VISION, ILLUSION AND PERCEPTION VIP 2

Marco Bertamini

Programming Visual Illusions for Everyone

Springer

Vision, Illusion and Perception

Volume 2

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Preface

A Book about Illusions and about Programming

Hello. If you find visual illusions fascinating this book is for you. I start by providing some background, some history and some theories about visual illusions, and I discuss in some detail twelve of my favourite illusions. Some are about surfaces, some are about apparent size of objects, some are about colour and some involve movement. But this is only one of the aims of the book. The other aim is to show you how you can create these effects on any computer.

The book includes a very brief introduction to a powerful programming language called **Python®**. No previous experience with programming is necessary. I will start from the basic concepts. I will also introduce a package called **PsychoPy** that makes it very easy to draw images on a computer screen. It is OK if you have never heard the names Python or PsychoPy before. I have chosen them because they are a great combination. Python is a modern and easy-to-read language, and PsychoPy takes care of all the graphical aspects of drawing on a screen and also interacting with a computer. By the way, both Python and PsychoPy are absolutely free, so you will not need to spend any money.

The structure of the book is simple. In Chapter 1 I discuss visual illusions, why they are more than just a curiosity, and how hard it is to classify them. I am an experimental psychology and in particular I study visual perception, therefore I have worked in this field for many years. In this chapter, however, I will not write an academic essay on illusions. Instead I will give a general introduction to the topic. Illusions are fun, and most people find them interesting and entertaining, I am sure that you will like them.

I have included many references in the text. The first example in Chapter 1 is "(Shepard 1990)". Each time that you will see a name and a year like this, the reference is in the Bibliography at the back of the book. They are not strictly necessary as you read the book. They are important for two reasons, one is that it is only fair to give credit to the people who wrote the original articles, and the other is because some readers may want to explore in more depth some illusions or some claims.

In Chapter 2 I talk about programming, and in particular about a language called Python. I have used Python as a tool extensively but I am not a professional programmer. This book is not a standard programming manual, it is a quick guide and it provides enough information to start using the language. It is a bit like one of those phrase books for when you go to a foreign country and you want to be able to say "I would like an ice cream please", and "let's go to the beach!".

Chapter 3 explains how to use PsychoPy to open a window, to set up the coordinates of a space in which to draw, and to show on the screen lines, rectangles and other shapes. We will use objects like windows, shapes, clocks and more. We will see how to create these objects and what properties they have. This approach is very powerful if you want to control the images on the screen, make them change in various ways, and it also allows the user to interact with the program for instance using the mouse.

Chapter 4 describes a program that draws a so-called **Kanizsa square**. This will be our first illusion. After that we will see several more. Many key references for these illusions are provided in a list of references at the back (if you would like to read more and delve into the science).

When I started on this project I was not sure whether I was going to teach programming with the excuse of looking at some visual illusions, or whether I was going to teach about visual illusions with the excuse of learning to program. I am still not sure.

The book has **figures** to illustrate both the illusions and some of the programming techniques, and **boxes** with information on specific topics. In addition, there are **messages** from twelve international scholars working on visual illusions in general, or on one in particular. They will introduce themselves and their work in a few sentences. I have included this feature so that you as the reader can meet some of the authors of the research that is discussed. They are from Belgium, England, France, Italy, Japan, Scotland and the USA.

There is, as you may have expected, a companion website to this book. The address has exactly the same name as the book:

www.programmingvisualillusionsforeveryone.online

Enjoy!

Marco Bertamini
Prescot, July 2017

Acknowledgments

Writing this book was a lot of fun. In the process I have also had help from a number of friends and colleagues. I would like to thank Stuart Anstis, Nicola Bruno, Floriana Grasso, Jacques Ninio, Jon Peirce, Alessandro Soranzo, Andrew Stewart, Nick Wade and Michele Zito.

I discussed my idea with Nick Wade in Aberlady, Scotland in May 2016, and he was immediately supportive. It is thanks to him that this book was included in the **Vision, Illusion and Perception (VIP)** series.

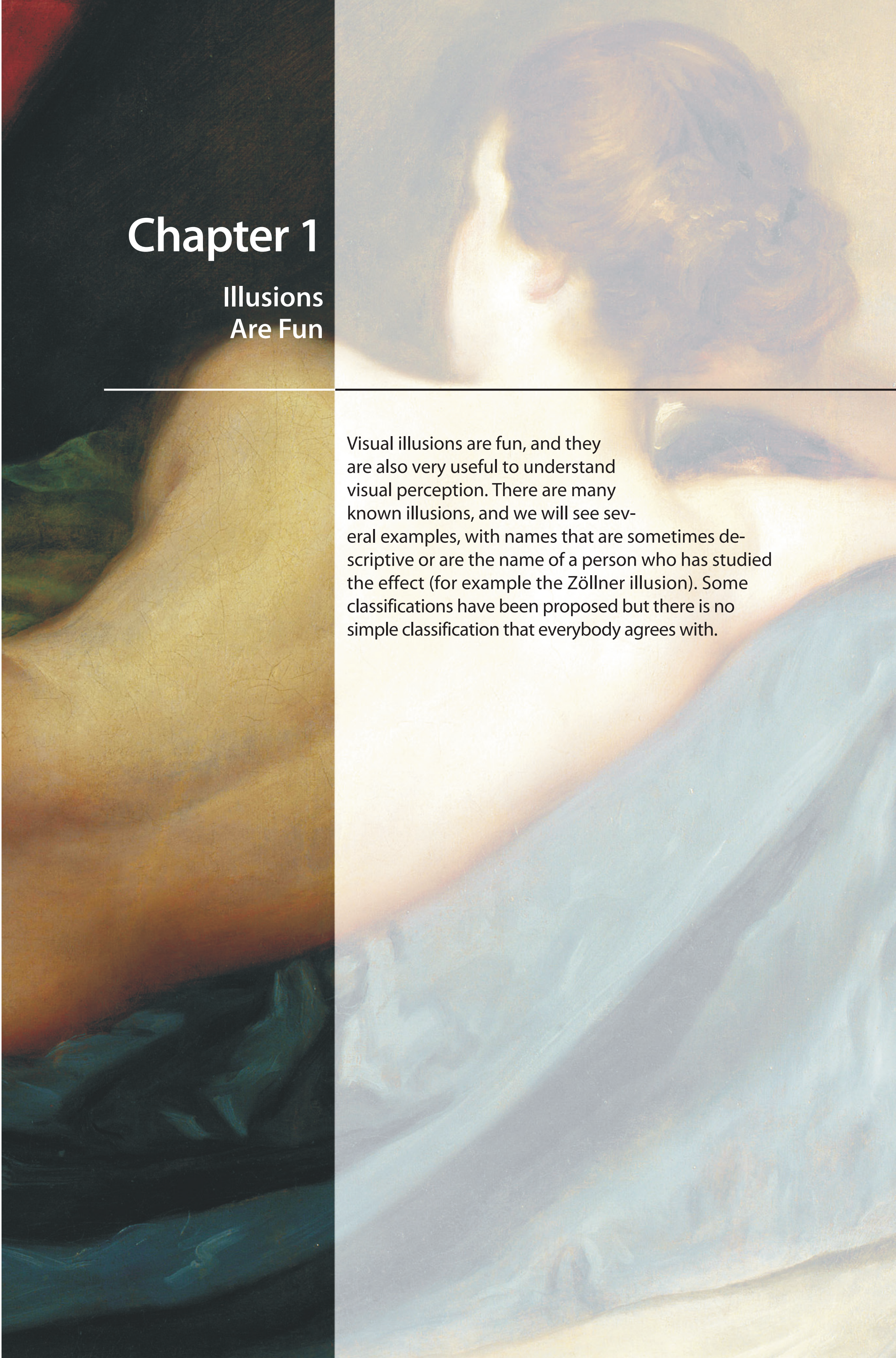
Thanks to the groups of experts who are featured in the book in individual boxes: Akiyoshi Kitaoka, Arthur Shapiro, Giorgio Vallortigara, Jacques Ninio, Jon Peirce, Michael Bach, Nicholas Wade, Nicola Bruno, Priscilla Heard, Stuart Anstis. It was not a conscious effort but it is nice to see how international the community is (with contributions from Belgium, England, France, Germany, Italy, Japan, Scotland, USA). Of all the resources I used, a special mention goes to Michael Bach's website, and to Giovanni Vicario's book.

In December 2016 I spent a week at the University of the Balearic Islands (**UIB**), and gave a series of workshops related to the book to the students in the Doctoral

Faculty and students from the Programme in Human Cognition and Evolution on a walk to the Castell d'Alarò (Tramuntana Range). Marco Bertamini is the fourth from the left, Enric Munar is the sixth. This castle is perched on top of a rocky mountain above the town of Alarò in Mallorca, Spain

Degree Programme in Human Cognition and Evolution. It was most enjoyable and I gained useful feedback as I was writing the book. Thanks to all of the staff and students at UIB, and to Enric Munar in particular. Thanks also to the EU Erasmus programme; just one of the countless ways in which the Erasmus programme has facilitated the exchange of people and ideas in Europe.

Contents



Chapter 1

Illusions Are Fun

Visual illusions are fun, and they are also very useful to understand visual perception. There are many known illusions, and we will see several examples, with names that are sometimes descriptive or are the name of a person who has studied the effect (for example the Zöllner illusion). Some classifications have been proposed but there is no simple classification that everybody agrees with.

Illusions are fun and they also challenge us to think about how perception works. Because they are fun they can make good tricks for parties and dinner conversation. Imagine that you have invited your friends for dinner and you use the picture in Fig. 1.1 to ask them a simple question: "which of the two tables should I use?" Some may prefer the square one and some the rectangular one, in any case you can then surprise them by showing that the two shapes are the same. This is illustrated in Fig. 1.1, which shows that the two rectangles (on a page or on a screen) differ only in orientation. You can put one on top of the other and they match, and if you print the image on paper you can cut out one rectangle and put it on top of the other. There is a technical word for this: *congruent*.

This is surprising because they do not **look** congruent. This is the essence of a visual illusion, our visual system organises images in certain ways, and we all see the same illusion (in most cases). Knowing that the two rectangles are identical will not change how they appear. The trick on your friends relies on the fact that you can be confident that they will not see the rectangles as identical in shape.

What we see in Fig. 1.1 is known as Shepard's illusion (Shepard 1990). Like many famous illusions it has taken the name of a researcher who has described the effect. Roger Shepard referred to it as *Turning the Tables*.

Visual illusions are helpful to counter what the psychologist Titchener called the **stimulus error** (Titchener 1909). That is what happens when we describe what we perceive in terms of what we **know**, instead of drawing on our perceptual experiences. To say I see a *rectangle* because there is a *rectangle*, or a *cat* because there is a *cat*, are examples of stimulus error.

Illusions make us also think about the nature of reality, and raise two types of questions. The first is why do we get it wrong; how is the trick working? The second is a more fundamental question about whether the senses tell us about some external reality, or whether our experience of the world is all an illusion. Let us briefly consider these two issues in turn.

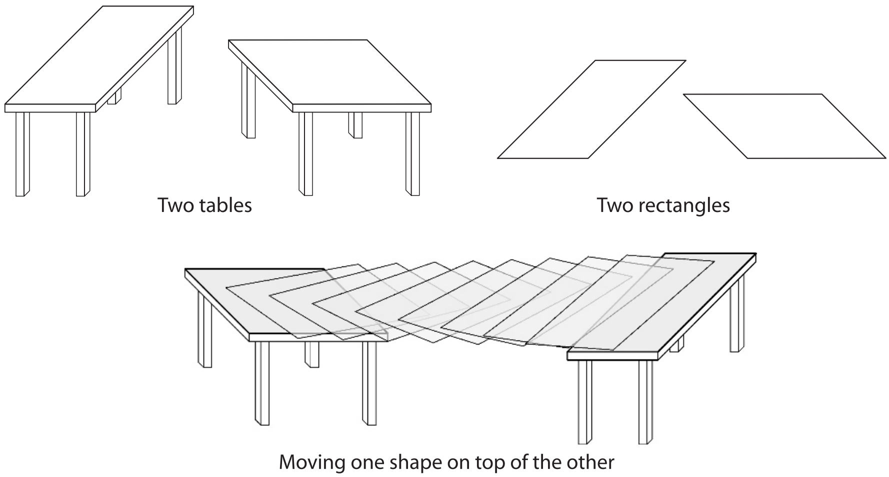


Figure 1.1. The two tables in the first image appear different in shape. On the right, the two rectangles are shown in isolation (not as tables). In the third image one shape is rotated on top of the other, something you can do with a piece of paper. If you cut out the two rectangles you can prove that they are identical

How Does It Work?

With respect to explanations, I will describe the best available theories as we will consider different visual illusions. In general, illusions have been useful in science exactly because they highlight some of the working of the sensory systems; we could even say that they tell us how our mind works (Kingdom 2015). A famous example is the fact that **colour afterimages** tell us about how colour vision works.

If you have never experienced an afterimage before, you should try. It's easy and there is no need for a computer. I have provided the necessary image in Fig. 1.2, and you can even make it with pen and paper. For instance, you can take a piece of paper and draw a red square on the left side. It is important that you fill in the square nicely with red ink. Next, place the page on the table in front of you, under normal illumination, and stare at the red square for 30 seconds. After that, move your gaze to the other side of the page, where there is a blank space. You will see something, and it is squarish, but it is not red. It is green. In Fig. 1.2 you should stare at the cross on the left for 30 seconds, and then look at the cross on the right. You will see four colours but again they are different from the colours that you have been looking at: red is replaced by green and green by red, blue is replaced by yellow and yellow by blue.

The explanation for the perception of a greenish shape after adaptation to red relies on the fact that the system **subtracts** red from the blank page and you see its complementary colour green. This is an important discovery. There is no law of physics that says that green is the complement of red, or yellow the complement of blue. This phenomenon is telling us something about the brain.

The illusion of colour afterimages played an important part in how scientists developed theories of colour. In the 19th century two main ideas were proposed and they were quite different. The Trichromatic theory was based on studies in which people

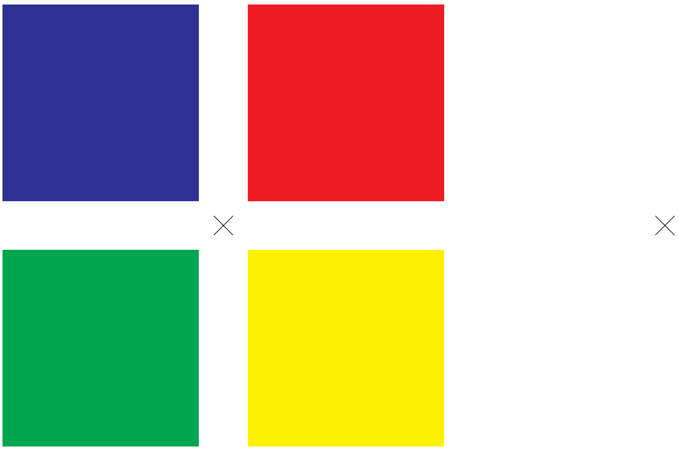


Figure 1.2. *Colour afterimages*. Fixate on the cross on the left for 30 seconds, then look at the blank page on the right. Notice the colours that you perceive around the cross. You will see that on the top right red is replaced by green, in the bottom left corner green is replaced by red, blue (top left) is replaced by yellow and yellow (bottom right) by blue

matched or mixed colours. By doing that, Thomas Young (1773–1829) and Hermann von Helmholtz (1821–1894) discovered that people needed three different unique colours (primaries) to match any other colour in the visible spectrum. Therefore the key idea was that there were three basic receptors. However, this theory could not explain colour afterimages like the ones you have just experienced.

In opposition to the proponents of the Trichromatic theory, Ewald Hering (1834–1918) proposed the Opponent-Process theory. The theory says that in the system there is a channel for black-white, one for red-green and one for yellow-blue. For example some cells increase their activity when stimulated with red light, and the same cells decrease their activity when stimulated with green light. We now know these cells exist and we call them red$^+$green$^-$ (other cells will do the opposite, and we call them red$^-$green$^+$). Which colour is perceived is the balance of the responses, and because of this common encoding of red-green we have complementary colours, and therefore afterimages. By staring at the red square, you have fatigued the red mechanism, and response to red will be depressed when staring at the blank page. Reduction in activity in the red$^+$green$^-$ channel is interpreted as the presence of green. What we have said about red and green applies also to blue and yellow.

Both theories had their strengths, and were based on careful observations. In fact they both were correct (but partial). The Trichromatic theory is more accurate in relation to receptors. Humans have indeed three different photoreceptors in the eye, identified more than a century later (that is, in the middle of the 20th century). The Opponent-Process theory captures something that takes place later, the way in which the information from the receptors is combined.

One may be tempted to say "well if this is the mechanism responsible for colour afterimages then it is not really an illusion. We perceive the output of a known mechanism in the brain". Whether we know the mechanism or not, however, it is reasonable to think that what we perceive is always the output of something that is going on inside our head. As you can see we are getting drawn into the fascinating study of perception, and some tricky questions about the relationship between mind and brain. At this point, if you are hooked, I will mention a few textbooks on visual perception that you can consult (see Box 1.1). Apart from this list, there will be many specific references that appear as names followed by a year. You can find a full list of references at the end of the book.

Although the example of colour afterimages shows that what we know about the visual system can explain some aspects of perception, and it can explain some illusions, this is not always the case. We do not have a good explanation even for some illusions that have been known for many years, or even centuries. There are still mysteries to solve.

Is Everything Just an Illusion?

Illusions may also lead us to ask a fundamental question about reality. Basically the question is whether we can ever trust our senses. At the very least illusions force us to accept the role of the observer in organising the incoming information and generate an interpretation. According to a constructivist view, any perception is a construction. Not everybody agrees with that view, however, because the term construction gives the impression that there is a very active role of the observer.

Box 1.1. Books on visual perception

Visual perception has a long history and it is the subject of many available books, including textbooks for university courses. Contributions have come and continue to come from a number of disciplines, including psychology, physiology, and neuroscience. This is a short personal selection (in alphabetical order).

- Bruce V, Green PR, Georgeson MA (2003) Visual perception: Physiology, psychology, and ecology, 4th ed. Psychology Press, Hove New York
  This is a textbook used in University courses, especially in Britain. As the title says research findings from three different approaches to visual perception are brought together.
- Goldstein EB (2013) Sensation and perception, 9th ed. Wadsworth Publishing
  If you want a standard textbook, very structured, and used in many University courses, this is an excellent one. It covers all the senses (not just vision) and it has been updated and revised over many editions.
- Gregory R (1966) Eye and brain: The psychology of seeing. Weidenfeld and Nicolson, London
  This is a classic, and many editions have followed (the 5th ed. was in 1997), so it is not difficult to find a copy. A very good introduction to visual perception.
- Hoffman DD (2000) Visual intelligence: How we create what we see. W. W. Norton & Company, New York
  This is a short but fascinating book that covers many aspects of perception. It is not written as a textbook and it includes some personal reflections.
- Kanizsa G (1979) Organization in vision: Essays on Gestalt perception. Praeger Publishers, New York
  This book is old and you may struggle to find a copy (except in a library) but it is a classic and it has some great illustrations.
- Rock I (1985) The logic of perception. MIT Press, Cambridge MA
  As the title suggests, in this book Irvin Rock argues that perception is a sophisticated, intelligent process. Rock was a clever experimenter and he supports his thesis with demonstrations and empirical studies.
- Shapiro AG, Todorović D (eds) (2017) The Oxford compendium of visual illusions. Oxford University Press, Oxford
  This is a compendium, which means a commented list, of visual illusions. It is a reference book (880 pages long), so you may want to consult it in the library, unless you are after a nice coffee table book.
- Snowden RJ, Thompson P, Troscianko T (2012) Basic vision: An introduction to visual perception. Oxford University Press, Oxford
  The topics covered are the traditional topics of visual perception, but the style of this book is very engaging, with many jokes and the authors clearly had a lot of fun writing it.

Finally, I will also mention a few books that are about the link between visual perception and visual art.

- Arnheim R (1974) Art and visual perception: A psychology of the creative eye. Revised and expanded. University of California Press, Berkeley Los Angeles London
  If you are interested in understanding Art in relation to psychology and perception, this is a classic, beautifully written book published originally in 1954.
- Seckel A (2007) Masters of deception: Escher, Dalí & the artists of optical illusion. Sterling Press, New York
  This is a book that combines visual illusions with history of visual art.
- Wade N (2016) Art and illusionists. Springer, Cham Heidelberg New York Dordrecht London
  This extensively illustrated book celebrates the many ways of manipulating pictures to produce illusions and works of art.

On the one hand our senses are reliable because they are useful, we manage to move around in the world and successfully recognise, say, our bicycle by its colour and shape. On the other hand useful is not the same as truthful.

The Greek philosopher Plato (427–347 B.C.) used a famous metaphor. Let us imagine that we are in a cave and what we see are shadows, and because of the direction that we are facing we can only see shadows. If we just look at the projected shadows on the wall of a cave we can never see the objects casting the shadows. Humans, under these circumstances, will mistake appearance for reality.

If this idea sounds familiar it is because there are many other examples in history. Perhaps you can see the similarity with the plot of the film *The Matrix* (1999).

A related concept is whether all of our knowledge must ultimately come from our senses. Philosophers in the empiricism camp would answer yes. Famous champions of this view were John Locke (1632–1704) and David Hume (1711–1776). However, rationalists like René Descartes (1596–1650) would say that knowledge and truth come from reason.

You can find this and related issues discussed many times in the history of philosophy (for a more recent discussion see Hoffman 2000). These fascinating questions about what we know through our senses and how much we can trust knowledge acquired through perception extend to all sensory experiences and are not specific to illusions. So I will not pursue them any further in this book.

With respect to illusions in general, I should point out that this book only deals with **visual** illusions, but that there are many interesting examples of illusions that affect what we hear, what we touch and the sense of having a physical body (body representation). Clearly illusions are present in relation to all our senses, not just vision.

How Are Illusions Discovered?

Many illusions have been discovered by chance. For instance, in 1870, a German physiologist called Ludimar Hermann was reading a book. He noticed that there were grey spots at the intersections of a grid of dark figures, but these spots would disappear when he looked directly at them. This effect is now famous as the Hermann grid illusion (again taking the name of the person who described it in the scientific literature) and is shown in Fig. 1.3. A similar effect is also present with white squares on black background, and therefore black intersections and bright spots (so everything reversed). This was noted by Hering and is therefore known as Hering grid (1907).

It is useful to attach a name to a specific illusion. For example, we will see the Ponzo, Delbœuf, and Ebbinghaus illusions, named respectively after an Italian, a Belgian, and a German psychologist. Later it may emerge that there were earlier descriptions, although it may be impossible to change the established name. This was the case for the Hermann grid, which had been described by Brewster in 1844 (Wade 2005) and it is actually the case for several other famous illusions.

We have seen that looking at a colour produces adaptation, which in turn produces a colour afterimage, also called a colour aftereffect. Similarly, looking at motion in one direction produces motion adaptation, and a motion aftereffect. This is an illusion that had been observed already in antiquity. The Roman philosopher Lucretius (99–55 B.C.) in his poem *De Rerum Natura* noted that after watching the fast flowing water of a river, everything on the bank of the river appeared to move in the opposite

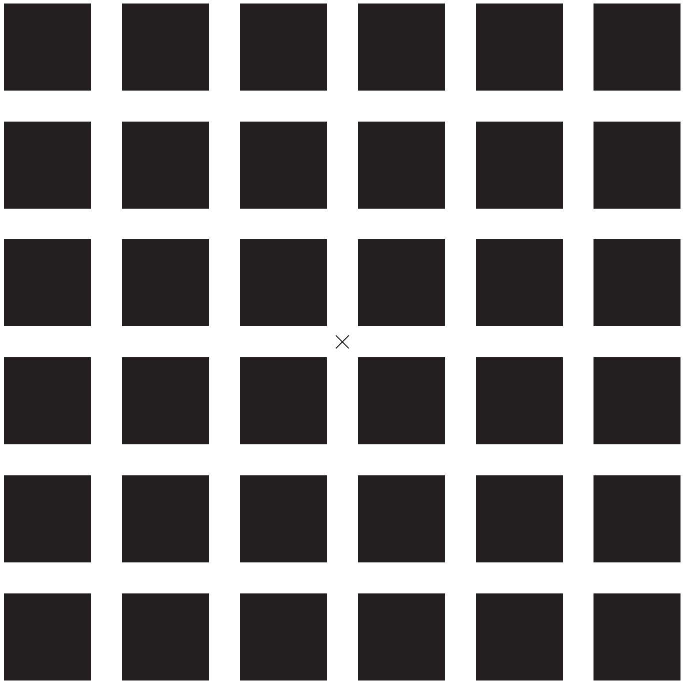


Figure 1.3. *Hermann grid*. Keep your eyes on the cross and pay attention to the rest of the grid. You will see dark spots on top of the white background at the intersections

direction (Verstraten 1996). This poem has had an interesting life. It was forgotten for over a millennium, and was rediscovered in a monastery by a book hunter called Poggio Bracciolini in 1417. It has many interesting observations about perception including possible descriptions of other illusions. Remember, however, that it was written as a poem about science, which is a fascinating format (we are certainly not used to this approach now).

As we have just seen there are descriptions of visual effects in the historical documents throughout the centuries. In the 19^{th} century however we start to see articles written in academic journals that specifically report visual illusions and start to use the current terminology. J. J. Oppel (1855) was the first scholar to use of term “geometrical-optical illusions” (Phillips and Wade 2014; Vicario 2011). One simple configuration described by Oppel has three lines; the longer one is straight but appears to bend slightly in the middle where it is intersected by the other two.

In Fig. 1.4 I am showing an illustration of the illusion described by Oppel, and another effect that was described by Necker (1832).

Some of the best sources of illusions are online and they are listed in Box 1.2. If you are interested in a book about illusions, full of detailed and academic writing, then I recommend the *Oxford Compendium of Visual Illusions*, edited by Shapiro and Todorović (see Box 1.1). In this book there is a chapter titled *Early History of Illusions* by Nicholas J. Wade (University of Dundee).

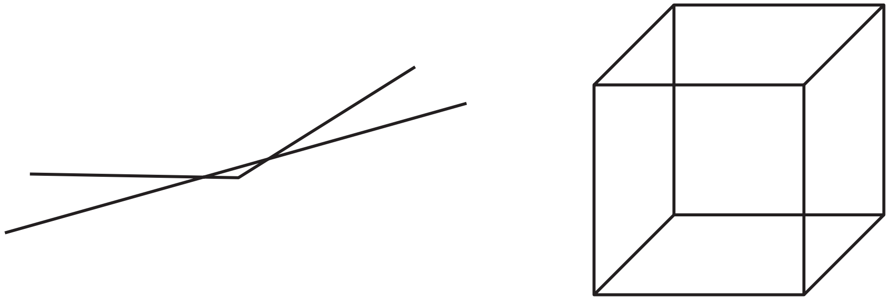


Figure 1.4. These are two effects reported in the 19th century. On the left we see a configuration described by *Oppel* (1855). The straight line appears to bend in the middle. A different kind of effect is shown on the right. Here instead of a distortion of shape or size we have an image that is ambiguous and can be perceived in two different ways, as a cube seen from above, or as a cube seen from below. Because of the two possible and stable interpretations this is a bi-stable image. This example is called the *Necker cube* (Necker 1832)

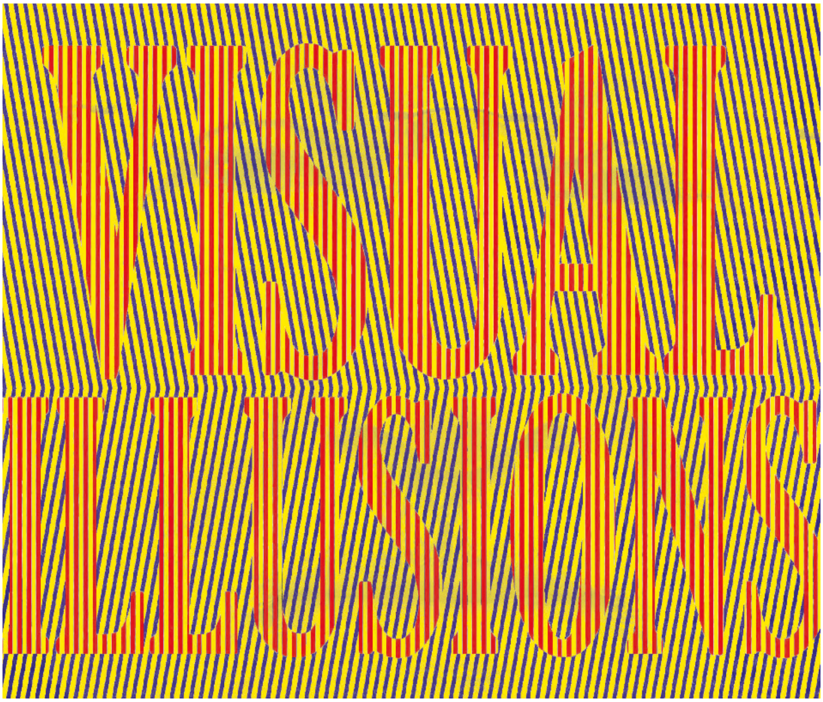
Box 1.2. Illusions online

These are some wonderful sites on which to see illusions, including animations showing dynamic illusions. If you are aware of suffering of dizziness or epilepsy be conscious that you may want to avoid looking at some visual illusions.

- An extremely well organised set of pages created by Michael Bach. The site shows the illusions and it also provides scientific explanations:
  http://michaelbach.de/ot/index.html
- A large collection of illusions created by Akiyoshi Kitaoka. The site has many variants of some illusions that contribute some really beautiful images:
  http://www.ritsumei.ac.jp/~akitaoka/index-e.html
- A simple set of pages with beautiful images showing a selection (about 100) of the *most popular and cool* optical illusions:
  http://www.optillusions.com/
- A site in which illusions are illustrated with dynamic examples. Created by the Science and Mathematics Education Center at Boston University:
  http://lite.bu.edu
- A site by David Phillips with many examples and writings about illusions and visual effects:
  http://www.opticalillusion.net
- The official site of The Best Illusion of the Year Contest, with submissions starting from 2005:
  http://illusionoftheyear.com

In Message 1.1 we hear directly from Nicholas Wade. He provided a portrait especially designed for this book. It is an image that combines his face with a visual illusion of colour (the yellow is the same throughout) and an illusion of orientation (the red lines are all vertical and the words are horizontal). We will have other messages like this (12 in total) in various chapters, where we can meet some of the scientists who are working in the field.

Message 1.1. "Illusions" by Nicholas Wade



Illusions have fascinated observers for many centuries – the Moon looks larger when near the horizon, it looks to be moving in the opposite direction to passing clouds and water appears to flow uphill after looking for some time at a waterfall. These observations do not require any theory to make them remarkable, simply the assumption that objects (like the Moon) remain constant over time. What we now call geometrical optical illusions received that name in the 1850s. Unlike the ancient illusions, they are pictures rather than objects and distortions in size or shape can be induced and manipulated. It is puzzling that such simple flat figures entered into visual science so late – they could have been drawn at any time in the preceding two thousand years! What changed in the 19^{th} century was a shift from observing objects in natural scenes to presenting flat depictions in laboratories using apparatus specially invented for the purpose. Since that time most experiments on vision have involved pictorial stimuli of which geometrical optical illusions provide a perfect example. It has been said that visual illusions reveal visual truths; it could equally be argued that visual truths will reveal the basis for visual illusions.

Nicholas (Nick) Wade received his degree in psychology from the University of Edinburgh and his PhD from Monash University, Australia. This was followed by a postdoctoral fellowship at Max-Planck-Institute for Behavioural Physiology, Germany. His subsequent academic career has been at Dundee University, where he is now Emeritus Professor. His research interests are in the history of vision research, binocular and motion perception, and the interplay between visual science and art.

Classifications

Some classic visual illusions are very simple and easy to draw with a pencil on a piece of paper. They often are about shape and size and therefore we can refer to them as geometrical illusions. Other illusions require dynamic displays, and for these programming will be very handy.

Richard Gregory (1997) has divided illusions into four types:

- ambiguities
- distortions
- paradoxes
- fictions (errors of language)

Coren et al. (1976) tried to group illusions based on the similarity in human responses (using a technique known as factor analysis). However, this approach only separated two groups, illusions of extent (size) and illusions of shape or direction.

Bach and Poloschek (2006) listed six classes based more on the type of stimulus:

- luminance and contrast
- motion
- geometric or angle illusions
- 3D interpretation: size constancy and impossible objects
- cognitive/Gestalt effects
- colour

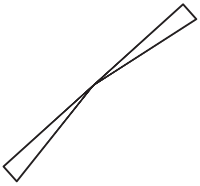
The whole history and problems of classification are discussed in Vicario (2011). According to Vicario an important aspect of a visual illusion is a sense of surprise and puzzlement. This surprise must be evident in the image, and not only after some aspects are pointed out to the observer. Because of this definition, some of the illusions in this book would not qualify as illusions at all for Vicario.

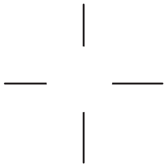
Both Ninio (2014) and Hamburger (2016) have recently argued that we need more work and better classifications. Clearly no simple way of organising illusions has yet emerged.

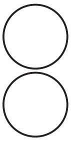
Because of these difficulties with definition and classification, it would be hard and arbitrary to create a list of all known illusions. We have already seen some examples and in Fig. 1.5 I have compiled a selective parade of some of the best-known geometrical-optical illusions. Many take the name from a discoverer, but not all, for some we just have a name.

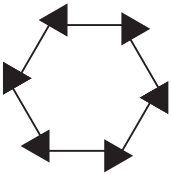
Figure 1.5. A parade of some famous geometrical illusions. *Amodal shrinkage* (Kanizsa 1972) (covered square shrinks), *Bourdon* (1902) (not straight edge), *Ehrenstein* (1941) (white disk), *Elevation* (Delbœuf 1865) (circle above bigger), *Gerbino* (1978) (hexagon distorted), *Giovannelli* (1966) (dots not aligned), *Helmholtz* (1866) (horizontal version taller), *Hering* (1861) (bending of horizontal lines), *Irradiation* (Galileo 1632) (white bigger), *Jastrow* (1892) (top shape smaller), *Loeb* (1895) (lines do not line up), *Müller-Lyer* (1889) (top line shorter), *Münsterberg* (1897), or *Café Wall* (Gregory and Heard 1979) (lines not parallel), *Oppel-Kundt* (Oppel 1855) (filled line longer), *Orbison* (1939) (circle distorted), *Poggendorff* (see Zöllner 1860) (lines do not appear aligned), *Sander* (1926) (right oblique line shorter), *Tolansky* (1964) (curvature different), *Vertical-horizontal* (Schumann 1900) (horizontal shorter), *Vicario* (1978) (steps not parallel), *Zöllner* (1860) (lines diverge) ▶

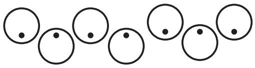

Amodal shrinkage

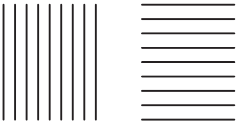

Bourdon illusion

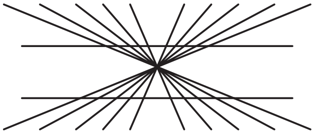

Ehrenstein disk

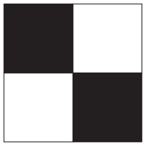

Elevation illusion

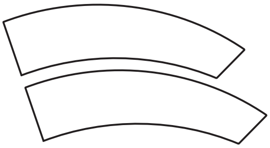

Gerbino illusion

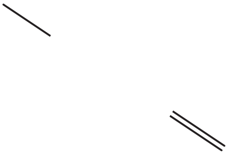

Giovanelli illusion

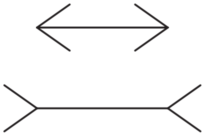

Helmholtz illusion

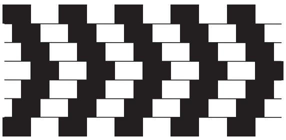

Hering illusion

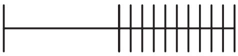

Irradiation illusion

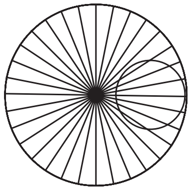

Jastrow illusion

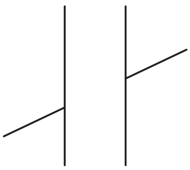

Loeb illusion

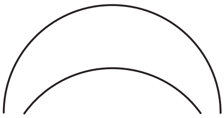

Müller-Lyer illusion

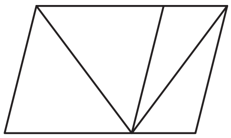

Münsterberg illusion

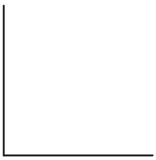

Oppel-Kundt illusion

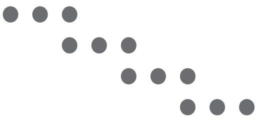

Orbison illusion

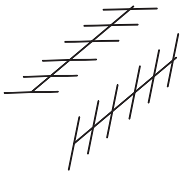

Poggendorff illusion


Tolansky illusion


Sander illusion


Vertical-horizontal illusion


Vicario illusion


Zöllner illusion