What can magic reveal about the brain

Gustav Kuhn & Cyril Thomas

Corresponding author: Gustav Kuhn

Full Postal Address – Department of Psychology, Goldsmiths University of London, New Cross, London, SE14 6NW, UK

E-mail: G.kuhn@gold.ac.ul
Telephone: +44 (0)20 7296 4388

Co-Author Author: Cyril Thomas
Full Postal Address: Institut de Psychologie
Université, Paris Descartes 71, avenue Édouard Vaillant, 92100 Boulogne-Billancourt, France

E-mail: cyril.thomas@univ-fcomte.fr

Abstract:

The art of magic relies on tricking our brains into experiencing the impossible. Years of performance experience has allowed magicians to refine and perfect their deceptive techniques, and scientists have now started to investigate these techniques to help uncover some of the mysteries of the human brain. The Science of Magic has become a field of its own right, and huge advances have been made in furthering our understanding why these illusions work. We review the latest scientific research on magic and misdirection and explore what these deceptive techniques tells us about perception, memory and reasoning.

Key words: Magic, Misdirection, Illusion, Deception, Attention, Perception, Memory, Reasoning, Consciousness, free will, meta-knowledge,

Main Text

Stage magic allows us to experience the impossible, and these artful performances captivate people of all ages and cultures. Magic deals with some of the most fundamental psychological and neurological questions – consciousness, free will, belief, deception – and yet, it has received far less scientific attention than most other artforms (e.g. music, fine art). In recent years scientists and magicians have started to collaborate and they are studying the cognitive

and neural mechanisms that underpin these unique experiences (Kuhn et al., 2008a, Rensink and Kuhn, 2015, Thomas et al., 2015, Macknik et al., 2008). The science of magic has now become a research field of its own right, and in this review, we will explore this new scientific endeavour and review some of this research.

The history of entertainment magic is shrouded in secrecy and mystery, making it difficult to establish its true origin. Many ancient texts mention magical events (e.g. turning water into wine) though little is known about how these demonstrations were created, nor do we have much reliable evidence on the nature of the miracles themselves (Lamont and Steinmeyer, 2018). In 1584 Reginald Scot (1584) published one of the first books on magic that described in detail how psychological and perceptual tricks are used to create magical illusions. Over the years, these tricks have been refined and perfected, and the context of performing live magic has provided magicians a rich testing bed to develop new and more powerful ways of tricking the brain. Today, magic is a popular form of entertainment and magicians have acquired vast amounts of real-world experience in tricking the mind, much of which is documented in books and journal articles intended for fellow conjurors.

Magicians are true experts in manipulating our conscious experiences, but they know relatively little about the nature of the experience that magic tricks elicit in the brain. Magic tricks allows us to experience the impossible and they elicit a wide range of emotional responses (e.g. wonder, surprise, awe, puzzlement, confusion…). At the core of this experience lies a cognitive conflict between the things we experience and the things we believe to be possible (Kuhn, 2019, Leddington, 2016). When a magician pulls a rabbit from a hat, you know that animals cannot simply materialize from nowhere, and yet that is exactly what you have experienced. Parris and colleagues (Parris et al., 2009) used neuroimaging to investigate the neural correlates that underpin this experience of magic. Participants were asked to watch short video clips of magic tricks and control videos that included similar actions but no magic, whilst having their brain activity monitored using fMRI. Their results revealed that the magical experience was associated with the activation in the ACC and the left dorsolateral prefrontal cortex, neural areas which are also involved in more general cognitive conflict such as conflict between automatic and volitional attentional processes (Fugelsang et al., 2005). However, we are still very much in the early stages of understanding the psychological and neurological mechanism that underpin our experience of magic.

Magicians use a wide range of psychological tricks to deceive the brain into experiencing events we believe to be impossible. We can describe magic tricks in terms of method and effects. The effect relates to the magical event that people experience (e.g. rabbit appears from an empty hat). The method relates to the secret deceptive trick magicians deploy to create these magical effects (e.g. sleight of hand). Misdirection lies at the heart of this deception, and yet it is a concept that is relatively poorly understood. Several attempts have been made to develop frameworks that explain misdirection, but most of them are grounded in the magic literature, rather than cognitive science. Kuhn and colleagues (Kuhn et al., 2014) have developed a psychologically based taxonomy of misdirection that attempts to link different misdirection principles to known cognitive processes. This approach is much broader than most previous attempts, and it is based on the assumption that misdirection can be applied to various stages of the information processing stream. Magicians use misdirection to manipulate what people perceive, or what they remember about the trick. However, there

is a large group of misdirection principles that simply manipulate the way in which people reason about the trick, and these principles can be independent of the information that has been encoded and stored. According to Kuhn et al., (2014) misdirection involves a wide range of often counter-intuitive psychological principles that magicians exploit to create their magical effects. Their taxonomy broadly differentiates between principles involving Perception – Memory – Reasoning. This psychologically based taxonomy of misdirection allows us to link magic principles to known cognitive mechanisms and potentially discover new ones (Thomas et al., 2015). We will now take a closer look at how research on magic has been studied scientifically. Our review is broadly structured in line with the psychologically based theory of misdirection (Kuhn et al., 2014).

Perceptual misdirection – Attentional misdirection

Our subjective experience of the world is one of full sensory detail. However Psychological and Neurophysiological research on attention and perception highlights vast gaps in our conscious perception. Magicians frequently exploit this "grand illusion of perception" by misdirecting our attention. Attention processes allow us to focus our limited cognitive resources by prioritizing the processing of attended information at the expense of the unattended sensory inputs. Indeed, research on inattentional blindness and change blindness illustrate that unless we attend to objects or features in our environment, we simply won't consciously perceive them (Mack and Rock, 1998, Simons and Chabris, 1999). Attentional misdirection refers to misdirection principles in which magicians systematically orchestrate the spectator's spatial and temporal attentional mechanisms and much of the research has focused on the nature of these processes and their impact on conscious perception.

Attentional misdirection has been scientifically studied using a range of misdirection paradigms. In the first such study a magician used a range of attentional misdirection cues (luminance contrast, movement, social cues, auditory sound) to misdirect the observer's attention away from salient and fully visible event - the magician dropped a cigarette, or lighter from his hand in his lap (Kuhn and Tatler, 2005) (see figure 1 for description). Since the method was fully visible, some of the participants were able to consciously perceive the dropping object, which allowed the researchers to identify factors that contributed to their conscious perception. Their result illustrate that most participants missed perceiving, what appeared to be a highly salient event, that took place right in front of their eyes (Kuhn et al., 2008b). Moreover, subsequent studies have shown that people vastly overestimate the extent to which they believe they and others would notice these types of events (Ortega et al., 2018). This research illustrates that we are literally blind to events we do not attend to and more importantly we are blind towards this blindness.

Figure 1: Figure 1: a) *The magician is seated at a table across from the viewer. A lighter is on the table. b) He picks up the lighter and flicks it on. c)-f) He pretends to take the flame away and make it vanish, providing a gaze cue as misdirection away from his other hand. At f), the lighter is visibly dropped into his lap. g)-h) The lighter appears to have vanished. Figure from (Friebertshauser et al., 2014)*

Much of the research on attentional misdirection has monitored participants' eye movements whilst watching the misdirection tricks. These eye movement measurements provide valuable online measures of overt attentional allocation, and they also allow us to gain insights into the relationship between where people look and what they see. Most people intuitively believe there is a close link between what our eye fixates on and our conscious perception (Ortega et al., 2018). Much of the research on attentional misdirection has examined this relationship more closely. For example, using the same misdirection trick Kuhn and colleagues (2008b) found no systematic relationship in eye fixation between participants who detected the dropping cigarette and those who missed it, nor were there any differences with regards to visual eccentricity. Likewise, Barnhart and colleagues (2014) used a misdirection paradigm in which attentional distraction was deployed to prevent participants from noticing a longer salient event (i.e. a coin visibly moving across the table), and yet again there was not systematic difference in eye fixations for those who detected the coin transition and those who missed it. Smith et al., (2012) used a magic trick in which a Quarter Dollar coin changed into a Half Dollar coin, and again there was no relationship between where people were looking and whether they detected the change. Kuhn et al., (2016) and others (Smith et al., 2013) likewise found no relationship between where people look and whether they detected the back of cards change colour. These findings contradict our intuitive assumption that looking equates seeing (Ortega et al., 2018), and dovetail findings from the inattentional blindness literature illustrating that people can be blind to events that appear right at fixation (Memmert et al., 2009, Mack and Rock, 1998).

Attentional misdirection can rely on cognitive mechanisms that have been identified in inattentional blindness research (Memmert, 2010, Kuhn and Tatler, 2011). Here participants are typically given an attentionally demanding task (e.g. count the number of times the team pass the ball from one player to the other) which prevents them from noticing an unexpected event (e.g. a gorilla)(Simons and Chabris, 1999). In some instances, misdirection is used to

reduce the overall attentional capacity available for visual processing. For example, Smith and colleagues (2013) explicitly instructed participants to complete an attentionally demanding task, which prevented them from noticing how the back of the playing cards changed. However, in most cases, participants' spatial attention is manipulated in ways that prevents them from detecting the secret method (Kuhn and Tatler, 2011). Magicians use a wide range of misdirection principles that exogenously (independently of people's intentions), or endogenously (based on people expectations/goals) orchestrate the spectators' spatial attention which allows the magician to manipulate what they see and what they miss.

Understanding the mechanisms by which we allocate attention has important theoretical and applied implications. Magicians are true masters of attentional misdirection and their principles can provide real-world insights into how we deploy attention and attentional distraction (Kuhn and Teszka, 2016). Much of the work on attentional misdirection reveals the importance of social cues, such as where the magician is looking. Kuhn and colleagues (2009) showed that the magician's eye gaze acts as a powerful cue to guide spectators' attention. Using the misdirection paradigm described above, they found that the performers directional eye gaze significantly influenced where people looked (i.e. they followed his gaze) as well as what they saw (detection of the secret method). Eye gaze can also be used to capture people's attention – here direct eye gaze is used to draw attention away from the secret and towards the magician's face (Kuhn et al., 2016). Even though participants were explicitly instructed to keep their eyes on the magician's hands and avoid being misdirected around 65% of the participants could not prevent themselves from looking at the magician's face, when he established eye contact and asked them a question ("do you remember the card?").

We are still at the early stages of establishing the extent to which attentional misdirection works. For example, Scott and colleagues (2018) used eye tracking to investigate the impact that auditory speech had on people's attentional allocation towards the performer's face. Rather surprisingly, no such effect was observed. Likewise, although eye gaze is one of the most reliable tools to orchestrate the spectator's attention, other studies have found no impact (Cui et al., 2011). Much more research is required to help understand the impact that these different misdirection cues have on our allocation of attention, and most importantly how they interact with one another. Magicians rarely use these misdirection principles in isolation, and a full understating of misdirection will require us to understand how they work together.

People typically think of misdirection in terms of attentional mechanisms, but there are countless misdirection principles that distort your perception without the need for attentional manipulation. Attentional misdirection can be used to prevent you from seeing things, but Ekroll and colleagues have identified a perceptual illusion that gives people the impression of seeing illusory empty spaces behind hidden objects (Ekroll et al., 2017). Figure 2 shows a table that has been occluded by bubbles. As you look at this table, it is very difficult to imagine that there are hidden objects that are hidden behind the "bubbled" occluders. This leads to the perception of empty spaces. Ekroll suggests that this illusion relies on a general perceptual processing mechanism in which the brain avoids perceptual interpretations involving suspicious coincidences. It is highly unlikely that the hidden objects accidentally

aligned to be out of sight, and thus our brain interprets the space to be empty. This form of 'amodal absence" plays and important role in many magic tricks (Ekroll and Wagemans, 2016). This illusion of empty spaces is a new concept in cognitive science, and the neural mechanisms underpinning this illusion are still unknown.

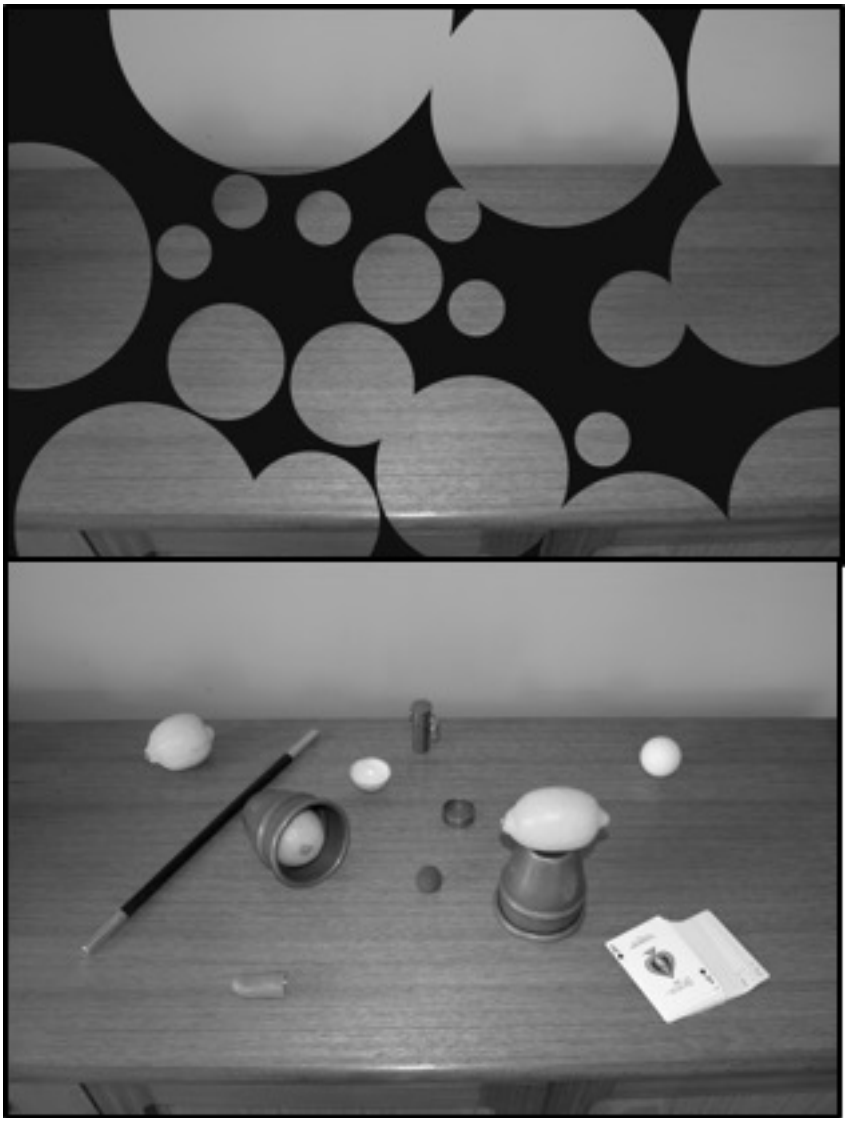

Figure 2: Bubble Illusion. Figure reproduced from (Kuhn, 2019)

Similar perceptual mechanisms are also involved in giving the illusion of solid objects. Our visual system tends to fill the invisible parts of occluded objects, or objects that are simply implied by Gestalt grouping principles. The best know illusion demonstrating this principle is the Kanizza triangle. Ekroll and colleagues (2016) have recently discovered a magic illusion that illustrates people not only fill in the gaps but create compelling impressions of solid objects when in reality there is a gap or missing information. If you look at figure 3 you will see an image of a solid ball and a shell. Even though you know the shell is empty, your visual system convinces you that the half-ball is a solid and complete ball. This illusion relies on

perceptual mechanisms that are impenetrable by higher level cognition. For example, Ekroll carried out a striking experiment in which participants balanced the shell on their fingertip and they were asked to judge the length of their finger (Ekroll et al., 2016). Although participants knew that the shell was hollow participants felt their finger shrink. They argue that this body distortion results from the internal logic of our perpetual system, rather than conscious reasoning, and points to an intriguing new perceptual illusion. This principle of "amodal volume completion" is commonly used in magic tricks, but we do not understand the brain mechanisms that are involved in this illusion yet.

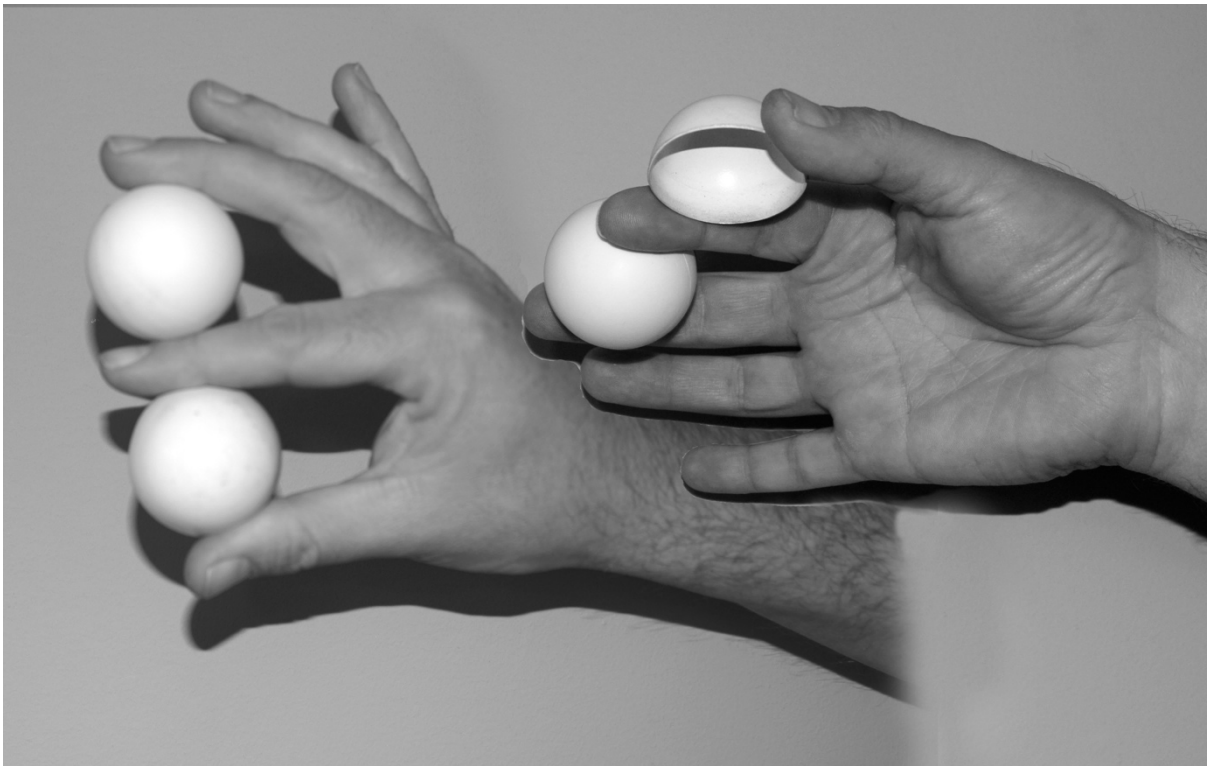

Figure 3: Billiard Ball Illusion. Both balls in the left figure are perceived as solid, when in reality the one on the top is a shell. Figure reproduced from (Kuhn, 2019).

Magicians can prevent us from seeing what exist (attentional misdirection), but they can also trick our mind to "perceive" what does not exist. Back in 1900 Norman Triplett came across an intriguing illusion that has occupied scientists minds for over a century (Triplett, 1900). In the Vanishing Ball Illusion, the magician is seen throwing a ball up in the air a few times before simply miming a throwing action. Although ball does not physically leave the magician's hand a majority of observers claim seeing a "ghost ball" moving upwards and vanishing (Kuhn and Land, 2006). This perceptual illusion results in people experiencing a visual event that has not taken place. The Vanishing Ball Illusion has attracted much scientific interest, but there remain many open questions about the neural mechanisms that underpin it. Triplett initially suggested that the illusion results from retinal after-images, but more recent studies point to expectation-based accounts. For example, Kuhn and Rensink (2016) have shown long term expectancies modulate the illusion, but rather surprisingly, it still seems to work even when the magician does not precede the fake throw with a real throw. One suggestion is that the illusion results from representational momentum effect, a principle by which mental representational of objects are governed by the same physical laws as real objects.

Behavioural (Hubbard, 2005) and neurological (Assad and Maunsell, 1995) evidence suggests that the mental representations of moving objects continue to exist even when out of sight, resulting in people miss perceiving or remembering objects along their predicted path of travel. However, the perceptual displacement experienced in the Vanishing Ball Illusion is much greater than that observed in typical representational momentum experiments (Kuhn and Rensink, 2016, Thomas and Didierjean, 2016a). Kuhn and Rensink (2016) have suggested that the illusion results from a predictive coding error. Our ability to interact with a dynamic world relies on continuously predicting our future actions and state of the world. All our perceptual experiences rely on such predictive visual processes and it is likely that the Vanishing Ball Illusion represent a predictive coding error. However, the size of the error exceeds most previously reported demonstrations, and we are yet to resolve the mystery of the neural mechanisms that underpin this intriguing illusion.

Figure 4: Vanishing ball illusion. Figure reproduced from (Kuhn, 2019).

Another principle that biases our perception is called the attribute substitution error. This error relates to our tendency to substitute elements of a complex problem to answer an easier version of it without realizing that a substitution has taken place (Kahneman, 2011). A famous problem that illustrate this error is the "bat and ball problem": "*A bat and a ball together cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?*". When confronted with this problem, most of the participants intuitively answer "10 cent", but the correct answer is "5 cent". According to several authors (De Neys et al., 2013), the "10 cent" incorrect answer results from an attribute substitution error: participants substitute the unusual statement "the bat cost $1 more than the ball" with the more usual and easier statement "the bat cost $1". Indeed, if the bat cost $1, the ball cost 10 cent. This error is so intuitive and automatic (system 1) that our analytical system (system 2) fails to detect and correct it. Recently, Thomas, Didierjean and Kuhn (Thomas et al., 2018) used a magic trick named "the flushtration count illusion" to investigate how the attribute substitution principle could also bias participants' perception. The flushtration count illusion is a technique often used by magicians to give the illusion of showing multiple cards with identical backs, when in fact only the back of one card (the bottom card) is repeatedly shown (see Figure 4).

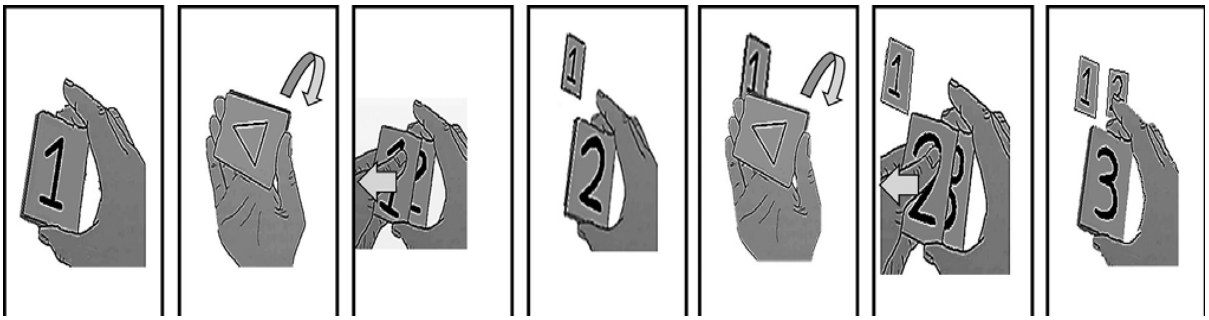

Figure 5: Flushtration Count Illusion's sequence. Figure reproduced from Thomas, Didierjean and Kuhn (2018)

Results from this study show that when participants are exposed to the Flushtration Count Illusion, they intuitively substitute some elements of the unusual visual sequence to build a simpler and more usual version of it. Specifically, they substitute the unusual "he showed me a card then he placed another one on the table" sequence with the more expected "he showed me a card then he placed the same card on the table" one. This substitution is so intuitive and automatic that it is not detected by a more analytical system that would have corrected it. According to Thomas and al., (2019, see also Ekroll, 2019) a wide range of other perceptual illusions could also result from attribute substitution errors. More generally, the Flushtration count Illusion is an interesting illustration of the dual process theory (see Kahneman and Frederick, 2002) which claim that our decisions results from a balance between an intuitive use of heuristics/short-cuts (system 1) and a more analytical/controlled process (system 2).

Memory misdirection

Our memories define who we are, and we experience our memories as truthful representations of the past. Indeed, most people believe that our brain stores and replays experiences like a video camera (Chabris and Simons, 2009). Empirical research on memory challenges this view – Our brains only encode a fraction of the information that we experience, and all new impressions are stored in the context of previous knowledge. As you recall your past experiences, your brain uses current knowledge to reconstructs the past. This reconstructive memory process allows our brains to efficiently encode and retrieve information, but it can lead to compelling errors in recollection. Our memories are far more mailable than we typically assume, resulting in some rather surprising memory illusions. Magicians frequently exploit these memory illusions and strategically manipulate what and how you remember the past to prevent you from working out how the tricks were done (Kuhn, 2019). These psychological tricks are known as memory misdirection and we will look at them in more detail next.

Attentional misdirection provides an effective way of preventing people from encoding the relevant information, and change blindness illustrates that people vastly overestimate the amount that they remember (Beck et al., 2007). The Princess Card trick exploits people's misconceptions about how much they remember. In the Princess Card trick, you are shown a set of six cards and you are asked to remember one of the cards. The magician then uses

sleight of hand to vanish one of the cards, and to your surprise it is the card that you are thinking of. How could the magician read your mind? This trick does not involve telepathy or any other forms of suggestion - it simply exploits people's limited short-term memory capacity, and more importantly people's erroneous beliefs about their memory (Ortega et al., 2018). The magician changed all of the cards ensuring that all of the cards have changed, and yet only 43% of the participants noticed this change. This trick only works because people are oblivious to their memory failure and thus exploits people erroneous belief about their own memory capacity.

Memory misdirection can also be used to distort the way people remember an event. Since the early work of Hodgson and Davey in the 1880s (1887) it has become apparent that people misremember crucial details of events. In their pioneering work Hodgson and Davey interviewed participants after they participated in a séance, and their reports revealed that participants misremembered much of the detail that took place in the room. Similar findings have been reported more recently in study where magic tricks were used to fake a séance (Wiseman and Morris, 1995). Magicians frequently deploy a range of misdirection strategies (e.g., verbal suggestions) to ensure their audience forget or misremember or misinterpret crucial details of the trick, which dovetails much of the research on memory illusions (Loftus, 2005).

Reasoning

Magicians use a wide range of mind tricks that manipulate a person's cognitive reasoning processes, and these mechanisms can be independent of what you see and remember (Kuhn et al., 2014). For example, magicians can misdirect people's mind away from the method of a trick using the false solution principle. The false solution corresponds to any method suggested by the magician (explicitly or implicit) and that is not the real method use to achieve the magic trick (Kuhn et al., 2014, Lamont and Wiseman, 1999, Tamariz, 1988). For example, when a magician claims that he can "use a crystal ball to read your mind", it is obviously a false solution, used to misdirect your mind away from the real secret of the trick (e.g., he obtained information from your Facebook profile). A false solution can prevent people from discovering the secret of the trick even when participants know that this solution is false or very unlikely. The false solution theory is very close to another principle studied in the problem solving literature: the Einstellung Effect is a principle by which familiar solution can fix our mind and make us "blind" to any alternative (Luchins, 1942, Bilalic et al., 2008)

Thomas, Didierjean and Kuhn (Thomas and Didierjean, 2016b, Thomas et al., 2017) have shown that a solution that is known to be false can also fix our mind and prevents the discovery of an obvious solution. Participants watched a simple magic trick in which a card seems to travel from the top of the deck of card to the magician's back pocket. The secret of the trick is very simple: the magician used a duplicate card (one in his pocket, one on the top of the deck). Half of participants were exposed to a control version of the trick (no false solution). In this condition, almost 90% of participants discovered the secret of the trick. The other half was exposed to a version of the trick in which the magician suggested a false solution that he directly proved to be wrong: he mimed to visibly conceal the card in the palm of his hand and before his hand reached his pocket, he opened his hand to show it empty

(ruling out the "palming" solution). Results showed that in this condition, the number of participants discovering the secret of the trick was significantly reduced (only 60% found the solution), even if none of them proposed the "palming action" as a solution. Thomas and his colleagues (Thomas et al., 2017) argued that a solution (e.g., the card is palmed) activates numbers of peripheral representations (e.g., the card is unique, it will travel physically) that remain activated even when the central solution (e.g. the card is palmed) is disactivated. Participants could abandon the idea that the card is palmed, but continued to believe that the card is unique and will travel physically.

One of the most striking and surprising mind tricks involves manipulating people's decision making. We cherish the idea of being in control of our thoughts and our actions. However, much of the psychological (Wegner, 2003) and neurological (Libet, 1985) research suggests that this compelling sense of free will we experience may be an illusion – an illusion magicians frequently exploit. Most card tricks start by having a spectator choose a card, and although this selection may feel free, the magician was in full control over which card the spectator chose. This form of mind control is known as forcing and magicians have developed a wide range of psychological tricks that allow them to covertly influence a person's selection process or its outcome.

At the core of these forcing techniques lies the erroneous assumption that we are in control of our thought and our actions and we are capable of introspection (Johansson et al., 2005). In one of the first empirical studies on forcing, Shalom et al., (2013) examined the classic force, a technique in which participants are asked to manually select a forced card. Although the spectator feels in control of his/her choice, the magician physically restricts the persons choice by only offering a subset of cards to be selected. Olson et al., (2015) conducted several experiments in which participants were asked to mentally select a card from a visual stream of different cards. However, one card was much more visible than the others, which meant that is was select on nearly 98% of the times. In both these studies the forcing techniques were extremely effective at manipulating participants' choices. Most importantly, participants erroneously felt they felt they had a free choice.

Forcing offers a remarkably effective way of influencing a person's choice and understanding the cognitive mechanisms that underpin some of these forcing principles can provide new insights into this illusory sense of free will. In the MAGIC (Mind Attention and General Illusory Cognition) lab, we are studying a wide range of these forcing techniques. There is a large number of forces that rely on exploiting people's unconscious stereotypical thought and behaviour patterns. The location force is a force in which relies on our tendency to choose items that can be easily reached. In this force four cards (from left to right: 1-2-3-4) are placed face-down on the table in a line, after which participants are asked to push out one card. The force is thought to rely on a behavioural bias in that people are more likely to choose the third card simply because it can be reached more easily than the others. When tested, participants felt that their choice was extremely free, and yet most (60%) selected the 3rd card, which was the most frequently chosen card (Kuhn et al., under review). After choosing their card, participants were asked to estimate how free they felt about their selection and estimate the number of other people who would choose the same card. The results found no difference in estimates and feeling of freedom between those who chose the target card (i.e. 3rd card) and those who selected a different card. Moreover, participants significantly underestimated

the actual proportion people who would select the target card. These results illustrate that participants' behaviour was heavily biased towards choosing the third card, but that they were oblivious of this bias.

Other forces rely on priming people's thoughts. For example, Pailhes and Kuhn (Pailhes and Kuhn, in preparation) have recently shown that specific gestures which mime numbers and symbols effectively prime people to choose a specific card. In a large series of experiments, the authors showed that participants were more likely to choose the three of diamond than any other cards, if the magicians used complex set of gestures to mime the card before participants were asked to simply name a card. As with the previous experiment, the force was extremely effective (approx. 20% of participants named the primed card), and most of the participants were oblivious to the prime.

Another group of forces relies on failures in apparent causation, which refers to the illusion that our action caused the outcome that we get. In these types of forces, the spectator has a genuinely free choice, but the action has no impact on the outcome of the action. Pailhes and Kuhn (under review) investigated one such force which is known as the Criss-Cross force to test whether people can tell the difference between an action which had an impact on the outcome they get and one which has no impact. Participants were asked to cut to a card – in the force procedure, a deceptive manoeuvre was used to ensure participants ended up with the same card regardless of where they cut. The force relies on an attribute substitution error, in which people represent a more unusual cut for a typical cut. Even though the deceptive manoeuvre was fully visible, most participants (93%) failed to reason that their actions had no impact on their choice (i.e. they felt the choice was free).

Reasoning misdirection encompasses a large number of deceptive principles that tap into reasoning biases and errors. They generally exploit inaccurate assumptions we have about the world and many of them exploit our erroneous beliefs about how and why we go about our decisions. These principles proved a valuable insights into the ease by which the mind can be influenced and future research may help highlight the neural mechanisms that are involved.

Conclusion

The ancient art of magic relies on tricking our brains into experiencing the impossible. Years of performance experience has allowed magicians to refine and perfect their deceptive techniques, and scientists have now started to investigate these techniques to help uncover some of the mysteries of the human brain. The Science of Magic has become a field of its own rights, and over the last two decades, huge advances have been made in furthering our understanding why these illusions work. A deeper understanding of why magic works helps magicians create more powerful effects, but more importantly, it provides us with a novel perspective to investigate the human brain. Our review focused on the principle of misdirection and illustrates how conjuring deceptions tap into a wide range of cognitive mechanisms, perception – memory – reasoning. Most of the reviewed research has focuses on behavioural experiments, and less is known about the neurological mechanisms that underpin these mechanisms. Rensink and Kuhn's science of magic framework (Rensink and Kuhn, 2015) highlights the importance of an interdisciplinary multileveled approach to this

new science. Now that some of the scientific foundations have been laid, we can start examining the neurological mechanisms that underpin these unique experiences.

Relevant Websites
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