Pupillary Responses in Art Appreciation: Effects of Aesthetic Emotions

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The authors examined effects of aesthetic emotions in art appreciation. Subjects were presented three groups of slides of cubistic paintings that differed in their processing fluency. In an explicit classification procedure, subjects were asked to indicate by button press the moment when they recognized any depicted object in the painting. The time to recognize a depicted object was shortest for high processing fluency paintings, which were also rated higher in their preference. This is in accordance with the "hedonic fluency model" that predicts higher processing fluency being associated with positive aesthetic emotions in art appreciation (Reber, Schwartz, & Winkielman, 2004). In addition, higher processing fluency was associated with increased pupil dilations following the point of explicit classification. The finding of higher pupil dilation associated with easy-to-process stimuli is interpreted as reflecting aspects of aesthetic emotions that follow explicit classification of art stimuli as proposed in the "model of aesthetic appreciation and aesthetic judgments" (Leder, Belke, Oeberst, & Augustin, 2004).

Keywords: aesthetic emotions, pupillary responses, fluency, cubistic paintings

Although empirical aesthetics have a long history in experimental psychology starting with the works of Fechner (1876), the processes underlying art appreciation are still not well understood. In his psychophysics approach Fechner (1876) mainly examined aesthetic experiences triggered by simple geometric stimuli aiming to confirm general laws of stimulus features, such as certain proportions, to evoke aesthetic pleasure. In contrast, recent studies in empirical aesthetics often focus on the perceiver characteristics that determine aesthetic experiences in the persons who are appreciating art. As such, results of modern experimental psychology rather support the Kantian subjectivist view that art provokes aesthetic experiences in the perceiver (see Kawabata & Zeki, 2004). Appreciation of art is seen as an ongoing elaboration of meaning (Cupchik, Shereck, & Spiegel, 1994; Leder et al., 2004). For example, Leder et al. (2004) proposed a stage "model of aesthetic appreciation and aesthetic judgments" that incorporates ongoing cognitive and affective evaluation and mastering at different levels of processing, from early perceptual analyses to cognitive mastering and its evaluation. The proposed outcomes of this model are aesthetic judgments and the experience of aesthetic emotions.

Aesthetic experiences, in particular experiences of preference and beauty, are often reported as responses to art (Berlyne, 1971; Leder et al., 2004; Martindale & Moore, 1988; Russell, 2003) and have been described as a result of evaluation or appraisal processes (Kawabata & Zeki, 2004; Reber et al., 2004; Russel, 2003; Scherer, 2001; but see Silvia & Brown, 2007, for a discussion on negative aesthetic emotions). For example, additional information like a descriptive or elaborative title have been shown to increase the pleasantness ratings of a painting (Russell, 2003) or its understanding (Leder, Carbon, & Ripsas, 2006). Such findings support theories that claim a close relationship between the pleasure derived from looking at a picture and "having grasped its meaning and understood it" (Russell, 2003, p. 100). Thus, part of the pleasure derived from looking at paintings is ascribed to successful cognitive processing.

Different theories of aesthetic experiences address this issue. According to Berlyne's psychobiological approach, experiences are driven by two opposing affect systems, a positive reward and a negative aversion system (Berlyne, 1971). Aesthetic preference is directly related to physiological arousal following an inverted u-shaped function. Apprehending art increases arousal, and it is claimed that the perceiver experiences either a drop or a sudden increase in arousal as pleasurable. Such hedonic reduction of arousal can be expected as a result of solving the challenges provided by the complexity or meaningfulness of an artwork (Berlyne, 1971). This model has been criticized by Martindale and Moore (1988), who found no evidence of an inverted relationship between preference and arousal. Rather, they pointed to the role of prototypicality for positive aesthetic experiences of preference and liking. Prototypical objects are preferred in everyday life (Rosch, 1975), and prototypicality is an important determinant of preference ratings (Hekkert, Snelders, & van Wieringen, 2003; Martindale & Moore, 1988; Winkielman, Halberstadt, Fazendeiro, & Catty, 2006).

Generally, some researchers proposed that the cognitive ease with which information is processed leads to positive affect. This has been discussed as an effect of processing fluency as part of the "hedonic fluency model" (Reber et al., 2004; Winkielman & Cacioppo, 2001; Winkielman, Schwarz, Fazendeiro, & Reber, 2003). This hypothesis assumes that affective feedback during...
cognitive evaluation is used to internally monitor cognitive processing. A positive affective response toward fluent processing is expected to indicate good progress toward the goal of successful mastering, which is itself rewarding and supposed to play a motivational role for further processing steps (Winkielman & Cacioppo, 2001). The authors presented evidence that processing fluency, which varied as a function of the visibility of line drawings, affected preference ratings as well as corresponding reactions in facial electromyography. Easy-to-process pictures elicited higher preference ratings and higher activations over the region of the zygomaticus major, which is known to indicate positive affect (Winkielman & Cacioppo, 2001). Similarly, Reber et al. (2004) reviewed data that suggest that processing fluency of aesthetic objects is closely associated with aesthetic pleasure. For example, subjects were found to report higher liking ratings for concrete pictures following conceptual priming, which was proposed to increase the processing fluency of the related concepts.

While in most of the previous studies the stimuli used were rather relatively simple, it remains an empirical question whether a sudden understanding of a rather complex, and even ambiguous stimulus such as an artwork might reveal something about the genuine nature of aesthetic experiences. Because artworks often require some perception and cognitive processing until a state of ambiguity is resolved (Leder et al., 2004), we used cubist artworks of different classes of accessibility (Hekkert & Van Wieringen, 1990) to measure the relationship between the processing of high and low fluency paintings and the aesthetic response. Because there is yet not much evidence for the affective consequence of fluency through understanding, we measured pupillary responses on artworks.

Pupillometric Indices During Art Appreciation

So far, empirical studies in aesthetics have mainly relied on behavioral data, like response times and preference ratings. Recently, psychophysiological measures have been introduced in the field of empirical aesthetics to further evaluate aesthetic experiences (e.g., Höfäl & Jacobsen, 2007; Jacobson & Höfäl, 2003; Lengger, Fischmeister, Leder, & Bauer, 2007) and the aesthetic emotions associated with processing fluency (Winkielman & Cacioppo, 2001).

We believe that the use of psychophysiological data, in particular measuring pupillary responses, could provide new evidence for the affective processes involved in art appreciation. Task-evoked pupillary responses have reliably been shown to be as sensitive to affective (Beatty, 1982; Mudd, Conway, & Schindler, 1990; Steinhauer, Boller, Zuben, & Pearlman, 1983; Vö et al., 2008) as to cognitive aspects of processing (Beatty & Kahneman, 1966; Granholm, Asarnow, Sarkin, & Dykes, 1996; Just & Carpenter, 1993; Kuchinke, Vö, Hofmann, & Jacobs, 2007). The peak pupil dilation has been found to vary with the amount of cognitive load associated with a memory task (Beatty & Kahneman, 1966) or emotional processing (Hess, 1965; Janisse, 1974). Regarding its role in emotional processing, two opposing proposals have been made. While Hess (1965) discussed the hypothesis of bidirectional pupillary responses to emotional stimuli with pupil dilations when looking at positive pictures and pupil constrictions for negative material (also see Mudd et al., 1990), others found pupil dilations in response to emotional stimuli independent of their actual valence (Janisse, 1974; Steinhauer et al., 1983; Partala & Surakka, 2003; Vö et al., 2008). Because the later studies controlled for the initial pupil constriction following stimulus presentation while the first two did not, these diverging results might partly be attributed to methodological differences. Taken together, these results support the assumption that pupil dilations are associated with the resources allocated to the processing of emotional stimuli.

Pupillary responses to artworks were measured by Libby, Lacey, and Lacey (1973). They observed that unpleasant slides produced greater pupil dilation than pleasant slides, which both dilated less than neutral slides. Moreover, the most reliable finding on pupil dilations in Libby et al.’s (1973) study was an effect of the artworks’ interestingness. The more interesting or attention-getting an artwork was rated, the greater the pupil dilated—indeed of its’ complexity and arousal.

The “model of aesthetic appreciation and aesthetic judgments” by Leder et al. (2004) proposes that aesthetic emotions contribute differently to art appreciation at certain processing stages. Early perceptual analyses of art stimuli could be experienced as less emotional than later stages of explicit classification and evaluation. Thus, the perceptual stages provide the material that reveals emotions in the later processing stages in respect to cognitive mastering, interpretation, and understanding. Therefore, to reveal an effect of aesthetic emotions, we implemented a task in which we directly focused on the moment of recognition of depicted objects during the apprehension of an artwork—that is the point of explicit classification (Leder et al., 2004). Subjects were asked to immediately indicate the moment when they recognized one or more familiar objects depicted in the cubistic painting (Hekkert & van Wieringen, 1990). Using this approach, Hekkert and van Wieringen (1990) observed that the time to recognize the depicted objects successfully constructed sets of artworks, which systematically differ in the ease with which the depicted objects can be recognized. We assume that this ease is equivalent to the processing fluency of the artworks. Hence, the ease of processing or processing fluency of these artworks should be reflected in the time needed to successfully recognize their depicted elements. Furthermore, in accordance with expectations from preferences for representative art (Leder et al., 2004), we also expected easy-to-process paintings to elicit higher preference ratings.

Using the explicit classification approach, we measured both the time needed to recognize a depicted object and the pupillary responses following the point of explicit classification of the cubistic paintings. By varying the processing fluency of the paintings as a function of the content accessibility or abstractness of the paintings, we expected that the processing advantage associated with processing fluency is reflected in the explicit classification times (Reber et al., 2004). In addition, pupillary responses were expected to differentially monitor the aesthetic emotions associated with processing fluency. In contrast to Libby et al. (1973) where subjects passively viewed artworks, the pupillary responses around the point of explicit classification were expected to be modulated by aesthetic emotions. In particular, higher processing fluency was expected to elicit higher pupil dilations following the point of explicit classification of depicted objects reflecting enhanced aesthetic emotions.
Method

Subjects

Twenty-five female and 10 male students and art novices \( M = 27.5; SD = 3.8 \) from Freie Universität Berlin participated in this study. The participants gave informed consent and received €5 for their participation. Data from eight participants were lost because of technical problems during pupil recording. The remaining 27 participants had normal or corrected-to-normal vision and reported no history of neurological and affective disorders.

Stimulus Material

To test our hypotheses, a one-factorial design was applied comprising the within-subject factor processing fluency (high, medium, low). Thirty-nine colored slides of cubistic paintings were selected from a larger list of 60 cubistic paintings previously rated on a 5-point scale on complexity, ranging from “low” (1) to “high” (5); abstractness, “representational” (1) to “abstract” (5); and familiarity, “unfamiliar” (1) to “highly familiar” (5), by a group of 66 students from the University of Vienna. The 60 cubistic paintings were divided into three lists with increasing but nonoverlapping rated abstractness. Thirteen slides of each list were selected so that these three experimental lists differed significantly in respect to their mean abstractness (in the following called content accessibility), but did not differ in terms of rated familiarity (an analysis of variance (ANOVA) revealed no significant differences for the rated familiarity across the three content accessibility conditions, \( p = .288 \), see Table 1).

The slides with the highest content accessibility (the list with the lowest abstractness ratings) were assigned to the high processing fluency level, medium content accessibility to medium processing fluency level, and the lowest content accessibility slides to the low processing fluency level (see Figure 1 for examples of the cubistic paintings). The selected paintings depicted either human figures or landscapes. Special effort was taken to control for the luminance of the slides of paintings, known to affect the pupillary response (Loewenfeld, 1999). The picture slides were edited using Adobe Photoshop and the colorlab toolbox for MATLAB to be comparable to the slides of paintings, known to affect the pupillary response landscapes. The filler slides were edited to be comparable to the experimental slides—a fact that was further supported by the use of our filler slides that included other contents.

Following each trial, the presentation of a smiley indicated a 3,000-ms period where subjects were allowed to blink before the new trial started with the presentation of a fixation cross. The test phase lasted approximately 8 min during which pupil raw data were recorded. Following the test phase, subjects were given a questionnaire with all 39 experimental slides printed in high quality to rate them on a 5-point scale on complexity, “low” (1) to “high” (5); abstractness, “representational” (1) to “abstract” (5); familiarity, “unfamiliar” (1) to “highly familiar” (5); and preference, “do not like” (1) to “highly prefer” (5).

Data Preparation and Analysis

Pupil data were prepared using a computer algorithm written in MATLAB (Version 6.5) that discarded trials with major blinks or linearly interpolated smaller artifacts on a trial by trial basis in the time window between 200 ms before stimulus onset and 10,000 ms poststimulus onset. Raw pupilary raw data were sampled down to a 60 Hz and smoothed using a 7-point weighted average filter. In addition, all trials were checked visually for undetected artifacts. Because of excessive blinking or recording artifacts during the long interval, 15.4% (ranging from 0% to 53.8% per subject) of all trials were discarded. Pupilary artifacts were not systematically distributed across experimental conditions.

A response-based analysis was computed where the baseline pupil diameter was defined as the average pupil diameter recorded during the last 200 ms preceding the subjects’ response and subtracted from the raw pupil diameter. Response-based peak dilations (PDs) were computed as the maximum baseline-corrected that the subjects understand the instructions correctly. The stimuli subtended at maximum a vertical visual angle of 17.19° and a horizontal visual angle of 15.28°.

The 44 slides (39 experimental and 5 filler slides) were randomly assigned on the computer screen using Presentation 9.0 software (Neurobehavioral Systems, Albany, Canada) including the IVIEW X interface to synchronize trial presentation and pupil data recording. A single trial started with the presentation of a fixation cross (+) in the center of the screen for 1,000 ms. The fixation cross was replaced by an experimental slide that remained on the screen until button press with a maximum trial duration of 9,000 ms. The slide remained on the screen for 1,000 ms following the button press for a continuous pupil recording around the time of the response (see Figure 1d).

Subjects were instructed to press the mouse button as quickly as they had recognized a concrete object depicted in the painting. In random intervals a control question appeared on the screen following a trial, where subjects were asked what they had seen in the pictures. These questions were included in the procedure to assure that the subjects correctly followed the instructions and responded only when they satisfyingly identified a recognizable object. It is important to note, that no mention was made to the subjects that only figures and objects of landscapes were potential recognizable objects in the experimental slides—a fact that was further supported by the use of our filler slides that included other contents.

1 Examples of participants’ answers for depicted objects in the presented paintings are: “a face” or “a person” in Figure 1a, “houses” or “a bridge” (Figure 1b), and “houses” or “boats” (Figure 1c).
pupil diameter in the 1,000-ms interval following the subjects’ responses. PDs were computed for all trials and afterward averaged per condition and subject. The response-based peak pupil diameter was expected to reflect affective processing around the point of explicit classification.

Only the pupillary responses to experimental trials were considered for the statistical analyses. Average PDs per experimental condition and subject were submitted to a one-way repeated measures ANOVA comprising the within-subject factor “processing fluency” (high, medium, low). Significance level was set at $\alpha = .05$, and a Greenhouse-Geisser correction was applied if necessary.

**Results**

To check whether the processing fluency manipulation showed the expected effect in the behavioral data, two repeated measures ANOVAs on response times and preference ratings were computed. The analysis of the response times revealed a main effect of processing fluency, $F(2, 52) = 126.67, p < .001; \eta^2 = 0.830$. The mean response times showed a parametric pattern with shortest response times when processing cubistic paintings with high processing fluency and the longest response times to paintings with the lowest processing fluency (see Table 2, Figure 2). A series of Bonferroni-corrected $t$ tests revealed that all pair wise comparisons were significant (all $ps < .001$). The analysis of the preference ratings revealed a main effect of processing fluency, $F(2, 52) = 8.858, p < .001; \eta^2 = 0.254$. The mean response times showed a parametric pattern with highest preference ratings to high processing fluency paintings and with lowest preference ratings to paintings with low processing fluency. A series of Bonferroni-corrected $t$ tests revealed that the preference ratings differed between the high processing fluency condition and both the medium and the low processing fluency condition (both $ps < .009$).

The response-based PD showed a main effect of processing fluency, $F(2, 52) = 4.795, p = .012; \eta^2 = 0.156$ (see Figure 2). The Bonferroni-corrected $t$ tests revealed a parametric effect in the pupil dilation following the explicit classification with the highest PD in the high processing fluency condition, medium in the medium processing fluency condition, and lowest in the low processing fluency condition (see Figure 3). The follow-up pairwise $t$ tests reached significance threshold only for the high versus low contrast ($p = .006$, Bonferroni corrected), whereas all other comparisons were not significant.

Additional analyses of correlation further verified these results. Item-based correlation coefficients averaged across the subjects were computed between the mean pupillary responses and the

![Figure 1](image)
mean postexperimental ratings (complexity, abstractness, familiarity, preference) for each cubistic painting. The results showed that the pupil dilation following the subjects’ responses (PD) was significantly correlated with mean abstractness ratings ($r = -0.551; p < .001$) and mean preference ratings ($r = .333; p = .038$), whereas no significant correlations were observed with complexity ($r = -0.234$) and familiarity ($r = .022$). Thus, higher pupil dilations following the subjects’ responses were associated with higher preference ratings (a measure of aesthetic pleasure) and with lower abstractness ratings (which we assume reflect higher processing fluency).

### Discussion

In this study, participants were asked to indicate the point of explicit classification of recognized objects depicted in abstract cubistic paintings. We found evidence for a relation between the pupillary response and aesthetic pleasure. Following the point of explicit classification, the highest pupil dilations were found for high fluency stimuli and the lowest pupil dilations for low fluency stimuli. Moreover, a post hoc analysis of correlation revealed that the pupil dilation following the subjects’ behavioral response was positively related to individually rated preference of the cubistic paintings.

In the present study, cubistic paintings with high content accessibility showed the shortest response times, indicating an effect of processing fluency. Moreover, the behavioral data supported the assumption of the hedonic fluency model that higher processing fluency is also associated with higher preference ratings (Winkielman & Cacioppo, 2001). Although our data present evidence for a relationship between content accessibility and processing fluency, one might ask whether content accessibility is a good operationalization of processing fluency. Stimulus features like prototypicality (Hekkert & Wieringen, 1990) and stimulus complexity (Bornstein, Kale, & Cornell, 1990) have been shown to contribute to preference judgments. However, from a theoretical point of view, it is difficult to isolate the factors that contribute to processing fluency (see Willems, van der Linden, & Bastin, 2007, for a review). Moreover, recent results strengthen the role of the subjects’ interpretation of the nature of fluency, especially in situations where fluency is unexpected (Whittlesea & Price, 2001; Willems et al., 2007). Because we controlled the familiarity of the cubistic paintings across the processing fluency conditions, we relate our findings to the content accessibility manipulation that directly influenced the ease of processing of our stimuli. Still, more research is needed on this issue.

A recent study by Locher, Krupinski, Mello-Thoms, and Nodine (2007) found that a gist of a painting, that is, initial information concerning its style, compositional aspects, and its semantic meaning, can already be reported after a 100-ms glance. Because this study differed in many methodological aspects from the present one, the results are not fully comparable. The eight paintings in Locher et al.’s (2007) study were presented tachistoscopically, thereby filling a square of 178 cm (in contrast to a computer screen in the present study). Most important, the paintings were mainly representational. On the one hand, it seems obvious that these presentation conditions may have affected the fluency with which these paintings could be processed, and on the other hand, Locher et al. (2007) cannot rule out the possibility that subjects’ responses relied on the processing of mental images—and thus are not purely automatic.

### Table 2

Behavioral and Pupillary Responses as a Function of the Processing Fluency Conditions

<table>
<thead>
<tr>
<th>Processing fluency</th>
<th>Response times (ms)</th>
<th>Peak dilation (mm)</th>
<th>Preference ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
</tr>
<tr>
<td>High</td>
<td>1338.27</td>
<td>480.48</td>
<td>0.211</td>
</tr>
<tr>
<td>Medium</td>
<td>1919.25</td>
<td>699.75</td>
<td>0.191</td>
</tr>
<tr>
<td>Low</td>
<td>2650.02</td>
<td>805.29</td>
<td>0.176</td>
</tr>
</tbody>
</table>
Still, we agree with their assumption that initial pictorial information is processed automatically at early (perceptual) processing stages, e.g., stages 1 to 3 in the Leder et al. (2004) model. Moreover, Locher et al. (2007) presented evidence that pleasingsness ratings following a 100-ms glance (Experiment 1) and an unrestricted viewing time (Experiment 2) are correlated, but that a valid judgment of aesthetic pleasure (resulting in higher pleasingsness ratings) is only available in the unrestricted viewing condition. This result fits well to the assumption that aesthetic emotions evolve during the early processing stages and are only fully available at later stages of evaluation and cognitive mastering (Leder et al., 2004). Thus, supporting the idea that aesthetic emotions are best measured when explicit pictorial information is available (e.g., following the point of explicit classification).

The psychophysiological results add further evidence to the literature that the pupil dilates not only in response to the amount of cognitive processing, but that pupil dilation also indicates affective processing (Beatty, 1982). While we observed the shortest response times to high processing fluency paintings and the longest response times to low processing fluency paintings, the opposite pattern was found in the pupil data. If pupil dilation was related to cognitive processing only, one would have expected that the highest pupil dilation is observed in the low processing fluency condition; that is, the condition with the longest response times. This phenomenon is often reported in pupillometric research (Nuthmann & van der Meer, 2005; Raisig, Welke, Hagendorf, & van der Meer, 2007). However, this is not the case in the present study. In fact, the highest pupil dilation following the point of explicit classification was observed in the high processing fluency condition. Accordingly, we interpret this as a result of affective processing following the explicit classification in the appreciation of artworks (Leder et al., 2004).

However, it is unclear how much negative emotions in response to the apprehension of the cubistic paintings contribute to the present results. Silvia and Brown (2007) discussed different negative aesthetic emotions in an expanded appraisal model of aesthetic experience. Following this model, the dilation of the pupil observed in the present study could partially be attributed to the processing of negative emotions. However, this question cannot be fully answered by means of pupillometric research. It has been shown that the pupil dilation reflects the resources associated with valence-independent processing of emotional stimuli (Janisse, 1974; Libby et al., 1973; Partala & Surakka, 2003). However, processing fluency is typically associated with positive experience (Reber et al., 2004; Winkelman & Cacioppo, 2001). Our analysis of correlation supports this view, in that preference ratings were positively correlated with WD. We would therefore propose that higher pupil dilation following explicit classification of objects with high processing fluency stimuli is not only attributed to aesthetic emotion, but to positive aesthetic emotions in particular.

Still, it is discussed that fluency might be interpreted as inherently positive as long as no additional information is available, whereas in other situations (e.g., under prior exposure conditions) the interpretation of fluency is shifted according to its learned validity (Unkelbach, 2006). All stimuli were presented twice in the present study, during the explicit recognition phase and in the follow-up questionnaire. The pupillary responses have only been measured during the first presentation, so that repeated presentations cannot be the basis of the observed differences in the pupillary responses in the present study. Nonetheless, a cognitive interpretation of the pupil data contradicts the expected processing demands (with higher demands in the low processing fluency condition) so that we think that the pupillary response following the explicit classification reflects positive aesthetic experiences.

The “model of aesthetic appreciation and aesthetic judgments” (Leder et al., 2004) discusses two different outcomes of art appreciation processes: aesthetic judgments and the experience of aesthetic emotions. Both outcomes are discussed to follow a multi-
staged evaluation approach. In the present study, the pupillary response indicated aesthetic experiences after the explicit classification of depicted objects in cubistic paintings. According to the model, aesthetic emotion depends on the subjective success of the information processing (Leder et al., 2004). The present pupillometric measures further support the notion of (early) affective responses in art appreciation even if the processes of cognitive evaluation and appraisal are not fully completed. Additional studies are required that address the question of the temporal dynamics of affective and cognitive responses using psychophysiological variables with a higher temporal resolution.

In sum, the results of the present study indicate that affective aesthetic responses in art appreciation somehow depend on the ease with which an aesthetic stimulus can be processed. Cubistic paintings with high content accessibility are processed faster toward the point of explicit classification of the depicted content. This processing fluency advantage is accompanied by two additional findings. First, the pupillary response following this explicit classification reflects the processing advantage with higher pupil dilations to stimuli with higher processing fluency, which can best be explained as indicating positive aesthetic emotions. Second, higher processing fluency was found to elicit higher preference of these paintings. The results are in accordance with the predictions of a model of aesthetic appreciation and aesthetic judgments, and it will be interesting to further investigate whether the present findings generalize to other aesthetic stimuli like for instance representational artworks or the music domain.

References


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