

Eye contricks

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Abstract. Pictorial images are icons as well as eye-cons: they provide distillations of objects or ideas into simpler shapes. They create the impression of representing that which cannot be presented. Even at the level of the photograph, the links between icon and object are tenuous. The dimensions of depth and motion are missing from icons, and these alone introduce all manner of potential ambiguities. The history of art can be considered as exploring the missing link between icon and object. Eye-cons can also be illusions—tricks of vision so that what is seen does not necessarily correspond to what is physically presented. Pictorial images can be spatialised or stylised; spatialised images generally share some of the projective characteristics of the object represented. Written words are also icons, but they do not resemble the objects they represent—they are stylised or conventional. Icons as stylised words and spatialised images were set in delightful opposition by René Magritte in a series of pipe paintings, and this theme is here alluded to. Most of visual science is now concerned with icons—two-dimensional displays on computer monitors. Is vision now the science of eye-cons?

Keywords: vision, art, icons, ambiguity, illusions, allusions.

1 Introduction

Observations provide the bedrock of perception. Records of observations precede records of their verbal descriptions; that is, the products of art precede those of writing. Relatively little is known about the origins of visual art. Examples of marks made on tools and cave walls have been dated to many thousands of years ago, but we do not know when such activities began. Writing had its origins around 5,000 years ago. The adoption of experimental methods to record observations is a development of recent centuries. What we consider to be art involves the distillation of specific observations into spatialised representations (what we call pictures) or of categories of observations into stylised representations (typically written words). Both pictorial images and written words are spatially extended, and both can be considered as icons. The term icon now has several connotations, but it derives from the Greek word *eikon* meaning likeness or image. It is in this sense that it will be used here so that an icon can be equated with a pictorial image.

Perception has evolved to make and maintain adaptive contact with the environment. Through the action of the senses an organism seeks sustenance, shelter, and sex in order to survive and reproduce. The senses of all species have become adapted to the demands of their survival and reproduction, and there is a great variety in the ways in which senses have evolved. In addition, the human senses are linked to an intricately organised brain, which has evolved to extract more than the elements of material sustenance. It furnishes us with intellectual sustenance, too, and extracts from the patterns of sensory stimulation links to language and thought. Humans not only use their senses but they also muse about them. Paradoxically, much of this musing has concerned minor errors of perception (referred to here as eye contricks) rather than the constancies of what we perceive. Despite the long history of recording perceptions, attention continues to be directed to eye contricks—the small deviations from constancy that we call illusions. Constancy and illusion can be considered as existing on a continuum from veridical perception (reflected as a Brunswik ratio of 1) to complete illusion (as in some instances of induced motion, when the physically moving parts are seen as stationary and the stationary parts as moving in the opposite direction).

Most of our perception involves constancy or minor deviations from it; these latter we call illusions (or eye contricks). Artists have developed an array of eye contricks in order to achieve their ends—conveying an allusion to the objects or classes of object they represent. It will be argued that visual scientists now share this concern with artists. They examine representations of objects (usually pictorial representations of them) rather than the objects themselves: they are engaged in intricate manipulations of eye contricks which might not further our understanding of object perception.

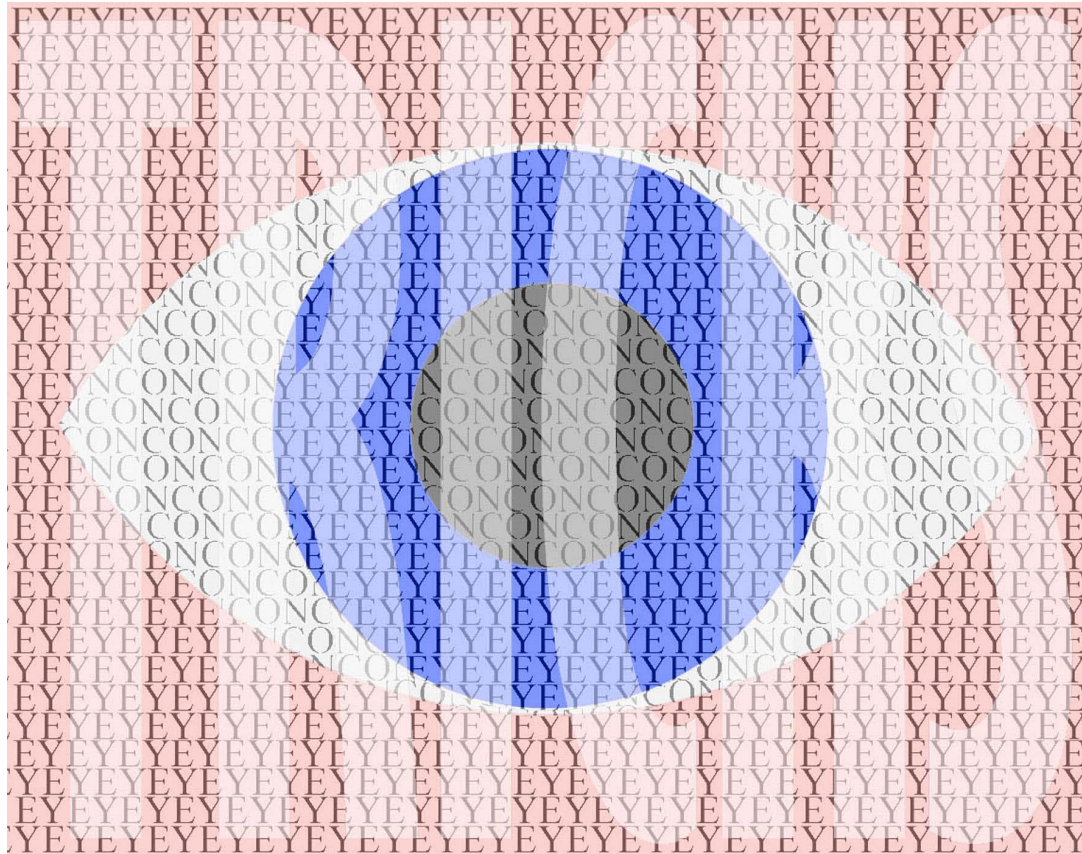


Figure 1. *Icon Tricks* (© Nicholas Wade).

The concepts of image and icon have thrived on their vagueness, and so attempts have been made to refine them (see Wade 1990). An icon corresponds to a pictorial image: it is spatially extended and can share some of the projective characteristics of the object represented. Thus a photograph of a pipe is an icon or spatialised image because it corresponds to a projection of the three-dimensional object onto a two-dimensional surface. It also represents a specific pipe viewed from a particular direction. The word PIPE is similarly an icon or stylised image, but it refers to a category of objects rather than to specific exemplars. Like all pictorial images, icons are eye-cons: they provide a distillation of a complex object or idea into a simple pictorial shape. They create the impression of representing that which cannot be veridically presented. Despite the cliché that the camera never lies, the links between icon and object are tenuous in photographs. The dimensions of distance or depth as well as motion are missing from the pictorial image or icon, and this alone introduces all manner of potential ambiguities. Wagemans et al (2011), Koenderink et al (2011), and van Doorn et al (2011) discuss the apparent depth in pictorial images and the ways in which they can be measured. The history of art can be considered as an exploration

of the missing link between icon and object: the many pictorial tricks applied by artists allude to the dimensions that icons and pictorial images do not contain—depth and motion. Eye-cons (as in [Figure 1](#)) can be more honest—they can reflect tricks of vision so that what is seen does not necessarily correspond to what is presented.

The term “eye-con” is also a play on words. The English language affords vast license for word play, and I will engage in this exercise in the titles of the eye-cons presented. However, my main concern with “eye contricks” is to engage in a play on images rather than words. That is, less attention has been directed to the shapes of letters and words than to the meanings they convey. Indeed, even that great artistic wizard with words and images—René Magritte (1898–1967)—did not apply his artistry to letter and word shapes. He was more concerned with confounding the verbal and visual labels than with complicating the shape of the word. Concrete or visual poetry has shown a similar reluctance to manipulate the fundamental features of typography (see Hollander 1991; Riddell 1972; Roberts 2011; Voss and Drucker 1996). I will use letter and word shapes in a variety of graphical ways in order to play tricks with icons. A broader range of eye contricks involving “perceptual portraits” can be seen in Wade (2006) and at <http://neuroportraits.eu>.

2 Stylised and spatialised icons

We all make icons (pictorial images) constantly, though we rarely think of them in this way—we can all write although most of our writing is now done indirectly via a computer keyboard. Accordingly, pictorial images can be either stylised, like the letters of our written language, or spatialised, like drawings, paintings, and photographs. [Figure 2](#) conflates these two types of icons by presenting the words in both conventional and idiosyncratic scripts: conventional uppercase letters spell the words IMAGE repetitively in the top half and WORD in the bottom half. However, these conventional letter shapes are enclosed within idiosyncratic and incomplete script for WORD at the top and IMAGE at the bottom; only parts of the complete letters are presented, and they are joined by an equally idiosyncratic AND. The handmade words are more difficult to read as a consequence, unlike the conventional printed letter shapes. Moreover, the colours themselves play parts in the perceptual puzzle: the red is physically equivalent throughout, as is the blue, but they do not appear so. Owing to colour assimilation, the red looks darker in the upper half than in the lower, and the blue looks lighter in the lower than the upper half.

Stylised pictures, as in written scripts, are obviously arbitrary and dependent upon convention. Chinese pictograms differ markedly from our alphabetical letters, but they can be arranged to allude to the same objects by those schooled in the rules of the language. Thus, written words are also instances of visual allusions. They present us with indirect references to objects and ideas. They are stylised images that usually have little spatial similarity to the things they signify. This is the basis for the discordant tune played by Magritte on his pipes ([Figure 3](#)). The word “pipe” has little in common spatially with the vast variety of objects that would be members of that category. In this sense, a word is worth a thousand images! To be more precise, a stylised image is worth an infinite number of spatialised images: any object can be represented by an infinite number of spatialised images by varying its pictorial dimensions, viewpoint, etc. We can make words less indirect by depicting the shape of the objects to which they refer. That is, the stylised image (the shape of the word) can represent the class of objects the word signifies, whereas the spatialised image is a specific instance of a member of that category. The simulated reality of both spatialised and stylised pictures is appositely portrayed in a picture by Magritte entitled *The Perfidy of Images* (see Foucault 1983; Gablik 1976; Whitfield 1992). Variations on the theme are played in [Figure 3](#); others can be found in Wade (1990, 2010).

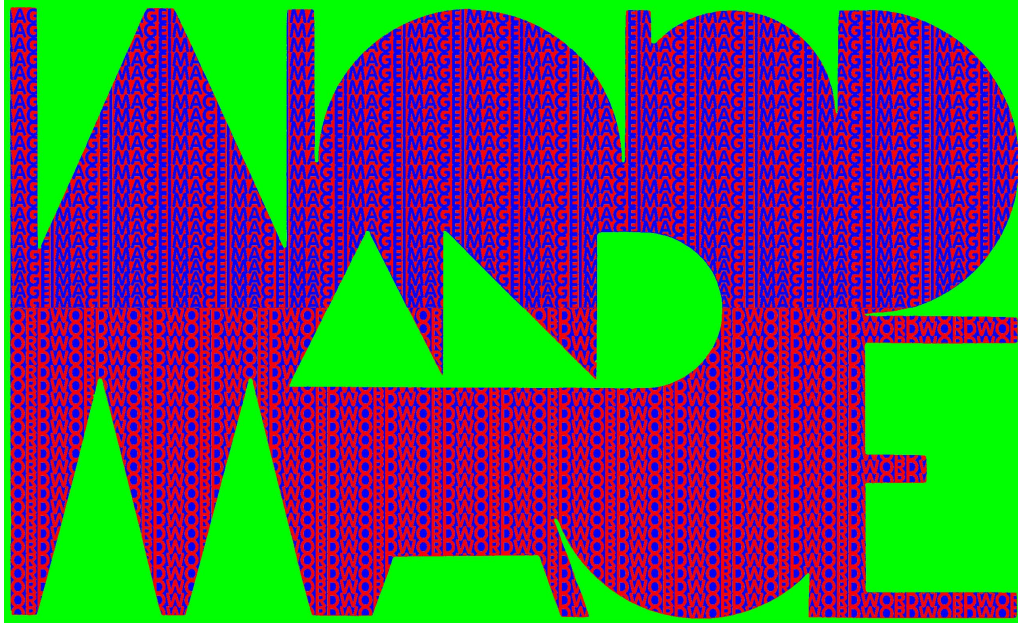


Figure 2. *Images and Words* (© Nicholas Wade).

Magritte's initial pipe painting was produced around 1928, and he made several variations on the theme. The title signalled his desire to pit word against image: printed beneath the spatialised image of the pipe are the words "This is not a pipe". Thus, the viewer is confronted with the message that although this looks like a pipe it is actually pigment on canvas, ink or silver crystals on paper, or light on a screen: the pictured pipe cannot be smoked or handled, indeed it seems to be floating in air rather than supported on any surface. We do not know if there ever was an actual pipe that Magritte painted. He might have represented a pipe from his imagination, in which case it would have been a pipe dream! Note that Magritte painted the words, too, so he was using one symbolic picture (the written word—a stylised image) to say that another symbolic picture (the shape and colour of the pipe—a spatialised image) was not the object represented. When the painted pipe and painted words are in conflict like this we are more likely to think that the pipe shape does not correspond to the object rather than question the relation of the word shape to its referent.

When objects are represented in isolation they tend to be depicted in what can be referred to as the stereotypical view (Wade 1990). This has also been called a typical outline; other terms for it have been canonical or prototypical views. They all involve minimal foreshortening of the most asymmetrical axis. Therefore, the stereotypical view is the most informative two-dimensional representation of a three-dimensional object. Another way of describing the stereotypical view would be as the least ambiguous silhouette (see Wagemans et al 2008). The pipes in Figure 3 could have been photographed from many other directions, some of which would not have been readily recognised as pictures of a pipe. Magritte's painting depicted a pipe from the side with its bowl inclined slightly towards the viewpoint; the side view does not shorten the asymmetrical axis of the pipe stem, and it is the stereotypical viewpoint. There is less relation between Magritte's painted word PIPE and the shape of actual pipes than there need be. The variety of letter shapes is vast—from the minor variations in typefaces to the extravagant ornamental shapes used in advertising and calligraphy. When we take the vagaries of handwriting into account, the range of recognisable letter shapes explodes even further, as is evident with the upper-right pipe in Figure 3. It encompasses two ways of writing the words UNE PIPE. The lower one corresponds to

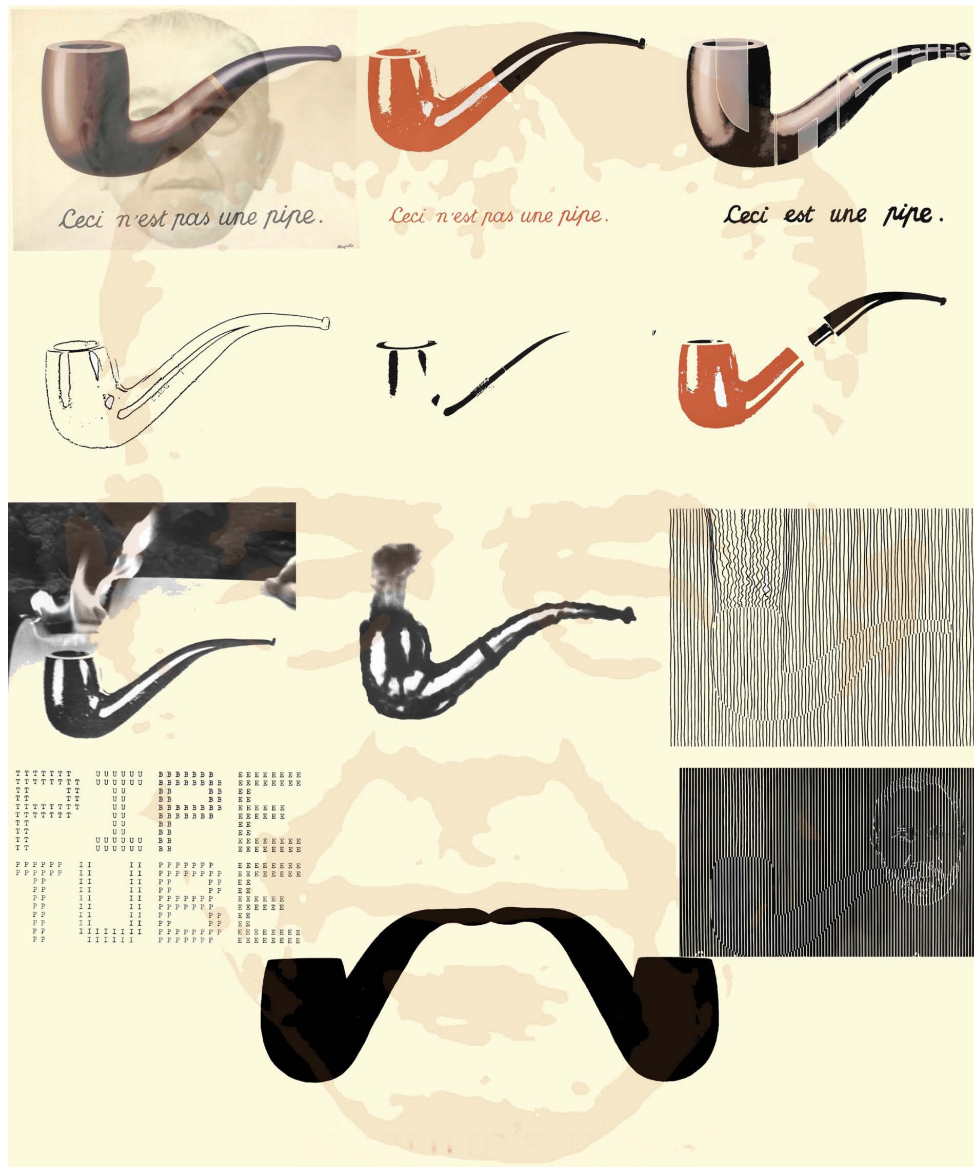


Figure 3. *These Are Not Magritte's Pipes* (© Nicholas Wade).

Magritte's handwriting, but the uppermost one is idiosyncratic and complements the shape of Magritte's painted pipe. Does the combination of the shape of the pipe with the word used to describe it make it more like a pipe? The pipe was not an arbitrary instrument on which Magritte played his surreal chords! He was, in fact, rebelling against ideas prevalent in the late 1920s regarding the universality of the pipe or tube shape, as advocated by the architect le Corbusier (Charles-Édouard Jeanneret, 1887–1965). Pipes can also be tubes, and they can have a variety of other meanings, too, which can be alluded to by word pictures shown in [Figure 3](#).

Magritte described himself as a philosopher who wielded a paint brush rather than a pen, and his confounding of stylised and spatialised images speak to this appellation. His tune was played on more than pipes. In his painting *Ceci n'est pas une Pomme* he painted an apple with the caption stating that it was not one. Again, the equivalence, rather than the conflict, between stylised and spatialised icons can be emphasised, as in [Figure 4](#) (left). Apples featured in many of Magritte's paintings and often obscured the facial features of his

subjects. For example, in *The Great War* an apple is painted in front of the bowler-hatted figure. A variant of the theme is played in Figure 4 (centre), in which identity is partially exposed. Magritte also made a series of paintings in which he gave false names to pictured objects. In his *Key of Dreams* he divided the canvas into four quadrants and painted a pictorial image in each of these. Three were accompanied by inappropriate verbal labels: beneath a picture of a horse the words THE DOOR were painted, a clock was accompanied by THE WIND, and THE BIRD beneath a picture of a jug. This icon trick has been turned on its stylised head in Figure 4 (right), where the jug is THE BIRD. The sounds of the verbal labels are determined by the demands of language, and the same object is given varied vocalisations in a variety of languages. In this sense they can be considered as arbitrary, as can the letter shapes or scripts used to capture the particular sounds.

One of the reasons why we equate pictorial images with the objects they represent is because of the many camera-derived images we see constantly in print, on television, and on computer screens. It is these perspective pictures that provide us with such a satisfactory substitute for reality. The camera always lies: it delivers a time-frozen image of a dynamic world. We do not see by means of static images in the eye; our eyes are in continual motion due to either involuntary or voluntary eye movements. This is quite unlike any image a camera can deliver.



Figure 4. *The Apple of His Eye*con (© Nicholas Wade).

3 Illusions as eye contricks

Eye contricks are much more than visual illusions, although they can operate at this level. Because icons and pictorial images generally seem to convey their meaning with such immediacy, we rarely stop to ponder the paradoxes they pose. If they are so important, we should understand more about the way we see them and the processes that are involved in making them. Pictorial representations, like those captured by a camera, are traditionally referred to as creating illusions of objects in three-dimensional space, but this is less than accurate because it betrays a misunderstanding of what is meant by the term illusion. Such pictures are visual allusions rather than visual illusions. The distinction is more fundamental than a single letter, and it can be illustrated in Figure 5. The words VISUAL ILLUSIONS are dimly defined by the green and yellow outlines and the slight difference in colour and contrast to the background. Throughout the figure there are red vertical lines; they are parallel to one

another, but they probably look tilted one way and then the other. This is an example of an illusion.

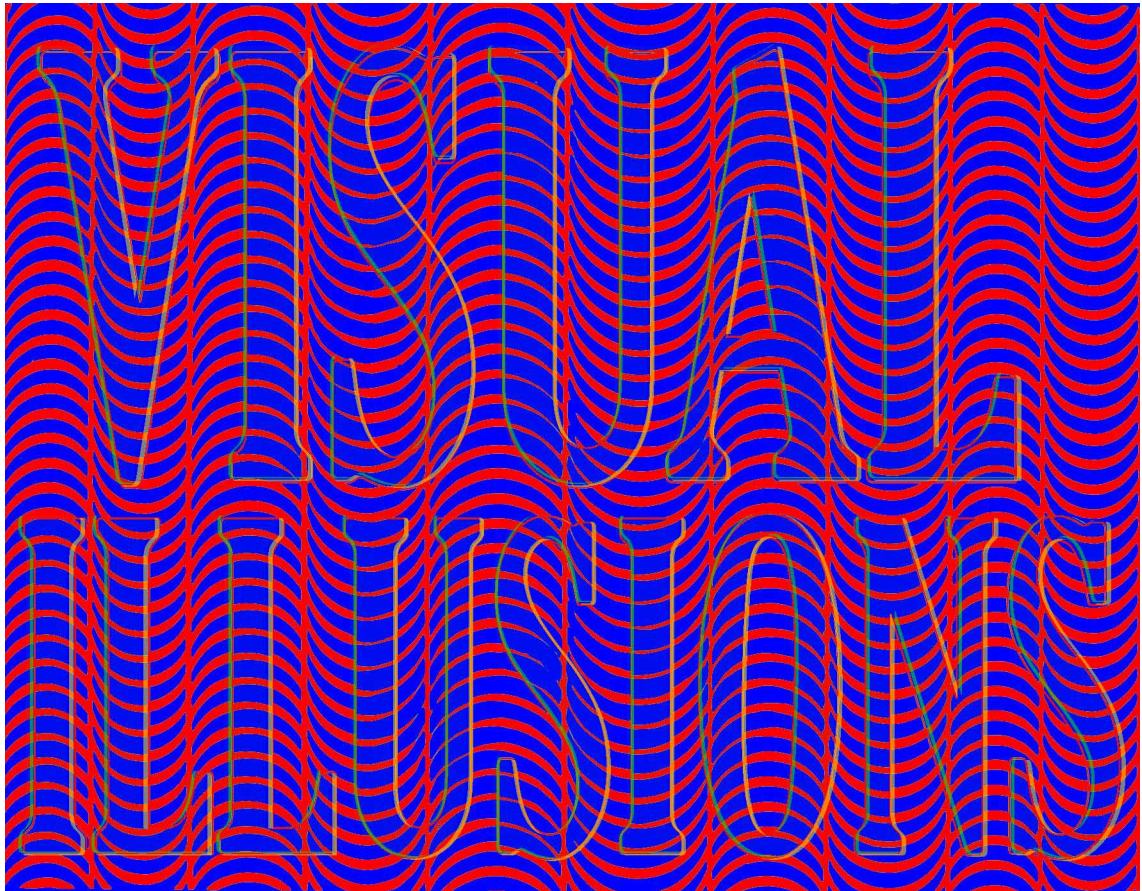


Figure 5. *Allusory Illusions* (© Nicholas Wade).

Illusions are the result of genuine and consistent mistakes in our perception (Gregory 2009; Ninio 2001; Robinson 1972; Wade 1982, 2005a), as in misjudging the orientation of the red vertical lines in Figure 5. That is, a constant mismatch occurs between perception of an object property and the physical description of it. The lines are physically vertical and parallel even though they appear to be tilted away from one another. This is because of the wavy lines they cross: without them the lines would look parallel and there would be no illusion. Illusions are unitary and compelling perceptions, whereas allusions involve the perception of at least two aspects of pictures simultaneously. There are two visual allusions in Figure 5. One is an allusion to depth—the wavy lines look like a three-dimensional surface; the depth might appear ambiguous, with one set of curves looking like humps then like hollows, but the depth is apparent while at the same time the surface of the page is seen as flat. This is the most pervasive form of visual allusion we encounter, and it has proved to be one of the most persistent concerns throughout the history of art. Representational pictures have a dual reality: they are perceived as what they are—marks on a flat surface—while at the same time representing objects. They are allusions because viewers do not try to handle the objects depicted as they would the actual objects they represent. There is no doubting the flatness of the surface on which the marks are made. The other allusion in Figure 5 (which is more difficult to discern) is a self-portrait. It might not be immediately visible, but it is there physically in the slight thickening of the blue wavy lines. The geometrical design carries within it, virtually unseen, another picture. It might be necessary to blur the pattern in some

way in order to see the hidden image; some people can do this by focusing their eyes on some imaginary point between the picture and their eyes, and others can do the same by shaking the head from side to side or by shaking the surface on which the picture is printed. This type of visual allusion is rather like a literary allusion, where the indirect reference remains in the background—but once appreciated it cannot be dismissed.

In visual science illusions provide the quintessential examples of eye-cons. Spatial or chromatic features that are physically equivalent appear otherwise because of the context in which they are placed. Illusions as departures from veridical perception have been a constant source of enquiry throughout the recorded history of vision. Nonetheless, they were imbued with increased significance in the late 19th century. On the one hand, they liberated psychology from physiology and, on the other, they were considered to hold the key to unlock the secrets of perception. Moreover, they could be readily visualised via simple icons which induced compelling contrasts. Paradoxically, some of the first illusions displayed in this form were of phenomena that could be experienced in the natural environment, like the moon and waterfall illusions (Wade 2005a). Helmholtz (1867) was able to see the start of this illusory movement, and he also added a static illusion that is called Helmholtz squares (Figure 6). It is basically an example of the horizontal–vertical illusion: the area defined by horizontal lines appears smaller than that made up of vertical lines.

The illusions that attracted the interests of many 19th-century visual scientists were those labelled “geometrical optical” by Oppel (1856). They consist of relatively small but reliable distortions of visual space, mostly in the domains of size or orientation. Many novel forms were devised and depicted in the final decades of the century, and they often bear the names of those who first drew and described them (see Vicario 2008). Geometrical optical illusions are phenomena of the late 19th century, when the likes of Ponzio, Poggendorff, Mach, and Müller-Lyer described their eponymous phenomena. It is, however, instructive to examine why there should have been this burst of illusory activity in the late 19th century. Put another way, why did icons assume such a central role in the study of visual perception? It could have been due to the combination of two powerful strands of thinking about vision. The first stems from the 17th century, when Kepler and later Scheiner elucidated the dioptrical properties of the eye. They thereby set in train the idea that the problem of perception has an icon as its starting point—the static, two-dimensional retinal image. The retinal image was considered as static, and the problem was seen as restoring the missing dimension of distance from the ambiguous projection. However, this is both a physical and a physiological fiction.

The static retinal image is a convenient physical fiction because it allows us to draw ray diagrams that describe the dioptrical properties of the eye. It is a physiological fiction because the eye is never still and the receptors collect energy at differential rates depending upon wavelength and luminance. Nonetheless, these fictions continue to drive our models of vision. The second strand relates to the experimental approaches to the study of perception introduced in the mid-19th century. Wheatstone (1838) and Helmholtz (1867) argued that experimental rigour of the physical sciences should be brought to bear on the study of perception. Thus stimulus variables should be isolated and manipulated in quite unnatural ways in order to determine how perception is modified. It is difficult to manipulate solid objects, but it is exceedingly easy to create novel pictorial images or icons. Moreover, Wheatstone himself had shown that the perception of three-dimensional space can be synthesised from the use of two appropriate flat drawings. So pictures or icons became the accepted stimuli for the study of vision. Once accepted, the psychologists then rediscovered eye contricks that had been a part of the artist’s armoury for centuries, and they devised some novel ones, too (see Pinna and Reeves 2009, Wade 2007a).

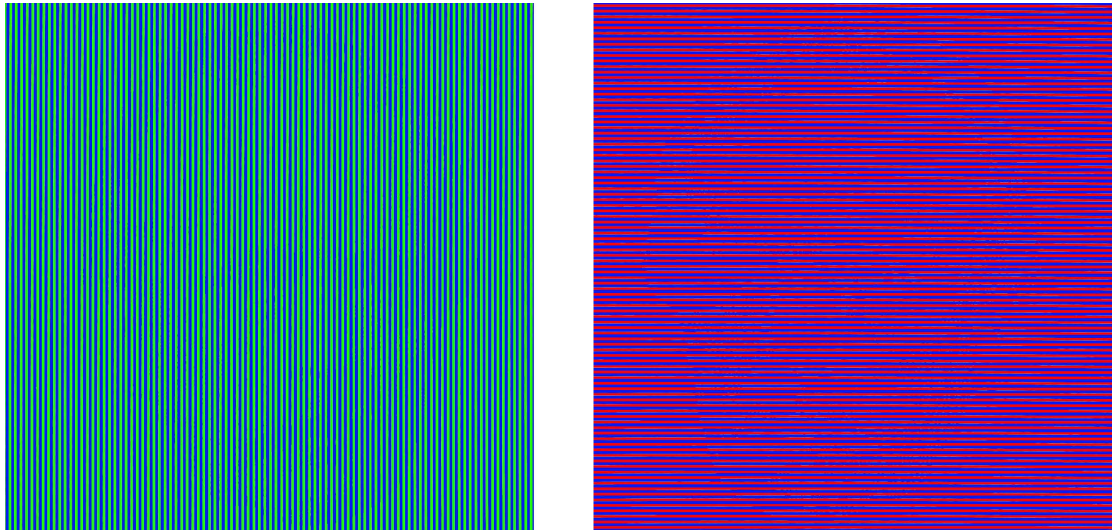


Figure 6. *Helmholtz Squared.* Helmholtz is enclosed twice within squares like those he printed, defined by either vertical or horizontal lines; the blue lines are physically the same throughout (© Nicholas Wade).

The Helmholtz squares illusion is based on the distortions of space in the cardinal orientations. It is now called the horizontal–vertical illusion, and it is usually represented as single lines in an inverted T shape. It incorporates both orientation and extent, whereas most others involve one of these dimensions alone. Two orientation illusions are shown in Figure 7. That on the left consists of the original figure used by Johann Karl Friedrich Zöllner (1834–1882; 1860) to show how cross hatchings in opposite directions result in lines appearing to be inclined. Zöllner sent his icon to the journal *Annalen der Physik und Chemie* which was edited by Johann Christian Poggendorff (1796–1877), whose portrait is shown in Figure 7, left. Poggendorff noted that the edges of the cross-hatched lines appeared out of alignment, and his name is now associated with that illusion. A more contemporary drawing of the Zöllner illusion is shown on the right: the concentric squares appear to be distorted because of the diagonal lines that cross them. Zöllner’s portrait is also alluded to in the illustration on the right; it might be difficult to discern initially, but when it is seen his palsied right cheek and lip will be evident.

Illusions of length were represented somewhat later, but they have been subjected to more intense experiment and interpretation than those of orientation. The illusions of Franz Carl Müller-Lyer (1857–1916) and Mario Ponzo (1882–1960) are shown in Figure 8. Geometrical optical illusions have an important place in the history of psychology, because they were amongst the factors that led Wundt to establish his Psychological Institute at Leipzig in 1879—he could not envisage how illusions could be accounted for in physiological terms; and so they, along with consciousness, required a separate discipline. Wundt took as his yardstick the proximal stimulus (the retinal image)—and he could not accept that, say, two linear extents (like the horizontal lines in Figure 8, left) that produced equivalent retinal extents could yield perceptual inequality due to physiological processes. Thus, geometrical optical illusions are important in the context of establishing psychology as an independent discipline: there was considered to be no physiological correlate of perception. Psychologists like Wundt sought to determine correlates, and the one most favoured at that time was in terms of eye movements, although other higher-level alternatives were also entertained.

Contrast phenomena provided another potent source of visual illusion. Although the influence that a surrounding colour can have on an enclosed one had long been known,

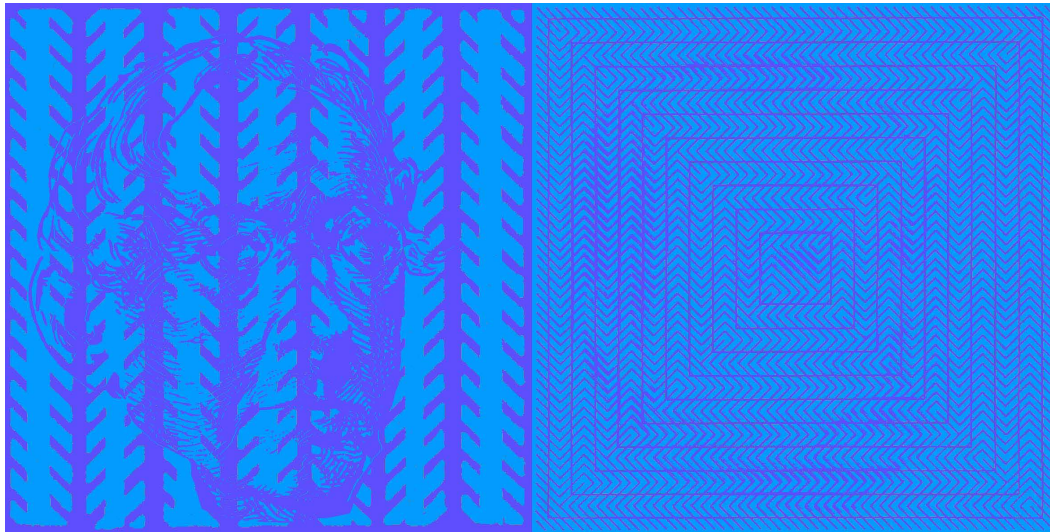


Figure 7. *Illusions of Orientation.* On the left Poggendorff is shown in the diagram Zöllner published in Poggendorff's *Annalen*; it illustrated the illusions with which both are associated. Zöllner can be seen on the right in a modern variant of his orientation illusion; his right eye is centred in the pattern and he is facing to the left (© Nicholas Wade).

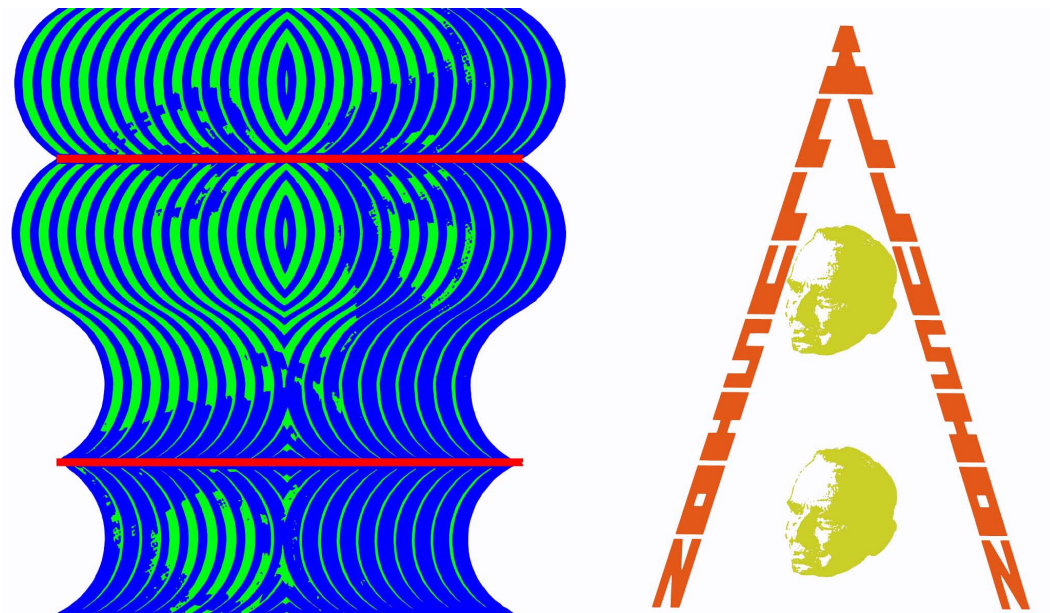


Figure 8. *Illusions of Extent.* Left, the two red horizontal lines are the same physical length but they appear different: the upper one appears longer. This was described by Müller-Lyer, whose bearded features are present in the illustration. Right, converging lines create contrasts in size perception, as is evident in the two same-sized portraits of Ponzo: the upper one appears larger than the lower one (© Nicholas Wade).

subtle effects of brightness contrast were described in the 19th century. For example, Ludimar Hermann (1838–1914; 1870) gave an account of the effects that can be seen in the grid on the left of Figure 9—dark dots appear at the intersection of the lighter lines. He related the illusory dots to the operation of simultaneous contrast. The converse, where light grey dots are seen at the intersections of the darker lines, was described later by Karl Ewald Konstantin Hering (1834–1918; 1907). Hermann's and Hering's original figures were in black and white.

The Hermann grid on the left of [Figure 9](#) contains the face of Hermann, and the Hering grid on the right contains Hering's portrait.

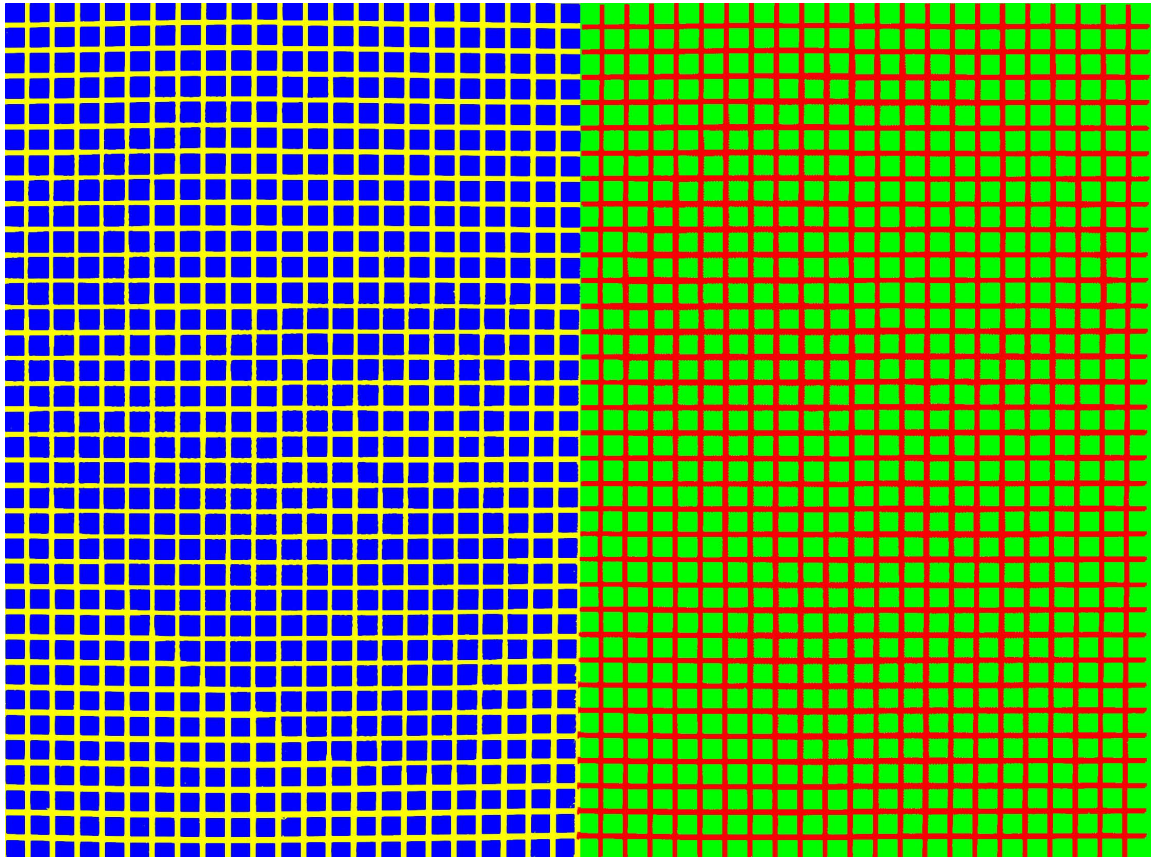


Figure 9. *Hermann-Hering Grids.* The grid on the left contains the face of Hermann, whereas the grid on the right carries the face of Hering. The faces will be seen more easily if the figure is viewed from several metres (© Nicholas Wade).

The Hermann and Hering grids have assumed a position of considerable importance in contemporary visual science, as they have provided a means by which receptive fields recorded physiologically can be related to “perceptive fields” determined psychophysically (see Lingelbach and Ehrenstein 2002; Schiller and Carvey 2005; Spillmann 1994; Wade 2005b). The dimensions of concentric receptive fields are smallest in the retinal ganglion cells receiving their input from the central fovea, and they increase in size with increasing distance from the fovea. This is probably the reason why the Hermann-Hering dots are not visible at the fixated intersection: both the centre and surround would fall between the squares and within the intersections, so that there would be no differential response from them, and no illusory dots. If the separations are made sufficiently small, then the dots can be seen at the fixated intersections. It is by this means that measuring the limiting dimensions of grids yielding the illusory dots has been used to estimate the sizes of perceptive fields at different eccentricities in human vision.

In the 19th century the study of illusions was used to argue for the independence of psychology from physiology. The static proximal stimulus had been described, and so the two lines of the Müller-Lyer illusion would project equal length lines on the retina and visual neuroscience stopped at the retina—so physiologists could not account for the illusion. Illusions were studied in the late 19th century because they were not amenable to the extant

physiology—hence their place in psychology. They also fostered the use of two-dimensional stimuli in perceptual experiments, giving vision the aura of scientific respectability.

4 Pictures as eye-cons

Pictorial images are icons which provide allusions to objects, and some of the eye contricks that can be played with the transition from three to two dimensions. Indeed, this is grist to the artistic mill: icons incorporate ambiguities and impossibilities that are rarely or never present in objects. Are icons so central to understanding perception? What is the relationship between perception of pictorial images and of the objects they portray? Will understanding icons facilitate our interpretations of vision, or vice versa? And how do those peculiar eye-cons, geometrical optical illusions, relate to other forms of pictorial representation? It could well be argued that the study of vision will not be furthered by the examination of such oddities.

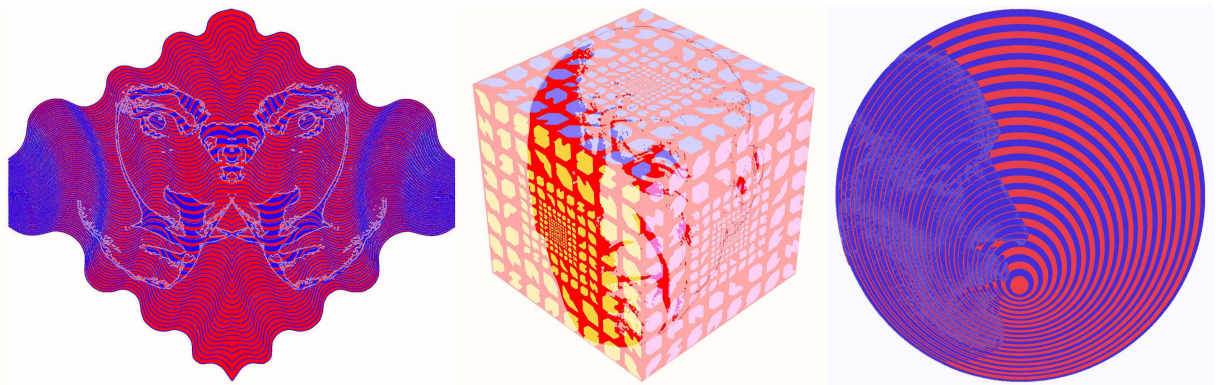


Figure 10. *Allusionists*. Portraits of Dali (left), Picasso (centre), and Duchamp (right) are carried in designs that characterise some of their artistic and visual endeavours (© Nicholas Wade).

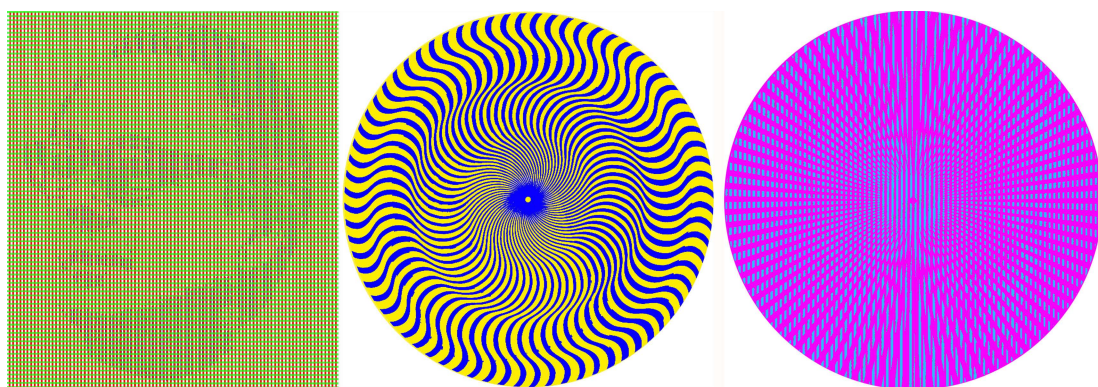


Figure 11. *Oprio*. Vasarely, Riley, and Wilding can be seen in Op Art designs of the type they produced. All include portraits facing to the left, but that of Wilding also contains a right-facing portrait (© Nicholas Wade).

Magritte was not alone in generating subtle eye contricks: others on the surrealist scene were sowing similar seeds. For example, Salvador Dali (1904–89) and Marcel Duchamp (1887–1968) drew upon the emerging experimental research on vision to further their artistic ends. Dali not only amplified ambiguities in many of his early paintings but also presented more subtle variations on the digitised images of Abraham Lincoln, constructed by Harmon and Julesz (1973)—see http://www.michaelbach.de/ot/fcs_mosaic/. Duchamp's

rotoreliefs, produced at around the same time as Magritte's pipe pictures, followed rapidly on the heels of Musatti's (1924) experiments with the stereokinetic effect, where simple circular patterns appeared in depth when rotated—see <http://lite.bu.edu/vision-flash10/applets/Depth/Benussi/Rotorelief.html> and <http://www.opprints.co.uk/stereokinetic-3-4-6.php>. Other kinetic works by Duchamp were based on visual persistence. His *Rotary Glass* consisted of propellers of glass on which arcs were painted: when they were rotated rapidly they created the impression of circles (see Wade 1978). Between both these artists, and influencing them artistically, was Pablo Picasso (1881–1973). The development of cubism represented an attempt to embrace the other missing dimension in icons—time—by capturing views of the same subject at different moments of movement. All three artists are shown in Figure 10. On the left Dali's trademark moustache encloses contours alluding to ambiguous depths from which his third eye peers. In the centre Picasso can be seen within cubist depictions of his name PABLO PICASSO, and Duchamp's profile is part of a pattern that, if rotated, would appear like a cone in depth.

The science and art of vision merge in the genre referred to as Op Art. Op Art is first and foremost geometrical and hard edged: the shapes displayed are precisely defined by sharp edges, and the assemblage is geometrical rather than naturalistic (see Follin 2004; Guigon and Pierre 2005; Houston 2007; Wade 1978, 1982, 1990, 2009; Zanker 2004). That is, the works are generally abstract, with no representational features. The aspect that distinguishes the genre from many other forms of geometrical abstraction is the dramatic visual effects produced by the arrangements of contours. The works induce an immediate interaction with the observer because the viewer's eyes are a fundamental feature of the interaction between icon and observer. Not only do Op Art works “strike the eye” but they also undergo dynamic changes in the process of observation. This is the context for the meeting between visual art and visual science. One of the leading exponents of the genre was Victor Vasarely (1906–97), who is dimly discernable in the red-and-green grid shown on the left of Figure 11. Vasarely constantly experimented with geometrical abstraction, and he tried to remove the imprint of personality from his work, much of which can be mechanically produced. His concern was with simple geometrical shapes like circles, squares, and triangles, and he varied the sizes, colours, and relations between these in many ingenious ways (Holzhey 2005; Vasarely 1965). He produced a large number of works in stark black and white, and these were often visually vibrant—they would appear to move, or the shapes would seem to reorganise themselves into novel configurations. These marked the beginning of Op Art in the 1950s. Later, he worked more with colour, often using synthetic materials for added intensity. Another pioneer of Op Art is Bridget Riley (Figure 11, centre), who is best known for her high-contrast, black-and-white paintings of geometrically periodic patterns. Movements and distortions of the patterns are seen even though none are occurring on the picture plane (Kudielka 1999; Riley 2001, 2009). The dynamic changes are a consequence of processes within the visual system of the observer, and so they are truly interactive paintings. Her portrait is embedded in a drawn design that displays many of the visual distortions seen in her paintings. The wavy radiating lines appear to shimmer and move, particularly around the inflection points of the curves; the contours fluctuate in clarity, being sharply defined at one moment and blurred at the next. These changes are a consequence of minor variations in the curvature of the crystalline lens, which produce transient astigmatism. It is when the contours are blurred that Bridget Riley's portrait can be seen. The wavy lines also display another phenomenon—that of impossible figures. The contours can appear to represent a three-dimensional surface, but one that could not be realised: curves which appear like bumps on one side look like hollows on the other. Following a hump or hollow from one side to the other will result in an inflection of the surface near the vertical midline, adding to

the visual tension generated by the design. Both Vasarely and Riley (as well as the other Op Artists) were, however, drawing on a longer tradition both in visual science and in art.

When two periodic patterns are superimposed, slightly out of alignment, a new configuration emerges that is determined by the intersections of the component patterns. This is called a moiré pattern (after moiré antique or watered silk, which has a pronounced parallel weave). When two gratings are inclined relative to one another, the dominant impression is of the parallel moiré interference fringes due to the regions of minimal overlap of the gratings. It is obvious from the name alone that moiré patterns have long been observed, but they have also proved to be of interest to physicists over the last century. Illustrations of more complex moiré patterns can be found in textbooks of optics as well as in many art galleries; examples can be found at <http://www.opprints.co.uk/moire-fantastic.php>. Moiré patterns have proved particularly potent in the works of a number of Op Artists. One of the greatest exponents was Ludwig Wilding (1927–2010), who is shown in Figure 11, right. The interference fringes are due to the interaction between a vertical grating and a radiating pattern. He is portrayed twice, facing left and right, with his features defined by slight variations in the sizes of the elements. Small separations in depth between the interfering components magnify the depth seen in the disparate moiré fringes, and Wilding utilised this effect to create a novel form of stereoscopic stimulus (Wade 2007b).

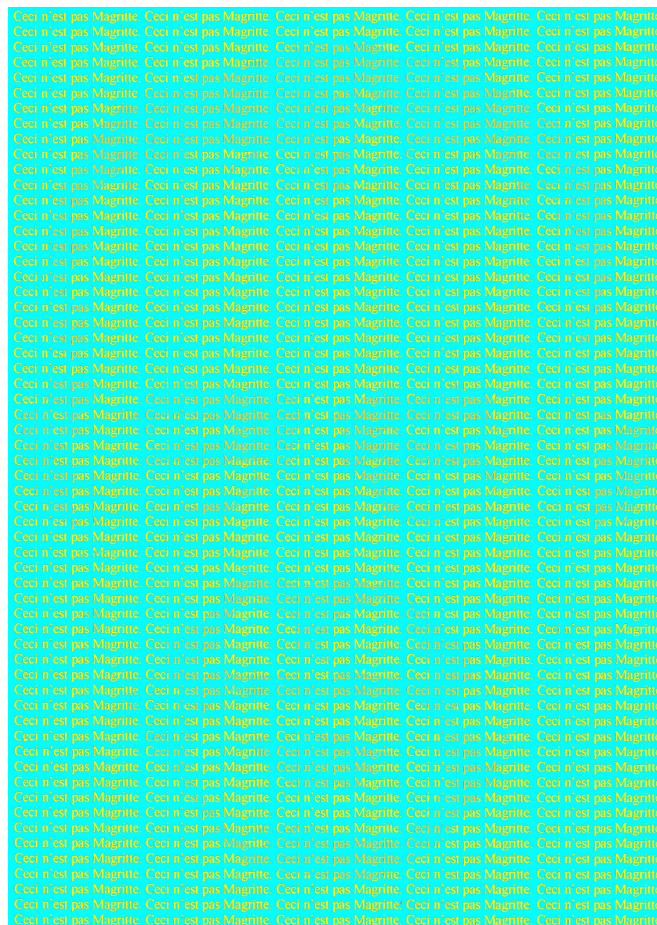


Figure 12. Ceci est Magritte (© Nicholas Wade).

This selected survey of eye contricks has now come to an end. As was intimated at the outset, it is rarely the eye that is being conned by icons, but it is the brain that is struggling to find the solution to the paradoxes that pictorial images pose. Magritte was concerned with

eye contricks—demonstrating the allusory nature of all images—and so it is fitting to end with one of him (Figure 12).

5 Conclusion

To question the appropriateness of icons as the stimuli for vision is more subversive than it might at first appear. Are not our ideas of the retinal image also iconic? We have certainly progressed in our physiological knowledge since Wundt; indeed, there are now physiological interpretations of illusions. But have our ideas about the nature of the retinal image advanced also? Visual phenomena provide the bedrock for science and art. Both disciplines revel in the license allowed by iconic manipulation. Natural vision is binocular and dynamic, yielding the perception of depth and motion. Icons are flat and static, but, when modified and presented via a computer, they can present us with perceptual paradoxes. The deeper puzzle is whether visual science is being conned by icons. Is it being seduced by the simplicity of image manipulation and losing sight of the functions that vision serves? Is vision now the science of eye-cons?

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