by Earthwatch Institute (Europe) and the Natural History Museum (London, UK) in association with the Earthworm Society of Britain. "Earthworm Watch" was launched for a first instalment to run through April and May, but it will continue each autumn and spring, which is the time when the worms are most active, as Dr Jenny Cousins from Earthwatch Institute explains. She and her colleagues have already registered several hundred participants, and the data collected will be analysed and disseminated in a range of publications and outreach events over the next three years. The project pack provides instructions and materials for lay participants of all ages to conduct a detailed survey of worms on two small plots in their gardens — or any other place where they can get permission to dig two holes (http://earthwormwatch.org/).

The instruction booklet (also downloadable as a PDF file) suggests to survey two 20 cm x 20 cm plots that either represent different types of habitat (e.g. lawn or flowerbed) or that have been treated in different ways (e.g. with and without fertiliser use). For each of these, volunteers should dig up the soil to 10 cm depth, recover the worms from the soil, and then pour in mustard water to encourage worms from deeper layers of the soil to come up.

Tables and helpful advice are provided to further characterise the worms that show up and to describe their soil environment. Participants learn to distinguish between adult and juvenile worms, as well as between deep-living, surface-feeding and soil-feeding worms. A simple acid test using vinegar clarifies if the soil contains carbonates.

Thus, anybody with access to a patch of land can now follow in the footsteps of Charles Darwin and contribute to our knowledge about those helpful worms that enable the soil to provide our food. Rather than taking them indoors and playing piano for them, however, Earthworm Watch suggests to return them to the hole and to fill up the soil.

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Essay

Magic and cognitive neuroscience

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In recent years, neuroscientists have shown an increasing interest in magic. One reason for this is the parallels that can be drawn between concepts that have long been discussed in magic theory, particularly misdirection, and those that are routinely studied in cognitive neuroscience, such as attention and, as argued in this essay, different forms of memory. A second and perhaps more attractive justification for this growing interest is that magic tricks offer novel experimental approaches to cognitive neuroscience. In fact, magicians continuously demonstrate in very engaging ways one of the most basic principles of brain function — how the brain constructs a subjective reality using assumptions based on relatively little and ambiguous information.

There appears to be a fundamental rule in magic: never perform the same trick twice. It is indeed common that, when an observer left wondering in amazement asks, or rather demands, that the magician repeats a trick, he will very politely decline and move on to something else. Harry Houdini, one of the most renowned magicians of all time, used to debunk the so-called psychics and other conjurors. About a century ago, he posed the challenge that, if shown any trick three times in a row, he should be able to figure out how it is done. On February 1922, during the Society of American Magicians convention in Chicago, Dai Vernon — at the time a young unknown magician who would later become a father figure of close-up magic and would be known as "The Professor" or "The man who fooled Houdini" — happily obliged. He asked Houdini to pick a card and sign it with his initials. He then lost the card in the deck and "Abracadabra", the card appeared on top. He proceeded to lose the card again and, once more, the card ended up on top of the deck. He repeated the trick a third time and, at Houdini's request, who remained clueless, he continued to do so up to seven times.

In fact, Vernon could have repeated what is now known as the "Ambitious Card Trick" the whole day long and Houdini would have never figured it out. For, as famous as he was as a remarkable escapologist, Houdini was only a novice magician. What he did not realize was that Vernon kept changing the method he used to make the card appear on top (for a detailed description, see [1]). That was Houdini's failure: he could not avoid making the perfectly sensible assumption that Vernon was always repeating the same trick. Thus, to refine the initial statement, the general rule for the magician is to never repeat the same trick using the same method (but see [2] for exceptions).

Repetition is a very powerful tool for conjurers. As psychologist Norman Triplett put it in a very comprehensive review at the turn of the 19th century [3]: *"First actually do what the spectators are to be led to believe you do… make a genuine experiment several times, then, when the association has been formed by repetition, a pretended experiment is made and the subject by reason of the suggestion responds as before"* (pp. 489 and 491). Triplett illustrates this principle with the "Vanishing Ball Illusion", in which a ball (or some other object) is thrown vertically a number of times and then, upon the final throw, it magically vanishes while in the air (pp. 492). The trick is no more sophisticated than the one we use to fool a dog running baffled after a stick he cannot find, which, instead of been thrown, remains concealed behind our backs. The first set of repetitions imprint a cause–effect association. The magician performs the movement of throwing the ball and it follows that the ball is then in the air, time after time, until he makes the same movement but keeps the ball concealed in his hand and it seems to have disappeared.

Con artists use the same principle in the "Three Card Monte" game: they place three slightly combed cards face down on the table, one of which is, for example, a Queen of Hearts that the audience has to follow; then they quickly rearrange the cards and whoever feels audacious enough to try his odds has to

place money on the one he believes is the Queen. The power of the deception is, however, not due to the intricate manoeuvres performed by the con artist — after all, it is not that difficult to follow — but due to the fact that he has an associate who appears to keep losing money by making obviously wrong choices. The observer then believes it is trivial to follow the card, as he is always getting it right while the associate is betting, but once he decides to bet himself, with a simple sleight of hand the con artist changes the method and he will lose time after time without ever realising why.

To the naïve observer, magic relies on myths such as "the hand is quicker than the eye" or on the fact that the magician diverts the audience's gaze and, while they are distracted looking at a glamorous assistant, he performs the trick out of sight. This is, however, far from truth. The way magic is achieved is actually much more interesting. In the late 19th century, the philosopher and amateur magician Max Dessoir observed: *"Apparatus and instructions do not reveal the kernel of modern magic… That which makes prestidigitation an art of deception, is not its technical appliances, but its psychological kernel. The working out in the realm of the senses of certain capacities of the soul is something incomparably more difficult than any finger-skill or machinery."* [4].

So, with very few exceptions, like the initial manoeuvre of the "Three Card Monte", or the "Snap Change" and the "Shape Shifter" sleight, in which one card changes to another in front of your eyes, the vast majority of close-up magic tricks do not require blink-of-an-eye fast sleight of hand. The secret magical moves can be performed relatively slowly and you will still fail to perceive them. Second, diverting attention by making you look to the side while the trick is performed is considered low class magic. It ruins the magic effect. There is a perfectly reasonable explanation: the trick was done while you looked away. With good magic, you should end up with the feeling of having absolutely no clue how the trick could have been performed. You are puzzled and amazed, and as Juan Tamariz, one of the most renowned close-up magicians put it [1], a good trick should leave you with one possible explanation: it has to be magic.

So, the key ingredient of modern magic is neither fast hand dexterity nor forcing the audience to look away. On the contrary, to a large extent it is based on what Vernon used to fool Houdini: playing with our relatively limited ability to attend to all incoming data (and to later recall it), which is compensated for by unconscious, unavoidable assumptions. Vernon made use of a very simple assumption, whose roots go back to the thoughts of 18th century philosopher David Hume: if an effect is repeated over and over again, it is difficult to avoid inferring that it always has the same cause. This is when magic gets interesting to cognitive neuroscientists; when a two-thousand-year-old art form shows different aspects of how the brain constantly uses inferences to make sense of the world around us, and how magicians break these inferences at will to let us believe what seems to be impossible.

Repetition is, however, just one of a large repertoire of tools that conjurers use to play with your assumptions at will. In general, the idea is quite simple: you cannot possibly process all the information that is presented to you; you need to select a few facts and infer the rest, but, unbeknown to you, the magician, with his apparently casual movements, posture, patter, timing, gaze and so on, will influence the facts that you unconsciously process and the ones that you leave aside. This is the cornerstone of magic: the concept of misdirection.

Misdirection

It has long been recognised that the success of a magic trick critically depends upon subtly deviating the spectator's focus away from 'the method' [3–6] — the actual technique used to cause the magic effect. I will not attempt to give a precise description or classification of misdirection techniques, as these have been largely covered elsewhere [7–9]. But I will focus on three main forms of misdirection, because they are tightly linked to cognitive neuroscience and, particularly, to memory processes, as I will argue in the next section.

A first form of misdirection deals with spatial and temporal attention — when and where the conjurer gets the spectator to focus his interest. This is far from the distraction of having the spectator looking away while the trick is performed. The deviation of attention should be subtle and remain unnoticed. The spectator should be left with the feeling that he has been carefully looking at the trick the whole time, which is the fuel that ignites his amazement when seeing the magical resolution. Therefore, rather than using distraction, the magician skilfully plays with bright and dark spots of attention.

Let us illustrate this with an example. Figure 1A shows a professional magician, Miguel Angel Gea, performing the well-known "Coin Vanishing Trick": he holds a coin in his right hand, then he tosses it to the left, holds it there, and then shows that it has disappeared. Of course, the coin remains concealed in the right hand. The figure shows the four main stages of this trick, with the points of fixation of several subjects (measured with an Eye-Tracker), while they watched a video of the performance. Note that he starts looking at the coin on his right hand, and this is where all subjects look at. Next, he momentarily looks at the (virtual) spectator while doing the false transfer manoeuvre, and most of the subjects who later claimed to not have seen how the trick was achieved (red crosses) looked at this face, while the others (green crosses) kept looking at the hand.

We note, in passing, that this effect is much stronger when the spectator observes the trick in person, because inherent social habits make it virtually impossible not to look back at a person who suddenly looks at you. When Gea apparently holds the coin in the left hand, he changes his gaze and body posture towards it. This sets the bright spot of attention, while the hand concealing the coin remains in the dark. All subjects inevitably focused their attention and gaze to the left hand until the resolution of the trick. Figure 1B shows exactly the same trick, but this time Gea kept looking at his hands (rather than at the observer) when performing the false transfer. In this case, most subjects looked at the manoeuvre and reported seeing how the trick was done.

The magician diverts attention away not only from the location but also from the time when the deceiving manoeuvre happens. Imagine that the magician now wants to repeat the coin vanishing trick. He starts with the coin on the table; he slides it to the border to pick