Crossing Boundaries: Imaging Innovations in Art and Science

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ABSTRACT

The perceptual analysis an artist brings to creating an object is explored in relation to how a viewer perceives a completed art object. Multiple styles, media, and historical images are surveyed to (1) explain the artist/object relationship is interactive, (2) contrast narrative, visual, and compositional goals and (3) explore underlying solutions that bring superficially dissimilar images together. Within this matrix, the discussion demonstrates how innovative artistic and scientific imaging technologies interface as they revise understandings of how we see surfaces, transparency, light, and even seeing itself.

Keywords: art, perception, imaging technologies, photography, vision

1. photography

Photography is a particularly rich starting point for considering how the perceptual analysis an artist brings to a developing work is strikingly different from a spectator's point of view when gazing upon a finished composition. Since photography is a mechanical as well as artistic technology, photographic images also offer the best vantage point for beginning to bring the artist's perspective into focus. As is well known, photographic images have the capacity to copy external objects aesthetically or without *attempting* to bring a pleasing result to the copy. When an interactive eye informs the composition, an end result many admire often conveys an artistic quality and the addition of the artistic perception enhances our view of the world. As will be demonstrated, active seeing can foster this kind of artistry. When active seeing is practiced the results then have a quality that reflects *what* the artist has chosen to focus on, the *time* in which she is working, the materials she uses, and her skill in manipulating the materials used to bring her vision to its final form.

Interestingly enough, photography is an imaging technology that was invented by both artists and scientists. Frequently presented as a lesser art historically, due to being narrowly defined as a means to render permanently images of nature, the artistry of the technology has often been lost when the nature of the technology has been debated. This paper proposes that while it is true that images previously had only been given a stable

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permanent form when one used the hand and eye,1 this conclusion obscured that many processes and, by extension many subtle perceptual differences, defined photographic results from the beginning.

Photography’s versatility as both an art and a scientific tool begins to clarify when we consider its history. In 1839 William Henry Fox Talbot, an English scientist who became interested in the problem because he was unable to draw easily using a *camera lucida,* determined how to create a single negative from which multiple copies of positive prints could be made. His photogenic drawings used a method by which an object on sensitized paper was first exposed to light. Then, when an image of the object became visible on the paper, the image was fixed with water.

Independent investigations were conducted early in the nineteenth century by the Frenchmen Jospeh NicÉphore NiÉpce and Louis-Jacques MandÉ Daguerre. Their experiments grew out of lithographic techniques and in 1839, after NiÉpce’s death, Daguerre likewise was successful. Unlike Fox Talbot’s negatives, Daguerr fixed a single positive image. The daguerreotype was fixed on a metal plate coated with chemicals and exposed to light. Generally the process used a silver-plated copper sheet and the glittery, reflective surfaces were exquisitely detailed.

Calotypes were another early photographic form, and one that grew out of the early photogenic drawings. Sheets of paper were brushed with salt solution, dried, and then brushed with a silver nitrate solution to produce the calotype. After being dried again, the paper was used in the camera. The calotype was more like a photogenic drawing than a daguerreotype, in part because it too could produce multiple copies of any image. These required long exposure times, and revealed less detail than the competing daguerreotype.

Over time the basic process of fixing the image was increasingly done on the ground glass of a camera obscura.1,2 What is noteworthy when we review the various technologies is that when the term photography was chosen (in 1855) it simplified the vocabulary, but not the varied approaches nor the contradictory responses people brought to the new medium. As such, simply acknowledging the varied products fails to suggest the exciting ways practitioners explored the medium technically and visually from the beginning. In other words, from the beginning, photographers produced images demonstrating that fixing the picture with the camera was not simply a mechanical activity that could free the eye to concentrate on composition and style.1,2 Thus the oft-stated conclusion was that photographs were secondary to hand-made pictures, like the conclusion that a mechanically created image did not embody the kind of artistry that dissolves into brushstrokes or pencil lines, is misleading.1,2 The summation notices that some skills could be transferred to an inanimate apparatus and concludes that these skills are not as valuable as some less easily definable aspect an individual imprints.

Individual imprinting was clearly apparent in early photography and remains visible in photography today. For example, Carleton Watkins' artistry is apparent when we are looking up while standing among the circle of sugar pines, in his 1878 photograph of that name. In the print it is as if we are in the middle of a circle of sugar pines, gazing upward to infinity. Julia Margaret Cameron, another exceptional nineteenth century photographer, demonstrated a quite different approach, though equally aesthetic. She avoided the perfect resolution and minute detail that glass negatives permitted, opting instead for carefully directed light, soft focus, and long exposures (counted in minutes when others did all they could to reduce exposure to a matter of seconds.).3 All of these elements explain why her portraits of extraordinary individuals, for example Lord Alfred Tennyson and Sir John Herschel, are so striking. We can also find examples of exceptional work such as a 1839 engraving of Christ's head superimposed on an oak leaf. This photogenic drawing, done by an anonymous artist, shows that experimentation began almost immediately.

These examples are among the many that demonstrate photographers brought artistry and versatility to this technology from the start. The prints likewise demonstrate that photographers frequently produced sophisticated images that included state of the art science, state of the art technology, and an ever-expanding understanding of method. Within this, science informed the young technology in clearly definable ways. These provide the best examples of the convergence of art, science, and photographic technology. Among the innovations, probably the easiest to decipher are photographs recorded with stereo cameras, with the cameras registering two slightly different images, the two lenses acting like two eyes.

These stereo recordings were then merged in printing or were printed as stereograms, which could be merged with the use of a stereoscope. The stereoscope would give the image a three-dimensional quality by fusing the two side-by-side images into one. The depth the fusion adds is a function of the slight differences between the two images, differences that are easy to see if you compare the edges of each image. These photographic stereograms and stereo cameras visually indicate that artist's were integrating the nineteenth century formulation of the idea of binocular vision into their work.

Carleton Watkins crafted many stereograms. Some, like *Victoria Regia* (1878) are formal and quite modern in their aesthetic. Other Watkins stereograms, such as his 1861 print entitled *Inverted in the Tide Stand the Grey Rocks* are more naturalistic. Maria Morris Hambourg, Curator of Photography at the New York Metropolitan Museum of Art, explains Watkin's aesthetic as follows:

In landscape, as in human life, meaning lies less in objects than in relations, the links that tie specific incidents and entities together as an event or a place. In grasping myriad related connections and recording them photographically, Watkins created an intelligible world that maps and illustrates mental activity, mimicking the skeins of meaning our perceptions generate. His photographs awaken us to the exquisite pleasure of active seeing, inducing that conscious visual alertness we experience when viewing landscapes by CÉzanne, for example. Only here the artist's mental calculations are not laid down in painted strokes. They merge diaphanously with the trees and dissolve on the surface of the objective world.

She continues.

Looking at the photograph, we think we see the true structure of nature, its orderly scaffolding and superb textures merely disclosed; it takes real imaginative effort to recognize that no things in the picture nor the relations between them were self-evident. Everything ÷ the slant of a shadow, the depth of the darkness in cracks in pine bark, the silkiness of slightly shimmering water ÷ reveals the delicate trace of the artist's considered attention.4, p. 16

The art historian Jonathan Crary adds some perspective to Hamboug's conclusions when he proposes that we understand both nineteenth century avant-garde painting and nineteenth century photography as Îoverlapping components of a single social surface on which the modernization of Îvision' was everywhere taking place. This is to say that the developments in optics and vision, like photography and the emergence of modernist painting, can be seen as parallel symptoms of a larger, more fundamental transformation occurring within Western culture, one already well under way by the middle of the nineteenth century.5,6

2. Analog and digital perspectives

Before integrating the nineteenth century painter's eye, by adding some remarks on the artist Paul CÉzanne, it is important to expand on a few points introduced above. A twentieth century invention, the autostereogram, offers a useful touchstone. The way these computer-generated images differ from the nineteenth century photographic stereograms discussed above also adds critical scientific information to our understanding of active seeing, thus allowing us to speak in more detail to the kind of active seeing Hambourg mentions when commenting on the exceptional visual quality in Watkin's work. In the case of the autostereogram, however, the task requiring active seeing takes another form.

With the autostereogram the viewer must fuse the representation experientially to see an embedded image ÷ and thus *cannot be* a passive viewer. As Tyler explains, "the information from each eye has to be connected so as to provide a fused representation in the brain of a single region in space."7 In other words, one must dissociate convergence (coming together from different directions) and accommodation (the reconciliation of opposing views),7 the point being that each eye must look independently of the other. It must be stressed that patience, not imagination, is required to Îsee' the image embedded in the random dot pattern since the embedded image can only be seen when each eye addresses the pattern separately, sends the information to the brain, and has the brain construct a means for one to visualize the image we then see. Moreover, unlike a Gestalt image where an ambiguous pattern can be perceived in more than one intelligible way (two faces or a vase, for example) the flat autostereogram does not actually contain the perceptual solution one eventually sees. Instead, computed densities with different textures draw on data from visual studies that allow the designer to derive patterns that *only* converge when each eye addresses the pattern separately.

While the random dot stereogram (RDS) was designed to eliminate all monocular depth cues the one that remains, which is easily overlooked, is the textural density. The RDS only *appears* to be uniform superficially. It is because it seems to indicate that no depth changes are occurring across the surface of the stereogram that we are initially convinced we see it this way at first glance. Visually, in order to perceive the stereoscopic information appropriately the visual system must conclude that the texture densities on the nearer surfaces are finer than on the further surfaces. This is how the 3-dimensional image is identified7 and why the pattern does not work like the Gestalt images.

The evidence of the eye/brain relationship revealed by the autostereogram is one of the most revolutionary aspects of the random-dot stereogram and the beauty of the discovery was that it empirically explained that neither eye alone can perceive the form because neither eye alone *contains* the stereoscopic form. From an artistic vantage point the autostereogram underlined there was a limitation in a long-standing academic technique in art education. Teaching students to draw what one sees has long included the exercise of closing one eye and pointing a finger to help define forms and relationships. This has been a common exercise despite the fact that we can easily see that we don't see this way at all. The simple experiment that offers us this knowledge only requires an individual point a finger at a spot with one eye closed. Then open the closed eye and close the open one without moving the finger. The viewer quickly sees the finger is no longer pointing at the original spot. Likewise, with the autostereogram, we find that closing either eye does nothing to clarify the hidden result. It is only our eventual perception of the embedded image that indicates that we do not see the form per se with our eyes superficially. Again, it is impossible to fake the perception for it is our brains that create the fused representation we eventually see when we fuse the slightly different strips that were used to create the random dot pattern.7

The autostereogram is also an example of how an image can be composed using computers. It has been introduced to show that both photographic and computer-generated stereograms can be created using technological tools. What needs to be factored into this is that while both the photographic and computer-generated stereograms can be produced using technological means, they are also contextually different. A key difference is that one is an analog image and the other digital.

The basic technical distinction is that an analog image is continuous and digital representation is comprised of discrete elements. As such, a photograph is defined as an analog representation because it varies continuously both spatially and tonally. A digital image, on the other hand, is encoded by subdividing the picture plane into pixels that can be stored in a computer's memory, electronically transmitted, displayed, printed, and manipulated on an ongoing basis. The pixels are markings on a finite Cartesian grid of cells. Color and shape are defined by specific assignment and a resulting two-dimensional array of integers (the raster grid) results. What is key here is that while the resulting digital image is machine generated, it does not have the continuity of color and shape as defined in a photographic image, where details and curves are smoothly interfaced. To the contrary, a digital image offers an approximation of continuity that is mapped by breaking up the components of the image into discrete steps, discrete shapes, discrete colors.

With this distinction in place we can now apply a broader scope to paintings and consider artistic perception in light of the historical idea that paintings are handmade, not mechanically informed images. Doing this in analog/digital terms is a good place to start, since we now know that the brain fuses what our eyes see. The analog/digital distinction is perhaps best conceptualized by first considering that digital pixels can reproduce a painting and then recognizing we have more than one option here. In other words, scanning, the obvious approach to replication is only one approach to duplicating the image. We can also re-create the work by using computer algorithms. Stylistic elements surrounding a re-created image, however, are more complex.

W. J. Mitchell has explained how to use computer algorithms to reconstruct Jan van Eyck's *Arnolfini Double Portrait* (1434), now at the National Gallery, London, which makes the van Eyck piece a good reference point for how one might digitally produce a painted image.8 Briefly, replicating the character of the representational scenes includes re-defining the complex combinations of diffuse and spectular effects we find in the double portrait. In the painting we see the faces and figures of Giovanni Arnolfini and Giovanna Cenami are gently modeled by a flood of light from the top left so that every nuance of surface curvature is brought out ÷ particularly on Giovanna's swelling body as she stares into the light. We also see soft shadows on the floor plane, a diffuse wash of window light across the plane of the wall behind them, and an interior space unified by careful attention to the subtleties of diffuse interreflection. There is also a sharply defined patch of luminous sky visible through the window. In addition, a striking feature is the central axis dividing man and wife that is occupied by specular effects: metallic highlights on the candleholder, distorted reflections on the convex mirror, the smooth glossiness of outstretched palms, and the wiry, shiny coat of the little terrier.

According to Mitchell, this kind of scene can be rendered effectively (and at considerable computational expense) by a two-pass process. One would use radiosity to divide the surface in the scene independent of the observer position and thus compute diffuse effects in the Arnolfini Double Portrait. The radiosity procedures begin by dividing the surfaces in the scene, rather than the picture plane, into small discrete elements independent of observer position. The method assumes that light energy is conserved in a closed environment and an attempt is made to account accurately for the way in which light emitted or reflected from each surface element is reflected from or absorbed by other surface elements. For complex scenes computation of the form factors is a massive task. In nondiffuse environments, however, radiosity calculations become much more complex and time-consuming to carry out because the energy-balance equations become more complicated when directional reflection must be considered and partly because smaller surface patches must be used to achieve satisfactory results.8

Ray tracing would be the procedure used to create an adequate perspective by matching shapes and colors on the picture plane to compute the specular effects. Ray tracing is an elegant systematization and extrapolation of an idea that goes back at least to Brunelleschi's early perspective studies. The idea is that you can create an accurate perspective view by painting on a transparent screen interposed between the eye and the scene, and matching shapes and colors on the picture plane to shapes and colors in the scene beyond.8 Summing the results of these two procedures produces the final image, a digital version of the painter's strategy of employing a multipass process. In other words, the painter might include the underpainting, scumbling, glazing, and so on.8

The questions of whether the computer image can be as robust an image and whether the image is art are complicated ones this paper will not address directly. This example has been introduced largely to offer a means to expand our vantage point on art and perception. In this case we find that Renaissance ideas about mathematical perspective are like a digital framework and the invention of oil paint added an analog-like quality. One could say that perspective was the ray tracing and oil provided the radiosity. The larger point is that oil paint and perspective, like the computer and the camera, challenged long-standing ideas about representation, perception, and seeing. This is important to note since the oil paint technology and perspective were both areas that Western artists began to develop in tandem.

In other words, our chronology is incomplete if it fails to consider that the earlier developments are not simply narrative differences but also include imaging innovations that visually informed how the viewer perceived the finished object. Results of different historical periods as such speak to how scientific technologies and visual models both informed artistic practice. As a whole the innovative details also display areas where science and art have communicated in other times. For example, it is not just that perspective is a monocular system, rather than a binocular one, which means it adopts a one-eye point of view where the main focus is the primary vanishing point. Of equal importance is that oil paint and the perspectival system quickly merged and compensated one another when artists created representations.

3. Paul CÉzanne

Returning to the nineteenth century we can see how Paul CÉzanne, a painter, incorporated revised ideas about color and vision into his practice in ways quite unlike the nineteenth century photographer Carleton Watkins. The influence of scientific ideas related to vision set CÉzanne's nineteenth century paintings apart from the early Renaissance work of van Eyck. Interestingly enough, on the one hand, we can thus say that while CÉzanne was a contemporary of Watkins and likewise influenced by nineteenth century changes in understanding regarding vision, perception, and color, the products of each man differ. On the other hand, we can say that CÉzanne, like Jan van Eyck the man who is often credited with inventing oil paint9,10 lived during an era where we find an extensive revision in the human understanding of optics, vision, perception, and painting. Yet, just as the work of Watkins and CÉzanne differ, so do the paintings of CÉzanne and van Eyck. In fact, an intriguing element of Paul CÉzanne's legacy is that while *he* aligned his work with the classical Renaissance tradition of Western art that was impacted significantly by the development of oil paint, CÉzanne's innovative body of work ushered in a decisive break with the standards of that tradition in the twentieth century.

Looking at CÉzanne's painterly intentions and the resulting representational system he developed shows that the formal content of CÉzanne's paintings no more appears classical than it appears to be like the pluralistic art of the twentieth century. Given this, and given CÉzanne's allegiance to classicism, his work offers an excellent vantage point for once again seeing how nineteenth century science radically changed painterly ideas of color, vision, seeing. More important here, CÉzanne's letters and his recorded conversations with Joaquim Gasquet indicate that while he was aware of the radically revised theories about optics, vision, and perception put forth by Brewster, Wheatstone, and von Helmholtz. While CÉzanne's awareness is not easy to isolate in terms of his art, we can surmise certain influences when we compare his art with others of his time and reflect on comments found in his writings and the works of his biographers.

CÉzanne's letters repeatedly indicate that he believed any artistic style governed by fundamental principles of communicative expression was properly signified as classical. Thus, from his perspective, we can surmise that his interest in scientific facts about vision and his turn toward the classical masters of painting was not one that would combine science and art in a way that would emphasize method alone, blind imitation, or simply copying the work of earlier painters. To the contrary, CÉzanne believed that artistic success came from solving technical problems and that seeking for solutions should guide the artist as he or she rendered his or her personal sensation. A perfect example of how an artistic solution to a technical problem resulted in exceptional painting due to an imaging innovation would be van Eyck's recognition of the value in binding oil with pigment to produce color and effects that were unlike anything ever done earlier.

CÉzanne, of course, solved the technical problems he encountered in the context of his time. His culture was undergoing radical re-formulation on many levels and, according to Crary, the break with classical models of vision in the early nineteenth century was far more than simply a shift in the appearance of images and art works, or in systems of representational conventions. Instead, it was inseparable from a massive reorganization of knowledge and social practices that modified in myriad ways the productive, cognitive, and desiring capacities of the human subject.6, p. 3.

CÉzanne's work reflects the nineteenth century environment, despite his isolated life style. As noted, he was versed in the scientific discourse of his time. He also actively mirrored many others of his time in pursing interests intended to show how an individual's perceptual knowledge can deviate from the weight of history, learned formulae, and conventional ideas. The resulting art simultaneously reveals how his context was informed by the nineteenth century overall ÷ and the ways in which he deviates from popular views. For example, many spoke of the value in bringing an Îinnocent eye' to one's painting process. Yet CÉzanne's success was founded on an approach quite unlike that of a na•ve painter. CÉzanne used an open, yet practiced eye, a point Gasquet makes when he speaks of how CÉzanne exclaimed that "the eye educates itself by contact with nature"11,12, p. 163 This education is what separated CÉzanne's eye from the Îinnocent eye' as generally understood in the nineteenth century. CÉzanne worked constantly and the dedication he invested in achieving his result further demonstrates that his open but yet practice eye was a part of an active and a slowly developed painting process. Thus while we might adopt the expression of Îthe innocent eye' to reference the break with academic procedures, and to CÉzanne's brushstrokes as Îstains' on the canvas, as some do, this is to miss his achievements. When we look closely at the body of work it is quite apparent that CÉzanne's markings are not naive and are more than just stains on the canvases.

CÉzanne's stains, if we call them that, show how CÉzanne first reaches out to capture something vital and vibrant and then expresses what he sees so that it captivates those who view his markings. CÉzanne's work also shows how he used his Îopen' but yet Îpracticed' eye to aid him as he developed the techniques *he* needed to solve the problems that arose in translating his vision and sensation onto the flat surface the canvas provided. More important in the context of this discussion is conceptualizing that oil paint, the imaging technology van Eyck perfected to solve particular problems and achieve his plastic goals was a familiar technology by CÉzanne's time. In other words, while van Eyck grappled with a virtually unknown medium, nineteenth century painters no longer even needed to bind oil with pigment manually. In a world with tubed paints, synthetic pigments, and manufactured brushes CÉzanne's solutions to technical problems, like his visual and imagistic decision-making process, were of another order entirely.

What must be stressed is that tubed paints and manufactured brushes are imaging innovations but they do not take the painter out of the painting process. To the contrary, CÉzanne's letters relate the degree to which he remained present in what he did. His letters also relate that his visual decision making process was neither abstract nor simply intuitive. We only need look at canvases at various stages of completion and at different periods of his life to see what CÉzanne meant. The range of completed and incomplete work clearly documents how deliberately this master painter approached perceiving solutions to his painterly problems.

For example, looking closely we see specific types of problem-solving led to the recorded solutions we find in the completed works. We can also decipher certain tendencies that defined how he worked. One defining element we can study is the way he carefully moved his canvases as a whole while building up the painted surface. After looking at many examples we can almost conceptualize what CÉzanne meant when he told Gasquet that

There are two things in a painter: the eye and the brain, and they need to help each other, you have to work on their mutual development, but in a painter's way: on the eye by looking at things through nature; on the brain, by the logic of organized sensations which provides the means of expression . . . The eye must concentrate, grasp the subject, and the brain will find a means to express it.11,12, p. 222

The unfinished compositions, however, most succinctly explain CÉzanne's technical relationship with his visual logic. They are descriptive, primary sources that reveal him slowly building up the paint and the color relationships. Comparing incomplete and complete compositions establishes how he approached developing the forms in relation to the colors. We can also find many examples illustrating that the harmony within each finished piece emerged as he gradually moved the entire canvas toward completion.

As noted, CÉzanne had access to tubed paints and other tools that allowed him to explore each composition in terms of its own potentials and harmonies. One result is that CÉzanne's deeply studied oil compositions offer a stark contrast to the spontaneous simplicity of CÉzanne's watercolors. Yet with each medium CÉzanne consistently shows that his Îopen' eye slowly comprehended ÷ i.e., learned ÷ how to coordinate seeing with touching, translating what he saw and sensed onto the flat picture plane.

In sum, CÉzanne systemized particular elements, learned to coordinate what he saw with what his materials could do, learned to push the materials to their limits, and found ways to record novel perceptual statements in paint. As a result, CÉzanne's paintings not only convey a studied visual complexity, they also record how he manipulated the technologies of his time, the constancy he felt within when gazing at the world he saw, and his urge for full expression. Indeed his way of combining constancy with expression cannot be underplayed when reviewing his work with a focus on art and perception. For example, despite the fact that he painted *Mont Sainte Victoire* over forty times, the constancy he expresses is not visually repetitive. Instead the freshness of each piece shows the degree to which he carefully studied his goals, brought a 'new' eye to each day of painting, and also brought particular intentions to his painting process.

Four points are key to understanding the degree that CÉzanne advanced painting more than he mirrored earlier painted narratives. First, rather than returning a na•ve vision to compositional development he developed new techniques, using technical imaging innovations that gave him a freedom van Eyck, for example, did not have. CÉzanne's work explicitly documents this freedom, for he paints in ways that would have been impossible if he had to regularly mix his colors from scratch. Second, CÉzanne's compositions also differ formally from the works of those who only bring an innocent eye to their painting process. This is evident when we review the work he produced over his life time and see how he developed novel ways of applying paint in order to eventually resolve some of plastic problems of interest to him. One solution is his use of small dabs of color to more forms toward the surface while having them appear as if they are receding as well. Third, as both Smith and Crary discuss, CÉzanne was influenced by scientific ideas and the stereoscopic transparency of his paintings reflect this nineteenth century context. Finally, as CÉzanne wrote in a 1905 letter to the art critic Roger Marx: "To my mind one does not put oneself in place of the past, one only adds a new link."

The late Clement Greenberg, often considered the critic who first recognized that abstract art was a valid and genuine form of artistic expression explains why painters so unlike CÉzanne stylistically held him in such great esteem. Briefly, evaluating CÉzanne's impact Greenberg concludes that CÉzanne sought to achieve mass and volume first, and deep space as their by-product. This reflected his desire to "save the key principles of Western painting ÷ its concern for an ample and literal rendition of stereometric space ÷ from the effects of Impressionistic color."13, p. 50 Thus, according to Greenberg CÉzanne's approach was one that attempted to connect the Impressionistic method of registering variations of light in a way that would indicate the variations in planar directions of solid surfaces. CÉzanne substituted modeling with the supposedly more natural ÷ and Impressionistic ÷ differences of warm and cool for the traditional modeling in dark and light and, as a result, CÉzanne's paintings show a kind of pictorial tension that had not been seen in the West since Late

Roman mosaic art. A noteworthy element is that CÉzanne appears to make no attempt to fuse the edges of the overlapping little rectangles of pigment that define many canvases. This stereoscopic technique brought depicted form toward the surface, while the modeling and shaping performed by these same rectangles drew it back into illusionistic depth. As Greenberg notes,

The Old Masters always took into account the tension between surface and illusion, between the physical facts of the medium and its figurative content ÷ but in their need to conceal art with art, the last thing they wanted was to make an explicit point of this tension. CÉzanne, in spite of himself, had been forced to make the tension explicit in his desire to rescue the tradition from - and at the same time with ÷ Impressionistic means.13, p. 52

In sum, it is often noted that CÉzanne remarked that he wanted to redo Poussin after nature and Îmake Impressionism something solid and durable like the Old Masters." Poussin, one must remember, had pointed out that there are two ways of looking at objects: one is quite simply to see them, the other is to consider them with attention. CÉzanne adopted this bias and later painters who admired CÉzanne's work were drawn to how CÉzanne transformed this attentive quality into paint. For example, Picasso, who acknowledged his debt to CÉzanne and who painted quite unlike CÉzanne, explained CÉzanne's special touch by referring to the Poussin comment, saying: "If CÉzanne is CÉzanne, it's precisely because of that: when he is before a tree he looks attentively at what he has before his eyes; he looks at it fixedly, like a hunter lining up the animal he wants to kill. If he has a leaf he doesn't let it go. Having the leaf, he has the branch. And the tree won't escape him."14, p. 53 Or, as a modern critic wrote, Cézanne painted the "treeness of a tree."

4. Imaging innovation in the twentieth century

Given the degree to which twentieth century art does in fact differ from that of earlier eras I want to close with some thoughts that add twentieth century images and images made with twentieth century technologies to the innovations discussed above. One important element is that the vast array and pluralistic nature of the art now being produced illustrates that representation per se is generally not an artistic goal today. A second area to consider is how the move away from representation speaks directly to the need to probe what artistic perception is in a way that does not assume representation is the definitive matrix when we speak of art and perception. While many twentieth century artists have had exceptional representational skills, many prefer to use their eyes to help them present other kinds of artistic solutions and perceptual statements. This suggests we might cover more territory is we ask broader questions when approaching art and perception.

For example, how artistic practices combine physical and neural domains is surely an area worthy of further investigation ÷ and we might ask whether key differences have been underplayed in psychophysical and neural studies. Another important question we might ask is why is it that behind the reflective surface of an individual's, as well as an artist's eyeball there is a brain that is making sense of the perceptions the eye has, more or less. The important words here are more or less. For, in a general sense, we can say that for all intents and purposes the eyeball is a camera obscura, admitting light in and allowing none to escape. The outer surface of the cornea, as such, reflects a small portion of light, most of which it otherwise transmits to the interior of the eyeball.

We can also say, as discussed in the sections on Watkins and the autostereogram, that there is a difference between active viewing and superficial viewing. For example, we know that the cornea betrays its presence by the highlight that gleams on its domed surface of the eye. Artists have long shown this. So when a Renaissance artist, for example, placed a window on a person's eye this image served multiple purposes. It indicated there was a window in the room and was also the highlight also indicated there was light hitting the otherwise invisible dome of the glistening cornea in the painted eye.15 Adding the highlight, of course, also allowed artists to display their ability to represent surfaces, colors, luminosity, and reflection.

Perhaps it is because art has so long been seen as other than science that we often fail to see the ways in which innovative imaging technologies have brought the two domains together repeatedly. Looking at these technologies contextually offers us a means to bring a greater understanding of what each domain does in its laboratory. This understanding, in turn, allows us to perceive the degree to which imaging innovations often record excellence ÷ be we artists or scientists. When this excellence effectively allows artists and scientists to communicate more, rather than less, our imaging tools are no doubt being used to greatest advantage.

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