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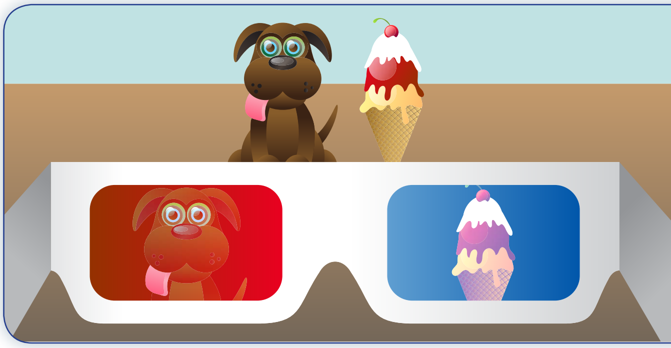

Now you see it, now you don't: interacting with invisible objects

Apoorva Rajiv Madipakkam, Karin Ludwig, Marcus Rothkirch, Guido Hesselmann

Visual Perception Laboratory, Department of Psychiatry and Psychotherapy, Campus Charité Mitte, Charité Universitätsmedizin, Berlin, Germany

Reviewed by:

Daren
13 years old

What do you do when you are playing in the park on a hot day and your parents offer you an ice cream? Most probably, you go running to them, keep your eyes on the delicious ice cream cone, and reach out to take it from them. Although this feels like the most natural thing to do, it requires the fine coordination of your different sense organs and movements. You need your eyes (sense of vision) to look at the ice cream, your arms to reach out (motor system), and your hands (sense of touch) to hold it firmly. It seems obvious that in order to be able to reach out and grasp something, we need to first be able to see it and know where it is. Surprisingly, this is not always true.

There are some people who cannot see even with their eyes open. Although these people are blind, there is nothing wrong with the eyes themselves. Instead, there has been an injury to the part of the brain that helps them see: the ***visual cortex*** (this and all other words printed in bold font are explained in the Section "Glossary" at the end of this text). What is fascinating is that even though they cannot see, some of these people can reach out and grasp for an object correctly more often than if they were just guessing where the object was. Even more fascinating is an experiment showing that a person with this type of blindness can find his way down a long corridor and correctly avoid the obstacles placed along the path without using any help like a cane [1]. It seems as if these people are able to sense the objects that are invisible to them. Medically, this phenomenon is called "***blindsight***" [2].

This means that some people with an impaired sense of vision can sometimes "act" as if they were actually seeing the things around them, like a sighted person. How is that possible? The accepted theory is that the brain of these blind people has found ways to process information about objects even though these objects are invisible to the person. This remarkable ability of the human brain has led scientists to question whether healthy people with normal vision can also react to and "interact" with objects that they cannot see, i.e., that they are not aware of.

The important question is how do we make things invisible to people who have normal eyesight? Normally, our left and right eyes see almost the same thing (as long as we have both eyes open of course). Our two eyes take in the same image, send this information to the brain, and the brain processes the information so that we can see the image. But we can also separate what the two eyes see and make them see different things, for example, by using special glasses which are shown in Figure 1. What do you think would happen if you saw a dog with your left eye and an ice cream with your right eye? Well, you may think that we see a mixture of the two, i.e., half ice cream and half dog. Surprisingly, we do not! What we do see is the image of the ice cream and dog switching back and forth. This is called ***binocular rivalry*** because the two ("bi") different inputs to the eyes ("ocular") compete (or, "rival") for dominance (to be the image we finally see).

Using a method called continuous flash suppression (CFS), which is based on the same principle as binocular rivalry, we can make objects invisible to people who have normal vision. In the CFS method, one eye is presented with the image of interest, also called the target, while at the same time the other eye is made to see colorful, flickering patterns. So using the same example as above, one eye is shown the image of an ice cream and the other eye is now shown colorful, flickering patterns instead of the dog. In such a situation, because the colorful patterns are flickering compared to the static ice cream, what we finally see (most of the time) are the colorful, changing patterns (i.e., the dominant image).

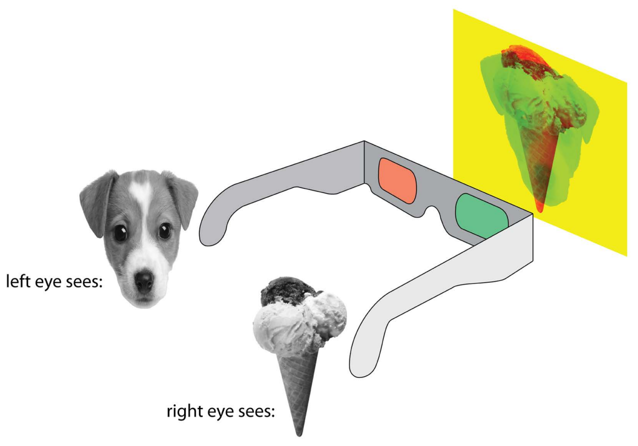

FIGURE 1 - There are many ways to show two different images to the two eyes so that the left and right eyes see different things.
Here, we use red-green glasses (also called anaglyph glasses). For this method, one needs to make one image green (here the dog) and one image red (here the ice cream) and mix those images. This you can see on the right hand side of the figure. If you then view this image through the glasses, the red transparent paper (here: left eye) filters the light so that the red image (the ice cream) cannot reach the left eye. The green transparent paper (here: right eye) filters the light so that the green image (the dog) cannot reach the right eye. This is why your left eye sees the dog and your right eye sees the ice cream.

Which image is dominant (the flickering masks or the ice cream) also depends on our ***eye dominance***. But remember; the target image (the ice cream in our example) is actually shown to one eye and this eye and also parts of the brain are still receiving the information of the ice cream. It is just rendered invisible by the masks so that we are not consciously aware of it. This technique can be used by scientists to make things invisible for up to many seconds [3] and help them study the processing of information in healthy subjects, who can otherwise see normally, before they become aware of the information itself.

How is CFS related to the phenomenon of "blindsight" that we mentioned above? Remember that CFS is a technique and blindsight is a phenomenon. Blindsight was originally observed in patients with damage to the visual cortex. In order to study whether blindsight also occurs in people without brain damage, techniques are needed to make stimuli invisible for them. One such technique is CFS. Most importantly, however, objects made invisible by CFS can still be processed by the intact visual cortex and can at some point become visible. Objects presented to a patient with blindsight will remain invisible because the visual cortex is damaged.

You can try the method of CFS out for yourself using Figure 2 and a pair of red-green glasses. You can make your very own red-green glasses using cardstock paper, a pair of scissors, and red and green transparent paper. All you have to do is draw the picture of your glasses (big enough to fit on your face) onto the cardstock paper, cut it out, and make two holes for the eyes. Stick the red transparent paper onto one eye hole and the green transparent paper on

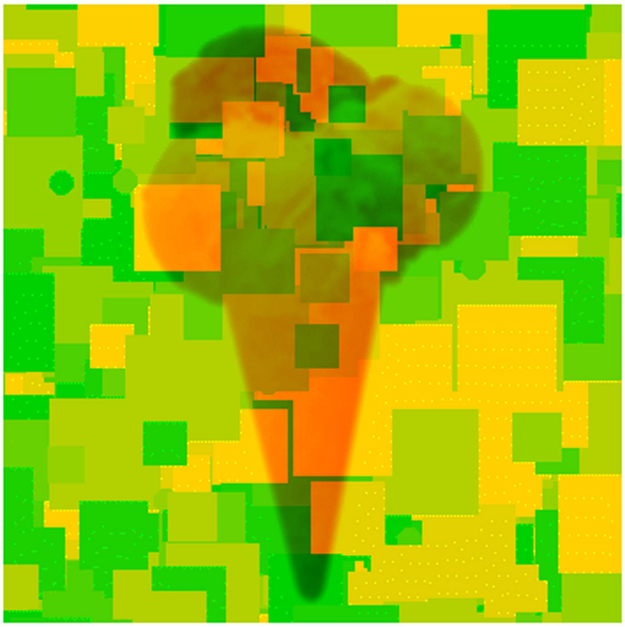

FIGURE 2 - An illustration of how the continuous flash suppression method works.
What can you see in the picture when you wear your special glasses? (It may take a few moments to notice something beyond the flickering masks. If you still see only flickering masks after a few minutes, then try closing your right eye to see the hidden object). Note: to be able to truly appreciate this demo and for it to work as intended, the image should be viewed on a computer or a device that can display the animated gif. The little rectangles and circles should move around. Click the image to view it online.

the other eye hole like in Figure 1 and you have your special glasses.

Now that we have a method to make things invisible to people with normal, healthy vision; we can study whether they can still process and react to this invisible image that is hidden behind the flickering masks. In one experiment, we used a video camera to record volunteers' eye movements while they searched for an invisible pattern. An interesting fact about our visual system is that our eyes make several scanning movements (also called ***saccades***) each second. Can you guess what we observed when our volunteers had to search for the invisible pattern?

Amazingly, we found that although the volunteers said that they could not see the pattern and could not even guess where it was, their eye movements were more often directed to the place where the pattern was [4]! Somehow, even though the pattern was invisible to the volunteers, they seem to have been able to use the information. So from this experiment, there is evidence that healthy humans can process some information without complete awareness of it. But can we also grasp for an object that is invisible to us like people with blindsight can sometimes do, as we have learned above?

In another set of experiments, CFS was used to make objects invisible and volunteers were asked to grasp these invisible objects. While one group of scientists could show that people were able to reach out for invisible objects (although they were not nearly as good as when they saw them) [5], we found that healthy people could not correctly grasp invisible objects [6].

What do these findings tell us? Well, first of all, that not all experiments in science give you the same result. The way in which an experiment is carried out plays a huge role. Sometimes even small changes in experimental setups can have large impacts on your results, and part of what scientists do is to try and explain these differences. It also tells us that science is a field where people talk about their new findings, and that even if the outcome of the experiment is different from what you expected, you have learned something new. The field of studying the processing of invisible information in healthy people is vast and there is so much to be discovered. Thus, although we have come a long way and know quite a bit about the processing of invisible information in healthy people, we do not know (yet) if we can grasp for that ice cream we cannot see. Finally, in order to establish a concept in science so that you can read about it in your textbook, it has to be supported over and over again by the work of several different research groups. And who knows, even after all that, you can come up with a new theory that you can test with your own experiment.

GLOSSARY

Blindsight: Made up of two opposites, "blind" and "sight," blindsight refers to the strange but fascinating phenomenon in patients who are"blind" because they claim they cannot see the world around them, but at the same time have "sight" because they are still able to correctly identify the location of some objects or move out of the way of obstacles that are invisible to them. Patients with blindsight have damaged part of the brain that helps them see, the visual cortex. Studying blindsight allows researchers to investigate what processes in the brain are necessary for us to be conscious or aware of what we see.

Eye dominance: Humans have two eyes and, just like we are either left-handed or right-handed, we are either left-eyed or right-eyed (although you do not have to be right-eyed if you are right-handed). This means that one of our eyes grows to be stronger than the other so that even when we have both eyes open, the picture of the world taken in by this "stronger" or dominant eye is treated as more important than the other "weaker" eye. Now this difference in the strengths of our eyes is not noticeable and does not matter usually, since our left and right eyes are seeing almost the same thing. But we begin to notice it when we separate what each eye sees like in our experiment above. So, for example, if your dominant (stronger) eye sees the flashing masks and the non-dominant (the other eye) sees the ice cream, it will take longer for the ice cream to finally become visible because the information coming from the dominant eye (the masks) is what is preferentially processed by the brain. Slowly, after some time, the brain begins to process the information coming from the other eye and this is when we finally see the delicious ice cream! If, on the other hand, you wear the glasses such that your stronger eye sees the ice cream and the weaker eye the masks, the ice cream might never be completely invisible to you.

Find your dominant eye: Here is a simple experiment for you to find out which one of your eyes is the dominant one. Make a circle with your thumb and forefinger and focus on an object on the wall or in the distance. Look at the object with both eyes open and center it inside the circle. Now, look at the object closing first only the left and then only the right eye. If the object jumps outside the circle when you close your left eye, you are left eye dominant. If the object jumps when you close your right eye, you are right-eye dominant.

Binocular rivalry: Binocular rivalry is a phenomenon that occurs when your eyes are made to see different images. In Figure 1, for example, the left eye is made to see a dog and the right eye is made to see the ice cream. This results in us seeing sometimes the one, sometimes the other image. The term comes from the two ("bi") different inputs to the eyes ("ocular") that compete (or, "rival") to be the image we finally see.

Saccades: Saccades are very fast movements that the eyes make. While you are reading this text, your eyes jump from word to word: these jumps are the saccades. We make several saccades every second. But most of these movements are made without us noticing and are directed toward objects that catch our attention.

Visual cortex: The visual cortex is the part of the brain that receives and processes information that is sent from the eyes. It is – among other parts – responsible for our ability to see the things around us.

Visual system: The visual system consists of the eyes, the optic nerve, as well as several parts of the brain that work together to process visual details. It helps to form a picture of the world by using the information that reaches us via our eyes.

REFERENCES

1. De Gelder, B., Tamietto, M., van Boxtel, G., Goebel, R., Sahraie, A. van den Stock, J., et al. 2008. Intact navigation skills after bilateral

loss of striate cortex. *Curr. Biol.* 18(24):R1128–9. doi: 10.1016/j.cub.2008.11.002

2. Stoerig, P., and Cowey, A. 2007. Blindsight. *Curr. Biol.* 17(19):R822–4. doi: 10.1016/j.cub.2007.07.016

3. Sterzer, P., Stein, T., Ludwig, K., Rothkirch, M., and Hesselmann, G. 2014. Neural processing of visual information under interocular suppression: a critical review. *Front. Psychol.* 5:453. doi: 10.3389/fpsyg.2014.00453

4. Rothkirch, M., Stein, T., Sekutowicz, M., and Sterzer, P. 2012. A direct oculomotor correlate of unconscious visual processing. *Curr. Biol.* 22(13):R514–5. doi: 10.1016/j.cub.2012.04.046

5. Roseboom, W., and Arnold, D. H. 2011. Learning to reach for 'invisible' visual input. *Curr. Biol.* 21(13):R493–4. doi: 10.1016/j.cub.2011.05.036

6. Ludwig, K., Sterzer, P., Kathmann, N., Franz, V. H., and Hesselmann, G. 2013. Learning to detect but not to grasp suppressed visual stimuli. *Neuropsychologia* 51(13):2930–8. doi: 10.1016/j.neuropsychologia.2013.09.035

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REVIEWED BY:

Daren, 13 years old

Daren is a 13-year-old, seventh grader from an academic family (his grandfather is a neurophysiologist and his mom has a Ph.D. in electrical engineering). He enjoys science, video games, playing the guitar, and doing Tae-Kwan-Do as a first degree black belt. He is also a double-bass player, sailor, fencer, and writer. He was inspired by his grandfather to enter the area of science.

AUTHORS

Apoorva Rajiv Madipakkam

I am interested in how the brain processes unconscious social information like eye gaze. I want to understand what happens in the brain of people who struggle to process such information. Outside of the lab I love swimming and basically any kind of sport as well as baking.

Karin Ludwig

Since I was given a book about visual illusions as a child, I have been interested in how we see the world around us. Now, my research focuses on how visual information is processed in our brain so that it leads to a conscious visual experience in the end. Besides research, I love travelling, skiing, singing in a choir, and reading.

Marcus Rothkirch

I am a psychologist and am interested in finding out what motivates people to behave in a certain way. I am particularly curious about human behavior when people are unconscious to the objects causing their particular behavior (for example, an invisible dollar note). For my research, I use methods like brain imaging and eyetracking.

Guido Hesselmann

I am a psychologist with a focus on cognitive neuroscience and visual perception. Ever since I learned about the "attentional blink" phenomenon from my doctoral advisor at university, I have been fascinated by conscious and nonconscious vision. When I am not doing science, I like riding and fixing my bikes.