Benham's Disk Optical Illusion

Introduction

Display the colors of the rainbow on a rotating black and white disk.

Concepts

- Colors of the visible spectrum
- Persistence of vision
- Optical illusions

Materials

Benham's disk blank cutout
Black permanent marker, fine-point
Bracken's Demonstration Spinner (optional)
Plastic container lid, e.g., margarine or Cool Whip®
Straight pin or pushpin
Scissors

Safety Precautions

Use caution when handling the pin. Please follow classroom safety guidelines.

Preparation

1. Photocopy the Benham's disk (found on page 4) onto a blank sheet of white paper. Enlarge the photocopy if desired.
2. Cut out the blank Benham's disk circle. *Optional:* Laminate the Benham's disk.
3. Use a black permanent fine-point marker to draw arcs on the white portion of the disk similar to those shown in Figure 1 on page 2. (If the disk is laminated, use a black, dry-erase marker so that the marks can be removed later.)
4. If the disk is not laminated, reinforce the paper by placing the disk on the inside of a plastic container lid. Trim the circle to fit the lid.
5. Use a straight pin or pushpin to poke a hole in the center of the Benham's disk. Rotate the pin in the hole to widen the hole slightly. This will allow the disk to spin freely on the pin.

Procedure

1. Show the students the non-rotating Benham's disk and ask them what colors they see on the disk. *(They will observe that the disk is black and white.)*
2. Hold the pin in a horizontal position so the black and white side of the disk faces the students.
3. Carefully, yet quickly, rotate the disk *clockwise* on the pin. Continue rotating the disk and allow students to observe the pattern created by the spinning disk. What colors do students see now? *(Many will see that the inner ring appears red, orange or yellow, the center ring appears green or blue, and the outer ring appears blue or violet.)*
4. Rotate the disk *counterclockwise* on the pin. Continue to rotate the disk and observe the pattern created by the spinning disk. *(The colors reverse—the inside ring now appears violet and the outside ring now appears red/orange.)*

Tips

- The larger the Benham's disk, the higher the resolution between the observed colors of the rings. To demonstrate this feature, enlarge the Benham's disk using a copy machine.
- Prepare multiple blank Benham's disks and allow students to draw their own arcs on the disks to test what color will appear when the disk is spun in a particular direction.
- The longer and thinner the line, the more brilliant the colors will be.
- *Optional:* Use the Bracken's Demonstration Spinner, Flinn Scientific Catalog No. AP6202, to rotate the disk. Use the pin to poke a hole in the center of the plastic container lid. Carefully press the center of the plastic lid onto the motor

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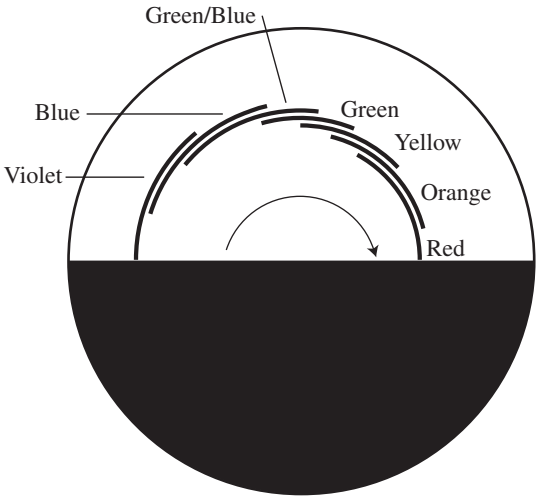
shaft of the Bracken's Demonstration Spinner. Make sure the lid presses against the motor shaft with a tight friction fit so that the lid will spin when the motor shaft spins. Carefully press the center of the Benham's disk onto the motor shaft above the plastic lid. Do not tear the disk. Press the disk down so that it rests on top of the plastic lid.

Discussion

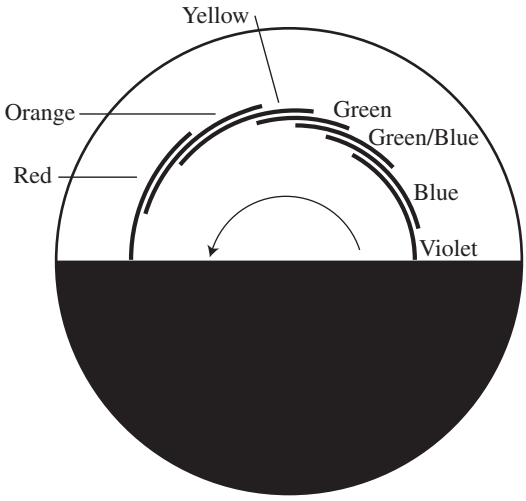
In 1894, the toymaker Charles E. Benham (1860–1928) introduced his "Artificial Spectrum Top." It later became known as the Benham's top or Benham's disk. When spun, the black and white top appeared to produce colored rings. The appearance of color is still a mystery even after more than 100 years, but it is believed to be at least partially the result of complex nerve responses in the cones of the retina. The cones of the retina allow individuals to see colors. Gustav Fechner (1801–1887), a German scientist and father of a branch of psychology known as *psychophysics*, was the first to describe the appearance of color from a spinning object in 1838. Psychophysics is the study of the relationship between stimulus intensity and a subjective experience (mental sensation) of the stimulus. The "pattern-induced flicker colors" (PIFCs) that are produced by the Benham's disk are known as *subjective* colors because the colors are perceived by our eyes due to the different response times of the cones of the retina. There are three color-sensitive cones on the retina—one for green, one for blue, and one for red. Each type of cone has different response and persistence times. For example, the "blue" cones have the slowest response times and continue to respond the longest after the stimulus is removed.

When the spinning Benham's disk is observed, alternating flashes of black and white stimulate the cones of the retina. White light has all three primary colors of light—red, green and blue. However, the brain only perceives white light when all the cones respond to the three primary colors equally. When the disk spins, each arc "flashes" at a different rate because each arc has a different amount of white space before and after. The different colors appear due to the location of the black arc on the disk. Lines that spin "into the black" with the least amount of white space between the black half-circle and the arc appear to be red in color. The middle arcs, with equal white space on each side, appear to be green. The arcs with the most white space between the arc and the black half-circle are blue. When the spinning disk reverses its direction, the arc that had the least amount of white space now has the most white space in the direction of the spin. This arc now appears blue. The middle arc still appears green, and the arc that first appeared blue is now red (see Figure 1).



When spun clockwise

Figure 1a.



When spun counter-clockwise

Figure 1b.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School
- MS-PS2 Motion and Stability: Forces and Interactions
  - PS2.A: Forces and Motion
- MS-LS1 From Molecules to Organisms: Structures and Processes
  - LS1.A: Structure and Function

Disciplinary Core Ideas: High School
- HS-PS2 Motion and Stability: Forces and Interactions
  - PS2.A: Forces and Motion
- HS-LS1 From Molecules to Organisms: Structures and Processes
  - LS1.A: Structure and Function

Science and Engineering Practices
- Developing and using models
- Constructing explanations and designing solutions

Crosscutting Concepts
- Patterns
- Cause and effect
- Structure and function
- Stability and change

References

Michaels's Visual Phenomena & Optical Illutions. Benham's Top. http://www.michaelbach.de/ot/col_benham/ (accessed March 2017).

Serendip. Mind, Brain, and the Experimental Psychology of Consciousness. http://serendip.brynmawr.edu/Mind/Consciousness.html (accessed March 2017).

Benham's Top. http://home.frognet.net/~ejcov/benham.html (accessed March 2017).

Materials for *Benham's Disk Optical Illusion* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP6202	Bracken's Demonstration Spinner
AP6402	Pushpins, Multicolored, Box of 100

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Benham's Disk Template