed to explaining the overall variance of the emotional scales with Kaiser criteria (Kaiser, 1960). This finding provides empirical support for the presence of mixed emotional experiences. Furthermore, the co-occurrence of aesthetic and basic negative emotions was quantified using a theory-driven approach to MI. The comparisons of PC scores and MIs between painting categories revealed that the results were close between the two methods; both the component scores of PC3 ("sad beauty") and MIs of the S×B pair were highest for the landscape category (mean PC3 score: 0.35, mean MI for S×B pair: 2.54) and lowest for the toward abstraction category (mean PC3 score: −0.36, mean MI for S×B pair: 2.07; Figures 6A and 9J, and Tables 5 and 8), while those of PC4 ("fearful beauty") and F×B were highest for the scenes category (mean PC4 score: 0.09, mean MI for F×B pair: 2.55) and lowest for the toward abstraction category (mean PC4 score: −0.10, mean MI for S×B pair: 2.18; Figures 6B and 9K, and Tables 5 and 8). The similarities between the methods (i.e., PCA and MI) support the validity of the quantification approaches for mixed emotional intensities.

Mixed aesthetic and basic negative emotions have been discussed in the context of the enjoyment of negative arts (Ishizu & Zeki, 2017; Menninghaus et al., 2017b). We studied the categorical characteristics of the artworks (i.e., paintings) that aroused high mixed emotional intensities. Qualitative investigations of the categories and content of paintings could contribute to interpreting the mixed emotional experiences quantified in the present study. For the co-occurrence of sadness and the feeling of beauty (PC3 and S×B), the component scores and MIs were high for landscape paintings depicting cloudy, rainy, or dark weather (Figure 8J and Figure S4C in the Supplementary Materials). Both component scores of PC3 and MIs of S×B showed negative correlations with emotional arousal (PC3: *rho* = −0.51 and S×B: *rho* = −0.24; Figures 7A and 10J, and Tables 6 and 9), indicating that low-arousal paintings elicited strong mixed

emotions of sad beauty. The perceptions of landscapes, and of natural scenes such as sunrises, sunsets, and plants, often arouse purely positive feelings of low-emotional arousal such as peacefulness, relaxation, and harmony (Chenoweth & Gobster, 1990; Joye & van den Berg, 2011; Kellert & Wilson, 1995; Ulrich, 1979, 1983; Wynn, 1997), which are experienced as "beautiful landscapes." Adding a negative flavor of sadness (e.g., cloudy, rainy, and dark weather) caused a "negative shift" of these low-arousal emotions in the valence axis, consequently experienced as a mixture of sadness and feeling of beauty. Alternatively, the enjoyment of sadness in artworks is often explained by its integration into episodes of nostalgia (Hosoya, 2020; Menninghaus et al., 2017b; Schindler et al., 2017). However, the feeling of nostalgia is often associated with people in close relationships, personal and momentous objects, and events, with landscapes barely being described in nostalgic narratives (Holak & Havlena, 1992; Routledge et al., 2013; Wildschut et al., 2006). Instead, in the present study, the sadness-mixed emotional experiences might have captured feelings of melancholy (Brady & Haapala, 2003), described as an aesthetic emotion characterized by a complex mixture of positive and negative emotional states, including longing, sadness, upliftment, and a subtle sense of excitement (Brady & Haapala, 2003). It is bound within a reflective and solitary state of mind and is often aroused in reaction to landscapes such as those depicted in Caspar David Friedrich's paintings—a desolate moor, and a picturesque landscape of ruins (Brady & Haapala, 2003). Landscape paintings with high mixed emotional intensities of sadness and the feeling of beauty (PC3 and S×B; Figure 8J and Figure S4C in the Supplementary Materials), which depict landscapes of this kind, can trigger a feeling of melancholy, consequently gaining a positive aesthetic rating on the feeling of beauty scale.

Interestingly, the landscape paintings gained, overall, less negative ratings than the other categories in their basic and aesthetic emotional ratings (Figure 3 and Table 2), indicating qualitative and/or quantitative difference in sadness aroused by the landscape and other paintings. Regarding the negative emotions expressed in the landscape paintings, they can depict threatening (e.g., lightning and flood) and disgusting (e.g., polluted rivers) scenery, and thus they can affect viewers directly and arouse fearful and disgusting emotions. However, it is difficult for landscape paintings to express sadness directly; they can only be experienced as sad when the depicted scenery is linked to viewers' personal sad experience, episodes, or memories. This may account for the qualitative and/or quantitative differences in the sadness in the landscape paintings. The difference was emphasized by the categorical rule of the VAPS database; the paintings in the landscape category did not usually depict people (Fekete et al., 2022). Although some pictures in the landscapes category included depictions of people, the main emphasis was on the landscape, where the depictions of people are only functional, such as miniature people as the foregrounding tool to emphasize the greatness of the landscape. Therefore, the sadness aroused by the landscape paintings could be an indirect expression of sadness, qualitatively and/or quantitatively different from the direct sadness aroused by other paintings, and compatible with the aesthetic emotion to form mixed emotional experience, such as melancholy. Melancholy is often studied in a clinical context, as it connects closely with depressive states (Leventhal & Rehm, 2005). Few studies have treated the concept non-clinically in the field of emotional psychology. However, because of its uniqueness in capturing complex and delicate emotional qualities, including the pleasure of indulgent reflection, feelings of sadness, loneliness, and emptiness, it is considered one of the principal scales for capturing the aesthetic emotions associated with a variety of artworks and is included in a subscale of the Aesthetic Emotions

725 Scale (Schindler et al., 2017). Our results empirically demonstrate that the melancholic
726 emotional state was aroused by paintings that were experienced aesthetically positively.
727 For the mixture of fear and the feeling of beauty (PC4 and F×B), the scores were high for
728 paintings depicting scary and dreadful scenes, such as moments when characters are (about to
729 be) hurt, expressing hostility to viewers (Figure 8K and Figure S4D in the Supplementary
730 Materials). Additionally, the component scores of PC4 and the MIs of F×B were positively
731 correlated with emotional arousal (PC4: *rho* = 0.40, F×B: *rho* = 0.22; Figures 7B and 10K and
732 Tables 6 and 9), indicating that high-arousal paintings elicited strong mixed emotions of fearful
733 beauty. Suspense often explains the link between negative fear and positive aesthetic
734 experiences. Feelings of suspense are pleasurably experienced in response to plot-based
735 artworks, such as novels and plays (Andrade & Cohen, 2007; Hoffner & Levine, 2005).
736 Although paintings are static, we can infer the background stories behind the depicted scenes.
737 Fearful paintings that successfully convey narrative information are evaluated as aesthetically
738 appealing and are consequently experienced as mixed emotions of fear and the feeling of beauty.
739 Among negative emotions, disgust is merely adopted for pleasurable purposes in the arts
740 (Menninghaus et al., 2017b). It differs from other emotions regarding its obtruding nature against
741 our enjoyment and anti-aesthetic effect (Kant, 1790; Kuplen, 2011). Disgust is a special
742 emotional reaction that does not possess a positive aesthetic mode (Korsmeyer, 2012;
743 Menninghaus, 2003). Therefore, it can be considered a negative emotion that cannot be sourced
744 or mixed with aesthetic emotions. Our result supported this view, showing that disgust was
745 coupled with the feeling of beauty rating in PC5 (“disgusting beauty”) in a less intense manner
746 than the other beauty couplings in PC3 (“sad beauty”) and 4 (“fearful beauty”), while it had an
747 eigenvalue of 0.81 (less than 1.0; Table 4). Although we named it “disgusting beauty” to make it

748 comparable to other components, the co-occurrence of the feeling of beauty and disgust was not
749 as evident in the biplot (Figure 5D) as in PC3 and 4 (Figures 5B and C). Instead, it may reflect
750 the contrast between negative emotions (i.e., disgust vs. fear) without capturing actual co-
751 occurrences of disgust and the feeling of beauty. It was also evident that the disgust and feeling
752 of beauty scales showed opposite component coefficients in PC3 and 4 (Figures 5B and C and
753 Table 4), suggesting their contradictory nature. Furthermore, the MIs for D×B (mean = 2.02)
754 were lower than those for the other beauty-mixing pairs (S×B: mean = 2.38; F×B: mean = 2.37;
755 Table 9), indicating that the mixed emotional intensity between disgust and the feeling of beauty
756 was, if present, weaker than the other mixed emotions. The presence of "disgusting beauty" was
757 much less evident than that of "sad beauty" and "fearful beauty."
758 The distinctions between disgust and other negative emotions were also evident in the
759 correlation between PCs and MIs. While PC3 ("sad beauty") and PC4 ("fearful beauty") showed
760 positive correlations with MIs for S×B and F×B, respectively, PC5 (potentially capturing
761 "disgusting beauty") exhibited a negative correlation with MI for D×B (Supplementary Figure
762 S6 in the Supplementary Materials). This also reflected the methodological differences between
763 the two quantification approaches. The PCs were determined according to the overall variance of
764 all datasets, and were advantageous in detecting the mixed emotions commonly found across
765 stimuli and/or participants. However, this approach cannot capture minor couplings of emotions,
766 which are evident in limited stimuli and/or participants. Contrastingly, MIs were determined
767 individually for each painting and for each participant, meaning that the approach did not
768 overlook minor co-occurrences of emotions, even though the intensity was weak. The present
769 study highlighted pros and cons of the data-driven (PCA) and theory-driven (MI) approaches in
770 mixed emotional studies, yielding distinctive values for mixed emotional intensities between the

methods. The quantification methods need to be considered carefully in future studies in relation to the research questions.

The results of the present study provide strong evidence that aesthetic emotional quality differs from normal (i.e., basic) positive emotions. Regarding the PCA, although the feeling of beauty behaved concurrently with the basic positive emotions in PC1 ("emotional valence") and PC2 ("emotional intensity"; Figure 5A and Table 4), which was also explicit in the raw data (Figure 2), it was distinctive in PC3 and 4, showing opposite polarities in their component coefficients (Figures 5B and C, and Table 4). For MIs, the intensities were much higher for the pairs of aesthetic and basic negative emotions (i.e., S×B, F×B, and D×B) than for those of positive and basic negative emotions (e.g., S×A, F×H, and D×P; Table 7). This indicates that negative emotions co-occur more easily with aesthetic emotion than with ordinary positive emotions, implying a distinction between aesthetic and positive emotions. The qualitative differences between aesthetic and ordinary positive emotions remain controversial (Brielmann & Dayan, 2022; Christensen, 2017; Menninghaus et al., 2019, 2020; Skov & Nadal, 2020). Our results provide objective evidence of the qualitative distinctions between aesthetic and positive emotions.

Mixtures of Basic Positive and Negative Emotions

Next, we discuss the results obtained as mixtures of basic positive and negative emotions. The mixed emotions of this type, i.e., the co-occurrence of basic positive and negative emotions, are relatively well-studied in the field of emotional psychology (Berrios et al., 2015; Larsen et al., 2001; Larsen & Green, 2013; Larsen & McGraw, 2011, 2014). In our results, the mixed positive and negative emotions were captured using a theory-driven MI quantification approach.

Overall, mixed emotional characteristics were distinct between their negative constituents: sadness-mixing (i.e., S×A, S×H, and S×P), fear-mixing (i.e., F×A, F×H, and F×P), and disgust-mixing (i.e., D×A, D×H, and D×P) pairs. Visualizing paintings with high MIs for each pair, the selections shared the same or similar characteristics when they constituted the same basic negative emotions (the column direction of Figure 8) instead of positive ones. We speculated that the negative emotions employed in this study (i.e., sadness, fear, and disgust) were emotionally more distinctive than the positive ones (i.e., amusement, happiness, and pleasure). The emotional constituents were selected from the list of basic emotions; however, basic emotions usually include negative emotions more often than positive ones (Tracy & Randles, 2011); consequently, we could not find an equal number of positive emotions to the negative ones that were eligible for the present study. To compensate for the missing basic positive emotions, we selected amusement and pleasure from the candidates of basic emotions (Ekman & Cordaro, 2011). Therefore, the negative emotions used in the present study would be more "valid" regarding their emotional discreteness (Ekman & Cordaro, 2011) than the positive ones, potentially yielding unbalanced "emotional resolutions" between positive and negative ones. This is corroborated by the results of the PCA (six-component model; Figure 4 and Table 3), showing that negative emotions were contrasted in more dominant PCs (e.g., PC3 for sadness vs. disgust; Figure 4B) than in the positive ones (e.g., PC5 for amusement vs. pleasure; Figure 4D). This indicates that the data variances were larger between negative emotions, whose contrast yielded PCs explaining larger overall variances than positive ones. Emotional research has been strongly biased toward negative emotions, which form clearer borders between negative than positive emotional categories (Sauter, 2010). Further studies and refinement of positive

emotional categories may lead to a better understanding of the mixed emotional characteristics of basic positive and negative emotions.

Regarding the qualitative characteristics of positive and negative mixed emotions, the MIs of the sadness-mixing pairs were marked by the landscape category of the paintings (Figures 8A, D, and G; Figures 9A, D, and G; and Table 8). As discussed for the mixture of sadness and the feeling of beauty, landscape paintings with calm and relaxed countryside scenery arouse melancholy (Brady & Haapala, 2003). A previous study described the emotion as a mixture of negative feelings such as loneliness, emptiness, and sadness from loss, which sometimes accompanies longing and pleasurable feelings, which are aroused primarily through reflection as a consequence of dwelling on happy memories (Brady & Haapala, 2003). This corresponded to the S×H and S×P pairs of mixed emotions, whose quantification using MIs can capture the intensity of melancholy. Interestingly, although the mixed emotional intensities of the sadness-mixing pairs were highest in the landscape paintings, the MIs did not correlate with the feeling of beauty score in the category (Figure 11A, D, and G and Table 11). The scatterplot showed that the landscape paintings generated a distinctive cluster at the right upper space with high MIs and the feeling of beauty, indicating that the feeling of beauty and sadness-mixing MIs were experienced most intensively in the landscape category without linear relationships. This implies that the high co-occurrences of sadness and basic positive emotions in the landscape paintings may be linked to aesthetic emotions other than the feeling of beauty, such as melancholy and/or nostalgia. Furthermore, the MIs for the sadness-mixing pairs showed strong positive and negative correlations with emotional valence and arousal, respectively (Figures 10A, D, and G, and Table 9). This indicates that co-occurring bipolar emotional constituents (e.g., sadness and pleasure) did not cancel out their emotional valences; instead, they were rated positively overall.

838 The dissociation of the overall valence from the addition of its constituting valences implies the
839 emergence of a new quality for mixed emotional experiences (e.g., melancholy), which are
840 irreducible to the components. Functional magnetic resonance imaging studies demonstrated that
841 mixed emotional experiences are associated with unique regional activities in the brain, which
842 differ from those of positive or negative emotions (Murray et al., 2023; Vaccaro et al., 2024).
843 These findings support the "*emergence account*" of mixed emotions, which suggests that the
844 patterns of a mixed emotional state would dissociate from their constituent emotions, resulting in
845 a distinct emotional profile (Kreibig et al., 2013; Murray et al., 2023). Our results provide
846 psychological evidence of the uniqueness and emergent properties of the mixed emotional
847 experiences aroused by paintings.

848 Our results indicate that fear-mixing emotions can be subcategorized into two types
849 according to their emotional arousal characteristics: one accompanying high arousal (i.e., F×A)
850 and the other accompanying low arousal (i.e., F×H and F×P). In the former case, weird or scary
851 objects (i.e., clowns and exotic animals/organic shapes in Hieronymus Bosch's painting)
852 appeared in paintings with high MIs for F×A (Figure 8B). They arouse a feeling of enjoyable
853 horror, reflected in the co-occurrence of fear and amusement ("paradox of horror"; Bantinaki,
854 2012; Gaut, 1993; Strohl, 2012). This corresponds to the suspenseful feeling captured by the case
855 of F×B and PC4 (in the seven-component model), as discussed in the previous subsection.
856 Suspense-driven arousal is important in making fearful emotions enjoyable (Menninghaus et al.,
857 2017b). The positive correlation between the emotional arousal scale and the MI of the F×A pair
858 (Figure 10B and Table 9) implies a mediating role of arousal between positive and negative
859 emotions. In the latter case, the MIs for F×H and F×P were negatively correlated with the
860 emotional arousal scale (Figures 10E and H and Table 9). The feeling of awe, particularly

positive awe, is a fear-mixed emotion with low arousal (Gordon et al., 2016). Awe is an emotional appraisal state defined as "the upper reaches of pleasure and on the boundary of fear" (Keltner & Haidt, 2003). It is further characterized by peripheral appraisals that "flavor" the experience, such as threat, beauty, ability, virtue, and supernatural causality (Keltner & Haidt, 2003). Other studies summarized the flavors and suggested subtypes of awe, such as positive-awe and threat-awe (Gordon et al., 2016; Takano & Nomura, 2022). Positive awe is triggered by the experience of spiritual phenomena, the virtue of a charismatic leader, and the perceived compassion and love of a benevolent God (Gordon et al., 2016). Threat-awe is aroused by threatening stimuli such as natural disasters, a punitive God, and a leader's coercive charisma (Takano & Nomura, 2022). The paintings with high MIs for F×H and F×P (Figures 8E and H) demonstrated mysterious, spiritual, and uncanny scenes/landscapes, which triggered positive awe, associated with increased responses of parasympathetic activation, indicating low-arousal calm states (Gordon et al., 2016) that could be captured by the negative relationships between MIs and the arousal scale (Figures 10E and H, and Table 9).

For the disgust-mixing emotions, the scenes, portrait, and toward abstraction categories showed higher MIs than the landscape and still life categories (Figures 9C, F, and I, and Table 8). Interestingly, the MIs for disgust-mixing pairs did not show correlations with valence/arousal scores, except for positive correlations between D×A and arousal (Figure 10C and Table 9). Disgust has been found to exert an anti-aesthetic effect, preventing it from co-occurring with aesthetic emotions (Kant, 1790; Korsmeyer, 2012; Kuplen, 2011; Menninghaus, 2003), and our findings corroborate this (see previous subsection). However, the aforementioned claim does not exclude the artworks' ability to arouse disgusting emotions or the presence of "disgusting artworks." Indeed, skillful artists can transmute disgusting objects or events to another aesthetic

884 category, stripping them of their disgusting nature and imparting aesthetic appeal (Korsmeyer,
885 2012). In mixed emotions aroused by artworks, the power of negative emotions to secure
886 attention drives intense positive aesthetic experiences (Menninghaus et al., 2017b). Therefore, if
887 disgust is successfully processed in artistic rendering, its highly arousing emotional
888 characteristics would enhance the artworks' aesthetic qualities. For example, Hemenover and
889 Schimmack (2007) demonstrated that disgusting objects in an art context can be experienced as
890 amusing and/or humorous. Our results showed that, on average, disgust-mixing emotions had
891 lower MIs than other mixed emotions (Table 7). However, the maximum MIs for D×A (2.64;
892 Figure 8C) were remarkably higher than those for the other disgust-mixing emotions (i.e., D×H
893 and D×P; Figure 8F and I) and even comparable to those of S×A and F×P (Figure 8A and H).
894 This implies that some paintings could capture cases of successful integration of disgusting
895 objects in the artistic context, which were experienced as amusing by viewers. The positive
896 correlations between D×A and the arousal scores (Figure 10C and Table 9) support the claim that
897 the arousing nature of disgust, which was retained after distillation, contributed to enhancing the
898 positive value of the artworks. Taken together, our findings suggest that disgust cannot pair with
899 the feeling of beauty but can co-occur with highly arousing positive emotions, even leading to
900 aesthetic experience when the negative visceral feeling successfully migrates to the art context.
901 Finaly, the results of the correlation analysis demonstrated that the co-occurrences of
902 basic positive and negative emotions were linked to the feeling of beauty (Figure 11 and Table
903 10). Since the overall experience of beauty was positive, it is surprising that the MIs and the
904 feeling of beauty scores were correlated positively in most painting categories, indicating that the
905 negative emotions, which co-occurred with positive ones, can contribute to enhancing the
906 aesthetic emotion. This successfully exemplified the theoretical framework which posits that

907 negative and mixed emotions presented in the artworks empower aesthetic rating (Menninghaus
908 et al., 2017a, 2017b) using the paintings as stimuli. The results not only captured the unique
909 characteristics of the aesthetic emotion, but implied the qualitative distinctions of negative
910 emotions. The correlation coefficients were higher in the sadness-mixing emotions, followed by
911 fear-mixing ones, and lowest in the disgust-mixing emotions; these results were consistent across
912 pairing positive emotions. Since the average MIs also exhibited behaviors similar to those of the
913 correlation coefficients (sadness- > fear- > disgust-mixing emotions), the three emotions
914 (sadness, fear, and disgust) should have had differences in the level of compatibility with
915 positive and aesthetic emotions. In contrast to fear and disgust, which function as signals of
916 threat and are linked directly to survival (Curtis, 2011; LeDoux, 2012, 2014), sadness has only
917 an indirect relationship with such evolutionary importance (Bonnano et al., 2008). The
918 biologically significant quality of the negative affects involved in fear and disgust would
919 interrupt their integrations into positive emotional experience, yielding lower MIs and weak
920 correlations with the feeling of beauty score. More strikingly, the landscape paintings showed
921 negative correlations between the feeling of beauty scores with MIs of fear-\disgust-mixing
922 emotions, which contradicts overall positive correlations in the other categories. This implies that
923 the direct negative emotions (i.e., fear and disgust) aroused by the landscape paintings only have
924 negative influences on the feeling of beauty scale, even when they are integrated into the mixed
925 emotional experiences. Taken together, the mixed emotions generally enhanced the aesthetic
926 emotional experiences, although the relationships were modulated by the negative emotional
927 ingredients of the mixed emotions and further interacted with painting categories. The study
928 demonstrated dynamic links between aesthetic, mixed, and negative emotions and painting
929 characteristics.

Philosophical and Psychological Implications of Mixed Emotions

This study explored the mixed emotional experiences aroused by paintings. The results provide new evidence supporting the presence of mixed emotions—which has been questioned in the field of emotional psychology (Larsen et al., 2001)—and empirical evidence for long philosophical discussions regarding aesthetic emotions. Our findings resonate with the longstanding philosophical debates on the "paradox of tragedy" and "paradox of horror," which question how and why individuals find pleasure, aesthetic satisfaction, or cognitive value in artworks that elicit negative emotions (Carroll, 1990; Feagin, 1983; Smuts, 2009). Philosophers such as Edmund Burke have emphasized the interplay of fear and delight in the experience of the sublime, suggesting that an aesthetic framework can transform a negative affect into a source of awe or profound engagement (Burke, 1757). Similarly, Schiller's idea that experiencing "artificial misfortune" through tragedy can cultivate our moral and emotional capacities aligns closely with our empirical evidence that negative emotions, when aesthetically contextualized, contribute to complex, positively valued emotional states (Matravers, 2003; Schiller, 1792). These considerations extend to the conceptual framework mapped out by Kendall Walton's idea of "quasi-emotions," where emotional responses elicited by fictional or representational art are not the same as everyday emotions but are imaginative and emotionally charged states governed by game-like rules of make-believe (Walton, 1990). Within such a framework, the mixture of the feeling of beauty and negative affect may be viewed as a quasi-emotional engagement that, while not threatening or literally harmful, invites viewers to experience the emotional textures of fear, sadness, or disgust in a controlled aesthetic context. This complements recent theoretical approaches in the philosophy and psychology of emotion, such as those discussed by Andrea Scarantino, who stressed emotions' flexible, context-sensitive, and multi-component nature

(Scarantino, 2012, 2014). In Scarantino's framework, emotional states are dynamically assembled responses that can shift in valence, intensity, and functional significance depending on the context; this is precisely what we observe when negative emotions find themselves aesthetically reframed and interwoven with beauty.

Moreover, these results lend empirical support to theories suggesting that aesthetic emotions form a distinct class of emotional experiences and are not easily reducible to ordinary hedonic valences or standard affective binaries (Brielmann & Dayan, 2022; Menninghaus et al., 2019). As Mojca Kuplen (2011) and other scholars argued, the aesthetic domain allows for a "re-signification" of negative emotions into something meaningful, contemplative, and potentially elevating. This transformative potential, in which sadness, fear, or even disgust can be integrated into the experience of beauty, underscores a philosophically significant idea: aesthetic experiences can exemplify emotional complexity and ambivalence that are not only tolerable but also intrinsically valuable. It challenges simple pleasure-displeasure dichotomies, thereby extending the interpretations of Kant's foundational analysis of aesthetic judgment to account for affective ambivalence (Brady & Haapala, 2003; Kant, 1790). In doing so, this study lends empirical weight to philosophical positions which have long posited that aesthetic judgments and emotional responses are uniquely capable of sustaining and meaningfully integrating opposing emotional qualities within a single, multifaceted evaluative frame.

The present findings also invite reconsideration and possible refinement of existing theoretical frameworks on mixed emotions in psychology and aesthetics, as reviewed above. Although classical bipolar or circumplex models of emotion (Russell, 1980; Russell & Barrett, 1999) have traditionally resisted the idea of co-occurring positive and negative valences, our data suggest that certain aesthetic emotions, especially those evoked by visual artworks, cannot be

adequately captured by strict valence-based categorizations. More flexible models, such as the ESM (Cacioppo et al., 1999, 2004; Norris et al., 2010) or bivariate approaches that allow independent activation of the positive and negative dimensions, appear better suited to accommodate the observed complexity. Furthermore, by employing stimuli from the VAPS, which was originally organized around classical emotional dimensions such as valence, arousal, and liking, our work extends this database's functional and conceptual scope. While the VAPS provides a robust baseline of affective evaluations grounded in traditional emotion theories, the multi-scale assessment conducted in this study supplements these data with mixed emotional and aesthetic scores to move beyond the conventional valence-arousal framework and enrich the VAPS with an additional layer of complexity. This supports the development of more nuanced theoretical models of emotion and aesthetics and provides richer empirical resources for future research that aims to understand the subtle interplay of positive, negative, and aesthetic emotions in the appreciation of art. Finally, our results may inspire refinements of theories that propose the generative mechanisms of aesthetic emotions. For example, the interplay of sadness and beauty could inform updated conceptualizations of nostalgia, melancholia, or the sublime and awe within the aesthetic domain (Brady & Haapala, 2003; Gordon et al., 2016; Menninghaus et al., 2019), suggesting that these states might be understood as “emergent” complexes rather than mere additive combinations.

Limitations

This study has four major limitations: (1) We used only one aesthetic emotional scale: the feeling of beauty. As discussed extensively, mixed emotional cases can correspond to other aesthetic emotions, such as nostalgia, melancholia, and suspense. The relationship between mixed emotional intensities and these aesthetic emotions should be directly addressed. We

focused on the beauty scale because it is considered a preeminent adjective for evaluating the aesthetic appeals of objects (Augustin et al., 2012; Hoshi & Menninghaus, 2018; Jacobsen et al., 2004; Knoop et al., 2016) and is commonly recognized among the population targeted by this online study (i.e., Japanese). Contrastingly, other aesthetic emotions are often nuanced and might be recognized poorly among Japanese; thus, a more considerate study design would be necessary to measure the other aesthetic emotions online. (2) Furthermore, the feeling of beauty scale might capture psychological processes other than the affective experience, such as cognition, evaluations, and appreciations of the aesthetic quality of the paintings (Armstrong & Detweiler-Bedell, 2008). Although the participants were instructed explicitly to rate their "feeling of beauty" (please see Procedure subsection in Methods section), we cannot preclude the possibility that participants might have (wrongly) emphasized the non-affective aspect. Therefore, alternative interpretations are always possible regarding the results involving the beauty scale, such as that the negative emotions led to positive aesthetic evaluation of the paintings. This limitation is owing to the inherent nature of the aesthetic emotion (please see Introduction section), and thus is not easily addressable. However, future in-person studies analyzing detailed qualitative self-reports regarding participants' mixed emotional experience may contribute to clarifying the role of beauty in the mixed emotional experience. This issue is partly relevant to the temporal dynamics of the co-occurrence of oppositely valenced emotions in mixed emotions. Previous studies showed that the mixing patterns were subcategorized according to the temporal dynamics of constituting emotions (Carrera & Oceja, 2007; Oceja & Carrera, 2009). If the beauty score functions as a scale of aesthetic evaluations/appreciations instead of emotions, it may be driven at time windows different from the arousal of basic emotions (e.g., evaluations followed by emotions), which needs to be addressed in future studies. (3) We used a previously

published database of paintings, namely the VAPS (Fekete et al., 2022), whose scores were obtained from a population (120 German-speaking students from the University of Vienna) which differed from ours (1,017 Japanese participants) and were not equally distributed in the VA space. The VAPS scores were used to explore their correlations with our data (i.e., mixed emotional intensities). However, the results may be biased by direct comparison without compensating for differences in population characteristics—such as age, education, language, and background culture—which are known to affect the emotional processing of paintings (Besnier, 1990; Leder & Nadal, 2014; Masuda et al., 2008; Palmer et al., 2013; Silvia, 2006). Furthermore, the paintings in the VAPS showed biased and ellipse-like distributions in the VA space (Figure 1), where insufficient samples were included for the top-right (i.e., positively valenced highly arousing) and bottom-left (i.e., negatively valenced low arousing) spaces. Our results will be replicated in future studies using paintings uniformly distributed in the VA space and validated under the control of the participants' background characteristics. (4) Although we used 356 paintings, our interpretations and general discussions were based on limited samples. It is not feasible to scrutinize the qualitative features of hundreds of paintings; thus, we scrutinized only representative paintings. Further analyses of the themes of paintings are necessary to enable a concrete interpretation. The publicly accessible dataset in the Supplementary Data Sheet would encourage these future studies.

Conclusion

Paintings are a major form of artistic expression and have been studied extensively in art research. They have attracted people and researchers owing to their aesthetic appeal, accompanied by strong and complex emotional experiences. The present study empirically demonstrated the links between mixed and aesthetic emotional experiences and their co-

occurrences, accounting for our complex emotional reactions when encountering paintings. The unique co-occurrences of negative and aesthetic emotions play significant roles in the psychological processing of paintings.

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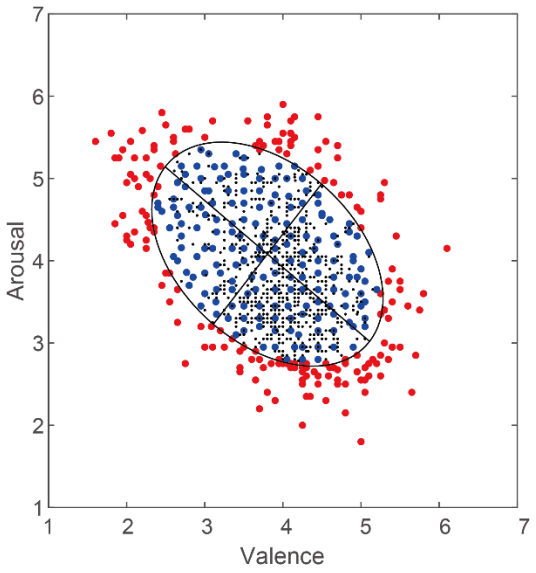
Figure 1

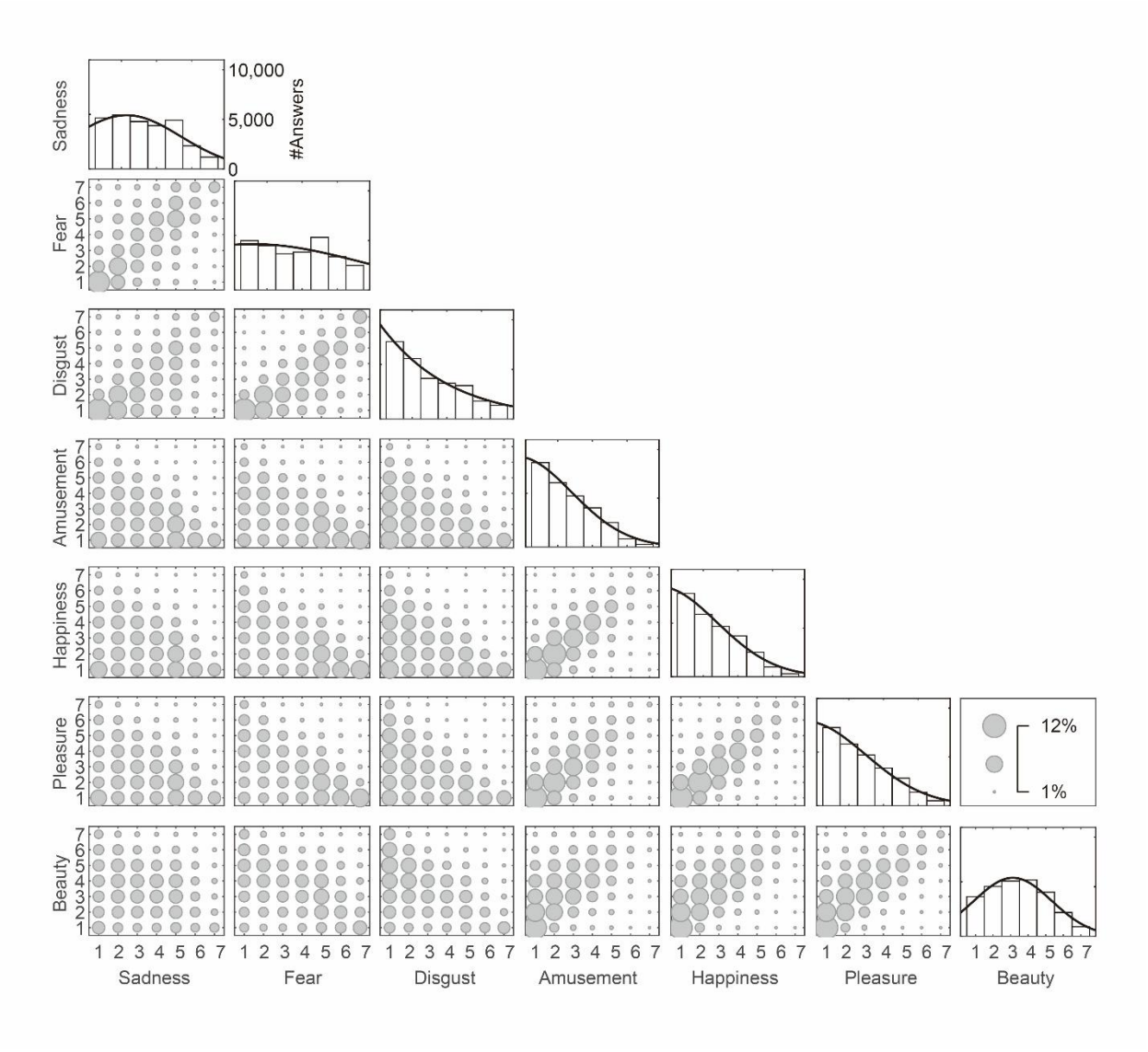
The Stimuli in the VAPS Database in the VA Space



Note. The scatter points represent 999 paintings in the VAPS database with accompanying ratings for emotional valence (X axis) and arousal (Y axis). The red and blue dots represent the 180 and 176 stimuli used for the first and second experiments, respectively, whereas the black dots represent the unused stimuli. The black lines represent an ellipse fitted to the data points with their minor and major axes, which were used to compute the standardized distance of each data point. VAPS: Vienna Art Picture System, VA space: valence–arousal space.

Figure 2

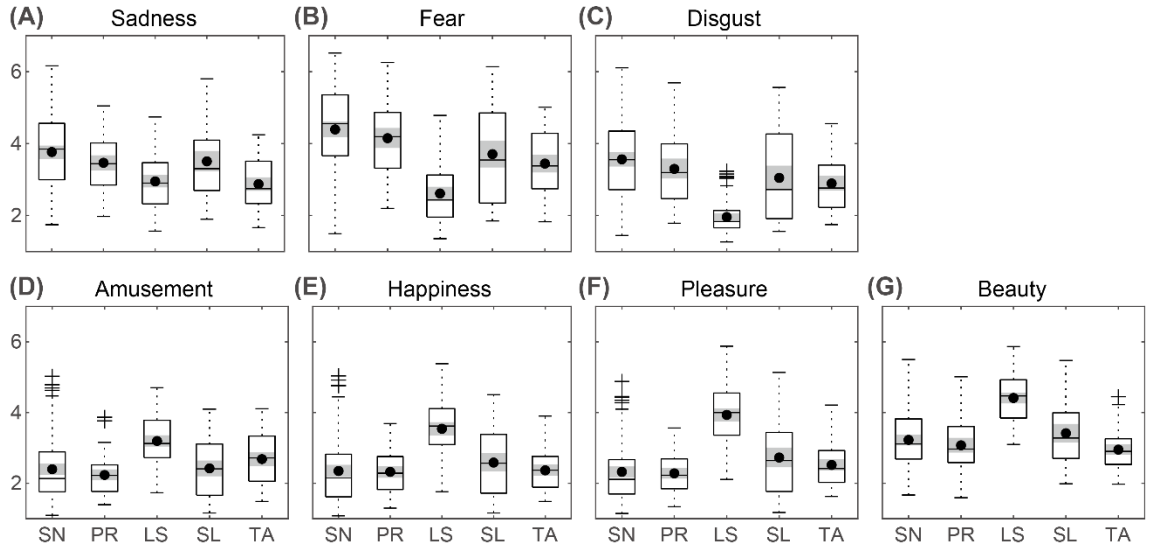
Raw Data Distributions



Note. The histograms represent the number of responses provided by participants for each score. Bubble plots represent the percentage of responses that fell into pairs of scores.

Figure 3

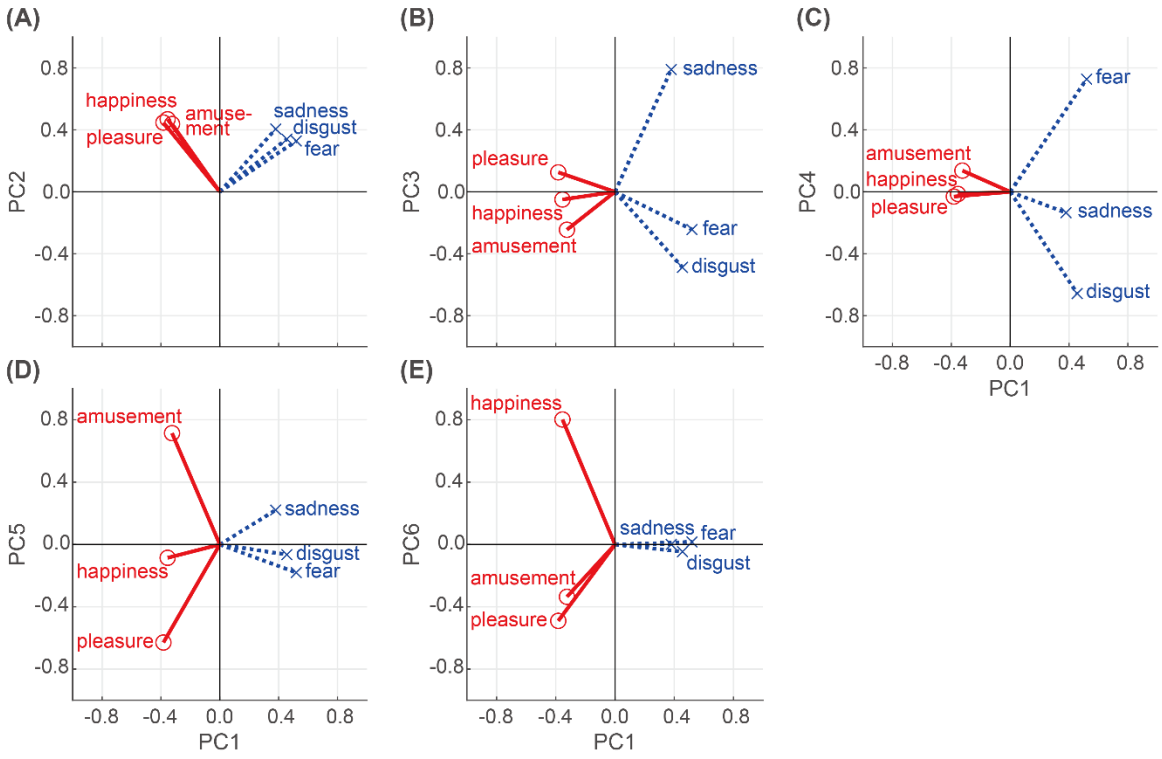
Distributions of the Raw Data for Each Content Type of the Paintings



Note. Each panel shows the distribution of raw data for (A) sadness, (B) fear, (C) disgust, (D) amusement, (E) happiness, (F) pleasure, and (G) the feeling of beauty. The boxplots represent the interquartile range, with whiskers ranging from the end to the furthest observation within 1.5 times the interquartile range away from the bottom or top of the box. The solid line in each box represents the median. The 95% bootstrap confidence interval was computed for each content type, as indicated by the gray-shaded area in each box. Black dots represent the mean of the bootstrap iterations. SN: scene painting category, PR: portrait painting category, LS: landscape painting category, SL: still life painting category, TA: toward abstraction painting category.

Figure 4

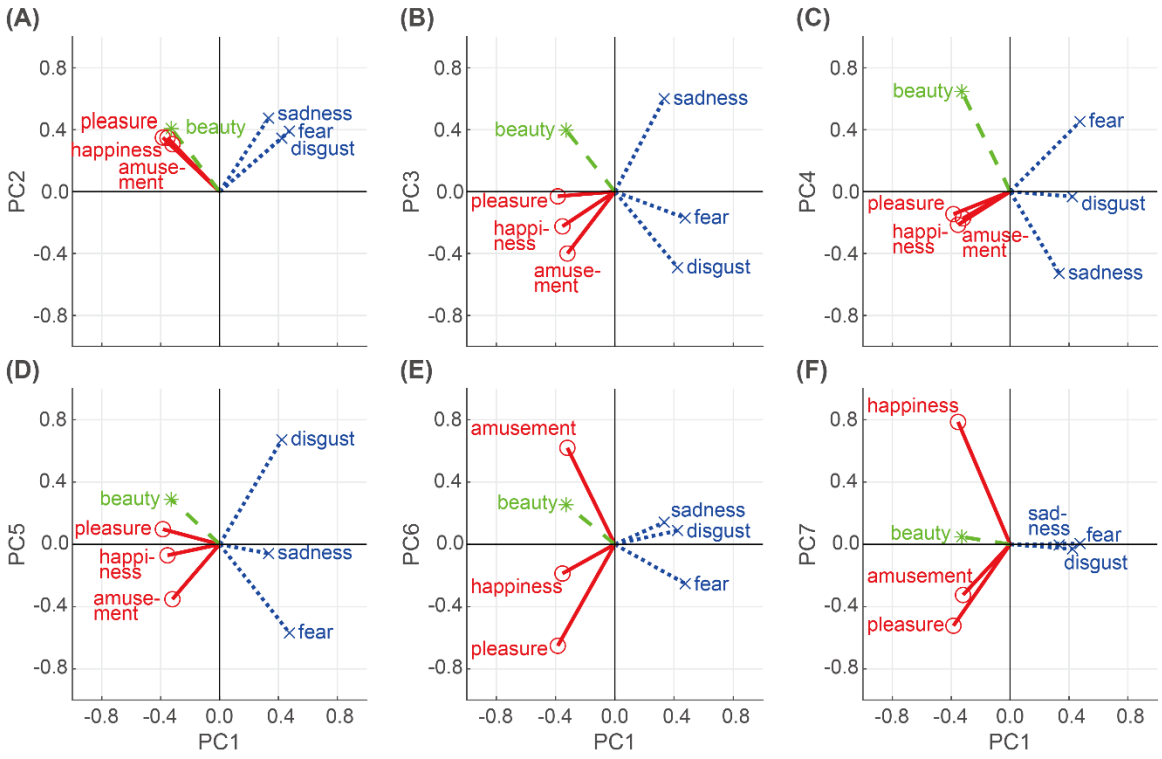
Visualization of the Component Coefficients (Six-Component Model)



Note. The biplot visualizes the relationships between the original scales (red solid lines with circle markers: basic positive emotional scales, blue dotted lines with cross markers: basic negative emotional scales) and PCs. (A)-(E) plot PC2-6 for the Y axis, respectively, against PC1 ("emotional valence") for the X axis. PC: principal component.

Figure 5

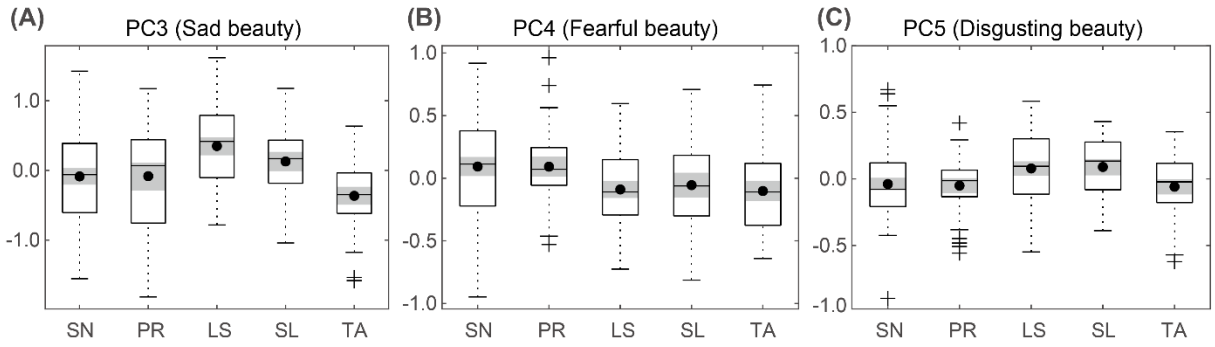
Visualization of the Component Coefficients (Seven-Component Model)



Note. The biplot shows the relationships between the original scales (red solid lines with circle markers: basic positive emotional scales, blue dotted lines with cross markers: basic negative emotional scales, green broken lines with asterisk markers: aesthetic emotional scales) and PCs. (A)-(F) plot PC2-7 for the Y axis, respectively, against PC1 ("emotional valence") for the X axis. PC: principal component.

Figure 6

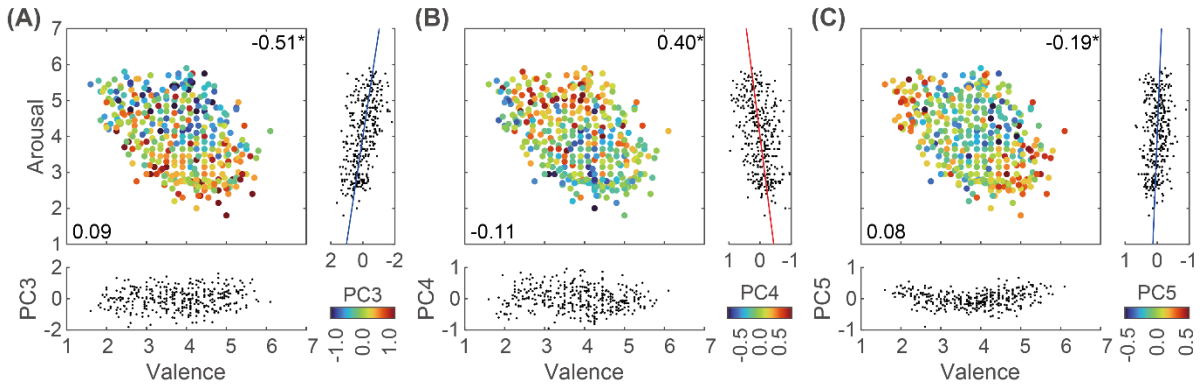
Distributions of the Component Scores (Seven-Component Model) for Each Content Type of the Paintings



Note. Each panel shows the distribution of component scores for (A) PC3 ("sad beauty"), (B) PC4 ("fearful beauty"), and (C) PC5 ("disgusting beauty"). The boxplots represent the interquartile range, with whiskers ranging from the end to the furthest observation within 1.5 times the interquartile range away from the bottom or top of the box. The solid line in each box represents the median. The 95% bootstrap confidence interval was computed for each content type, as indicated by the gray-shaded area in each box. Black dots represent the mean of the bootstrap iterations. PC: principal component, SN: scene painting category, PR: portrait painting category, LS: landscape painting category, SL: still life painting category, TA: toward abstraction painting category.

Figure 7

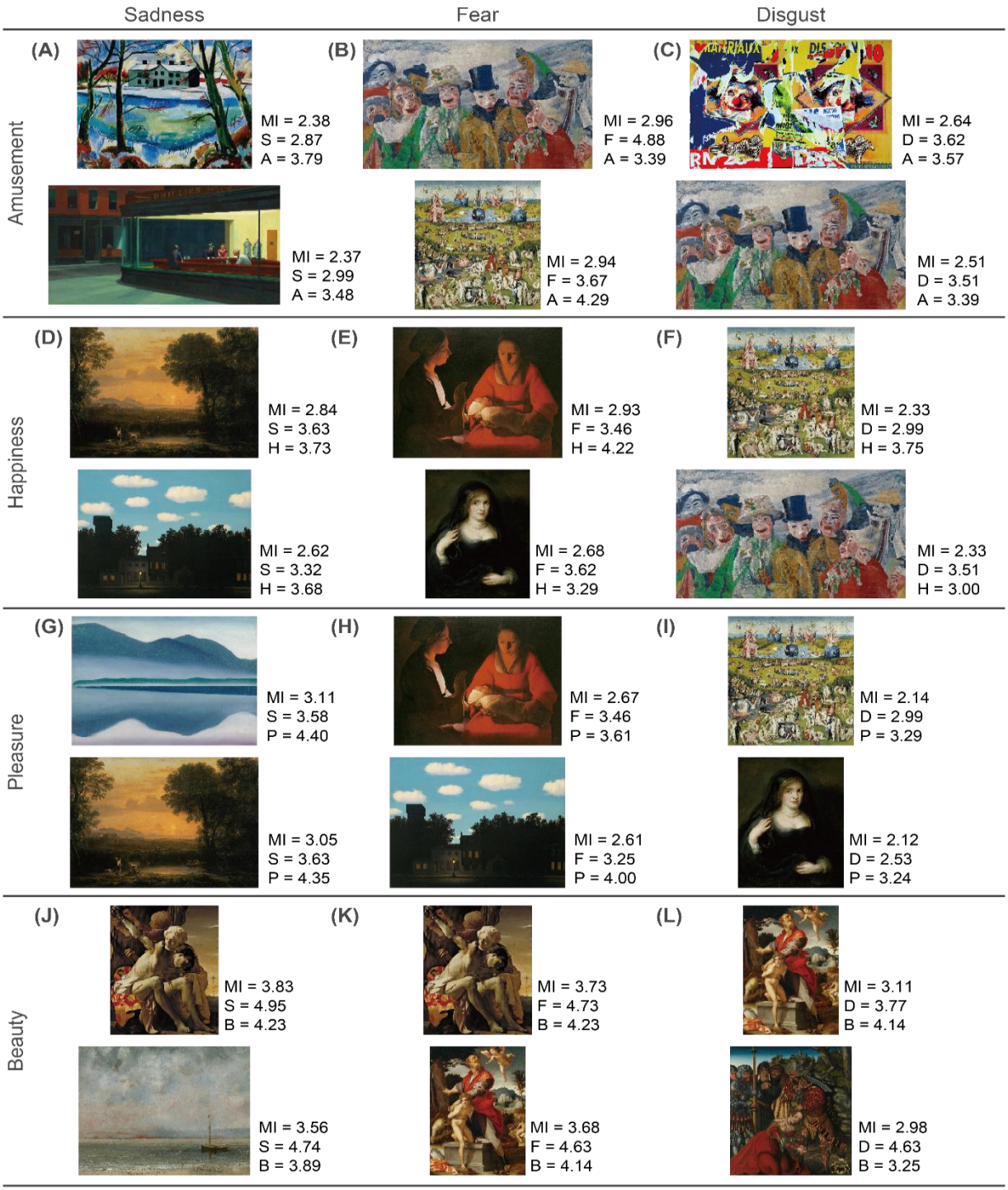
Relationships Between Component Scores (Seven-Component Model), Emotional Valence, and Emotional Arousal Scores



Note. Each panel shows the relationships of component scores for (A) PC3 ("sad beauty"), (B) PC4 ("fearful beauty"), and (C) PC5 ("disgusting beauty"). In the top-left plot of each panel, the X and Y coordinates of the scatterplot represent the position of paintings in the VA space (X axis for emotional valence and Y axis for emotional arousal), whose color represents the component score. The bottom plot of each panel represents the relationship between the component score (Y axis) and emotional valence (X axis), whose Spearman's coefficient (averaged across bootstrap iterations) is shown in the bottom-left corner of the top-left plot of each panel. The right side of each panel represents the relationship between the component score (X axis) and emotional arousal (Y axis), whose Spearman's coefficient (averaged across bootstrap iterations) is shown in the top-right corner of the top-left plot of each panel. The least-squares line was added for significant correlations (red, positive, and blue, negative). An asterisk indicates a significant correlation. PC: principal component.

Figure 8

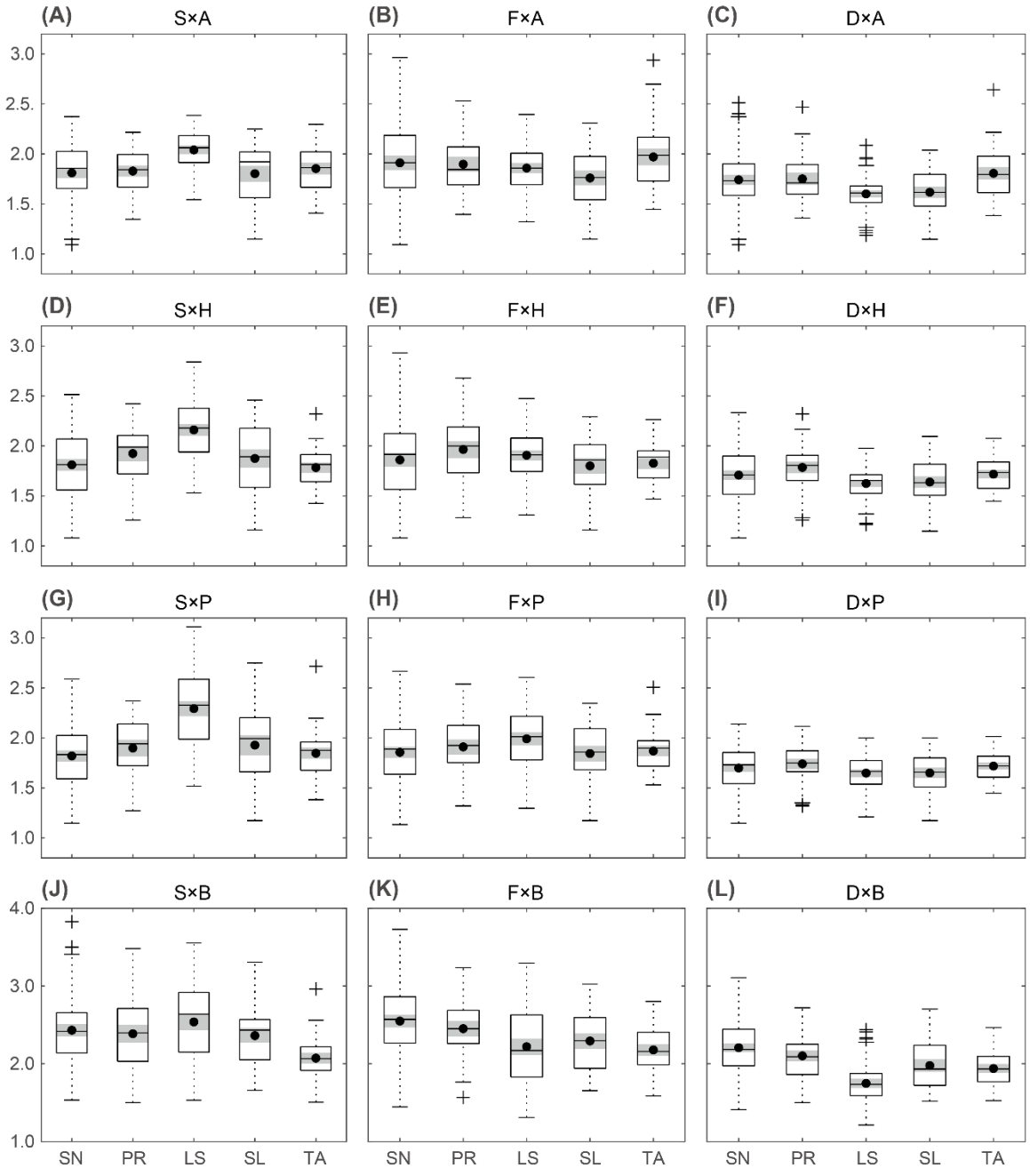
Top Two Paintings with the Highest MIs Displayed for Each Mixed Emotional Pair


Sadness
Fear
Disgust
Amusement
Happiness
Pleasure
Beauty
(A)
MI = 2.38
S = 2.87
A = 3.79
MI = 2.37
S = 2.99
A = 3.48
(B)
MI = 2.96
F = 4.88
A = 3.39
MI = 2.94
F = 3.67
A = 4.29
(C)
MI = 2.64
D = 3.62
A = 3.57
MI = 2.51
D = 3.51
A = 3.39
(D)
MI = 2.84
S = 3.63
H = 3.73
MI = 2.62
S = 3.32
H = 3.68
(E)
MI = 2.93
F = 3.46
H = 4.22
MI = 2.68
F = 3.62
H = 3.29
(F)
MI = 2.33
D = 2.99
H = 3.75
MI = 2.33
D = 3.51
H = 3.00
(G)
MI = 3.11
S = 3.58
P = 4.40
MI = 3.05
S = 3.63
P = 4.35
(H)
MI = 2.67
F = 3.46
P = 3.61
MI = 2.61
F = 3.25
P = 4.00
(I)
MI = 2.14
D = 2.99
P = 3.29
MI = 2.12
D = 2.53
P = 3.24
(J)
MI = 3.83
S = 4.95
B = 4.23
MI = 3.56
S = 4.74
B = 3.89
(K)
MI = 3.73
F = 4.73
B = 4.23
MI = 3.68
F = 4.63
B = 4.14
(L)
MI = 3.11
D = 3.77
B = 4.14
MI = 2.98
D = 4.63
B = 3.25

Note. Each panel shows the paintings selected for each mixed emotional pair: (A) S×A, (B) F×A, (C) D×A, (D) S×H, (E) F×H, (F) D×H, (G) S×P, (H) F×P, (I) D×P, (J) S×B, (K) F×B, and (L) D×B. MI: minimum index, S: sadness, F: fear, D: disgust, A: amusement, H: happiness, P: pleasure, B: the feeling of beauty.

Figure 9

Distributions of the MIs for Each Content Type of the Paintings and Each Mixed Emotional Pair

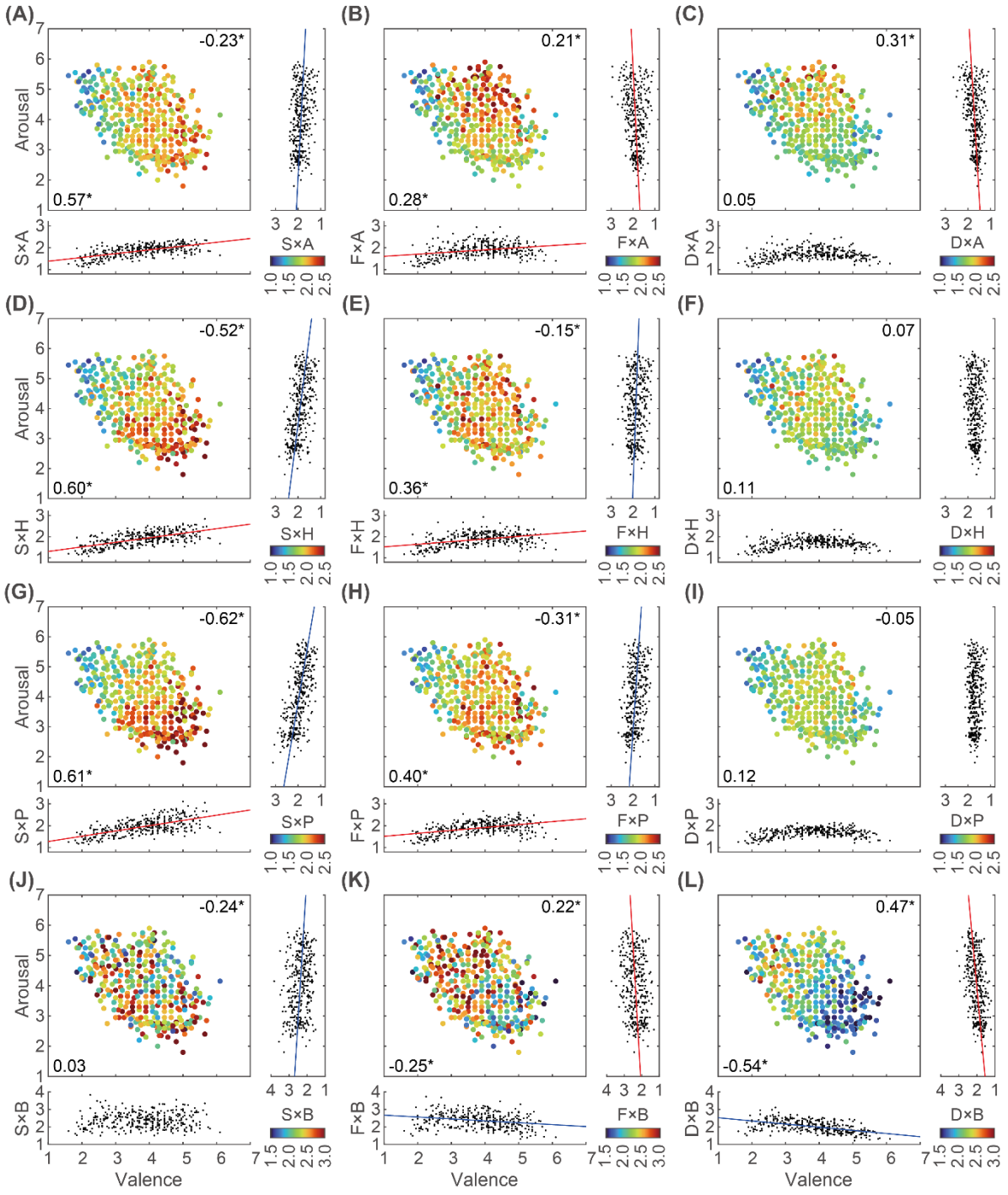


Note. Each panel shows the distributions for each mixed emotional pair: (A) S×A, (B) F×A, (C) D×A, (D) S×H, (E) F×H, (F) D×H, (G) S×P, (H) F×P, (I) D×P, (J) S×B, (K) F×B, and (L) D×B.

The boxplots represent the interquartile range, with whiskers ranging from the end to the furthest observation within 1.5 times the interquartile range away from the bottom or top of the box. The solid line in each box represents the median. The 95% bootstrap confidence interval was computed for each content type, as indicated by the gray-shaded area in each box. Black dots represent the mean of the bootstrap iterations. MI: minimum index, S: sadness, F: fear, D: disgust, A: amusement, H: happiness, P: pleasure, B: the feeling of beauty, SN: scene painting category, PR: portrait painting category, LS: landscape painting category, SL: still life painting category, TA: toward abstraction painting category.

Figure 10

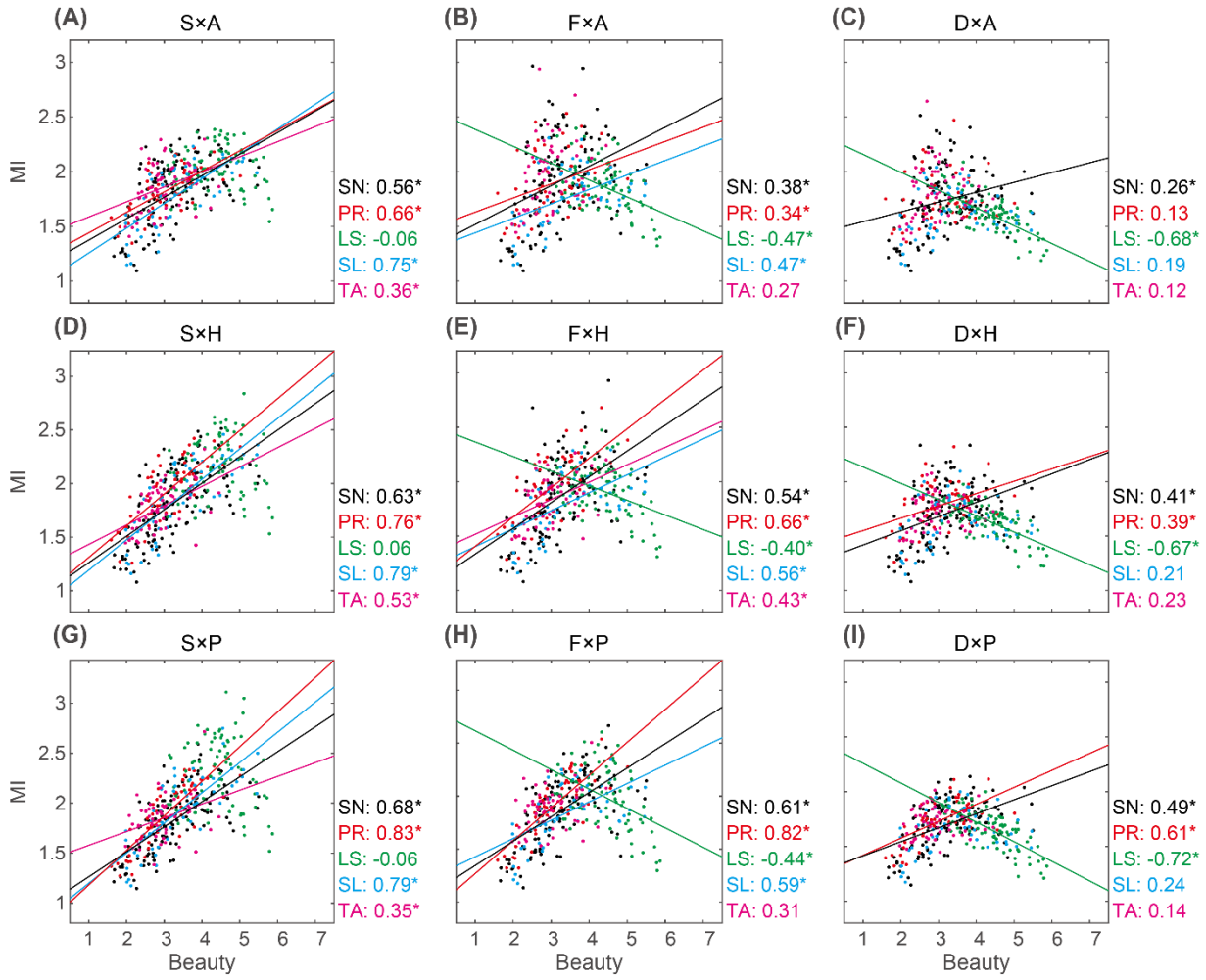
Relationships Between MIs, Emotional Valence, and Emotional Arousal Scores


(A)
-0.23*
0.57*
(B)
0.21*
0.28*
(C)
0.31*
0.05
(D)
-0.52*
0.60*
(E)
-0.15*
0.36*
(F)
0.07
0.11
(G)
-0.62*
0.61*
(H)
-0.31*
0.40*
(I)
-0.05
0.12
(J)
-0.24*
0.03
(K)
0.22*
-0.25*
(L)
0.47*
-0.54*
Arousal
S×A
F×A
D×A
S×H
F×H
D×H
S×P
F×P
D×P
S×B
F×B
D×B
Valence

Note. Each panel shows the relationships for MIs computed for each mixed emotional pair: (A) S×A, (B) F×A, (C) D×A, (D) S×H, (E) F×H, (F) D×H, (G) S×P, (H) F×P, (I) D×P, (J) S×B, (K) F×B, and (L) D×B. In the top-left plot of each panel, the X and Y coordinates of the scatterplot represent the position of paintings in the VA space (X axis for emotional valence and Y axis for emotional arousal), whose color represents the MI. The bottom plot of each panel represents the relationship between the MI (Y axis) and emotional valence (X axis), whose Spearman's coefficient (averaged across bootstrap iterations) is shown in the bottom-left corner of the top-left plot of each panel. The right plot of each panel represents the relationship between the MI (X axis) and emotional arousal (Y axis), whose Spearman's coefficient (averaged across bootstrap iterations) is shown in the top-right corner of the top-left plot of each panel. The least-squares line was added for significant correlations (red, positive, and blue, negative). An asterisk indicates a significant correlation. MI: minimum index, VA space: valence-arousal space, S: sadness, F: fear, D: disgust, A: amusement, H: happiness, P: pleasure, B: the feeling of beauty.

Figure 11

Correlations Between MIs and Aesthetic Emotional Score



Note. Each panel shows the correlations between the feeling of beauty score and MIs computed for each mixed emotional pair: (A) S×A, (B) F×A, (C) D×A, (D) S×H, (E) F×H, (F) D×H, (G) S×P, (H) F×P, and (I) D×P. The data were colored according to the painting category (SN: black, PR: red, LS: green, SL: blue, and TA: yellow). The least-squares line was added for significant correlations. The Spearman's coefficient (averaged across bootstrap iterations) is shown in the right-bottom corner of each panel. An asterisk indicates a significant correlation. MI: minimum

index, S: sadness, F: fear, D: disgust, A: amusement, H: happiness, P: pleasure; SN: scene painting category, PR: portrait painting category, LS: landscape painting category, SL: still life painting category, TA: toward abstraction painting category.

Table 1

Descriptive Statistics of Basic/Aesthetic Emotional Scores

	Mean	*SD*
Sadness	3.36	0.83
Fear	3.71	0.80
Disgust	2.98	0.84
Amusement	2.60	0.70
Happiness	2.65	0.70
Pleasure	2.76	0.69
Beauty	3.45	0.82

Note. SD: Standard deviation.

Table 2

Descriptive Statistics of Basic/Aesthetic Emotional Scores for Each Painting Category

	Scenes		Portrait		Landscape		Still life		Toward Abstraction	
	Mean	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*
Sadness	3.77	3.58, 3.95	3.47	3.26, 3.67	2.95	2.78, 3.12	3.51	3.24, 3.79	2.87	2.69, 3.06
Fear	4.39	4.17, 4.61	4.15	3.87, 4.43	2.61	2.43, 2.81	3.71	3.34, 4.07	3.45	3.21, 3.69
Disgust	3.56	3.36, 3.76	3.30	3.02, 3.58	1.96	1.86, 2.06	3.05	2.71, 3.40	2.89	2.69, 3.10
Amusement	2.40	2.24, 2.56	2.23	2.09, 2.40	3.20	3.04, 3.36	2.42	2.21, 2.64	2.68	2.49, 2.88
Happiness	2.35	2.19, 2.52	2.32	2.16, 2.49	3.54	3.36, 3.73	2.58	2.33, 2.84	2.37	2.21, 2.53
Pleasure	2.32	2.18, 2.47	2.28	2.12, 2.44	3.93	3.75, 4.12	2.73	2.45, 3.00	2.52	2.36, 2.69
Beauty	3.23	3.08, 3.37	3.07	2.87, 3.27	4.41	4.25, 4.57	3.42	3.15, 3.68	2.95	2.80, 3.10

Note. CI: 95% bootstrap confidence interval, UL: upper limit of CI, LL: lower limit of CI.

Table 3

Summary of PCA (Six-Component Model)

PC	Name	*Eig.*	*Var.*	Component coefficient					
				Sadness	Fear	Disgust	Amusement	Happiness	Pleasure
#1	Emotional valence	10.45	60.62	0.38	0.52	0.46	−0.32	−0.35	−0.38
#2	Emotional intensity	3.29	19.07	0.41	0.33	0.34	0.44	0.47	0.45
#3	Sadness vs. disgust	1.55	9.02	0.79	−0.24	−0.49	−0.25	−0.05	0.13
#4	Fear vs. disgust	0.86	4.98	−0.14	0.73	−0.66	0.14	−0.01	−0.03
#5	Amusement vs. pleasure	0.66	3.81	0.22	−0.18	−0.06	0.72	−0.09	−0.63
#6	Happiness vs. other positive emotions	0.43	2.50	< 0.01	0.02	−0.05	−0.34	0.80	−0.49

Note. PCA: principal component analysis, *Eig.*: eigenvalue, *Var.*: explained variance in %.

Table 4

Summary of PCA (Seven-Component Model)

PC	Name	*Eig.*	*Var.*	Component coefficient						
				Sadness	Fear	Disgust	Amusement	Happiness	Pleasure	Beauty
#1	Emotional valence	11.49	57.66	0.33	0.47	0.42	−0.32	−0.35	−0.39	−0.33
#2	Emotional intensity	3.78	18.96	0.48	0.39	0.34	0.31	0.35	0.35	0.41
#3	Sad beauty	1.71	8.60	0.60	−0.17	−0.49	−0.40	−0.22	−0.03	0.40
#4	Fearful beauty	1.09	5.45	−0.53	0.45	−0.03	−0.17	−0.21	−0.15	0.65
#5	Disgusting beauty	0.81	4.07	−0.06	−0.57	0.67	−0.35	−0.07	0.10	0.29
#6	Amusing beauty	0.62	3.10	0.14	−0.25	0.09	0.62	−0.19	−0.65	0.25
#7	Happiness vs. other positive emotions	0.43	2.15	< 0.01	< 0.01	−0.03	−0.33	0.79	−0.52	0.05

Note. PCA: principal component analysis, *Eig.*: eigenvalue, *Var.*: explained variance in %.

Table 5

Descriptive Statistics of PCs for Each Painting Category

	Scenes		Portrait		Landscape		Still life		Toward Abstraction	
	Mean	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*
PC3	−0.09	−0.20, 0.03	−0.08	−0.29, 0.11	0.35	0.22, 0.48	0.13	−0.01, 0.27	−0.36	−0.49, −0.24
PC4	0.09	0.02, 0.17	0.09	0.01, 0.17	−0.09	−0.16, −0.02	−0.06	−0.15, 0.04	−0.10	−0.18, −0.02
PC5	−0.04	−0.08, 0.01	−0.05	−0.11, 0.01	0.08	0.03, 0.13	0.09	0.03, 0.15	−0.06	−0.12, > −0.01

Note. PC: principal component, *CI*: 95% bootstrap confidence interval, *UL*: upper limit of *CI*, *LL*: lower limit of *CI*.

Table 6

Correlations Between PCs and VAPS Scores

	Valence		Arousal	
	rho	*CI (UL, LL)*	*rho*	*CI (UL, LL)*
PC3	0.09	−0.02, 0.21	−0.51*	−0.60, −0.42
PC4	−0.11	−0.22, < 0.01	0.40*	0.30, 0.50
PC5	0.08	−0.06, 0.21	−0.19*	−0.30, −0.07

Note. An asterisk (*) indicates a significant correlation. PC: principal component, rho: Spearman's coefficient averaged across bootstrap iterations, CI: 95% bootstrap confidence interval, UL: upper limit of CI, LL: lower limit of CI.

Table 7

Descriptive Statistics of MIs

	Mean	*SD*
S×A	1.87	0.57
S×H	1.91	0.57
S×P	1.96	0.57
F×A	1.89	0.57
F×H	1.87	0.57
F×P	1.89	0.57
D×A	1.70	0.55
D×H	1.69	0.54
D×P	1.69	0.54
S×B	2.38	0.67
F×B	2.37	0.69
D×B	2.02	0.61

Note. MI: minimum index, SD: standard deviation, S: sadness, F: fear, D: disgust, A: amusement, H: happiness, P: pleasure, B: the feeling of beauty.

Table 8

Descriptive Statistics of MIs for Each Painting Category

	Scenes		Portrait		Landscape		Still life		Toward Abstraction	
	Mean	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*	*Mean*	*CI (UL, LL)*
S×A	1.81	1.76, 1.86	1.83	1.77, 1.89	2.04	2.00, 2.08	1.80	1.72, 1.88	1.85	1.79, 1.91
S×H	1.81	1.75, 1.87	1.92	1.85, 2.00	2.16	2.10, 2.22	1.87	1.78, 1.97	1.78	1.73, 1.84
S×P	1.82	1.77, 1.88	1.90	1.81, 1.99	2.29	2.22, 2.37	1.93	1.83, 2.03	1.85	1.79, 1.91
F×A	1.91	1.84, 1.98	1.90	1.82, 1.97	1.86	1.81, 1.91	1.76	1.69, 1.84	1.97	1.89, 2.05
F×H	1.86	1.79, 1.93	1.96	1.88, 2.05	1.91	1.86, 1.96	1.80	1.72, 1.87	1.83	1.77, 1.88
F×P	1.86	1.80, 1.91	1.91	1.83, 1.99	1.99	1.93, 2.05	1.84	1.77, 1.92	1.87	1.82, 1.92
D×A	1.74	1.69, 1.79	1.75	1.69, 1.82	1.60	1.56, 1.64	1.62	1.56, 1.67	1.81	1.75, 1.87
D×H	1.71	1.66, 1.75	1.78	1.73, 1.84	1.62	1.59, 1.66	1.64	1.58, 1.70	1.72	1.68, 1.76
D×P	1.70	1.66, 1.74	1.74	1.69, 1.79	1.65	1.61, 1.69	1.65	1.60, 1.70	1.72	1.68, 1.75
S×B	2.43	2.35, 2.51	2.39	2.27, 2.51	2.54	2.43, 2.64	2.36	2.27, 2.45	2.07	2.00, 2.14
F×B	2.55	2.47, 2.63	2.45	2.35, 2.55	2.22	2.11, 2.32	2.29	2.19, 2.40	2.18	2.11, 2.25
D×B	2.21	2.15, 2.26	2.10	2.03, 2.17	1.75	1.69, 1.81	1.98	1.90, 2.06	1.94	1.88, 1.99

Note. MI: minimum index, CI: 95% bootstrap confidence interval, UL: upper limit of CI, LL: lower limit of CI, S: sadness, F: fear, D: disgust, A: amusement, H: happiness, P: pleasure, B: the feeling of beauty.

Table 9

Correlations Between MIs and VAPS Scores

	Valence		Arousal	
MIs	*rho*	*CI (UL, LL)*	*rho*	*CI (UL, LL)*
S×A	0.57*	0.48, 0.66	−0.23*	−0.34, −0.11
S×H	0.60*	0.51, 0.68	−0.52*	−0.61, −0.42
S×P	0.61*	0.51, 0.68	−0.62*	−0.69, −0.53
F×A	0.28*	0.14, 0.40	0.21*	0.08, 0.33
F×H	0.36*	0.23, 0.47	−0.15*	−0.26, −0.02
F×P	0.40*	0.27, 0.51	−0.31*	−0.41, −0.20
D×A	0.05	−0.08, 0.19	0.31*	0.18, 0.42
D×H	0.11	−0.02, 0.24	0.07	−0.05, 0.19
D×P	0.12	−0.01, 0.25	−0.05	−0.17, 0.07
S×B	0.03	−0.09, 0.16	−0.24*	−0.35, −0.12
F×B	−0.25*	−0.37, −0.12	0.22*	0.10, 0.32
D×B	−0.54*	−0.63, −0.44	0.47*	0.38, 0.55

Note. An asterisk (*) indicates a significant correlation. MI: minimum index, rho: Spearman's coefficient averaged across bootstrap iterations, CI: 95% bootstrap confidence interval, UL: upper limit of CI, LL: lower limit of CI, S: sadness, F: fear, D: disgust, A: amusement, H: happiness, P: pleasure, B: the feeling of beauty.

Table 10

Correlations Between MIs and the Feeling of Beauty Scores for Each Painting Category

	SN		PR		LS		SL		TA	
MIs	*rho*	*CI (UL, LL)*	*rho*	*CI (UL, LL)*	*rho*	*CI (UL, LL)*	*rho*	*CI (UL, LL)*	*rho*	*CI (UL, LL)*
S×A	0.56*	0.41, 0.67	0.66*	0.47, 0.79	−0.06	−0.33, 0.23	0.75*	0.60, 0.84	0.36*	0.02, 0.61
S×H	0.63*	0.51, 0.72	0.76*	0.64, 0.85	0.06	−0.24, 0.33	0.79*	0.69, 0.86	0.53*	0.16, 0.74
S×P	0.68*	0.56, 0.76	0.83*	0.71, 0.91	−0.06	−0.34, 0.21	0.79*	0.66, 0.86	0.35*	0.02, 0.64
F×A	0.38*	0.17, 0.54	0.34*	0.07, 0.59	−0.47*	−0.65, −0.24	0.47*	0.20, 0.64	0.27	−0.03, 0.53
F×H	0.54*	0.33, 0.67	0.66*	0.46, 0.79	−0.40*	−0.61, −0.15	0.56*	0.36, 0.70	0.43*	0.09, 0.68
F×P	0.61*	0.42, 0.73	0.82*	0.68, 0.89	−0.44*	−0.63, −0.21	0.59*	0.36, 0.73	0.31	−0.03, 0.61
D×A	0.26*	0.05, 0.44	0.13	−0.18, 0.39	−0.68*	−0.80, −0.52	0.19	−0.14, 0.45	0.12	−0.15, 0.39
D×H	0.41*	0.21, 0.56	0.39*	0.10, 0.62	−0.67*	−0.78, −0.52	0.21	−0.09, 0.46	0.23	−0.09, 0.49
D×P	0.49*	0.28, 0.63	0.61*	0.33, 0.78	−0.72*	−0.82, −0.58	0.24	−0.10, 0.51	0.14	−0.14, 0.44

Note. An asterisk (*) indicates a significant correlation. MI: minimum index, rho: Spearman's coefficient averaged across bootstrap iterations, CI: 95% bootstrap confidence interval, UL: upper limit of CI, LL: lower limit of CI, S: sadness, F: fear, D: disgust, A:

amusement, H: happiness, P: pleasure, SN: scene painting category, PR: portrait painting category, LS: landscape painting category, SL: still life painting category, TA: toward abstraction painting category.