Art & Illusions

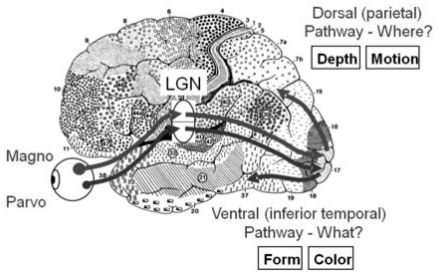
How do we perceive art?

- Begins when light enters lens of eye and passes through to the retina
- There the light strikes two types of cells:
  - Rods
    - 1 Type; more sensitive; important for dim light
  - Cones
    - 3 Types maximally sensitive to different wavelengths (short=blue; medium=green; long=red, yellow, orange)
- Electrical signals from photoreceptors get transmitted to ganglion cells
- Information then passes to the LGN

How do we perceive art?

- Visual signals processed by two pathways in LGN
  - Magnocellular (magno=large)
    - Sensitive to brightness contrast, responds faster, has lower acuity
  - Parvocellular (parvo=small)
    - Sensitive to color & fine detail
- Visual effects created by artists succeed because light information is processed this way

How do we perceive art?



Luminance

Equiluminance

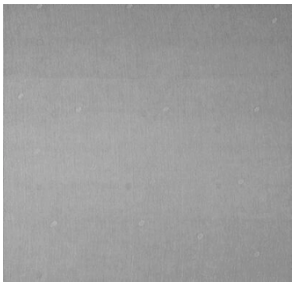
- Luminance: describes the amount of light that passes through or is emitted from a particular area
- For any pair of colors there is a particular brightness ratio at which in a black & white photo the colors would appear the same shade of gray
- At some brightness level the two colors will appear identical to the magno system

Equiluminance

- Color combinations chosen that are strong activators of the parvo system but weakly stimulate magno system
- Objects that are equiluminant with their background look vibrant & unstable
- Parvo system signals object's shape but magno system cannot see its borders and therefore can't signal the movement or position of the object so object appears to jump around, drift or vibrate

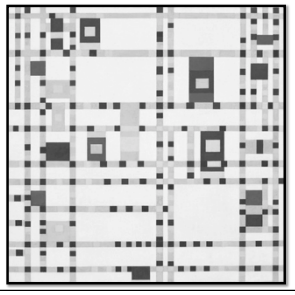
Modern Art

- Early example is Larry Poons' *Sunnyside Switch*



Mondrian & Equiluminance

- Mondrian's *Broadway Boogie Woogie,* 1942-43
  - Gray and yellow in lines are equiluminant

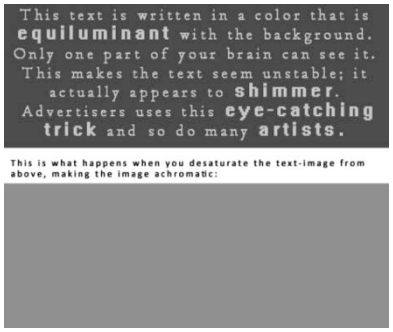


Equiluminance in Impressionism

- Claude Monet's *Poppies Near Argenteuil,* 1873
- Poppies are equiluminant with field
  - Taking color out makes it impossible to see the difference between poppies & field

Equiluminance in Advertising

- Advertisements often contain key words in a color that is equiluminant with background
- These conditions make it harder to read the text, but the weird/ jumpy appearance created may draw the viewer's attention
- This results in the reader spending more time with those words



Equiluminance in Fashion

- Similar in fashion- lines in a garment must have luminance contrast to be effective: higher the luminance contrast, the greater the effect
- Horizontal stripes will not make the wearer appear shorter and wider if they are close to equiluminant or very narrow

Equiluminance in Fashion

- Different color combinations have a different effect:
  - A kelly green shirt with royal blue pants produces a vibrant horizontal border that will not conrtibute much to overall impression of shape
  - If the same royal blue pants are worn with a shirt of a similar hue (sky blue vs. navy) the eye is drawn to the border and the effect is less vertical

Form & Color

Juxtaposition of Color

- Two colors can have opposite effects on each other depending on spatial arrangement
- Juxtaposing two colors causes them to oppose each other
  - i.e. each tends toward the complement of the other
- When the two colors are interdigitated in a fine pattern they start to look more like each other
  - i.e. they start to blend or “bleed”
  - Occurs when the pattern is too fine for the color system to resolve

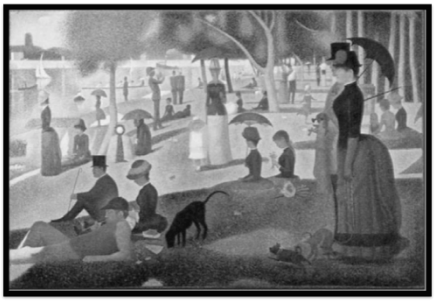
Juxtaposition of Color

- Occurs in magazine illustrations
  - the microscopic dots that form the image blend together because a neither a human's color or form system cannot discriminate the small dots
- Becomes noticeable when the pattern is too small to be resolved by the color system but is large enough to be resolved by the form system
  - Brush strokes in Impressionist painting
  - Dots in pointillist painting
  - Can see brushstrokes/dots but colors blend away

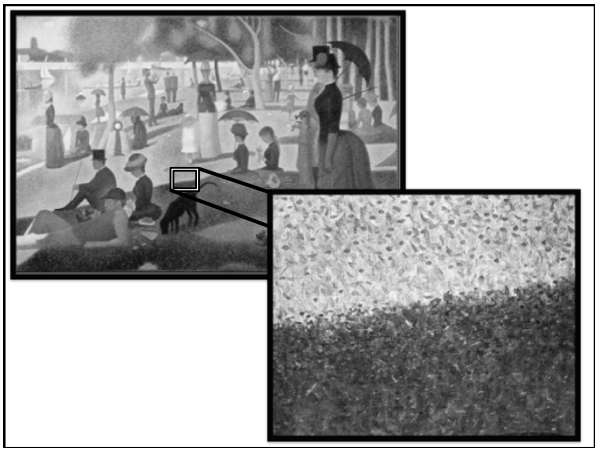
Impressionist Painting

Monet, The Water-Lily Pond, 1899

Pointillism

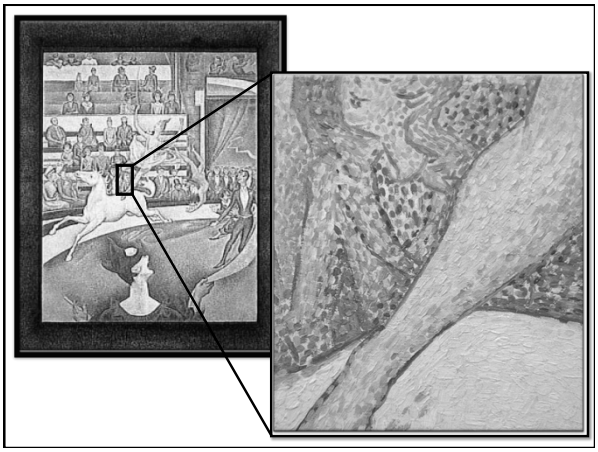


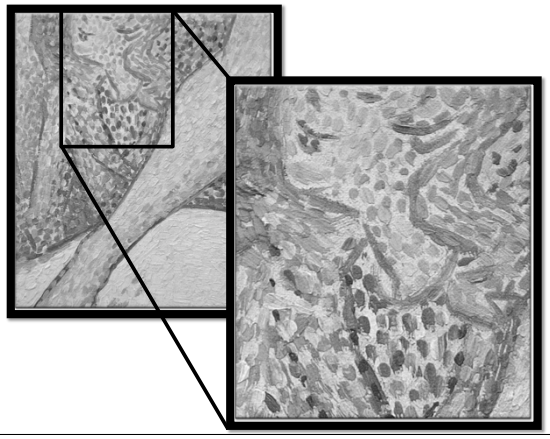
Seurat, Un dimanche apres-midi a l'lle de la Grand Jatte, 1884-1886



Pointillism

Seurat, The Circus, 1890-1891

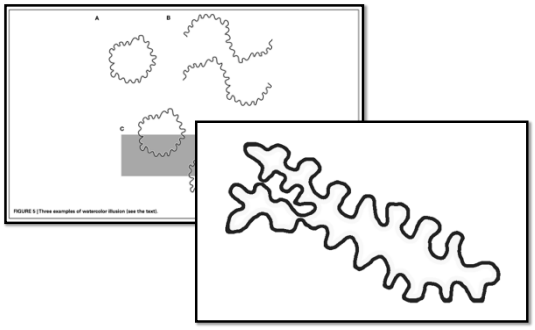




The Watercolor Illusion

- Where is information about shape and color mostly located?
- Info placed on the contour & boundaries
- Concept is highlighted in the water color illusion
  - Bright color seems to spread out from one side of a contour as a pale tint across the figure
  - Dependent on luminance and color contrast

The Watercolor Illusion



The Watercolor Illusion

- Subjects' description of "wiggly orange object" does not mention the color of the boundary contour
  - Even though the purple line is likely clearly perceived, it doesn't appear as a color of the object, but rather like the boundary belonging to the orange object
  - However, the adjacent orange contour defines the color of the object, but not the boundary
- The contour with the highest luminance contrast in relation to the surrounding regions tends to appear as the outermost boundary of the figure

Examples in Art

- Picasso's drawing of a rooster highlights the effects of the watercolor illusion

FIGURE 6 | Yellow cock by Picasso.

Examples in Art

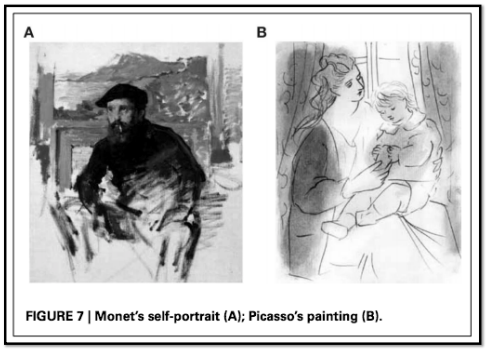


FIGURE 7 | Monet's self-portrait (A); Picasso's painting (B).

Examples in Art

- How does the contour become color?

FIGURE 6 | Yellow cock by Picasso.

Experimental Evidence

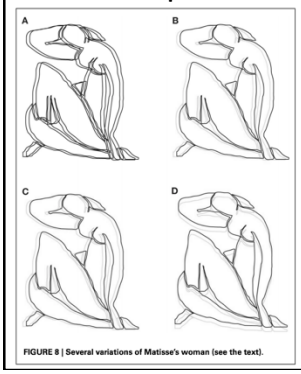


FIGURE 8 | Several variations of Matisse's woman (see the text).

- **A:** two shifted contours elicit an effect of blur; both contours perceived as boundaries
- **B:** an orange woman is perceived
- **C:** replacing the black contour with a purple one produces the same effect
- **D:** vertical rather than horizontal shift gives the same effect

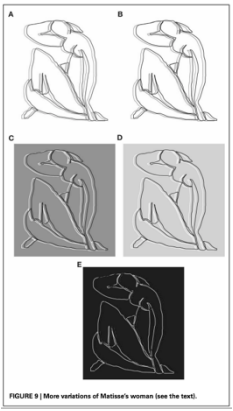


FIGURE 9 | More variations of Matisse's woman (see the text).

- What happens when the contours are equiluminant?
  - Unable to assign color and boundary contours
  - When contrast of the contours is adjusted assignments can then be made (B)
- Can produce a reversal of the contour assignment by altering the background → change in highest contrast (C-E)

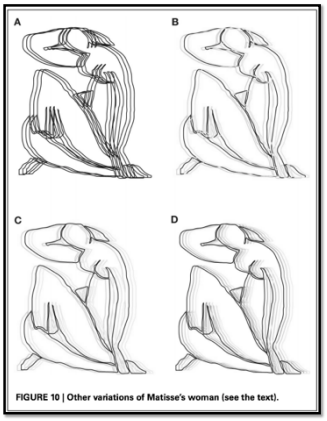


FIGURE 10 | Other variations of Matisse's woman (see the text).

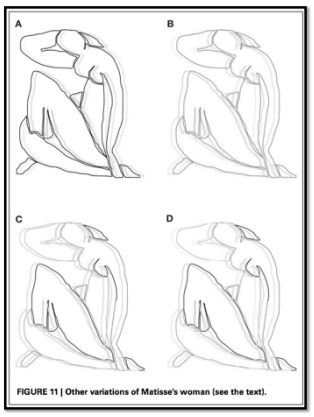


FIGURE 11 | Other variations of Matisse's woman (see the text).

What role does line thickness play?

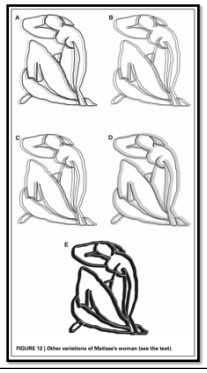


FIGURE 12 | Other variations of Matisse's woman (see the text).

Experimental Evidence

- SUMMARY:
  - Information about shape & color is placed along the contours
  - The contour with the highest luminance contrast is perceived as the boundary contour
  - If one contour takes on a role (i.e. boundary) then the adjacent contour takes on the other role (i.e. color)
  - Typically there is only one boundary contour whereas there can be multiple color contours
  - Line thickness influences contour assignment

The Mona Lisa

Mona Lisa

- Why is Mona Lisa's smile so mysterious?
- Expression appears to change depending on where the observer looks
- *Sfumato* Technique
  - Described by DaVinci as "without lines or borders, in the manner of smoke or beyond the focus plane"
- In periphery of vision have more gradual changes in luminance
- Smile is less prominent in fine details perceived at center of gaze
- See her smiling when looking at her eyes (mouth is blurred) but smile vanishes when one tries to verify by looking at mouth
- "You can't catch her smile by looking at her mouth. She smiles until you look at her mouth" (Livingstone, 2000)

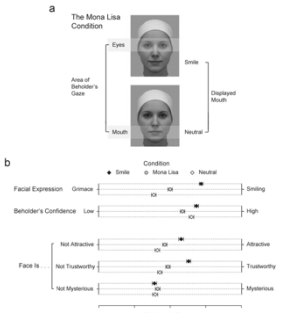
BLURRED
•Simulates perception in our periphery
• global info (downward curved eyes, upward curved mouth, shadows in her cheekbones), the features that convey her smile

DETAILED
•Simulates perception in our fovea
• fine, local details (wrinkles, pupils)
• These local details do not convey the happiness in her expression

Experimental Evidence

- *Mona Lisa Condition*
  - Faces alternated between a smiling mouth and a neutral mouth
  - Smiling mouth displayed only as long as participants gazed toward a region around the eyes
  - As soon as the mouth was examined directly , it displayed a neutral expression

Fig. 1. Illustration of a stimulus in the Mona Lisa condition (a) and participants' mean ratings (with standard errors) of faces in the Mona Lisa condition and the two control conditions (smiling and neutral; b).



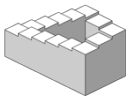
Bohrn I et al. Psychological Science 2010;21:378-380

Psychological SCIENCE

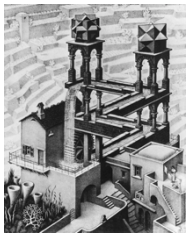
Perspective

M.C. Escher

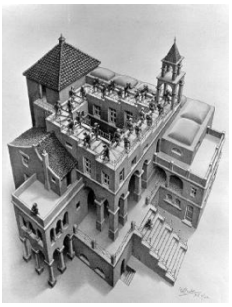
- *Klimmen en dalen* (*Ascending and Descending*) & *Waterval* (*Waterfall*)
- Uses the Penrose Steps illusion created by Lionel & Roger Penrose
- Stairs make four 90 degree turns as the ascend or descend, but the stairs form a continuous loop
- Impossible in 3D
- Depends on false perspective
  - Escher used conflicting proportions
- Each region of the print makes sense but together they create an impossible object



Penrose Stairs



M.C. Escher's *Waterfall*

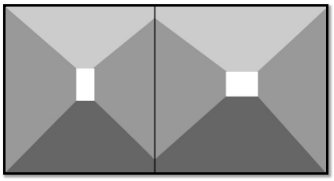


M.C. Escher's *Ascending and Descending*

Reverspective

- Patrick Hughes
- Creates illusions on 3D surfaces where the parts of the picture that seem farthest away are actually the closest physically

Patrick Hughes' *Vanishing Venice*



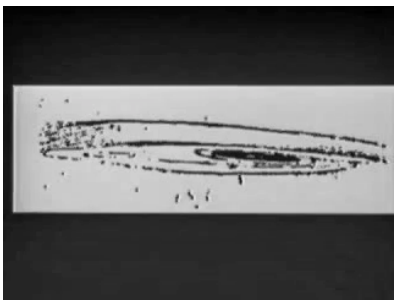
Patrick Hughes

- Takes how our brain processes perspective and inverts it
  - far= small retinal image, close=large retinal image
- He inverts both the 3D geometry of perspective and the painted cues
- Draws far objects as large and further complements this reverse perspective by painting it on a reverse surface
  - i.e. the surface is literally smaller in size when it is closer to you

Anamorphosis

- Distorted projection or perspective
- Requires viewer to look from a particular vantage point or use a special device to reconstruct the image
- Two types:
  - Perspective Anamorphosis
  - Mirror Anamorphosis
- Used in Renaissance art

Leonardo's Eye

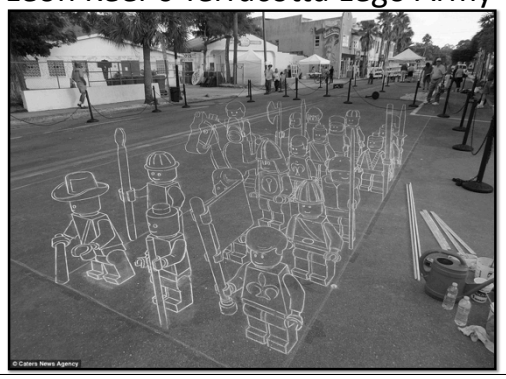


The Ambassadors

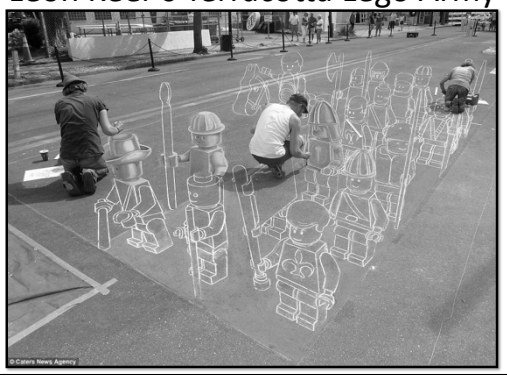
3D Sidewalk Artists

- Use perspective to create what looks 3D on a 2D surface
- When viewed from the wrong angle the pictures appear smeared & distorted
- But, when standing at the correct viewing point the illusions are perfect & very convincing
- Artist chooses a viewing point and then plots how everything in that person's viewpoint needs to recde/ elongate as it gets further away
- Use the idea that the further the objects are the smaller they should appear

Leon Keer's Terracotta Lego Army



Leon Keer's Terracotta Lego Army



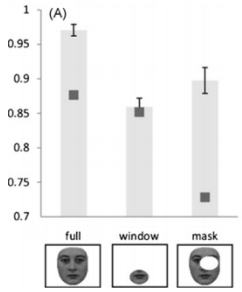
Leon Keer's Terracotta Lego Army

Leon Keer's Terracotta Lego Army

Face Processing

Holistic vs. Feature-Based Perception

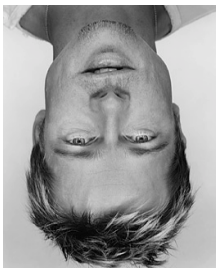
- Humans are experts at recognizing faces
- Two opposite views proposed:
  - Ability to extract local feature-by-feature info
  - Ability to process all features at once over the whole face
- Prosopagnosia: face blindness
  - Damage to the fusiform gyrus

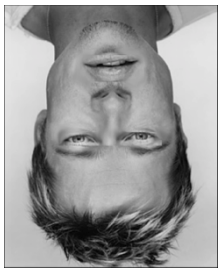


Giuseppe Arcimboldo

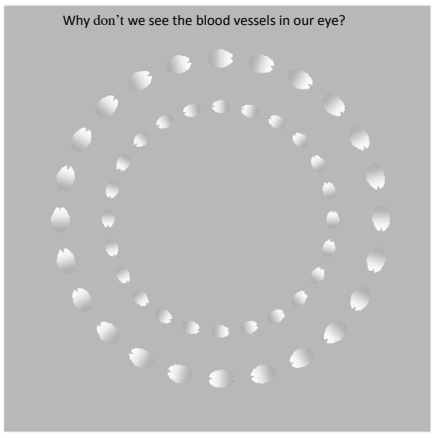
- Famous for creating portrait heads made out of objects like fruits, vegetables, flowers...
- *Vertumnus* typical example: appears to be both fruit & a face
- Prosopagnosics can't really see the face here!

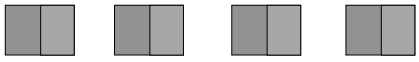
Brangelina Illusion

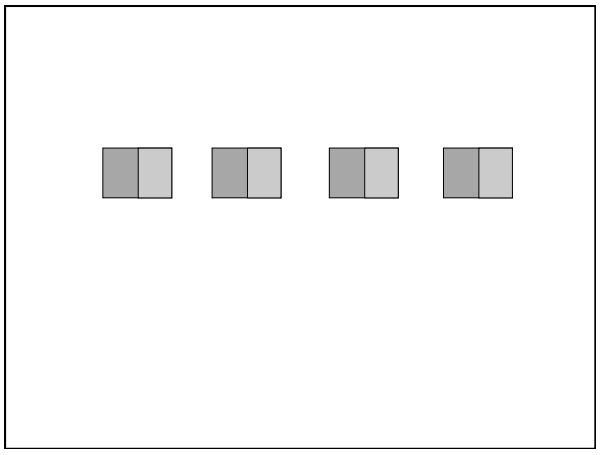


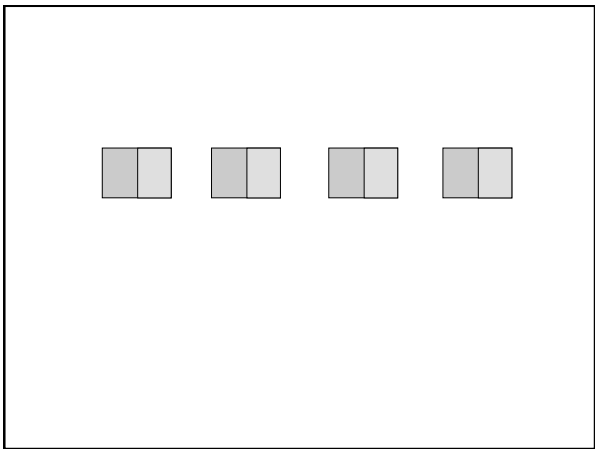


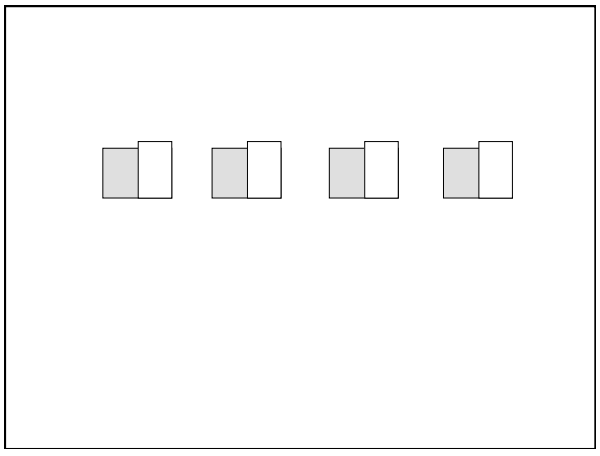

Motion & Adaptation



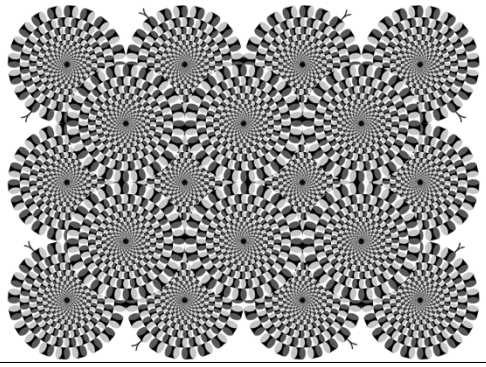








Akiyoshi Kitaoka's Rotating Snakes



Adaptation

- We adapt to lower contrasts faster than higher contrast so the neurons that get adapted first reduce their responses to the low contrast and you get an apparent motion in the direction of the low contrast to the high contrast
- Making small eye movements (microsaccades) causes the neurons to "un-adapt" and it happens all over again
- These illusions work poorly when you don't blink or move your eyes

Preferences In Art

Peak Shift Principle

- Basic idea that animals (and humans) will respond more strongly to exaggerated shapes than to the original shape they are trained on

Baby gull response: + ++ +++ ++++

Niko Tinbergen, 1953

Peak Shift Principle in Art

- Artists try to extract the "essence" of what they are conveying
- Hindu artists talk of capturing the *rasa*, or essence, of an emotion in their artwork
- Think of obvious examples like caricatures
- "May not be a coincidence that the ability of the artist to abstract the 'essential features' of an image and discard redundant information is essentially identical to what the visual areas themselves have evolved to do" – Semir Zeki

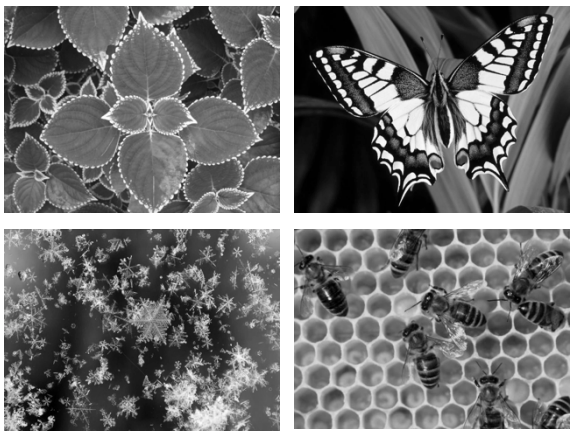
Art as caricature

"There's an analogy here in what's going on in the brain's of our ancestors, the artists who were creating these Venus figurines were producing grossly exaggerated versions, the equivalent for their brain of what the stick with the three red stripes is for the chicks brain"
– V.S. Ramachandran

Perceptual fluency

- The more fluently we process an artwork, the more we tend to prefer and enjoy it
  - Features that are prevalent in our environment like symmetry are preferred because they are easy to process

Reber, Schwarz, Winkielman, 2004, *PSPR*



Symmetry

- Both humans and other species such as birds prefer symmetrical features in faces & bodies of others, as well as in simple patterns within nature
  - Preference may have emerged specifically to determine whether a mate is strong and healthy
  - May serve as an "attention grabber"
  - Provides humans with info about recognizing an object in visual space irrespective of its position or orientation in the visual field

Raphael, *The School of Athens*, ca 1509-1510

Zen garden at Ryoanji Temple in Kyoto, Japan

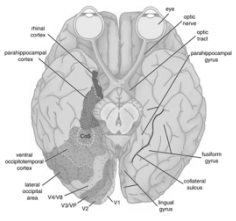
Symmetry here is implicit-- humans have an unconscious visual sensitivity to the axial-symmetry skeletons of stimulus shapes, randomly perturbing the rocks to break the axial symmetry is not preferred.

Van Tonder, Lyons, & Ejima (2002), *Nature*

Perceptual fluency

- The more fluently we process an artwork, the more we tend to prefer and enjoy it
  - Features that are prevalent in our environment like symmetry are preferred because they are easy to process
  - Mere exposure effect
  - This suggests that the more familiar we become with an artwork, the more we like it

Reber, Schwarz, Winkielman, 2004, *PSPR*



Visual areas V1-V4 are involved in analyzing the low to high-level information (colors, contours, objects, faces, scenes).

↓

Mu-opioid receptors activated (density of these receptors increases in higher levels)

↓

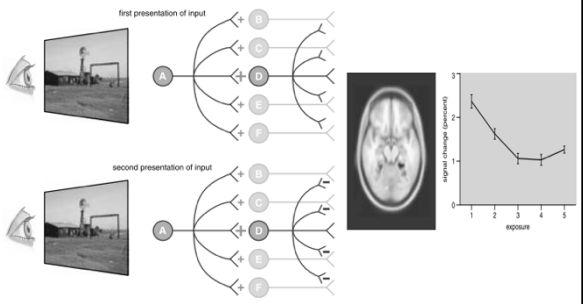
The richer the image is in interpretability, the more memories and previous experiences will be tied to it

↓

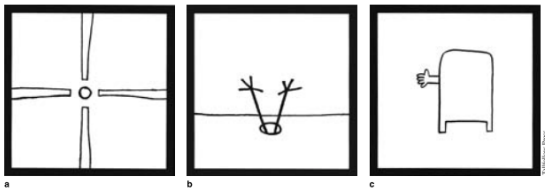
more activation of mu-opioid receptors

Biederman & Vessel (2006), *American Scientist*

Fluency in the brain



Images rich in information & ambiguity, which we reinterpret every time we engage with them do not necessarily lower the neural responses with repeated exposure because we activate higher levels of processing



a Four elephants sniffing an orange

b An early bird catches a very strong worm

c A man in a mailbox signaling a left turn

Images rich in information & ambiguity, which we reinterpret every time we engage with them do not necessarily lower the neural responses with repeated exposure