Subjective Color - Benham disk

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Subjective Color
Definitions

Webster's Revised Unabridged Dictionary

Subjective color a false or spurious color seen in some instances, owing to the persistence of the luminous impression upon the retina, and a gradual change of its character, as where a wheel perfectly white, and with a circumference regularly subdivided, is made to revolve rapidly over a dark object, the teeth of the wheel appear to the eye of different shades of color varying with the rapidity of rotation. See Accidental colors, under Accidental.
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This is my favorite visual illusion. You can spend hours playing with this illusion and you can even make your own unique spinners too!
In 1894, toymaker Mr. C.E. Benham discovered that a spinning disk with a particular pattern of black and white marks could cause people to see colors. Mr. Benham called his disk an "Artificial Spectrum Top" and sold it through Messrs. Newton and Co. Benham's Top (or Benham's Disk) has puzzled scientists for over 100 years.

Here is how to make your own Benham Top:

1. Make the Spinner

Method #1

Get an old compact disk (CD) and a penny.
Clamp a penny with pliers.
Heat the penny (I use a Bunsen burner). CAUTION: the penny must get very hot. Adult supervision is required.
Insert the penny halfway into the center of the CD so that the penny is PERPENDICULAR to the CD. The hot penny will melt two slots on each side of the center CD hole. When the penny cools, it will stick in the middle of the CD. (See the picture below.)

Twist the penny to spin the spinner.

Method #2

Get the top of a plastic, round container (margarine containers work well) and a toothpick.
Poke a very small hole in the middle of the plastic top. You may have to use a metal nail. The hole should be smaller than the width of your toothpick.
Break or cut the toothpick in half. Insert the pointed end of the toothpick through the center hole in the plastic top. The toothpick should stick in the hole. (See the picture below)
Twist the toothpick to spin the spinner.

Method #3

Get some cardboard and a toothpick.
Draw a circle (with a diameter of at least 4 inches) on the cardboard.
Cut out the circle carefully. It is important that the circle is as round as possible.
Poke a hole in the center of the circle with the toothpick.
Insert the toothpick into the hole. The toothpick should stick out about half an inch. Break or cut the toothpick in half.
Twist the toothpick to spin the spinner.

2. Get Benham disk graphics: Download and print out the disks.

Small Disks
Disk #1 | Disk #2 | Disk #3 | Disk #4 | Blank Disk
ALL DISKS on ONE PAGE (PDF file)

Large Disks
Disk #1 | Disk #2 | Disk #3 | Disk #4 | Blank Disk

3. Add a Disk to a Spinner

If you are using the CD spinner:
Carefully cut out each disk.
Cut a small slot in the center of the disk.
Place the disk on the spinner by putting the slot over the penny on the spinner. The disk should lay flat on the top of the CD.
SPIN THE SPINNER! Try other disks.

If you are using the plastic top spinner or cardboard spinner

Carefully cut out each disk.
Poke a small hole in the center of the disk.
Poke the toothpick through the disk.
Put the toothpick (with the disk) through the plastic top or cardboard spinner. The disk should lay flat on the top of the spinner. You should use a little glue from a glue stick to keep it in place.
SPIN THE SPINNER! Try other disks.

Special Notes

The colors are seen best at slow speeds (between 3-5 rotations/second). Try different speeds!
It is important that your spinner can spin at slow speeds. Therefore, make sure your spinner is centered properly. Make sure you place the penny or toothpick in the center of the spinner.
Experiment!

Change the lighting conditions. Test it outside in sunlight; test it under different types of light (incandescent, fluorescent, etc.)
Change the pattern. Make you own pattern using the blank disk. Use a black marker to draw a pattern or series of arcs on the white side of the disk.
Change the color of the disk. What happens if you use a blue disk?
Spin the spinner clockwise and counter-clockwise.

Try these Benham-like images without a spinner. Click on one of the images below to open a new browser window with the image. Hold your finger about 1 inch from the image on your screen. Move your finger from left to right. Focus on your finger as it moves. You should still be able to see the background image. The colors of the horizontal lines should change color. Don't move your finger too fast! Try the experiment when you move your finger from right to left.

What's Happening? What Causes the Colors?

The retina of the eye is composed of two types of receptors sensitive to light: cones and rods. Cones are important for color vision and for seeing in bright light. There are three types of cones, each of which is most sensitive to a particular wavelength of light. Rods are important for seeing in low light.

It is possible that the colors seen in spinning Benham disks are the result of changes that occur in the retina and other parts of the visual system. For example, the spinning disks may activate neighboring areas of the retina differently. In other words, the black and white areas of the disk stimulate different parts of the retina. This alternating response may cause some type of interaction within the nervous system that generates colors.

Another theory is that different types of cones take different times to respond and that they stay activated for different amounts of time. Therefore, when you spin the disk, the white color activates all three types of cones, but then the black deactivates them. The activation/deactivation sequence causes an imbalance because the different types of cones take different times to respond and stay on for different times. This imbalance in information going to the brain results in colors.

Neither of these theories explains the colors of Benham's disk completely and the reason behind the illusion remains unsolved.

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Did you know?

The full text of the announcement of the "Artificial Spectrum Top" in Nature, 51:113-114, 1894:

An "Artificial Spectrum Top," devised by Mr. C.E. Benham, and sold by Messrs. Newton and Co., furnishes an interesting phenomenon to students of physiology optics. The top consists of a disc, one half of which is black, while the other half has twelve arcs of concentric circles drawn upon it. Each arc subtends an angle of forty-five degrees. In the first quadrant there are three such concentric arcs, in the next three more, and so on ; the only difference being that the arcs are parts of circles of which the radii increase in arithmetical progression. Each quadrant thus contains a group of arcs differing in length from those of the other quadrants. The curious point is that when this disc is revolved, the impression of concentric circles of different colors is produced upon the retina. If the direction of rotation is reversed, the order of these tints is also reversed. The cause of these appearances does not appear to have been exactly worked out.

Did you know?

Many years before Benham's "discovery," Gustav Fechner and Hermann von Helmholtz experimented with black and white disks. They were both aware that spinning these disks produced the perception of colors.

The colors that you see when you spin Benham's disks have been called "subjective colors," "Fechner-Benham colors," "Prevost-Fechner-Benham colors," "polyphan colors," and "pattern-induced flicker colors" (PIFCs).

References

Nature, 51:113-114, 1894.
von Campenhausen, C. and Schramme, J., 100 years of Benham's top in colour science, Perception, 24:695-717, 1995.
Benham's Top and Fechner Colors - Background
A theory of the Benham Top based on center-surround interactions in the parvocellular pathway - Neural New., 17:773-786, 2004.
Neural correlates and effective connectivity of subjective colors during the Benham's top illusion: a functional MRI study - Cerebral Cortex, 21:124-133, 2011.

Usage

In literature:

The color of the original painting has a sombre magnificence which is in keeping with the seriousness of the subject.

"Sir Joshua Reynolds" by Estelle M. Hurll

We have seen, then, that every subject is to be taken up first in its terminal lines, then in its light and shade, then in its color.

"Lectures on Landscape" by John Ruskin

On this subject of what is called abroad the prejudice of color, the North has been censured, even by many of our best friends.

"The Continental Monthly , Vol. 2 No. 5, November 1862" by Various

They were not all highly-colored, naked subjects, as he had been led to expect.

"The Eagle's Heart" by Hamlin Garland

Color, and its minute effects, seem in some sort to degrade the subject.

"Aurelian" by William Ware

He is subjected to many petty annoyances and injustices and ofttimes deep humiliation solely on account of his color.

"Masterpieces of Negro Eloquence" by Various

On subjecting cotton, silk, wool, and worsted goods to inspection, color is found to have a different tone or cast in each fabric.

"Textiles" by William H. Dooley

It was of very large size; of brilliant color, and of agreeable subject.

"On the Old Road Vol. 1 (of 2)" by John Ruskin

Our subject is coloration.

"The Glow-Worm and Other Beetles" by Jean Henri Fabre

In turning to the condition of our own free colored people, who rejected homes in Liberia, we approach a most important subject.

"Cotton is King and The Pro-Slavery Arguments" by Various

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In news:

Her work, which incorporates abstractionism , is known for its vibrant colors and subjects that range from florals to wispy scenes of sailboats in the distance.

timesrecordnews.com

This week's Flyer on the Wall employs selective color and subjective contrast to hype a Halloween show featuring Mark Mallman, Shoulder Voices and Mrdrbrd.

alibi.com

My body of work up to this point has been made up of art created by using very toxic mediums - all highly stable and with lasting brilliant color – but running counter to my subject matter and personal lifestyle.

mdjonline.com

Coloring books might be a welcome change for children who have been drawing skyscrapers since September -- especially now that the latest books have moved away from coloring-as-usual subjects like Barbie, Pokémon and Winnie the Pooh.

nytimes.com

And her choices of colors, texture, construction, and subject matter emerge straight from her heart.

dollsmagazine.com

When you install a theme, your Desktop wallpaper, screen saver, system icons, mouse pointers, colors, fonts, and even system sounds all change to reflect the theme's subject.

pcmag.com

Color additives used in combination to achieve variable effects, such as those found in pearlescent products, are subject to the same regulations as all other color additives .

cosmeticsandtoiletries.com

Demos were carried out using 4,000 dpi printing plates on six-color print subjects, including a metallic color.

labelandnarrowweb.com

Repeatedly subject to foreign occupation, most Okinawans, remarkably, don't sing the blues, but have maintained a sunny outlook on life -- an attitude that colors their music.

wfdd.org

This Chicago band's skittish energy recalls Talking Heads and TV on the Radio, lightening any dark subject matter with twitchy bursts of color.

spin.com

Among the realistic landscapes of her contemporaries, Nancy Whitman's paintings stand out for their bright colors and playful subjects.

venturacountystar.com

Related Stories for Artist uses bright colors, playful subjects.

venturacountystar.com

Later, he became attached to the rich quality of the color and the unique bond between subject and artist that Polaroids encourage.

baltimoremagazine.net

On the subject of race in the Washington Post Magazine 's Date Lab, a former Date Labber weighs in with some insight into some behind-the-scenes engineering on the subject of skin-color (I've edited the remarks slightly for clarity).

washingtoncitypaper.com

Follow a single highway from the coast all the way to the colorful hinterlands Image subjects: Long Pond from Blueberry Hill Location: Route 27 Belgrade.

downeast.com

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In science:

W?n Central and functional central limit theorems for W?nxi have been the subject of several papers in the literature [2,3,7] especially for two-color models and also some multicolor models.

A functional central limit theorem for a class of urn models

Thus we may call (X, N) a random walk in a directed graph subject to a road coloring.

Realization of finite-state mixing Markov chain as a random walk subject to a synchronizing road coloring

Our μ-random walk may also be called a random walk in a ?nite directed graph subject to a road coloring.

Random walk in a finite directed graph subject to a synchronizing road coloring

Papers were presented on different subjects, from spectroscopy, including pentaquarks and hadron structure, to new physics effects (non commutative ?eld theories, supersymmetry and extra dimensions) and the problem of color con ?nement, both in ordinary Yang-Mills models and in supersymmetric Yang-Mills.

QCD, hadrons and beyond

The nomenclature is colorful but the nature of the central regions remains a subject of confusion.

Island Universes

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Related words

Reverse dictionary (*)
Accidental colors, projection