Misdirection – Magic, Psychology and its application

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Misdirection is magic and magic is misdirection.

(Hugard, 1960: 7)

Abstract

The art of magic relies on deception and illusions to create human experiences that appear impossible. Misdirection lies at the heart of this deceptive art, and yet there is little consensus as to what this concept aims to describe. The concept of misdirection is not limited to magic, and its principles are applied to wide aspects of our lives (e.g., politics, public health, marketing). In recent years, scientists have started to examine the psychological mechanisms that underpin misdirection and new theoretical frameworks have been developed to help understand the concept itself. This paper provides two different perspectives on misdirection. In the first section we will discuss its use in magic and examine some of the key features involved in using misdirection to create magical illusions. This section will examine some common misconceptions of misdirection. The second section will provide a psychological perspective that discusses the key psychological mechanisms that are involved in misdirection (perception, memory, reasoning). The third section examines the uses of misdirection in other domains. This paper aims to provide a clearer understanding of how misdirection is used in magic which can serve as the basis for its use in other domains, such as public health.

Keywords: misdirection, magic, deception, attention, psychology, cognition

Introduction

Stage magic is an artform that allows us to experience things we believe to be impossible (Kuhn, 2019). To do so, magicians rely on powerful psychological tricks and illusions that allow them to manipulate their audience's conscious experience (Kuhn et al., 2008). For thousands of years, magicians have perfected the art of deception (Lamont and Steinmeyer, 2018), and many of these principles have been applied to areas that go beyond the magician's stage (Kuhn, 2019). Hieronymus Bosch's 16th Century painting of the conjuror nicely illustrates the intersection between misdirection and the social world of deception (Figure 1). Here the conjuror skilfully misdirects his audience's attention to hide his secret actions. However, closer inspection of the painting reveals how the magician's misdirection also prevents a member of the audience noticing two pickpockets' stealing

his pouch. Misdirection plays a fundamental role in the magician's armoury of deception, but misdirection has often been used for more less magical means. Throughout history, there has been a vibrant knowledge exchange between the world of magic and individuals/organisations seeking ways to gain an unfair advantage over others. For example, Victorian spiritualist frequently borrowed magicians' deceptive tricks to convince the public of their supernatural powers (Tompkins, 2019). Similar deceptive techniques have been applied by contemporary psychics (Marks, 2000), and politicians are often seen misdirecting the public on a much larger stage. Donald Trump was a true master of misdirection, and he effectively used his twitter account to command the political narrative of the world media. This form of political misdirection shares much resemblance with conjuring misdirection, and insights into the

Figure 1. The Conjuror, by Hieronymus Bosch c. 1502

nature of misdirection may provide effective ways of countering this form of deception. The concept of misdirection has been applied to fields such as politics (Freudenburg and Alario, 2007), Human Computer Interaction (Tognazzini, 1993), deception (Hyman, 1989; Jastrow, 1888), cyber deception (Malin et al., 2017) and, in this issue, global health.

The art of magic deals with some of the most fundamental questions about the human mind and culture (Smith, 2015), and as such has relevance to a wide range of disciplines. For example, During (2002) examined how modern magic emerged as a form of show-business that was distinct from the occult, and he illustrates how cultural contexts helped shaped this secular form of magic. Smith (2015) took this approach further and examined the intersection between science, technology, society and magic, both in terms of how magicians chose to frame their performances in the context of new scientific discoveries, as well as the deceptive principles being deployed. Smiths showed that stage magic provides a valuable tool to study how people perceive and learn about new forms of technology, and the deep entanglement between human and non-human agents. Even though magic is frequently discussed in the context of magical rituals and the occult (Sørensen, 2007), the art of stage magic (i.e. secular magic) has received relatively little systematic investigation. In this paper we will focus on the deceptive principles magicians use to manipulate people's experiences, rather than the experience itself that magic elicits. As we will see, these practices have important implications for our understanding of the nature of the human mind, and our relationship with technologies and society.

In recent years cognitive scientists have started to examine the psychological tricks magicians use to create these illusions, and scientific investigations into these principles provides insights into the ease by which our mind can be manipulated (Kuhn et al., 2008; Macknik et al., 2008; Rensink and Kuhn, 2015; Thomas et al., 2015). Misdirection is key to magic (Kuhn et al., 2014), which is why it has gained much interest from magicians, academics and others. Even though misdirection is central to magic, the concept itself is relatively poorly understood and defined (Lamont and Wiseman, 1999).

Magic relies on preventing the audience from discovering the deception, and the magic community has worked hard to prevent the public from discovering how their tricks are done (Jones, 2011). The secretive nature of magic has prevented outsiders from accessing much of this knowledge, and this may explain why the nature of misdirection has received relatively little critical examination from outsiders. This in turn may explain why misdirection has been less thoroughly studied, and thus remains relatively poorly understood. However, in recent years academics have started to study magic empirically and systematically, and this science of magic has enabled new concepts about some of the fundamental aspects of this deceptive artform. In this paper we will examine the nature of misdirection and present ideas and concepts from a magician's perspective, and from a psychological perspective, and illuminate some of the key cognitive principles that underpin misdirection. In the final section we will highlight different areas where direct comparisons have been made between misdirection and other more applied forms of deception.

What is misdirection? - Magicians' perspective

Magic is a performing artform that allows you to experience things that seem impossible. Stage magicians use deception and misdirection to create experiences that violate our understanding of the world (Lamont, 2013). For example, as you witness the magician pulling a rabbit from their hat you experience a cognitive conflict between then things you believe to be possible (i.e. rabbits cannot materialize from nowhere) and the things you have just experienced (i.e. rabbit appeared inside what seemed to be an empty hat). Witnessing such events elicits a wide range of emotions, such as wonder, awe, surprise, astonishment, curiosity…(Lamont, 2017; Leddington, 2017). However, at the centre of this experience lies a cognitive conflict between the things we believe to be possible, and the things that we believe to have experienced (Kuhn, 2019; Leddington, 2016). Indeed, neuroscientific research shows that witnessing

such magical effects activates neural centres that are involved in monitoring more general forms of cognitive conflict (Danek et al., 2015; Parris et al., 2009).

Stage magicians create these magical experiences by using secret deceptive methods, which they typically refer to as the *method* to the *effect* (Lamont and Wiseman, 1999). A magical method might involve a secret compartment in the top hat, which allows you to conceal the rabbit inside what would otherwise appear to be an empty hat. It is important to note that the same effect can often be achieved through different means (Rensink and Kuhn, 2015). For example, the magician might misdirect your attention to prevent you from noticing how they secretly sneak the rabbit into the hat. Even though the method may be different, it should result in the same effect – a rabbit appears in the hat. The magician's main objective is for you to experience the effect without noticing the secret method that is being used to create the effect – the principle that allows them to do so is misdirection. It is important to stress that magic never happens without a cause. The magician's objective is to prevent their audience from noticing the true cause of the effect, and guide them towards endorsing the magical cause of the effect (Kuhn, 2019; Lamont, 2013).

Misdirection is central to magic, and it is difficult to envisage any magic trick that does not involve some form of misdirection. Randal (1976: 380), suggests that "[m]isdirection is a principle element in the art of deception", whilst Leech (1960: 6) refers to misdirection as "the meat of deception, the stuff of which illusion is made". Jean Hugard went as far as claiming that misdirection is magic and magic is misdirection (Hugard, 1960). Magicians have written countless books about misdirection and it is a concept that is frequently used to describe phenomena outside the context of a magic performance. However, the concept itself is still poorly understood, and prone to misconceptions by both magicians and the general public. Let us therefore examine the concept in more detail, and highlight some common misconceptions about misdirection regarding its use in magic.

Let us start by examining a popular definition of misdirection. Wikipedia (n.d) defines misdirection as "a form of deception in which the performer draws the audience attention to one thing to distract it from another". This idea of attentional distraction is commonly encountered in definitions of misdirection, and attention does indeed play an important role in misdirection. The human brain has a limited processing capacity, and thus rather than processing all perceptual information, our attentional system systematically prioritizes information that is of importance and ignores things that are less relevant. Within the context of a magic performance, there are lots of different things that occur simultaneously, and attentional distraction can prevent the audience from attending to the crucial detail and thus failing to perceive it (Sharpe, 1988). For example, an assistant riding a unicycle would provide ample attentional distraction to prevent the audience from noticing how the magician sneaked a rabbit into the hat. In this instance the misdirection would have successfully prevented people from noticing the method, but in doing so it will have distracted people's attention from the effect - noticing the magician pulling the rabbit from the hat.

Rather than simply distracting people's attention, misdirection typically involves guiding attention towards something interesting and relevant to the effect (Wonder, 1994). This is in contrast to how politicians often misdirect attention to distract from negative news stories. Boris Johnson's campaign adviser Lynton Crosby's "dead cat" manoeuvre is a good example of attentional distraction that is used as disguise. According to him

> There is one thing that is absolutely certain about throwing a dead cat on the dining room table. ... [E]veryone will shout, 'Jeez, mate, there's a dead cat on the table!' In other words, they will be talking about the dead cat—the thing you want them to talk about—and they will not be talking about the issue that has been causing you so much grief. (Delaney, 2016)

Throwing a dead cat on stage would certainly prevent people from noticing the magician sneaking the rabbit into the hat, but it would also distract

them from the effect – the rabbit appearing from the hat.

Misdirection is typically associated with guiding or distracting people's attention, but it is important to note that many misdirection principles do not necessarily rely on attentional process. As Leech (1960: 6) points out, "real misdirection deceives not only the eye of the spectator, but his mind as well". There are lots of misdirection principles that are independent of what people perceive. For example, Juan Tamariz explains how "a magician can create lagoons in the spectators' memories in order to make them forget whatever we wish for the magical effect, or to make them believe they remember things that in reality never existed." (Tamariz, 2012: 157). Other memory misdirection techniques rely on influencing how people remember an event, and this form of misdirection provides an extremely powerful tool to prevent people from discovering the true cause of the effect.

Other misdirection techniques rely on manipulating peoples' thoughts and reasoning. For example, magicians often give you the impression that a trick involves little planning, and these types of tricks are designed to appear impromptu (Teller, 2012). In reality, most magic tricks involve considerable preparation, and people typically fail to realize just how much work goes into creating them. Presenting a trick as if it is performed impromptu prevents the audience from considering more elaborate setups, and thus provides a valuable form of mental misdirection. Although attention plays an important part in misdirection, misdirection is a much broader concept than one may naturally assume.

Let us now look at the final, and possibly most important component of misdirection – your awareness of the misdirection. Misdirection is only effective as long as the audience fails to realize how they have been misdirected. Once you notice that your attention has been distracted, you will no longer experience the magical effect – now you attribute the cause of the effect to your inability to detect the method rather than the magical effect. Good misdirection must therefore be unnoticed, and occur naturally within the context of the performance (Lamont and Wiseman, 1999). Tossing a "dead cat" on stage will prevent you

from noticing the secret method, but since it is an obvious form of distraction, you will attribute the appearance of the rabbit to your failure in perception, rather than the intended magical cause. Once people become aware of the misdirection, the impossible becomes possible, and the magic disappears (Pareras, 2011).

Misdirection is central to magic, and yet it's a concept that is generally poorly understood. From the magician's perspective we can think of misdirection as any process that "directs the audience towards the effect and away from the method" (Lamont and Wiseman, 1999: 31).

What is misdirection? – psychological theories

Magicians have spent hundreds of years performing their tricks in front of live audiences, and this performance experience gives them great insights into how best to misdirect their audience. However, even though magicians know what tricks work, they may not necessarily know why they work (Kuhn, 2019). In recent years, scientist have taken a keen interest in studying magic because it provides valuable insights into some of the limitations of human cognition. Much of this science of magic endeavour has focused on misdirection, and many of the key misdirection principles are now being scientifically evaluated. This scientific research allows us to move beyond informal anecdotal descriptions and adapt a more systematic approach to misdirection. This interdisciplinary collaboration between magicians and cognitive scientist has led to new frameworks of misdirection, which not only explain which principles work, but also why they work.

In 1999 Wiseman and Lamont published the first psychological theory of misdirection, a framework that drew informal links between psychology and misdirection (Lamont and Wiseman, 1999). This informal taxonomy offered an important starting point as it tried to link magic practice to psychological processes. However, this theory lacked scientific rigour, and many of the psychological processes were rather loosely defined. In 2014 Kuhn et al. developed a new taxonomy of misdirection that was based on known and established psychological mechanisms (Kuhn et al., 2014).

Most previous theories focused on misdirection from the performer's perspective – The psychologically-based taxonomy of misdirection tries to explain how misdirection affects the spectator's mind. This new perspective allows us to draw direct links between misdirection and established cognitive mechanisms, and evaluate them scientifically.

The psychologically-based taxonomy of misdirection

The psychologically-based taxonomy of misdirection uses a rather broad definition of misdirection that encompasses any psychological principles that guides the audience towards experiencing the magical effect. According to Kuhn (2019) misdirection is an umbrella term that describes a range of psychological principles that are used to prevent the audience from discovering the true method and focuses the audience's attention to the magical effect. From a psychological perspective misdirection includes cognitive processes that manipulate people's beliefs about what they are experiencing. To do so effectively, misdirection exploits many of our mind's limitations. The key is that these limitations must be counter-intuitive, since once you become aware of them, you start attributing the effect to your limitations rather than the magical effect. Any effective misdirection principles must not only exploit people's cognitive limitations, but also failures in their beliefs about their cognitive processes, also known as meta-cognitions (Ekroll, 2019; Kuhn et al., 2014; Ortega et al., 2018, 2021). People often hold erroneous beliefs about their true cognitive abilities, and these errors in metacognition are a crucial component of any effective misdirection principle.

The psychologically-based taxonomy of misdirection has become an influential framework for examining misdirection and it is based on the notion that human cognition generally involves several different types of information processing. When watching a magic trick, the observer must first perceive the event sequence, and thus capture the relevant sensory information. The observer must then store key aspects of this information in memory, which is then used to reason about how the trick is done. According to Kuhn et

al. (2014) misdirection encompasses any psychological process that prevents the observer from attributing the true cause to an effect. To do so, the magicians can manipulate any of these three mental processes (Kuhn and Martinez, 2012).

The psychologically-based taxonomy of misdirection has three broad categories that correspond to the three broad types of cognitive mechanisms. The first category refers to procedures that manipulate perceptual mechanisms and have the potential to prevent people from noticing an event. Attention plays a crucial role in determining what aspects of the world that we perceive, and unless we attend to something, we are unlike to see it. All of the attentional misdirection principles fall within this category. For example, there are lots of techniques that misdirect a person's attentional focus either by external or internal triggers. For example, our attention is automatically drawn towards salient features (e.g. a bright light, loud sound, eyes) and such features are used to misdirect people's attention towards the desired objects and thus away from the secret method (Sharpe, 1988). Kuhn and colleagues (Kuhn et al., 2009; Kuhn et al., 2008) have shown that this form of attentional misdirection is extremely effective at preventing people from noticing events that are taking place in full view. For example, in several such studies, attentional misdirection is used to prevent people from noticing the magician from dropping a lighter and a cigarette in full view (Kuhn and Tatler, 2005; Kuhn et al., 2008; Land and Tatler, 2009).

Alternatively, magicians often orchestrate the narrative to manipulate the audience's internal motivation to attend to things. For example, magicians often use *patter* to talk about certain objects or events, which results in people's attention being allocated towards these objects without them necessarily being aware of it (Smith et al., 2013). These implicit suggestions can increase or decrease the level of attention given to something. For example, magicians may reduce the level of attention by making an object or event seem mundane. One of the key principles here involves familiarity – the first time you see the magician place a special prop on the table (e.g. a pair of scissors), you will become interested in the object and start attending to it. However,

if the magician uses them to cut a piece of rope in half several times, the audience will become familiar with the object and thus start to pay less attention towards it.

Just as we control what object we attend to, we can also focus our attention on particular moments in time (Barnhart et al., 2018; Fraps, 2014). There are huge fluctuations in how we process information over time, and magicians exploit these natural fluctuations or induce them to ensure that their secret method is carried out during time points where their audience is less attentive (Wiseman and Nakano, 2016). For example, a joke, or surprising event typically elicits a strong emotional response which and magicians suggest that this is followed by an attentional relaxation (Macknik et al., 2008). People are less likely to notice events that take place during these natural relaxations in attention, which provides a perfect opportunity to carry out the secret methods without it being noticed.

The final form of attentional misdirection relates to our overall attentional resources. Our attentional recourses are limited, and people who engage in attentionally-demanding tasks often fail to notice extremely obvious events, a phenomenon known as inattentional blindness (Mack and Rock, 1998; Simons and Chabris, 1999). For example, Chabris and Simons (1999) have shown that if people were asked to count the number of times basketball players pass a ball from one player to the other nearly 60% of participants failed to notice a gorilla walking across the screen. This principle is frequently exploited in misdirection whereby the magician may ask the spectator to engage in a complex task, which will deplete their attentional resources making them less likely to notice other things going on (Smith et al., 2013). This is also one of the main reasons why magicians avoid repeating the same trick. Observing a trick for the first time requires more attentional resources than when it is perceived the second time round. Indeed, empirical work has shown that people are often more likely to discover the secret when the trick is repeated (Ekroll et al., 2018; Kuhn and Findlay, 2010; Kuhn and Tatler, 2005; Kuhn et al., 2008). Magicians also often introduce a sense of confusion by having lots of different things going on simultaneously, which depletes attentional resources and thus prevents spectators from noticing the secret.

The second main category of misdirection principles relate to how people remember an event. Perceiving an event does not imply that you will remember the event. Only a tiny fraction of the information that we perceive can be recalled later from memory and even remembering an event does not necessarily imply that you have experienced it in the first place. Our memories are highly selective reconstructions, that are based on fragments of remembered experiences, rather than complete representations. Hence lots of misdirection techniques are designed to manipulate how people remember an event.

Most of the memory misdirection techniques try to ensure that the audience forgets the relevant information about the magic method. There are several ways in which this can be achieved. For example, people are more likely to remember an event if they are immediately asked to recall it, rather than later on. The magician may therefore include a time delay between the method and the effect, which is known as time misdirection (Fraps, 2014; Leech, 1960). Another effective principle that can be used to prevent people from remembering the relevant details involves creating confusion. It is highly unlikely that people can remember all aspects of a complicated magic routine, and this ensures that they won't remember the crucial detail that are necessary to work out how the trick is done.

Most people intuitively assume that our brain encodes information so that it can be replayed in its original form, like a video camera (Chabris and Simons, 2009). Our memories are based on reconstructions rather than the accurate retrieval of information, which means that our memories are far less stable than we intuitively believe they are. There are lots of misdirection techniques that exploit the fluid nature of memory by controlling and influencing this reconstruction process. This can result in people misremembering entire event sequences. For example, people often misremember related event sequences as actual sequences simply because they appear related. In the context of a card trick the spectator might misremember a false shuffle (one that does not mix up the cards) with a real shuffle, which has an

entirely different function (the cards are genuinely mixed up).

Suggestions can also be used to influence people's memory and change the way events are later remembered. Elisabeth Loftus has conducted much pioneering works showing that individual words or phrases can alter memories and even induce memories for events that have never been experienced (Loftus and Hoffman, 1989). Magicians frequently exploit such memory distortions and use verbal and non-verbal suggestions to alter how people remember an event sequence. For example, Wiseman and Greening (2005) have shown that verbal suggestions given at the time a spoon was bending resulted in people falsely remembering that the spoon was still bending when it was in fact static on the table. These types of memory distortions are often exploited in the context of a séance, and some of the earliest work on memory documented how these memory distortions can be exploited by spiritualists (Hodgson and Davey, 1887). Magicians will often include critical misinformation (e.g., that you shuffled the cards) when recapitulating the magic performance to change the way the events are remembered – you falsely remember shuffling the cards. Indeed, unpublished research from our lab shows that verbal suggestions about who has shuffled a deck of cards can significantly alter to way in which the even sequence is later recalled. People often cannot distinguish between veridical memories and these false memories, which provides magicians a tool to rewrite the past, making it a very effective form of misdirection.

The final category of misdirection involves reasoning. Each member of the audience brings along a different set of pre-existing beliefs and assumption about the nature of the world, and the magic performance. Even though some of these assumptions are correct, others are not, and lots of misdirection principles manipulate these assumptions. It is beyond the scope of the current article to examine each of these assumptions, but we will highlight a few to illustrate the principle in more detail.

The theory of false solution is a principle in which the magician presents the audience with an obvious, yet false solution to the trick, which later is revealed to be wrong. For example, in one experiment participants were shown a simple magic trick in which the queen of hearts invisibly travelled from a deck of cards into the magician's pocket (Thomas et al., 2017). The method was simple – the magician used a duplicate card which had been placed in his pocket at the beginning of the trick. Indeed, when performed like this, 80 % of the participants correctly identified this simple method. However, when the magician added a false solution, participants struggled to identify the method. Here the magician pretended to palm a card from the top of the packed, but immediately destroyed this as a potential solution by revealing that his hand was empty, before it reached into the pocket to reveal the other card. This false solution prevented participants from discovering the simple solution to the trick - a duplicate card. The theory of false solution is a powerful form of reasoning misdirection (Thomas and Didierjean, 2016) that is related to the Einstellung effect (Luchins, 1942) whereby people are reluctant to abandon a false solution despite knowing that it is false, and prevents people from considering alternatives. This principle has been found in domains outside magic, such as chess problems, in which expert chess players fail to abandon a suboptimal solution even if better alternatives are available (Bilalic et al., 2008).

The Ruse is another effective way in which people's mind can be prevented from discovering the solution to trick. Simply putting your hand into your pocket may seem suspicious and attract attention. However, using a ruse to justify the action (e.g., reaching in to my pocket to fetch some magic dust) will make it seem less suspicious and thus people will take less notice of it (Van de Cruys et al., 2015). Van de Cruys and colleagues have argued that people simply cannot represent an action has having two simultaneous, yet different functions. Therefore, an action such as placing your hand in your pocket can only ever be represented as a putting action (e.g., dropping a secret prop in my pocket) or a fetching action (picking up magic dust), but not both. Once an action has been justified as an action that is mutually exclusive to the to be concealed action, our mind will struggle to entertain the alternative action.

Most people assume that a magic trick has a single pre-determined end. However, magicians

often perform tricks that have several possible endings, which allows the magician to choose between them depending on what choices have been made. This principle of multiple outs is often used in mentalism and forcing (Pailhès and Kuhn, 2021). For example, the magician might have multiple predictions for four different outcomes, and simply reveal the one based on the spectator's choice. The multiple out principal exploits people's erroneous assumptions about the nature of magic trick in that they are all presumed to have a predetermined end.

The psychologically-based taxonomy of misdirection highlights and isolates a wide range of psychological principles which has helped identify the cognitive mechanisms that underpin them. However, it is important to note that magicians rarely apply these principles in isolation. In a typical magic performance, the magician will deploy several of these misdirection principles simultaneously resulting in complex layers of deception that complement each other (Olson and Raz, 2021). Indeed, unpublished research from the MAGIC lab shows that combining different deceptive methods simultaneously prevents people from working out relatively simple deceptive principles. In this study participants were asked to watch a demonstration in which the magician held up cards which he subsequently named. If one deceptive method was applied alone (marked cards, transparent blindfold), participants managed to work out the deception easily. However, combining the two methods made them virtually impenetrable.

Bayesian approach to misdirection

Grassi and Bartels (2021) have recently proposed a Bayesian approach to misdirection which uses a computational approach to explain how each of these different cognitive processes affect the way in which magicians can manipulate the observer's beliefs away from the real cause of the magic effect (i.e. the method) and accept the alternative beliefs about the effect (i.e. the magical effect). Bayesian predictive coding is a computational framework that is typically used to explain perception. Our senses receive lots of incomplete and often ambiguous sensory information about the physical world and making sense of this informa

tion poses huge computational challenges. To do so effectively, our brain employs prior knowledge to resolve these ambiguities which helps us make sense of this fragmented information. We acquire this prior knowledge by learning statistical regularities about the world, and we can use these priors to predict the most likely cause of the incoming sensory information. Bayesian inference is a mathematical principal based on probability theory that combines the observed information (i.e. likelihood) with probabilistic predictions that are based on previous beliefs (i.e. prior beliefs) to calculate the most likely interpretation of the event (i.e. posterior probability). The difference between our prior beliefs and the incoming sensory information is known as the prediction error, and we use this prediction error to update our beliefs about the world.

Bayesian predictive coding theories view the brain as a system that maximizes the evidence for its world model by minimizing the difference between its prediction (prior beliefs) and the sensory data. To reduce this prediction error, we can update our beliefs about the world and/ or change our interpretation of the sensory data. This process of reducing prediction errors is seen as the basis of all human learning and this model has been applied to numerous cognitive processes. Grassi and Bartels (2021) have applied Bayesian predicative coding to explain misdirection, and this new model provides an effective way of explaining how misdirection principles interact with our current beliefs about the world. Grassi and Bartels (2021) argue that magic is best explained in terms of surprise, and an individual's level of surprise can be operationalized as the difference between our prior beliefs about the situation and the incoming sensory information – prediction error. For example, it is very unlikely that rabbits appear from nowhere, and thus our prior beliefs about this occurring are extremely low. Seeing a rabbit appearing from a hat results in a huge prediction error between our expectations (i.e. priors) and the incoming sensory information, which in turn results in the phenomenological experience of surprise.

Grassi and Bartels' Bayesian framework relies on a relatively broad definition of misdirection that incorporates any process that manipulates

the audience's beliefs away from the real cause of the magic effect and misdirection is intended to guide it towards an alternative belief. Accordingly, misdirection intends to maximise the level of surprise that the trick elicits by maximizing the prediction error. Bayesian predictive coding models explain how this can be achieved and it also provides mathematical tools that in principle allow us to calculate the effectiveness of such principles. According to this theory magicians can increase the level of surprise a trick elicits by either shifting an individual's expectations (i.e., prior beliefs) or by shifting the sensory information. This model of misdirection does not conflict with previous approaches (e.g. Kuhn et al., 2014; Lamont and Wiseman, 1999), but it shifts the focus from the individual misdirection principle towards a process by which our prior beliefs affect the misdirection principles themselves, and it highlights how magicians manipulate our prior beliefs.

Grassi and Bartels' model acknowledges the important role that attentional control plays in misdirection, and they see its role in terms of modifying the prediction errors in favour of those that maximize the mismatch between expectations and observations (i.e. surprise). There are two ways in which magicians can control their audience's attention to achieve this. Firstly, attention can be manipulated to prevent viewers from detecting the secret method (e.g., magician sneaking the rabbit into the hat) which would result in a reduced prediction error. Secondly, magicians control the audience's attention to highlight the strength of the efficiency that supports the trick, and therefore increases the spectator's confidence in having observed all of the relevant information, which in turn increases the level of surprise that the effect elicits.

The psychologically-based model of misdirection (Kuhn et al., 2014) is helpful in identifying individual misdirection principles, and it allows us to illuminate the cognitive mechanisms that underpin them. However, this model fails to explain how our prior knowledge and experience influence the effectiveness of each of the misdirection principle (Kuhn, 2019), nor does it tell us much about how they interact with one another. Grassi and Bartels's Bayesian predictive coding model makes specific predictions about how these principles interact as well as how our prior knowledge affects them. Moreover, this computational model potentially allows us to directly implement the principle in the brain and thus enables us to make important connections to neurophysiological processes. To date, the Bayesian predicative coding model has not been empirically evaluated, but it certainly offers a step in the right direction.

Misdirection is a principle that lies at the heart of magic, and much of the research on misdirection has focused on the psychological mechanisms that underpin misdirection. Advances in cognitive science and the science of magic are providing new insights and perspectives on the issue. The concept of misdirection is also widely used in other domains, and in the next section we will examine how misdirection is being applied to other domains.

Applying misdirection to other domains

Deception lies at the heart of magic as well as many other human activities, and it is therefore no surprise that misdirection has been used to deceive people in other domains (Kuhn, 2019). Misdirection provides an effective model of deception and has plaid an important role in more formal theories of deception (Hyman, 1989; Jastrow, 1888). For example, in his memoires, Robert Houdin recounts how the French government called upon his conjuring skills to help suppress the Algerian colonial uprising (Robert-Houdin, 1859). In a similar vein, British Magician Jasper Maskelyne allegedly used his misdirection skills to deceive the German forces in World War 2, by using misdirection to vanish the port of Alexandria, and hiding the Suez Canal from view. These examples have received much public attention, but there is little actual evidence suggesting that these acts ever took place (Allen, 2007; Lamont and Steinmeyer, 2018). Instead, these stories are instances where magicians either used misdirection to misdirect the public about their legacy (Lamont and Steinmeyer, 2018), or government agencies misdirecting the public about their true capabilities.

In the 1950's the CIA did commission the American magician John Mulholland to write a manual outlining different ways in which conjuring deception and misdirection can be used by CIA field operatives to poison enemy agents as well as many other elaborate forms of deception (Melton & Wallace, 2009). It is unknown as to how much impact this manual truly had in the field, but it illustrates how principles of misdirection can potentially be applied to other domains. Indeed, the connection between misdirection and real-world deception is most prominently felt in the world of cyber deception.

Arthur C. Clark suggested that "any sufficiently advanced technology is indistinguishable from magic," (Clarke, 1999, ch. 2) and there has been much interest in exploring links between the digital virtual world, and the misdirection principles deployed by magicians to create their own illusory experiences. In 1993 Togazzini (1993) published an influential paper that highlights many of the similarities between human computer interface designers and the art of magic, and Togazzinis suggested that insights from magic could help human computer interface designers create more immersive and compelling user experiences. There are clear parallels between these two domains, and misdirection principles are frequently used to guide the user's attention through complex visual displays to enhance the ease by which information can be accessed and thus enhancing the overall user experience. More recently, this connection between misdirection and the online world has been explored in the world of cybercrime.

Magicians use misdirection to change people's perceptions and beliefs, and alterations of beliefs and perceptual experiences are also important components of cyber deception. There is a clear resemblance between the tools used by cyber-criminal to defraud an individual into handing over sensitive information, and the principles magicians use to elicit such information as part of a magic trick. Law enforcement agencies have therefore become interested in the connections between the magician's skilful use of misdirection and cyber threat actors who intend to circumvent human defences (Malin et al., 2017). Malin and et al. (2017) conducted a thorough analysis

of previous misdirection theories (Fitzkee, 1945; Lamont and Wiseman, 1999; Sharpe, 1988) and examined ways in which such principles are being applied by cyber criminals. For example, the principle of repetition is frequently used by magicians to familiarize the audience with objects or actions so that they attract less attention in the future. This principle of repetition is often applied in the digital online world. We visit websites and we have learnt that the most basic ubiquitous navigational action is to click on a link or button presented to us. We have repeated this action thousands of times making it virtually automatic, which means that it requires very little conscious attention. Malicious online actors take advantage of this behaviour to distract us from carefully examining the details of the web page that might tip us off that there is something amiss about the website. Malin et al. (2017) cite countless other example, that highlight the similarities between the deceptive principles deployed by cyber criminals and conjuring miserection, and this connection certainly warrants further investigation.

Henderson and colleagues (Henderson et al., 2015) also highlight how misdirection and magic deception principles resemble many of the tricks deployed by hackers in the world of intelligence and cyber security. Their case study illustrates how cyber criminals can operationalize misdirection principles to gain access to sensitive information, as cyberworkers try to make sense of complex, dynamic and uncertain scenarios that closely resemble a magic trick. Their case study particularly highlights how a single cyberattack episode often involves multiple strategies and forms of deception, that are combined in a similar fashion to how magicians combine their multiple forms of misdirection.

Politicians are often accused of misdirecting the public, and political distraction forms a central part of most political campaigns. When Boris Johnson was recently questioned about his attendance of a party at Downing Street, whilst the rest of the public was banned from social mixing, and he was quick to deflect the question and talk about his government's effective vaccine rollout. Such forms of political misdirection are widespread, and Freudenburg and Alario (2007) put out a call to examine the relationship between

political discourse and misdirection more closely. Whilst most sociologist have focused on how "tradition" and "culture" have influenced the political discourse, Freudenburg and Alario suggest that more attention should be paid to how misdirection is used to prevent the public from fully perceiving the political discourse. In their article Freudenburg and Alario (2007) link some of the principles used by politicians to the conjuror's concept of misdirection. Their main focus is on attentional distraction for the purpose of disguise, and reframing arguments to alter people's memories of the political discourse.

Governments frequently use distraction to prevent the public from taking notice of the true impact that a particular set of policies have. For example, Dennis (2019) suggests that one of the best ways for governments to disguise high-taxing policies is by drawing the public's attention to large tax cuts that are being done for the highest earners, whist cutting welfare spending and keeping lower tax bases unaffected. This form of misdirection is effective in that these tax cuts have a relatively minor impact on the overall money that is being collected, and whilst the net effect results in fanatical surplus, the government can be seen as supporting lower taxes, and protect the interest of the rich.

Political misdirection often involves reframing questions as a form of misdirection that allows politicians to manipulate the political discourse (Freudenburg and Alario, 2007). Much of the literature suggests that the mass media have a relatively small impact what people think, but instead that they are particularly effective at manipulating what people think about (Iyengar and Kinder, 2010). Within this context, the questions can form a potent form of misdirection that allows politicians to reframe the political discourse. Freudenburg and Alario cite a powerful example surrounding the anti-Vietnam war movement, which describes how skilful politicians raise questions to reframe the argument and misdirect the political discourse. As peace activists marched the streets, politicians were unable to simply ignore these protests, and therefore needed a way to misdirect the public's attention away from the issues raised. An extremely effective way of doing so, is to change the question that was most salient

about the issue (i.e., the detrimental social impact of the war), whilst continuing to talk about the issue (i.e., the war). This form of political misdirection allows politicians to alter the narrative in the main stream news. During the peace marches, politicians proclaimed that they support the troops, which implies that the protesters do not (Beamish et al., 1995). Subsequent analysis of the media coverage showed that this simple rephrasing of the question changed the focus of the discussion from the protester's concerns about was and destruction to whether the protesters were being unpatriotic or were undermining the troops in the field. Political spin is an important tool in the politician's handbook, and the connections between such forms of deception and misdirection are clear, and a fuller analysis may make us better equipped counter misdirection.

There are lots of other areas where principles of misdirection are applied to the real world. For example, Ekroll and colleagues how shown how some of the psychological principles underlying magic tricks may be relevant for understanding traffic accidents (Ekroll et al., 2021). Leathley (2019), has shown how misdirection principles can help us understand health and safety issues more generally. Misdirection has also been applied in health settings where it can be effectively used to in pain management (Bagienski and Kuhn, 2019, 2020).

Recently, in the field of global health, Peeters, Gryseels and Verschraegen (2019) have used the term misdirection to refer to processes by which attention is diverted from certain scientific approaches that do not fit the hegemonic malaria elimination paradigm to favour universalistic biomedical and biotechnical interventions. More concretely, the authors look at how the use of vector control tools, such as bed nets and topical repellents, is measured and how the success of related interventions is evaluated, drawing attention to standardized metrics while diverting attention away from social context, local variability and the potential of localizing interventions. The papers presented in this special issue will further the discussion on misdirection in global health.

Our discussion of how misdirection is applied in other domains is not intended as a full review

of the field, but instead as examples of how these conjuring techniques can translate to other fields.

Conclusion

Magicians have vast experience in effectively manipulating people's perceptual experiences. The scientific study of misdirection has helped unravel the many layers of misdirection that magicians deploy to deceive their audiences, and it has helped identify the mechanisms that underpin these illusions. The secretive nature of magic often prevents outsiders from drawing parallels between misdirection and other forms of deception. The science of magic has helped facilitate the knowledge transfer between magicians and scientists, and in this article, we shed light onto the some of the core misdirection principles and explain their use in magic and beyond. Most people have a rudimentary understanding of how basic attentional misdirection can be deployed to prevent people from noticing things. However, misdirection goes beyond simply distracting your audience and many of the lesser-known principles are particularly relevant to wide aspects of our lives.

Misdirection relies on exploiting often surprising and counterintuitive limitations and biases in cognition, and these processes are not restricted to performing magic tricks. Instead, they highlight cognitive processes that underpin our everyday behaviours, which makes them relevant to most aspects of our lives. As we have seen, misdirection strategies are being used, and abused in many aspects of society and technology. By examining the cognitive mechanisms that underpin these misdirection principles, we can move beyond simple descriptions, and start to explain how and why they work so effectively.

Misdirection is central to magic, and yet, it has received relatively little systematic examination from magicians or academics. The science of magic provides a new perspective on misdirection, and it has helped highlight some common misconceptions. The scientific study of misdirection is still in its infancy, but in the last decade we have seen huge advances in our understanding of misdirection. Misdirection is not limited to magic, and its use in other domains raises important questions about the nature of misdirection itself. The science of magic has provided a working definition of misdirection, as applied by magicians, and its use in other areas may shed new light on the concept itself.

Most misdirection principles exploit deep rooted psychological processes, and it is often impossible to counter their impact. However, awareness of our limitations and biases, and understanding how misdirection is applied on personal and societal levels can help us change our behaviours and devise policies and strategies to counter this form of deception.

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