Student Sheet

In this practical I will be:

- Carrying out the practical, making careful observations about what is seen and whether there are any differences between group members.
- Using my knowledge and understanding of how we perceive objects to explain my observations and the differences between group members' observations.
- Applying and testing my explanations by altering the speed and designs on the spinners.
- Thinking about how differences in observations and misinterpretations of information may apply to other experiments, and what implications this may have.

Introduction:

The year is 438 BCE and as a well-respected, ancient Greek science-artist, you have been invited to the opening of the Parthenon, in Athens. You speak to the architect, in charge of the project, and he explains that he used several tricks to alter how people perceive the temple. This gets you thinking about how people see objects, and in particular colour. Like all good science-artists, you decide to investigate further…

Equipment:

- 1 piece of white card
- 1 pencil with a good depth of eraser on the end of the pencil
- 1 black crayon or felt tip pen
- 1 protractor
- 1 pair of scissors
- 1 drawing pin
- Photocopies of the disk patterns (below)
- Electric hand held mixer (if available)

Method:

1. If you are given a photocopy of a disk then cut it out. You will need to stick this onto some card and cut that out too. Then go straight to step 6.
2. If you have been given a piece of stiff white card, cut out a circle of about 10–12 cm diameter.
3. Draw a line across the centre of the disk and colour one half black using a black crayon or a black felt tip pen.

4. Use the protractor to divide the white half into four equal parts. To do this draw a line at 45° to the centre line then repeat by drawing a line at 45° to the line just drawn. Repeat until you have four sections.
5. Now use a black crayon to draw the following design. Each set of drawn lines is about 2 cm thick.

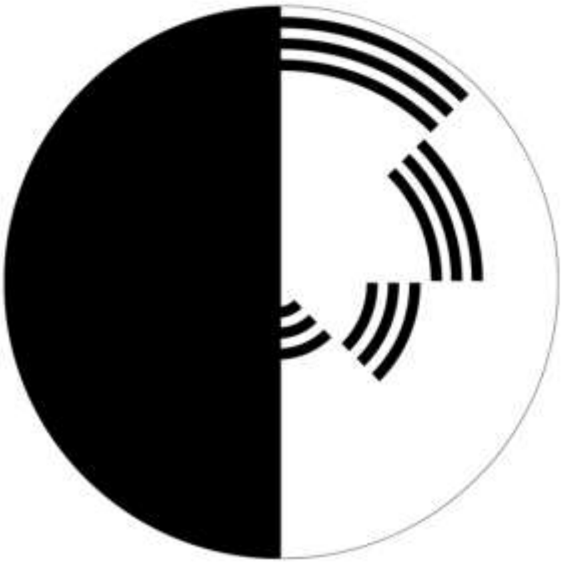

Image courtesy of Wikipedia

6. Carefully push a drawing pin through the centre of the disk and pin the disk to an eraser on the end of a pencil.
7. Spin the disk clockwise and anticlockwise at different speeds.

Write some notes about what you see and in groups of three discuss what you have seen.

Questions:

- What do you observe when you spin the disk?
- Do others see exactly the same colours or shapes as you?
- Do you see any colour?

Going further:

Try different patterns on the white half of your disk. Try spinning the disks at different speeds.

Use the same group of people to observe and compare the range of results.

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Is there any pattern?

Does the same person see the same range of effects?

Theory:

We do not always get it right when we observe things. Our brains can **misinterpret information** especially if we perceive things moving at speed. The phenomenon seen here in Benham's Disk is not entirely understood but there is an accepted theory.

The **colour receptors** (cones) in our eyes react at different rates to red, green and blue, and fast moving objects. This difference in response rate can deceive our brains when interpreting the signals.

When stimulated the cones and rods in the retina send a signal to the **neural ganglion cells**. Different ganglion cells become selectively tuned to detect subtle features of the **visual terrain; colour, size, direction and speed of motion**. These are called '**trigger features'**. Signals detected by the ganglion cells do not have a unique interpretation. The same signal might result from an object changing brightness, changing shape, or moving. The brain determines the most likely interpretation of events and, in the context of events detected by the other ganglion cells, takes appropriate action based upon the mass of information.

So, the different types of **colour-specific ganglion cells** respond differently to the effect of spinning objects. When the disk is spun, arcs of pale colour, called **Fechner colours** or **pattern-induced flicker colours,** are visible at different places on the disk. These can range from brown to pink depending upon the individual and speed of rotation. Neural activity in the **retina** and the ability to interpret the edges of shapes in the **primary visual cortex** of the brain is thought to create the different pattern-induced flicker colours. Importantly, because each person's eyes and their ganglion cells respond slightly differently to different signals, not everyone sees the same colours.

In 1826 Benedict Prévost observed colours when he waved his hands about, which he described as being like a heavenly light on his fingers. He experimented with white cardboard designs and realised that it has a **physiological origin**, in the eye. He attributed it to different rates of action of specific colour mechanisms of the retina. He was essentially correct but Provost's discovery was forgotten until 1838 when Fechner described the same phenomenon. In 1895 Charles Benham, an English toy maker, was the first to use the effect and that gave it its name, he sold a spinning top called an 'Artificial Spectrum Top'.

Research is currently being carried out on the use of the Benham Disk effect as a diagnostic tool for diseases of the eye.