Rembrandt's Textural Agency: A Shared Perspective in Visual Art and Science

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TECHNICAL ARTICLE

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ABSTRACT

The authors hypothesize that Rembrandt developed new painterly techniques in order to engage and direct the gaze of the observer. Although these methods were not based on scientific evidence at the time, they are nonetheless consistent with a contemporary understanding of human vision. The authors propose that artists in the late early-modern period developed the technique of textural agency—selective variation in image detail—to guide the observer's eye and thereby influence the viewing experience. They conclude with the presentation of laboratory evidence that Rembrandt's techniques indeed guide the modern viewer's eye as proposed.

A fundamental feature of human vision is that our experience of a scene or an artwork is not uniformly detailed [1]. Each eye contains only a small area (about the size of a thumbnail viewed at arm's length) in which the cone receptors are packed densely enough to provide us with detailed color and shape perception. Thus, viewing experience actually extends over time, including periods of fixation, in which eye position is almost stationary and visual information is taken in, interrupted by saccades, rapid movements of the eye from one image region to another, during which we are also effectively blind [2]. This makes seeing a highly interactive process, in which information acquired in a fixation influences the content of mental experience, while at the same time mental content (including goals and cognitive strategy) guides our eyes to new image regions in order to acquire further high-resolution information [3–5].

To differing degrees, many modern artists are aware of this understanding of human vision and deliberately seek to incorporate and exploit it in their work. A specific technique typically associated with 20th-century painting is to use painterly brushwork on the textural plane to direct and coerce the viewer's gaze through a painting, thereby influencing fixation points and eye gaze paths within the work. Well-known portraitist John Howard Sanden [6] describes the "center of focus" techniques he uses to help structure the experience of the viewer. For example, in Fig. 1, increased textural and color detail rendered in the sitter's left eye and eyebrow are intended to move the viewer's gaze to these locations, thus drawing attention to the intelligent yet playful personality of the sitter. Sanden's loose directional brush strokes under the eye also guide the viewer's gaze to the accentuated eye area, both by the implicit gestures of the spiraling paintbrush and by repetition of asymmetric curvature in both the eyes and the mouth.

Directing the gaze to selected regions in a portrait is one tool a modern artist has for emphasizing certain character traits of the sitter and for giving viewers a glimpse into the collaboration between sitter and painter in the development of a portrait [7–9]. In addition to consistency with the modern understanding of mind-eye dynamics, artists' selective application of detail is also consistent with the specialized neural processing of human vision: Coarse brushwork corresponds to low-spatial-frequency information, which is transmitted very rapidly to many regions of the visual system to help orient the eyes to points of possible interest, whereas fine brushwork corresponds to higher-spatial-frequency channels that transmit more slowly to the centers involved in detailed and prolonged inspection [10,11].

Modern artist Harley Brown also exploits the tendency for the observer's gaze to follow a line or edge. Brown uses what he and others describe as the "lost and found edge" technique: Because the eye often prefers to follow regions of strong con-

Fig. 1. John H. Sanden, *Reverend Cole Close-up*, oil painting, 1999. (© John H. Sanden)

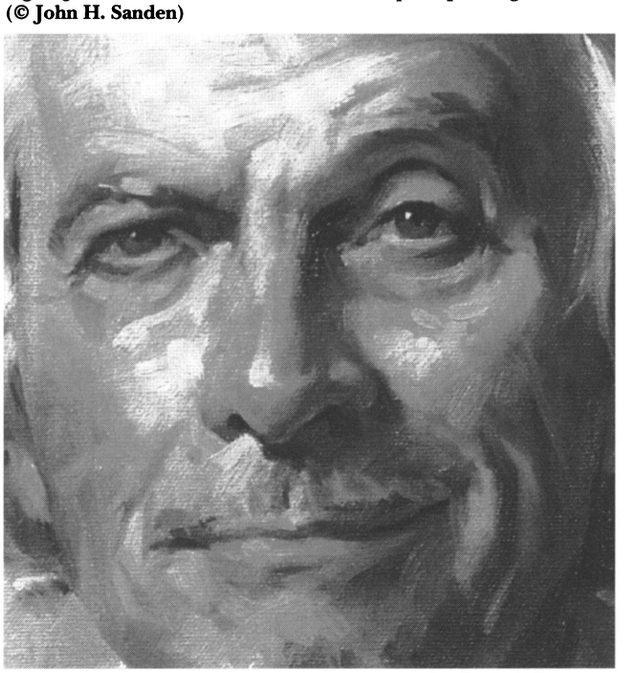

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Fig. 2. H. Brown, *Charlo Girl*, oil painting, 1978. (© Harley Brown)

trast in tone or color, when such edges disappear, the eye can be guided to a new artistic center of focus [12]. While several examples of this technique are evident in Fig. 2, most blatant are the lost edges along the elbows, which lead directly into the edges and detail of the downward-looking face. How these techniques of textural agency work in detail, both in guiding the unconscious gaze and in altering the conscious viewing experience of the observer, is, we think, of great interest to artists and vision scientists alike. Both parties have an interest in better understanding the interface of intuition and consciousness, although each brings different tools and perspectives to the problem. In what follows, we explore the role of selective textural detail in structuring the art viewing experience, both reviewing art history and presenting an empirical attempt to test the textural agency hypothesis with a study of eye tracking.

Early Modern Painting: A Monolithic Mechanistic View?

Art historians usually assume the deliberate use of textural agency does not stretch back to Renaissance painters of the early modern period. We conjecture that a closer look at late Rembrandt and his performative discourse with Italian art suggests instead that it does. Specifically, Rembrandt experimented with and developed these techniques in reaction to, and as a further step beyond, the more uniformly detailed artworks of the Italian Renaissance. As Harry Berger, Jr. [13], puts it, textural agency techniques help to guide the viewer's gaze through the "act of finishing the painting" as a personal and subjective mental act, rather than experiencing the artwork in the more mechanical way one might view a uniformly detailed photograph. If Rembrandt used and developed some of these techniques, then it can also be argued—more speculatively—that his understanding of human vision, at least at an intuitive level, was consistent with our own modern understanding of human vision. We acknowledge that a phrase such as "intuitive understanding" can be contentious, especially given different connotations in art and science. It is beyond the scope of this paper to resolve these issues, yet we think it is worth considering that a historical artist necessarily silent on a question that has become of interest to us only recently can nonetheless be credited through the historical record of his artworks with understanding, at some level, a scientific principle that has entered the currency of our modern discourse.

A commonly held belief about the Renaissance is that science and art were very much intermingled, as a result of the introduction of the scientific method, which provided a new process for discovery and placed an emphasis on empirical evidence and the importance of mathematics. In Renaissance art, the crowning achievement of this new intermingling was the development of highly realistic linear perspective. The development of perspective can be seen as part of a much broader trend in both the sciences and arts towards realism. Berger [14] describes what he and others see as a monolithic view in academic discourse on the early modern period. Martin Jay termed this view "Cartesian Perspectivalism" [15]: The eye is treated as an abstract Cartesian point or pinhole camera that forms the visual image and presents it to the brain for interpretation, rather than as a complex organ that interacts dynamically with the brain. In support of this interpretation, Alberti commented in his classic *On Painting* that this trend "hailed mathematics over physics or physiology" [16] in its recasting of vision. This prompts us to wonder whether other, more organic, forms of painterly intention have been buried by the static understanding of perspective through which this period has been viewed. It also raises the paradoxical possibility that, although scientific thinking may have contributed to this mechanized view of vision during the early modern period, science may now be called upon to restore the eye to a more properly dynamic understanding of vision.

Early Modern Painting Modes

To help provide a framework for our historical and scientific discussion, we turn to Berger's "The System of Early Modern Painting," in which he describes four painting modes: decorative, graphic, optical and textural [17]. The *decorative* mode uses pigment, color, light and techniques to give a sense of beauty and to honor the painting and the subject. In the *graphic* mode, subjects are painted as they are known or thought to be—as people imagine they really are and appear. Lifelike, naturalistic imitation of 3D forms in space and spatial relations are significant in the graphic mode, as is the visualization of knowledge such as from anatomical studies. Berger posits that the transition from decorative mode to graphic came as patronage changed

from religious clientele to that of the merchant class.

In the *optical* mode, things are painted as they are seen, with an emphasis on the conditions of visibility that affect, alter or in some cases interfere with the graphic mode. This mode offers the observer a more active interpretive role than does the graphic mode. The optical mode brings about a shift from an "objective" to a "subjective" set of cues. Finally, the *textural* mode concerns "the trace," the work of the brush in "real time" and as an extension of the painter's body. The textural mode can therefore be read as an interpretive act, calling for an interpretive response from the viewer. Texture generates conflicting modes of observership and can be seen as a window to the graphic mode. Berger claims that the textural mode "obscures where the graphic clarifies [and] softens where it hardens" [18].

We wish to extend Berger's view of the textural mode to include a level of agency. Our primary proposal is that the textural mode can be used to enrich, invite and move the viewer's gaze via the artist's intention, so that the oft-cited direct connection between artist's trace and observer's perception can be understood as more than a metaphor. Stated in its strongest form, our hypothesis is that the creative act of painting begins with the artist's hands, and that these hands leave a trace that can be used to hint at, guide and sometimes even coerce the viewer's gaze through the act of completing the painting as a mental experience. In our exploration of this hypothesis, we restrict ourselves to Rembrandt's portraits, in particular those done late in his life.

Rembrandt's Portraits, Eye Gaze and Intent

In his 2000 book *Fictions of the Pose: Rembrandt against the Italian Renaissance*, one of Berger's main points concerns what he thinks "the Rembrandt look 'sees'" [19]. What Rembrandt sees, challenges, critiques and at times parodies is "the embarrassment of the Renaissance riches" of the Italian model. Berger asserts, expanding on Kenneth Clark [20], that "Rembrandt transformed his style by the study of Italian Renaissance art" [21]. This dialogue between Rembrandt and Italy, one-directional as it may seem, gave way to both a classical and an anti-classical style in Rembrandt's art and, more importantly, saw a shift in the discourse in the other direction, presenting Italy through Rembrandt's eyes. Berger shows the process by which painters can "imitate, emulate, appropriate, and sublate" [22] prior art and Rembrandt's performative mastery of this process. Berger refers to this as "revisionary allusion," which allowed Rembrandt's implied reconstructions to "creatively distort the past" in order to reflect the present and "more immediate[ly] focus on critique" [23].

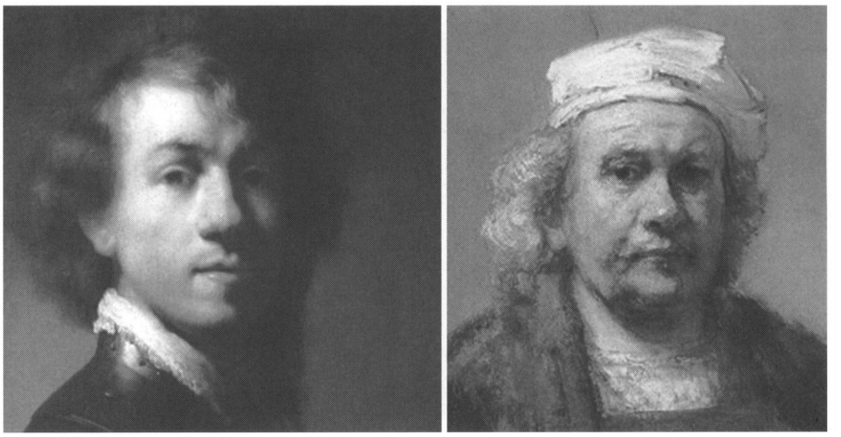


Fig. 3. Rembrandt, (left) *Early self-portrait*, 1629, with more uniform and higher levels of textural detail versus (right) a late self-portrait, 1661, with reduced and more selective use of textural detail.

The adoption of oil painting as a medium was controversial when it first appeared. Titian quickly recognized its merits and added several innovations to early oil painting techniques. The fact that the mature Rembrandt was deeply influenced by 16th-century Venetian painting—especially by Titian and Giorgione—was not unknown when Kenneth Clark published his classic study on Rembrandt and the Italian Renaissance. When an inventory was taken of Rembrandt's possessions, an album was found devoted almost entirely to Titian's work. As Vasari noted, Titian's late works were "carried out in bold strokes, broadly applied in great patches in such a manner that they cannot be looked at closely but from a distance appear perfect" [24].

Noted art historian David Rosand described the appeal of these late paintings as "tactile as well as visual, inviting us to touch as well as to look" [25]. Seventeenth-century Venetian critic Marco Boschini reported that toward the end of Titian's painting process he painted more with his fingers than with the brush, comparing himself to God, who formed the human body out of earth with his hands [26]. Titian never taught his assistants, but, as Vasari reports, each disciple took whatever he could from the master's example. The same can be said for Titian's most significant followers, like Rembrandt. Rosand describes how

> Titian's facture, for all the revelation of his textured surfaces, continues to remain just beyond the reach of comprehension. In comparison, Rembrandt's technique seems quite straightforward, much more accessible to direct visual analysis [27].

We know that Rembrandt revered and emulated late Titian. In typical Rembrandt style, he appropriated and extended Titian's practice of leaving traces of the artist's gesture in the texture of the painting, with the result that his gestures also embodied a deep communicative link with the eye gaze of his viewers.

In further support of this interpretation, Virgil Elliott states that "the highly refined imagery of [Rembrandt's] younger days gradually gave way to a rougher, more painterly finish in his middle and later years, perhaps due to changes in his eyesight" [28] (Fig. 3). Rather than attributing these changes to a visual impairment—a diagnosis consistent with a mechanical understanding of vision but not the dynamic interplay between eye and brain—we propose that a mature Rembrandt was simply continuing his lifelong critique of and discourse with the Italian Renaissance. Specifically, he was performatively inventing another, more painterly technique, one "more cognizant of his discourse with his viewers" [29], more personal and direct than what Berger has called the graphic and optical modes.

A New Look at the Influence of Textural Agency

When first examining the textural agency hypothesis from the perspective of modern vision science, we were surprised to

learn that it had not yet been put to a direct test. Numerous previous studies have examined the gaze patterns of viewers inspecting works of original art [30,31], but in each case it was difficult to attribute the gaze patterns of viewers directly to the selective emphasis in the painting involving the degree of textural detail. The reasons for this lack of direct evidence are quite straightforward: When a painter selects one region over another region of the canvas for increased detail, these regions also invariably differ from one another in their meaningful content (more detailed regions are usually of foreground rather than of background interest), in relative degree of lighting (textural detail is usually increased for surfaces depicted as in direct light) and in relative spatial location (regions of increased detail are often at the center of the composition). Of course, such strong correlations in an artwork—between the semantic level, the compositional level and the level of textural detail—all likely conspire synergistically to guide the gaze of the viewer to selected regions of the painting. However, for the purposes of putting the current claim—that textural variations in themselves guide the viewer's eye—to a proper scientific test, these inherent correlations in original portraits make it impossible to confirm or deny the hypothesis simply by having viewers examine original artwork while their gaze is recorded.

Testing the Textural Agency Hypothesis in Modern Viewers of Rembrandt-Like Art

Our approach to testing the texture-gaze hypothesis involved generating portraits that were plausible works of art, and yet in which the textural level of detail was not correlated with other levels of analysis (content, lighting, spatial layout). This was done in three steps. We first photographed human models in a way similar to four of Rembrandt's most famous late portraits: *Self Portrait with Beret and Turned-Up Collar* (1659); *Man with a Magnifying Glass* (1661); *Hendrickje Stoffels* (1660); and *Large Self-Portrait* (1652) (Fig. 4). Second, we rendered these photographs in the style of Rembrandt using a knowledge-based computer painterly rendering system [32]; approximately 50 parameters of brush detail, color palette and other painterly attributes were matched as closely as possible to the original Rembrandt portraits [33]. Third, we selected four regions in each rendered portrait for selective manipulation with regard to textural detail: one region centered about each eye and one region centered on each side of the chin, where the material of the collar meets the skin of the neck, as illustrated in Color Plate C No. 2 and Fig. 5. The variation in textural details for each eye and chin side was achieved using additional passes of progressively smaller brush strokes in the painterly system algorithm as a base, with additional Gaussian blur and stroke manipulations where appropriate.

This gave us the opportunity to compare gaze patterns of viewers examining the original photo of the models (where textural detail is uniformly high for all image regions) with their gaze patterns when viewing the same models rendered as portraits with systematic variation of detail in the chosen regions. Finally, to ensure that our results would be specific to the degree of relative detail—independent of relative location in the image—we presented viewers with both the original orientation and the mirrored image of the portraits.

Eye Tracking and Art Viewing Methodology

Our study participants were students in psychology at the University of British Columbia (32 in all, mean age = 20

Fig. 4. Four original Rembrandts and photographs of human model analogues (© Steve DiPaola) used in the eye tracking study.

years, 11 male) who volunteered for a study advertised as "Eye Movements and Art." Participants were each tested separately in a 1-hour session, being told they would have the opportunity to view 30 portraits on a 19-in high-definition flat screen, each for a 5-second period, while their eye fixations and movements were recorded. The task they were given was simply to view all the portraits an initial time, with the goal of assigning a subjective rating of "artistic merit" to each portrait, using an 8-point scale. However, participants were also told that the ratings would be made only after each of the images had been seen once, so that the entire range of the scale could be used in a consistent manner (8 = best, 1 = worst). It was this first viewing period that interested us for the purposes of eye tracking, since it allowed us to measure whether relative differences in textural detail in the eye and neck regions of the portraits influenced gaze patterns. On a second viewing of the same portraits, in a new random order, participants then assigned ratings to the images.

Participants' eyes were monitored using an SR Research Eyelink II tracking system, which sampled the position of the eye every 2 milliseconds. Saccades (eye movements) and fixations (periods of stable gaze) were assessed using the default settings: a saccade is a spatial shift with amplitude exceeding 0.5°, with an acceleration threshold of 9,500°/sec^2 and a velocity threshold of 30°/sec. A brief period of calibration preceded the first viewing by each participant.

The 30 portraits viewed by each participant consisted of 10 critical portraits (2 models × 5 images) and 10 "filler" portraits that we selected from an assortment of fine-art books covering portraits by noted artists of different periods and styles (e.g. Lenbach, Hopper, Freud, Kinstler). Each of these filler portraits was viewed twice within a session, in an effort to balance the fact that the models in the critical photos were also repeated within a viewing session. The five critical images taken of each model consisted of the studio photo and four Rembrandt-renderings of the photo—either the left or the right eye in greater detail combined with either the left or the right neck region in greater detail. In order to test all combinations of critical images involving the four models, the four textural regions and the two image orientations (original, mirror), the 32 participants were divided into four groups, with each group of eight participants viewing all four image variants of the 2 models in one of two orientations.

Fig. 5. Detailed crops of the same painterly rendered portraits, showing each subject's left eye and neck region in greater detail (left image of each pair) versus each subject's right eye and neck region in greater detail (right image of each pair). (© Steve DiPaola)

Eye Tracking Results

The eye tracking of the first viewing period by our participants yielded promising support for the textural agency movement hypothesis. All results reported were statistically significant (having a less than 5% likelihood of a difference being reported where none existed).

We began by examining the overall level of activity in the eyes of participants viewing the filler portraits, the studio photos of our models and the critical portraits. These results (Fig. 6a) indicated that a Rembrandt-like rendering resulted in a calmer eye. Participants made a significantly smaller number of fixations when viewing filler and photo portraits than when viewing the critical images: $F(1,62) = 35.70$, $p < .001$. This supports the idea that reducing the amount of textural detail in a portrait causes the eye to inspect fewer locations overall but to dwell longer in each one.

We next examined where participants tended to fixate in the portraits and found, consistent with many previous studies [34,35] that a majority of all fixations (~60%) centered on the two eye regions in each photograph. The next most frequented region lay in a stripe along the nose extending to the mouth (~25%), with the relatively few fixations that remained (< 15%) inspecting locations that varied from image to image around the silhouette of the face, hair and shoulders. With specific regard to our Rembrandt-like portraits, an even larger percentage of all fixations were in the two eye regions: $F(1,124) = 21.02$, $p < .001$. Interestingly, there were almost no fixations directly in either of the two neck regions we had manipulated for textural detail, although these regions did have an influence on the fixations made to the two eye regions. Figure 6b shows an increased likelihood of a fixation on the detailed eye when it was on the same side

as a less-detailed neck region, as though the detailed eye became an even more salient attractor in fixations in the context of a less-detailed neighboring region: $F(1,124) = 16.30$, $p < .001$.

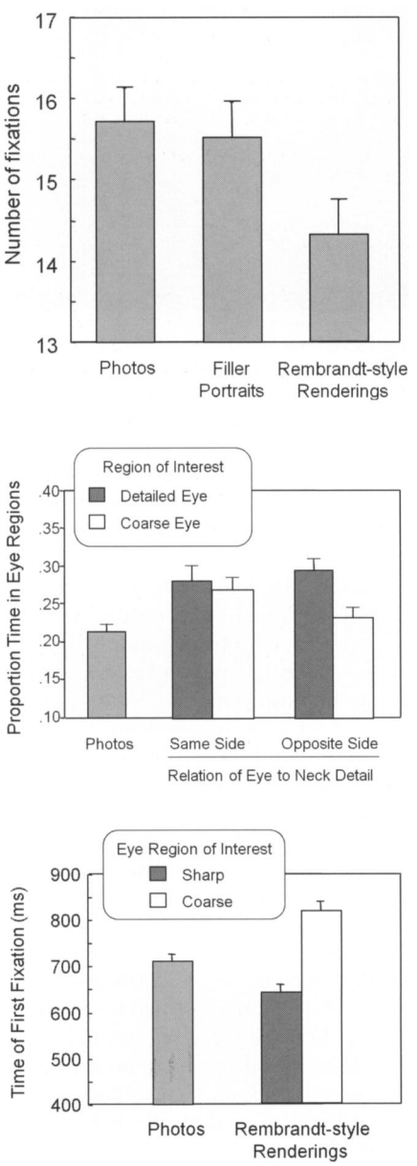
When we measured the time it took for the first fixation to land in either of the two eye regions of the portraits, we observed a strong influence of textural detail. Figure 6c shows that, whereas the time to first fixation in the eye regions of the photos was around 700 milliseconds (ms), the first fixation in an eye region of greater textural detail was more than 70 ms earlier: $F(1,62) = 3.93$, $p < .05$. Furthermore, the first fixations to eye regions of greater detail were more than 170 ms earlier than to eye regions of reduced detail in the same portraits: $F(1,62) = 21.74$, $p < .001$. When we examined the conditional probability of successive fixations in the same region versus a different region, there was a stronger trend for viewers' gazes to move from an eye region of reduced detail to one of greater detail than in the opposite direction: $F(1,62) = 5.09$, $p < .05$.

These results clearly suggest that relative differences in textural detail guide the modern viewer's gaze when inspecting a portrait. This study provides definitive evidence for this hypothesis, because the eyes of viewers were tracked in a context in which the only differences from one portrait to another were on the level of textural detail. Unlike actual great works of art, the images we used in our test varied in textural detail while not varying at all in their semantic content, in the nature of the lighting depicted in the portrait or in the spatial location of the textural regions. Yet these images were viewed as plausible works of art by our participants, lending credence to the possibility that these results can be generalized to the viewing of original portraits painted by master artists.

Our confidence comes in part from our analysis of the ratings the participants made on their second viewings of each of the portraits. These ratings showed considerable agreement among participants. Filler portraits judged to be the very best obtained mean ratings of 6.2 to 6.4 (standard error = .3); those judged the worst obtained mean ratings of 2.9 and 3.0 (standard error = .2). In this context, the model photos garnered mean ratings ranging from 3.5 to 5.2 (standard error = .5) and the critical portraits rendered from these photos ranged from a mean of 4.2 to 5.2 (standard error = .4). Most importantly, when we gave eight separate participants the opportunity to select which one of the four renderings of each model was the "very best," with all four images presented simultaneously in random quadrants on a 24-in iMac viewing screen, they selected the most Rembrandt-like rendering (detailed eye and neck regions on the same side of the image) at a rate significantly greater than chance (chance = .250, obtained p = .352, chi-sq (1) = 7.04, $p < .01$).

What the eye tracking shows, in combination with participants' ratings of artistic quality, is that the artist's selection of regions of a portrait for more and less detail has a direct influence on viewing behavior and on aesthetic experience. The relative level of detail chosen by the artist guides the eye in at least two important ways. First, regions of greater detail serve as attractors for more detailed inspection by the viewer (fixation frequency). Second, and perhaps even more important, the relative detail in a region in a portrait that is not fixated directly (e.g. the neck regions in our portraits) guides the viewer's gaze by increasing the salience of a detailed region that is the target of multiple fixations (i.e. the eye regions). This study therefore provides strong support for the idea that portrait artists, perhaps even as early as Rembrandt, guided the viewer's gaze through their selection of textural detail. Whether this guidance occurred because of an implicit (unconscious) understanding of the texture-gaze link by artists or whether artists discovered this explicitly (consciously) by observing their own visual behavior while their work was in progress is a fascinating question, but beyond the scope of the present paper. We hope it is one of the questions that artists and scientists will collaborate to pursue in the future.

Fig. 6. (a, top) Mean number of fixations during the first 5-sec viewing period for three different types of portraits. (b, middle) Proportion of total viewing time (5 sec) spent examining the two eye regions in each portrait for photos (light gray bar) and Rembrandt-style renderings (dark gray and white bars), as a function of the relations between detail in the eye and neck regions. (c, bottom) Mean time (milliseconds) of first fixation to one of two eye regions in photos and Rembrandt-style renderings. (© Steve DiPaola)



Conclusion

We have taken a two-pronged approach to advance the hypothesis that Rembrandt and other artists that followed him developed the technique of textural agency in order to guide the observer's gaze and viewing experience, selectively emphasizing certain image regions by varying the relative level of image detail. These artists may have thus explored the possibilities that arise when the viewer's eye is guided to these selectively emphasized regions, as opposed to leaving the viewer with greater freedom in their pattern, as occurs in a more uniformly rendered artwork of that period with strong perspective, and as now occurs when viewing photographs. Thus the early modern period could be credited not only with the development of perspective to its highest form, but also with emergent attempts to understand the inherently dynamic interaction of eye and brain that characterizes human vision. Our analysis supports the contention of art critics such as Martin Jay and Harry Berger, Jr., that the Renaissance application of science to art went well beyond the contribution of mathematics and geometry to the construction of an image. It may have also included an understanding, implicit or explicit, of the behavioral and experiential dynamics

that occur when a human eye with limited spatial resolution is confronted with a large scene or image [36].

In the second section, we empirically tested the hypothesis that the viewer's gaze is guided by variations in textural detail. The results demonstrated that variation in image detail could influence viewing on at least two levels: simply guiding the viewer's gaze at a lower level of eye-brain function, and influencing the conscious attributions the viewer makes about the skill of the artist in portraying the characteristics of the sitter. We suspect that textural variations may even influence the conversation between artist and viewer that occurs at a meta-cognitive level (including the larger community of other artists and viewers), but this hypothesis will have to await a future test.

Of course, the present results are limited in their direct generality to the textural details of edge contrast and color and to artworks consisting of portraits. Future work will need to explore the idea of textural detail with much more rigor than in this initial demonstration and will also have to examine how variations in textural detail influence gaze patterns in more complex scenes involving multiple objects and perhaps even in more abstract artworks. Nonetheless, the proof-of-concept that textural agency has an influence even in this one domain inspires us, as we hope it will other artists and scientists, to examine the textural-agency hypothesis more widely. Artists and scientists may each indeed at times use specialized language, but it seems that our questions about the human experience have a deep common core.

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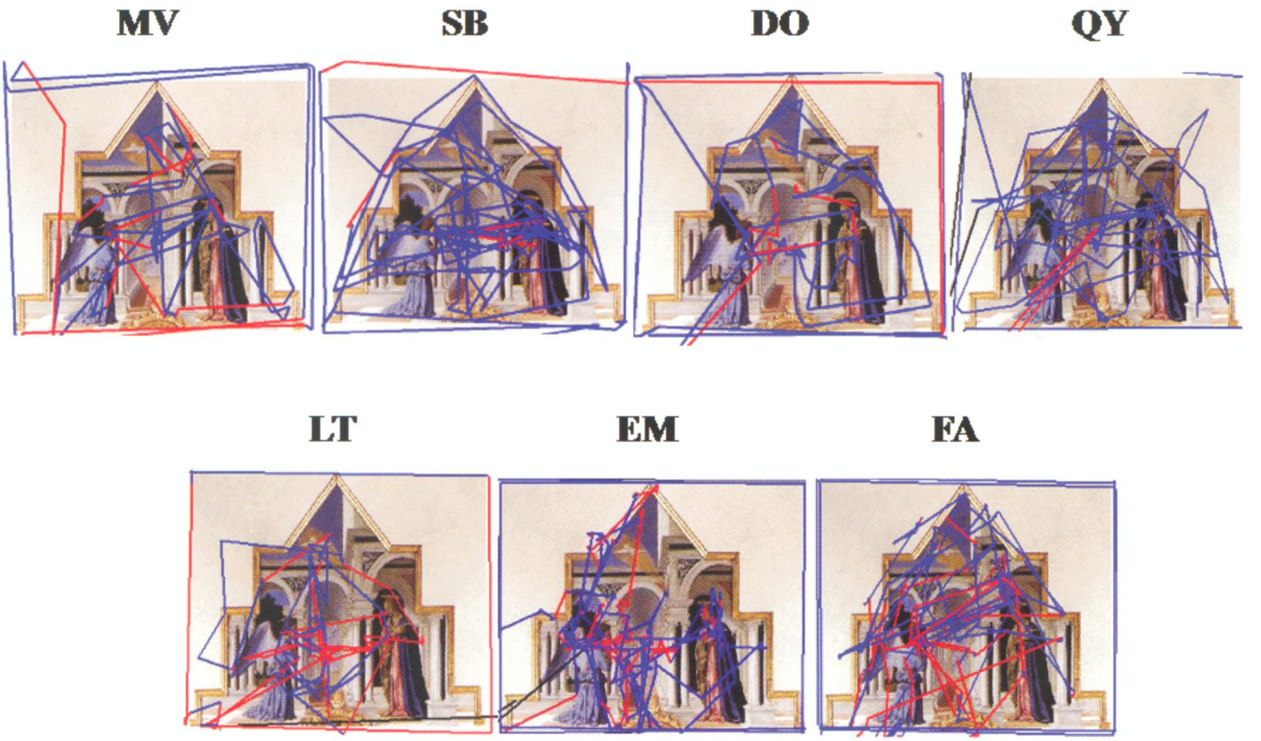
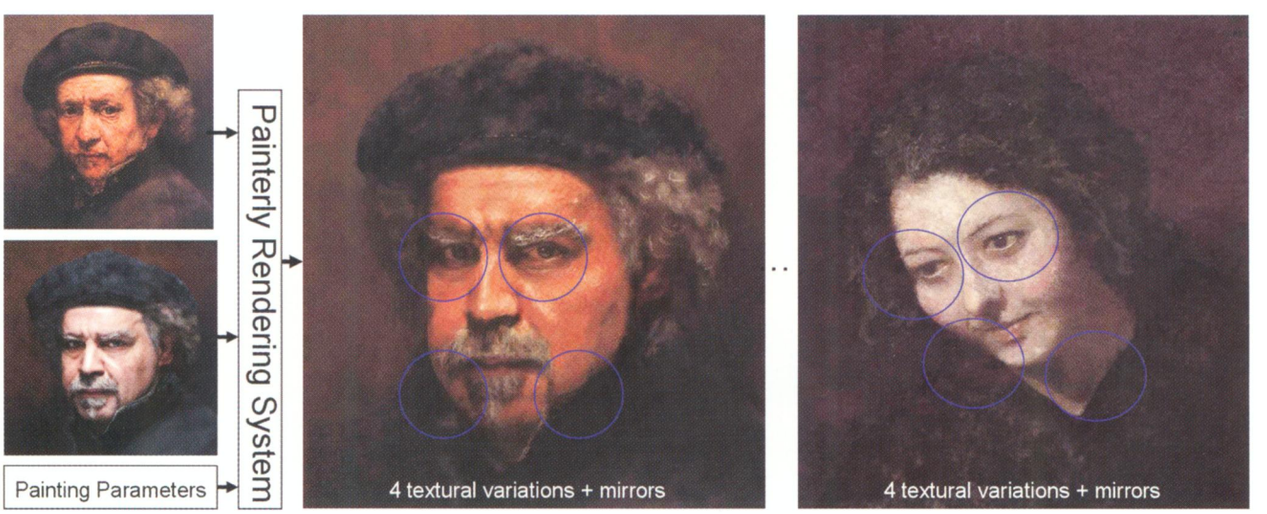
Color Plate C



No. 1. Zoï Kapoula et al., eye scanning of the painting for the total 30-sec period during which the painting was present on the screen. Lines connect successive fixations following saccades; only saccades larger than 1° were considered. Colors of lines connecting successive fixations have also been assigned by the analysis software as follows: The lines are red if fixation occurs after the saccade beyond or exactly at the range between 50 and 800 ms; blue lines are used when the fixation is in the painting area. After 30 sec of free exploration, each subject was instructed to fixate successively the four corners of the painting. (© Zoï Kapoula)



No. 2. Steve DiPaola, detailed crops of two of the painterly rendered portraits, showing the regions of textural variation (outlined in blue circles only for purposes of illustration; circles were not shown to participants). (© Steve DiPaola)