The Seven Deadly Retinal Rivalries

by Jeff Boller

Stereoscopic imagery is based on a deceptively simple concept. Two slightly different pictures are displayed: one intended to be viewed solely by the left eye, the other by the right. The eyes view the pictures, the brain fuses the images, and we perceive the picture as being three-dimensional.

But what happens when the differences between the pictures are too great? The brain then has trouble fusing the images. The most extreme differences between the two pictures will appear to flash rapidly between each eye. This effect is called retinal rivalry.

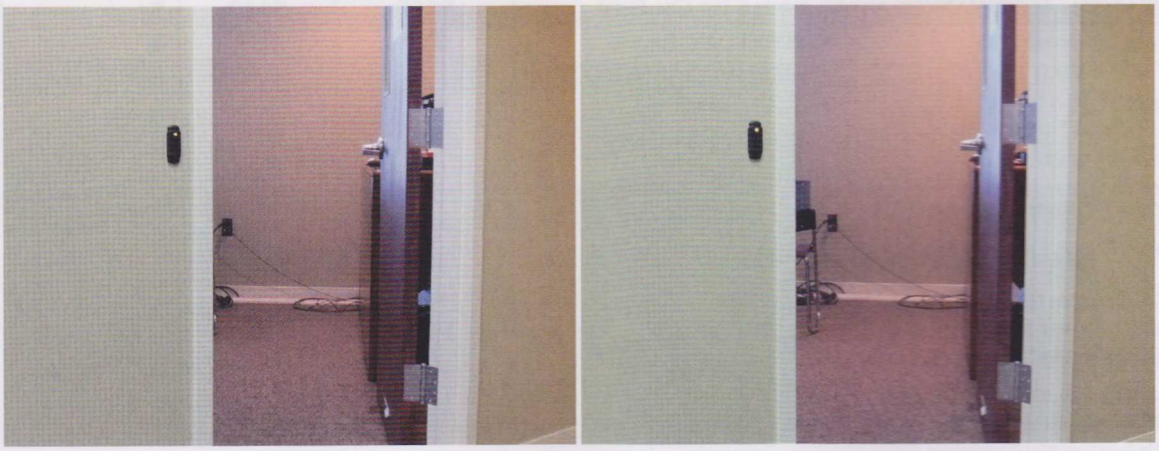
At 3D-Con 2013, I became fascinated with retinal rivalry for all the wrong reasons. While there were many superb stills projected in the Stereo Theater, a surprising number were marred by a disconcerting form of retinal rivalry. I naively assumed that this very distinctive—and annoying—form of retinal rivalry had a name. After researching the subject and discussing it with several experienced stereo photographers, I discovered that, not only is there no name for this particular effect, but there's very little written information about retinal rivalry in general. This article is a step toward rectifying both of these issues.

Retinal Rivalry in Real Life

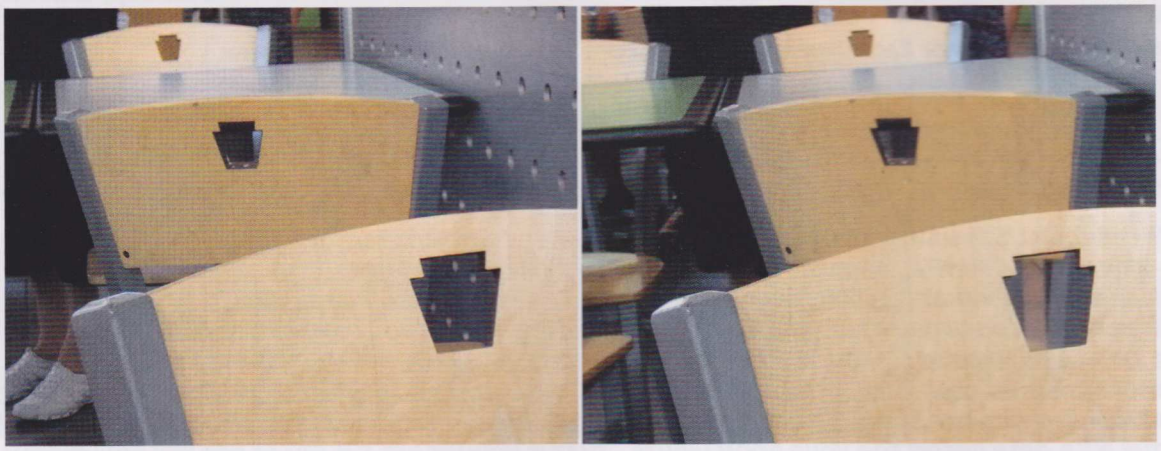
Retinal rivalry occurs hundreds of times a day in real life and goes by unnoticed. That's because real life is always in motion. For example, if the viewer is looking at a bird just before it flies behind a tree, the bird will be seen briefly with one eye but not the other. Since this retinal rivalry occurs so quickly, the brain doesn't register any discomfort.

Even when objects are at rest, our bodies are not. If the viewer is looking at a chair poking out from behind a doorway and it's seen by only one eye, all it takes is a slight turn of the head or a shift of the body to change the view. Then the viewer can see the chair with both eyes.

However, stereoscopic images aren't real life; they are an illusion of life frozen from a particular point of view. In a stereoscopic image, if part of a chair is visible through a doorway with only one eye, no amount of moving around will allow the



Example A.
Try as you might, there's no way to view the chair with both eyes.



Example B.
It's impossible to fuse the hole inside the front chair (obtrusive retinal rivalry), but the woman's white shoes are fine (unobtrusive retinal rivalry) The hole inside the front chair also demonstrates the deadly retinal rivalry effect called keyholing. [And yes, thanks to the hole shape, this is also a unique case of keystoning!]

Example C: The flower pot and foliage on the left that's closest to the viewer demonstrates a window violation.

Example D. The shadow behind my close-up demonstrates an edge annoyance.

viewer to see the chair with both eyes (Example A).

Most descriptions of retinal rivalry suggest that it's an undesirable effect that should be avoided at all costs. However, if stereo photographers avoided *all* retinal rivalry, it would severely limit their compositional palette. Not every instance of retinal rivalry that occurs in real life or in stereoscopic images causes discomfort. Therefore, it would be more helpful to split retinal rivalry into two categories: obtrusive and unobtrusive.

Obtrusive vs. Unobtrusive

Obtrusive retinal rivalry is impossible for a viewer's brain to fuse. It takes the viewer out of the stereoscopic experience and calls attention to the fact that there's something uncomfortably wrong with the image. In extreme cases, obtrusive retinal rivalry can cause eye strain and headaches. *This* is the kind of retinal rivalry that should be avoided at all costs.

Unobtrusive retinal rivalry, on the other hand, is retinal rivalry that doesn't call attention to itself. In fact, the viewer might not even notice that it exists.

Example B demonstrates both obtrusive and unobtrusive retinal rivalry. The hole inside the front chair demonstrates a case of obtrusive retinal rivalry. There's almost nothing in common between the left and right images in that area of the picture, so there's very little for the eyes to latch onto. When viewed stereoscopically, the hole inside the front chair flashes uncomfortably between the left and right eyes.

The woman's white shoes are an example of unobtrusive retinal rivalry. Even though I shot this picture to demonstrate obtrusive retinal rivalry, I didn't notice that the shoes appeared only in the left image until someone pointed it out.

Except in the most extreme cases, classifying retinal rivalries as obtrusive or unobtrusive is a subjective judgment, not a scientific one. One viewer's unobtrusive retinal rivalry might be another viewer's headache.

Movies vs. Stills

When it comes to retinal rivalry, stereoscopic movies have it easier than stereoscopic stills. If there's a quick bit of retinal rivalry in a stereoscopic movie—such as the example with the bird flying behind the tree—it's often unnoticeable. Stereoscopic movies only run into problems when a shot lingers on a feature with some sort of retinal rivalry. Otherwise, if the retinal rivalry is fleeting and painless, a filmmaker can get away with it.

Stereoscopic stills are another matter. Stills—by their very definition—cannot be fleeting. Anything that's perceived as annoying or distracting will exist for as long as the image is displayed to the viewer.

Now that we've established what retinal rivalry is, let's examine what I call the seven deadly retinal rivalries. Each of these rivalries can be obtrusive or unobtrusive, depending on degree.

Deadly Retinal Rivalry #1: Window Violations

If an object is partially visible near the edge of a stereo picture and is located in front of the stereo window (in other words, the object is sticking out at the viewer), you've got a deadly retinal rivalry called a *window violation*.

Window violations are the bane of the conservative stereo photographer's existence. It's also the type of retinal rivalry that's discussed most often online and in print. Example C shows a typical window violation. The large flower pot on the left that's closest to the viewer flashes uncomfortably because it's located in front of the stereo window and is partially cut off.

There's some debate among stereographers on whether window violations should be completely avoided on all four sides of the window.

From a purely technical perspective, the only sort of window violations that have the potential to inflict visual pain are violations on the left and right sides. Window violations on the top or bottom edges aren't actually a retinal rivalry, but they have the potential to look unnatural and break the suspension of disbelief.

On the 3-D movie side of the equation, I deliberately violate the bottom edge of the window in my films, especially for closeups. When a filmmaker keeps absolutely everything behind the stereo window, viewers invariably complain that the film didn't feel "3-D" enough. In my experience, window violations on the bottom edge of the window are almost always acceptable, and that technique is becoming a part of the still-evolving 3-D cinema vocabulary.

Deadly Retinal Rivalry #2: Keyholing

When there's a hole or opening that the viewer can peer through, and the viewer finds it difficult or impossible to fuse what is shown in that area, I call this deadly retinal rivalry *keyholing*.

Keyholing is the effect of looking through a keyhole with both eyes—the viewer is never able to see a complete stereo picture when a hole is extremely small. Remember when I mentioned that I saw a particular type of retinal rivalry at 3D-Con which had no name? Look again at Example B. The hole in the front chair demonstrates a keyholing effect. There's not enough common visual information between the left and right images in that part of the picture, so the brain finds it difficult to fuse the area inside of the hole.

Keyholing can happen in any enclosed space—it can happen underneath someone's arm, within the center of a flower, or, yes, even when looking through a keyhole.

Deadly Retinal Rivalry #3: Edge Annoyances

When there is something behind a subject that is visible with one eye but not the other, the viewer may be subjected to a deadly retinal rivalry called an *edge annoyance*.

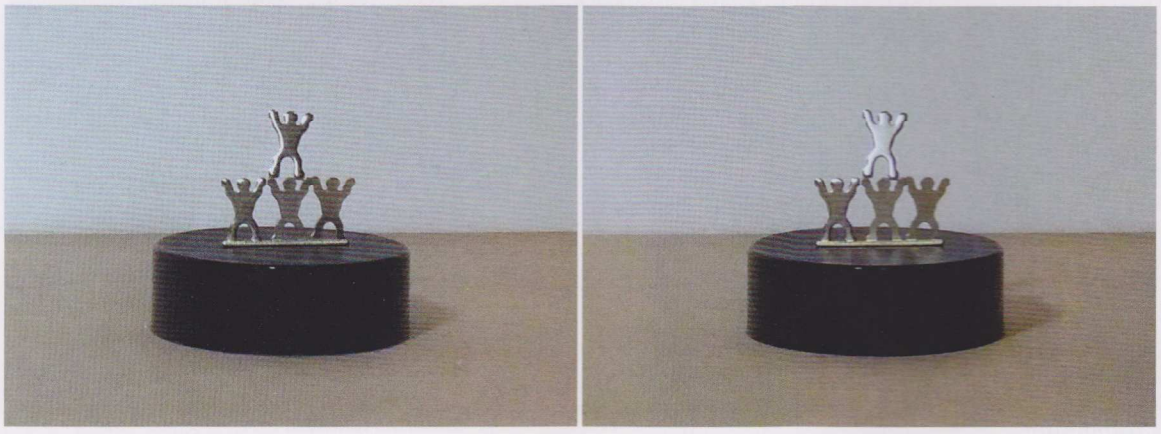
Example D is an outtake from an animated music video I made called "A Geek Like Me." If you look at my mug on the left half of the screen, there's a hard shadow to the right of my body that is visible only in the right eye image. Likewise, there's a hard shadow behind my right shoulder that is only visible with the left eye image. These discrepancies lead to an annoying, flashing effect along those edges.

Keyholing and edge annoyances occur for the same reason—there is too much parallax (horizontal difference between the left and right eyes). However, keyholing and edge annoyances are not the same thing. Keyholing features a hole that provides nothing for the eyes to latch onto. An edge annoyance still allows the viewer to fuse what's behind a particular feature, but has some sort of retinal rivalry along the edge.

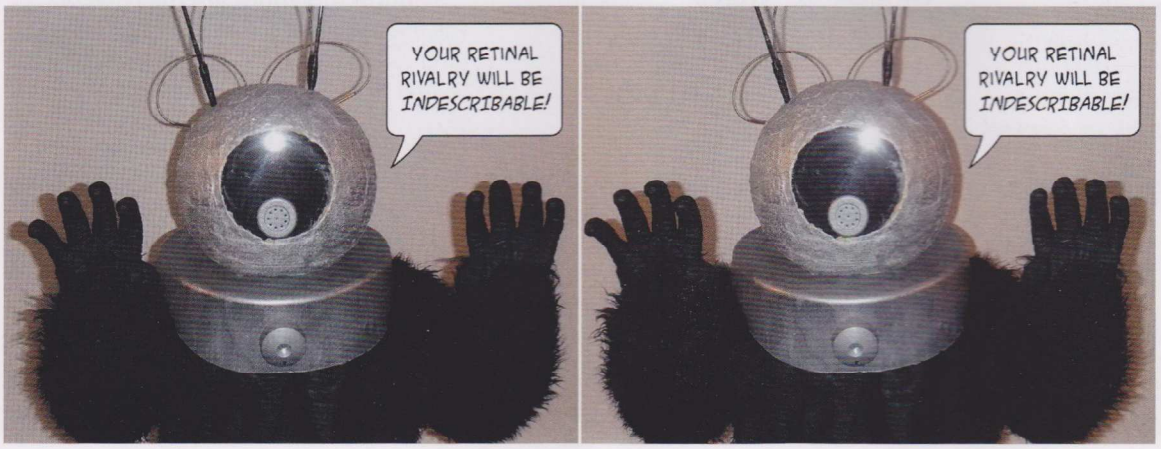
Although edge annoyances happen most frequently with shadows, the chair behind the edge of the door frame in Example A could also be classified as an edge annoyance. It wouldn't be considered keyholing because, despite the partially-visible chair, the viewer's brain can easily fuse the room inside the doorway.

Deadly Retinal Rivalry #4: Anomalous Reflections

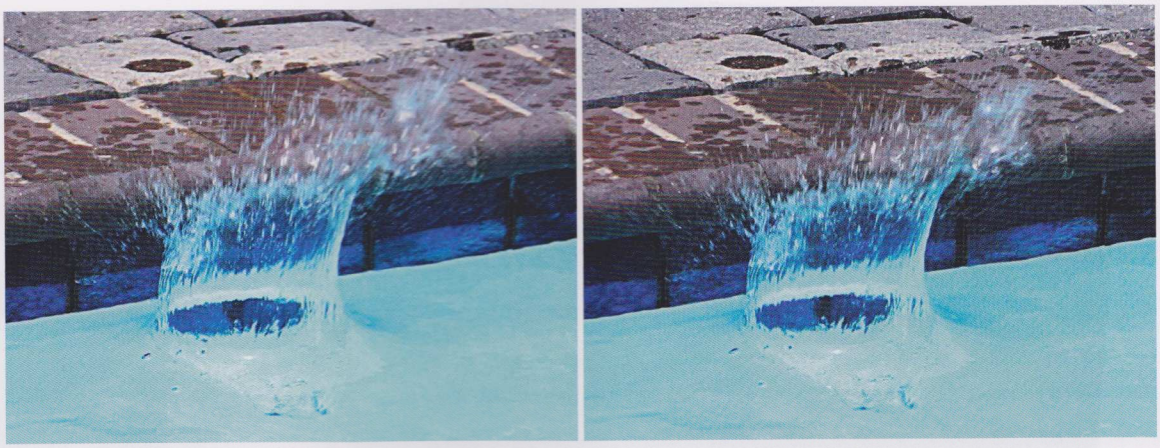
Anomalous reflections are light reflections that look different in each eye. The sparkles from ocean waves are an example of anomalous reflections—almost certainly a pleasant and unobtrusive form of the effect. In other cases, they may be a deadly retinal rivalry to avoid.



Example E.
The flashing effect in the top figure is an example of an anomalous reflection. While the effect can add sparkle to water and snow stereos, it can ruin others.



Example F.
A Fuji W3 camera with its flash on [like any with the flash located directly between the lenses] creates some unpleasant shadow effects in this example of unbalanced light.



Example G. The top part of the splash demonstrates mis-sync, where two cameras have taken their pictures at slightly different instants in time.

Example H. A demonstration of an unobtrusive color shift.

Notice how the light reflects off of the magnetic desk toy in Example E. The top figure has the flashing effect associated with anomalous reflections, while the bottom figures are reflecting light consistently between both eyes. The anomalous reflection effect on the top figure disappears when moving the camera horizontally just a fraction of an inch. In other words, the camera must be in the "sweet spot" to pick up this deadly retinal rivalry.

Anomalous reflections can be more prominent with dark backgrounds, which can emphasize the difference between the angle showing a reflection compared to an angle with no reflection. Christmas tree ornaments can be problematic, but flat jewelry can be worse, picking up dazzling light in one image but blending into clothing or hair in the other.

Deadly Retinal Rivalry #5: Unbalanced Light

If you use a Fuji W3 camera—turn that flash off! Otherwise, you're in serious danger of experiencing a deadly retinal rivalry called *unbalanced light*.

The Fuji W3 is a wonderful camera. However, one of its design compromises was to place the flash between the left and right lenses. That means the left image has the flash hitting the subject from the right, and the right image has the flash hitting the subject from the left. Check out the shadows behind Ro-Man (the title character from the 1953 movie *Robot Monster*) in Example F. There are shadows on the opposite sides of the subject for each eye because the light from the flash is being projected in opposite directions. Even worse cases of unbalanced light can be caused by synchronized dual camera rigs in which two flashes fired.

Deadly Retinal Rivalry #6: Mis-sync

Mis-sync is a deadly retinal rivalry which occurs when the left and right images aren't captured simultaneously while the subject is in motion. Look carefully at the top part of the splash in Example G. Something appears "off" because each eye is looking at the subject at a slightly different instant in time.

If you use a Fuji W3 or another all-in-one 3-D camera, you don't need to worry about this deadly retinal rivalry. Mis-sync can only afflict those who are using a two camera setup.

Deadly Retinal Rivalry #7: Color Shift

If you're using two cameras to shoot stereo pictures and the cameras aren't color balanced with each other, you run the risk of creating a deadly retinal rivalry called *color shift*. It's also possible to capture a color shift when there is unbalanced light. Look at Example H—the left image has a slight reddish tint compared to the right. The color difference between the two pictures doesn't draw attention to itself when viewing the image stereoscopically, so this would be classified as an unobtrusive color shift.

Conclusion

In one of my past lives as a professional audio engineer, when something wasn't recorded or played well, someone would mutter that we could "fix it in the mix." While fixing something "in the mix" was sometimes possible, usually the less time-consuming option (which often achieved a better end result) was to get a good sound or performance at the source.

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All of the seven deadly retinal rivalries can be fixed "in the mix" with programs like StereoPhoto Maker or Photoshop. When you don't have total control over every aspect of a shot, fixing it "in the mix" may be your only option. However, if you suspect that you captured a deadly retinal rivalry, a quicker solution—sometimes—is to nudge the camera horizontally and take a second picture as a safety measure. At the very least, being aware of the different types of retinal rivalry will help you achieve better stereo images when post-processing. The end result will have your audience reaching out to grab your images, rather than reaching over to grab some aspirin.

Thanks

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Jeff Boller is Pittsburgh-based 3-D filmmaker/musician who is creating an animated music video movie called Smitten 3D. And yes, he made his own Ro-Man Halloween costume. You can see and hear his work at www.simplecarnival.com.