Digital Photography School

Photography 101 - Light and the Pinhole Camera

by Neil Creek

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The following post is from Australian photographer Neil Creek who is part of the recently launched Fine Art Photoblog, and is participating in Project 365 - a photo a day for a year - on his blog.

Welcome to the first lesson in ***Photography 101 - A Basic Course on the Camera***. In this series, we cover all the basics of camera design and use. We talk about the 'exposure triangle': shutter speed, aperture and ISO. We talk about focus, depth of field and sharpness, as well as how lenses work, what focal lengths mean and how they put light on the

sensor. We also look at the camera itself, how it works, what all the options mean and how they affect your photos.

This week's lesson is ***Light and the Pinhole Camera***

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About Light

Light is everywhere, even where you can't see it. Without delving too deeply into the mysterious physics of light, there are some basics that are helpful to know as a photographer:

- We only see light when it reflects from something, or we look directly at the source
- Light can be bounced (reflected) or bent (refracted) and always does so in predictable ways
- Reflected light scatters depending on the "smoothness" of the surface
- White light is made up of all of the visible colours
- Different coloured light has different energy levels or "wavelengths"
- Shadows occur when something comes between a light source and another surface
- Light varies hugely in brightness, and our eyes very cleverly adapt to see clearly in a wide variety of brightnesses
- Cameras are far less capable of "seeing" clearly in as wide a variety of lighting conditions

Fig 1.1.1 *Light hitting a textured surface scatters in all directions, like water splashing from a thrown water balloon. Click for clearer version.*

These observations are pretty basic, and most of them are either obvious or should have been taught in the science classroom. As straightforward as they are, these basic points are at the heart of photography, and understanding them is very important. Throughout this course, and through your adventures with the camera, you will be working with some or all of these essential principles of light. If you are unclear about any of the above points, it would be helpful to do a little bit of independent research. You'll find some good links for further reading at the end of today's lesson, and I encourage you to explore further by searching the 'net.

The central point of photography is **turning light into an image**. An image is actually just an illusion. Anything that is a representation in light of a real thing is an image. So how do we turn light, which scatters randomly around the universe into an image that we can recognise?

The Camera Obscura

Fig 1.1.2 - Imagine a typical outdoor scene with the sun shining brightly on a tree. The light from the sun travels in parallel rays, shown here in black. When they hit the tree, the light is scattered in all directions, shown in grey. This is known as "diffuse" light. Because of diffuse light you can see the pretty tree, as some of this scattered light hits your eyes.

Fig 1.1.3 - Now lets imagine we pitch a tent with perfect light blocking material

and a tiny hole in one wall. To keep it simple, a single ray hitting the tree will diffuse in all directions, but only a very tiny sliver of that light will go through the small hole. If you were sitting in this tent in the middle of the floor and you closed one eye and looked through the hole from there, you would only see a very tiny part of the tree at once. If you move to the right a bit, you will see the left of the tree. If you move up, you will see further down the tree. Your view of the tree is opposite to the direction of your movement.

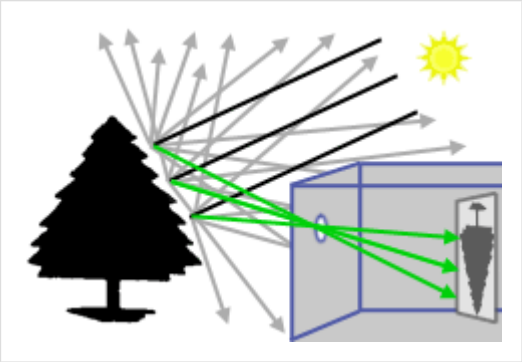

Fig 1.1.4 - Of course there is more than one ray of light hitting the tree. These rays reflect diffusely in all directions. This is why you can see more of the tree by moving around inside the tent. If we were to set up a screen in the tent opposite the hole, which is made of nice bright white material, we would actually be able to see an **image** of the tree, projected onto it! For the reason that we saw parts of the tree in the opposite direction when we moved, the projected image of the tree appears upside down.

The room we just made in our imagination is called a “camera obscura” and you can make one just as I have described. Instead of a tent, you could find a room in your house with one window, and cover the whole window with thick card or foil. Then make a tiny hole (1-5mm) in the cover and look at the opposite wall. You should see a very dim, upside down image of the world outside.

Fig 1.1.5 *A camera obscura made by blocking a window. Photo by brighterorange, used under creative commons.*

The image will be dim because only a small amount of light can pass through the hole. If you make the hole bigger, the image will be brighter, but less sharp. Why is this? A small hole is very good at restricting the direction from which rays of light can enter the room. If the hole is bigger, then more light can get in, but that extra light comes from a bigger range of angles, and it overlaps nearby parts of the projected image.

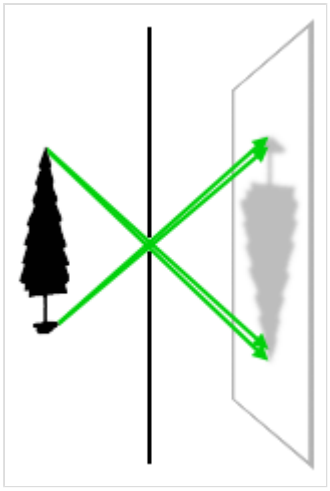

Fig 1.1.6 - A small hole through which the light passes, restricts the possible angles of light reflecting from a certain part of the tree. The overlap of light rays on the projection is very small and the result is a sharp image. The trade-off is that the image is dim.

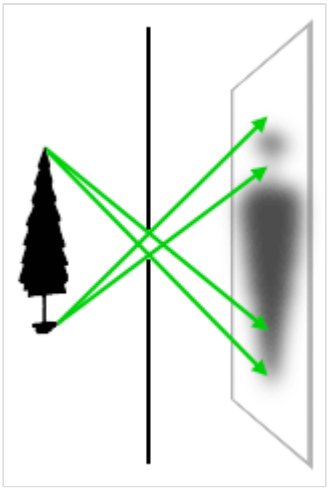

Fig 1.1.7 - A large hole allows a greater variety of angles of reflected light from a particular part of the tree to pass through onto the projection. This means that much light from neighbouring parts of the tree overlap each other. This results in lower contrast and a blurry image. The benefit however, is that more light can get through and the projected image is brighter.

How is it relevant?
The trade-off between sharpness and brightness should be a familiar one to many photographers. The "hole" of the camera obscura is the aperture of a modern camera. When you open up the aperture you let more light into the camera, but the depth of field narrows, and more of the image drops out of focus. We'll talk more about this in a future lesson.

The Pinhole Camera

The camera obscura is a very old idea, first built around 1000AD in what is now Iraq. A variation on the concept is the pinhole camera. This shrinks the room of the camera obscura into a handheld box, and is the simplest possible camera. Pinhole cameras can easily be made of almost anything. All it needs is a light-proof box, something to project the image onto, and a tiny hole. There are countless projects online to make your own pinhole camera, or make a pinhole "lens" for your DSLR. Due to the tiny hole used in these cameras, one advantage is that they have is an enormous depth of field.

Homework

To help you get a feel for the issues discussed in each lesson, I'm going to be assigning some homework. Naturally it's completely voluntary, but you learn by doing, and practical exercises will certainly help you improve your photography. I list a few assignments below, and you are welcome to do any or all of them. Please post links to your completed homework assignments in the comments on this post.

- **Make a camera obscura** - Whether it be a tent or a room of your house, build and photograph a camera obscura in action.
- **Visit a camera obscura** - There are a handful of publicly accessible camera obscuras around the world as tourist attractions. Visit one and take photographs.
- **Make a pinhole camera** - There are many projects online to build pinhole cameras from matchboxes, sardine tins, or various other materials. Make one yourself and share photos you take with it.
- **Make a pinhole attachment for your DSLR** - By drilling hole in a body cap for your DSLR camera, putting some foil over the hole and making a tiny hole in the foil, you can turn any DSLR into a pinhole camera. Show us your modification and photos you took with it. Have a look at my attempt at this.
- **Project the sun** - This technique for viewing a solar eclipse can work all year round. Put a pin hole in a piece of card, and project the sun onto another piece of card. You will be able to see clouds pass in front of the sun, and maybe even observe sunspots. Share photos of your experiments.

Resources

- Specular vs Diffuse Reflection
- Camera obscura on wikipedia
- Pinhole photography on photo.net
- How to make a pinhole Polaroid camera on Make Magazine
- Making a pinhole "lens" for your DSLR
- Pinhole photography group on Flickr

Next Week

Photography 101 - Lenses and Focus.

In addition to posting his Project 365 photos to his blog, Neil also runs a monthly photography project. This month's topic is Iron Chef Photography - The Fork.

Read more from our Photography Tips for Beginners Category