The twofold role of subjective fluency in displeasing but preferable visual artworks:

Self-report and eye-tracking analysis

Jinwoo Yi[1], Dayoun Choi[2], Joung A Eom[3], Mijung Kang[3]

Affiliations

[1] Department of Brain and Cognitive Sciences, Seoul National University, South Korea

[2] Department of Psychology, Seoul National University, South Korea

[3] Department of Aesthetics, Seoul National University, South Korea

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Author Note

Data collection and preliminary analysis were supported by Student-Directed Education Regular Program from Seoul National University. We have no conflicts of interest to disclose. Correspondence concerning this article should be addressed to Jinwoo Yi, Department of Brain and Cognitive Sciences, Seoul National University, Gwanak-ro 1, Building 16, Office M519, Gwanak-gu, Seoul, 08826, South Korea. Email: adem1997@snu.ac.kr

Abstract

Subjective fluency affects preference evaluation in daily objects through two routes: increasing preference ('hedonic effect') and amplifying valence effects on preference ('amplifying effect'). Contrarily, empirical aesthetics suggest that contextual knowledge, the primary source of fluency, prevents valence-dependent appreciation, challenging the amplification model. Here, we examined the dual effects of fluency on preference for visual artworks with varying valence. We found that fluency increased preference and weakened valence effects. Using an eye-tracking approach, we also investigated the cognitive mechanism bridging fluency and preference. We hypothesized that contextual information facilitates controlled processing-related eye movement, and this gazing behavior enhances fluency and preference. While contextual information facilitated controlled processing and fluency, controlled eye movement did not mediate its effect on fluency. Although our findings motivate further research into the complex interplay between processing style and fluency, they elucidate art-specific affect-fluency-preference interactions.

Keywords*:* subjective fluency, valence, preference, visual artworks, empirical aesthetics

Introduction

Humans uniquely exhibit preferences for artworks, even those that initially evoke negative emotions such as horror or disgust. This raises an intriguing question: How do people come to like artworks that initially provoke negative feelings? This paradox has garnered considerable scholarly attention beyond philosophy (Gaut, 1993; Korsmeyer, 2012). In psychology, subjective fluency – defined as the ease and speed of cognitive processing of a given stimulus – is recognized as a fundamental contributor to human preferences (Forster et al., 2013). Research has shown a strong link between subjective fluency and preference for neutral or positive stimuli (Forster et al., 2015; Forster et al., 2016; Graf et al., 2018; Reber et al., 2004). However, their relationship for negative valence stimuli has yielded mixed findings. For example, some studies have found that increased fluency of displeasing objects (e.g., images of guns) lead to heightened preference (Halberstadt, 2006), while others report a decrease in preference (Albrecht & Carbon, 2014). These mixed findings suggest that subjective fluency plays a complex role in shaping preference. Specifically, two models have emerged: the hedonic fluency model (HFM) says fluency increases preference no matter the object's valence (Winkielman & Cacioppo, 2001; Winkielman et al., 2003), while the fluency amplification model (FAM) says fluency amplifies valence impact on preference (Albrecht & Carbon, 2014). Landwehr and Eckmann (2020) showed that both models might work together: increased fluency can boost preference (HFM) but also intensify negative feelings, reducing preference (FAM).

However, the prediction of FAM contradicts some findings in empirical aesthetics, particularly for the context of art appreciation. Theoretical models of art appreciation suggest that cognitive resources, a primary source of subjective fluency, mitigate the influence of valence on artwork appraisal. For instance, the distancing-embracing model identifies an 'art schema' as a critical distancing factor, preventing beholders from being overwhelmed by negative feelings to assess displeasing artworks (Menninghaus et al., 2017). Similarly, the model of aesthetic appreciation and judgement includes the buffering effects of art expertise and contextual information on gut feelings (Leder et al., 2004; Leder & Nadal, 2014). Empirical evidence also supports that various cognitive factors weaken the valence-driven evaluation of visual artworks (Leder et al., 2014; Silvia, 2013; Steciuch et al., 2021; Van Paasschen et al., 2015). Given that fluency amplification effects have been mainly observed in daily objects processing such as words or images, these findings imply that its moderating power on valence effect may show different patterns between daily object and art processing (i.e., amplification versus mitigation). Since these expectations were not explicitly examined in terms of subjective fluency, it needs to be examined. We hypothesized that subjective fluency not only enhances preferences for displeasing artworks as predicted by HFM but also dilutes the valence effect, challenging FAM.

Then, how does subjective fluency weaken the valence effect on preferences during art appreciation? The pleasure-interest model (PIA model) offers a theoretical framework for this investigation (Graf & Landwehr, 2015). The PIA model says people feel negative about a stimulus when fluency is lower than expected. But ‘controlled processing’ can reduce this disfluency, increasing liking despite initial negative feelings. This means that increases in subjective fluency through controlled processing enables preference even for initially displeasing artworks by leading beholders to focus on semantically relevant parts of stimuli rather than gut feelings per se. As controlled processing is a key player in this cognitive process, previous studies based on the PIA model motivated participants to execute controlled processing by asking them to come up with the title of the stimuli in the appreciation task (Graf & Landwehr, 2017; Steciuch et al., 2021; Vissers & Wagemans, 2023). Despite its straightforwardness and utility, previous experimental protocol is limited in assessing participants’ fidelity of controlled processing because the titles they suggested were not explicitly evaluated. Also, this behavioral response could not fully capture one's dynamic processing progresses.

To address these limitations, we employed eye-tracking as an objective measure of processing style since gaze-related metrics (e.g., total fixation duration) offer insights into the spatiotemporal profile of individual- or group-level visual attention (Borys & Plechawska-Wójcik, 2017; Harezlak et al., 2021; Krauzlis, 2005). Researchers applied the eye-tracking approach to examine different top-down/bottom-up strategies between children and adults in the art appreciation (Walker et al., 2017). Inspired by this approach, we recorded participants' eye movement while they appreciated artworks to investigate their processing styles. While only images were provided to the control group, descriptive texts were also presented along with images to the experimental group to motivate this group to conduct controlled processing in the main appreciation task. Every text highlighted a perceptually unremarkable area as a semantically core region in the appreciation of the artwork (area of interest, 'AOI'). Considering that while selective attention to the perceptually salient region is performed without any involuntary processing (Egeth & Yantis, 1997; Itti & Koch, 2001; Shelton & Scullin, 2017), attention to the peripheral areas here requires biases such as contextual information (Baluch & Itti, 2011), we operationally defined fixation to AOIs as controlled processing. We predicted that the experimental group would pay attention to these AOIs, while the control group would display dispersed gazing patterns.

In this study, we examined the cognitive chains from the motivation for controlled processing based on contextual information (experimental manipulation), processing style (reflected in gazing behavior), subjective fluency to preference (measured by self-report ratings). Regarding each step, we formulated research questions and hypotheses as follows:

Q1. Experimental manipulation → Processing style: Does reading descriptive texts activate controlled processing for art appreciation? (experimental validation)

H1. Yes. The experimental group displays significantly longer fixation duration on AOIs than the control group.

Q2. Processing style → Subjective fluency: Does the effect of contextual information raise one's subjective fluency and this effect is mediated by processing style? (inspired by the PIA model)

H2. Yes. The experimental manipulation increases subjective fluency, and this effect is mediated by fixation duration on AOIs.

Q3. Subjective fluency → Preference: Does subjective fluency enhance preference for artworks? (inspired by HFM)

H3. Yes. Subjective fluency is positively associated with preference ratings.

Q4. Subjective fluency → Preference: Does subjective fluency alleviate the valence effect on preference? (inspired by theoretical models and empirical findings challenging FAM)?

H4. Yes. The interaction effect between fluency and valence on preference ratings is negative.

Methods

Participants

A total of 41 young Korean adults participated in the study (30 females; M_{age} = 22.707 yr; SD_{age} = 2.716 yr). Individuals who majored in art-related fields (i.e., art history, aesthetics, or fine arts) were excluded during recruitment process. To control for baseline emotional states that might influence preference appraisal (Lerner et al., 2015), all participants completed the Korean version of the Positive and Negative Affect Schedule ('K-PANAS') validated by Lim et al. (2010). One participant was excluded due to exceptionally high positive affect scores (i.e., exceeding the 1.5 × interquartile range). The remaining participants exhibited moderate mood states (positive: M = 17.875, SD = 4.879; negative: M = 12.950, SD = 7.082). Participants were randomly assigned to the experimental or control group, ensuring equal sample sizes. A Welch two-sample t-test did not find significant differences in positive and negative affect between groups (positive: $t(37.851) = .807$, $p = .425$; negative: $t(37.974) = 1.213$, $p = .233$). Additionally, the Vienna Art Interest and Art Knowledge Questionnaire ('VAIAK'), developed by Specker et al. (2020), was administered to manage potential effects of individual differences in art interest and knowledge on the appreciation of art (Leder et al., 2014; Silvia, 2013; Szubielska et al., 2021; Van Paasschen et al., 2015). Participants' knowledge and interest levels were comparable to those of Western laypeople reported by Specker et al. (2020) (knowledge: M = 9.050, SD = 4.679; interest: M = 45.125, SD = 12.971). Welch two sample t-test did not find any significant differences detected in both art interests and knowledge scores between groups (interest: $t(37.120) = -.205$, $p = .839$; knowledge: $t(37.889) = -.945$, $p = .351$).

Materials

Artwork stimuli

A preliminary survey was conducted to measure the affective valence of artwork stimuli and select significantly affective ones. Seventy Korean respondents (40 females; M_{age} = 22.957; SD_{age} = 3.454) participated via an online survey. They rated the valence of 100 artworks on a 7-point Likert scale (i.e., 1: "*Very negative*", 7: "*Very positive*"). Artworks with a median valence score of two or less were classified as 'negative', and those with four or more were classified as 'positive'. This labeling criteria was based on previous studies (Kliem et al., 2022; Leder et al., 2014). Thirty-four artworks were classified as 'negative' and 42 as 'positive'. To select the final stimuli, we excluded artworks that were too clear, unclear, or familiar to control for confounding effects of visual contrast (Mayer & Landwehr, 2018; Reber et al., 1998) and familiarity (Alter & Oppenheimer, 2008; Manahova et al., 2020) on processing fluency. Fifteen artworks with root-mean-squared ('RMS') contrast values outside 1.5 × interquartile range were excluded using the 'cv2' package in Python. Twenty six artworks that might be familiar to participants were also excluded (i.e., displayed at the National Museum of Modern and Contemporary Art, Korea or Seoul National University Museum of Art from April 2022 to April 2023). From the remaining 35 artworks, we selected four negative and four positive stimuli, avoiding redundancy in artists and themes. Detailed information on these eight artworks is available in **Table 1**.

Descriptive texts

To manipulate motivation for controlled processing of artworks, we included a descriptive text session before the main appreciation task. Given that motivation for controlled processing requires both stimulus- and perceiver-intrinsic triggers (Graf & Landwehr, 2017), we provided the experimental group with printed images and texts together. Negative stimuli images aimed to signal participants to pay more attention to resolve initial negative feelings (stimulus-intrinsic triggers) as reported by (Carver, 2003; Graf & Landwehr, 2017), while texts were intended to facilitate a more sophisticated approach to problem-solving by presenting contextual information (perceiver-intrinsic triggers). This approach was inspired by literature (e.g., Swami, 2013;

Szubielska & Sztorc, 2019; Walker et al., 2017). Each text, written in Korean by the first and second authors, was limited to 300 words to ensure efficiency in information delivery (Yi, 2017). Each text consisted of four paragraphs: (1) Background (e.g., “This painting presents a scene from the Book of Judith of the Old Testament, which portrays Judith and Abra, her maid, who are beheading Holofernes, an Assyrian commander.”), (2) Overall Description (e.g., “While Judith is cutting his throat, Abra holds Holofernes with all her might, who resists by kicking off his arms and legs. The firm expression of Judith shows that she is indeed determined.”), (3) AOI (e.g., “Abra, with her lips resolute and forehead wrinkled just like Judith, Abra is carrying out her part with utmost strength. She is not just the obeying maid anymore. She knows what she is doing, and the importance of her work sets her willingness.”), and (4) Message (e.g., “The lack of hesitation Judith and Abra are displaying can be interpreted as the rage that the painter must have felt at the unacceptable verdict she has received from the society, and as her hope to find someone whom she can share her pain and compassion together.”). While (1) Background and (2) Overall Description present art history knowledge for the given stimuli, (3) AOI aimed to draw participants’ attention to specific area by emphasizing that the region plays an essential role in appreciation. To rule out potential confounding effects of each artwork’s perceptual saliency on the eye-tracking analysis, we chose perceptually peripheral areas as AOIs of each stimulus. We plotted a saliency map of all eight stimuli using the Salience Toolbox (Walther & Koch, 2006). Through this, we mapped visually salient areas in terms of low-level perceptual features including contrast and orientation. We excluded all pixels mapped as salient regions to define AOIs. Among inconspicuous regions in the image, we defined AOIs considering specific details highlighted in other art historical texts to ensure the motivational effect of descriptive texts based on its plausibility (Swami, 2013)(see **Fig 1a**). The size of AOIs was unified to 5% of the given stimulus. The example of saliency map and the AOI of the stimuli N1 is demonstrated in **Fig 1** (see **Supplementary Fig 1** for those of the other stimuli). Lastly, (4) Message presented an interpretation of the given stimuli based on the AOI to facilitate controlled processing centered on the AOI. Translated versions of descriptive texts for eight stimuli are included in **Supplementary Table 1.**

Measurements

After viewing each artwork in the main appreciation task, participants answered three questions: (1) subjective fluency ("How easily did you comprehend the topic and meaning of the given artwork?"), (2) preference ("How much did you like this artwork?"), and (3) initial valence ("Which type of emotions did you feel toward this artwork when you first saw it?"). Each question was rated on a 7-point Likert scale. A single item measure was used to assess subjective fluency, which is sufficient for predictive validity (Graf et al., 2018), to minimize respondent fatigue.

Procedures

Participants first completed the descriptive text session. The experimental group read printed materials for 16 artworks (8 used in the appreciation task and 8 randomly selected to prevent them from predicting which artwork will be suggested in the appreciation task) for 10 minutes. The control group viewed printed images only for 2 minutes, ensuring the only difference between groups was the presence of text (see **Fig 1b**). Participants then sat 70cm from a monitor in a well-lit room and underwent a calibration session for the eye-tracking software, Tobii Studio Pro. For the calibration, a small black disc moving randomly on the screen was shown. Participants were asked to follow the movement of this disc. If the calibration was not completed, the process was repeated. During the appreciation task, participants viewed each artwork (4,000ms) after a fixation point (500ms), followed by three sequential questions (no time limit) and a black screen (1,000ms). This process was repeated for all eight artworks in a random sequence. In tracking participants' eye movement during the appreciation task, Tobii-X120 and Tobii Studio Pro were applied. The eye tracking software followed eye movement to a rated accuracy of 0.5° with a sampling rate of 60Hz. The fixation event was stated by the Tobii fixation filter (I-VT filter) as when the gaze to a specific spot within 0.5° of the visual angles was fixed for at least 100ms. Overall procedures of the experiment are described in **Fig 2.**

Analysis

Bayesian mixed effect modeling

Hypotheses were tested using Bayesian mixed effect modeling with the 'brms' package (Bürkner, 2017) in R studio (version 2023.03.1+446). Bayesian modeling is advantageous for small sample sizes due to its use of informed priors (Bürkner, 2017; Kruschke et al., 2012; Smid et al., 2020). The models (1) and (2) examined whether fluency and preference ratings were confounded by art-related knowledge and interest levels. Bayesian mixed models included VAIAK knowledge and interest scores as regressors and random intercepts for participants and stimuli:

$$\text{fluency}_{ij} = \beta_{10} + \beta_{11} \cdot \text{VAIAK}_i^{\text{knowledge}} + \beta_{12} \cdot \text{VAIAK}_i^{\text{interest}} + u_{1i} + u_{1j} + \epsilon_{ij} \quad (1)$$

$$\text{preference}_{ij} = \beta_{20} + \beta_{21} \cdot \text{VAIAK}_i^{\text{knowledge}} + \beta_{22} \cdot \text{VAIAK}_i^{\text{interest}} + u_{2i} + u_{2j} + \epsilon_{ij} \quad (2)$$

in which i is a participant index, j is a stimulus index, u is a random intercept of each participant and stimulus, and ϵ is an error term.

We extended the integrated HFM-FAM model suggested by Landwehr and Eckmann (2020) by including total fixation duration ('TFD') and total visit duration ('TVD') metrics extracted from eye-tracking measurement (see **Fig 3**). Six models were constructed:

$$\text{TFD}_{ij} = \beta_{30} + \beta_{31} \cdot \text{group}_i + u_{3i} + u_{3j} + \epsilon_{ij} \quad (3)$$

$$\text{TVD}_{ij} = \beta_{40} + \beta_{41} \cdot \text{group}_i + u_{4i} + u_{4j} + \epsilon_{ij} \quad (4)$$

$$\text{fluency}_{ij} = \beta_{50} + \beta_{51} \cdot \text{group}_i + \beta_{52} \cdot \text{TFD}_{ij} + u_{5i} + u_{5j} + \epsilon_{ij} \quad (5)$$

$$\text{fluency}_{ij} = \beta_{60} + \beta_{61} \cdot \text{group}_i + \beta_{62} \cdot \text{TVD}_{ij} + u_{6i} + u_{6j} + \epsilon_{ij} \quad (6)$$

$$\text{preference}_{ij} = \beta_{70} + \beta_{71} \cdot \text{valence}_{ij} + \beta_{72} \cdot \text{group}_i + u_{7i} + u_{7j} + \epsilon_{ij} \tag{7}$$

$$\begin{aligned}\text{preference}_{ij} = \beta_{80} + \beta_{81} \cdot \text{valence}_{ij} + \beta_{82} \cdot \text{group}_i + \beta_{83} \cdot \text{fluency}_{ij} + \\ \beta_{84} \cdot \text{valence}_{ij} \cdot \text{group}_i + \beta_{85} \cdot \text{valence}_{ij} \cdot \text{fluency}_{ij} + \\ u_{8i} + u_{8j} + \epsilon_{ij}\end{aligned} \tag{8}$$

The models (3) and (4) examines the effect of the experimental manipulation on processing style (Q1). Models (5) and (6) test the effect of experimental manipulation on fluency mediated by processing style (Q2). For mediation analyses, the model pairs (3)/(5) and (2)/(4) were respectively applied and we estimated posterior median and its equal-tail interval (‘ETI’) of direct and indirect effects of manipulation variable and mediator effect of processing style, using ‘bayestestR’ package (Makowski, Ben-Shachar, & Lüdecke, 2019). Model (7) assess the total effects of manipulation and valence on preference ratings. Lastly, model (8) tests the effect of fluency (Q3, β_{83}), the interaction between fluency and valence (Q4, β_{85}), and the interaction between manipulation and valence (β_{84}) on preference. According to our hypotheses, positive estimates are expected for β_{31}, β_{41}, β_{51}, β_{52}, β_{61}, and β_{62} (H1 and H2). Positive and negative estimates are expected for β_{83} and β_{85}, respectively (H3 and H4).

All parameters’ posterior median and 95% credible intervals (‘CI’) were estimated using Markov Chain Monte Carlo (MCMC) sampling with four chains of 5,000 iterations and a warmup of 2,000 times. Since well-informed prior distribution in the models was not available, priors were set as default distribution - student’s *t* distribution (location = 0.00, scale = 2.50). The validity of this prior setting was assessed through the posterior predictive check (see ‘Results’). To prevent divergent transitions after warmup sampling, we set ‘adapt_delta’ argument as 0.99. We applied effect coding for the experimental manipulation variable (‘1’ = the experimental group; ‘-1’ = the control group). All numeric variables were standardized. Following the Sequential Effect eXistence and sIgnificance Testing (‘SEXIT’) framework (Makowski, Ben-Shachar, & Lüdecke, 2019), we report the median of the estimates’ posterior distribution and its

95% credible interval ('CI'), along the probability of direction, the probability of significance and the probability of being large. The thresholds beyond which the effect is considered as 'significant' and 'large' are |.05| and |.30| (i.e., corresponding respectively to .05 and .30 of the outcome variable's standard deviation, 1). Convergence and stability of the Bayesian sampling have been assessed using R-hat, which should be below 1.01, and Effective Sample Size ('ESS'), which should be greater than 1,000. All statistics were summarized using the 'report' package (Makowski, 2023) in R studio.

Gaze clustering analysis

In addition to the models (1) and (2), we plotted group-level clustered gaze plots for each stimulus to examine Q1 qualitatively. These plots displayed the top two clusters of eye fixations per group. The clustering algorithms computed the distance between any two points and assigned them to the identical cluster if the distance was below a distance threshold, validated by Santella and DeCarlo (2004). Initially, it consolidated gaze points into denser configurations, gathering them around mode values. After several iterations, if the distances between the mode values exceeded a specified threshold, it grouped each gaze point located around the same mode value into the same cluster. This algorithm is formulated as follows:

$$\text{Spatial kernel}_{(x_i, y_i)} = \exp\left(-\frac{x_i^2 + y_i^2}{\sigma^2}\right) \tag{9}$$

where σ denotes the distance threshold. The algorithm displayed a single cluster if the modes for each distribution were within the distance threshold. If the modes were beyond this threshold, it exhibited the top two clusters. We examined whether one of the two clusters contained the predefined AOI. Based on the H1, we expect that the clusters from the experimental group's eye movement would include the AOIs across stimuli unlike the control one.

Results

Confounding analysis

The model (1) displayed moderate explanatory power to the variance of the fluency rating with two fixed regressors – VAIAK knowledge and interest scores (adj R^2 = .15). In this model, the effects of VAIAK knowledge score (β_{11} = .07, 95% CI = [-.14, .29]) has a 74.90% probability of being positive (> 0), 58.31% of being significant (> .05), and 1.78% of being large (> .30). The effects of VAIAK interest score (β_{12} = .02, 95% CI = [-.20, .23]) has a 55.49% probability of being positive (> 0), 37.53% of being significant (> .05), and 0.42% of being large (> .30). Estimates of all regressors successfully converged and the indices were reliable.

The model (2) also showed moderate explanatory power to the variance of the preference rating with two VAIAK scores (adj R^2 = .14). In this model, the effects of VAIAK knowledge score (β_{21} = .10, 95% CI = [-.04, .24]) has a 92.78% probability of being positive (> 0), 77.31% of being significant (> .05), and 0.32% of being large (> .30). The effects of VAIAK interest score (β_{22} = .08, 95% CI = [-.05, .22]) has a 88.58% probability of being positive (> 0), 68.57% of being significant (> .05), and .19% of being large (> .30). Estimates of all regressors successfully converged and the indices were reliable.

Results of the model (1) and (2) suggest that participants' fluency and preference ratings were not confounded by their baseline art-related knowledge and interest levels.

Relationship between experimental manipulation and processing style

The model (3) displayed substantial explanatory power to the variance of TFD with experimental manipulation variable (adj R^2 = .49). In this model, the effects of experimental manipulation (β_{31} = .35, 95% CI = [.05, .66]) has a 98.91% probability of being positive (> 0), 97.58% of being significant (> .05), and 63.89% of being large (> .30). Estimates of the regressor successfully converged and the indices were reliable.

The model (4) also exhibited substantial explanatory power to the variance of TVD with experimental manipulation variable (adj R^2 = .48). In this model, the effects of experimental manipulation (β_{41} = .35, 95% CI = [.06, .65]) has a 98.96% probability of being positive (> 0), 97.72% of being significant (> .05), and 63.32% of being large (> .30). Estimates of the regressor successfully converged and the indices were reliable.

Results of the model (3) and (4) imply that our experimental manipulation successfully motivated the experimental group to appreciate stimuli based on the controlled processing, supporting H1.

Mediation of processing style between experimental manipulation and fluency

The model (5) displayed moderate explanatory power to the variance of fluency ratings with experimental manipulation and TFD variables (adj R^2 = .17). In this model, the effects of experimental manipulation (β_{51} = .77, 95% CI = [.50, 1.04]) has a 100.00% probability of being positive (> 0), 100.00% of being significant (> .05), and 99.97% of being large (> .30). The effects of TFD (β_{52} = -.04, 95% CI = [-.16, .08]) has a 74.58% probability of being negative (< 0), 44.38% of being significant (< -.05), and 0.00% of being large (< -.30). Estimates of regressors successfully converged and the indices were reliable. Based on the model (3) and (5), direct effect of experimental manipulation on the fluency ratings was estimated as .774 (95% ETI = [.49, 1.06]). Indirect effect mediated by TFD was -.01 (95% ETI = [-.12, .09]). Mediator effect of TFD was -.05 (95% ETI = [-.29, .22]).

The model (6) displayed moderate explanatory power to the variance of fluency ratings with experimental manipulation and TFD variables (adj R^2 = .17). In this model, the effects of experimental manipulation (β_{61} = .77, 95% CI = [.50, 1.04]) has a 100.00% probability of being positive (> 0), 100.00% of being significant (> .05), and 99.96% of being large (> .30). The effects of TVD (β_{62} = -.04, 95% CI = [-.16, .08]) has a 75.51% probability of being negative (< 0), 45.02% of being significant (< -.05), and 0.00% of being large (< -.30). Estimates of regressors successfully converged and the indices were reliable. Based on the model (4) and (6), direct effect of experimental manipulation on the fluency ratings was estimated as .78 (95% ETI = [.50, 1.06]). Indirect effect mediated by TVD was -.02 (95% CI = [-.13, .08]). Mediator effect of TFD was -.06 (95% CI = [-.31, .21]).

Two mediation models indicate while our experimental manipulation successfully increases the fluency ratings, but this effect was not meaningfully mediated by gazing behaviors, not fully supporting H2.

Dual effects of subjective fluency on preference

The model (7) displayed substantial explanatory power to the variance of preference ratings with experimental manipulation and valence variables (adj R^2 = .36). In this model, the effects of initial valence (β_{71} = .59, 95% CI = [.48, .70]) has a 100.00% probability of being positive (> 0), 100.00% of being significant (> .05), and 100.00% of being large (> .30). The effects of experimental manipulation (β_{72} = .17, 95% CI = [-.05, .40]) has a 93.79% probability of being positive (> 0), 86.45% of being significant (> .05), and 13.25% of being large (> .30). Estimates of regressors successfully converged and the indices were reliable.

The model (8) displayed substantial explanatory power to the variance of the preference rating with multiple fixed regressors – valence, experimental manipulation, subjective fluency, the interaction between experimental manipulation and valence, and the interaction between fluency and valence (adj R^2 = .47). In this model, the effects of the valence (β_{81} = .46, 95% CI = [.33, .59]) has a 100.00% probability of being positive (> 0), 100.00% of being significant (> .05), and 99.17% of being large (> .30). The effects of the experimental manipulation (β_{82} = -.09, 95% CI = [-.32, .13]) has a 79.17% probability of being negative (< 0), 63.69% of being significant (< -.05), and 3.34% of being large (< -.30). The effects of subjective fluency (β_{83} = .35, 95% CI = [.26, .44]) has a 100.00% probability of being positive (> 0), 100.00% of being significant (> .05), and 87.15% of being large (> .30). The interaction between experimental manipulation and valence (β_{84} = .18, 95% CI = [.00, .35]) has a 97.49% probability of being positive (> 0), 92.37% of being significant (> .05), and 8.12% of being large (> .30). Lastly, the interaction between subjective fluency to the valence (β_{85} = -.08, 95% CI = [-.18, .01]) has a 95.35% probability of being negative (< 0), 74.43% of being significant (< -.05), and 0.00% of being large (< -.30). All estimates successfully converged, and the indices were reliable.

The results of the model (7) and (8) suggest that while subjective fluency directly enhances preference ratings as suggested by HFM, it reduces the valence effect on preference, challenging FAM. These findings support H3 and H4.

Detailed statistics of all models are summarized in **Table 2**. All posterior distributions of coefficient estimate in the model (8) are visualized in **Fig 4**. Additionally, in the model (8), our default setting for the prior distribution resulted in the predictive model of the preference ratings with modest accuracy in the posterior predictive check (see also **Fig 4**). Observed preference scores and predicted values by the model (8) exhibited significant correlations, showing moderate predictive performances (Pearson's r = .752, 95% CI = [.700, .796], p < .001).

Clustered gaze behaviors associated with processing style

Group-level clustered gaze plot for each artwork stimulus displayed distinguishable attention patterns between two groups in a qualitative manner (**Fig 5** for negative stimuli and **Supplementary Fig 2** for positive one). In the stimulus N1 and N3, only the experimental group's clusters included predefined AOIs. The control group showed a tendency to fix their eye movement at the visually salient areas (e.g., the body of the troll in the N1 and the face of Judith in the N3). In case of the stimulus N4, both groups' clusters encompassed AOI. Nevertheless, while the control group's attention pattern was somewhat dispersed across the image – we detected only a single large cluster from the control group, the experimental group paid attention to the AOI specifically. Also, regarding the stimulus N2, both groups' clusters contained the AOI specifically. In the cases of positive stimuli, both groups displayed distinctive patterns in gazing behaviors except for the stimulus P1.

Despite the variability among stimuli, these results imply a distinct spatial pattern of group-level attention. The experimental group paid attention to both AOIs and perceptually salient regions, but the control one fixed their eye movement in a dispersed way centered on the salient regions.

Discussion

In this study, we examined the dual role of subjective fluency in the preference for visual artworks that evoke negative affect, based on the integrated HFM-FAM model. We also explored the cognitive mechanisms linking subjective fluency and preference, inspired by the PIA model. We hypothesized that participants who received contextual information about the artwork stimuli would engage in controlled processing (H1), which would be associated with high subjective fluency (H2). Additionally, we hypothesized that subjective fluency would increase preference (H3) and mitigate effect of valence on preference (H4). Our findings suggest that while contextual information facilitates controlled processing at eye movement level, this processing style does not significantly result in enhanced subjective fluency. However, subjective fluency was found to increase preference and reduce the impact of valence on preference, supporting H1, H3, and H4, but not H2.

Contextual information and controlled processing

The experimental group that read descriptive texts alongside the stimuli images focused more on perceptually peripheral but semantically relevant regions (i.e., AOIs) during the appreciation task, indicating controlled processing. This aligns with psycho-historical perspectives of aesthetic appreciation. For instance, Bullot and Reber (2013) proposed a three-stage model of aesthetic appreciation: ‘basic exposure’, ‘artistic design stance’, and ‘artistic understanding’. While the basic exposure phase is triggered by perceptual features of objects (e.g., size or shape), the artistic design stance requires historical knowledge, leading viewers to infer background information about the composition (e.g., authorship or style). This stance helps viewers progress to the final stage, artistic understanding, where they interpret the value of the composition and its emotional impact. Experimental studies have shown that contextual information, such as titles or descriptive texts, enhances viewers’ artistic design stance and understanding, resulting in better appreciation (Brieber et al., 2014; Gartus & Leder, 2014;

Swami, 2013; Szubielska & Sztorc, 2019). These findings suggest that experimental participants engage more actively and thoughtfully in the appreciation task when provided with contextual information from descriptive texts.

In terms of information processing, the experimental group's gazing behavior reflects 'top-down' selection, driven by prior knowledge, as opposed to the 'bottom-up' selection in the control group, driven by perceptual features (Itti & Koch, 2000; Katsuki & Constantinidis, 2014). This top-down selection, characterized by controlled processing (Shelton & Scullin, 2017), suggests that contextual information effectively motivates participants to engage in controlled processing, opening opportunities for disfluency reduction and stronger aesthetic preference.

Nevertheless, it should be noted that fixation metrics of the experimental participants to AOIs might be overrated due to the experimental design in which they explored stimuli images before the main appreciation task so that they could identify AOIs a priori. To minimize the bias, our findings need to be examined based on the refined design protocol in which they are not exposed to artwork images before the main task.

Controlled processing and fluency dynamics

Our manipulation increased subjective fluency, but this effect was not mediated by the processing style reflected in gazing behavior, seemingly contradicting the PIA model. The distinction between disfluency reduction in the PIA model (i.e., fluency delta) and subjective fluency (i.e., resultant fluency) we measured is crucial here. The PIA model emphasizes fluency delta – the change from initial to resultant fluency – as the main source of aesthetic liking. If resultant fluency is higher than initial fluent feelings (i.e., fluency delta > 0), perceivers show aesthetic interest. Conversely, a negative delta value results in confusion.

This implies that fluency delta needs to be distinguished from resultant fluency in the relationship between controlled processing and aesthetic preference. For example, perceivers who initially felt high levels of fluency may still rate their subjective fluency high after appreciation without controlled processing (i.e., low fluency delta but high resultant fluency). In contrast, others who displayed extremely low levels of initial fluency would increase their fluent feelings through controlled processing, but their resultant fluency could still be lower than that of already-fluency individuals (i.e., high fluency delta but low resultant fluency). Considering that our measurement of subjective fluency corresponds to resultant fluency, it is necessary to compute fluency delta by also measuring participants' initial fluency levels to investigate the effects of processing style during art appreciation more precisely.

Subjective fluency and preference for displeasing artworks

The dual role of subjective fluency in influencing preferences for displeasing artworks supports previous findings in empirical aesthetics. Firstly, the positive effect of subjective fluency on preference aligns with the HFM prediction. Subjective fluency indicates successful understanding of a stimulus and provides confidence in the processing of that stimulus, thus contributing to hedonic feelings during appraisal (Landwehr & Eckmann, 2020; Winkielman et al., 2003). This hedonic marker influences beholders' preference ratings for an artwork, even if it initially evokes negative feelings.

Secondly, the protective effect of subjective fluency against the negative valence effects on preference challenges the FAM but aligns with some theoretical models in empirical aesthetics. The distancing-embracing model (Menninghaus et al., 2017) and the model of aesthetic appreciation and judgment (Leder et al., 2004; Leder & Nadal, 2014) emphasize the role of cognitive resources, including art expertise, in fostering less gut-dependent appraisals of artworks, especially those inducing negative emotions in modern art. Also, experimental studies have shown that cognitive factors such as art expertise (Leder et al., 2014; Silvia, 2013; Van Paasschen et al., 2015), motivation for cognitive enrichment (Steciuch et al., 2021) and trait neuroticism (Chamorro-Premuzic et al., 2010) buffer emotional reactivity in the appreciation of artworks. Our results highlight a unique aspect of art appreciation compared to processing ordinary stimuli in daily life.

What makes art appreciation different from daily object processing? One explanation is the aesthetic dimension of art appreciation. Influenced by Kantian and Schillerian ideas, contemporary philosophical and empirical aesthetics identify ‘disinterestedness’ as a key factor (Hilgers, 2016; Matherne & Riggle, 2020; Vandenabeele, 2012). Disinterestedness contrasts with desire, as it is not driven by gut feelings or personal interest (Guyer, 1978). Instead, it involves contemplating the object and adjusting one’s mental state to fit the external environment. In other words, “while desire is about making the world fit the mind, experiences with aesthetic dimension are about making the mind fit the world.” (Van de Cruys et al., 2024). This disinterested attitude aims at object-driven ‘meaning construction’, a potent source of aesthetic preference (Ball et al., 2018; Belke et al., 2015; Belke et al., 2010; Millis, 2001). In this meaning-making process, the role of affective valence in preference assessment is reduced to being part of the ingredients of meaning construction rather than a direct source of preference. For instance, the disgusting feeling evoked by the gruesome beheading scene in stimulus N3 is not a direct deterrent during disinterested processing but is used to highlight Abra’s firm beliefs and actions, enhancing the overall theme and preference for the artwork. This argument clarifies the cognitive differences between art appreciation and daily object processing, suggesting critical considerations regarding the application of FAM in empirical aesthetics.

Limitations

Several limitations should be considered. First, a larger sample size and more trials are necessary to enhance statistical power and reproducibility. Additionally, participants with more diverse cultural backgrounds are mandatory to test the generalizability of our findings, considering the association between cultural variability and heterogeneity in appraisal patterns (Darda & Cross, 2022; Kharkhurin & Yagolkovskiy, 2021; Mastandrea et al., 2021). Second, the potential bias in the experimental group's fixation duration at AOIs need to be addressed by ensuring they do not see images prior to the main appreciation task. Third, real-time measurements of fluency would provide a more nuanced understanding of the relationship among processing style, fluency dynamics and preference ratings. Furthermore, neurophysiological tracking such as an electroencephalogram linked to the dynamics of fluency and valence during the appreciation task will be promising to integrate the brain-cognition-behavior interactions in the art-related experiences.

Conclusion

Notwithstanding these considerations, this study broadens the understanding of the relationship between fluency, valence, and preference in empirical aesthetics. Using an eye-tracking approach, we found that prior information about the artworks facilitates controlled processing. Even though gazing behavior related to controlled processing was not directly related to subjective fluency levels, participants who engaged in controlled processing felt more fluent with the artwork stimuli compared to the control group who used automatic processing. Complementing conventional instruction-based manipulation of processing style, our integrated approach of gaze tracking and self-reporting allows researchers to assess differences in processing style relative to fluency levels in a more nuanced manner. With this methodology, we evaluated the generalizability of fluency-preference models in the context of art appreciation. The hedonic value of subjective fluency was observed in art appreciation as it is in ordinary contexts, but its amplifying effects in the valence-preference relationship were reversed – weakening the valence effect. This finding suggests fundamental differences in cognitive processes between daily object processing and artwork appreciation. We anticipate that our work will motivate further studies to explore the source of this difference between ordinary object and artwork processing.

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Table 1. A List of Selected Eight Artwork Stimuli

Condition	Index	Title	year	artist	theme
Negative stimulus	N1	The Ash Lad beheads the Troll	1900	Theodor Kittelsen	Folks
	N2	The Execution of Lady Jane Grey	1833	Paul Delaroche	Historical event
	N3	Judith beheading Holofernes	1620	Artemisia Gentileschi	Religious episode
	N4	Here Comes the Bogeyman, plate three from Los Caprichos	1797-1799	Francisco José de Goya y Lucientes	Daily lives
Positive stimulus	P1	Love of Winter	1914	George Wesley Bellows	Daily lives
	P2	Italian Landscape	17th century	Pieter Spiernckx	Landscape
	P3	Roses in the Glass	1831	Ferdinand Georg Waldmüller	Still life
	P4	Belshazzar's Feast	1636-1638	Rembrandt	Religious episode

Table 2. Statistics of the Model (1) to (8)

Model	Adjusted R^2	Parameter	Posterior median	95% Credible interval	Probability of being positive/negative (%; ≠ 0)[a]	Probability of being significant (%; > |.05|)	Probability of being large (%; > |.30|)	$\hat{R}$	ESS
Q1. Experimental manipulation → Processing style (experimental validation)									
(1)	.15	β_{11}	.07	[-.14, .29]	74.90	58.31	1.78	1.001	5,087
		β_{12}	.02	[-.20, .23]	55.49	37.53	0.42	1.000	4,871
(2)	.14	β_{21}	.10	[-.04, .24]	92.78	77.31	0.32	1.000	10,791
		β_{22}	.08	[-.05, .22]	88.58	68.57	0.19	1.000	11,204
Q2. Processing style → Subjective fluency (inspired by PIA model)									
(3)	.49	β_{31}	.35	[.05, .66]	**98.91**	97.58	63.89	1.001	2,669
(4)	.48	β_{41}	.35	[.06, .65]	**98.96**	97.72	63.32	1.001	2,851
(5)	.17	β_{51}	.77	[.50, 1.04]	**100.00**	100.00	99.97	1.000	5,709
		β_{52}	-.04	[-.16, .08]	74.58	44.38	0.00	1.000	11,026
(6)	.17	β_{61}	.77	[.50, 1.04]	**100.00**	100.00	99.96	1.000	6,731
		β_{62}	-.04	[-.16, .08]	75.51	45.02	0.00	1.000	14,080
Q3 & Q4. Subjective fluency → Preference (inspired by HFM-FAM model)									
(7)	.36	β_{71}	.59	[.48, .70]	**100.00**	100.00	100.00	1.000	4,733
		β_{72}	.17	[-.05, .40]	93.79	86.45	13.25	1.000	14,006
(8)	.47	β_{81}	.46	[.33, .59]	**100.00**	100.00	99.17	1.000	8,165
		β_{82}	-.09	[-.32, .13]	79.17	63.69	3.34	1.001	3,898
		β_{83}	.35	[.26, .44]	**100.00**	100.00	87.15	1.000	10,429
		β_{84}	.18	[.00, .35]	**97.49**	92.37	8.12	1.000	14,632
		β_{85}	-.08	[-.18, .01]	**95.35**	74.43	0.00	1.000	10,857

[a] In Bayesian linear model, the existence of effects is mainly evaluated by probability of being positive/negativity (as known as 'probability of direction' or 'PD'). Makowski, Ben-Shachar, Chen, et al. (2019) suggested the following referential values of PD for interpretation: PD ≤ 95%: 'uncertain' (~ p > .10); PD > 95%: 'possibly existing' (~ p < .10); PD > 97%: 'likely existing'; PD > 99%: 'probably existing'; PD > 99.9%: 'certainly existing'. We bolded parameter whose PD > 95%.

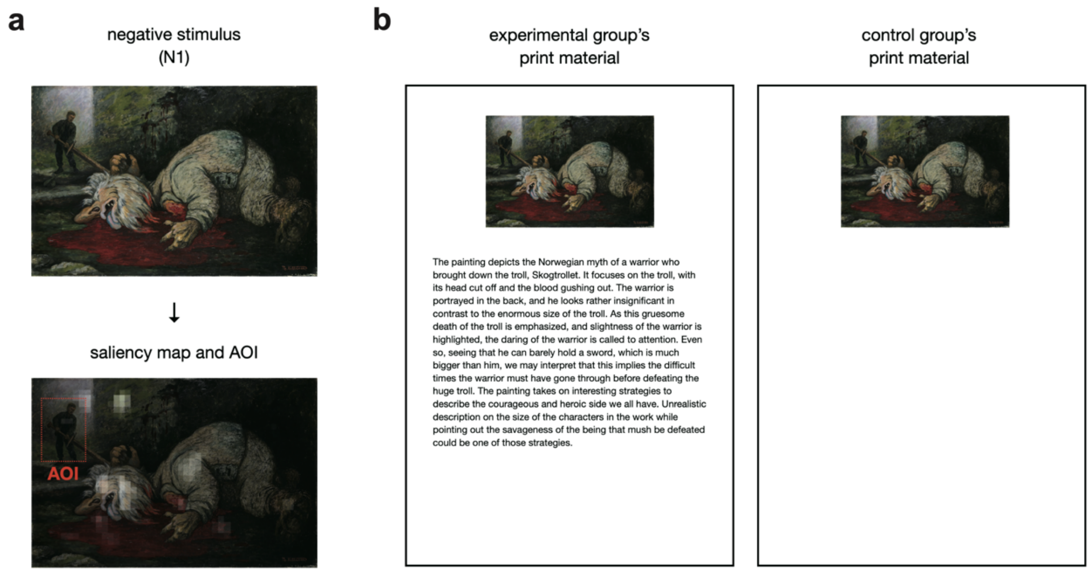

Fig 1. Saliency map, AOI, and Descriptive texts: example of stimulus N1. a. The artwork stimulus and its saliency map and AOI. The saliency map of each stimulus was computed by the Salience Toolbox (Walther & Koch, 2006). In the saliency map, white pixels remark salient regions. We defined 5% of the whole artwork stimulus as the AOI among the areas not identified as 'salient regions'. **b.** Print materials given to the experimental and control group in the descriptive text session. Total 16 materials were given to both groups. The experimental group was instructed to read texts along with images for 10 minutes while the control group to explore only images for two minutes. Artwork image reproduced with permission; Theodor Kittelsen, *The Ash Lad beheads the Troll*, Oil on canvas, 690×460mm. Nasjonalmuseet for kunst, arkitektur og design. Copyright of the images: © Nasjonalmuseet for kunst, arkitektur og design (https://www.nasjonalmuseet.no/).

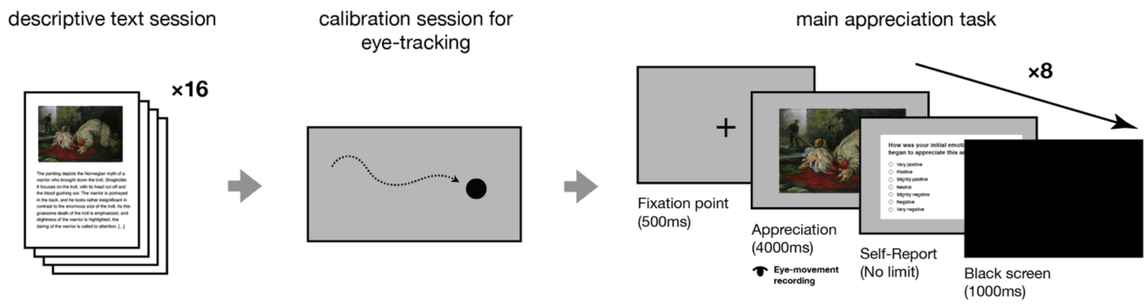

Fig 2. The Overall Procedure of the Experiment. Descriptive text session (left). Calibration session for precise measurement of eye movement (center). Main appreciation task (right). The appreciation task consisted of eight blocks with the random order. In a single block, a fixation point (500ms), the artwork stimulus (4,000ms), three-item questionnaire measuring one's initial valence, subjective fluency, and the preference (no time limit), and a black screen (1,000ms) were sequentially displayed. Artwork image reproduced with permission; Theodor Kittelsen, The Ash Lad beheads the Troll, Oil on canvas, 690×460mm. Nasjonalmuseet for kunst, arkitektur og design. Copyright of the images: © Nasjonalmuseet for kunst, arkitektur og design (https://www.nasjonalmuseet.no/).

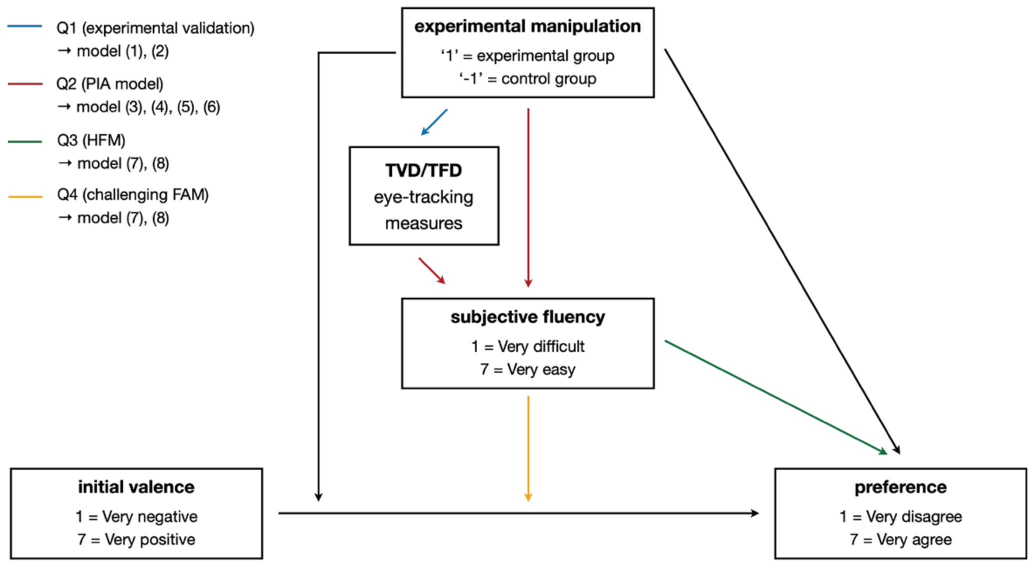

Fig 3. The Conceptual Scheme of the Models. The blue edge corresponds to the model (1) and (2) for Q1 while the red ones to the model (3), (4), (5) and (6) for Q2 based on PIA model. The yellow and green edges indicate the model (7) and (8) to examine Q3 and Q4, respectively. The scheme is adopted from the Landwehr and Eckmann (2020).

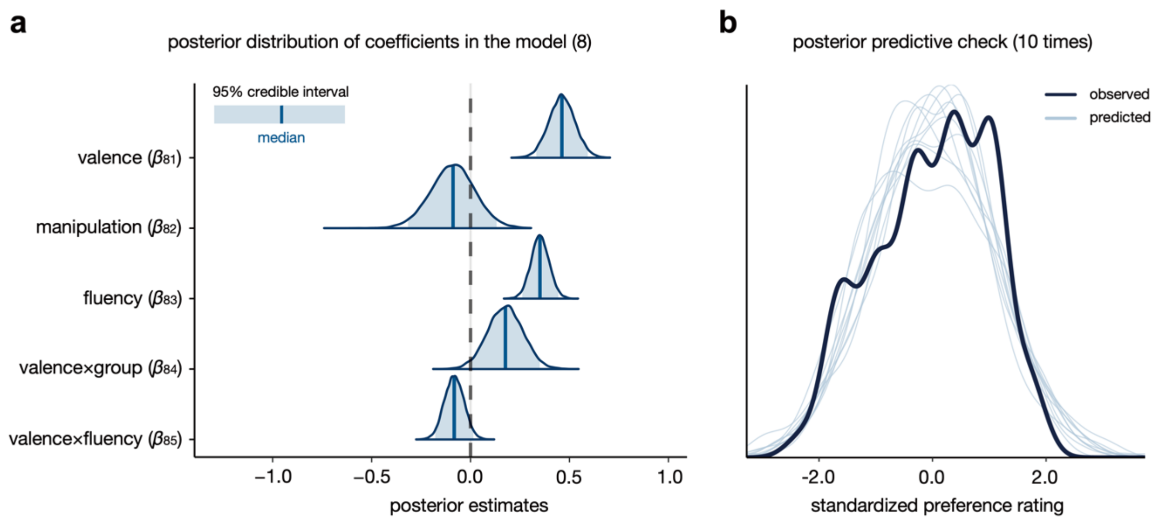

Fig 4. The Posterior Distribution of Estimates in the Model (8) and Posterior Predictive Check. a. Posterior distribution of coefficients in the model (8). Shaded area of each distribution plot denotes 95% credible interval. Blue vertical line indicates the posterior median. Dotted vertical line shows zero. **b.** Posterior predictive check. It compares the distribution of observed preference ratings and its predicted distribution by the model (8).

Fig 5. The Clustered Group-level Gaze Plots of Negative Valence Stimuli. The red and blue solid lines indicate the group-level clusters of the control and experimental groups, respectively. The percentage shows how many participants in each group fixed their eye movement at least once in the cluster. The yellow dotted line displays defined AOIs. (N1) Artwork image reproduced with permission; Theodor Kittelsen, The Ash Lad beheads the Troll, Oil on canvas, 690×460mm. Nasjonalmuseet for kunst, arkitektur og design. Copyright of the images: © Nasjonalmuseet for kunst, arkitektur og design (https://www.nasjonalmuseet.no/). (N4) Artwork image reproduced with permission; Francisco José de Goya y Lucientes, Here Comes the Bogeymen, plate three from Los Caprichos, Etching and aquatint on ivory laid paper, 19.3×13.6cm. The Art Institute of Chicago (https://www.artic.edu/). Open-access public domain copyright.

The twofold role of subjective fluency in displeasing but preferable visual artworks:

Self-report and eye-tracking analysis

Jinwoo Yi[1], Dayoun Choi[2], Joung A Eom[3], Mijung Kang[3]

Affiliations

[1] Department of Brain and Cognitive Sciences, Seoul National University, South Korea

[2] Department of Psychology, Seoul National University, South Korea

[3] Department of Aesthetics, Seoul National University, South Korea

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▪ Supplementary Table 1

▪ Supplementary Figure 1~2

Author Note

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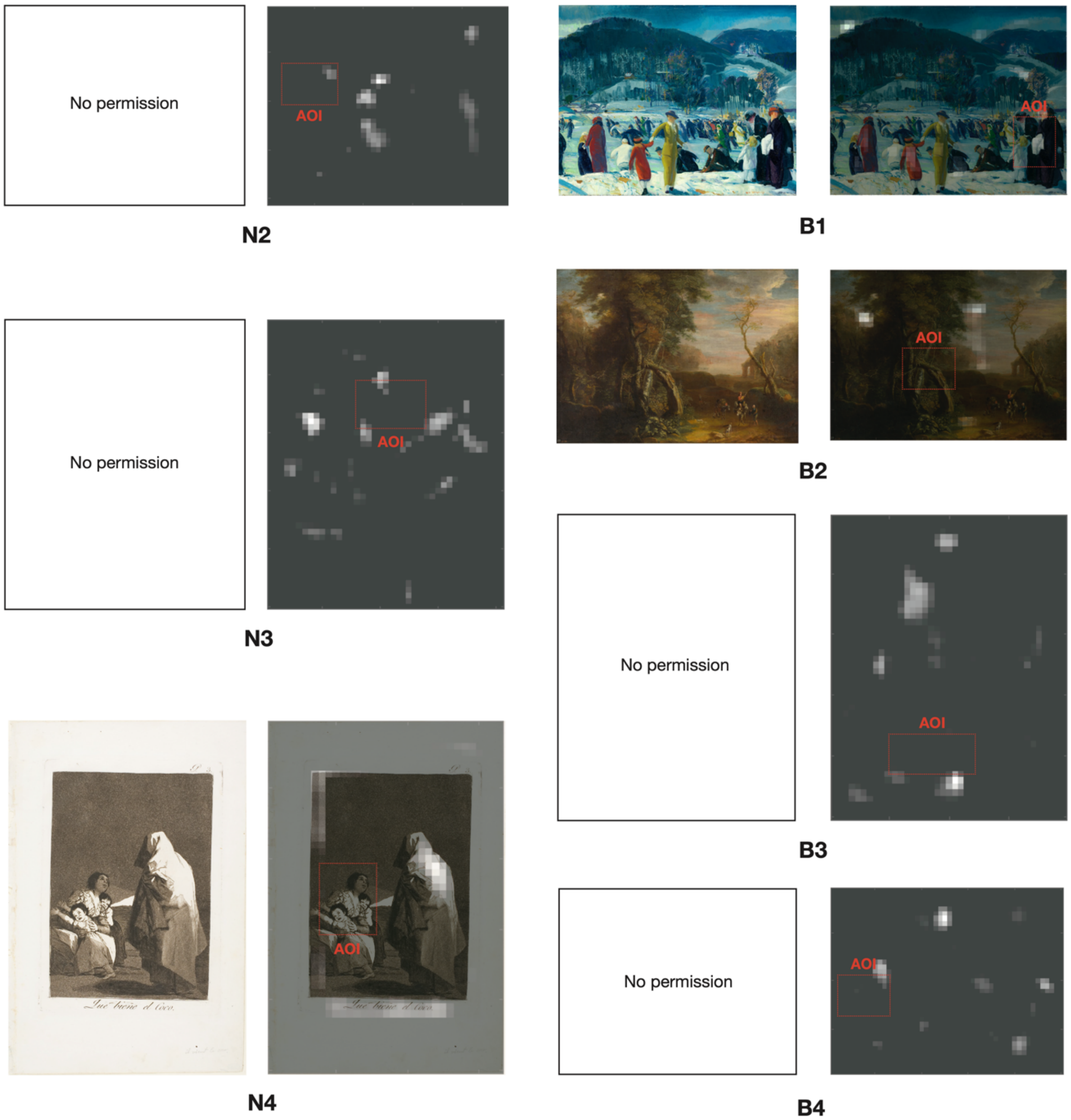
Correspondence concerning this article should be addressed to Jinwoo Yi, Department of Brain and Cognitive Sciences, Seoul National University, Gwanak-ro 1, Building 16, Office M519, Gwanak-gu, Seoul, 08826, South Korea. Email: adem1997@snu.ac.kr

Supplementary Table 1. The Descriptive Texts for Each Artwork Stimulus

Stimulus	Component	Descriptive Texts
N1	Background Knowledge	The painting depicts the Norwegian myth of a warrior who brought down the troll, Skogtrollet.
	Overall Description	It focuses on the troll, with its head cut off and the blood gushing out. The warrior is portrayed in the back, and he looks rather insignificant in contrast to the enormous size of the troll.
	AOI	As this gruesome death of the troll is emphasized, and slightness of the warrior is highlighted, the daring of the warrior is called to attention. Even so, seeing that he can barely hold a sword, which is much bigger than him, we may interpret that this implies the difficult times the warrior must have gone through before defeating the huge troll.
	Message	The painting takes on interesting strategies to describe the courageous and heroic side we all have. Unrealistic description on the size of the characters in the work while pointing out the savageness of the being that must be defeated could be one of those strategies.
N2	Background Knowledge	The painting introduces the tale of Jane Grey, the English queen who became a victim of political war by greediness of court people.
	Overall Description	The person who is trying to find the scaffold, with her eyes covered up,is Jane Grey, and this disturbing scene inspires sympathy. But perhaps the most sympathetic of all, who are the memorable eyewitnesses of this tragic historical event, would be the people sobbing in the back .
	AOI	Especially two women at the left side, who seem to have fainted, unable to bear the sight of the scene. They would be the maids who must have been most loyal to Jane Grey, and their crouched backs convey their sorrow.
	Message	Unlike the paintings that present notable historical events in neutral light, this painting uncovers injustice of the era. It could be interpreted as novel directions of historical painting, since the painter clearly shows one’s political views as a citizen might have.
N3	Background Knowledge	This painting presents a scene from the Book of Judith of the Old Testament, which portrays Judith and Abra, her maid, who are beheading Holofernes, an Assyrian commander.
	Overall Description	While Judith is cutting his throat, Abra holds Holofernes with all her might, who resists by kicking off his arms and legs. The firm expression of Judith shows that she is indeed determined.
	AOI	Abra, with her lips resolute and forehead wrinkled just like Judith, is carrying out her part with utmost strength. She is not just the obeying maid anymore. She knows what she is doing, and the importance of her work sets her willingness.
	Message	The lack of hesitation Judith and Abra are displaying can be interpreted as rage that the painter must have felt at the unacceptable verdict she has received from the society, and as her hope to find someone whom she can share her pain and compassion with.
N4	Background Knowledge	The painting satirizes the conduct of those days when fear was used to discipline one’s children.
	Overall Description	Mother and two children were looking up at someone covered in a long cloak. He is the Bogeyman, who punishes ‘bad children’. There is indeed terror toward Bogeyman clearly shown on children’s faces.
	AOI	However, their mother is smiling faintly instead. She, unlike her children, knows that Bogeyman does not exist; he is only a superstition made up by the adults. Rather, it is easier for mothers to control children as their alarm for the Bogeyman grows.
	Message	Making us realize how education of those days must have brought intense anxiety upon the children through frightful illusions, the painting poses the question whether this discipline would not cease to control children as they grow older.

P1	Background Knowledge	The painting describes local people who are enjoying seeing the town covered up with snow, as there was a huge blizzard at New York where the painter lived, in 1914.
	Overall Description	People in colorful coats are running everywhere, and it implies the cheerful atmosphere the scene beholds.
	AOI	Yet, there are people at the right side, in black attires, and their sober air is quite different from the general mood. But the gleeful and the mourners, who must have attended the funeral of one’s kin, are all mingled into a crowd, surrounded by the glittering snow.
	Message	True, this beauty of the scene would melt away one day, just like sadness suddenly invading our lives. Nevertheless, the painting seems to want to tell us to forget about the flow of time and take pleasure in the wonders and delights before us.
P2	Background Knowledge	Italy in the late 19th century was much unstable, in political and in economic sense, due to the changes introduced by constitutional monarchy and industrial regulations.
	Overall Description	The painting depicts countryside scenery during the era. Ironically, people are playing guitar, and they are laughing and having a good time themselves, unlike the mood of the country.
	AOI	Now, although dawn in its golden glory does enhance the atmosphere, look: how does the broken tree at the side, all shrouded in darkness, appear to our eyes?
	Message	The confusion, anxiety, and desperation of the people do exist still. In this unique way, the painting claims that although we should not forget difficulties underneath the enjoyment, daily happiness could be the solution in such a situation.
P3	Background Knowledge	The still-life painting, painted in the 19th century, depicts objects often used in daily lives of aristocrats.
	Overall Description	Roses in full bloom, cups, books, candles, and candlesticks can be observed in the work.
	AOI	The book draws our interest, as it reminds us of its permanence by preserving human knowledge, with the development of publishing, unlike the fleeting flowers and candles.
	Message	The preciousness of solid, timeless value among the ravishing, but short-lived objects is what can be derived from the painting.
P4	Background Knowledge	The painting describes a scene, where Belshazzar, who became the king of Neo-Babylonian Empire after Nebuchadnezzar, is throwing a feast.
	Overall Description	Here we see gold and silver plates which were stolen from Jerusalem to be used in the feast. This was unacceptable behavior, since the plates used for holy occasions were stolen and moreover, reused as luxuries in one’s feast.
	AOI	There, a hand appears out of nowhere, and is writing a warning message from God, which makes everyone shudder in fear. The notorious flatterer and his wife on the left are the ones who seem the most shocked.
	Message	Thus, the painting is teaching us a religious lesson that one must be held again in reverence to God, which could be easily forgotten among earthly riches.

Supplementary Fig 1. The Saliency Map and AOI Setting of the Other Seven Stimuli.



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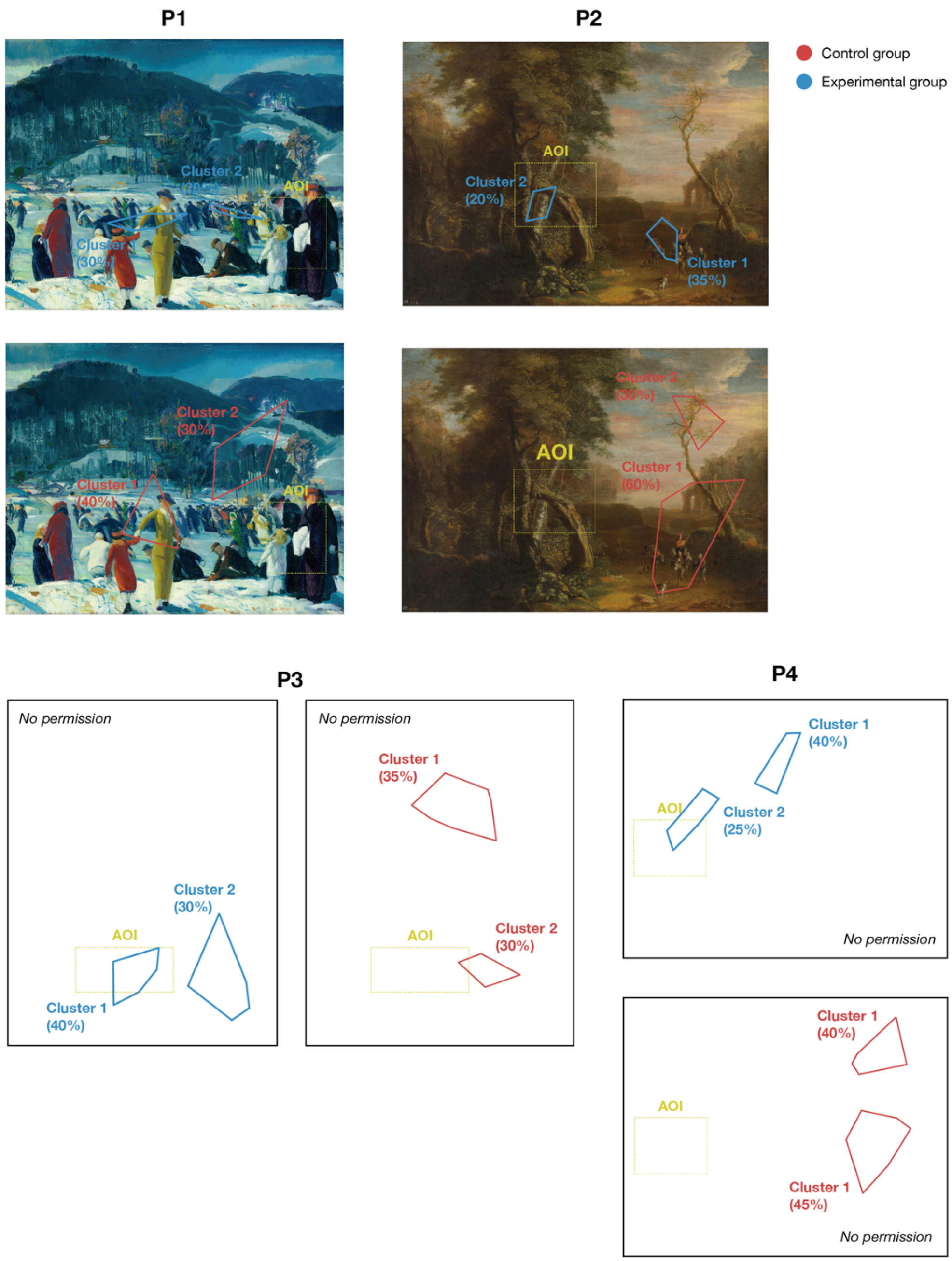
Supplementary Fig 2. The Clustered Group-level Gaze Plots of Positive Valence Stimuli.



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