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Rembrandt's textural agency: A shared perspective in visual art and science

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Abstract

This interdisciplinary paper hypothesizes that Rembrandt developed new painterly techniques — novel to the early modern period — in order to engage and direct the gaze of the observer. Though these methods were not based on scientific evidence at the time, we show that they nonetheless are consistent with a contemporary understanding of human vision. Here we propose that artists in the late 'early modern' period developed the technique of textural agency — involving selective variation in image detail — to guide the observer's eye and thereby influence the viewing experience. The paper begins by establishing the well-known use of textural agency among modern portrait artists, before considering the possibility that Rembrandt developed these techniques in his late portraits in reaction to his Italian contemporaries. A final section brings the argument full circle, with the presentation of laboratory evidence that Rembrandt's techniques indeed guide the modern viewer's eye in the way we propose.

INTRODUCTION

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 in which the cone receptors are packed densely enough to provide us with detailed color and shape perception (a region in our visual field about the size of a thumbnail when viewed at arm's length). Thus our viewing experience is actually one that extends over time, including periods of fixation, in which the 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, one in which information acquired in a fixation is influencing the content of our mental experience, while at the same time the content of our mind (including its goals and cognitive strategy) is guiding our eyes to new image regions in order to acquire further high resolution information [3,4,5].

At differing levels, 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 of this kind, 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 the observer's fixation points and eye gaze paths within the work. Well-known portraitist John Howard Sanden [6] describes how he believes "center of focus" sharpening techniques help to structure the experience of the viewer. For example, in the portrait shown in Figure 1, the 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 helping to draw attention to the intelligent, yet playful personality characteristics of the sitter. Sanden further emphasizes this interpretation with his loose directional brush strokes under the eye, which guide the viewer's gaze to

the accentuated eye area, both by the implicit gestures of the spiraling paintbrush and by the repetition of the asymmetric curvature in both the eyes and the mouth.

Directing the viewer's gaze to selected regions in a portrait is one of the tools 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 [7,8,9]. In addition to being consistent with the modern understanding of mind-eye dynamics, artists' selective application of detail is also consistent with the specialized neural pathways of human vision: coarse brushwork corresponds to low spatial frequency information that 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 in their writings as the 'lost and found edge' technique, referring to the idea that because the eye often prefers to follow edges (regions of strong contrast in tone or color), when those edges disappear the eye can be guided in its search for new edges to an artistic center of focus [12]. While several examples of this technique are evident in Figure 2, the 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 unconsciously guiding the eyes and in altering the viewing conscious experience of the observer, is a question we think is of great interest to artists and vision scientists alike. This is because both parties have a vested interest in better understanding the interface of intuition and consciousness, although they each bring different tools and perspectives to the problem. In what follows, we will explore the role of selective textural detail in structuring the art viewing experience, both from the perspective of art history and from the perspective of an empirical attempt to test the textural agency hypothesis with a study of eye tracking.

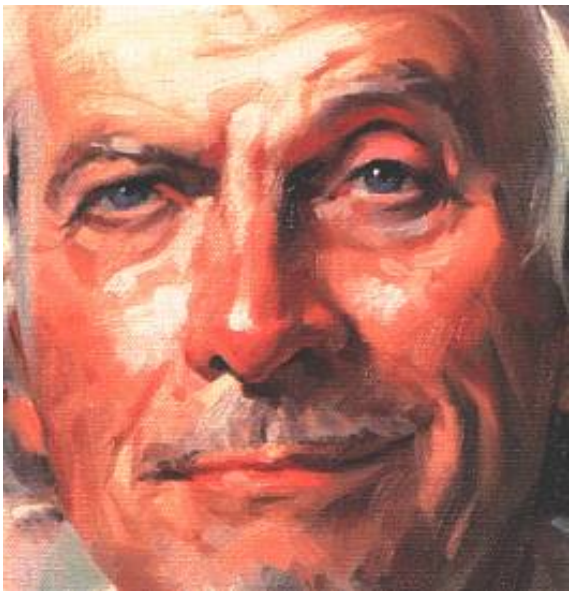

Fig. 1. J.H. Sanden's "Reverend Cole Close-up"

Fig. 2. H. Brown's "Charlo Girl"

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. The conjecture we put forward here is that a closer look at late Rembrandt and his performative discourse with Italian art suggests instead that it does. Specifically, we will argue that 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 art historian, 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 — and this is admittedly the more speculative aspect of our proposal — 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 when these terms have different connotations in the art and science communities. It is beyond the scope of this paper to resolve these issues; yet, we think it is worth considering the possibility that an historical artist who was necessarily silent on a question that has become of interest to us only recently, can nonetheless be credited through the historical record of his performance (artworks), for understanding, at some level, a scientific principle that has entered the currency of our modern discourse more recently.

A commonly held belief about the Renaissance is that science and art were very much intermingled. This was the 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 one part of a much broader trend in both the sciences and the arts towards realism. Harry Berger Jr., in his 1998 essay [14], describes what he and others see as a monolithic view in academic discourse on the early modern period. Martin Jay termed this view as "Cartesian Perspectivalism" [15] in which the eye is treated as an abstract cartesian point, or a pinhole camera, which forms the visual image and presents it to the brain for interpretation, rather than as a complex organ that interacts dynamically with brain. Alberti described 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 there might be other, more organic, forms of painterly intention that have been buried by the static understanding of perspective in which this period has been viewed. To us 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 once again to relocate the eye back into a more properly dynamic understanding of vision.

Systems of Early Modern Painting - Painting Modes

To help provide a framework for our historical and scientific discussion, we turn to Berger's 'Systems of Early Modern Painting', in which he describes four painting modes: decorative, graphic, optical and textural. The *decorative* mode uses pigment, color, light, and techniques to give a sense of beauty and, even more importantly, to honor the painting and the subject. In the *graphic* mode, subjects are painted as they are known or thought to be, i.e., 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 well as the visualization of knowledge, for instance incorporating the knowledge 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. Looking deeper into the optical mode, we see that this mode offers the observer a somewhat more active interpretive role than the graphic mode. The optical mode brings about a shift from "objective" to a "subjective" set of cues. Finally, the *textural* mode is about 'the trace,' the work of the brush in "real-time" and as an extension of the painter's own body. The textural mode can therefore be read as the painter's interpretive act, which calls 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."

In this paper 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 the artist's trace and the observer's perception can be understood as more than just 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, to guide, and to sometimes even coerce the viewer's gaze through the act of completing the painting as a mental experience. As a case study for our exploration of this hypothesis, we will restrict ourselves to Rembrandt 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*, Berger [17] uses Rembrandt as a vehicle to demythologize a more standard view of the intellectual and cultural history of the early modern period. One of Berger's main points concerns what he thinks 'the Rembrandt look "sees"'. 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 [18], that "Rembrandt transformed his style by the study of Italian Renaissance art." This dialogue, one-directional as it may seem, between Rembrandt and Italy gave way to both a classical and anti-classical style in Rembrandt's art and, more importantly, shifted the discourse in the other direction, reading Italy through Rembrandt's eyes. Berger shows us the process by which painters can "imitate, emulate, appropriate, and sublate" prior art and, more specifically, Rembrandt's performative mastery of this process. Berger refers to this as "revisionary allusion" which allows Rembrandt's implied reconstructions to "creatively distort the past" in order to make it reflect the present and "more immediate[ly] focus on critique."

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 - wasn't new 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 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".

Noted art historian Rosand [19] described the appeal of these late paintings as “tactile as well as visual, inviting us to touch as well as to look.” A 17th-century Venetian critic Marco Boschini, which claims to report the words of a late-16th-century disciple of Titian, writes that toward the end of Titian painting process, he painted more with his fingers than with the brush, comparing himself to God, who formed the human body, created it out of earth with his hands [20]. 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.” We know that Rembrandt revered and emulated late Titian. In typical Rembrandt style, he appropriated and extended Titian’s process of textural and bodily touch, with the result that his touch, while still gestural, embodied a deep communication link with the eye gaze of his viewers.

In further support of this interpretation, Virgil Elliott [21], an artist and writer on Rembrandt states of Rembrandts technical innovations, states that “the highly refined imagery of his younger days gradually gave way to a rougher, more painterly finish in his middle and later years, perhaps due to changes in his eyesight” (Figure 3). But rather than attributing these changes to a visual impairment — a diagnosis consistent with a mechanical understanding of vision but not of the dynamic interplay between eye and brain — we propose that a mature Rembrandt was simply continuing his lifelong critique and discourse with the Italian Renaissance. Specifically, he was performatively inventing another, more painterly, technique, one ‘more cognizant of his discourse with his viewers’, more personal and direct than what Berger has called graphic and optical modes.

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.

A NEW LOOK AT THE INFLUENCE OF TEXTURAL AGENCY ON VIEWING ART

When we first began to examine 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. There have been numerous previous studies examining the gaze patterns of viewers while they were inspecting works of original art [22, 23], 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 considered from the perspective of art creation. When a painter selects one region of the canvas for increased detail over another region, these regions also invariably differ from one another in their meaningful content (i.e., they are usually of foreground rather than of background interest), in relative degree of lighting (i.e., textural detail is usually increased for surfaces depicted as in direct light) and in relative spatial location (i.e., regions of increased detail are often at the center of the composition). Of course, strong correlations such as these in an artwork — between the semantic level, the compositional level, and at the level of textural detail — all likely conspire in a synergistic way to guide the gaze of the viewer to selected regions of the painting. But, for the purposes of putting the current claim to a proper scientific test — the hypothesis that textural variations in themselves guide the viewer's eye — these inherent correlations in original portraits make it impossible to confirm or deny the hypothesis by simply having viewers examine original artwork while their gaze is being 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 portraits in which the textural level of detail was uncorrelated with the other levels of analysis (i.e., content, lighting, spatial layout). This was done through a three-step process. We first photographed human models posing, dressed, and lit in a similar way 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. (Figure 4). Second, we rendered these photographs in the style of Rembrandt using a knowledge-based computer painterly rendering system [24] where approximately 50 parameters of brush details, color palette and other painterly attributes were matched as close as possible to the original Rembrandt portraits [25]. 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 figures 5 and 6. The variation in textual details for each eye and chin side was achieved using additional passes of progressive smaller brush strokes in the painterly system algorithm as a base, with additional Gaussian blur and stroke manipulations where appropriate.

Fig. 4. Four original Rembrandts and our photographs of human model analogues used in the eye tracking study.

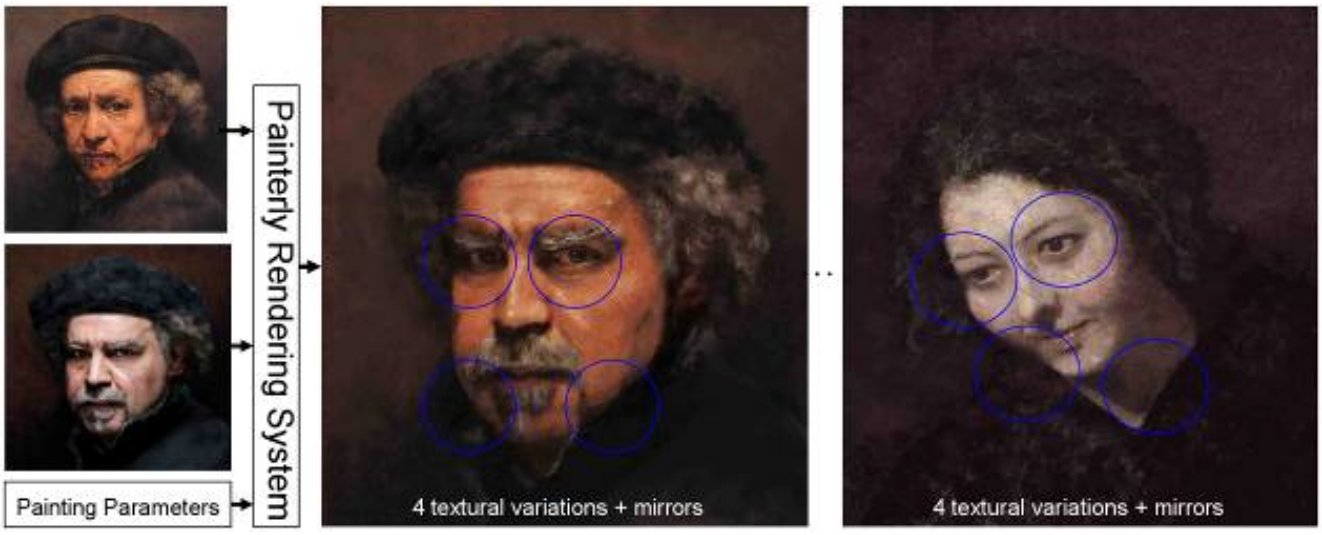

Fig. 5. Detailed crops of two of the painterly rendered portraits, showing the regions of textural variation (outlined in blue circles only for purposes of illustration, circles were not shown to participants).

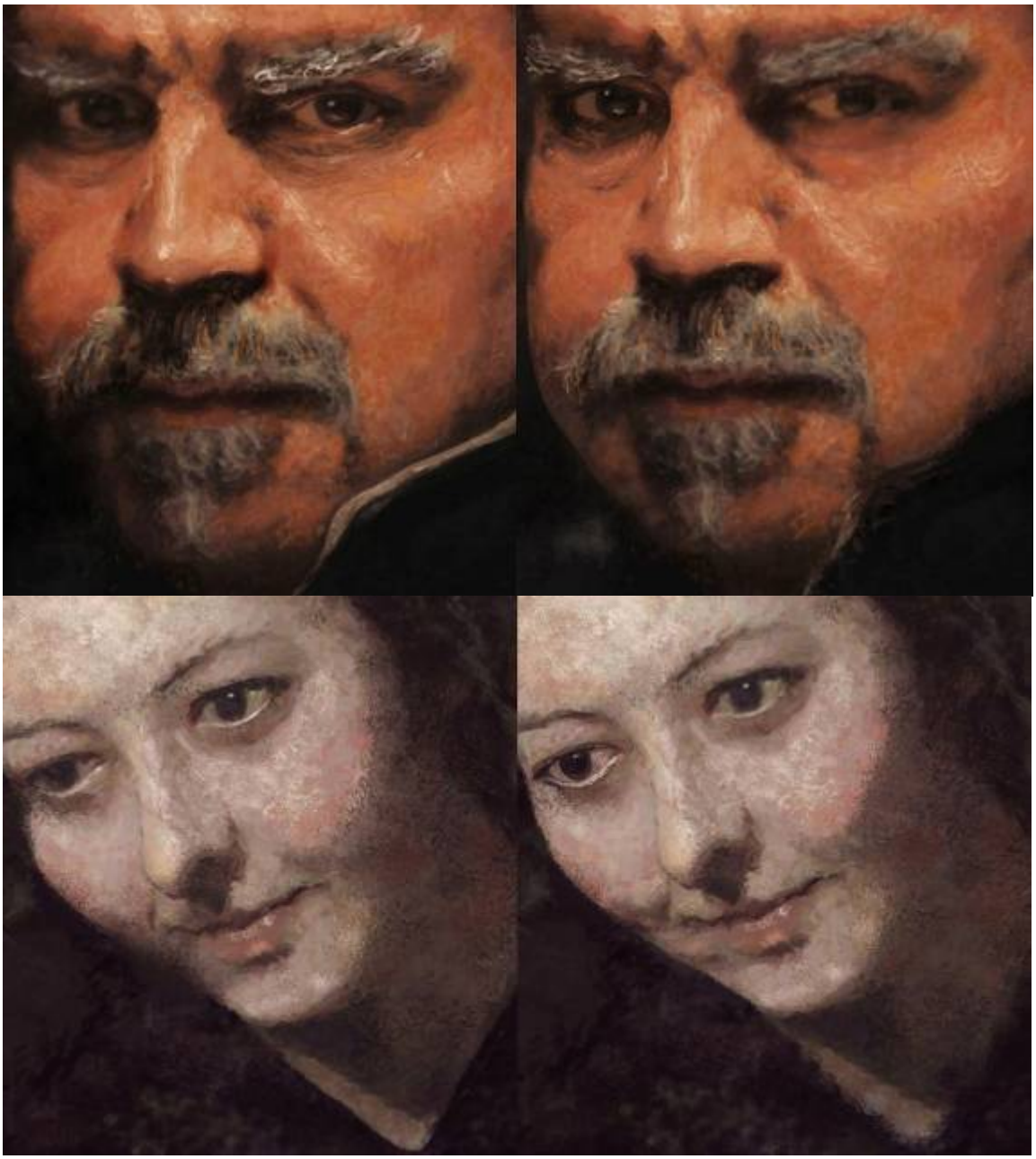

Fig. 6. Detailed crops of the same painterly rendered portraits, showing the model's left eye and neck region in greater detail (left image of each pair) versus model's right eye and neck region in greater detail (right image of each pair).

This left us with 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 courses at the University of British Columbia (31 in all, mean age = 20 years, 11 male) who volunteered for a study advertised as "Eye movements and Art." Each participant was tested separately in a one hour session in which they were told they would have the opportunity to view 30 portraits on a 19-inch high definition flat screen, each for a 5 second period, while their eye fixations and movements were recorded. The task they were given was to simply view all the portraits for the first 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 we were interested in 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 their gaze patterns. On a second viewing of the same portraits, in a new random order, participants then assigned their ratings to the images.

Participant's eyes were monitored using an SR Research Eyelink II tracking system, which samples the position of the eye every 2 milliseconds. Saccades (eye movements) and fixations (periods of stable gaze) were assessed using the default settings, namely a saccade is a spatial shift with amplitude exceeding 0.58 degrees, with an acceleration threshold of 9,5008/s2 and a velocity threshold of 308/s. A brief period of calibration preceded the first viewing of the portraits by each participant.

The 30 portraits viewed by each participant consisted of 10 critical portraits (2 models x 5 images) and 10 filler portraits that we selected from an assortment of fine art books covering portraits by noted artists from different periods and styles (e.g., Lenbach, Hopper, Freud, Kinstler). Each of these filler portraits was viewed two times 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 5 critical images taken of each model consisted of the studio photo and 4 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 4 models x the 4 textural regions x the 2 image orientations (original, mirror), the 32 participants were divided into four groups, with each group of 8 participants viewing all four image variants of the 2 models in one of two orientations.

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 here were statistically significant (i.e., a less than 5% likelihood of reporting a difference when in reality none exists).

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 (shown in Figure 7A) indicated that a Rembrandt-like rendering resulted in a calmer eye. Participants made a significantly smaller of fixations when viewing filler and photo portraits, than when viewing the critical images, $F(1, 60) = 41.57$, $p < .001$. 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 [26,27] that a majority of all fixations (~60%) were centered on the two eye regions in each photograph. The next most frequent 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, $F(1, 120) = 22.09$, $p < .001$. 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 7B shows there was an increased likelihood of a fixation to 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 of fixations in the context of a less detailed neighboring region, $F(1, 120) = 15.31$, $p < .001$.

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 7C shows that whereas the time to first fixation in the eye regions of the photos was around 700 ms, the first fixation in an eye region of greater textural detail was over 70 ms earlier, $F(1, 60) = 7.2$, $p < .01$. 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, $F(1, 60) = 26.29$, $p < .001$. When we examined the conditional probability of successive fixations in the same region versus moving to a different region, there was a stronger trend for viewers' gaze to move from an eye region of reduced detail to an eye region of greater detail in a portrait, than in the opposite direction, $F(1, 60) = 3.85$, $p < .05$.

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 at the level of textural detail. Unlike actual great works of art, the images we used in our test varied in textural detail, while at the same time not varying at all in their semantic content, in the nature of the lighting depicted in the portrait, and in the spatial location of the textural regions. Yet at the same time, 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 in the generality of our results comes in part from our analysis of the ratings the participants made in this study on their second viewing of each of the portraits. These ratings showed considerable agreement among the 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 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 8 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 19-in 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 participant's 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 ultimately 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 occurs because of an implicit (unconscious) understanding of the texture-gaze link by artists, or whether artists discover this explicitly (consciously) by observing their own visual behavior while their work is in progress, is a fascinating question, but beyond the scope of the present paper. We hope it is one of the questions that future artists and scientists will collaborate to pursue.

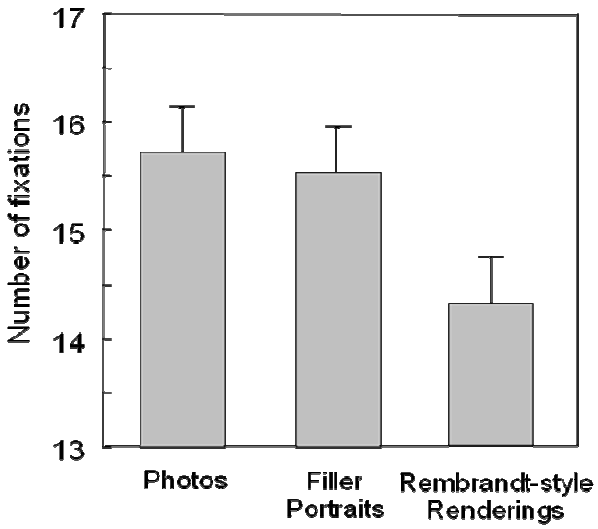

Fig. 7A. Mean number of fixations during the first 5 second viewing period for three different types of portraits.

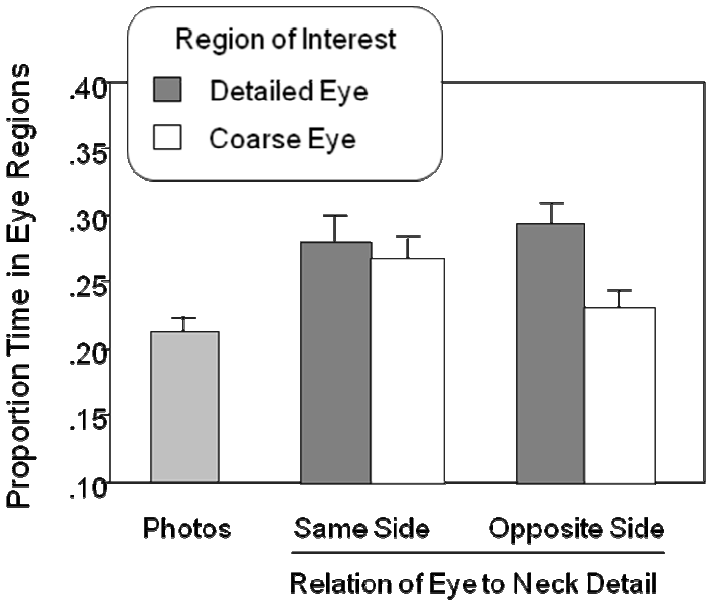

Fig. 7B. Proportion of total viewing time (5 seconds) spent examining the two eye regions in each portrait for photos (light gray bar) and Rembrandt-style renderings (dark gray and white bars), as a function of the relations between detail in the eye and neck regions

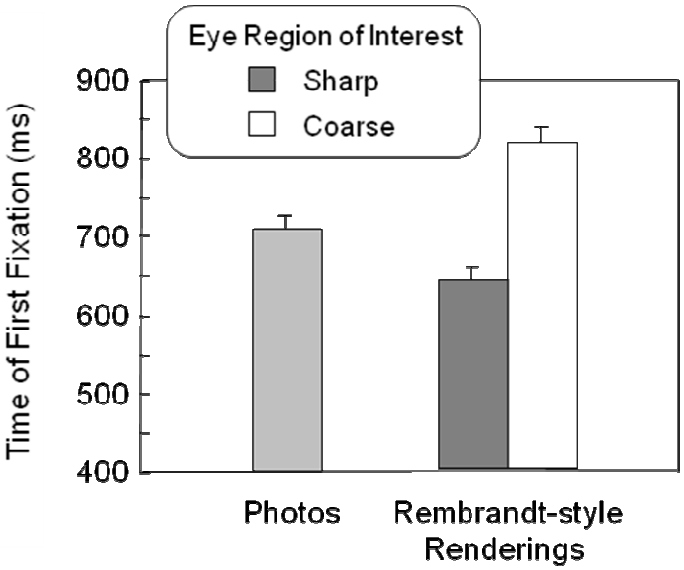

Fig. 7C. Mean time (milliseconds) of first fixation to one of two eye regions in photos and Rembrandt-style renderings.

CONCLUSION

In this paper we have taken a two-pronged approach to advance the hypothesis that artists in the late 'early modern' period developed the technique of textural agency in order to guide the observer's gaze and viewing experience. We first considered how this development might have come about in the work of Rembrandt, through his background familiarity with the spectacular developments of perspective in the work of the Italian masters, and then through his desire to innovate beyond these developments by

placing the viewer once again as a more active participant in the exchange between artist and viewer. Rembrandt, and other artists that followed him, did this by selectively emphasizing certain image regions over others by varying the relative level of image detail. In doing so, these artists may have been exploring 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 gaze pattern, as occurs in a more uniformly rendered artwork of that period with strong perspective, and as now occurs when viewing photographs. Thus, it is our view that the early modern period should not only be credited with the development of perspective to its highest form, but should also be credited with emerging attempts to understand the inherently dynamic interaction of eye and brain that characterizes human vision. In doing so, 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 [28].

In the second section of the paper, using Rembrandt as a guide, we empirically tested the hypothesis that the viewer's gaze is guided by variations in the textural detail of an artwork. The results demonstrated that variation in image detail could indeed influence the viewing experience on at least two levels, including that of simply guiding the viewer's gaze at a lower level of eye-brain function, as well as 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 wait for a future test.

Of course, the present results from the eye tracking study are limited in their direct generality to the textural details of edge contrast and color, as well as being restricted 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 it will also have to see 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, and we hope other artists and scientists, to examine the generality of 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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References

1. J. Hochberg, In the Mind's Eye, In R. N. Haber (Ed.) *Contemporary Theory and Research in Visual Perception* (New York: Holt, Rinehart and Winston, 1968).
2. M.F. Land, "Motion and Vision: Why Animals Move Their Eyes," Journal of Comparative Physiology A Vol. 185, 341–352 (1999).
3. J.T. Enns & E.L. Austen, Mental Schemata and the Limits of Perception, In M. A. Peterson, B. Gillam, & H. A. Sedgwick (Eds.), *In The Mind's Eye: Julian Hochberg On The Perception of Pictures, Film, and The World* (New York: Oxford University Press, 2007).

4. J. Henderson, “Human Gaze Control During Real-World Scene Perception,” Trends in Cognitive Sciences Vol. 7, No. 11, 498-504 (2003).
5. D. Melcher & C. Colby, “Trans-Saccadic Perception,” Trends in Cognitive Sciences Vol. 12, No. 12, 466-473 (2008).
6. John Sanden, *Portraits from Life* (Cincinnati: North Light Books, 2004).
7. Harry Berger Jr., “The System of Early Modern Painting,” Representations Vol. 62, Spring, 31-57 (1998).
8. R.C. Miall & J. Tchalenko, “Painter's Eye Movements: A Study of Eye and Hand Movement during Portrait Drawing,” Leonardo Vol. 34, No. 1, 35-40 (2001).
9. M. Nicholls, D. Clode, S.J. Wood & A.G. Wood, “Laterality of Expression in Portraiture: Putting Your Best Cheek Forward,” Proceedings of the Royal Society B Vol. 266, No. 1428, 1517-1522 (1999).
10. M. Livingstone, *Vision and Art: The Biology of Seeing* (New York: Harry N. Abrams 2002).
11. T.R. Vidyasagar, “A Neuronal Model of Attentional Spotlight: Parietal Guiding the Temporal,” Brain Research Reviews Vol. 30, No. 1, 66-76 (1999).
12. Harley Brown, *Harley Brown's Eternal Truths for Every Artist* (Cincinnati: North Light Books, 2001).
13. Berger Jr. [7].
14. Berger Jr. [7].
15. Martin Jay, Scopic Regimes of Modernity, In Hal Foster (Ed.) *Vision and Visuality* (Seattle: Bay Press, 1988).
16. L.B. Alberti, On Painting [First Appeared 1435], Trans. John R. Spencer (New Haven: Yale University Press, 1956).
17. Harry Berger Jr., *Fictions of the Pose: Rembrandt against the Italian* Renaissance (Palo Alto: Stanford University Press, 2000).
18. K. Clark, *Rembrandt and the Italian Renaissance* (New Haven: Yale University Press, 1966).
19. D. Rosand, *Painting in Cinquecento Venice: Titian, Tintoretto, Veronese* (New Haven: Yale University Press, 1990).
20. D. Rosand, “Titian and the Eloquence of the Brush,” Artibus et Historiae Vol. 2, No. 3 (1981).
21. V. Elliot, *Traditional Oil Painting: Techniques and Concepts of Classical Realism from the Renaissance to the Past* (New York: Watson-Guptill Publications, 2007).
22. Miall [8].
23. Livingstone [10].
24. S. DiPaola, “Exploring a Parameterized Portrait Painting Space,” International Journal of Art and Technology Vol. 2, No. 1-2, 82-93 (2009).
25. S. DiPaola, “Painterly Rendered Portraits from Photographs Using a Knowledge-Based Approach,” In Proc: SPIE Human Vision and Imaging, Int. Society for Optical Engineering. San Jose, p. 33 (2007).
26. Melcher [5].
27. E. Birmingham, W.F. Bischof, & A. Kingstone, “Gaze Selection in Complex Social Scenes,” Visual Cognition Vol. 15, 341-355 (2008).
28. S. Zeki, *Inner Vision* (New York: Oxford University Press, 1999).