S3D – psycho-visual illusion or experiment with your eyesight?

Samsung is at the forefront of flat-panel design and its innovation in the production of S3D screens leads the world. Yet, in June 2010, the company felt the need to issue a series of warnings when it released its new 3D-enabled TVs in Australia. BOB AUGER, Head of Newmérique, wonders whether stereoscopy 3D is really cause for alarm.

Imagine the scene: In the reception area of the BBC Television Centre in Wood Lane, London, a small crowd jostles for a clear view of two small television sets. They are looking at something that few people have seen before in public, and excitement is in the air because everyone knows that they are looking at the future of TV. The fortunate few, including a junior technical operator, were watching the first public 625-line PAL colour transmission, from Colour Mobile Control Room One (CMCR-1) at the All England Tennis Club in Wimbledon. The date was July 1967.

This year, with the help of Sony Outside Broadcast, the BBC transmitted the Wimbledon men's final in stereoscopic 3D (S3D), with selected members of the public invited to the soon-to-be-sold TV Centre to watch in 3D on a large screen. After 44 years, television without colour is almost as unthinkable as a world without the Television Centre. Will the same be true of S3D in 2055?

The tale of S3D is one of a long-term experiment with our eyesight. Two cameras point at the same scene from slightly different horizontal viewpoints, more or less equivalent to the distance between the human eyes. The captured images are presented to the viewer in a way that prevents the right eye from seeing the left image and vice versa and the brain combines the two views into a single scene, interpreting the displacement between objects in the two images as depth information. This fools the viewer into believing that the two 2D images have three dimensions. It is a convincing illusion.

There are many 'depth cues' involved in our perception of 3D and unless stereographers are aware of them, there is a risk of baffling the brain of the viewer at best or causing headaches, confusion and convulsions at worst. However, before that, and the health and safety warning, let's take a look at the historical background.

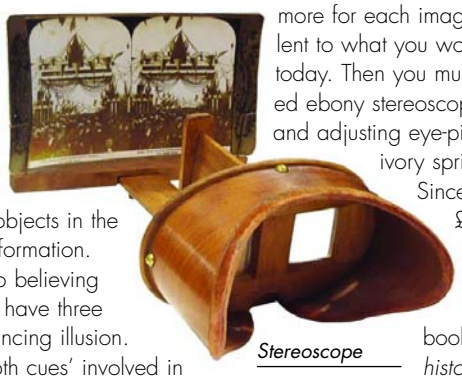
Stereoscopy – a short history

Charles Wheatstone was the first person to offer a theory of binocular vision, which he presented to the Royal Society of London in June 1838. In the introduction to his paper, *Contributions to the Physiology of Vision,* he wrote, "The frequent reference I shall have occasion to make to this instrument, will render it convenient to give it a specific name, I therefore propose that it be called a stereoscope, to indicate its property of representing solid figures."

Charles Wheatstone

Today, Wheatstone is acknowledged as the founder of stereoscopy and in October 2010 the International 3D Society presented the inaugural Charles Wheatstone Award to Panasonic, in recognition of the company's advocacy of Full HD 3DTV.

Wheatstone did have his critics, amongst them Sir David Brewster, who in 1849 invented the Lenticular Stereoscope. This viewer for stereoscopic prints was an instant success at London's Great Exhibition in 1851, spawning several publishers of 'Binocular Pictures' – S3D slides, which fetched three shillings (£0.15) or more for each image pair, roughly equivalent to what you would pay for Blu-ray disc today. Then you must add £50 for a "Polished ebony stereoscope, with brass shifting and adjusting eye-pieces, reflecting flap and ivory spring to retain the slides".



Stereoscope

Since this equates to around £5,000, the modern 3D Blu-ray player seems quite a bargain.

Brewster's 1856 book *The Stereoscope, its history, theory and construction* is still worthy of study by today's budding stereographers, particularly chapter 14, entitled "Application of the stereoscope to the purposes of amusement."

Not long after the first demonstration of S3D, Dr. Wilhelm Rollmann described the two-colour anaglyph method of separating left and right images in 1853. In an entry entitled "A note on stereoscopy" on page 350 of *The Annals of Physics and Chemistry* published in Leipzig, Rollmann wrote, "After looking at the red and green images for a short while, I definitely saw grey, as I have not seen in other methods. By the way, as Dove says, one soon notices the test is not good for the eyes." Elsewhere in the same journal, his contemporary Dr. Heinrich Dove from Berlin wrote about polarised light – we will return to applications of that technology shortly.

'The Power of Love' theater audience

At the end of the nineteenth century the pioneering British cinematographer William Friese-Greene demonstrated moving 3D images in public and by 1922, according to IMDb, audiences were paying to see a full-length feature, *The Power of Love* in 3D, at the Ambassador Hotel Theatre in Los Angeles.

By now another new medium was on the horizon and stereoscopy quickly followed in its wake. John Logie Baird, the inventor of 'chemical socks' and several other items of benefit to the human race. Contrary to the view of many British citizens, Baird did not actually invent television but he does have a string of 'firsts' to his credit, and S3D television is one of them.

In the magazine *Radio News* of November 1928, under the headline "John L. Baird Produces Moving Images Which Are Given

the Appearance of Solidity", R.F. Tiltman reported, "Television images in, apparently, three dimensions were demonstrated for the first time on August 10 in the Baird Laboratories in Long Acre, before an audience of scientists and representatives of the press."

This was not Baird's only attempt to bring stereoscopic television to the British public. In May 1942, almost 70 years ago, an issue of the *London Illustrated News* included Baird's proposals for S3D under the title "Stereoscopic Television Pictures: a notable British achievement."

The 1944 Hankey Committee on the future of television took evidence from Baird and from the film tycoon J. Arthur Rank, before recommending, "vigorous research work" to ensure that the post-war BBC would launch a 1,000-line television service, followed quickly by "the introduction of colour and stereoscopic effects." Had Baird not died in 1946, the current debate on S3D TV might have been resolved by the middle of the last century!

The story of the short-lived S3D booms in the cinemas of the 1950s, 1960s and 1980s has been retold several times and does not need to be repeated here, except perhaps to say the "A LION in your lap! A LOVER in Your Arms!" has to be one of the all-time great movie slogans. It comes from the poster for *Bwana Devil*, billed in 1952 as 'The World's first feature length motion picture in Natural Vision 3 Dimension.'

Although *Bwana Devil* employed the same anaglyph technology that Rollmann revealed a century before, a better technology was already available. In 1932, the US patent office granted the inventor Edwin H Land a patent for Polaroid filters. The German company Zeiss-Ikon used a similar process to screen the 3D colour film "You can nearly touch it" to an audience in Berlin in 1936.

The technology forges ahead

Acquiring S3D content requires two cameras, one for the viewpoint of each eye. Projection of an anaglyph print is little different to 2D, just a single release print and a single projector is required. This keeps it simple and inexpensive for cinema owners and distributors alike. The situation is different for S3D with polarised glasses, which requires two synchronised projectors side-by-side and a left- and right-eye copy of the print. In a perfect world, the results can be excellent and modern digital projection comes close to perfection. However, stability is very hard to achieve with such a mechanical system.

Greendow was the leading film production company in Manchester during the 1970s, and in 1979 we experimented with S3D acquisition on 16mm film, with a view to producing corporate and advertising films. After some tests in the studio, two top-end Arriflex cameras were lashed together for the shoot in and around Manchester. Two versions were shot and edited together with some Oxberry aerial image camera material, using the most comprehensive editing and post-production facilities that were then available. A small group of management and production staff viewed both polarised and anaglyph results.

They were not promising! The S3D images were excellent, giving convincing and effective stereo views, but the problem lay with the projection and a mechanical artefact known as 'weave.' As the film goes through the gate in the projector, it doesn't always align perfectly with the frames before and after. This is not a problem in 2D, as the movement from frame to frame is small.

With two mechanical projectors projecting two 16mm prints through polarising filters, one for the left and one for the right eye, film weave makes it almost impossible to achieve perfect alignment. As each eye tries to move independently to stabilise the image, a more effective migraine machine is hard to imagine!

We abandoned the polarised version and turned to the anaglyph print, from a single projector. At least the film weave was the same for each eye but the colour rendition was poor and there was a strange 'raining' effect, probably caused by the film grain. The project was quietly wound down and has never been referred to since!

At the end of the 20th century, the use of polarised glasses in broadcast television was impractical outside the lab, but several anaglyph trials took place. In 1997, the coffee company Gevalia distributed red/green 3D glasses to every TV household in Sweden, so they could watch a TV commercial made by Oh La La Films for the HCYR agency in Stockholm.

With the first DVD Summit about to take place in Versailles at about the same time, Nimbus decided to give away a promotional DVD to all delegates to the event. Both client and agency granted permission to put the Gevalia 3D TV spot on the disc, which Adam Justice-Mills produced for Electric Switch. This disc became the first-ever S3D DVD and today it is a collector's item (see picture bottom left). Although the anaglyph image has its flaws, it stands up well against recent productions, as

Anaglyph 3D video and glasses

delegates to the 2011 Blu-ray Disc Academy in Hamburg acknowledged. As a proof of concept, it was invaluable.

In the 150 years since the Great Exhibition of 1851 in London there have been many successes and many false starts, but the arrival of stereoscopic 3D HDTV (and its lower resolution relatives) has led to increasing interest in the fundamentals.

However, before we deal with those, it is time for a health and safety warning.

Samsung's 3D health warning

As we learned, back in 1853 Rollmann was already worrying about the effect that stereoscopic images might have on his eyes and the concerns have not lessened over the years. Samsung is at the forefront of flat-panel design and its innovation in the production of S3D screens leads the world. Yet, in June 2010, the company felt the need to issue a series of warnings when it released its new 3D enabled TVs in Australia. Prepare to be alarmed!

The warning began with an outline of visual problems that some people have reported:

If you experience any of the following symptoms, immediately stop watching 3D pictures and consult a medical specialist: (1) altered vision; (2) light-headedness; (3) dizziness; (4) involuntary movements such as eye or muscle twitching; (5) confusion; (6) nausea; (7) loss of awareness; (8) convulsions; (9) cramps; and/or (10) disorientation. Parents should monitor and ask their children about the above

symptoms as children and teenagers may be more likely to experience these symptoms than adults.

This broad range of symptoms may arise from any number of medical conditions, but at least Australian ophthalmologists will have picked up a few new clients because of the warning. Worried that people might injure themselves when they tried to escape from the effects of the 3D, the warnings continued:

Viewing in 3D mode may cause disorientation for some viewers. DO NOT place your television near open stairwells, cables, balconies or other objects that may cause you to injure yourself.

Again, good advice, particularly if the S3D content is so poor, or repeated so frequently, that viewers are tempted to pick up the TV and throw it down the stairs or out of the window. However, the final paragraph probably excludes 90% of the couch potatoes who would most enjoy watching S3D programmes:

We do not recommend watching 3D if you are in bad physical condition, need sleep or have been drinking alcohol.

Despite these strictures, a year later it appears that very few Australians have felt the need to return their 3DTVs, and Samsung Australia forecasts sales of 10 million 3D-ready displays in 2011!

A century and a half after the invention of the stereoscope, conference delegates at IBC in 2008 were told, "There are very few good stereographers in the world today, and most of those don't know what they are doing."

How imagery plays tricks

Now for some details. Watching a 3D movie, the viewer may spend 90 minutes trying to make visual sense of such elementary matters as subtitles, for example, that appear in one plane of vision and action that is in another. It is not the 3DTV that causes head-aches; it's a lack of understanding of how sighted people judge the position of an object in space.

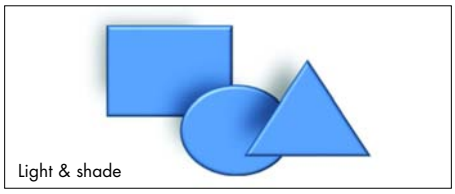
A combination of eight depth cues allow us to assess the relative position of everything we see and you don't need two eyes to see most of them. Filmmakers working in 2D are well versed in the first of these cues, which is ***focus***. The picture of a giraffe at Port Lympne wild animal park in Kent illustrates this well.

The young giraffe calves are clearly in the background of the shot and this fact is emphasised by the sharp focus on the foreground mother. Although we are very used to this convention in 2D, restricted depth of field should be avoided in 3D photography, since in a well-composed shot our eyes automatically focus on the plane of the action.

The image also illustrates a second depth cue that viewers use to judge relative positions, ***occlusion***. The horns of the giraffe are in front of the window frame at the top, the neck is behind it at the side. Whether you have one eye or two, you can only come to one conclusion: the giraffe's head is projecting through the opening. In fact it is hard to convince yourself that this image actually has no depth at all, it is in two dimensions on a printed page.

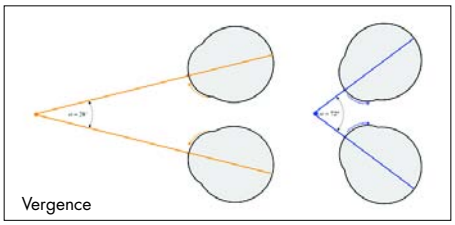
Most of us will be familiar with depth cue number three, which is ***perspective***, the way that parallel lines, such as railway tracks, will eventually meet at an imaginary 'vanishing point.' It is a useful way to draw the viewer into a picture, whether 2D or 3D.

The fourth cue will be familiar to fans of the Austrian expressionist filmmaker Fritz Lang: ***light & shade*** gives depth to an otherwise 2D object. Graphic designers exploit this tendency for our brain to assign depth to flat objects by using tricks such as drop-shadows and edge highlights to create the illusion of 3D.



Next on the list is ***saturation & contrast***. As we look over a landscape, objects close to us appear fuller in colour (more saturated) and more detailed (contrasty) than similar objects on the horizon. Although city dwellers will rarely notice this, except perhaps from the top of a tall building, it is obvious on a cloudless day in the countryside.

The sixth depth cue is ***relative motion***, which is widely used in cartoon films. As we drive along a fenced road for example, objects by the roadside appear to go past us at high speed, while those much further away seem to move at a more sedate speed. This effect is believed to be the cause of the "Are we nearly there yet?" syndrome in children.



Only with cue seven do we reach the point where we need two eyes to assess properly the relative depth of objects in a scene. It is ***vergence***, the term for the movement of our eyes towards and away from a centre line, as we change focus from foreground to background.

The brain uses minute differences in angle to work out how far away an object is. The rate at which the angle changes, and whether it is converging or diverging, provides the depth cues that the human brain needs to catch a ball. It also allows us to avoid the flailing claws of a dinosaur as it strikes out at a cinema audience in an S3D screening.

Finally, we arrive at ***stereopsis***, depth cue number eight, which was the subject of Wheatstone's 1838 paper. Because of the separation of our eyes, each one sees a slightly different view of the world. It gives us the ability to judge the volume of an object and in normal 3D vision we may also move our head slightly to improve our judgement of where an object is in space. Bowls players are great exponents of this skill.

Moving your head whilst wearing 3D glasses can produce a strange effect, however, since the apparently three-dimensional image appears to be a series of two-dimensional planes that move as if locked together, the so-called 'cardboard cut-out effect'.

S3D is not 'real' 3D and it never will be, since the audience cannot view any object in the scene from all sides. Nevertheless, until something better comes along – whether holographic or directly through an implant in the brain – S3D offers the closest approach to the original scene that we can get. In the hands (and eyes) of an expert stereographer and with a little assistance from a good story, a great script, a talented director and a brilliant director of photography, a stereoscopic movie can look very convincing.

Do remember though, it is only the illusion of 3D…

BIOGRAPHY

BOB AUGER was founder and MD of top London DVD authoring house Electric Switch in 1990, then produced over 400 educational DVDs for the Ohana Foundation in Hawaii. He is the founder and President of consultancy Newmérique. Bob specialises in tracking and analysing the full range of video delivery technologies. Contact: bob@newmerique.com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