

HOW TO SEE IT BOTH WAYS

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YOUNG REVIEWERS:



CAMILA

AGE: 11



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AGE: 13

When you see something, how do you figure out what it is? It might seem like you “just know”, but your brain uses two methods to help you know what you are seeing. One method is called bottom-up processing. In this method, the brain uses the shapes and colors seen by your eyes to figure out what something is. The other method is called top-down processing, which uses experiences, memories, or expectations to figure out what you are seeing. These processes happen at the same time in different parts of the brain. This article will explain how the brain’s top-down and bottom-up expectations can change what you see, and we include special pictures so you can experience it yourself.

INTRODUCTION

What do you see when you look at [Figure 1](#)? Is it a rabbit? Or is it a duck? Can you see it both ways? Most people see this picture as either a duck or a rabbit. First, they see it one way, but then they can see it the other way, even though they are still looking at the same picture! This

AMBIGUOUS FIGURE

A picture that does not change but can look like different things at different times, depending on how the person sees it.

Figure 1

This picture can be seen as either a duck or a rabbit. The two long parts on the left side can either look like long ears on a rabbit's head, or like a beak on a duck's head (image source: Wikimedia Commons).

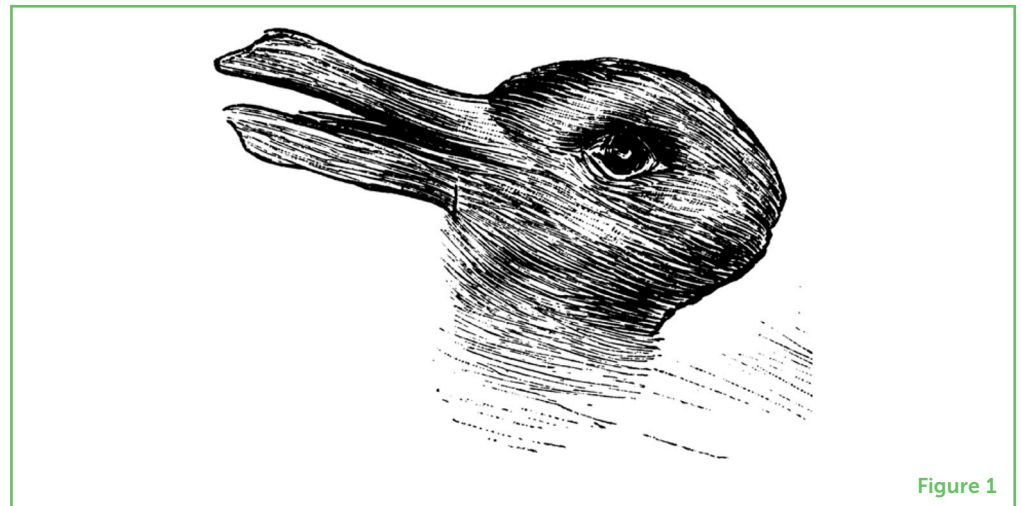


Figure 1

BOTTOM-UP PROCESSING

When your brain uses information from the senses to try to figure something out.

SENSATION

The information our brains get from our five senses: touch, taste, sight, smell, or hearing.

VISUAL CORTEX

The area of the brain at the back of the head that helps you see and understand what your eyes are looking at.

is a special type of picture that can trick a part of the brain that helps you figure out what you are seeing. Pictures like this, which can be seen in more than one way, are called **ambiguous figures**. Ambiguous figures helped scientists understand how the brain knows what regular everyday objects are. For example, when you see something ordinary, like a flower, it might seem like you “just know” what it is. In reality, your brain uses two separate methods to help you recognize what you see [1]. The brain is so good at this that you usually do not even know that two methods are playing a role.

WHAT YOUR EYES SEE

How do you know a flower when you see one? The first step involves using your senses to identify it, which is called **bottom-up processing**. When you look at a flower like the one in [Figure 2](#), your eyes take in light to see colors and lines and shapes (this process is remarkably complex, and you can read more about it [here](#)). If you sniff the flower with your nose, you might smell a nice scent. If you touch it with your fingers, it might feel smooth. Humans typically have five primary senses with which to experience the world: sight, smell, touch, hearing, and taste. When the brain gets information from one or more of these five senses, we call that a **sensation**. The color you see is determined by the type of light entering your eyes. The type of light on the leaves and stem is interpreted by the brain as the color green, while the type of light on the petals is interpreted as red. This is called bottom-up processing because the very basic information from the senses is sent *up* to the brain. For vision, this sensory information is first processed in the **visual cortex** at the back of the head. The visual cortex receives and organizes all the sensation information about color, shape, lines, movements, and more in a fraction of a second [2]. If the image of the flower were a puzzle, the visual cortex is the part of the brain that notices the pieces. It does not put those pieces

together to identify the flower, though. That happens in a different part of the brain.

Figure 2

When you see a flower, light bounces off it and enters your eyes. The information is sent to the visual cortex (yellow) and is called bottom-up processing, since information is sent “up” from the senses to the brain. The prefrontal cortex (purple) helps you recognize the flower, too. This brain area uses what you already know about flowers to help you figure out what you are seeing. This is called top-down processing (image by Chris Zappe).

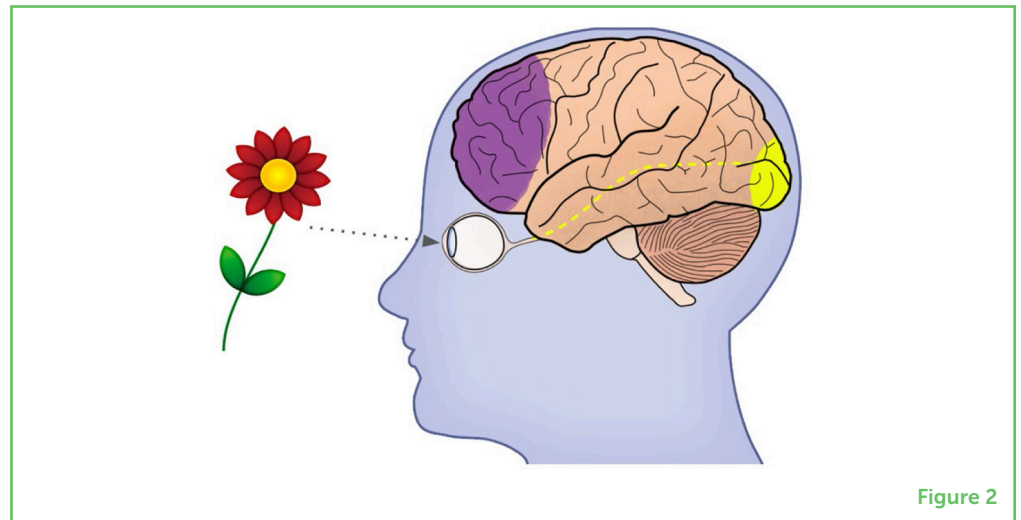


Figure 2

TOP-DOWN PROCESSING

When your brain uses what it already knows to figure something out. For example, your brain might use context to influence how you see information from your senses.

PREFRONTAL CORTEX

The area of the brain behind the forehead that helps with higher-level functions such as planning, making decisions, and problem solving.

WHAT YOUR BRAIN THINKS YOU SEE

Just having sensations is not always enough to figure out what something is. We see with our eyes, but we also see with *more* than just our eyes. You have probably never seen a flower that looks exactly like the one in [Figure 2](#), but you probably still know that it is a flower. When you look at it, you also use your experience with other flowers you have seen and the things you know about them. For example, you know that flowers are plants, and that they usually have green leaves and colored petals. When your brain uses what you already know to help you figure out what you are seeing, this is called **top-down processing** [1]. It is called top-down because it uses ideas and memories from your brain to help you figure out what you are sensing. Although your visual cortex is working with the sensation from your eyes, a different brain area, called the **prefrontal cortex**, gives you the top-down type of information about what you are seeing [3]. While your visual cortex is viewing an image with green lines and colored ovals around a circle, the prefrontal cortex can “remind” you that flowers have long green stems and colorful petals bunched together, helping you to decide that the image is probably a flower.

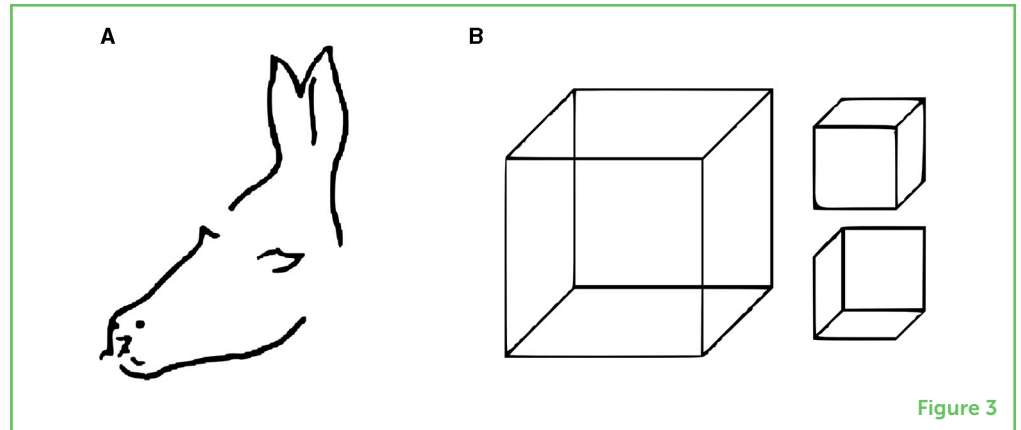
Both top-down and bottom-up processes happen at the same time to help your brain figure out what it is seeing. The two brain areas interact in a back-and-forth “conversation” until the brain decides what the image is. The brain can use these processes together to identify an image in as little as 13 ms [2]. That is very fast! It takes more than 150 ms just to blink the eye.

TRY IT!

To help you experience top-down and bottom-up processing for yourself, look at the ambiguous figure in [Figure 3A](#).

Figure 3

(A) The seal-donkey picture can be seen as either a swimming seal with flippers at the top or a donkey with ears at the top. **(B)** The Necker cube is an ambiguous figure that can be seen as pointing in two different directions. The two smaller cubes on the right show the two ways the Necker cube can be seen (image credit: Marina C. Wimmer).



Can you see an animal? The bottom-up processing from your eyes tells the brain that there are black lines against a white background. The top-down processing from your brain helps you figure out what the shape means. If you only had bottom-up processes, you would only see lines and no animals. But your top-down processing can help you identify it as an animal. But what animal? First, imagine that someone told you it is a picture of something you might see at an aquarium or at the beach. Now look again at the picture. When you expect to see something from an aquarium, you might see the image as a seal. Now, imagine someone said it is a picture of a farm animal. Look again at the picture with the idea of a farm animal in mind. With this expectation, your top-down processing might think it looks like a donkey. Nothing about the picture changed to make you see it as either a seal or a donkey. The only thing that changed was your top-down expectations!

[Figure 3B](#) is a simple ambiguous figure called a Necker cube. It shows a cube, but which way is it facing? There are two directions that you can see the cube pointing. Can you see it both ways shown in the smaller cubes? Can you change the way you see it on purpose? Try to challenge yourself to use your top-down process to change the way you see the lines.

Lastly, look at the duck-rabbit picture again ([Figure 1](#)). One scientific study [4] showed this picture to people at different times of the year, to see if holidays might influence their top-down processes. First, they showed the picture to people right before Easter—a holiday in the spring often associated with lots of pictures of rabbits. The scientists wondered if people who recently saw Easter bunnies as part of local celebrations would be more likely to see this ambiguous figure as a rabbit first. The researchers learned that the people who looked at the ambiguous duck-rabbit figure around Easter time most often saw

a rabbit at first. Then the scientists showed the picture to people in October, which is when ducks migrate nearby. Those people said they saw a duck at first.

HOW DO YOU SEE THINGS?

Now that you know about top-down and bottom-up processing, can you explain why people saw a rabbit near Easter time but a duck in October, even though they were looking at the same picture? Was it bottom-up or top-down processing that made it look different?

We think it is amazing that people can look at the same picture but see it in different ways because of their top-down expectations. Other people might look at the very same picture you are looking at, but still see it differently than you see it. On a larger scale, we can also “see” the world differently from others when we have different opinions, different beliefs, or grow up in different cultures. Knowing about such differences in how we “see” things can help us be more understanding when people see or react to things differently than we do.

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YOUNG REVIEWERS

CAMILA, AGE: 11

My name is Camila and I am 11 years old. I am in my last year of primary school and the subject I like the most is science and mathematics, but also social sciences. I really like swimming because when I am in the water I think about my things, I remember and review what I have learned and I have a lot of fun. I play the Spanish guitar and I really like to travel.

MIRIAM, AGE: 13

Hi, I am Miriam, I am 13 years old and I live in Madrid. I really like biology and mathematics. I love to learn about the human body! I am very entertained doing mathematical operations. I also love to hang out with my friends, watch scary movies and cook.

AUTHORS

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Ashley Zappe completed her M.A. in experimental psychology at New Mexico State University. Her research explores how our brains make decisions in social contexts. She enjoys reading very old books, hiking, teaching kids which wild plants are edible, and thinking about thinking. *ashleyz@nmsu.edu

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