Two Eyes, *3D*: A New Project to Study Stereoscopy in Astronomy Education

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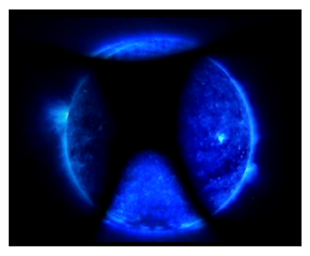
Two Eyes, *3D* is a 3-year NSF funded research project to study the educational impacts of using stereoscopic ("3D") representations in science education. It funds two studies about how children learn from static stereoscopic images and how families learn from high-definition, stereoscopic films.

Research Questions



How does the presentation of scientific objects and processes in stereoscopic format affect the learning of their spatial properties by children and adults? How is it related to prior spatial ability and other demographic factors?

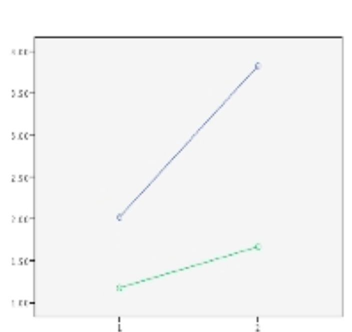
Background

Young children today grow up not knowing of a world where films were not available in 3D. Yet our knowledge about how to implement stereoscopic visualizations in education is far behind our knowledge about using it in entertainment.

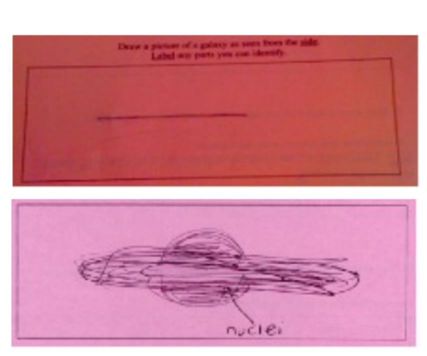
Two-dimensional representations of scientific objects and concepts found in textbooks, on television and computer screens, in film, etc. all distort the appearance of real objects. Furthermore, people often need to perform mental manipulations of 3D objects in order to understand how they work or move. Some concepts, such as the 3D spatial arrangement of planetary orbits, may be too difficult to understand based on 2D representations alone (Barab, et al., 2000; Gotwals 1995; Hansen, et al. 2004).

In a prior study, we found no difference in accuracy on spatial cognition tasks performed by middle school students viewing them through 2D or stereoscopic representations (Price & Lee, 2010). However, we did find that stereoscopic tasks took longer and that difference was related to the amount of 3D manipulations required of the student. Interviews suggest this is due to the students transforming the images to 2D, performing the mental rotation, then transforming it back to 3D.

Pilot Data 1: Pre-post test performance of students in science classes on distance questions about objects they saw in a 2D slide (green) or a stereoscopic slide (blue). Higher numbers reflect increased accuracy. Differences are statistically significant, $F(1,38)=46.9$, $p<.001$.

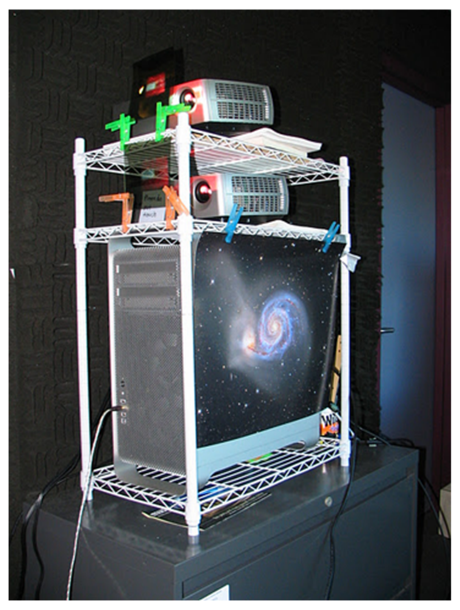


Pilot Data 2: Pre-post test performance of the same students on a task asking them to draw and label galaxies from different angles. The average 2D student included an additional 0.6 structural elements to their post-test image and the average stereoscopic student added 2.0 new structural elements. Differences are statistically significant, $F(1,32)=184.5$, $p<.001$.



Pilot Data 3: Figure 5. Typical drawings of what galaxies look like from the side by two students who saw the 2D slides (left) or the stereoscopic slides (right).

In a pilot study for this project, we found no difference between the ability of middle school students to count the number of galaxies in a stereoscopic version of the Hubble Deep Field. However, we did find differences in how students estimated distances between galaxies and how much they learned about the spatial structure of galaxies.



This is the geowall we used for pilot testing. It cost <$4,000 to assemble (3 years ago, prices have likely dropped further) and is easily transportable. It uses only open source software available at geowall.org.

Goals

1. To develop a set of design principles for production of stereoscopic media accessible to those of all spatial ability
2. Development of two public-domain, high-definition stereoscopic astronomy films
3. Development of a platform for using mobile devices for assessments in informal science education

Research Design

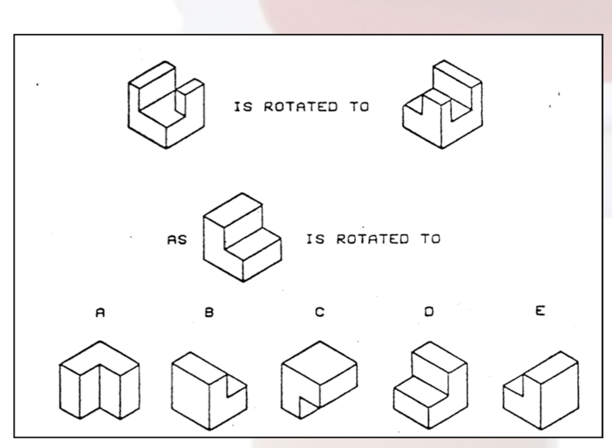
Research Project #1: *Investigating Spatial Perception of Scientific Concepts Using Personal Stereoscopic Displays*

This study will take place in the Living Laboratory on the museum floor at the Boston Museum of Science (above). About 400 children, ages 7-12, will be given a spatial cognition test on a tablet device. They will then be shown a random selection of slides of highly spatial scientific objects (clouds, snowflakes, planets, etc.) in either 2D or stereoscopic formats. They will be asked a spatial question about the object. For the last object, they will be asked to draw it from memory. During the test, parents will be interviewed for demographic information (experience with video games, visual disabilities, etc.).

Research Project #2: *Comparing Adult Learning of Scientific Concepts through 2D and Stereoscopic Films*

Study 2 will take place at the Adler Planetarium and Astronomy Museum in Chicago, IL. About 1,000 adults will view one of two new, high-definition films about either galaxies or Type-1a supernovae. They will randomly be assigned a stereoscopic or 2D version of the film. Prior to the film, they will take a spatial cognition test on a tablet device. Then, they will take a 5-item pre-test with learning questions about the film. After the film, they will take the identical test again. 20 participants will be interviewd after the film to look for deeper meaning behind their answers. Six months later all participants will be e-mailed a delayed post-test which they can take online.

The items on the test will be focused on learning about spatial properties of the processes in the films and will involve a mix of explanation and drawing tasks.



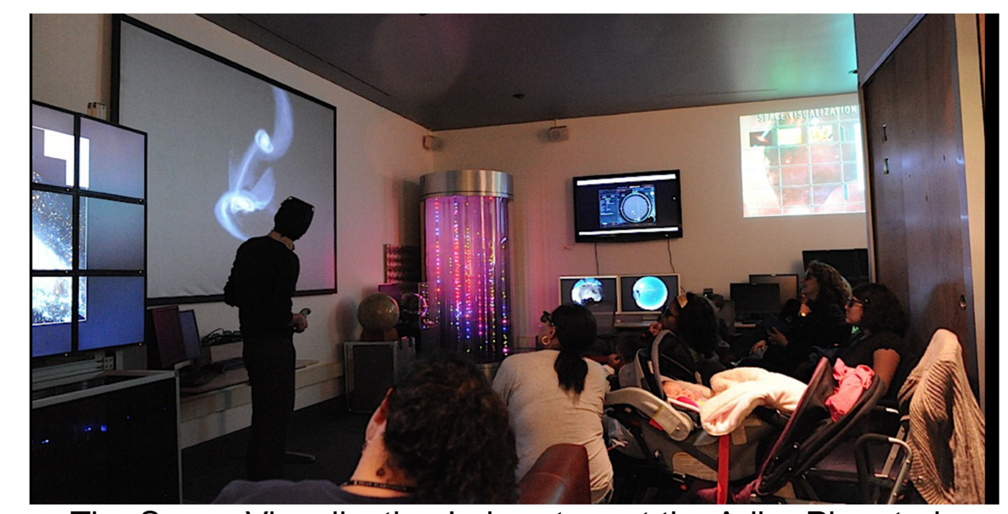
Spatial cognition items will be taken from the Purdue Visualization of Rotations Test (Bodner & Guay, 1997).

To learn more, visit our blog at:

www.twoeyes3d.org

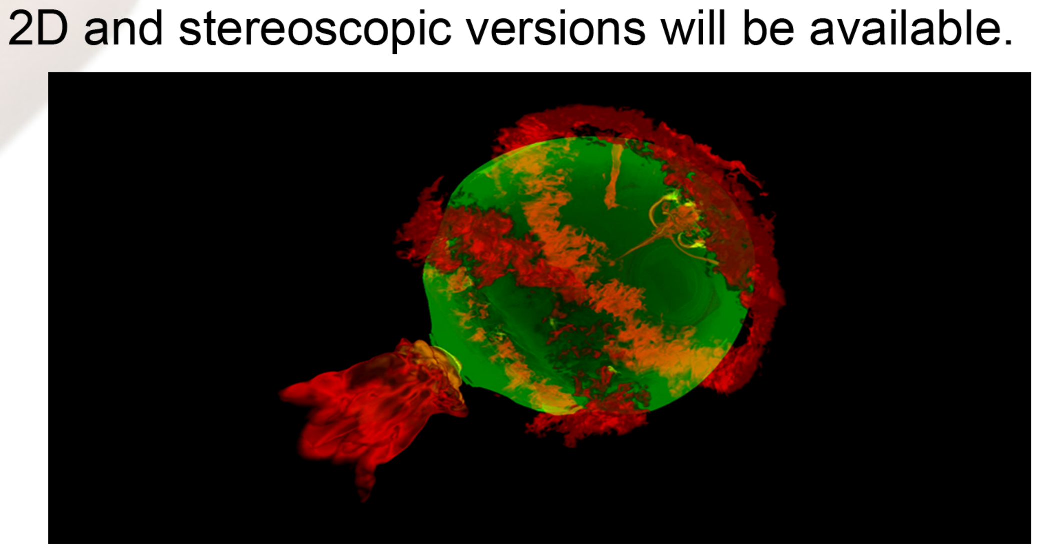
The Films

Two films will be produced by the Adler Planetarium and Astronomy museum with production advice and models shared by other organizations, including the California Academy of Sciences (a member of the advisory board). The films will adhere to a set of design principles assembled from the research literature and past experience in film production. The role of the principles is to make the film accessible to those of both high and low spatial ability.



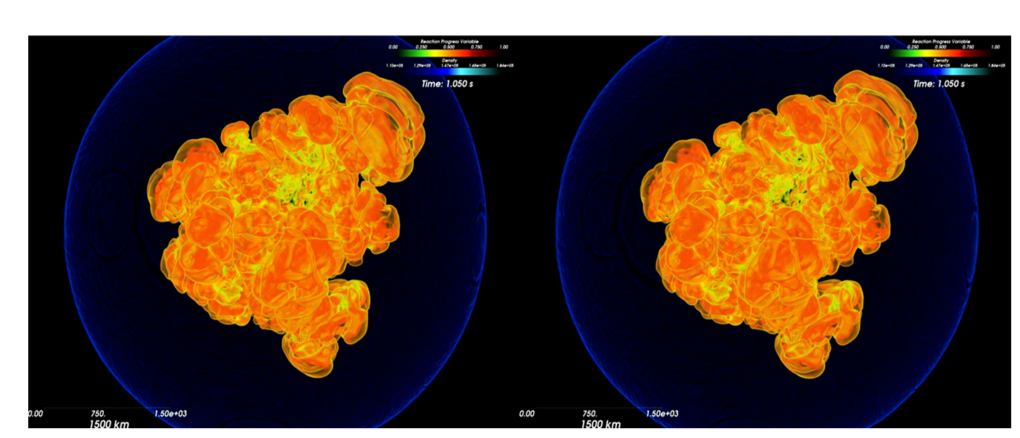
The Space Visualization Laboratory at the Adler Planetarium

One film will be about Type-1a supernovae. It will focus on the process of the exploding star and how its structure evolves. Another film will be about the evolution of galaxies, focusing on the spatial elements that changes as they shift from spiral to irregular to elliptical. The films will be rendered for all the popular, digital planetarium systems and will be made available to the public via a Creative Commons license. A spanish language version will also be released. Both 2D and stereoscopic versions will be available.



Type-1a SNe simulation (The Flash Center for Computational Science)

All tests will use tablet devices with software by Clockwork Active Media Systems. As an investigation into embodied cognition, the accelerometers record spatial movements of the device during the test. Item completion time will also be recorded. The drawing tasks can be completed with fingers or a supplied stylus. The software will be released under a public domain license (likely GPL Affero) with proper documentation so anyone can adapt this software for your own assessment needs.



Type-1a SNe simulation stereo pair
(The Flash Center for Computational Science)

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