Using illusions to teach children about the science and art of seeing

Sara J Downham
R Beau Lotto
David Strudwick

The principal way that people draw information from the world is through the visual system. Yet the seemingly coherent view we gain about the world is a creation of our brain, and not necessarily an accurate representation of how things really are. This can be vividly illustrated by illusions, which have delighted and bemused for generations. But as *Sara J Downham, R Beau Lotto*, and *David Strudwick* point out, illusions offer the potential not just to teach about visual perception but also to act as an illustration of the brain's role as an active interpreter rather than a passive observer.

An illusion is the phenomenon of perceiving something different from what is physically there. This chapter will describe why illusions may be a useful tool in the classroom for learning how and why we see what we do, and consider how the exploration of illusion encourages children's (and adults') curiosity, creativity and confidence (the three 'C's). The chapter is divided into three sections. The first describes the science of seeing illusions: why we see them and what it tells us about how the brain works. The second section describes one example of applying this scientific understanding in the context of an art project in a primary school classroom. The third section explains the importance of using illusions to break with some received methods of learning and teaching by emphasising the ambiguity of learned and inherited truths and conventions, with the implicit aim of encouraging children to respond more empathetically to the world around them.

The science of seeing

The 19th-century French painter Delacroix exclaimed: "Give me the mud of the streets and I will turn it into the luscious flesh of a woman, if you will allow me to surround it as I please." Goethe in the mid-19th century 'discovered' that a grey shadow appears anything but grey when surrounded by light of a different colour. The effects of the surround on our perceptions of colour are well known and have been much explored by philosophers and artists for centuries. What remained unknown until recently is why we see illusions at all, or more generally, why context matters. Answering this question is the topic here, and explaining why the answer is important for models of pedagogy and learning is the point of the chapter. When you open your eyes you are aware of objects, shapes, shadows, locations in space, a relatively stable world (even though your head may be moving); you see people, dogs, trees, the blue sky and the yellow sun…a coherent whole and you do so immediately… or at least it feels that way. But is this what your eyes see? Not at all – and this is important! What your eyes see are objectless, complex patterns of light. More accurately, your eyes see *completely ambiguous*, objectless, complex patterns of light, patterns of light that could – literally – mean anything. This is because images of the world are not the world itself.

There are many differences between images that fall onto the eye and the world that creates those images. For instance, the retinal image does not represent the colours of surfaces and illuminants directly, but only indirectly. The reason is that surfaces cannot be seen unless they are illuminated: no light and the world disappears; turn on the lights, and the light passes through the air, bouncing off surfaces in its path until it eventually hits the back of the eye. When the light hits a surface, its spectral composition changes according to how well the surface reflects the light's different constituent wavelengths. This means that the light that the eyes see is determined by the 'colour' of a surface and the 'colour' of its illumination. Change the colour of an object's illuminant – by placing it in the darkness of a shadow, the yellow of sunlight or the blue of skylight, for example – and the quality of light hitting the eye from that object will change even though the object is physically unchanged itself. Since a blue object under yellow light will look the same to the eyes as a yellow object under blue light, and similarly a dark grey surface under bright light will reflect the same amount of light to the eye as a light grey surface under dim light, each image the eyes see could – literally – mean any of an infinite combination of objects and illuminants. Clearly, then, if you are to see effectively, seeing the retinal image is not going to do it: there simply isn't enough information in the retinal image. So how, then, do we see? How does the brain translate the ambiguous images of the world that fall onto the eye into perceptions that will be used to influence our behaviour? The brain can use only information that it has direct access to: the surrounding context and what that contextual information meant for behaviour in the past. Put another way, the brain solves the ambiguity of images because it has evolved the ability to find useful patterns in images, and to associate those patterns with previous behaviour that accord with past experience.

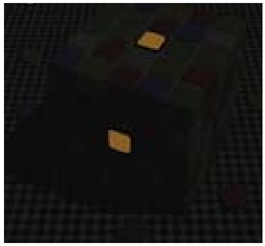
Our interpretation of language is an example of the power of this fundamentally empirical process of seeing. Like images on the retina, letter strings are, of themselves, meaningless. The letter string:

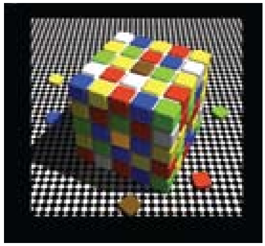
'H W AR Y U RE ADI G THI ?'

means nothing. And yet most of you will read something coherent in it. Why? Because your brain, through its past interaction with the world (in this case the world of language), retains in its architecture an understanding of English. So while there is no a priori reason to put any letter between the 'H' and the 'W' in the above letter string, because it was useful to put an O there in the past, you reflexively do so again here, which is why you read the word 'HOW'. The same is true when you see colour.

Look at the small 'spots' in figure 1, which reflect the same amount of light to the eye. The two – not surprisingly – also look the same. But consider the fact that these two dots could actually have arisen from many different possible real-world sources. For instance, rather than arising from similar surfaces under similar lights, they could just as well have arisen from a dark surface in bright light on the one hand, or a light surface in dim light on the other. What happens if we provide contextual information that is consistent with these possibilities?

Well…look at the cube in figure 2. There are 25 tiles on its top surface that appear to be under direct light, and 25 tiles on the side of the cube that appear to be in shadow. There is a central tile on each of these two surfaces. On the illuminated surface this central tile appears brown, but bright orange on the shadowed surface. And yet these two are in fact the same tiles from figure 1. That is to say, the actual 'reality' of the scene is that the two tiles reflect the same amount to the eye, as shown in the 'mask', but this is not what you see. Instead you see what would have been useful to see in the past: that the tiles are different.





From top:
Figure 1: The 'spots' reflect the same amount of light to the eye and look the same.
Figure 2: The central tile on the illuminated surface appears darker brown than the central tile on the shaded surface, yet they are the same tiles shown in figure 1.
Beau Lotto

The art of seeing

Illusions tell us how the brain works. It constructs what it knows by searching for useful patterns in sensory information and then associating those patterns with a past record of their behavioural relevance. Which means that the brain is innately a creative and curious machine that evolved to continually redefine normality, a 'normality' that is necessarily contextual and historical, and on which one's perceptual truths are based. This point is relevant to all aspects of human thought, and can (and should) be explored at an intuitive level in the classroom through art.

There are a number of ways of engaging children with this point. One way is by enabling children to build physical models of illusions that are typically only seen in books or on the web. With these models in hand one can then explore why it is we see what we do. Another approach is to give children the opportunity to actively engage with the creative processes by which we actually construct our perceptual and conceptual truths, which – as described above – underlies why 'context is everything'. Here we describe an example of the latter approach, which took place in 2007 at Blackawton Primary School in Devon with five-to-six-year-old children. The school's head is David Strudwick – co-author of this chapter, and the workshop was undertaken as a collaboration between Beau Lotto and visual artist Sara Downham (also authors of this chapter).

The first day focused on 'the patterns we see', beginning in the children's immediate environment: the classroom. Before starting, the children were gathered together on the carpet, where the afternoon's activities were explained. There we elicited from them their understanding of what we might mean by 'the patterns we see'. Their ideas and descriptions were written on the board, and were discussed as a group. A typical relationship was between pattern and surface texture. An abstract notion was that a pattern was something that repeated across space (though that the repetition need not be exact, or even made up of all the same material).

The children were then put into several small groups and in those groups the game was to find as many visual patterns as possible, and re-create them using paint, pen and paper. Note that the aim wasn't to draw the objects in the classroom, but to represent the patterns that make up objects and to capture the spaces in between. Next the children were taken outside, where they repeated the task: observing and discovering patterns in nature, again drawing them on paper and – where possible – bringing the objects they had chosen back to class. When back in the classroom, they reassembled in their groups and, using words and pictures, they explained to the rest of the class the patterns they had found. Particularly imaginative examples included the branching patterns of trees, the texture of grass, the repetition of the carpet tiles, yellow lines on the road, the symmetry of a face, the stripes of a bumblebee, and the repetition of window, frame, window, frame of the school bus (as well as the tread on its tyres). It was a highly enjoyable activity – led largely by the children – that fostered their ability to observe, and resulted in abstract drawings and paintings. This emphasis on observing and re-creating patterns gave the children a fuller sense of the world around them.

The second day followed a similar programme to the first, with the exception that the focus was on the patterns we hear. As before, the children were initially gathered together on the carpet, and after explaining to them what was going to happen during the next couple of hours, we asked them to describe what we might mean by 'the patterns we hear'. Repetition of sound was the principle description. We then elicited from them examples of natural and artificial sound patterns, which we listed on the board: the lapping of waves, the dripping of a leaky tap, the running of a horse, the call of a bird, the beating of a wind turbine. After making this list, the children were encouraged to use their hands and feet, and were given instruments, sticks, books and so on to use to re-create some of these patterns. They were also given the chance to use these instruments (as well as the floor, whistling, humming, clapping, etc.) to create their own natural-esque patterns (both individually and in groups). This led on to discussions of music, or more generally to talking about 'the created pattern': the beating of the drum, the strum of a guitar, rhythm and beat, and thereby relating musical concepts to acoustic patterns that occur naturally. We also provided the children with examples of different kinds of musical pattern, and – as before – the children were given the chance to make their own music.

On the third day the children gathered on the carpet – this time in a circle, where we revisited the ideas and experiences of the previous two days. We then began a process of eliciting from them the potential relationship between the patterns we see and patterns we hear: What might the stripes on Misha's shirt sound like? What about the branching pattern of the tree outside the window? Or black-and-white stripes of a zebra? The children volunteered many ideas for relationships: "I think the petal pattern of flowers would sound like this…", "I think the pattern of carpet might sound like this…". Tempo was strongly related to the frequency of the pattern, though they also incorporated colours (or more generally the colour contrast) into their translations, with strong colours usually

sounding louder than weaker – less saturated – colours. The sound of alternating thin black-and-white lines on a zebra, for example, had a higher tempo and sounded louder than the thick black-and-white shadows across the wall.

The children were then organised into smaller groups, and given a large black piece of paper, upon which they were asked to create their own visual pattern using paint, paper cut-outs, pen and pencil (called 'mark-making'). Their task was to think less about the visual pattern in terms of what it 'looked like', and more in terms of what it might sound like. In essence, the children were being asked to create a piece of music, not with notes on a stave, but with colour (which we call a 'colour score'). One could literally hear the children 'humming their image' as they created it, all of which are shown in figure 3.

Each child's colour score was then photographed with a digital camera, and sent to the lottolab in London, where they were uploaded into 'Synesthetic', which translates colours into musical notes in space and time. To get a sense of this program, imagine a horizontal line a few pixels high scanning down an image from top to bottom. Now imagine that this line is made up of 32 consecutive boxes, and that each box represents a musical instrument – a violin, a piano, drum, etc. The note each instrument plays at any point in time is directly related to the average colour in its box at that location of the image. As the line scans down the image, the colour of each box changes, and how it changes depends, of course, on the child's image. This process changes the instruments' note in time, which means that time is encoded along the image's vertical axis and tone across the image's horizontal axis. This means that each image is literally the score of a musical composition. The instruments (or ensemble) included violins, cellos, woodwind and brass instruments. The Synesthetic program then takes each digitised image, scans it from top to bottom, translates each pixel into a note, plays that note in stereo, with the sound arising in

Left:
A 'colour score' created by children asked to create a piece of music with colour.
Beau Lotto

space according to its horizontal location across the page, and then saves the whole process as a QuickTime movie on a DVD. These movies were then given to each child.

The results were fabulous. Not just in the sounds and music created, but also in the children's responses to their own and to their classmates' compositions. Not only did each child want everyone else to hear their composition, but also they wanted to hear the compositions of others. In other words the children took pride in what they had created, as well as in the works of their classmates, partly because the activity was so novel that they had no basis for competition.

But did the children learn what we had hoped they would? The answer seems to be yes. For weeks afterwards, the children who took part continued to discuss with each other and the teacher the sounds that different visual patterns might make (and vice versa). Parents, too, positively reported to the headteacher that their child, "who was not previously artistic", was coming home and "doing art". In other words the children continued to apply the idea of actively exploring their environment and in doing so finding and creating new (abstract) patterns of relationships therein. Thus, the objective of getting the children to look beyond the obvious – to consider the relationships between things, by providing them with a wholly new kind of experience, one that was both very interesting and resulted in a high-status outcome – fostered the brain's innate process of redefining normality.

Illusion as metaphor in eduction

Illusions show us that the mind is an evolved machine that continually redefines normality. It is a machine that innately searches for, and creates, relationships and patterns from sensory information, and this information is then used to guide behaviour. Thus, illusions ultimately tell us who we are as individuals: creators, defined by our history of interaction. For the world of education and learning, the important suggestion is that it is not the event that defines us, but that we are defined by our interpretations of our experiences.

Fleas in a jar learn that they can only jump so high without banging their heads. As a result, when the jar is removed, their jumping behaviour is constrained to the height of the jar. Children who are teased in lessons for being wrong experience the equivalent of banging their head on the roof of a jar. The process contributes to their overall history of experience, which necessarily contributes to their future understanding of the world and of themselves. Most commonly such children – understandably – conclude that they are no good at particular lessons with the result that the next jump is 'safer'…one less high, or at least a level lower than their potential! Such an association can become self-reinforcing, since – especially in social and emotional areas of learning – we tend to see only those patterns that support our world-view. In other words, if you believe that you are no good at something, you will come to see the world through that filter, finding, collecting and creating information that supports this 'truth'. This process of creation and re-affirmation can lead to irrational, but very real, fears that stop us from attempting new experiences, of seeing things differently. Instead one adopts strategies for dealing with these fears. For example, children are often amazed when they learn that others in the class use all kinds of strategies to avoid the challenge of a difficult task: when we are really learning it is often uncomfortable, since our view of the world is being challenged!

The importance of illusions in breaking negative pattern-matching has tremendous potential. The process of seeing illusion as metaphor has the capacity to foster a different kind of learning: 'this is how you see it now, but with a bit of courage it is possible to see it differently'. By supporting children through physical instances where the same object can be perceived differently, children can be led away from the admittedly more comfortable black-and-white view of the world to the more challenging but also more enlightening realisation of the greys in between. The learner can be shown in real terms that their perceived truths are not necessarily *the* reality, but *one* reality among others. In this way, illusions can help learners to become positively excited about getting things wrong, since it is through 'getting things wrong' that we begin to see things differently, or at least more wholly. By going beyond the 'refrigerated facts' of the black-and-white, towards the more open-ended view of relationships, children can develop the ability to respond empathically to others by considering the potential meanings of an event, action or object that is outside of their own histories.

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