Indian J Physiol Pharmacol 2016; 60(4) : 410–412

Opinion in Physiology and Pharmacology

Using Stereogram for Demonstrating Visual Optics to Undergraduate Medical Students

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Abstract

Visualization of stereogram involves an important aspect of cerebral functions. However, it has never has never been demonstrated to undergraduate medical students. We have used stereograms to demonstrate to the students this interesting phenomena of vision that few are aware of. We also explained its physiological basis. This practical has implications in cognitive sciences and the study of perception.

Background:

Stereograms are two-dimensional pictures which appear to be three-dimensional when viewed in a particular way. A distinction has been made in the following passages between the terms-picture and 'stereogram', the former signifying ordinary pictures that always look two-dimensional. A common feature of all stereograms is that they comprise horizontally-repetitive designs, hereafter called 'motifs'.

Need to innovation/alternative method:

An internet search shows that almost all articles on stereograms describe the different types of stereograms and explain how to view them but none of them gives a simple explanation for this interesting physiological phenomenon. In this article, we briefly describe how we used stereograms to demonstrate and explain the physiology of visual projection to the first-year undergraduate medical students.

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(Received on April 12, 2015)

What was done:

A book with printed stereograms was purchased online (1). Its pages were taken apart and each student was given a stereogram for viewing after which they were told how to view a stereogram and were explained the reason why it appeared 3-dimensional. The students were given four simple instructions: (a) Hold the stereogram vertically about 20 cm away from the eyes. (b) Do not focus your gaze on the stereogram; instead, defocus your gaze so that there is double-vision and the stereogram appears blurred. (c) Keep the eyes defocussed for several minutes till a new design seems to pop out of the stereogram. (d) If the hidden design does not pop out, move the stereogram slightly towards or away from the eyes and try afresh.

What was found:

On following these instructions for stereogram viewing, 58 out of 93 students were able to discern the hidden designs in the stereograms. Without exception, those who could appreciate the stereograms let off a gasp of astonishment at the very moment they saw the two-dimensional designs morph into three-dimensional images.

Physiological explanation of phenomenon:

The explanation given to the students was as follows: Consider an array of two-dimensional motifs comprising a hexagon, a star, and a circle, all linearly aligned. Normally, both eyes focus on a single motif and therefore identical images are formed on the retinas of the two eyes with the image of the fixated motif (in this case, the star) formed on the fovea centralis (Fig. 1A). Past experiences have taught the brain that identical retinal images are formed only when light rays originate from a single source. Hence, the brain infers that the object lies at the intersection of the two visual axes. This is known as "visual projection". Thus, if the subject focusses on the star, two images of the star will be formed on the fovea centralis of the retina – one in each eye. Since the two images are identical, the brain projects them in front of the eyes to the point of intersection of the two visual axes.

Next, consider two sets of the same array, as shown in Fig. 1B. Consider also that instead of focussing on a single motif, the two eyes focus on two different but identical motifs, which in this case are the two adjacent stars. The task is quite difficult since it is a very unusual thing to do but it is possible with adequate patience and tenacity. Here too, two identical images are formed on the retina of the two eyes and therefore, the image is projected at the point of intersection of the two visual axes. As the identical motifs are spaced farther apart, the visual

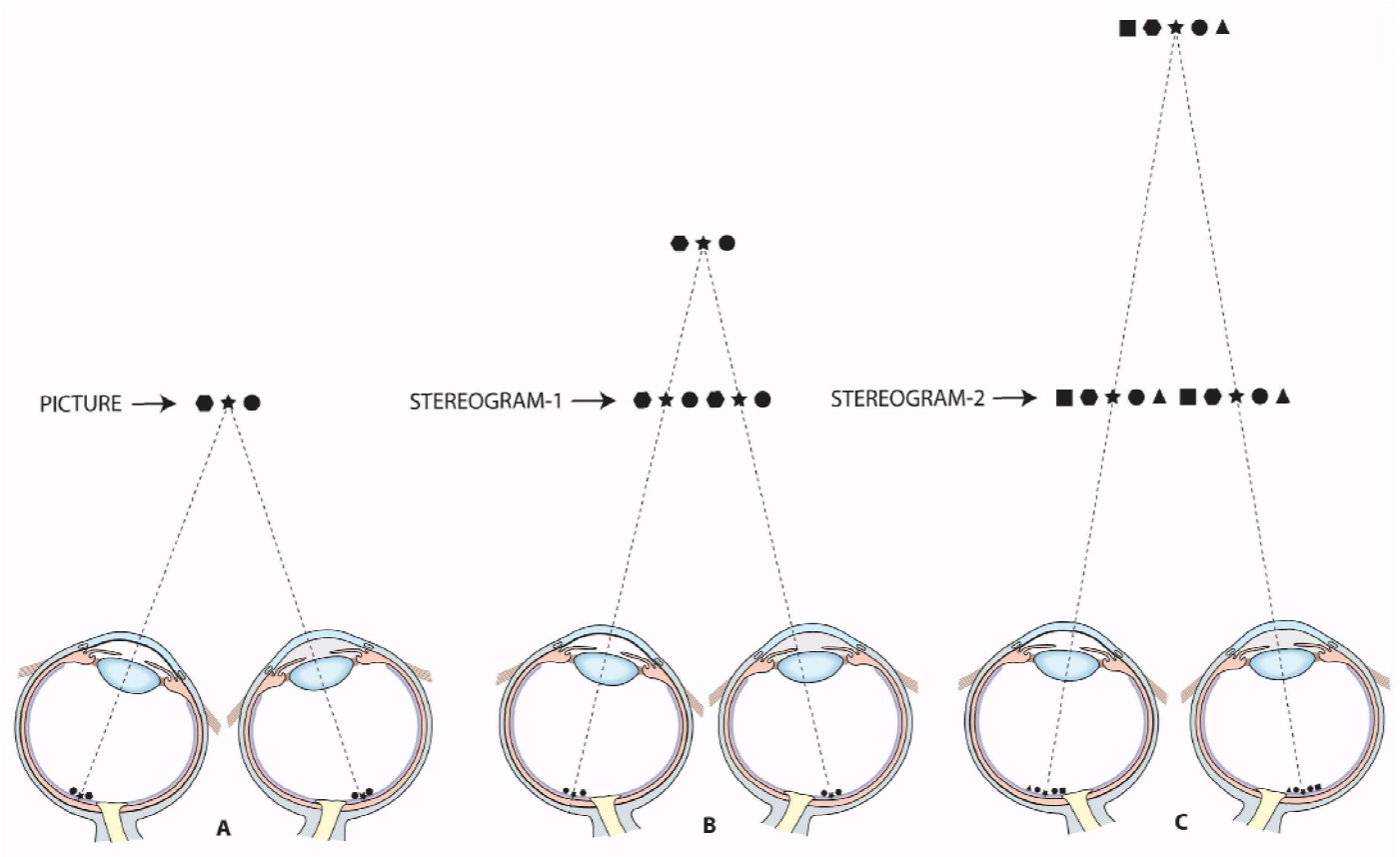

Fig. 1 [A] Convergence of both eyes on a single motif (star).
Fig. 1 [B] Convergence of both eyes on two identical motifs (stars) that are spaced apart.
Fig. 1 [C] Convergence of both eyes on two identical motifs (stars) that are spaced farther apart.

projection occurs at a greater distance (Fig. 1C). Stereograms are designed by exploiting this elementary rule.

The reason why the stereograms appear three-dimensional is as follows: Since the retinal images in both the eyes are identical when viewing a stereogram, the brain is tricked into believing that the two images originate from a single motif. Accordingly, there is “visual projection” to a greater distance from the eyes, as shown in Fig1B. Greater the gaps between the motifs, farther is its projection, as shown in Fig-1C. However, the sizes of the retinal images are identical because the “picture” and the “stereogram” are located at the same distance from the eyes. Therefore, the stereogram appears bigger than the picture. The observer’s brain argues that if two images of identical shapes and sizes are formed on the fovea centralis of the two eyes, then both the images must be originating from a single source. Moreover, past experience has taught the brain that the object viewed binocularly is always located at the point of intersection of the visual axes of the two eyes. Hence, based on the degree of convergence of the two eyes, the brain interprets that stereogram-1 must be nearer than stereogram-2. Yet, the retinal images in A and B are identical in size and therefore, the brain concludes that the motifs in stereogram-2 must be bigger.

Advantage:

To create an awareness that ‘there is more to it than meets the eye’ i.e., that one picture can have two different versions. Which of the two versions is perceived by the brain depends on how the eyes are focused on the picture. Thus, students get to know a phenomena they never knew existed.

Limitation:

Students may have difficulty in seeing the depth in a stereogram. However, most of them were able to perceive the three dimensional image after persisting with it for several minutes.

Carry home message and future direction:

This practical provides a simple insight on how stereo vision is processed by the human brain. Though interesting as a phenomenon producing a sense (stereopsis) of depth in a printed image, this practical also has implications in cognitive sciences and the physiology of three-dimensional perception.

References

1. Stephen Schutz and Susan Polis Schutz. Sea Life in 5-D stereograms. 1995 Blue Mountain Press, Boulder, Colorado.