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1 Beauty is in the eye of the beholder: evidence from a common mnemonic
2 advantage between aesthetics judgement and self-reference

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10

11 **Abstract**

12 A long-lasting and unresolved debate in the field of aesthetics is whether beauty is inherent to
13 the object of appreciation or to the subject contemplating it. Several studies suggest that
14 physical features (e.g., symmetry, contrast) of an artwork influence aesthetic rating.
15 Nevertheless, this objectivist approach fails to explain the idiosyncratic nature of aesthetic
16 experiences (AE). Recent models propose a multi-process account of AE, integrating a
17 subjective evaluation based on self-referential processing. This proposition seems coherent
18 with neuroimaging studies showing activation of a common neural network during AE and
19 self-reference. Nevertheless, behavioural data supporting this hypothesis is missing. We took
20 advantage of the self-reference effect (SRE) in memory – the mnemonic advantage for
21 material encoded in a self-related mode - to test the hypothesis that aesthetic judgement is
22 based on self-related processes. We predicted that if aesthetic judgement recruits self-
23 referential processing, incidentally encoding artworks in this condition should produce a
24 similar mnemonic advantage as the SRE. To test this hypothesis, 30 participants incidentally
25 encoded 60 painting in three conditions: self-reference, judgement of beauty and judgement
26 of symmetry (control condition). We found that items encoded in the aesthetic judgment
27 condition were as well recognized as those encoded in self-reference condition when
28 participants gave extreme judgements on the beauty scale during encoding. These findings
29 suggest that at least intense AEs activate an individual's sense of self.

30 **Keywords:** aesthetics judgement, beauty, self, memory

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38

Introduction

39 A long-lasting and unresolved debate in the field of aesthetics is whether beauty is inherent to
40 the object of appreciation or to the subject contemplating it. In other words: is beauty in the
41 eyes of the beholder? In recent years, the scientific interest for the foundation of aesthetic
42 experiences (AE) has been renewed by the emerging field of neuroaesthetics. Mirroring this
43 philosophical and historical debate, there have been two main approaches explaining
44 aesthetic appreciation in modern neuroaesthetic research. The dominant research endeavour
45 in this field, that we can call the objectivist approach, has tried to determine the physical
46 features of an artwork influencing aesthetic judgement. Another, more neglected, line of
47 research has investigated the subjective factors modulating aesthetic judgement.

48 The objectivist approach has shown that various physical properties of an object are reliable
49 predictors of AE. The symmetry of an artwork is considered a stable and robust predictor of
50 aesthetic preference. Indeed, symmetry positively influenced aesthetic preference for
51 geometric shapes, and this effect was additionally resistant to familiarisation (Tinio & Leder,
52 2009). In another study, a mild disruption in symmetry resulted in a significant decline in
53 aesthetic preference for geometric shapes (Gartus & Leder, 2013). Complexity also appears
54 as influencing aesthetic preference: its effect on aesthetic judgement has been found for
55 abstract and representational artwork (Osborne & Farley, 1970; Roberts, 2007), or for
56 geometric shapes (Tinio & Leder, 2009). In the same vein, aesthetic preference was greater
57 for photographs with higher level of fractal dimensions (Spehar et al., 2003). Regarding
58 visual contrast, participants' preference for abstract and representational paintings was
59 greater when the contrast was adjusted higher than the original level, compared to a lower-
60 than-original contrast, independently of the subjects' cultural and social status (Van Dongen
61 & Zijlmans, 2017). Another study, providing further understanding of this effect, suggested
62 the existence of an 'optimal level of contrast in paintings' most preferred by viewers (Dijkstra
63 & van Dongen, 2017). Abstract paintings were most appreciated when the contrast was
64 moderately higher than the original, but not excessively. Curvature and angularity are also
65 properties that influence aesthetic judgement. Higher preference for curved shapes and
66 polygons over angular ones has been reported (Bertamini et al., 2016; Silvia & Barona, 2009).
67 Aesthetic judgement is also affected by the content of the artwork. Some studies observed a
68 higher appreciation among the general population for representational compared to abstract
69 art (Roberts, 2007; Sidhu et al., 2018), and more generally for real-world scenes compared to

70 abstract images (Vessel & Rubin, 2010). Taken together, these findings show that the
71 physical features of visual stimuli robustly modulate subjects' aesthetic judgments.

72 These studies are grounded in cognitive models trying to isolate single key factors
73 determining AE (e.g., Berlyne, 1971; Reber et al., 2004), and they give precious information
74 on the physical characteristics of an artwork influencing AE. Nevertheless, they probably fail
75 to capture the complexity of the phenomenon, neither they explain the widespread intuition
76 that AE is somewhat subjective. An intuition that seem confirmed by experimental studies
77 showing that there is low inter-individual agreement on aesthetic response to visual artistic
78 stimuli, suggesting that aesthetic experience is highly subjective (Vessel et al., 2012). To
79 account for this subjective variability, more recent models propose a multi-process account of
80 AE (Leder et al., 2004; Leder & Nadal, 2014). Leder and collaborators' model proposes five
81 main processing stages leading to aesthetic judgement: perception, implicit memory
82 integration, explicit classification, cognitive mastering, evaluation, and continuous emotion
83 evaluation. By assessing dimensions, such as the evaluative one, pertaining to elements
84 unrelated to the object, these models account for AE beyond the simple elaboration of
85 physical properties. Critically for the present work, the last stages of this model, cognitive
86 mastering and evaluation, account for the subjective component of aesthetics judgement. In
87 particular, the authors propose that self-related cognitive information could be a gateway in
88 understanding and evaluating an artwork. Anecdotally, they state that "[...] perceiver might
89 be satisfied with the recognition of the train station in Monet's La Gare St Lazare, because
90 'he likes trains because they remind him of a journey'" (Leder et al., 2004, p.499). Thus, they
91 explicitly link AE with self-related processing associated to autobiographical information.
92 The link between AE and the self seems to be sustained by the fact that many people consider
93 their artistic taste to be an important part of their identity, their sense of *who they are* (Vessel
94 et al., 2013).

95 These observations echo neuroimaging findings showing that key regions of the default mode
96 network (DMN) are activated during aesthetic judgement (Jacobsen et al., 2006; Kawabata &
97 Zeki, 2004; Martín-Loeches et al., 2014; Vessel et al., 2012, 2019). In particular, the medial
98 prefrontal cortex (mPFC) is of utmost relevance. Importantly, the DMN and the mPFC are
99 known to underpin self-representation at different levels of abstraction (for a meta-analysis,
100 see Martinelli et al., 2013). Nevertheless, it is necessary to avoid haphazardly associating two
101 cognitive processes only on the basis of shared cortical activations. Behavioral data

102 suggesting a possible link between the self and AE also exist. For example, a large corpus of
103 literature demonstrates the importance of familiarity on the aesthetic judgement of proverbs,
104 human faces, and music (Bohrn et al., 2013; Bornstein, 1989; Park et al., 2010; Schubert,
105 2007; Verhaeghen, 2018). Moreover, it is interesting to note that some studies reported that
106 aesthetic judgement during incidental encoding lead to increased memory performance for
107 representational and abstract art pictures (Nadal et al., 2006), for photographs of real-world
108 scenes (Choe et al., 2017), and for paintings (Ishai et al., 2007). Some authors proposed that
109 this effect could be due to the fact that aesthetic judgment may have increased self-related
110 processing (Choe et al., 2017). Indeed, it is well known that items requiring a self-related
111 processing gain a robust mnemonic advantage, in comparison to other types of treatment (e.g.,
112 semantic processing), an effect known as self-reference effect (SRE) in memory (Conway,
113 2005; Cunningham et al., 2008; Kalenzaga et al., 2015; Leshikar et al., 2015; Sui &
114 Humphreys, 2015; Symons & Johnson, 1997). Nevertheless, no study to date directly
115 compared the mnemonic advantage produced by aesthetic judgement and self-reference in
116 order to investigate the potential existence of a common mechanism organizing AE and the
117 self-representation.

118 To test this hypothesis, we asked participants to incidentally encode artworks in three
119 conditions: an aesthetic judgement condition, a self-referential judgement condition, and a
120 control condition (judgement of symmetry). Our main hypothesis was that if AE is linked to
121 self-referential processing, we should find a comparable mnemonic advantage for the self-
122 referential and the aesthetic judgement condition, compared to a control condition requiring
123 judgement of low-level visual features. An exploratory and complementary hypothesis was
124 that the mnemonic advantage for item encoded in the aesthetic judgement condition should
125 be modulated by participants' evaluation during encoding. In particular, accordingly to a
126 recent study showing better memory performance for the location of paintings that elicited
127 extreme aesthetic experiences, whether positive or negative (Babo-Rebelo et al., 2020), we
128 made the hypothesis that paintings receiving judgments at the two poles would receive the
129 greatest mnemonic advantage.

130 **Material and Methods**

131 **Participants**

132 30 university students (27 women; mean age 20.7 ± 2.76 years) were recruited for this study.
133 The participants were undergraduate students in psychology at the University of Paris. All
134 participants had a normal or corrected vision. No participant showed expertise in art, based
135 on the Aesthetic Fluency Scale (Silvia, 2007; Smith & Smith, 2006; mean score 11.63 ± 4.69
136 out of 40). All participants were informed of the academic nature of the study and accepted
137 that their responses would be processed anonymously. After the nature of the procedure had
138 been fully explained, all participants gave written informed consent before carrying out the
139 study. The protocol was carried out in accordance with the local ethical standards.

140 **Material**

141 **Visual stimuli**

142 One hundred pieces of visual art were selected from the Wiki Art data base, across nine
143 different artistic styles representing some of the most important styles between the 16th and
144 20th century: Nordic renaissance art, Baroque art, Rococo art, Romanticism, Realism,
145 Symbolism, Expressionism, Impressionism, and Post-impressionism. We only selected color
146 and representational paintings with a landscape width-height ratio. We excluded painting
147 including easily recognizable elements (e.g., artist' signature, writings). A complete list of the
148 painting is presented in the **Supplementary Material 1**. Among the selected 100 pieces, 60
149 were used as target stimuli during the encoding phase. The remaining 40 were used as
150 distractors in the recognition phase. The distractors were visually paired with some of the
151 target stimuli in terms of content (people, animals, landscape, style etc.) and color schemes,
152 in order to make sure they were not dissimilar. The two groups of stimuli did not show any
153 significant differences concerning their physical features: luminance (Targets mean = $93.28 \pm$
154 40.53 ; Lure mean = 101.5 ± 40.79 ; $t(98) = -1.00$, $p = .321$); contrast (Targets mean = $50.60 \pm$
155 11.11 ; Lure mean = 48.8 ± 9.90 ; $t(98) = 0.82$, $p = .415$).

156 **Encoding phase**

157 There were three within-subject experimental conditions (encoding conditions): an aesthetic
158 judgement condition, a self-referential judgement condition, and a symmetry judgement
159 condition (control). In the aesthetic judgement condition, the subjects were asked to judge
160 their appreciation of the stimuli ("Judge how beautiful the image is") on a scale from 0 to 10.
161 In the self-referential judgement condition, the subjects were asked to judge to what degree

162 the stimuli reminded them personal memories (“Judge how much the image reminds you of
163 your personal memories”) on a scale from 0 to 10. In the symmetry judgement condition, the
164 subjects were asked to judge the stimuli’s level of symmetry (“Judge how symmetric the
165 image is”) on a scale from 0 to 10. Participants were not informed of the following memory
166 test (incidental encoding).

167 Prior to the beginning of the encoding phase, a painting not employed in the experimental
168 task (i.e., Viktor Vanetsov’s “The Bard Bayan”, which is about a Slavic mythological scene)
169 has been used to instruct participants. The self-reference condition was explained to the
170 subjects with the example painting in the following way: “Although it is improbable that you
171 have experienced the event represented in this painting, it is possible that the painting
172 reminds you personal memories such as a friendly hillside picnic, a museum visit where you
173 may have seen similar paintings, a scene of a movie, or even a visual representation of a story
174 that you have read”. The beauty condition was explained to the subjects with this image by
175 asking them to simply judge how subjectively beautiful they found the image. The symmetry
176 condition was explained with this image by explaining that although some elements of the
177 painting are quite symmetrical (e.g., the shape and colors of the hill and the sky), some other
178 elements are not (e.g., the left-heavy way people are dispersed on the hill, the people’s
179 appearances, the diagonally placed central weapon, etc.), and that they could judge the global
180 symmetry in their own way.

181 Each condition contained 20 target images presented in a block. The distribution of the 60
182 target stimuli on the encoding conditions was counterbalanced across participants, so that
183 each item was presented in each experimental condition. The order of block was randomized
184 across subjects. In each block, a trial started with a fixation cross for 500 ms that was
185 followed by the presentation of a stimulus for 3 seconds. Once the stimulus presentation
186 ended, the rating scale appeared on the screen, where the subjects had to enter their score
187 according to the experimental condition. There was no time limit for the evaluation. Once the
188 participants responded, the next trial started. The end of the block was signaled by the
189 presentation of written instructions for the next block.

190 **Recognition phase**

191 During the recognition phase, all target stimuli were presented intermixed with 40 distractor
192 stimuli in a random order. After the presentation of the fixation cross (500ms), each stimulus

193 was presented for 3 seconds. Once the stimulus presentation was over, participants had to
194 indicate if they had seen the picture before. They could choose between 3 different responses
195 appearing on the screen: “Yes”, “Maybe” and “No”. If the answer was either “Yes” or
196 “Maybe”, participants were asked to indicate in which encoding condition they had seen the
197 image. There was no time limit to answer. Once the recognition response was entered, the
198 fixation cross appeared, followed by the next trial.

199 **Procedure**

200 The experiment was conducted at the MC²Lab, located at the Paris University Psychology
201 Institute. Participants were invited to an experimental room, where they were seated at
202 approximately 40cm in front of a 14-inch computer screen (1920x1080, 60Hz). The screen
203 was adjusted to maximum brightness for all participants. The experiment, implemented in
204 Psychopy v3.1.1 (Peirce, 2007), was conducted in three parts for all participants in this order:
205 the encoding phase, the retention interval, the recognition phase. The duration of the retention
206 interval was about 30 minutes (30.32±8.13 minutes). During this phase, participants filled in
207 four questionnaires¹, and watched an 8-minute short film (Alike, Lara & Cano Méndez, 2015).
208 All the above listed material except for the Aesthetic Fluency Scale was used solely as a way
209 to guarantee a sufficiently long retention interval. The results for these questionnaires were
210 thus not analyzed.

211 **Data analysis**

212 The first two sets of analyses model the item (Yes responses) and source recognition (a
213 binary variable) as a function of the condition (3 levels; Beauty, Self-reference and Symmetry)
214 using mixed logistic models (participants and items were entered as random factors).
215 Marginal means-based contrasts were then estimated to allow us exploring the pairwise
216 differences between the levels. In the second part, we additionally modelled the effect of the
217 rating during encoding (a continuous variable ranging from 0 to 10), in each condition, for
218 item and source recognition, allowing to investigate possible non-linearity using second order
219 polynomials.

¹ The Desire for Aesthetics Scale (Lundy et al., 2010), the Aesthetic Fluency Scale (Silvia, 2007; Smith & Smith, 2006), the Tellegen Absorption Scale (Tellegen & Atkinson, 1974), and the Autism Quotient (Auyeung et al., 2008).

220 Data processing was carried out with R (<https://www.r-project.org/>) and the *easystats* suite
221 (Lüdtke et al., 2019; Makowski, Ben-Shachar, & Lüdtke, 2019). The whole analysis was
222 performed under the Bayesian framework using MCMC sampling with the *rstanarm* package
223 (Goodrich et al., 2018; <http://mc-stan.org/>). To assert effect significance, we used the
224 Probability of Direction (effects were considered “significant” when $pd > 97\%$), a Bayesian
225 equivalent of the p -value (Makowski, Ben-Shachar, Chen, et al., 2019). For clarity, only the
226 relevant effects will be described in the text, but the full reproducible analysis script
227 (containing the full description of all models along with complementary results and figures as
228 well complete descriptive statistics) is available in **Supplementary Materials 2**.

229 **Results**

230 **Effect of Condition**

231 The mixed logistic model predicting the item recognition had a total explanatory power
232 (Bayes R²; Gelman et al., 2019) of 22%, from which 3% (marginal R²) were related to the
233 effect of the condition alone. Within this model, the Self-reference condition led a
234 significantly higher item recognition probability than the Beauty (difference = 0.91, 95% CI
235 [0.61, 1.23], $pd = 100\%$) and the Symmetry (difference = 1.10, 95% CI [0.80, 1.40], $pd =$
236 100%) conditions. The difference between the latter two was not significant (difference =
237 0.18, 95% CI [-0.08, 0.46], $pd = 90.75\%$). See **Figure A1**.

238 The mixed logistic model predicting the source recognition had a total explanatory power of
239 10%, from which 3% was related to the effect of the condition alone. Within this model, there
240 were no significant differences between any of the conditions (Beauty – Self-reference,
241 difference = -0.28, 95% CI [-0.58, 0.03], $pd = 96.35\%$; Beauty – Symmetry, difference = -0.
242 22, 95% CI [-0.50, 0.13], $pd = 91\%$; Self-reference – Symmetry, difference = 0.06, 95% CI [-
243 0.25, 0.41], $pd = 65\%$). See **Figure B1**.

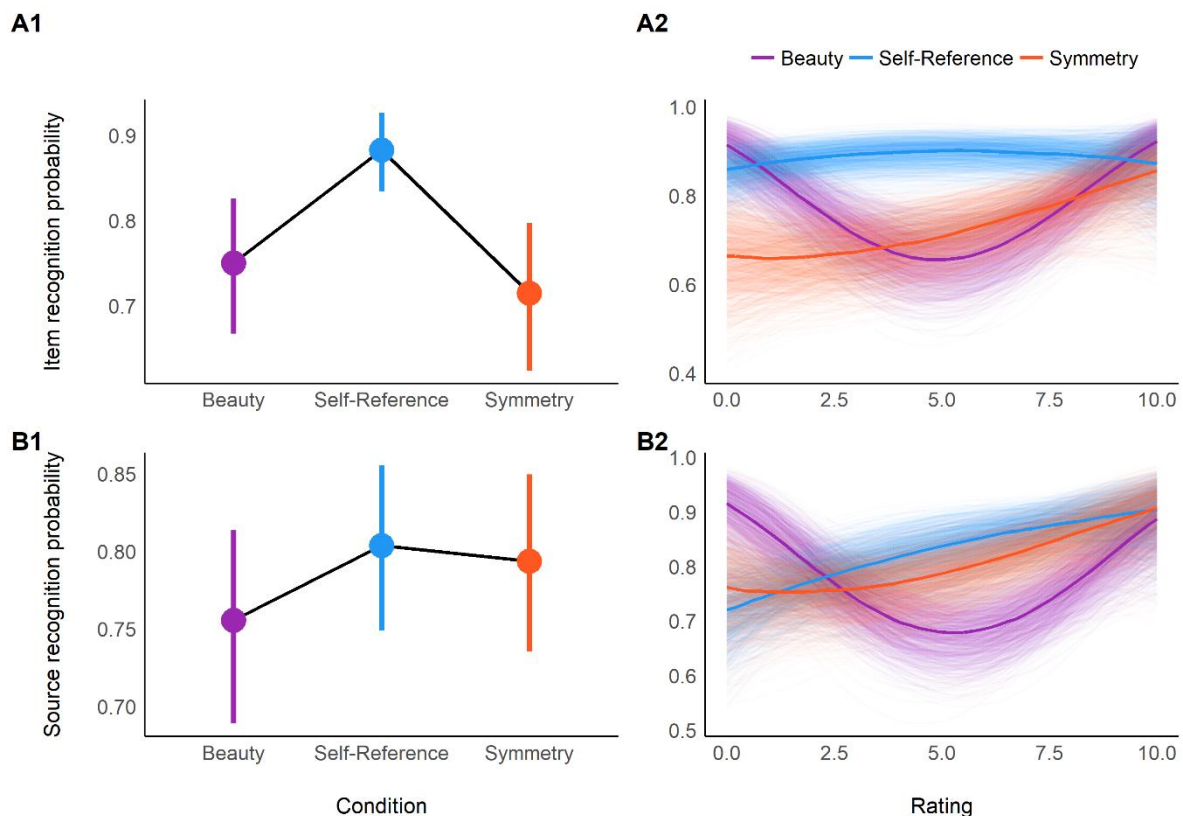
244 **Effect of Rating**

245 The mixed logistic model predicting the item recognition had a total explanatory power of
246 24%, from which 5% were related to the condition and the rating. Within this model, only the
247 rating of Symmetry displayed a significant linear positive relationship with the probability of
248 item recognition (median = 12.50, 95% CI [2.79, 23.14], $pd = 99\%$). However, the rating of
249 Beauty had a significant quadratic relationship (median = 24.29, 95% CI [14.02, 36.62], $pd =$

250 100%), with middle ratings leading to a lower probability of item recognition. Additionally,
 251 contrast analysis confirmed that at the rating extremities (0 and 10), the difference between
 252 the Beauty and the Self-reference was not significant (difference = 0.55, 95% CI [-0.34, 1.52],
 253 $pd = 87.92\%$; difference = 0.55, 95% CI [-0.60, 1.69], $pd = 82.85\%$, respectively). See
 254 **Figure A2**.

255 The mixed logistic model predicting the source recognition had a total explanatory power of
 256 11%, from which 3% were related to the condition and the rating. Within this model, both the
 257 ratings of Symmetry (median = 12.41, 95% CI [1.01, 24.46], $pd = 98.20\%$) and Self-
 258 reference (median = 16.44, 95% CI [6.39, 26.97], $pd = 99.95\%$) displayed a significant linear
 259 positive relationship with the probability of source recognition. The rating of Beauty had a
 260 significant quadratic relationship (median = 20.04, 95% CI [8.90, 32.08], $pd = 99.98\%$), with
 261 middle ratings leading to a lower probability of source recognition. See **Figure B2**.

262



263

264 **Figure 1.** The estimated probability of item (A) and source (B) recognition averaged by
 265 conditions (1) and its modulation by the rating (2). The error bars represent the 95% Credible

266 Intervals (CI). Thin lines represent individual posterior draws (i.e., the possible effects) and
267 the thick line shows the median effect.

268 **Discussion**

269 In this study, we investigated the relationship between AE and the self at the behavioral level.
270 We tested the hypothesis that AE is grounded on self-reference by examining the common
271 mnemonic advantage produced by incidentally encoding aesthetic visual stimuli under
272 aesthetic judgement, self-reference and a control condition. Given that self-referential
273 encoding produces robust mnemonic advantage (Conway, 2005; Cunningham et al., 2008;
274 Kalenzaga et al., 2015; Leshikar et al., 2015; Sui & Humphreys, 2015; Symons & Johnson,
275 1997), we expected that comparable results would be observed for aesthetic encoding, owing
276 to the potential shared mechanism. The main result, confirming our hypothesis, was that
277 items in the aesthetic judgment condition were as well recognized as those encoded in self-
278 reference condition when participants gave extreme judgements on the beauty scale during
279 encoding.

280 First of all, we replicated the self-reference effect (SRE) in memory. Indeed, items encoded
281 in this condition were generally better recognized than the other two conditions (aesthetics
282 and symmetry judgement). This result confirms the effectiveness of our experimental
283 manipulation. Our main result was that items encoded in the aesthetic judgement condition,
284 although they were not generally better recognized, showed the same recognition probability
285 of items encoded in the self-reference condition, when participants had given an extreme
286 judgement (very high or very low) during encoding. Several studies reported a positive link
287 between aesthetic evaluation and memory. For example, Nadal, Marty and Munar (2006)
288 reported that aesthetic preference was higher for artworks that have left stronger memory
289 traces. Similar results have been observed by Ishai, Fairhall & Pepperell (2007) reporting that
290 the higher the appreciation of the stimuli during encoding, the more probable their
291 recognition was. In the same vein, Choe et al. (2017) showed that rating aesthetic value
292 during an incidental encoding task boosted memory performances, compared to an intentional
293 encoding condition or to a search task. Finally, a recent study reported better memory
294 performance for the location of paintings that elicited extreme aesthetic experiences, whether
295 positive or negative (Babo-Rebelo et al., 2020). Although these results suggest that in general
296 aesthetic judgement enhances memory performance, at first glance, this effect seems to vary

297 between studies. Indeed, memory can be facilitated independently of the extent of the rating
298 during encoding (Choe et al., 2017), can linearly vary with the rating (Ishai, Fairhall and
299 Pepperell, 2007), or can be associated with extreme (positive or negative) judgements. This
300 heterogeneity could be linked to the type of aesthetic judgement required. Indeed, Ishai and
301 colleagues (2007) asked participants how strongly the paintings affected them. This measure
302 can capture both positive and negative aspect of the AE. Babo-Rebelo et al. (2020) employed
303 liking and intensity rating (the squared liking rating), the latter being a more robust predictor
304 of subsequent memory. In this light, one hypothesis would be that the absolute intensity of
305 AE, more than the valence, determines the subsequent memory enhancement. Our findings
306 seem to be coherent with this hypothesis. Moreover, we showed, for the first time, that the
307 memory enhancement for items receiving extreme aesthetic rating is comparable to that
308 produced by self-reference. Our results directly support the proposal that the memory
309 advantage produced by AE is linked to the recruitment of self-referential processing (Choe et
310 al., 2017).

311 Interestingly, some neuroimaging studies seem to confirm that intense AE recruits brain
312 regions involved in self-referential processing. For example, Vessel et al. (2012) asked
313 participants to rate how strongly paintings move them while recording their brain activity
314 with fMRI. They identified two brain networks showing different pattern of activity. The
315 activity in the first network, composed by sensory regions, increased linearly with
316 participants' rating. The second network, mainly encompassing region of the DMN, showed
317 increased activity only for the most moving stimuli. This was particularly true for the medial
318 prefrontal cortex (MPFC). Interestingly, in another study the MPFC showed a nonlinear
319 pattern of activity when participants were asked to judge their appreciation of a human face
320 and body stimuli. Indeed, this region showed increased activation for both ugly and beautiful
321 stimuli, compared to neutral ones (Martín-Loeches et al., 2014). Again, these results suggest
322 that strong AE, whatever their valence, recruit brain regions underpinning self-representation.
323 Our behavioral data seems to corroborate the suggestion that at least strong AE can activate
324 an individual's sense of self (Vessel et al., 2013), involving either an apprehension of the
325 object as conveying one's deep identity (in the case of positive valence) or its very opposite
326 (in the case of negative valence).

327 One alternative explanation for our results could be that the reported effect is not due to
328 aesthetic judgement per se, but would be linked to the emotional reaction associated to highly

329 aesthetically moving stimuli. Indeed, emotional evaluation is central to AE (Chatterjee &
330 Vartanian, 2014), and comes into play at almost every processing level during AE (Leder et
331 al., 2004; Leder & Nadal, 2014). In addition, emotional content is known to facilitate
332 memory (Adelman & Estes, 2013; Leppänen et al., 2007; Meng et al., 2017; Schaefer et al.,
333 2009; Sharot & Phelps, 2004). Further studies should explore the relation between AE and
334 the self, disentangling the potential effects of emotional content not controlled in the present
335 work.

336 We also reported that judgement of symmetry showed a linear relationship with subsequent
337 recognition probability. This can be due to the well-known link between symmetry and
338 aesthetic preference as mentioned in the introduction (Gartus & Leder, 2013; Tinio & Leder,
339 2009). Probably, stimuli judged as highly symmetric were also implicitly judged as beautiful,
340 and produced the same mnemonic advantage. Further studies should use different control
341 conditions not pertaining to judgement of features that are known to be associated with
342 aesthetic evaluation. Concerning source memory, the results were less clear. Indeed, for this
343 measure we did not report any effect of the encoding condition. The blocked presentation of
344 conditions could have facilitated the source memory task leading to a ceiling effect as shown
345 by the high rate of correct answers (see **Supplementary Material 2**). Thus, although the
346 probability of source memory for items encoded in the aesthetic judgement condition
347 followed the same u-shaped pattern than recognition probability, these data are less easily
348 interpretable.

349 In conclusion, we presented here behavioral results corroborating previous neuroimaging
350 findings suggesting that intense AEs are strictly linked to self-referential processing. These
351 data support the idea that beauty, but also ugliness, is (at least partly) in the eye of the
352 beholder, and give a cognitive explanation to intersubjective variability in aesthetic
353 appreciation. Beyond the fundamental theoretical interest in the field of neuroaesthetics, our
354 results could have some implications for clinical research. Indeed, some studies reported that
355 patients suffering from Alzheimer's disease showed a preserved stability of aesthetic
356 preferences, even if they not have explicit memory for the artworks (Halpern et al., 2008;
357 Silveri et al., 2015). These findings suggest that AE could be a window to preserved portions
358 of the self in these patients.

359 **Author contributions**

360 HL, AJ and MS wrote the article. HL and MS conceptualized the experiment. HL and DM
361 did the data analyses. All the authors contributed to the final draft of the article.

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366 **References**

- 367 Adelman, J. S., & Estes, Z. (2013). Emotion and memory : A recognition advantage for
368 positive and negative words independent of arousal. *Cognition*, *129*(3), 530- 535.
369 <https://doi.org/10.1016/j.cognition.2013.08.014>
- 370 Auyeung, B., Baron-Cohen, S., Wheelwright, S., & Allison, C. (2008). The Autism Spectrum
371 Quotient : Children’s Version (AQ-Child). *Journal of Autism and Developmental*
372 *Disorders*, *38*(7), 1230- 1240. <https://doi.org/10.1007/s10803-007-0504-z>
- 373 Babo-Rebelo, M., Travers, E., & Haggard, P. (2020). *Looking, liking and locating : An*
374 *experimental aesthetics of orienting* [Preprint]. PsyArXiv.
375 <https://doi.org/10.31234/osf.io/a59e2>
- 376 Berlyne, D. E. (1971). *Aesthetics and Psychobiology*, New York: Appleton-Century-Crofts
- 377 Bertamini, M., Palumbo, L., Gheorghes, T. N., & Galatsidas, M. (2016). Do observers like
378 curvature or do they dislike angularity? *British Journal of Psychology*, *107*(1),
379 154- 178. <https://doi.org/10.1111/bjop.12132>
- 380 Bohrn, I. C., Altmann, U., Lubrich, O., Menninghaus, W., & Jacobs, A. M. (2013). When we
381 like what we know – A parametric fMRI analysis of beauty and familiarity. *Brain and*
382 *Language*, *124*(1), 1- 8. <https://doi.org/10.1016/j.bandl.2012.10.003>

- 383 Bornstein, R. F. (1989). Exposure and Affect : Overview and Meta-Analysis of Research
384 1968-1987. *Psychological Bulletin*, 106, 265–89.
- 385 Chatterjee, A., & Vartanian, O. (2014). Neuroaesthetics. *Trends in Cognitive Sciences*, 18(7),
386 370- 375. <https://doi.org/10.1016/j.tics.2014.03.003>
- 387 Choe, K. W., Kardan, O., Kotabe, H. P., Henderson, J. M., & Berman, M. G. (2017). To
388 search or to like : Mapping fixations to differentiate two forms of incidental scene
389 memory. *Journal of Vision*, 17(12), 8. <https://doi.org/10.1167/17.12.8>
- 390 Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language*, 53(4),
391 594- 628. <https://doi.org/10.1016/j.jml.2005.08.005>
- 392 Cunningham, S. J., Turk, D. J., Macdonald, L. M., & Neil Macrae, C. (2008). Yours or mine?
393 Ownership and memory. *Consciousness and Cognition*, 17(1), 312- 318.
394 <https://doi.org/10.1016/j.concog.2007.04.003>
- 395 Dijkstra, K., & van Dongen, N. N. N. (2017). Moderate Contrast in the Evaluation of
396 Paintings Is Liked More but Remembered Less than High Contrast. *Frontiers in*
397 *Psychology*, 8. <https://doi.org/10.3389/fpsyg.2017.01507>
- 398 Gartus, A., & Leder, H. (2013). The Small Step toward Asymmetry : Aesthetic Judgment of
399 Broken Symmetries. *I-Perception*, 4(5), 361- 364. <https://doi.org/10.1068/i0588sas>
- 400 Gelman, A., Goodrich, B., Gabry, J., & Vehtari, A. (2019). R-squared for Bayesian
401 Regression Models. *The American Statistician*, 73(3), 307- 309.
402 <https://doi.org/10.1080/00031305.2018.1549100>
- 403 Goodrich, B., Gabry, J., Ali, I., & Brilleman, S. (2018). rstanarm : Bayesian applied
404 regression modeling via Stan. R package version 2.17. 4. *Online* < <http://mc-stan.org>.

- 405 Halpern, A. R., Ly, J., Elkin-Frankston, S., & O'Connor, M. G. (2008). "I Know What I
406 Like": Stability of aesthetic preference in alzheimer's patients. *Brain and Cognition*,
407 66(1), 65- 72. <https://doi.org/10.1016/j.bandc.2007.05.008>
- 408 Ishai, A., Fairhall, S. L., & Pepperell, R. (2007). Perception, memory and aesthetics of
409 indeterminate art. *Brain Research Bulletin*, 73(4- 6), 319- 324.
410 <https://doi.org/10.1016/j.brainresbull.2007.04.009>
- 411 Jacobsen, T., Schubotz, R. I., Höfel, L., & Cramon, D. Y. v. (2006). Brain correlates of
412 aesthetic judgment of beauty. *NeuroImage*, 29(1), 276- 285.
413 <https://doi.org/10.1016/j.neuroimage.2005.07.010>
- 414 Kalenzaga, S., Sperduti, M., Anssens, A., Martinelli, P., Devauchelle, A.-D., Gallarda, T.,
415 Delhommeau, M., Lion, S., Amado, I., Krebs, M.-O., Oppenheim, C., & Piolino, P.
416 (2015). Episodic memory and self-reference via semantic autobiographical memory :
417 Insights from an fMRI study in younger and older adults. *Frontiers in Behavioral*
418 *Neuroscience*, 8. <https://doi.org/10.3389/fnbeh.2014.00449>
- 419 Kawabata, H., & Zeki, S. (2004). Neural Correlates of Beauty. *Journal of Neurophysiology*,
420 91(4), 1699- 1705. <https://doi.org/10.1152/jn.00696.2003>
- 421 Leder, H., Belke, B., Oeberst, A., & Augustin, D. (2004). A model of aesthetic appreciation
422 and aesthetic judgments. *British Journal of Psychology*, 95(4), 489- 508.
423 <https://doi.org/10.1348/0007126042369811>
- 424 Leder, H., & Nadal, M. (2014). Ten years of a model of aesthetic appreciation and aesthetic
425 judgments : The aesthetic episode – Developments and challenges in empirical
426 aesthetics. *British Journal of Psychology*, 105(4), 443- 464.
427 <https://doi.org/10.1111/bjop.12084>

- 428 Leppänen, J. M., Kauppinen, P., Peltola, M. J., & Hietanen, J. K. (2007). Differential
429 electrocortical responses to increasing intensities of fearful and happy emotional
430 expressions. *Brain Research, 1166*, 103- 109.
431 <https://doi.org/10.1016/j.brainres.2007.06.060>
- 432 Leshikar, E. D., Dulas, M. R., & Duarte, A. (2015). Self-referencing enhances recollection in
433 both young and older adults. *Aging, Neuropsychology, and Cognition, 22*(4),
434 388- 412. <https://doi.org/10.1080/13825585.2014.957150>
- 435 Lüdecke, D., Waggoner, P., & Makowski, D. (2019). insight : A Unified Interface to Access
436 Information from Model Objects in R. *Journal of Open Source Software, 4*(38), 1412.
437 <https://doi.org/10.21105/joss.01412>
- 438 Lundy, D. E., Schenkel, M. B., Akrie, T. N., & Walker, A. M. (2010). How Important is
439 Beauty to You? The Development of the Desire for Aesthetics Scale. *Empirical*
440 *Studies of the Arts, 28*(1), 73- 92. <https://doi.org/10.2190/EM.28.1.e>
- 441 Makowski, D., Ben-Shachar, M., & Lüdecke, D. (2019). bayestestR : Describing Effects and
442 their Uncertainty, Existence and Significance within the Bayesian Framework.
443 *Journal of Open Source Software, 4*(40), 1541. <https://doi.org/10.21105/joss.01541>
- 444 Makowski, D., Ben-Shachar, M. S., Chen, S. H. A., & Lüdecke, D. (2019). Indices of Effect
445 Existence and Significance in the Bayesian Framework. *Frontiers in Psychology, 10*.
446 <https://doi.org/10.3389/fpsyg.2019.02767>
- 447 Martinelli, P., Sperduti, M., & Piolino, P. (2013). Neural substrates of the self-memory
448 system : New insights from a meta-analysis. *Human Brain Mapping, 34*(7),
449 1515- 1529. <https://doi.org/10.1002/hbm.22008>
- 450 Martín-Loeches, M., Hernández-Tamames, J. A., Martín, A., & Urrutia, M. (2014). Beauty
451 and ugliness in the bodies and faces of others : An fMRI study of person esthetic

- 452 judgement. *Neuroscience*, 277, 486- 497.
453 <https://doi.org/10.1016/j.neuroscience.2014.07.040>
- 454 Meng, X., Zhang, L., Liu, W., Ding, X., Li, H., Yang, J., & Yuan, J. (2017). The impact of
455 emotion intensity on recognition memory : Valence polarity matters. *International*
456 *Journal of Psychophysiology*, 116, 16- 25.
457 <https://doi.org/10.1016/j.ijpsycho.2017.01.014>
- 458 Nadal, M., Marty, G., & Munar, E. (2006). The Search for Objective Measures of Aesthetic
459 Judgment : The Case of Memory Traces. *Empirical Studies of the Arts*, 24(1), 95- 106.
460 <https://doi.org/10.2190/5NJ2-7F9J-487P-DCPW>
- 461 Osborne, J. W., & Farley, F. H. (1970). The relationship between aesthetic preference and
462 visual complexity in abstract art. *Psychonomic Science*, 19(2), 69- 70.
463 <https://doi.org/10.3758/BF03337424>
- 464 Park, J., Shimojo, E., & Shimojo, S. (2010). Roles of familiarity and novelty in visual
465 preference judgments are segregated across object categories. *Proceedings of the*
466 *National Academy of Sciences*, 107(33), 14552- 14555.
467 <https://doi.org/10.1073/pnas.1004374107>
- 468 Peirce, J. W. (2007). PsychoPy—Psychophysics software in Python. *Journal of Neuroscience*
469 *Methods*, 162(1), 8- 13. <https://doi.org/10.1016/j.jneumeth.2006.11.017>
- 470 Reber, R., Schwarz, N., & Winkielman, P. (2004). Processing Fluency and Aesthetic
471 Pleasure : Is Beauty in the Perceiver's Processing Experience? *Personality and Social*
472 *Psychology Review*, 8(4), 364- 382. https://doi.org/10.1207/s15327957pspr0804_3
- 473 Roberts, M. (2007). *Complexity and aesthetic preference for diverse visual stimuli*, Doctoral
474 Universitat de Illes Balears

- 475 Schaefer, A., Fletcher, K., Pottage, C. L., Alexander, K., & Brown, C. (2009). The effects of
476 emotional intensity on ERP correlates of recognition memory. *NeuroReport*, *20*(3),
477 319–324. <https://doi.org/10.1097/WNR.0b013e3283229b52>
- 478 Schubert, E. (2007). The influence of emotion, locus of emotion and familiarity upon
479 preference in music. *Psychology of Music*, *35*(3), 499- 515.
480 <https://doi.org/10.1177/0305735607072657>
- 481 Sharot, T., & Phelps, E. A. (2004). How arousal modulates memory : Disentangling the
482 effects of attention and retention. *Cognitive, Affective, & Behavioral Neuroscience*,
483 *4*(3), 294- 306. <https://doi.org/10.3758/CABN.4.3.294>
- 484 Sidhu, D. M., McDougall, K. H., Jalava, S. T., & Bodner, G. E. (2018). Prediction of beauty
485 and liking ratings for abstract and representational paintings using subjective and
486 objective measures. *PLOS ONE*, *13*(7), e0200431.
487 <https://doi.org/10.1371/journal.pone.0200431>
- 488 Silveri, M. C., Ferrante, I., Brita, A. C., Rossi, P., Liperoti, R., Mammarella, F., Bernabei, R.,
489 Marini Chiarelli, M. V., & De Luca, M. (2015). “The Memory of Beauty” Survives
490 Alzheimer’s Disease (but Cannot Help Memory). *Journal of Alzheimer’s Disease*,
491 *45*(2), 483- 494. <https://doi.org/10.3233/JAD-141434>
- 492 Silvia, P. J. (2007). Knowledge-based assessment of expertise in the arts : Exploring aesthetic
493 fluency. *Psychology of Aesthetics, Creativity, and the Arts*, *1*(4), 247- 249.
494 <https://doi.org/10.1037/1931-3896.1.4.247>
- 495 Silvia, P. J., & Barona, C. M. (2009). Do People Prefer Curved Objects? Angularity,
496 Expertise, and Aesthetic Preference. *Empirical Studies of the Arts*, *27*(1), 25- 42.
497 <https://doi.org/10.2190/EM.27.1.b>
- 498 Smith, L. F., & Smith, J. K. (2006). *The Nature and Growth of Aesthetic Fluency*.

- 499 Spehar, B., Clifford, C. W. G., Newell, B. R., & Taylor, R. P. (2003). Universal aesthetic of
500 fractals. *Computers & Graphics*, 27(5), 813- 820. <https://doi.org/10.1016/S0097->
501 [8493\(03\)00154-7](https://doi.org/10.1016/S0097-8493(03)00154-7)
- 502 Sui, J., & Humphreys, G. W. (2015). The Integrative Self : How Self-Reference Integrates
503 Perception and Memory. *Trends in Cognitive Sciences*, 19(12), 719- 728.
504 <https://doi.org/10.1016/j.tics.2015.08.015>
- 505 Symons, C. S., & Johnson, B. T. (1997). *The Self-Reference Effect in Memory : A Meta-*
506 *Analysis*. 25.
- 507 Tellegen, A., & Atkinson, G. (1974). Openness to absorbing and self-altering experiences
508 (« absorption »), a trait related to hypnotic susceptibility. *Journal of abnormal*
509 *psychology*, 83(3), 268.
- 510 Tinio, P. P. L., & Leder, H. (2009). Just how stable are stable aesthetic features? Symmetry,
511 complexity, and the jaws of massive familiarization. *Acta Psychologica*, 130(3),
512 241- 250. <https://doi.org/10.1016/j.actpsy.2009.01.001>
- 513 Van Dongen, & Zijlmans. (2017). The Science of Art : The Universality of the Law of
514 Contrast. *The American Journal of Psychology*, 130(3), 283.
515 <https://doi.org/10.5406/amerjpsyc.130.3.0283>
- 516 Verhaeghen, P. (2018). Once More, with Feeling : The Role of Familiarity in the Aesthetic
517 Response. *The Psychological Record*, 68(3), 379- 384.
518 <https://doi.org/10.1007/s40732-018-0312-1>
- 519 Vessel, E. A., Isik, A. I., Belfi, A. M., Stahl, J. L., & Starr, G. G. (2019). The default-mode
520 network represents aesthetic appeal that generalizes across visual domains.
521 *Proceedings of the National Academy of Sciences*, 116(38), 19155- 19164.
522 <https://doi.org/10.1073/pnas.1902650116>

- 523 Vessel, E. A., & Rubin, N. (2010). Beauty and the beholder : Highly individual taste for
524 abstract, but not real-world images. *Journal of Vision*, *10*(2), 18- 18.
525 <https://doi.org/10.1167/10.2.18>
- 526 Vessel, E. A., Starr, G. G., & Rubin, N. (2012). The brain on art : Intense aesthetic experience
527 activates the default mode network. *Frontiers in Human Neuroscience*, *6*.
528 <https://doi.org/10.3389/fnhum.2012.00066>
- 529 Vessel, E. A., Starr, G. G., & Rubin, N. (2013). Art reaches within : Aesthetic experience, the
530 self and the default mode network. *Frontiers in Neuroscience*, *7*.
531 <https://doi.org/10.3389/fnins.2013.00258>
- 532

533 **Figure 1.** The estimated probability of item (A) and source (B) recognition averaged by
534 conditions (1) and its modulation by the rating (2). The error bars represent the 95% Credible
535 Intervals (CI). Thin lines represent individual posterior draws (i.e., the possible effects) and
536 the thick line shows the median effect.