Sight and brain: an introduction to the visually misleading images

Daniele Murra, Paolo Di Lazzaro

ENEA, UTAPRAD Research Center of Frascati, via Enrico Fermi 45, 00044 Frascati (Rome, Italy)
daniele.murra@enea.it

Abstract
The visual perception of the reality is a complex process involving eyes and brain. The result of this process is an individual response to the external stimulus which, in some cases, can differ person-to-person and, most important, can give a false representation of the reality. In this paper we discuss some aspects of the visual perception, focusing our attention to shapes and colors recognition. We also present a brief introduction to the physiology of the vision and a discussion about the potentially misleading use of the modern techniques for elaborating images. The link beteween the visual perception and the acheiropoietos images is commented.

Keywords: visual perception, optical illusions, image processing, pareidolia

1. INTRODUCTION

The visual perception is a very complex process which mainly involves the eye and the brain. The former behaves as an electronic device that collects the data while the latter elaborates the information.

The result of this process is what we call "perception" and it is a subjective sensation, which can be different person-to-person.

Sometimes, the aspect of many images can be modified by our brain, depending on many reasons linked to the internal mechanisms of our mind. The state of mind, the past experience, the particular context in which the object is inserted act as a filter that transforms the objective image in a personal sensation.

In this paper, starting from a brief introduction on the basics of the human vision, we demonstrate how much is easy to be deceived by our senses thus achieving a wrong or, at least, a debatable conclusion.

2. THE HUMAN VISION

The eye is the main organ of sight. It takes light from an external subject and sends electrical pulses to the brain [1].

The human eye is an excellent detector, and in spite of the impressive development of the electronic technology, it is still largely better than the most advanced CCD cameras available today [2].

The active region of the eye is the retina, a membrane that lies on its back and where the crystalline lens let the light rays converge to form an image. Unlike electronic devices, where there are three detectors per pixel (one for each primary color), on the retina there are two distinct detectors, namely the cones and the rods.

The cones are sensitive to the colors and they are subdivided into three categories (red-, green- and blue-sensitive) similarly to the electronic pixel. On the contrary, the rods are sensitive only to the luminance and they are particularly active to low levels of light. So, the cones are responsible for the day-light vision (and they distinguish colors), while the rods are responsible for the vision in the darkness (and they distinguish shapes).

Figure 1 shows the section of a human eye and an electron microscope image of the retina, where cones and rods are well visible.

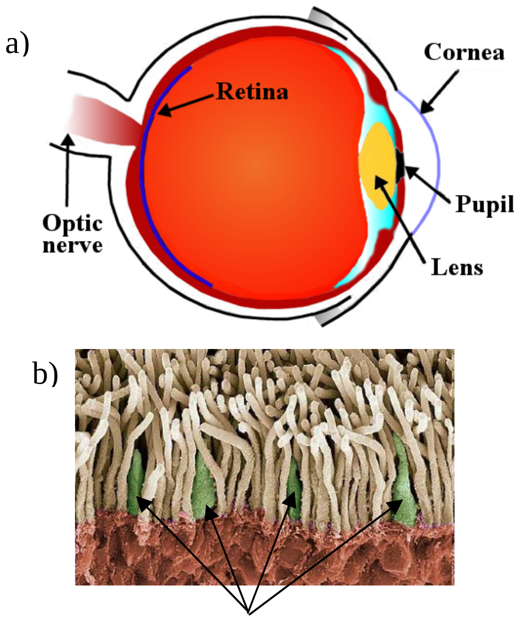

Figure 1. a) Schematic of the section of the human eye.
b) A scanning microscope photo of the retina, where the rods (thin and long) and the cones (thicker and shorter, marked by arrows) are visible.

The cones are concentrated in the central region and their number is about 5-6 millions, while the rods are distributed around the peripheral region and their number is greater than 100 millions.

A so large number of micro-detectors and the mechanical movement of the iris allow us to adapt our vision within a very broad range of light levels. The "*dynamic contrast*", that is the ability to distinguish different luminosity levels, is of the order of some millions to one. As a consequence, we are able to recognize the objects in a dark room illuminated by a single candle (an illumination level of about 0.001 lux) and we can perfectly see in a sunshine day (up to 100,000 lux).

On the contrary, when the light level is fixed, our ability decreases down to a few hundreds to one. In this case we speak of "*static contrast*" and in Section 4 we will discuss the consequences of the limited static contrast.

Despite the eye is an almost perfect detecting system, and the information sent to the brain are the result of a physical-chemical process, the data given by the eyes and elaborated by the brain do not always correspond to the object seen.

In particular, both the shape and the colors of an object are elaborated by the brain, filtered by the experience, and the integral outcome of this process, that is the perception, may give a misleading result.

3. THE PERCEPTION OF SHAPES AND COLORS

There are several sources of errors that can lead to a wrong perception of the shapes. Some of these errors are unexplainable, and they are probably due to a wrong mechanism of the image elaboration caused by the elements surrounding the subject. Figure 2 shows two examples of wrong perception of the reality.

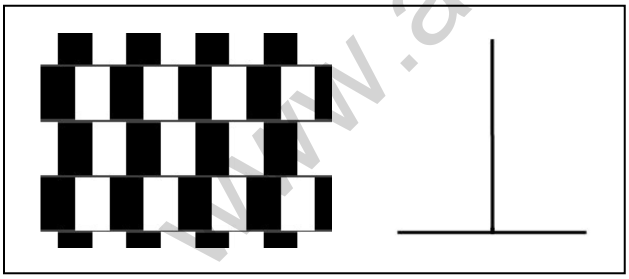

Figure 2. On the left, the horizontal lines are parallel, but we have the impression. that they are converging and diverging. Source: [3]. On the right the horizontal and the vertical lines have the same length, but we perceive that the vertical line is much longer than the horizontal one.

The experience is another element that influences the perception. A typical situation happens when we are in front of a paint with a strong perspective effect: we are able to describe the bi-dimensional scene as if it was in three dimensions because we are familiar with the concept of perspective. So, we understand that e.g., some people are short because they lie at a larger distance from the observer than the tall ones. But if children or aboriginals (who are unaware of the perspective rules) examine the same image they would reach a different conclusion: in their view, short people are just short people, not more distant persons [4].

Figure 3 shows an example of the strong impact of experience on to the "reconstruction" of a scene with some missing parts. What do you see in fig. 3?

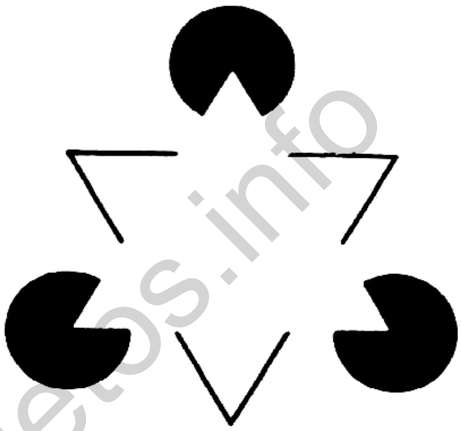

Figure 3. This drawing demonstrates the principles of the Gestalt theory. We see this picture as an ensemble of geometrical figures (circles and triangles), reconstructing the contours of some shapes, in particular of the (not existing) white triangle. Source: [5].

Probably your answer could be: "A white triangle above the black contour of another white triangle, and three black circles". It would be unlikely someone giving the correct description, that is a set of three circles with a missing portion and three couples of segments!

This happens because the presence of a boundary is not essential for the perception of the shape. So, our brain chooses the "best" interpretation of the data coming from the eyes, following one of the principles of the Gestalt theory [6]. According to this theory, the visual perception is not a simple sum of the elements seen by the subject, but it is the result of the relations among the detected objects.

Not only the shape may be perceived in a wrong (or subjective) way: also colors reveal an impressive limit of our eye-brain system. What we see as a definite color, in fact, is the consequence of the comparison between the observed object and its frame. Figure 4 shows two identical gray-level objects that appear different just because they are surrounded by different contexts.

So far we tried to demonstrate that we may have a wrong perception of the reality, but the error sources are independent of our will, and what is more important, the response of our eye-brain system to an image is almost the same for all the humans having similar experiences. When this happens we normally consider it is an optical illusion. In other cases, the interpretation of an image becomes more subjective and the next section describes how the modern computing techniques can introduce a misleading element.

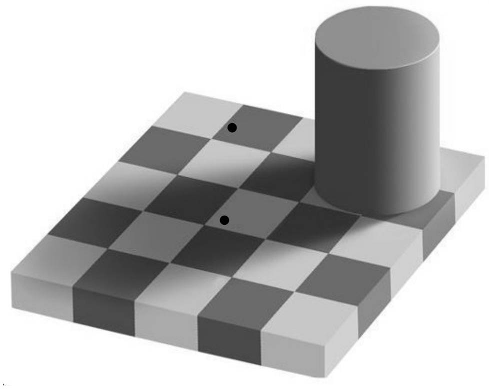

Figure 4. An amazing misleading interpretation concerning colors. It is hard to admit the two squares marked by the black dots have the same gray level. To convince us it is necessary to cover all the surrounding picture and to observe only the marked squares, using, e.g., a screen with two holes. Source: [7].

4. IMAGE PROCESSING TECHNIQUES AND ACHEIROPOIETOS IMAGES

As discussed in section 2, the human eye has a very high dynamic contrast, but a limited static contrast. This means that, at a fixed light level, we can distinguish differences in terms of brightness only in a range of about 1 to 100. An image seen on the computer monitor may hide many details that we can see only if we adjust the brightness/contrast level. In this case, it is hard to establish if the original image has or has not embedded the information that we can reveal only by manipulating it. Probably this is a philosophical doubt rather a scientific argument but, in the case of acheiropoietos images, the possibility to disclose some hidden signs may have crucial consequences.

Also the use of other software skills, as, for example, the boundary detection or the texture removal, may lead to a moot point.

The examples shown in figures 5a-5d may help to understand that it is relatively easy to achieve a result which is completely alien to the original image.

Figure 5a shows the photo of hands detail of the Turin Shroud framed with very high resolution by the STURP photographer B. Schwortz. At a first glance we cannot see any trace of particular importance, except for the hands image and the blood stains. Figure 5b is a zoomed region of fig. 5a where, again, only some darker details can be noticed. By adjusting the brightness/contrast setting and using some processing filters, some signs come out from the background. The last (and the potentially most dangerous) operation is the interpretation of these signs. Figure 5d represents the (personal) reconstruction of the hidden writing. Obviously, this writing has no meaning, but it demonstrates that the results of image processing techniques should be very carefully weighed up.

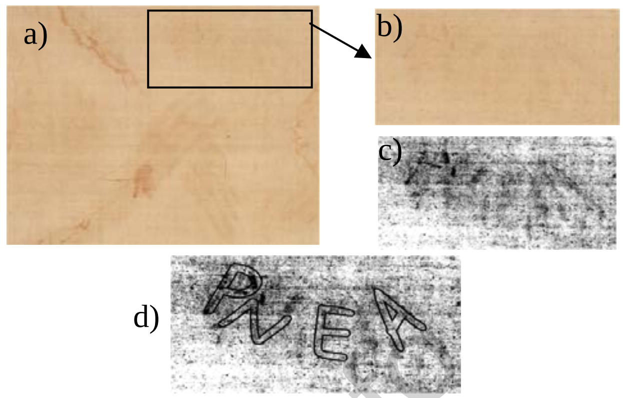

Figure 5. A trial to let appear a writing on the Shroud that does not exist. Although the photo does not seem to hide anything, by using a image processing software it is possible to make visible some letters.
a) Original photo of a particular of the Turin Shroud.
b) Detail of a)
c) What happens after applying some software filters.
d) The "interpretation" of the hidden written.

The "ability" to recognize particular writings or familiar shapes can be referred to a phenomenon called "pareidolia" [8]. A common example is represented by clouds shapes reminding animals, objects, or faces. Generally, we are able to distinguish between a genuine image and what is arising from an subjective sensation. But as in the case of some optical illusions, the state of mind may induce a sort of "I think, I see".

Figure 6 is a surprising example of this phenomenon [9]. The old photograph represents a family with a man, a woman and a child. But, at a first glance, the profile of a human face is well visible, similar to the Jesus profile depicted according to the classical iconography. In order to agree that this is a false interpretation, or better, it is a pareidolia effect, it is necessary to recognize that what we believe is a face profile, in reality is a child with a white hat sitting on the knees of the man.

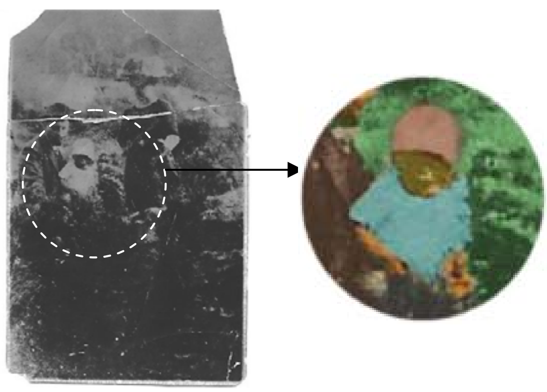

Figure 6. An example of pareidolia. On the left: the original photo (taken from the web), where the profile of Jesus seems to appear. On the right: the detail of the photo (artificially colored) where a child with a white hat can be recognized.

Of course, this is just a remarkable pareidolia example, but it may help to be aware that, although the information given by our eyes are objectively right, the elaboration made by our brain may lead to a wrong result. Our mind tends to see what it expects and/or wants to see.

Clearly, when the pareidolia phenomenon regards a cloud whose shape is similar to a horse, we are aware that it is only a figment of our imagination. But when we are looking to an image like that in fig. 6, probably we are not sure that it is just an interpretation mistake and not the result of a paranormal mystery [9].

The figures 2 to 6 discussed above are just few selected examples of optical illusions and pareidolia. Interested readers should know that Internet is an amazing source of optical illusions [10] and of pareidolia images [11].

5. CONCLUSION

When observing an object, we trigger a complex process involving our eyes-brain system. The result of this process is what we call “perception”. The perception is individual, and in some cases, it is highly subjective. Even when the answer to a stimulus is the same for almost all people, we cannot be sure that our perception is correct, like in the cases shown in figures 2, 3, 4 and 6.

Moreover, it is likely the perception process can be strongly influenced when external events, past experiences or personal beliefs are linked to the phenomenon we are observing. Our mind tries to make sense out of any "patterns" our eye can see, see fig. 5.

We should consider this “subjectivity risk” when using computer tools to elaborate images, because we may generally have the propensity to make visible something that we want to see but that is not embedded in the original image.

Concerning the scientific approach to the acheiropoietos images, only reproducible experiments are scientifically acceptable. Interpretations of shapes, coins, faces, flowers or letters “seen” on acheiropoietos images by means of image processing tools should be considered a track useful to address further studies, but they cannot be considered as self-consistent proofs.

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10. See, e.g., www.illusionsciences.com

11. See, e.g., www.yoism.org/?q=node/129

PHOTO CREDIT

Figures 5a and 5b: Barrie Schwortz.