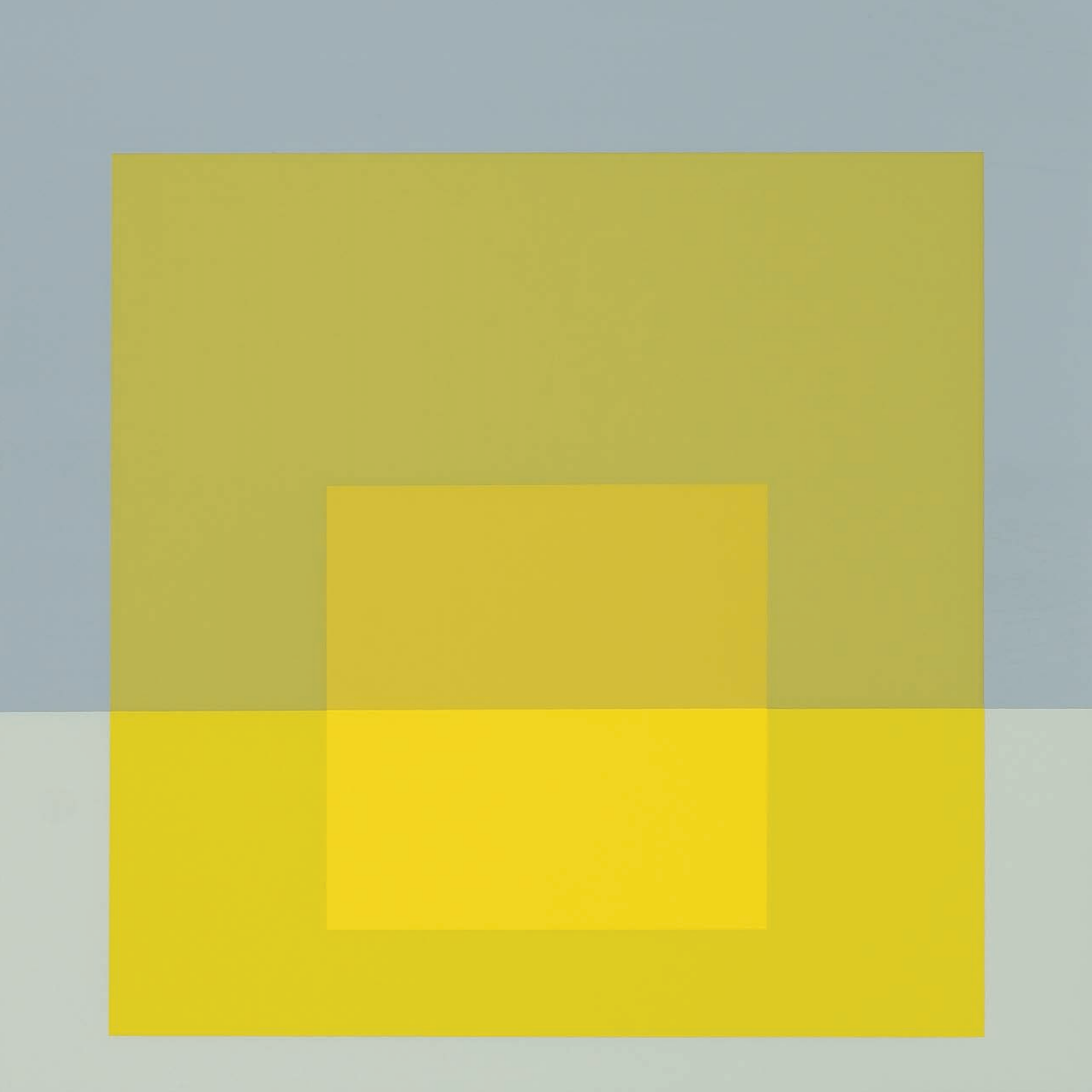


SEEING COLOR

Art, Vision & the Brain

APRIL 13 – JULY 5, 2015

In visual perception a ***COLOR*** *is almost never seen as it really is – as it physically is... No normal eye, not even the most trained one,* ***IS*** *fool proof against color deception... Colors present themselves* ***IN*** *continuous flux, constantly related to changing neighbors and changing conditions... As we begin principally with the material, color itself, and its action and interaction as registered in* ***OUR MINDS****, we practice first and mainly a study of ourselves.*

- Josef Albers, *Interaction of Color*

Introduction

You trust your eyes to give an accurate representation of the world, but are the colors you see truly *there*? Color is often regarded as a physical property. However, the instability and relativity of color cannot be chalked up to the workings of wavelength and light. What defines our experience of color is the brain.

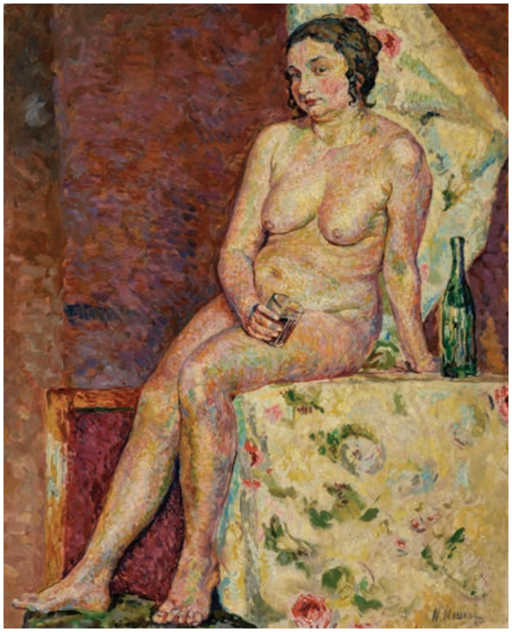
Artists and scientists have been fascinated and perplexed by the visual and neural mechanisms contributing to visual perception. Their collaborative efforts have explained and contextualized visual phenomena. French chemist Michel Chevreul's theory of simultaneous contrast and optical mixing informed the work of impressionist and symbolist artists. Josef Albers' empirical approach to understanding color phenomena taught modern and op-artists new ways to apply color theory. This mutual curiosity in the existence and interactions of color culminated to inform why we see what we see.

Seeing Color brings together artists whose works explore and exploit the neural mechanisms of the eye and brain. Spanning from 1920 to 2007, the artwork featured in this exhibit investigates the intersection between art and neuroscience, with an emphasis on color and luminance. Some works ask you to confront the instability of visual perception. Others challenge you to accept colors not physically present. Do you trust what you see?

It is clear then that when we say we perceive colors in objects, it is really just the same as saying that we perceived in objects something as to whose nature we are ignorant but which produces in us a very clear and vivid sensation, what we call the sensation of color.

- René Descartes

Optical Mixing



ABOVE: Ilya Mashkov, *Seated Nude*, c. 1920. Oil on canvas. Collection of the Nasher Museum of Art at Duke University. 2000.28.4. Gift of Anatol and Maya Bekkerman. BELOW: David Davidovich Burliuk, *Untitled*, c. 1930. Oil on canvas. Collection of the Nasher Museum of Art at Duke University. 2001.31.3. Gift of Drs. Irene and Alex Valger.

As you move closer to Mashkov's *Seated Nude*, you may notice that the rosy appearance of her skin lessens, while the shadow on her front leg is reduced to olive green brushstrokes. Only from a distance does the subject look realistic.

The landscape painting by Burliuk follows suit. Here, the thickly applied paints of sky blue, lavender, and pink create mountainous forms in the background. Dabs of bright green, red, and yellow oil paint form a road and the shadows of surrounding buildings. Each of these forms can only be distinguished from the right viewing distance; up close, they dissolve.

Both artists build color and form through painting techniques that rely on optical mixing. Instead of physically mixing paints to a hue that matches the object represented, two or more colors are painted next to each other. When viewed from an appropriate distance, visually responsive cells in our retina cannot perceive each dot individually. The brain, instead, perceptually mixes the color of adjacent dots together. As a result, we are able to see a coherent image rather than a jumble of multicolored brushstrokes.

Optical Mixing: Our ability to distinguish discrete from mixed spots depends upon the size of the dots and viewing distance. All visually responsive cells in the retina respond to a small part of the world, called a "receptive field." If adjacent spots are small enough, they will all fall within the same receptive field and the brain will not perceive them as separate. This is also how TV and computer monitors work.

Color Induction

Hines' fascination with the interaction of color is reflected in the perceptual phenomena demonstrated in his paintings. In *Yellow on Yellow*, Hines paints three regions using different yellows. However, after looking at this painting for some time, you may begin to notice that additional hues appear where the swaths of yellow meet. An orange hue floats at the edge where the top yellow meets the bottom yellow. A similar effect can be seen around the yellow circle in the bottom half of the painting where a slight greenish outline appears. *Yellow on Yellow* capitalizes on color induction, the tendency for a color to change and move away from its surrounding color context. This phenomenon is especially intense at the edges where the colors meet. The process is not immediately seen, but slowly begins filling in from the edges after a few seconds of looking. By exploiting this effect, Hines introduces perceptual colors not physically present on the canvas.

OPPOSITE: S. Felrath Hines, *Yellow on Yellow*, 1968. Oil on canvas. Collection of the Nasher Museum of Art at Duke University. 2009.9.1. Gift of Dorothy Fisher, wife of the artist.

Chevreul Effect

Michel Chevreul was a French chemist and director of dye works in the 19th century at the Gobelins Manufactury in Paris, a well-known tapestry company. Chevreul was hired to determine why their yarn dyes were fading, but determined that there was nothing wrong with the dyes. Chevreul discovered that when colors of the same hue but different intensities are placed side-by-side the visual system perceives a gradual brightening and darkening along the boundaries of the two colors. Chevreul's systematic studies of this and other color principles influenced Delacroix, the Impressionists, Matisse, Albers, and many other artists.

Color is never as it seems. In this work, Felrath Hines uses a simple palette of three shades of gray and a green to demonstrate the ambiguity of color perception. In the upper half of the painting, viewers may see a brighter area, or gradient, near the boundary between the gray circle and the darker gray background. This illusion is called the Chevreul Effect.

Notice the green circle in the bottom half of the painting. Is the circle truly green as the work's title implies? Interestingly, the color of the circle depends on the surrounding. If the light gray surround were replaced with a white background, the circle appears more yellow. If the background were black, the circle appears greener. By using mid-tone gray, Hines achieves something in the middle—a circle with a greenish-yellow tinge. Hines, as well as many other artists in this exhibition, demonstrates the subjectivity associated with seeing color.

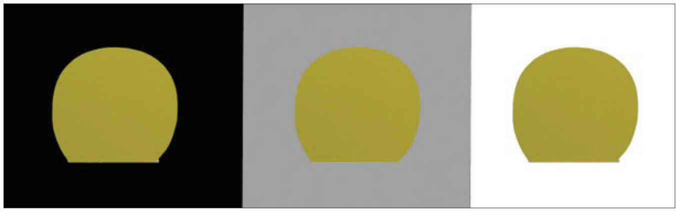
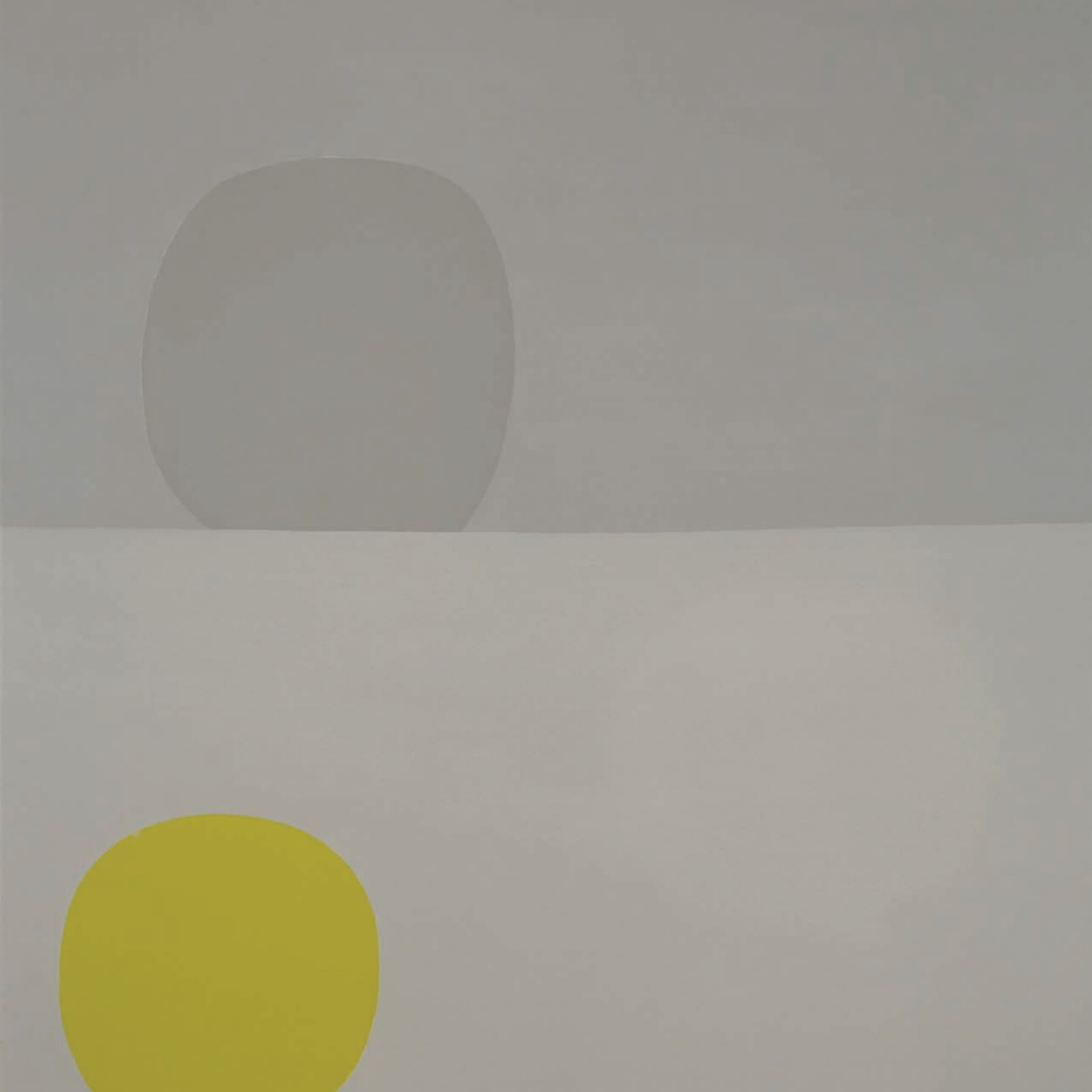
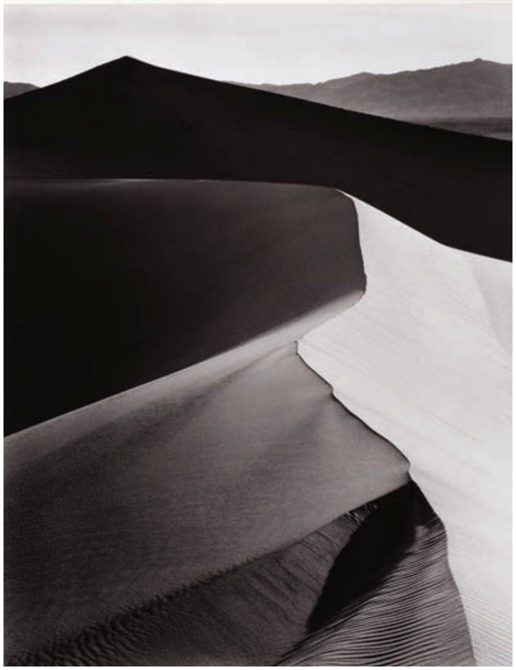


Illustration of green circle against black, gray, and white.

OPPOSITE: S. Felrath Hines, *Three Grays with Green Circle*, 1975. Oil on canvas. Collection of the Nasher Museum of Art at Duke University. 2009.9.2. Gift of Dorothy Fisher, wife of the artist.





ABOVE: Ansel Adams, *Sand Dunes, Sunrise, Death Valley National Monument*, 1948 (printed 1980). Gelatin silver print. Collection of the Nasher Museum of Art at Duke University. 2011.8.11. Gift of the Aubrey Courtney Shives, Jr. (T'66) Trust. BELOW: April Gornik, *Red Dune* from the portfolio *America: Now and Here*, 2007 (printed 2009). Chromogenic print. Edition 94/100. Collection of the Nasher Museum of Art at Duke University. 2013.15.1.10. Gift of Dr. and Mrs. Ronald Francesco.

Black & White Luminance

Can you tell that this photo was taken at sunrise even though it is in black and white? In the absence of color cues, our eyes must acquire information solely from luminance, or brightness, cues. Despite this lack of color, it is still possible to perceive this photograph as a nuanced image of remarkable clarity and depth. However, there is still a level of ambiguity—it could be sunrise, or sunset. This shows that while spatial details are often derived from luminance differences, color still provides a wealth of information that is not present in an achromatic image. For example, if we were able to perceive the color of the sand dunes in this photo, we might be able to tell what type of sand it was, where it was from, what time of day it was, or what the weather was like, just to name a few possibilities. The perception of color is not only aesthetically pleasing, but is also an invaluable factor in our ability to perceive and make sense of the world around us.

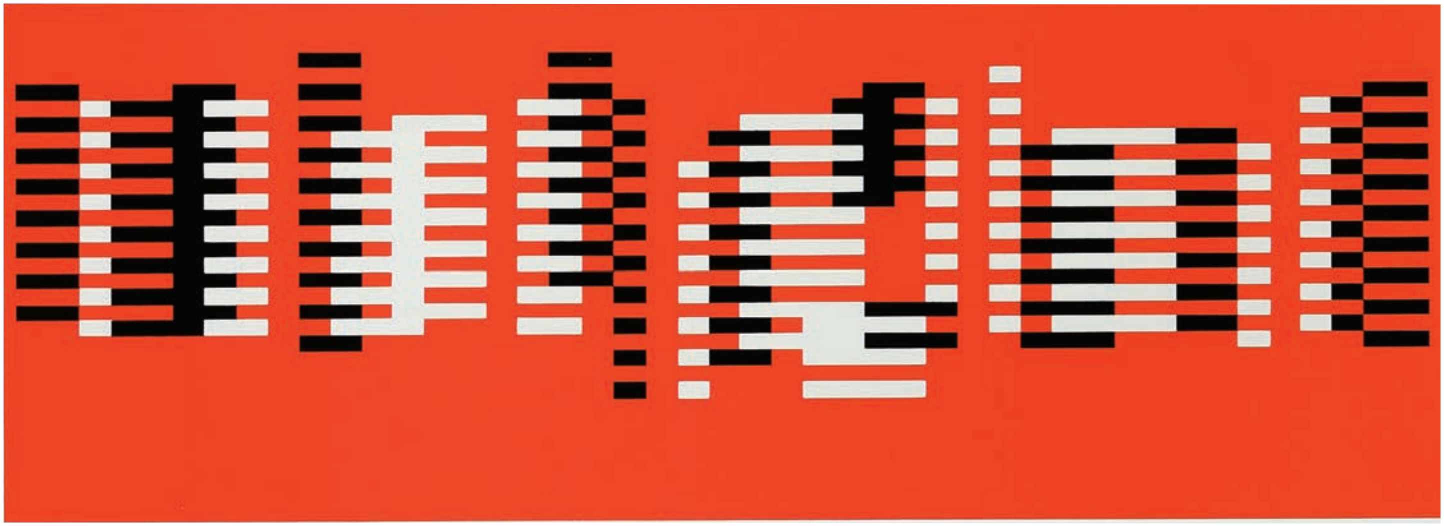
Color Constancy

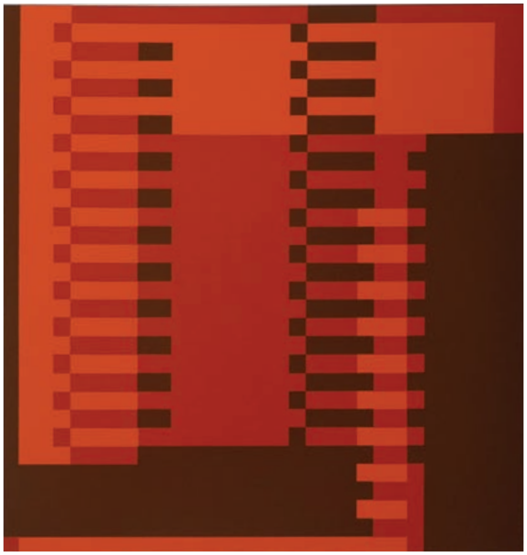
Gornik's *Red Dune* is a parallel to Adams' photograph and Calder's print. She approaches the same subject matter as Adams with a Calder-esque color scheme. Once more, we see the importance of luminance cues in discerning the form of the photographed sand dune. There is a profound contrast in brightness at the edges of the dune. The color difference between the red of the sand and the black of the shadow alludes to how the sun hits the surface. The drastic variation in not only luminance, but also the saturation of colors, produces a photograph with dramatic depth. The vivid blues, reds, and yellows may appear as unrealistic colors, yet the sand dune remains recognizable. Through color constancy, our visual system has the ability to discount the lighting changes that happen in our natural world, but in some cases it fails. Is the sand really red, or is the light of a low sun creating the saturated colors you see?

Calder's Unsettling Luminance

Calder uses color and luminance cues to create the illusion of three-dimensional pyramids. For instance with the yellow-red pyramid near the center, the yellow face is brighter and reads as the illuminated face, with the red triangle in the shadow. Comparing the luminance contrast of adjacent sides of each pyramid suggests the light source's location and how it lights each face. However, the black and blue pyramid on the left disrupts this illusion by placing the black triangle to the left, where we expect the light to shine, and the blue triangle in shadow. This contradicts the perceived orientation of the other pyramids. Does the print become visually unsettling once this contradiction is perceived?

ABOVE: Alexander Calder, *Pyramids*, 1971. Lithograph in colors on paper. Collection of the Nasher Museum of Art at Duke University. 1973.12.1 Gift of Mr. and Mrs. Samuel Dorsky. BELOW, LEFT TO RIGHT: *Pyramids* without shading. How do you perceive the orientation of each? *Pyramids* with only luminance cues reveals an inconsistant light source.

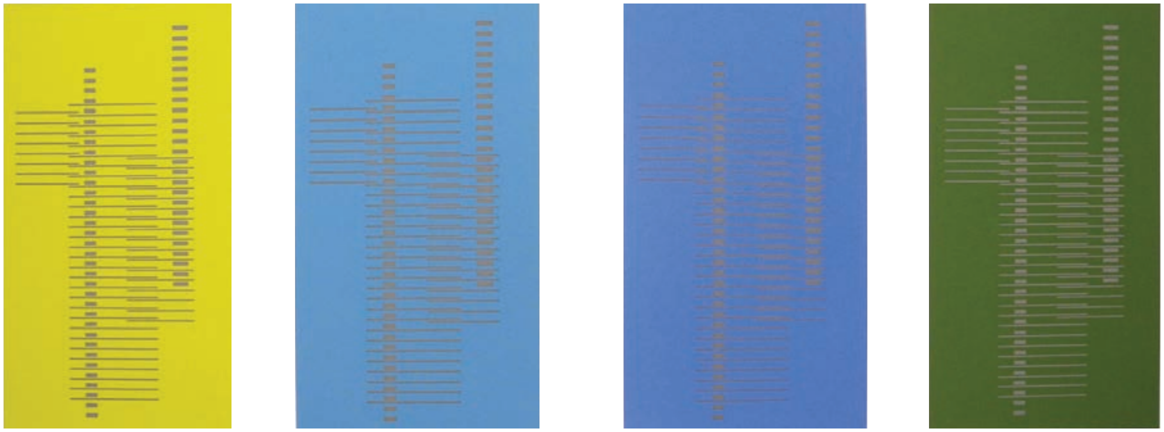




ABOVE: Josef Albers, I.8 from the portfolio *Formulation: Articulation*, 1972. 1975.8.1.8. BELOW: Josef Albers, I.22 from the portfolio *Formulation: Articulation*, 1972. Published by Ives Sillman, Inc., New Haven, Connecticut, in collaboration with Harry N. Abrams, New York. Printed by Sirocco Screenprints, New Haven, Connecticut. Screenprint on Mohawk Superfine Bristol paper. Edition 362/1000. Collection of the Nasher Museum of Art at Duke University. 1975.8.1.22. Gift of The Josef Albers Foundation.

Bezold Effect

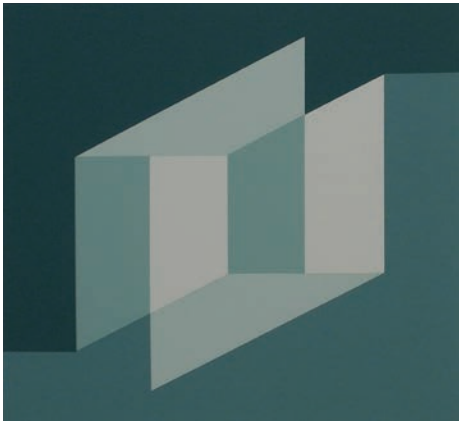
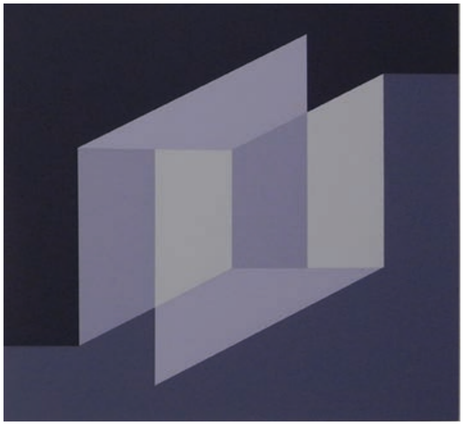
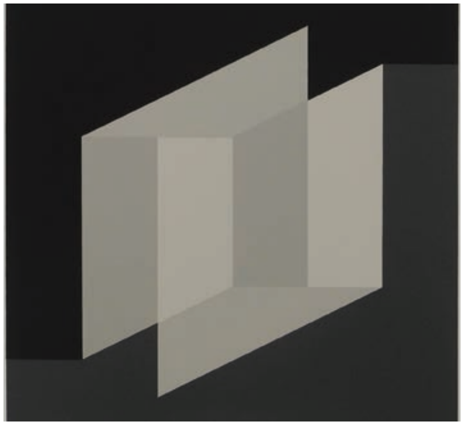
How many colors do you see in these artworks? The answer may seem simple, but look closer. Albers used only three colors in each of these: red, white, and black in one, and red, orange, and brown in the other. Any other shades you may see are due to color assimilation, or the Bezold Effect, where small areas of color may appear different when closely interspersed with other colors. This phenomenon makes these regions appear closer to the color of the interspersed areas (darker if surrounded by black, lighter if surrounded by white). Here, the white and red bars between the black bars may be perceived to be darker, as though they are gray and dark red in color, whereas the red and black bars between white ones may appear lighter in color, as though they are pink and gray.



Color Contrast

Josef Albers, I.6 from the portfolio *Formulation: Articulation*, 1972. Published by Ives Sillman, Inc., New Haven, Connecticut, in collaboration with Harry N. Abrams, New York. Printed by Sirocco Screenprints, New Haven, Connecticut. Screen-print on Mohawk Superfine Bristol paper. Edition 362/1000. Collection of the Nasher Museum of Art at Duke University. 1975.8.1.6. Gift of The Josef Albers Foundation.

In his handbook on color theory, *Interaction of Color*, Albers writes that color is "the most relative medium in art." This is demonstrably true in this work. The different colored backgrounds cause the central ladder-like design in each panel to appear a slightly different color. Against the chartreuse color, the ladder takes on a slightly purplish hue. The design on the light blue is perceived as grayish green. Against the royal blue rectangle, the ladder is dark gray, and perhaps most strikingly, the design within the dark green appears lavender. Because the gray ink used in each ladder design is identical across all four rectangles, this is a perceptual, rather than physical, change in its color. This color contrast, or color induction, phenomenon occurs here with a mid-gray that shifts in appearance depending on the effects of colored surround. By demonstrating this phenomenon, Albers reveals how our color perception is contextually relative.

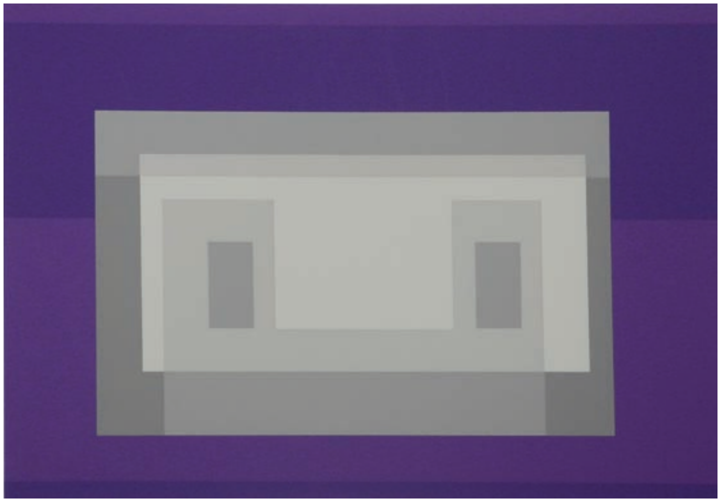




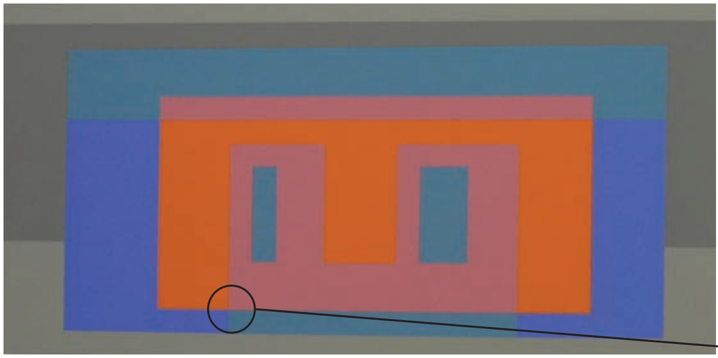
Perceptual Ambiguity

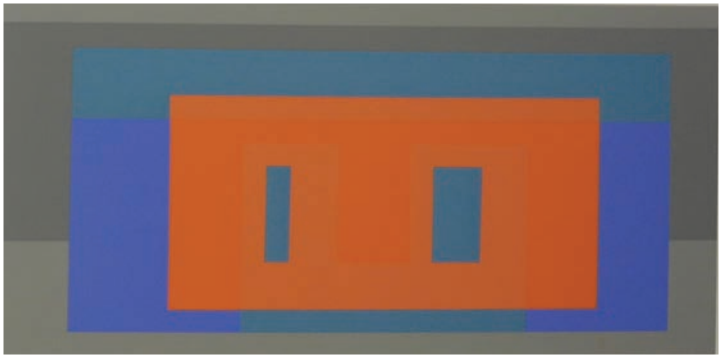
Josef Albers, II.23 and II.26 from the portfolio *Formulation: Articulation*, 1972. Published by Ives Sillman, Inc., New Haven, Connecticut, in collaboration with Harry N. Abrams, New York. Printed by Sirocco Screenprints, New Haven, Connecticut. Screenprint on Mohawk Superfine Bristol paper. Edition 362/1000. Collection of the Nasher Museum of Art at Duke University. 1975.8.2.23 and 1975.8.2.26. Gift of The Josef Albers Foundation.

OPPOSITE PAGE, TOP: Josef Albers, II.18 from the portfolio *Formulation: Articulation*, 1972. 1975.8.2.18. PAIR AT BOTTOM: Josef Albers, I.17 from the portfolio *Formulation: Articulation*, 1972. Published by Ives Sillman, Inc., New Haven, Connecticut, in collaboration with Harry N. Abrams, New York. Printed by Sirocco Screenprints, New Haven, Connecticut. Screenprint on Mohawk Superfine Bristol paper. Edition 362/1000. Collection of the Nasher Museum of Art at Duke University. 1975.8.1.17. Gift of The Josef Albers Foundation. This last pair of Albers prints are on display in the *Colour Correction: British & American Screenprints from 1967-75* exhibition at the Nasher on view through August 30, 2015.

In these prints Albers explores perceptual ambiguity, an illusion with multiple visual interpretations. The juxtaposition of darker and lighter shades creates an ambiguous three-dimensional effect, where the viewer may perceive either the darker or lighter shades as coming forward. Albers writes, "Such illusions are not possible in three-dimensional reality. They are a privilege of two-dimensional design." In real three-dimensional life, there are more luminance (brightness) cues that allow us to correctly perceive spatial depth. In two-dimensional images, where luminance contrasts can be stark, however, it may be more difficult to judge spatial orientation.



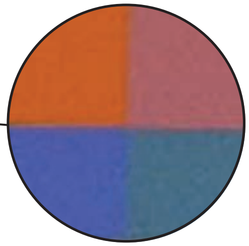




Captions on opposite page.

Illusion of Transparence

By carefully altering hue and value, Albers demonstrates what he called the “illusion of transparence.” This effect is responsible for the believable illusions artists have created with paint in renderings of water, glass, and sheer fabrics, for example. This perceptual phenomenon creates the appearance of one color superimposed on another where shapes seem to overlap. Notice the boundaries where the perceived background and overlay cross, or the X-junctions. The repetition and placement of these X-junctions implies a continuous, translucent surface. Take a look at the gray overlapping rectangles towards the top of the purple print. The way they are arranged creates the illusion of translucent overlays. In actuality, these intersections are physically opaque in color.



The X-junction formed at the contours splits the intersection into four regions of color. Experiments suggest that hue, saturation, and values of the four areas defined at the X-junction must be related for perceptual transparency to occur.

Here to the left, in the top orange print, in particular, it appears as though there is a translucent pink overlay superimposed over a bright orange. The resulting salmon color matches what we imagine would happen if these layers were translucent and overlapping at these intersections. Are certain instances of this phenomenon more believable than others?

The X-junction in (A) and (B) work in this illustration to create the illusion of transparence. The (C) X-junction does not create this illusion.

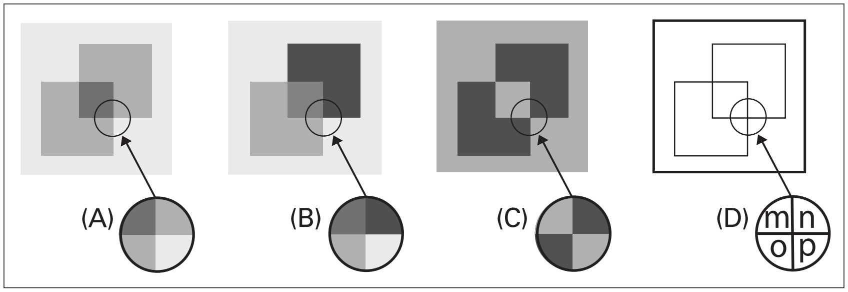
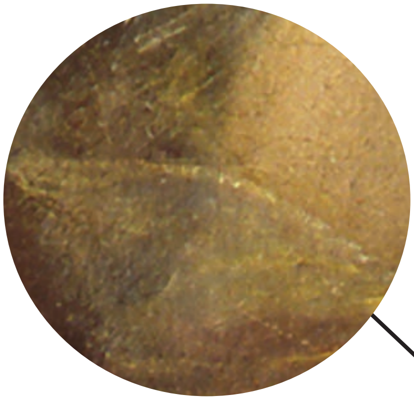
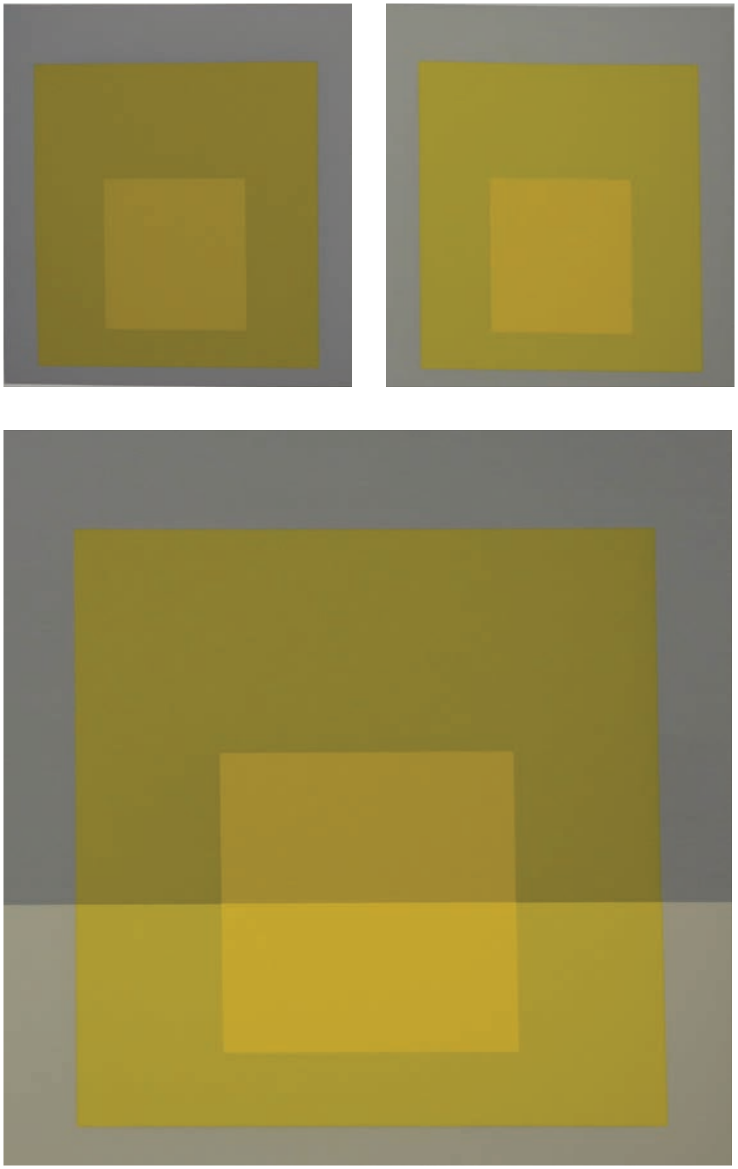


Illustration above: After Adelson and Anadan, 1990, figure 5



Illusion of transparence X-junction happens here in this older Italian painting.

Francesco Furini, *Angel* (detail), 17th century. Oil on canvas,33 ¼ x 28 ⅛ inches (84.5 x 71.5 cm). Collection of the Nasher Museum of Art at Duke University. 1998.1.1. Gift of J. F. McCrindle.



Josef Albers, II.4 and II.5 from the portfolio *Formulation: Articulation*, 1972. Published by Ives Sillman, Inc., New Haven, Connecticut, in collaboration with Harry N. Abrams, New York. Printed by Sirocco Screenprints, New Haven, Connecticut. Screenprint on Mohawk Superfine Bristol paper. Edition 362/1000. Collection of the Nasher Museum of Art at Duke University. 1975.8.2.4 and 1975.8.2.5. Gift of The Josef Albers Foundation.

Simultaneous Contrast

In these pieces from his famous *Homage to the Square* series, Albers explores color induction, or simultaneous contrast—the phenomenon that causes surrounding colors to influence the perception of an adjacent color. The squares of the first print are gray, green, and yellow, while the squares of the second print consist of lighter tints of the same colors. The colors of the third print have been taken from the other two. These colors are exactly faithful to those of the others, yet in an interesting visual effect, they appear quite different when placed side-by-side. Next to each other, the darker colors may appear deeper, and the lighter colors may appear paler. This illustration of simultaneous contrast shows that the perception of color is not an inherent physical property of an object; rather, it is constructed entirely by the brain.

Richard Anuszkiewicz, *Untitled* from the portfolio *Inward Eye*, 1970. Published by Aquarius Press, Baltimore. Printed by Edition Domberger, Stuttgart, Germany. Screenprint on paper. Edition 108/510. Collection of the Nasher Museum of Art at Duke University. 1997.17.2.7. Gift of Ramona Morgan.This Anuszkiewicz print is on display in the *Colour Correction: British & American Screenprints from 1967-75* exhibition at the Nasher on view through August 30, 2015.

Are the Triangles the Same Color?

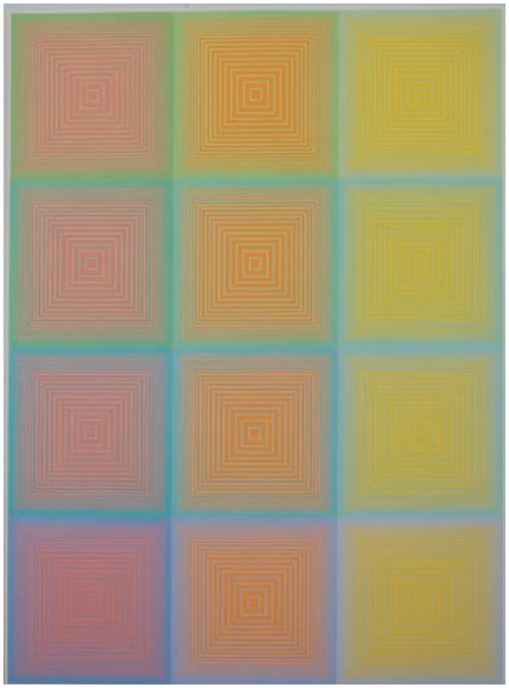
Anuszkiewicz's prints explore ways color is perceived by the brain. Ask yourself this simple question: are the two triangles the same color? The answer is that while Anuszkiewicz used the same red ink in both triangle shapes, many people see different colors. The visual system interprets color, in part, based on the local context. The turquoise blue in the upper right causes the red to seem more pink, whereas the periwinkle blue in the lower left causes the red to look more orange.

Color Context

Colors can often be used to group objects. In this first screenprint, the orange hues are recognized as part of the greater whole, and they are perceived by the brain as a collection of four L shapes and a central rectangle.

Anuszkiewicz used the same hue of orange for each of these five shapes. However, the brain perceives each L shape as a different orange based on the surrounding color. For instance, it seems lighter when surrounded by light green but darker when surrounded by blue.

A similar phenomenon occurs in the second work. The predominant hues in each of the 3 columns are pink, orange, and yellow, respectively. When these are surrounded by a warm background, such as the light green in the top row of the print, each appears a lighter tint than when surrounded by a cooler background. The blue used in the bottom row makes the same pink, orange, and yellow appear darker. This work helps show that the relationships between juxtaposed colors may be just as important as the colors themselves.



Richard Anuszkiewicz, *Untitled* from the portfolio *Inward Eye*, 1970. Published by Aquarius Press, Baltimore, Maryland. Printed by Edition Domberger, Stuttgart, Germany. Screenprint on paper. Edition 108/510. Collection of the Nasher Museum of Art at Duke University. 1997.17.2.2 and 1997.17.2.4. Gift of Ramona Morgan.

Richard Anuszkiewicz, *Untitled* from the portfolio *Inward Eye*, 1970. Published by Aquarius Press, Baltimore, Maryland. Printed by Edition Domberger, Stuttgart, Germany. Screenprint on paper. Edition 108/510. 1997.17.2.9 and 1997.17.2.5. Gift of Ramona Morgan.

Adjacent Colors

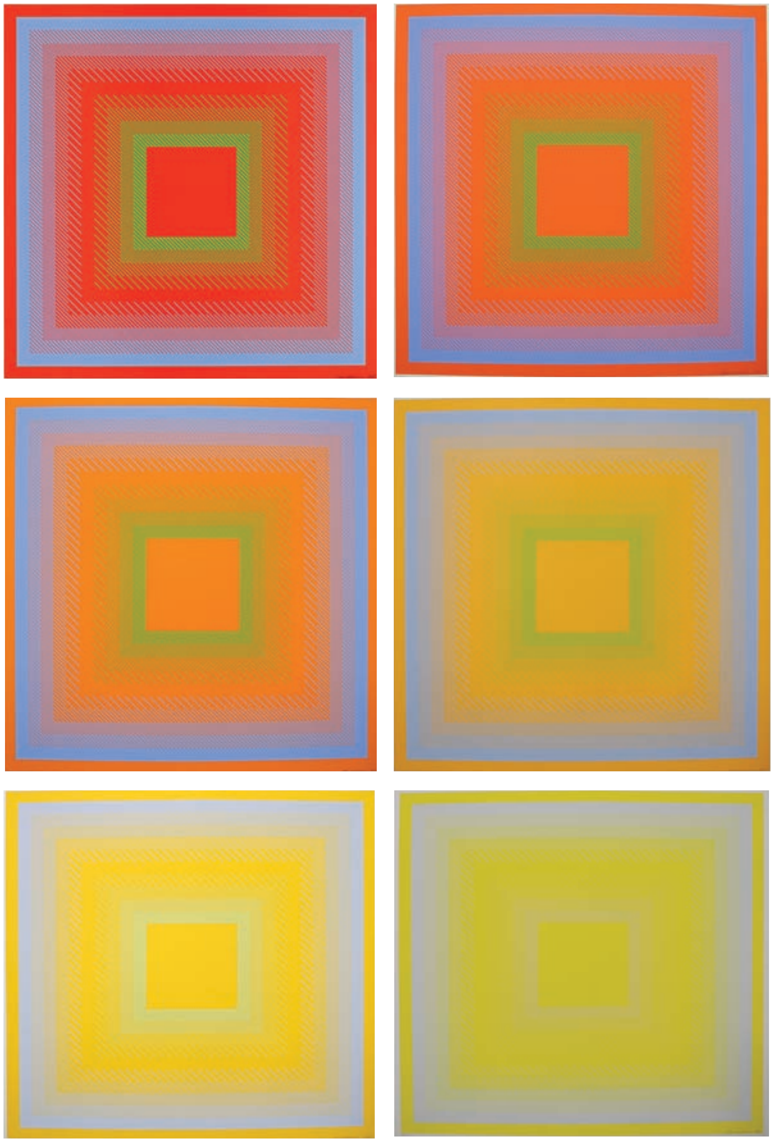
Anuszkiewicz once said of his art, "My work is of an experimental nature and has centered on an investigation into the effects of complementary colors of full intensity when juxtaposed."

In these two prints, Anuszkiewicz demonstrates the effects of intense, juxtaposed colors closely interspersed with each other.

In the first work, this effect is especially pronounced within each of the vertical rows. The middle of each colored row appears to be lighter than the edges because the adjacent colors are placed further apart. Notice also the enhanced vividness when blue and yellow or red and green are paired. The effect is particularly noticeable because the visual system is highly attuned to the contrast between these pairs of colors. The artist has also chosen to pair equiluminant colors, or colors with the same level of brightness, creating a sense of increased vibrancy.

Equiluminance

One way that the visual system identifies objects is by brightness, or luminance, cues. In this series of prints, Anuszkiewicz chose colors with the same level of brightness for each work, so that the visual system can no longer use differences in luminance to help discern shapes or objects. Any colors that are the same brightness are called equiluminant. Because equiluminance is rare in nature, the visual system is ill-equipped to interpret these images, resulting in perceptual instability. Because of this, these prints evoke the sensation of vibration and motion.



Richard Anuszkiewicz, *Spectral Cadmium* from the portfolio *Spectral Cadmiums*, 1968. Published by Galerie der Spiegel, Cologne, Germany. Printed by Haas Stuttgart, Germany. Screenprints on paper. Edition 118/125. Collection of the Nasher Museum of Art at Duke University. 1971.61.3-8. Gift of Nancy Hanks. These Anuszkiewicz prints are on display in the *Colour Correction: British & American Screenprints from 1967-75* exhibition at the Nasher on view through August 30, 2015.

Expected Luminance

It may be difficult to tell that this portrait is of Marilyn Monroe due to the unnatural and jarring colors. The difficulty in identifying any face, not just Monroe's, is due to more than just Warhol's nonrepresentational colors—he often uses such colors, but the subjects remain recognizable. In this particular piece, Monroe's face is difficult to discern and seemingly without depth. This is because we expect specific luminance, or brightness, differences to recognize faces and objects. The brain uses the relative constancy of color and brightness relationships to maintain face recognition even when the lighting varies. Eyes and lips are normally darker than their surround. Here, those expectations are reversed because both are brighter than the adjacent areas of the face. The color and brightness relationships in this particular portrait are not what the brain expects to see in a realistic face, which is why it is so hard to identify Monroe.

One way to test the color and brightness relationships in an image is to reduce it to gray scale (see inset)—if the image is still recognizable, then the luminance cues fit with our expectations.

OPPOSITE: Andy Warhol, *Marilyn Monroe*, 1967. Screenprint on paper. Extra, out of the edition. Collection of the Nasher Museum of Art at Duke University. 2013.9.2. Gift of The Andy Warhol Foundation for the Visual Arts, Inc. Designated for research and educational purposes only. This Warhol print is on display in the *Colour Correction: British & American Screenprints from 1967-75* exhibition at the Nasher on view through August 30, 2015. ABOVE: Illustration of the Andy Warhol, *Marilyn Monroe* screenprint in grayscale.

The Visual System and Color

The remarkable process of seeing is initiated by the eye and continued by complex brain structures. Light first passes through the pupil, the dark opening in the iris or the colored part of the eye (Figure 1). Light is then focused by the lens on the retina, a thin, translucent sheet of tissue that lines the back of the eye. The retina, part of the central nervous system, is composed of many layers, including neurons called photoreceptors (cones and rods) that respond directly to light (Figure 2). We owe our sharp central vision used for reading and

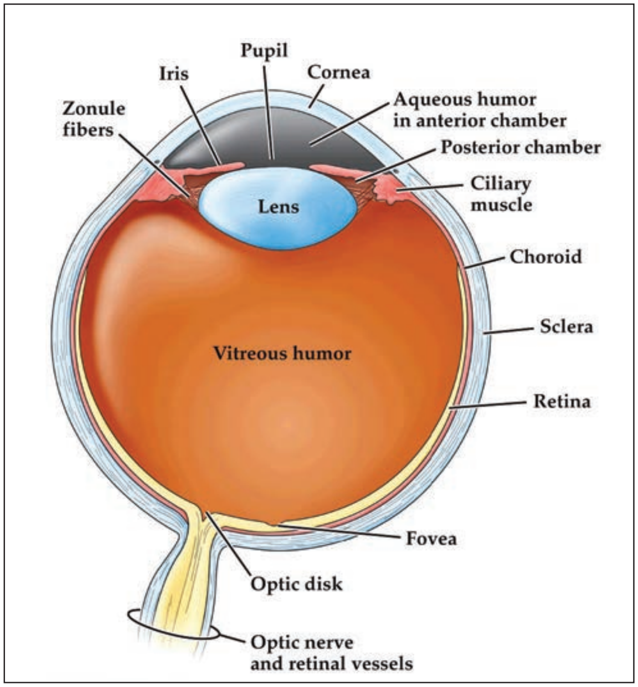


Figure 1

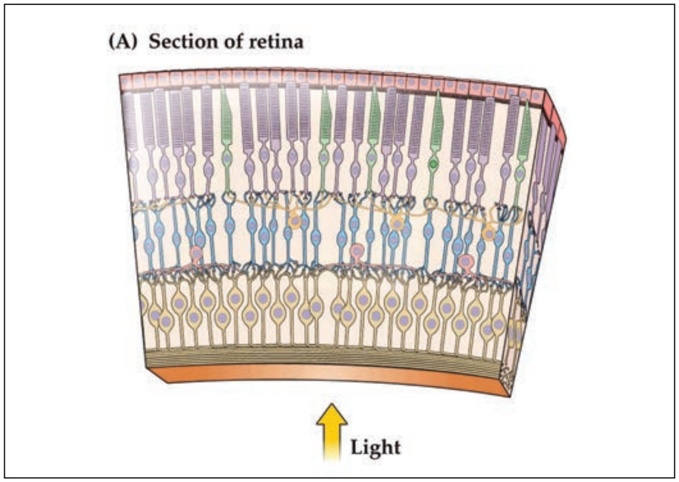
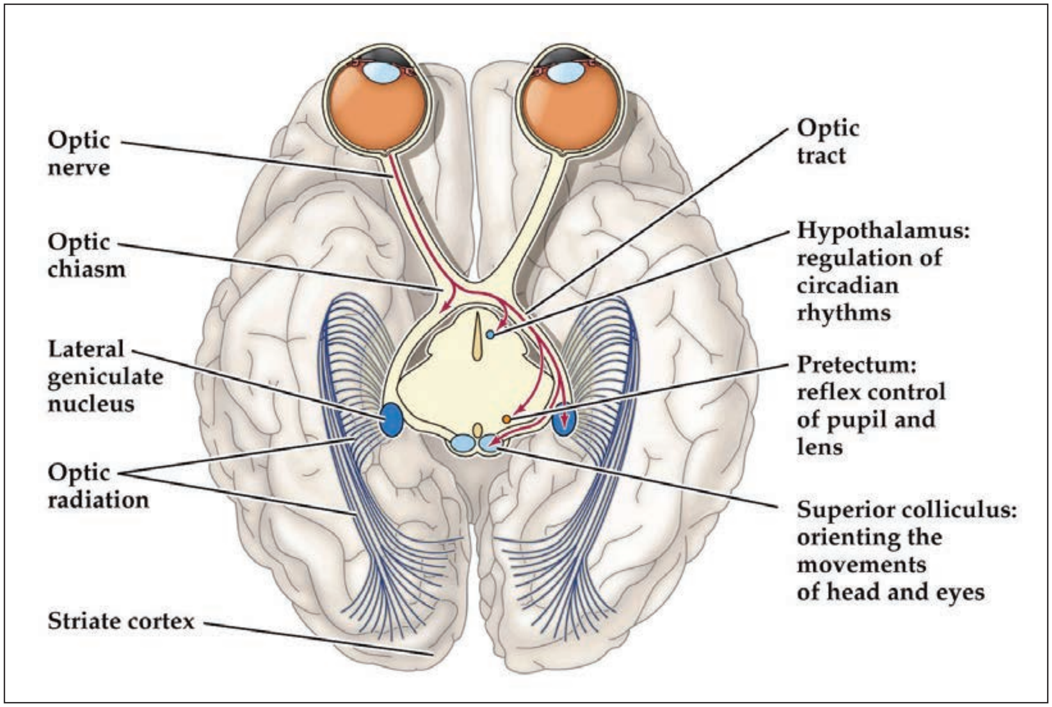


Figure 2

seeing fine detail to the fovea, the central area of the retina characterized by a high concentration of cone photoreceptors, and we move our eyes to what we are most interested in looking at so that it lands on our fovea. Cones are responsible for daylight color vision, while the rods are active under dim (nighttime) conditions. When these cells absorb light, they generate neural signals, which are passed to other retinal cells and eventually onto the optic nerve, where the signals continue to the brain.

In the human brain, visual information is transmitted through the optic nerve to the lateral geniculate nucleus, a relay center for the visual pathway, and then through fiber tracts known as the optic radiations to the striate cortex in the back of the brain (Figure 3). Visual signals are processed first in the striate visual cortex, and then refined sequentially

Figure 3



by higher visual areas of the brain to give rise to the complex images and colors we all perceive in our day-to-day living.

Painters place pigment on canvas, but it is light that enters our eyes. Visible light is electromagnetic radiation of a particular, limited range of wavelengths (390-780 nanometers). What we see is usually reflected light. As light falls on an object, the surface absorbs specific wavelengths and reflects others. During daylight vision, most of us have three different kinds of cone photoreceptors in our retina, each responding best over a different range of visible wavelengths. The cones themselves do not carry information about color; the visual system compares the activation of each type of cone with the others in order to tell us about color.

To most people, lights and objects either seem colored or not. This seems simple enough. Although color is related to the physical composition of light, color itself does not exist outside the brain. Our representation of color starts with the responses of the photoreceptor cells to light falling onto the eye's retina and continues with patterns of connectivity among neurons at further levels of visual processing within the brain. Our visual system is exquisitely sensitive to both brightness and color differences, responding most to contrasts between black and white, red and green, and blue and yellow. This exhibition aims to convince the viewer that the perception of color depends greatly on the context, and cannot be deduced from the physical nature of light itself.

Hue, Saturation, and Value

Artists describe color as having three properties: hue, saturation, and value. Hue is the dominant wavelength of light; saturation is the strength of the color relative to white; and value is the absolute brightness (or luminance).

Symposium

Seeing Color: Art, Vision, and the Brain

Monday, April 13, 2015 - 9 AM to 5 PM

Join scientists and artists in an exploration of color, brightness, visual perception, and the intersection of neuroscience and art. This symposium is a collaboration between the Duke Institute for Brain Sciences, Bass Connections: Brain & Society, and the Nasher Museum.

Bevil Conway, Associate Professor of Neuroscience, Wellesley College, "Color: Neuroscience and Art Practice"

Anya Hurlbert, Professor of Visual Neuroscience, Newcastle University (UK), "New Light on Old Masters: Experiments at the National Gallery"

Michael Marmor, Professor of Ophthalmology, Stanford University School of Medicine "Color Blindness and Art: History, Physiology, Aesthetics"

Chieko Murasugi, Artist, Golden Belt Arts, Durham, NC, (chiekomurasugi.com) "How One Painter Uses Color"

Robert Shapley, Natalie Clews Spencer Professor of the Sciences and Professor of Neural Science, New York University, "Single- and Double-Opponent Cortical Cells in Color Perception"

John S. Werner, Distinguished Professor of Ophthalmology & Vision Science, and Neurobiology, Physiology, & Behavior, University of California, Davis, "Transformations of Light and Color through the Aging Eyes of Claude Monet"

Sanford Wurmfeld, Phyllis and Joseph Caroff Professor of Fine Arts Emeritus, Hunter College, City University of New York, "Color in Painting"

Art, Vision, and the Brain: An Exploration of Color & Brightness Project Description and list of participants

Art, Vision, and the Brain: An Exploration of Color & Brightness
Bass Connections: Brain and Society, 2014

Art—painting, drawing, sculpture, weaving—is a visual medium for both the artist and the viewer. Although we often think of vision as the act of seeing a physical depiction of the world, we are actually constructing a representation of the world through a complicated process by which light signals are transformed by the eye and brain. As such, scientists and artists both work towards understanding many aspects of visual perception; art informs how we see, and as we learn more about how the brain works, we deepen our appreciation of both art and science. Processing of color and brightness has many implications for both perception and art. Moreover, elements of visual perception (luminance, contrast sensitivity, and color vision) are affected in diseases of and trauma to the retina and brain. Understanding the neural mechanisms of visual perception will aid the development of medical treatments and medical devices for these disorders. Together as a project team, we propose to explore the topic of color and brightness in art and the visual system using art in the Nasher Museum's collection and archives. We will analyze how color and luminance are treated in art, using a combination of image processing analyses and spectrophotometric studies. These analyses will inform the design and testing of psychophysical experiments exploring how the brain processes color and luminance. The Project will culminate with an exhibit on the Duke campus curated by the team as well as a co-organized symposium on Art and the Brain, in conjunction with this Bass Connections team and the Duke Institute for Brain Sciences (DIBS).

Project Participants:

**Elizabeth Johnson, Ph.D., Assistant Research Professor,
Neurobiology and Associate Director, Duke Institute for Brain Sciences**

Eleonora Lad, M.D., Ph.D., Assistant Professor, Ophthalmology

Sina Farsiu, Ph.D., Assistant Professor, Biomedical Engineering and Ophthalmology

Marianne Wardle, Ph.D., Andrew W. Mellon Curator of Academic Programs, Nasher Museum

Charlie Hass, Ph.D., Postdoctoral Fellow, Neurobiology

Emily Chen, Duke Undergraduate Neuroscience Major ('17)

Indrani Saha, Duke Undergraduate Program II Major in Cognitive Aesthetics ('17)

Justin Yu, Duke Undergraduate Biomedical Engineering Major ('15)

**This project team had a summer component from May 27-August 1, 2014,
plus Fall 2014 and Spring 2015 semesters of independent study.**

Duke Institute *for* Brain Sciences

NASHER
MUSEUM OF ART AT DUKE UNIVERSITY

Duke UNIVERSITY

BASS CONNECTIONS
Brain & Society