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Portrait Hemispheric Laterality Measured Using Pupil Diameter and Aesthetic Judgments

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Eckhard Hess's claim that pupils dilate to pleasant images and constrict to unpleasant images was confounded because of inconsistent contrasts and luminances across his images. Building upon the work of Powell and Schirillo (2011) that explored multiple portraits by Rembrandt, we offer a new and promising methodology that overcomes this limitation. We presented leftward- or rightward-facing female and male portraits by 12 artists from various epochs to observers in either their original or mirror-reversed positions. Simultaneously, we asked observers to report how (dis)pleasing they found each image while measuring their pupil size. We found that pupil diameter was a function of arousal only while viewing male portraits. That is, for male images rated both low and high in pleasantness, larger pupil diameters were obtained. We postulate that our findings may be the result of the perceived dominance of males and how hemispheric laterality may drive emotional expression.

Keywords: hemispheric laterality, pupil size, face perception, emotion, aesthetic judgments

A Novel Method to Investigate Hess's Proposal

One influential figure in the field of psychological aesthetics was Eckhard Hess (1965, 1972), who postulated that pupils enlarge when viewing pleasant images and constrict when viewing unpleasant images (see also Fitzgerald, 1968; Goldwater, 1972; Hess & Polt, 1960; Hess, Seltzer, & Shlien, 1965; and Simms, 1967). However, Hess compared images with different intensities and contrast levels, and because pupil size covaries with luminance, his work was hopelessly confounded (Goldwater; Janisse, 1973, 1974; Locher, 1996; Loewenfeld, 1966, 1999; Loftus, 1985; Mannan, Ruddock, & Wooding, 1995; Woodmansee, 1966). To overcome Hess's limitations, one of us (Schirillo) designed a new methodology with Powell that matched pupil diameter with reports of pleasantness between original portraits by Rembrandt and their mirror-reversed counterparts (Powell & Schirillo, 2011). By measuring both original and mirror-reversed images, contrast and luminance are made irrelevant, because this novel technique only compares pupil size across paired-images. As a consequence, pupil size differences must not be because of differences in an image's contrast or luminance, but instead, be the result of variations in observers' perception of the image's emotional content.

By using original and mirror-reversed portraits by Rembrandt, we were also able to ascertain whether there was any hemispheric laterality in their emotional expressions. We postulated that Rembrandt may have painted like many artists who may have rotated their subject's faces leftward or rightward to magnify specific emotional displays inherent in their facial musculature. For example, male subjects may be perceived in terms of dominance; thus, a viewer's emotional responses to features depicting power might be quantified by pupil size (Schirillo, 2000). That is, the more dominant the male, the larger the pupil size might be for someone viewing that male.

Thus, instead of trying to refute Hess, we created a methodology to explore the relationship between a self-reported emotive measure (i.e., pleasantness) and an unconscious physiological measure (i.e., pupil size). As explained later, we found that Hess inappropriately focused on valence. Instead, he should have concentrated on arousal, because this is what we found drives pupil diameter for male portraits.

Judging the emotions of original and mirror-reversed images also served as a foray into a better understanding of the reading-direction laterality research by Gonzalez (2011) and others. In judging the emotions of chimeric faces (Sakhuja, Gupta, Singh, & Vaid, 1996; Vaid & Singh, 1989), Hindi (who read left-to-right) and Arabic (who read right-to-left) individuals show opposite preferences when judging happy versus neutral faces. Likewise, Nachshon, Argaman, and Luria (1999) had Hebrew, Arabic, and Russian readers point to the more "beautiful" of multiple left and right profiles of faces and human bodies, placed (with their mirror reverse) as outward-outward, or inward-inward. That is, the two profiles faces away from each other (outward-outward) or toward each other (inward-inward) profiles face. They found that Arabic and Hebrew readers preferred left profiles, whereas Russian readers preferred right-profiles. Thus, they argue that observers like images best when scanning into the nose of a profile. In total, these findings suggest that the asymmetric bias in perception of facial

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affect among Roman and Arabic script readers (Heath, Rouhana, & Ghanem, 2005) may be the result of eye movement patterns and are thus dependent upon the viewer's perspective, not the laterality of the portrait being viewed per se.

It is interesting to note that by comparing several hundred photographs from Spain (where one reads left-to-right) to several hundred nineteenth-century photographs from Iran (where one reads right-to-left), Gonzalez (2011) showed that left-to-right readers prefer stimuli with a rightward directionality, whereas right-to-left readers prefer stimuli with a leftward directionality. Thus, our use of mirror-reversed images not only control for Hess's potential confound, but also test whether lateralized enhanced attractiveness is because of the viewer's perspective (as Gonzalez and others might argue) or is contained in the lateralized musculature of each side of a portrait's face. Given that we found comparable results when images were mirror-reversed, we conclude that such preferences are indicative of differences in facial musculature.

Measuring Conscious Emotional Judgments and Unconscious Pupil Size

Facial expression research has been beset with problems (Rinn, 1984). For example, one of the most popular methodologies is to determine an observer's subjective impression of stimuli (Russell & George, 1990). This method may cause observers to make judgments that use separate, immeasurable criteria (e.g., one observer may use the contrast of an image, while another may judge via facial features, such as cheeks or eyebrows). This obfuscates relating aesthetic judgments to cerebral laterality. Thus, we decided to better understand portrait laterality using what may be a related unconscious process.

One previously used measure has been a low-level unconscious indicator of affective processing—pupil size (Hess & Polt, 1960; Janisse, 1974; Loewenfeld, 1999). As in Powell and Schirillo (2011), we avoided Hess's aforesaid luminance and contrast confounds by having observers view right- and left-cheeked portraits, *and* their mirror images (e.g., see Figure 1, b and d), while they determined the aesthetic pleasantness of each image. However, unlike Powell and Schirillo, we had observers view artists' works from multiple epochs, not just Rembrandt portraits. This was done to determine whether the Powell and Schirillo findings would generalize to other famous portrait artists. Simultaneously, we monitored the size of observer's pupils, which allowed us to correlate portrait pleasantness to pupil size. Given that original and mirror images have identical luminance profiles, we only compared pupil size and pleasantness ratings across matched pairs of images. This eliminated Hess's confounds.

Because there are "significant pupillary constriction with shifts in gaze from darker to brighter areas of the picture" (Woodmansee, 1966, p. 133), we preceded each clear image with its blurred counterpart to minimize pupil size fluctuations. For example, Figure 1 shows original and mirror-reverse orientation images (Figure 1, b and d) along with their preceding corresponding blurred images (Figure 1, a and c). We significantly blurred these images so that observers could not extract their facial pleasantness (Bachman, 2007).

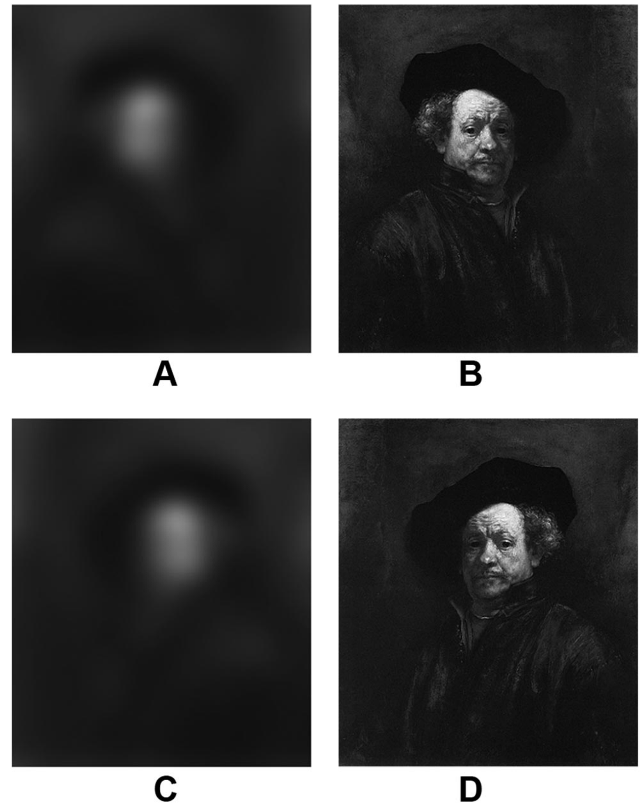

Figure 1. (a) Blurred original orientation, (b) original orientation of a right-cheeked male, (c) blurred mirror-reverse, and (d) mirror-reverse orientation (Rembrandt Self-Portrait (1660) oil on canvas, Metropolitan Museum of Art, New York).

Valence, Arousal, and Dominance

When discussing emotion, valence means the intrinsic attractiveness (positive valence) or aversiveness (negative valence) of an event or object. The term is also used to indicate the hedonic tone of affect and certain behaviors (e.g., approach and avoidance). Because Woodmansee (1967) found that unpleasant stimuli may evoke larger pupils, our methodology allowed us to reexamine works that disagree with Hess's findings regarding valence. Similarly, Tinio and Robertson (1969) found that larger pupil size was elicited using unpleasant compared with control Thematic Apperception Test cards, and some authors could not determine any of the stimulus characteristics that would produce a given pupil size (Libby, Lacey, & Lacey, 1973).

One provocative gender difference found in the literature is that larger pupil size is sometimes evoked by dominant males (Darwin, 1872). This may be tied to the fact that males also smile less than females because of having more testosterone (Ellis, 2006), making them more effective in intimidating rivals. Thus, while our methodology was partially motivated to overcome Hess's initial confound, we found that pupil size was actually driven by arousal instead of valence. When testing Rembrandt's, we found that only male portraits accentuate dominance (Schirillo & Fox, 2006). Thus, we predicted we would only find dominance differences in viewing male portraits painted across various eras (Powell &

Schirillo, 2011). Darwin first posited this notion by showing that each side of the face reflects different emotional expressions of dominance.

We decided to use artworks compared with photographs of faces by assuming that artworks would elicit stronger aesthetic reactions. Consequently, we test how portrayed hemispheric asymmetries may regulate facial displays of emotion, which then get revealed by observer's aesthetic portrait judgment. Because we used self-reported ratings of pleasingness, we chose to explore its relationship with pupil diameter because Hess and others suggested it could be an unconscious indicator of pleasingness. Hopefully, any relationship between these two measures might provide insights into the emotional content of the images' facial musculature. For example, if assumptions regarding dominance are present in self-reports, they may also appear in the emotional qualities that elicit larger pupil diameters.

Materials and Methods

Subjects

Forty observers (17 men; 35 right-handed; ages 18–22) with normal or corrected-to-normal vision (but no eyeglasses) from the introductory psychology research pool at Wake Forest University participated in the study. The study was performed in accordance with the ethical standards of the Declaration of Helsinki.

Stimuli

Twelve colored images taken from oil paintings were chosen from famous artists from the 15th to the 20th century. Three were right-cheeked males, three were left-cheeked males, three were right-cheeked females, and three were left-cheeked females (see Appendix). Next, these images were used to produce 12 mirror-reversed images using PhotoShop. Each scanned portrait was projected individually to each observer using MediaLab on an IBM CRT computer monitor. Viewing distance was set using a chinrest at 24" to retain a constant depth of field making the image size range from 11.7° (height) × 9.5° (width) to 11.8° × 12.1° (Simms, 1967). The close distance from the screen to the observers' eyes limited their capacity to spend considerable time viewing off-screen. To verify this fact, because the head-mounted Applied Science Laboratories (ASL; series 6000) eye-tracker was also able to measure eye position, we determined that observers were only off-screen approximately 3% of their total viewing time. Our equipment also provided data that showed that time with no record (because of eye closure) was minimal. In addition, 24 blurred images were created (12 from original and 12 from mirror-reversed images) in PhotoShop using a Gaussian blur function (Figure 1). The experimental chamber had no ambient lighting given that it was a windowless room and with the door closed, the only available light came directly from the computer screen that projected the images.

The pupil size of the left-eye was measured using the eye tracker. Observers were told the purpose of the eye-tracker was to measure their pupil size, which, in fact, was the case. The pupil size of the right-eye was not measured because pupil size is thought to be conjugate across the two eyes (Loewenfeld, 1999). Pupil diameter was recorded for each 15-s trial automatically every 17 ms. The average size for the entire 15-s viewing period was computed minus any time the pupil computation was off-line (because of to blinks, etc.). Because the ASL eye-tracker stops recording when the eye closes more than 50% (assumedly because of blinks or partial eye closure), we have no record of these data.

We decided to not use linear interpolation to estimate the pupil size during this off-line period (Steinhauer, Siegle, Condray, & Pless, 2004), because blinks can alter pupil size (Nakayama, 2006). Thus, we felt it best to simply eliminate these segments from our data set. Head-movements did not alter pupil diameter recordings or result in loss of tracking because the ASL eye-tracker is head-mounted. Consequently, we did not remove any data artifacts other than time spent eye-blinking. We did the data cleaning by importing the remaining data into Excel, which we then converted to SPSS to perform the statistical analysis. We calculated each image's average pupil size across the observation period, which excluded instances of blinks or partial eye lid closures.

Observers viewed 12 images in their original and mirror-reversed posed orientation (resulting in a total of 24 images). Given that we compared only pupil size across original versus mirror-reversed images, our within-subject's design excludes possible confounding factors such as medication or age. Left-cheeked mirror-reversed images are portraits that originally faced leftward but because of the reversal appeared to be original right-cheeked images. Likewise, right-cheek mirror-reversed images appeared to be of original left-cheek portraits. All images were randomized and presented in a different random order to each observer. Each blurred version of a given image was presented for 10 s and was followed by the clear version of one of the 24 images for 15 s. Three prior findings were taken into consideration in deciding that 15 s was necessary and sufficient. First, art viewers examined The Metropolitan Museum of Art paintings for a median of 17 s (Smith & Smith, 2001). Second, it has been established that pupil size rapidly decreases when presented with a new image, after which it recovers to either baseline or above baseline levels. Consequently, pupil size is best measured for at least several seconds to overcome this initial depression (Aboyoun & Dabbs, 1998). Last, Richer, Silverman, and Beatty (1983) found that pupil size can also begin to increase approximately 1.5 s before stimulus presentation. Consequently, we allowed observers more time than needed to generate a complete response to each image. Observers' pupil size was measured during each clear image presentation while they were to contemplate how pleasant they found that image. We instructed observers to think about the aesthetic pleasingness of each image for the entire 15 s it was shown and then report their judgment after the image was removed. This was possible by using a subsequent mouse-activated rating scale.

Observers were also told that they may see some or all of the images more than once and that at times certain images would be mirror-reversed. They were not told each image was paired with one and only one mirror-reversed image. They were told the reversals' were included to insure that their pupil size was dilating by the correct proportions. This, in fact, was part of why mirror-reversed images were used. They were not told that reversing the images was to test their rating reliability, because that was not the case. However, they might have falsely assumed this anyway which may be part of why there were either no or only small differences in their rating scores between original and mirror-reversed images (see Results).

We used a 1–9 numerical scale to record the rating pleasantness scores for each image, with 1 = *most displeasing*, 5 = *neutral*, and nine = *most pleasing*. Pleasingness is only one aesthetic dimension but seemed to be appropriate based on a study by Russell and George (1990) that used five evaluative scales (e.g., pleasingness, likability, preferability, interestingness, and complexity). In their study, pleasingness and likability and preferability were highly correlated, and pleasingness had the highest intersubject agreement. We then correlated the difference in aesthetic rating between the original and mirror-reverse images to the difference between the average pupil diameters.

Results

We initially parsed out the five left-handed observers from the data set without altering any of the results. Thus, we included them in the final reported analysis. During debriefing, observers often commented that they saw images multiple times. However, because the image orders were randomized, most observers were unsure just how many times they saw each image or that there was only one pair (original and mirror-reversed) of each image. Also during debriefing, observers were specifically asked whether they were familiar with one or more of the images. Most observers said they were not familiar with most of the portraits. This is not unusual for, what were primarily, freshman college students.

Pleasantness Ratings

Before examining individual pleasantness ratings, we obtained each observer's average pleasantness ratings for each of the eight portrait types (e.g., original right and left, mirror-reverse right and left, males and females). This resulted in each observer having eight data points. Then, pleasantness ratings for male and female portraits were submitted to a 2 (Portrait Gender: male vs. female) × 2 (Orientation: original vs. mirror-reversed) × 2 (Side of Face: left vs. right) repeated-measures analysis of variance (ANOVA). Male and female observers were not included as a within-subjects factor because the present design lacked sufficient power.

Figure 2a shows the mean ratings for each portrait group. There was a main effect for Side of Face, with left cheeks rated higher than right cheeked individuals (M = 5.11 vs. M = 4.60), $F(1, 39) = 8.92$, $p = .005$. In addition, there was a Side of Face × Gender interaction, $F(1, 39) = 5.54$, $p = .024$. While left-side portraits (original and reversed) were rated higher than right-side portraits (see Side of Face main effect), left-side female portraits were rated higher than right-side female portraits (M = 4.86 vs. M = 4.70), whereas the same is true for male portraits but to a greater degree (M = 5.35 for left male portraits and M = 4.50 for right male portraits).

The error bars in Figure 2a indicate the *SEM* for each condition. Their relatively small size reflects the fact that no given image was a group outlier. Thus, even though some images may have been more famous, and therefore may have garnered more attention, such as the left-cheeked *Mona Lisa*, neither this nor any other portrait was rated significantly different in pleasantness than other portraits in its class. Their mean ratings and *SD* are reported in the Appendix.

Pupil Size

Presenting images in random order meant that either an original or reversed image could appear first. We conducted a test to compare the average pupil diameter between an image's first and second presentation. For this analysis, we used a generalized estimating equation (GEE; Liang & Zeger, 1986) approach to explain the correlation of responses within viewers. GEEs estimate the within-subject similarity of the residuals that is then used to estimate the regression parameters and calculate *SE*s (Hanley, Negassa, Edwardes & Forrester, 2003). GEEs extend the use of the generalized linear model to estimate parameters and reflect more efficient and unbiased regression parameters than a standard linear regression. This is because it adjusts the covariance matrix of the estimated parameters to account for dependencies that occur across observations (Ballinger, 2004; Zorn, 2001). To have just one outcome variable, we took the change in pupil size from the first presentation to the second presentation. An intercept-only model was fitted and analyzed. If one presentation impacted pupil size more than the other, then we would expect the intercept to be statistically significantly different from zero. However, the results of the test failed to show that the presentation of the image impacted pupil size, Wald $\chi^2 = 0.685$, $p = .408$. Thus, it was not during the second presentation where surprise might have occurred that pupil size got larger (i.e., arousal occurred). However, observers may have had an anticipatory response to all of the images. Unfortunately, we did not record pupil diameter during the preceding blurred images because our within-subjects design did not need baseline responses. Even so, we expect no difference in anticipation between an original and mirror-reversed image because all images were presented in random order.

Before we examined individual pupil size, we obtained each observer's average pupil size for each of the eight types of portraits. Mean pupil sizes for these groups are shown in Figure 2b. There was a main effect of Side of Face across the eight types of portraits, $F(1, 39) = 43.39$, $p = .001$. Average pupil diameter when viewing right-side portraits was larger ($M = 5.04$) than when viewing left-side portraits ($M = 4.89$). This analysis also yielded a significant Side of Face × Gender interaction, $F(1, 39) = 70.97$, $p = .001$. Left-cheeked female portraits ($M = 4.98$) elicited greater average pupil size than right-cheeked female portraits ($M = 4.94$). Conversely, average pupil size was larger for right-cheeked male portraits ($M = 5.15$) than for left-cheeked male portraits ($M = 4.80$).

Overall, pupil diameters were well within the normal range. As expected, the luminance of each portrait viewed dramatically affected pupil size (range = 4.14 mm – 8.38 mm). The fact that pupil contraction increased with an increase in image luminance fortifies our decision to use mirror-reversed images.

Relationships Between Pleasantness Ratings and Pupil Diameter

We examined quadratic relationships between pleasantness and pupil size. We did this by taking each portrait (original or mirror-reversed) for each observer as an individual case. Figure 3a shows that there was a significant quadratic effect for male portraits, $b = 0.451$, $t(237) = 4.16$, $p = .0001$, $R^2 = 0.508$. Pupil diameter was largest when there were the greatest differences in aesthetic ratings

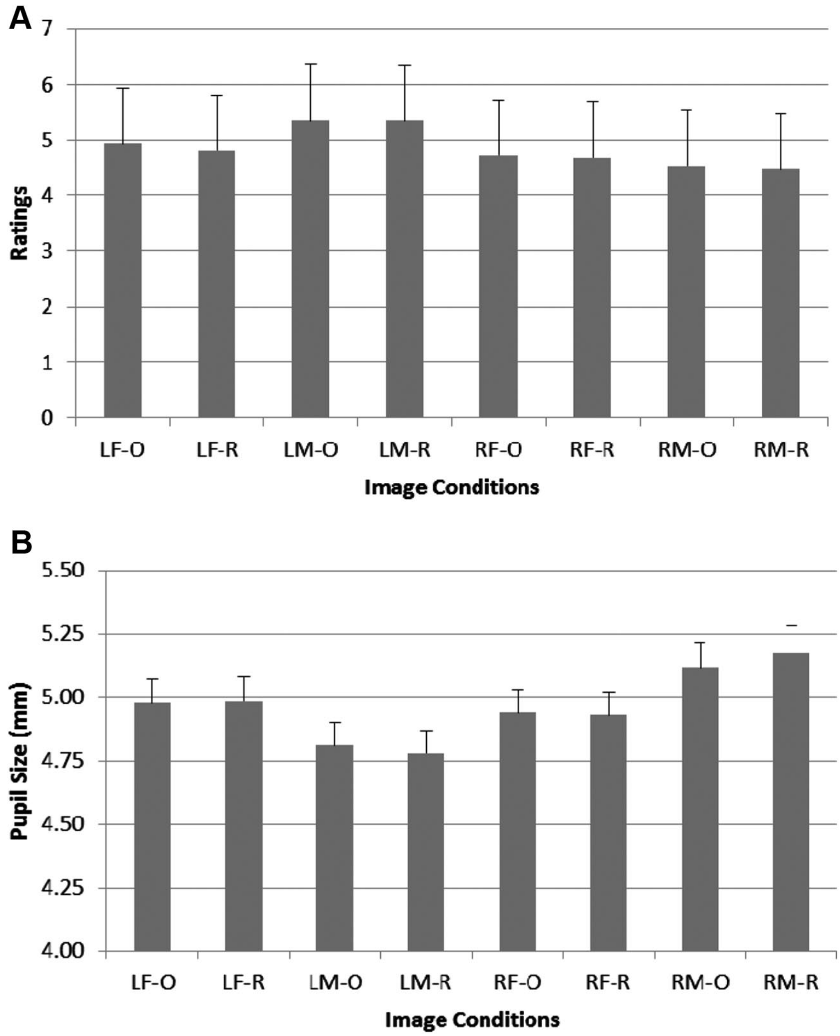

Figure 2. (a) Aesthetic ratings as a function of portrait type on a 1–9 scale, with 1 = *most displeasing*, 5 = *neutral*, and 9 = *most pleasant*, (b) pupil size in mm as a function of portrait type (L = Left-cheeked, R = Right-cheeked, F = Females, M = Males, O = Original orientation, R = Mirror-reversed orientation). Error bars represent *SEM*.

between an original and mirror-reversed male image. That is, pupil size increased when images were extremely liked or disliked. However, for female portraits, the regression model failed to find a significant quadratic relationship between pupil diameter and pleasantness, $F(2, 237) = 1.32$, $p = .270$, $R^2 = 0.026$ (Figure 3b). Because each observer viewed multiple portraits, we examined whether the data was potentially clustered at the observer level. Therefore, we explicitly modeled between-cluster variation as a random effect by fitting our data within a multilevel model. If the data was clustered by observer, we would expect the covariance parameter estimate between observers to account for some portion of the total variance. However, the attempt to fit a multilevel model failed to reveal observer clustering for our outcome variable because the estimated variance between observers was negative. As a result, we removed this random effect from the model.[1] Because pupil size could be confounded by the luminance of an image, we calculated difference scores to compare across images. If we did not use difference scores but instead, used pupil size for original and mirror-reversed images in the regression, then our findings would be seriously confounded because these values do not account for the changes in luminance/contrast across images and comparisons across images would be misleading. In total, there were 480 cases (that is, 40 observers × 12 portraits, original-minus mirror-reversed) used in the analysis.

Outcome (DV) variable = pupil difference

Predictor (IVs) variables = aesthetic rating difference; quadratic aesthetic difference

[1] The estimated variance covariance matrix (G matrix) of the random effect of viewer is not positive definite, which meant that the between-subjects variation component being estimated was negative. Because it is not possible to have a negative variance, SAS automatically set the negative variance estimates to zero.

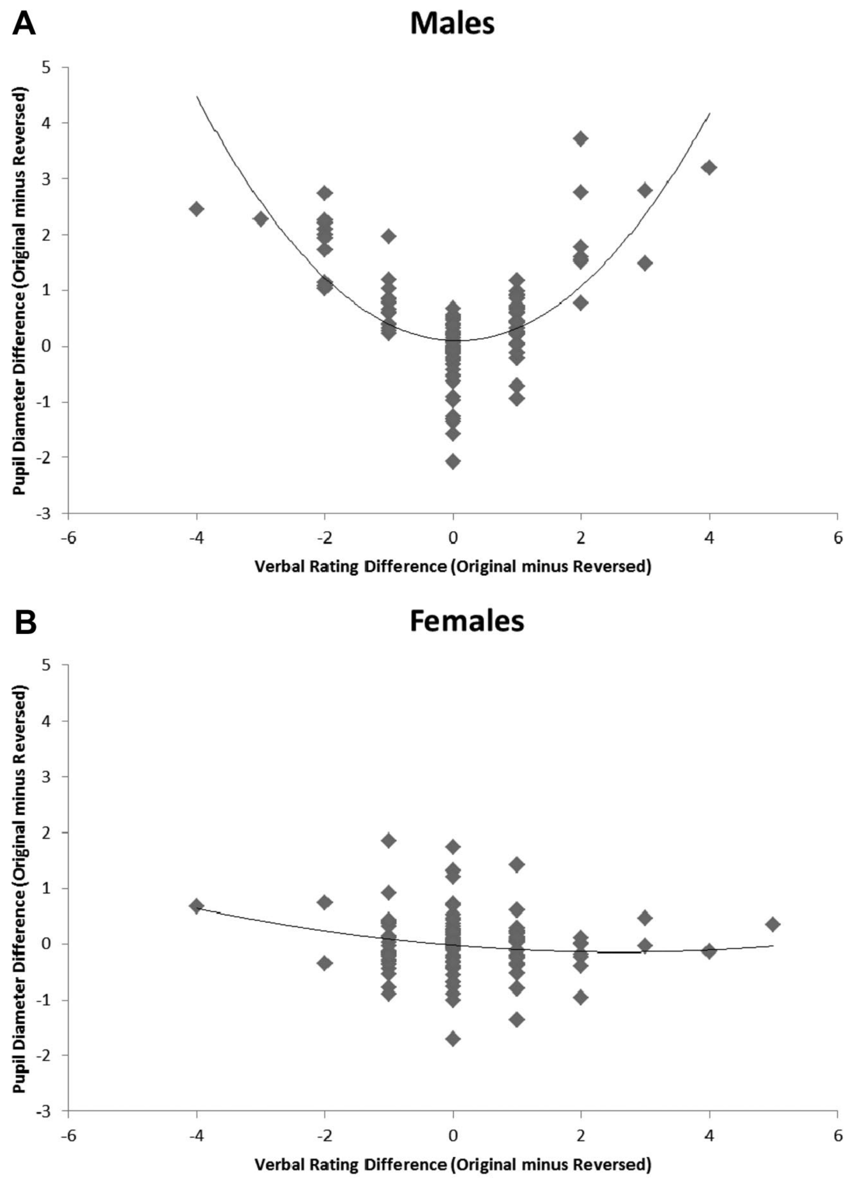

Figure 3. Pupil size difference score (original minus mirror-reversed) as a function of the difference in 1–9 aesthetic rating scores (between an original minus mirror-reversed image) for all (a) male portraits, (b) female portraits.

It is important to realize that our images were *not* necessarily less pleasing in their nonoriginal orientation. Instead, we found that only if there was a large difference in the rating between original and mirror-reversed images (where either orientation could have been more pleasing), would there also be a large difference in pupil size between those images.

Because pupil size is one indicator of pleasantness, when aesthetic reported differences are zero, pupil size differences should also be zero. Consistent with this assumption, we failed to find a significantly different from zero intercept for either male portraits, $t(237) = 1.33$, $p = .18$, or female portraits, $t(237) = 0.98$, $p = .33$.

As expected, there were almost as many zero differences between original and reversed-image aesthetic ratings as there were difference scores. This inevitable outcome can potentially affect any of our quadratic relationships.

Discussion

We only replicated for male portraits that pupils get larger to intense (i.e., arousing) stimuli. Schirillo (2000) and Powell and Schirillo's (2011) analysis of Rembrandt's portraits suggest this may be because observers perceived dominance of male portraits was rated higher than for female portraits. One may associate dominance with positive (e.g., self-assurance, arrogance, and feeling bold or triumphant) or negative affective states (e.g., hostility, irritability, and anger; Demaree, Everhart, Youngstrom, & Harrison, 2005). Thus, while Rembrandt painted males to exhibit these positive dominant traits (see Humphrey & McManus, 1973), it is possible that negative dominance traits may have also been captured. The notion that Rembrandt's male portraits may actually be perceived as domineering is consistent with Libby et al. (1973) and Woodmansee (1967), who found that larger pupil sizes were associated with unpleasant compared with pleasant images. It is important to note that we replicated these same trends in the current study by using different artists across several centuries.

Because our aesthetic self-reported ratings of pleasingness measure what may contain emotive expressions, we were interested to determine their relationship with an unconscious indicator of pleasingness (i.e., pupil diameter) as suggested by Hess and others. Moreover, we were interested in how this in turn might be related to the lateralized emotional content of the facial musculature displayed in the portraits. For example, pupil size relationships capture self-reported assumptions regarding dominance that can be present in the portraits emotional qualities. We revealed this possibility while simultaneously eliminating Stern and Strock's (1987) apprehension that one disadvantage to pupillometry is that changes associated with such variables are considerably smaller than those associated with illumination effects.

Our methodology eliminates Hess's luminance and contrast vacillations across images that allow us to observe how pupil size varies as a function of the differences in reports of pleasant and less pleasant original and mirror-reversed portraits. This was done by *only* comparing measurements between original and mirror-reversed images that make irrelevant image luminance and contrast. This method also allowed us to not require a baseline pupil size from the blurred images; because pupil size should not vary between original and mirror-reversed images, such images have constant image contrast and luminance. If the images do differ, it must be because their emotional content varies, not their contrast or luminance.

Research testing Hess's hypothesis had ceased given that it is impossible to equate apparent contrast or mean luminance across images. However, we created a methodology that reexamined the relationship between a conscious self-report and emotive measure (i.e., pleasingness) and an unconscious physiological measure (i.e., pupil size). We found that Hess was incorrect by focusing on valence. Instead, he should have concentrated on arousal because arousal drives our male portrait effect, not valence.

Male portraits exhibited a quadratic relationship between pupil diameter and aesthetic judgments of pleasantness where pupil diameter increases to both highly pleasant and unpleasant male portraits. Thus, it is plausible that researchers who only used a linear function found that unpleasant images were associated with larger pupil sizes compared with pleasant images (Libby et al., 1973; Tinio & Robertson, 1969; Woodmansee, 1967). These findings contradict Hess's (1965) prediction, which suggested that unpleasant images would have been associated with a smaller pupil diameter.

In nonvisual stimuli studies, arousing situations have been shown to produce larger pupil diameter. For example, painfully loud sounds increase muscle tension causing larger pupil size (Nunnally, Knott, Duchnowski, & Parker, 1967). Similar findings were obtained when observers expected to hear a gunshot. Likewise, when observers believed they would be shocked for incorrect mental arithmetic answers, Polt (1970) obtained larger pupil size.

In summary, this study explores a new methodology first tested using only Rembrandt portraits (Powell & Schirillo, 2011) regarding the association between pupil diameter and aesthetic judgments. We found, as with the Rembrandt work, that Eckhard Hess's (1965, 1972) hypothesis that pupils dilate to pleasant images and constrict to displeasing images seems incorrect. Instead, for male portraits pupil size is a function of arousal such that pupil size difference increases when the difference in aesthetic reports are both most pleasant and most displeasing. We consider the possibility that this phenomenon is related to perceived dominance (Ellis, 2006). We consider the possibility that this is related to disliking perceived threat (Darwin, 1872), which may have been a dominance trait that Rembrandt, and apparently artists throughout the ages, inadvertently depicted.

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(*Appendix follows*)

Appendix

Listing of Painting Titles by Original Orientation (Mean Pleasingness Ratings and *SD* Are Included in Parentheses)

Female Left

John Singer Sargent (1856–1925) Miss Eliza Wedgewood: 1905 ($M = 4.97$; $SD = 1.9$)

Jan van Eyck (1390–1441) Eve: The Ghent Altarpiece: 1432 ($M = 4.91$; $SD = 1.7$)

Leonardo da Vinci (1452–1519) Mona Lisa: 1503 ($M = 4.94$; $SD = 1.6$)

Female Right

Theodore Gericault (1791–1824) Woman Addicted to Gambling: 1822 ($M = 4.70$; $SD = 2.0$)

Hans Holbein the Younger (1497–1543) Lady With Squirrel & Starling: 1526-8 ($M = 4.76$; $SD = 1.7$)

Diego Velazquez (1599–1660) Las Meninas: 1656 ($M = 4.73$; $SD = 1.8$)

Male Left

Giuseppe Arcimboldo (1527–1593) Librarian Man Made Out of Books Portrait of Wolfgang Lazius: 1566 ($M = 5.35$; $SD = 2.1$)

Raphael (Raffaello Sanzi) (1483–1520) Pope Leo X: 1518 ($M = 5.38$; $SD = 1.9$)

Vincent Willem van Gogh (1853–1890) Self-portrait: 1889 ($M = 5.32$; $SD = 2.0$)

Male Right

Sir Anthony Van Dyck (1599–1641) Cardinal Bentivoglio: 1623 ($M = 4.56$; $SD = 1.7$)

Jan van Eyck (1390–1441) Adam From the Ghent Altarpiece: 1432 ($M = 4.51$; $SD = 1.9$)

Rembrandt van Rijn (1606–1669) Self-Portrait: 1660 ($M = 4.54$; $SD = 1.9$)

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