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Self-reference and emotional reaction drive aesthetic judgment

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Traditional philosophical inquiry, and more recently neuroscientific studies, have investigated the sources of artworks' aesthetic appeal. A substantial effort has been made to isolate the objective features contributing to aesthetic appreciation. While variables such as contrast or symmetry have been shown to robustly impact aesthetic judgment, they only account for a small portion of the intersubjective variability in aesthetic ratings. Recent multiprocess model of aesthetic appreciation could accommodate this finding by proposing that evaluative processes based on self-reference underpin the idiosyncrasy of aesthetic judgment. We tested this hypothesis in two behavioral studies, that were basically conceptual replications of our previous work, in which we took advantage of the self-reference effect on memory. We also tried to disentangle the role of self-reference and emotional reaction to artworks in guiding aesthetic judgments, by comparing an aesthetic judgment encoding condition to a self-reference condition (Study 1), and an emotional evaluation condition (Study 2). We show that artworks encoded in an aesthetic judgment condition exhibit a similar mnesic advantage compared to both the self-reference and the emotional evaluation encoding conditions. Moreover, retrospective emotional judgment correlates with both self-reference and aesthetic judgments ratings. These results suggest that a basic mechanism, appraisal of self-relevance, could ground aesthetic judgments.

To which extent aesthetic appreciation is linked to the object of contemplation or the subject contemplating it has been a long-lasting philosophical debate[1–4]. In recent years, with the emergence of neuroaesthetics, this philosophical debate has been the focus of scientific interest. Experimental studies show that aesthetic evaluations result from the combination of shared and private taste, and that the latter, corresponding to interindividual variations, is particularly relevant, above all when judging artworks[5,6]. These results suggest that aesthetic judgment has a strong subjective component.

Recent multiprocess accounts of aesthetic judgment propose that perceptual, motor, emotional, motivational, and evaluative processes are responsible for aesthetic appreciation[1,2,7,8]. In particular, the last stages of the model proposed by Leder et colleagues[1] and Leder and Nadal[2], namely cognitive mastering and evaluation, can account for the subjective component of aesthetic judgment. Crucially, the authors suggest that self-related information could be a gateway in understanding and evaluating an artwork. Anecdotally, they state that a "[…] perceiver might be satisfied with the recognition of the train station in Monet's La Gare St Lazare, because 'he likes trains because they remind him of a journey'" (p. 499)[1]. Thus, they explicitly link aesthetic judgment with self-referential processing associated with autobiographical information.

A link between self-referential processes and aesthetic judgment is also suggested by neuroimaging findings. Indeed, several studies have shown that regions of the default mode network (DMN) that are known to be linked to self-referential processing and autobiographical memory[9] are also activated during aesthetic judgment[10–14]. In particular, the medial prefrontal cortex (mPFC) is of utmost relevance. Indeed, some neuroimaging studies suggest that this region is particularly recruited by artworks triggering intense aesthetic reactions. For example, Vessel and colleagues[12] asked participants to rate how strongly paintings move them while recording their brain activity with functional magnetic resonance imaging (fMRI). They identified two brain networks showing different patterns of activity. The activity in the first network, composed by sensory regions, increased linearly

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with participants' rating. The second network, mainly encompassing the regions of the DMN, showed increased activity only for the most moving stimuli. This was particularly true for the mPFC. In another study, the mPFC showed a nonlinear pattern of activity when participants were asked to judge their appreciation of human faces and body stimuli[15]. Indeed, this region showed increased activation for both ugly and beautiful stimuli, compared to neutral ones. These results suggest that moving aesthetic stimuli, whatever their valence, recruit brain regions underpinning self-representation. Despite these interesting findings, complementary behavioral evidence is necessary to support the link between self-referential processes and aesthetic experience. In this vein, recently, Vessel and colleagues[16] have shown, in a series of studies, that the degree of self-reference (e.g., "the extent to which something relates to you, your experiences, or your identity" p.1009)[16] of artworks robustly predicted aesthetic appeal (i.e., being moved) of the same artworks. Moreover, synthetically participant-tailored artworks based on self-reference were rated as more aesthetically appealing than control paintings. These findings strongly support the idea that self-referential processing guides aesthetic judgments.

Nevertheless, these results are only based on subjective reports. It could be interesting to supplement this hypothesis with more reliable objective measures. Nadal and colleagues[17] have proposed that a good candidate objective measure of aesthetic judgment could be the strength of memory traces. Accordingly, studies reported a bidirectional link between memory and aesthetic judgments. Indeed, on the one hand, items that are recognized as old in a memory test, are also judged as more beautiful[17]. On the other hand, aesthetic judgment during incidental memory encoding leads to increased memory retention[18,19]. Some authors proposed that this effect could be due to increased self-related processing prompted by aesthetic judgment[18]. Indeed, it is well known that items requiring a self-related processing gain a robust mnemonic advantage, in comparison to other types of treatment (e.g., semantic processing), an effect known as self-reference effect (SRE) in memory[20–24]. Recently, we directly compared the mnemonic advantage produced by aesthetic judgment and self-reference in order to investigate this hypothesis[3]. We asked participants to incidentally encode artworks in three conditions: an aesthetic judgment condition (rate the extent to which they find a painting beautiful), a self-referential judgment condition (rate to what extent a painting is linked to personal memories), and a control condition (judgment of symmetry). We reported a classical SRE according to which paintings encoded in the self-referential condition had a higher probability of being correctly recognized, compared to the other two conditions. Nevertheless, items encoded in the aesthetic judgment condition did not show a mnemonic advantage compared to the control condition. These findings seem in line with Kasdan and Belfi (2020)'s study in which the authors did not report a mnemonic advantage for music excerpts encoded in an aesthetic judgment condition (e.g., judgment of liking), compared to two control conditions[25]. Notwithstanding, in our study[3], those items that received extreme judgments on the beauty scale during encoding were as well recognized as those encoded in the self-reference condition. We proposed, in line with other findings[18,19,26], that the absolute intensity of the aesthetic experience determines the subsequent memory enhancement. Our results contribute to strengthen the proposal that an aesthetic judgment, at least when it produces strong aesthetic reaction, is linked to the recruitment of self-referential processing. This interpretation is also compatible with the aforementioned neuroimaging studies[12,15].

Nevertheless, alternative explanations linked to emotional reaction to aesthetic stimuli cannot be ruled out in both our[3], and Vessel and colleagues[16] studies. Emotional evaluation is central to aesthetic judgment[7], and comes into play at every processing level during [1,2]. In particular, one alternative explanation for our previous results could be that the reported effect is not due to aesthetic judgment per se, but would be linked to the emotional reaction associated with highly esthetically moving stimuli. Indeed, emotion is also known to boost memory encoding[27–31]. The same criticism can be applied to the aforementioned study by Vessel and colleagues[16]. On one hand, this study operationalized (in two out of three studies) aesthetic appeal with ratings of "being moved". Asking participants how much they feel personally touched likely assesses the emotional component of the aesthetic experience. Indeed, "being moved" is considered by some authors as an emotion *per se*[32]. Thus, this data could be reinterpreted as showing a link between self-relevance and emotional reaction, and not between the former and aesthetic judgment. Moreover, even if we take these results as evidence of the link between aesthetic judgment and self-relevance, this latter is known to entertain a tight relationship with emotional reaction. Indeed, self-relevance is known to modulate emotional reaction at both subjective[33] and neural levels[34–36]. On the other hand, rating of one's emotional response to stimuli has been commonly used to study the neural underpinning of self-referential processing[37]. Thus, it is possible that self-relevance stimuli are associated with higher aesthetic appeal since they trigger stronger emotional reactions.

The aim of the present work is to try to disentangle the role of self-reference and emotional appraisal in the mnemonic advantage produced by aesthetic judgment, and thus to shed light on the link between aesthetic judgment, self-representation and emotional processes. With this goal, we conducted two studies, which were basically conceptual replications of our previous work[3]. In both studies, we combined both subjective rating and objective measures (memory strength) of the variables of interest. In the first study, participants were asked to rate, in an incidental encoding phase, paintings in three conditions: aesthetic judgment (beauty), self-referential judgment (memory) and a control condition (color judgment). Moreover, they had to retrospectively judge their emotional reaction (valence and intensity) for all the artwork presented during the encoding phase. The aim of this study was threefold: (i) we wanted to replicate the results of our previous work; (ii) we wanted to assess to what extent emotional reaction correlated with both aesthetic and self-referential rating; (iii) we wanted to test if retrospective emotional rating predicts memory performance similarly to aesthetic judgment. Indeed, if emotional appraisal is automatically triggered during encoding in the aesthetic judgment condition, it should predict subsequent memory in the same manner. In the second study, we directly compared aesthetic judgment (beauty) with emotional judgment (emotion) encoding conditions. Again, we reasoned that if the link between aesthetic judgment and memory performance was due to participants' emotional reaction, we should observe a similar pattern of results linking emotional judgment (retrospective in the first study and on-line in the second study) and subsequent memory.

Results

Study 1

Data analysis

The initial two sets of analyses use mixed logistic models to examine item and source recognition (a binary variable: correct or incorrect response) as influenced by the encoding condition (three levels: beauty, self-reference, and color), with participants and items as random factors. Marginal means-based contrasts were then estimated to explore the pairwise differences between the levels. In the next phase, we included the rating during encoding in each condition (a continuous variable ranging from 0 to 10) as a predictor, allowing us to investigate potential nonlinearity using second-order polynomials. Finally, we additionally predicted the probability of item and source recognition by the retrospective emotional valence and intensity ratings (continuous variables ranging from 0 to 10) for each encoding condition, following the same rationale. Only the findings regarding item recognition are presented here. Detailed analyses of item and source recognition are available in the Supplementary Materials.

Data analysis was conducted with R (https://www.r-project.org/) using the easystats suite[38,39]. Bayesian statistics were conducted using Markov chain Monte Carlo sampling with the rstanarm package[40] (http://mc-stan.org/). We used the probability of direction (pd), a Bayesian equivalent of the p value[41], as an index of effects existence (a pd > 97% was used as a threshold for "significant" effects). For brevity, only the relevant effects will be described in the text. The full reproducible analysis script is available in the Supplementary Materials.

Effect of condition on memory

The mixed logistic model accounting for the item recognition had a total explanatory power (Bayes $R2$) of 29%, with 17% (marginal $R2$) being related to the condition effect. The model shows significant higher item recognition probability in the self-reference condition compared to the beauty condition (difference = −0.62, 95% Confidence Interval [CI] [−0.89, −0.35], $pd = 100\%$) and color condition (difference = −2.32, 95% CI [−2.58, −2.06], $pd = 100\%$). The item recognition probability was also higher in the beauty condition than in the color condition (difference = 1.70, 95% CI [1.46, 1.93], $pd = 100\%$). See Fig. 1A.

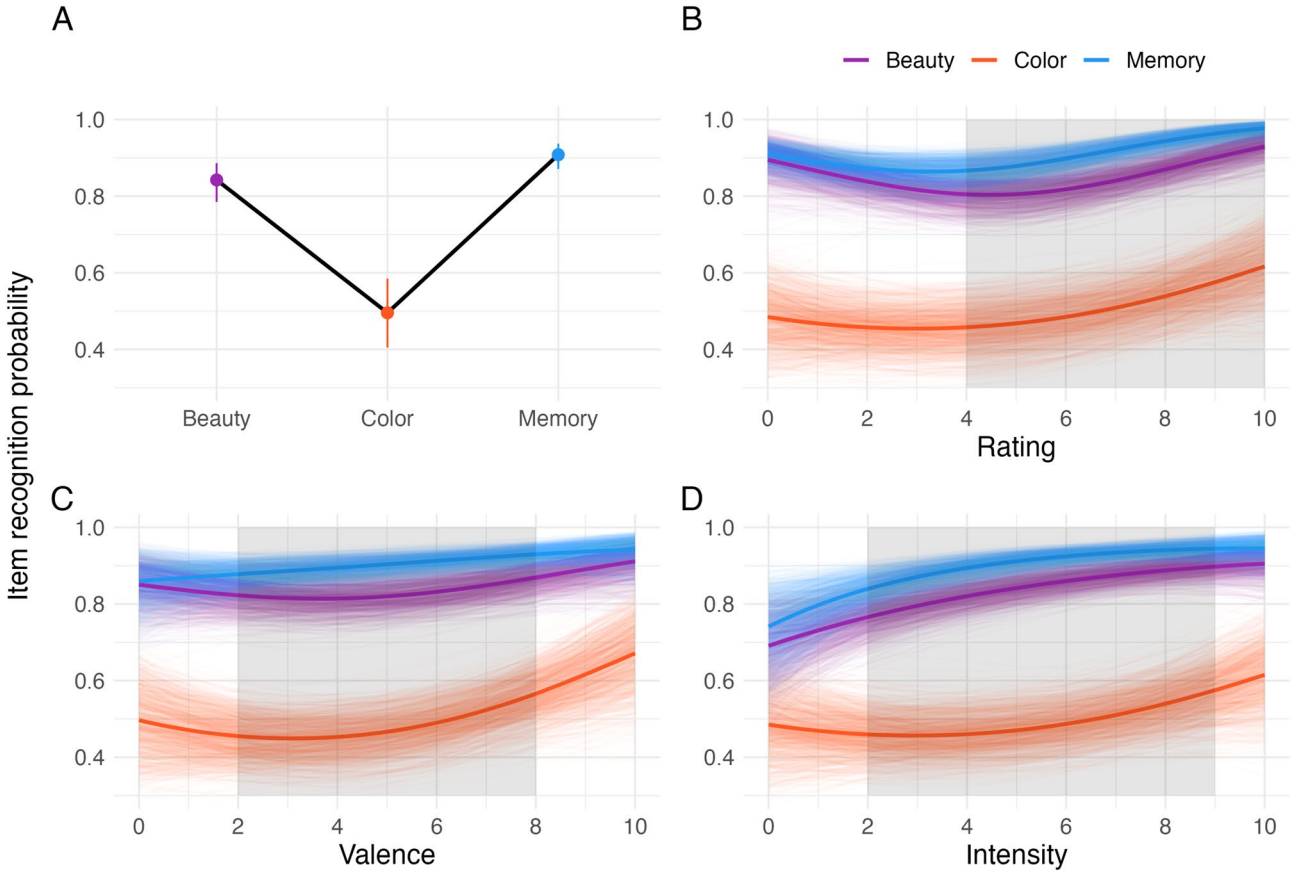

Figure 1. The estimated probability of item recognition averaged by conditions (**A**), and its modulation by rating during encoding (**B**), retrospective valence rating (**C**) and retrospective intensity rating (**D**). The error bars represent the 95% credible intervals (CI). Thin lines represent individual posterior draws (i.e., the possible effects), and the thick line shows the median effect. Gray areas represent significant contrasts between the beauty and memory conditions.

Effect of rating in the encoding phase on memory
The mixed logistic model accounting for the item recognition had a total explanatory power of 30%, with 18% being related to the condition and the rating in the encoding phase. Within the model, ratings in the self-reference condition had a significant quadratic (median = 19.66, 95% CI [7.31, 32.27], *pd* = 99.98%) relationship with item recognition probability. Contrasts analyses evidenced that paintings that received extreme ratings were better recognized than paintings receiving intermediate ratings, but also that items receiving higher extreme ratings were better recognized than items receiving lower extreme ratings. Rating of beauty also followed a quadratic relationship (median = 17.37, 95% CI [4.24, 31.22], *pd* = 99.48%) with item recognition probability. Contrasts analyses evidenced that paintings that received extreme ratings were better recognized than paintings receiving intermediate ratings. Moreover, significant differences between item recognition probability between aesthetic judgment and self-reference, in favor of the latter, were observed only in the 4 to 10 range (see Supplementary Materials for complete contrasts statistics). There was no evidence of a relationship of any kind between the rating of color and item recognition probability. See Fig. 1B.

Effect of retrospective emotional valence rating on memory
The mixed logistic model accounting for item recognition had a total explanatory power of 29%, with 19% being related to the condition and the retrospective valence rating. Within the model, the retrospective valence rating had a significant linear relationship with the item recognition probability in the self-reference condition (median = 13.42, 95% CI [1.60, 26.11], *pd* = 98.42%). Items presented in the self-reference condition and retrospectively receiving a more positive rating have higher probability to be correctly recognised. The same pattern was found for the color condition (median = 10.06, 95% CI [0.94, 18.88], *pd* = 98.42%). Conversely, valence did not have any significant relationship with the item recognition probability in the beauty condition. See Fig. 1C.

Effect of retrospective emotional intensity rating on memory
The mixed logistic model accounting for item recognition had a total explanatory power of 30%, with 19% being related to the condition and the retrospective intensity rating. Within the model, the retrospective intensity rating had a significant linear relationship with the item recognition probability in the beauty (median = 19.58, 95% CI [9.80, 29.53], *pd* = 100%) and self-reference conditions (median = 24.41, 95% CI [12.11, 37.08], *pd* = 100%). The more the paintings were retrospectively rated as emotionally arousing the higher the probability of being recognized when presented in the aesthetic or the self-reference judgment condition. Intensity rating did not have any relationship with the item recognition probability in the color condition. See Fig. 1D.

Relationship between retrospective valence rating and rating in the encoding phase
The mixed linear model accounting for rating in the encoding phase had a total explanatory power of 21%, with 10% being related to the condition and the retrospective valence rating. Within the model, the retrospective valence rating had a significant linear relationship with the rating in the self-reference (median = 0.35, 95% CI [0.28, 0.43], *pd* = 100%) and beauty condition (median = 0.35, 95% CI [0.27, 0.43], *pd* = 100%), meaning that paintings that were rated more relevant to the participant or judged as more beautiful in the encoding phase were also those that were rated as having a more positive valence (see Fig. 2A). In contrast, the retrospective valence rating did not predict color rating (median = −0.05, 95% CI [−0.13, 0.02], *pd* = 91.40%).

Relationship between retrospective intensity rating and rating in the encoding phase
The mixed linear model accounting for rating in the encoding phase had a total explanatory power of 17%, with 5% being related to the condition and the retrospective intensity rating. Within the model, the retrospective intensity rating had a significant linear relationship with the rating in the self-reference (median = 0.11, 95% CI [0.03, 0.19], *pd* = 99.83%) and beauty condition (median = 0.22, 95% CI [0.15, 0.29], *pd* = 100%). Paintings that were rated more relevant by the participant or judged as more beautiful in the encoding phase were those that elicited more intense emotions (see Fig. 2B). In contrast, the retrospective intensity rating did not predict the color rating condition (median = 0.02, 95% CI [−0.06, 0.09], *pd* = 68.03%).

Study 2

Data analysis
As in Study 1, the first two sets of analyses model the item and source recognition as a function of the encoding condition (three levels: beauty, emotional reaction, and color) using mixed logistic models with the same parameters. We also estimated marginal means-based contrasts between levels. In the second set of analyses, we additionally modeled the effect of the rating during encoding in each condition, for item and source recognition as in Study 1. Data processing was carried out using the same procedure as in Study 1. The full reproducible analysis script is available in Supplementary Materials.

Effect of condition on memory
The mixed logistic model predicting the item recognition had a total explanatory power of 24%, from which 12% was related to the effect of the condition alone. The model shows a significantly higher item recognition probability in the emotion condition than in the beauty (difference = 0.46, 95% CI [0.25, 0.67], *pd* = 100%) and color conditions (difference = −1.84, 95% CI [−2.05, −1.64], *pd* = 100%). The item recognition probability was also significantly higher in the beauty condition than in the color condition (difference = −1.39, 95% CI [−1.57, −1.20], *pd* = 100%). See Fig. 3A.

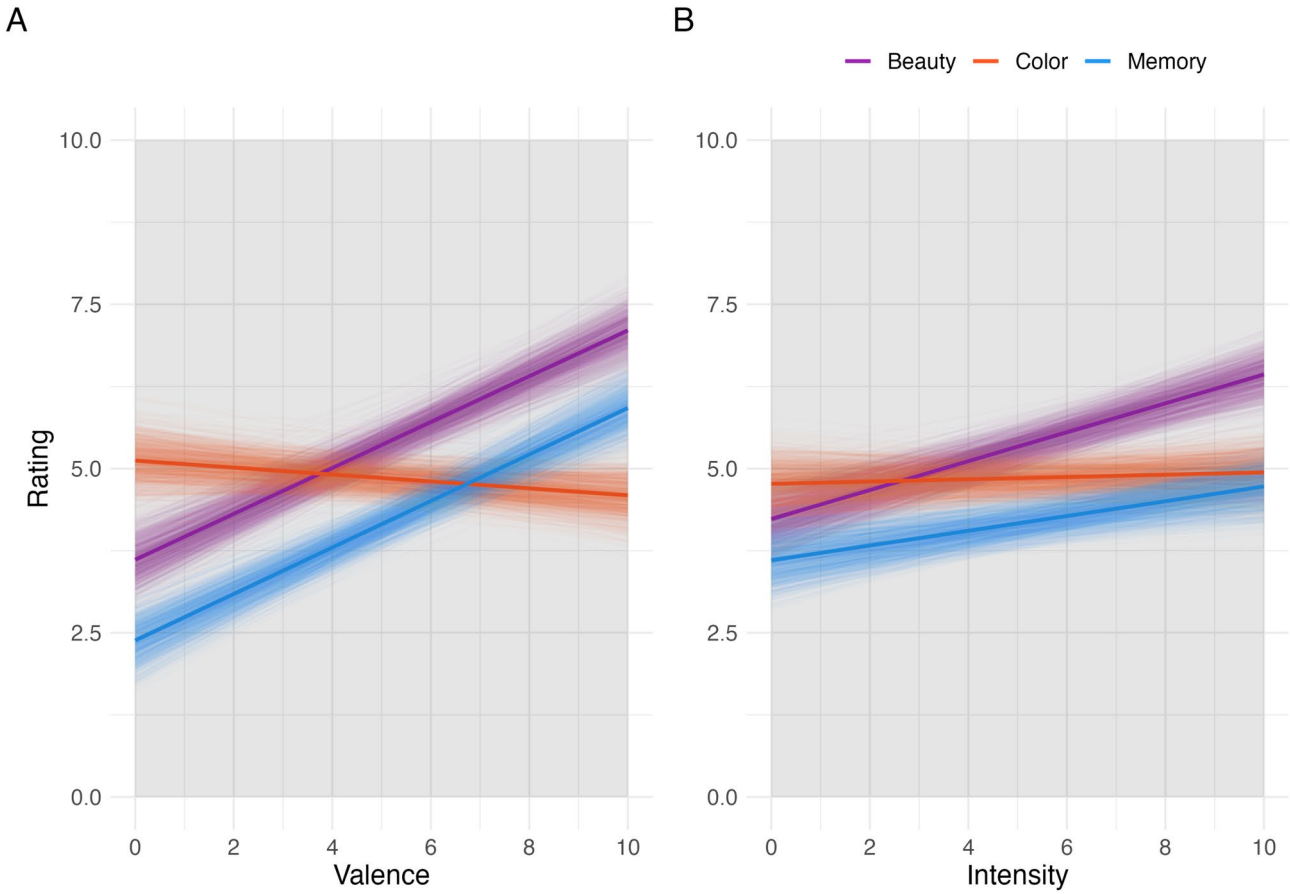

Figure 2. Prediction of rating, in each experimental condition, during encoding by retrospective valence (**A**) and intensity (**B**) ratings. Thin lines represent individual posterior draws (i.e., the possible effects), and the thick line shows the median effect. Gray areas represent significant contrasts between the beauty and memory conditions.

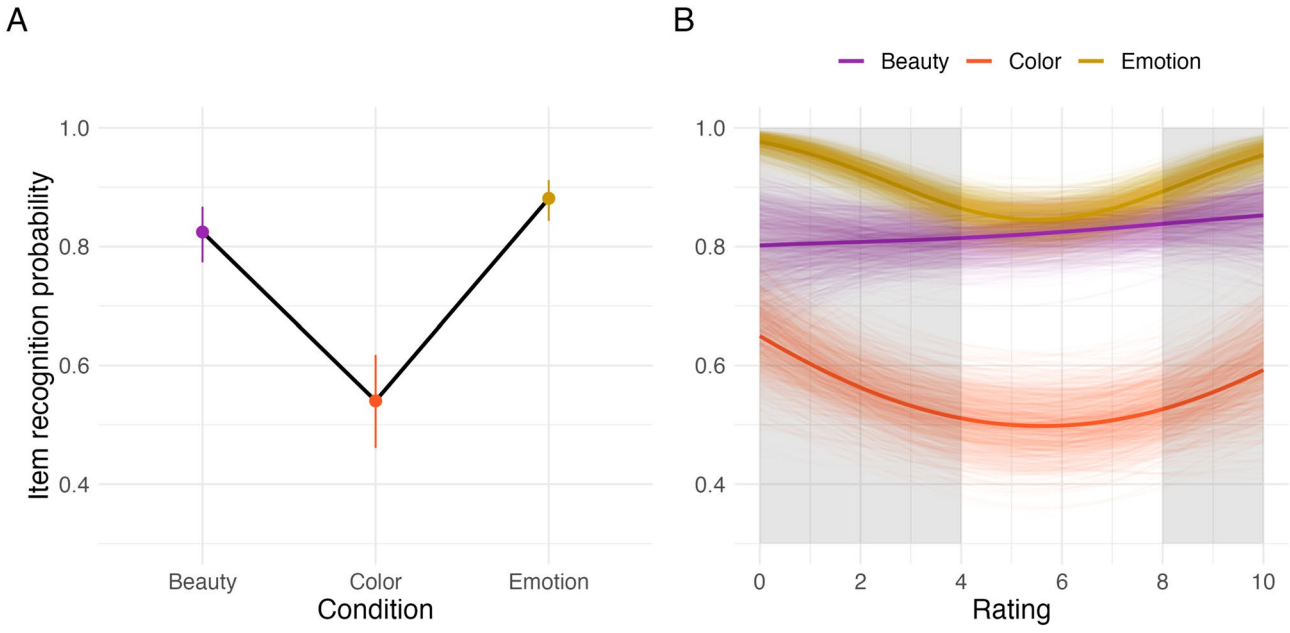

Figure 3. The estimated probability of item recognition averaged by conditions (**A**), and its modulation by rating (**B**). The error bars represent the 95% credible intervals (CI). Thin lines represent individual posterior draws (i.e., the possible effects), and the thick line shows the median effect. Gray areas represent significant contrasts between the beauty and memory conditions.

Effect of rating in the encoding phase on memory

The mixed logistic model predicting the item recognition had a total explanatory power of 25%, with 13% being related to the condition and the rating. Within the model, the rating of emotion had a significant quadratic relationship with the probability of item recognition (median = 32.39, 95% CI [17.84, 48.52], *pd* = 100%). Contrast analyses showed that items that received extreme emotional ratings had a higher probability of being remembered. The same pattern was observed for the rating of color (median = 9.33, 95% CI [1.41, 17.57], *pd* = 99.12%). Contrast analyses showed that items that received extreme color rating ratings (in particular lower ratings) had a higher probability of being remembered. See Supplementary Material for complete statistics of contrast analyses. No significant relationship was found between the rating of beauty and the probability of item recognition. See Fig. 3B.

Discussion

The main goal of the two present studies was to test to which extent the mnemonic advantage for items in aesthetic judgment, reported in our previous study[3], was due to self-reference or a byproduct of emotional reaction to paintings. In the two studies, we employed both subjective ratings and objective measures (the strength of the memory trace), and we reported results that suggest a complex relationship between self-reference, emotional engagement and aesthetic judgment. In both studies, we reported a mnemonic advantage for paintings presented in the aesthetic judgment condition, compared to the control condition (color judgment). Nevertheless, this mnemonic advantage was lower than those produced by both self-reference (Study 1), and emotional appraisal (Study 2). We also reported that beauty rating during encoding presented a U-shaped relationship with item recognition probability in Study 1. This result basically replicated our previous findings[3]. Nevertheless, we were unable to replicate this result in Study 2. We also found that retrospective rating of emotional intensity predicted positively and linearly the item recognition probability in both self-reference and aesthetic judgment conditions (Study 1), and that emotional rating during encoding predicted in a U-shaped fashion the item recognition probability (Study 2). Retrospective rating of emotional valence only predicted item recognition probability in the self-reference condition. Finally, retrospective subjective rating of emotional valence and intensity both positively predicted self-reference and aesthetic judgment (Study 1).

We showed a robust mnemonic advantage of items encoded in the aesthetic judgment condition, compared to our control condition (color judgment). This is generally in line with several studies showing a positive association between aesthetic evaluation and memory [3,17–19,26]. Nevertheless, these results also seem to partially contradict those of our previous study[3], since we reported a mnemonic advantage only for items receiving extreme rating. This discrepancy can be explained by two opposing effects. On the one hand, compared to our previous study[3], we changed our control condition. This led to a decrease of about 15% in the hit rate for the control condition in the present studies, compared to the control condition in the precedent study. This is probably due to the fact that our previous control condition (judgment of symmetry), implicitly prompted aesthetic appreciation, and thus boosted memory performances. On the other hand, we observed an increase of about 9% in the hit rate in the aesthetic judgment condition, compared to our previous study. The reasons for this difference are not clear, but one possible explanation could be the wider sample size in the present two studies.

According to our previous work[3], this mnemonic advantage was modulated by subjective rating in a U-shaped curve in Study 1. In particular, paintings receiving extreme ratings were better recognized than paintings receiving intermediate ratings. Nevertheless, contrary to our previous study[3], the mnemonic advantage similar to that of self-reference was only found for paintings in the low window of rating (rating between 0 and 4). This is probably due to the fact that self-reference rating also showed a quadratic relationship with item recognition probability, whereas this was not the case in our previous study[3]. In particular, this relationship was characterized by a steeper increase in recognition probability for high ratings, thus maintaining a memory difference between the two conditions. Nevertheless, the quadratic relationship between item recognition probability and aesthetic judgment was not replicated in Study 2. In this second study, we did not report any relationship (linear or quadratic) between aesthetic judgment and item memory. It has to be noted, however, that in both studies aesthetic rating predicted the source recognition probability, following a U-shaped curve (see Supplementary Materials). Taken together, these results suggest that aesthetic judgment is sufficient to produce a mnemonic advantage, that this effect could be modulated by the level of aesthetic appreciation, and that in some cases this could lead to a mnemonic advantage similar to self-reference.

The mnemonic advantage produced by aesthetic judgment was nevertheless generally smaller than those produced by self-reference and emotional judgment. Indeed, self-reference produced a strong mnemonic advantage that was descriptively very similar to that reported in our previous study. This is generally coherent with the self-reference effect (SRE) in memory[24]. Moreover, emotional rating in the second study produced a strong mnemonic advantage. Again, this is coherent with a great amount of literature showing an interaction between emotion and memory (for a review [42]). However, it is important to note that most of the previous studies on the link between emotion and memory either manipulated the emotional content of the to-be-encoded material[42], or investigated how the magnitude of emotional reaction to the same material influences memory encoding[28,43,44]. For example, one study showed that factual memory for the same movie correlated with participants' emotional reaction to the movie. In the same vein, two studies have reported that the interindividual variability in the activity of the amygdala while watching arousing films correlated with subsequent recall[43,44]. Here we reported that, more generally, a task demanding emotional introspection is sufficient for producing a memory boost, even if this effect could be stronger for items associated with strong, either negative or positive, emotional reactions. This is also coherent with results of Study 1, showing that retrospective ratings of emotional intensity linearly predicted recognition probability in the self-reference and aesthetic judgment conditions, but not in the control condition. These results suggest that emotional appraisal can be implicitly triggered during both self-reference

and aesthetic judgment. Indeed, retrospective rating of both emotional valence and intensity predicted rating of self-reference and aesthetic appreciation: the more a painting evoked more positive and more intense emotions, the more it was rated as triggering personal memories and aesthetically appealing. Obviously, due to the retrospective nature of emotional rating in Study 1, these results could not be interpreted as a causal relationship.

Taken together these results suggest that these three modes: aesthetic judgment, self-reference, and emotional appraisal are tightly intertwined. This is generally coherent with evidence produced in different research domains showing a link between self-relevance and emotion[45], emotion and aesthetic judgment[46,47], and self-relevance and aesthetic judgment[16]. They seem to suggest that in the context of art appreciation, self-relevance and emotional appraisal contribute to aesthetic judgment. In particular, when an item is associated with high self-reference it is also appraised as strongly emotionally charged, and this contributes to the final aesthetic judgment. But what is there in common between these different "modes"? Schmitz and Johnson[48] made the proposal of two distinct networks underlying appraisal of self-relevance, such as one biases attention toward salient or explicit self-relevant signals, whereas the other engages introspection toward evaluation. Such networks comprise the dorsal–ventral MPFC, the dorsolateral anterior cingulate cortex (ACC) and the posterior cingulate cortex (PCC)[48]. Among these structures, the vMPFC contributes heavily to emotional processes, and has been attributed the role of assigning personal value or significance to stimuli[49]. And as mentioned in the introduction, this brain area plays a pivotal role in aesthetic judgment. The proposal of Schmitz and Johnson [48] is of a dissociation between the ventral network, that underpins emotional evaluation of self-relevant phenomena, and the dorsal network that would allow a meta-cognitive stance requiring reflection on one's internal states. We argue that self-reference and emotion would be linked to the activation of both systems, while aesthetic judgment would only engage the second.

Some EEG studies also advocate for such a dissociation. Emotional processing is associated with early brain responses, self-reference can modulate later components associated with emotional processing, and both would be predicted by early brain patterns activity reflecting automatic processing[50–52]. But aesthetic judgment would involve late lateralized components[53–55]. Similar EEG phenomena accounting for self-reference processing are reported even when there are no explicit instructions[56], but not in the case of aesthetic appreciation[53]. While emotional appraisal and self-reference mechanisms seem to operate automatically, aesthetic judgment would involve intentionality, that would be reflected through an early fronto-central negativity[53]. The mnemonic advantage of emotion and self-reference could be regarded as a consequence of automatic processing, notably since high-level processes such as decision making can be inferred from those early fast and automatic processing[51]. This would be consistent with the proposal of Schmitz and Johnson[48], in which higher-level self-relevant processing would rely on controlled internal mechanisms of introspection. Future studies should investigate the temporal dynamic of the integration of these different sources of information, and how they contribute to the final aesthetic judgment.

To conclude, we propose that appraisal of self-relevance is a basic mechanism grounding aesthetic judgment. This will be underpinned by a brain networks, comprising medial structures, that are known to ground both self-reference and emotional appraisal. Future studies, employing neuroimaging techniques, in particular those allowing a fine-grained temporal analysis like EEG, are granted to inform on the interaction and temporal integration of this different self-relevance layers.

Material and methods

The material and the experimental procedure is similar to that described in Lee et al. (2023)[3].

Study 1. Participants

Forty-Five participants (37 women; age M = 20.89 years, SD = 3.47 years) were recruited for this study. The participants were undergraduate students in psychology at the University Paris Cité. They all had a normal or corrected to normal vision. No participant showed art expertise, based on the Aesthetic Fluency Scale[57,58] (M = 8.83, SD = 4.79 out of 40, min 0, max 21). All participants were informed of the academic nature of the study and accepted that their responses would be processed anonymously. After the nature of the procedure had been fully explained, all participants gave written informed consent before carrying out the study. The protocol was carried out following the local ethical standards.

Material

One hundred pieces of visual art were selected from the WikiArt database, across nine different artistic styles representing some of the most important styles between the sixteenth and twentieth century: Nordic renaissance, baroque, rococo, romanticism, realism, symbolism, expressionism, impressionism, and postimpressionism. We only selected color and representational paintings with a landscape width–height ratio. We excluded painting including easily recognizable elements (e.g., artist's signature, writings). Pictures were the same as those used in our recent study[3], and a complete list of the paintings is presented in Supplementary Materials. Among the selected 100 pieces, 60 were used as target stimuli during the encoding phase. The remaining 40 were used as lures in the recognition phase, and were visually paired with some of the target stimuli in terms of content (people, animals, landscape, style, etc.) and color schemes, in order to make sure they were not dissimilar. The two groups of stimuli (target and lures) did not show any significant differences concerning their physical features: lightness (targets M = 93.28, SD = 40.53; lures M = 101.5, SD = 40.79; t[98] = − 1.00, p = 0.321); contrast (targets M = 50.60, SD = 11.11; lures M = 48.8, SD = 9.90; t[98] = 0.82, p = 0.415).

Encoding phase

There were three within-subject experimental conditions (encoding conditions): an aesthetic judgment condition (beauty), a self-referential judgment condition (memory), and a color judgment condition (color). In the beauty condition, the participants were asked to judge their appreciation of the stimuli ("Judge how beautiful

the image is for you") using a 11-point Likert scale (0 = not at all, 10 = a lot). In the memory condition, the participants were asked to judge to what degree the stimuli reminded them of personal memories ("Judge how much the image reminds you of a personal memory") using a 11-point Likert scale (0 = no memories, 10 = a very vivid memory). In the color condition, the participants were asked to judge how much blue the paintings contained compared to red ("Judge how much more present blue is than red in the painting") using a 11-point Likert scale (0 = blue, 10 = red). Participants were not informed that a recognition task would follow (incidental encoding). Before the beginning of the encoding phase, a painting not employed in the experimental task (i.e., Viktor Vanetsov's "The Bard Bayan," which is about a Slavic mythological scene) has been used to instruct participants. The memory condition was explained to the participants with the example painting in the following way: "Although it is improbable that you have experienced the event represented in this painting, it is possible that the painting reminds you of personal memories such as a friendly hillside picnic, a museum visit where you may have seen similar paintings, a scene of a movie, or even a visual representation of a story that you have read." For the color condition, we simply asked participants to judge the blue/red ratio in the same painting and to justify their answer to assure that they correctly understood what we meant for color.

Each condition contained 20 images presented in a block in a random order. The distribution of the 60 target stimuli across the encoding conditions was counterbalanced between participants, so that each item was presented in each experimental condition. The order of blocks was randomized across participants. In each block, a trial started with a fixation cross for 500 ms that was followed by the presentation of a stimulus for 3 s. Once the stimulus presentation ended, the rating scale appeared on the screen, and the participant had to enter their rating score according to the experimental condition. There was no time limit for the evaluation. Once the participants responded, the next trial started. The end of the block was signaled by the presentation of the written instructions for the next block.

Recognition phase

During the recognition phase, all target stimuli were presented intermixed with 40 lures in a random order (100 stimuli in total). After the presentation of the fixation cross (500 ms), each stimulus was presented for 3 s. Once the stimulus presentation was over, participants had to indicate if they had seen the picture before. They could choose between three different responses appearing on the screen: "Yes," "Maybe," and "No." If the answer was either "Yes" or "Maybe," for both targets and lures, participants were asked to respond to a source memory question, indicating in which encoding condition they had seen the image (beauty, memory, or color condition). There was no time limit to answer. Once the recognition response was entered, the fixation cross appeared, followed by the next trial.

Retrospective emotional rating

In the emotional rating phase, all 60 targets were presented again in a random order. They were preceded by a fixation cross (500 ms), were displayed for 3 s, and right after their presentation, participants had to rate their emotional reaction to the painting according to two criteria: valence and intensity. Each criterion was assessed consecutively but separately, using each time a 11-points Likert scale (valence: 0 = negative, 10 = positive; intensity: 0 = very weak, 10 = very intense) that was displayed on the screen. There was no time limit for the emotional rating. The next trial started once participants responded to both criteria.

Procedure

The experiment was conducted at the MC2Lab, located at the Institute of Psychology of the Université Paris Cité. Participants were invited to an experimental room, where they were seated at approximately 40 cm in front of a 14-in. computer screen (1920 × 1080, 60 Hz). The screen was adjusted to maximum brightness for all participants. The experiment, implemented in PsychoPy (Version 3.1.1; Peirce, 2007), was conducted in four phases for all participants in this order: the encoding phase, the retention interval, the recognition phase, and the retrospective emotional rating. The duration of the retention interval was about 30 min (29.70 ± 1.42 min). During this phase, participants filled in the Aesthetic Fluency Scale, watched a 18-min short film, and responded to eight questions on the short film.

Study 2. Participants

Sixty-Five participants (57 women; age M = 21.51 years, SD = 5.27 years) were recruited for this study. The participants were undergraduate students in psychology at the University Paris Cité. They all had a normal or corrected to normal vision. No participant showed art expertise, based on the Aesthetic Fluency Scale[57,58] (M = 10.85, SD = 5.55 out of 40, min 3, max 28). All participants were informed of the academic nature of the study and accepted that their responses would be processed anonymously. After the nature of the procedure had been fully explained, all participants gave written informed consent before carrying out the study. The protocol was carried out following the local ethical standards.

Material & procedure

We used the same stimuli and procedure as in Study 1. The only two differences were: (1) the removal of the retrospective emotional judgment phase after the recognition phase; (2) one of the encoding conditions that were proposed to participants (see below).

Encoding phase

Similar to experiment 1, there were three within-subject experimental encoding conditions. The major difference was that the self-reference condition (memory) was replaced by an emotional judgment (emotion) condition. In this condition, participants were asked to judge their emotional reaction to the stimuli ("Judge your emotional reaction to the image") using a 11-point Likert scale (0 = Very negative, 10 = Very positive). The beauty and color conditions were proposed with the same parameters as in Study 1.

Ethics declarations

This research was conducted in accordance with the local ethical standards and the Declaration of Helsinki. The study was accepted by the local ethical committee from Institute of Psychology—UPC.

Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Author contributions

M.S. and A.J. Conceptualization and Methodology; M.S., S.S., and A.J. Writing—Original Draft; S.S., C.T., and J.B. Investigation; S.S. Software; S.S. and D.M. Formal analysis, Data Curation, and Visualization. P.P., J.D, and M.A. Writing—Review & Editing; M.S. Supervision and Project administration; P.P. Resources; J.D and P.P. Funding acquisition.

Competing interests

The authors declare no competing interests.

Additional information

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