

# **Where science and magic meet: the illusion of a 'science of magic'**

Peter Lamont, John M. Henderson & Tim J. Smith  
Psychology Department  
University of Edinburgh

Correspondence to:

Peter Lamont  
Psychology Department  
University of Edinburgh  
7 George Square, EH8 9JS  
TEL: 0131 650 3372  
Peter.Lamont@ed.ac.uk

## **Abstract**

Recent articles calling for a scientific study of magic have been the subject of widespread interest. This article considers the topic from a broader perspective, and argues that to engage in a science of magic, in any meaningful sense, is misguided. It argues that those who have called for a scientific theory of magic have failed to explain either how or why such a theory might be constructed, that a shift of focus to a neuroscience of magic is simply unwarranted, and that a science of magic is itself an inherently unsound idea. It seeks to provide a more informed view of the relationship between science and magic, and suggests a more appropriate way forward for scientists.

## **Keywords**

Magic, inattentional blindness, change blindness, deception.

## Introduction

Scientific interest in magic has been aroused by two articles that have recently appeared in *Nature Reviews Neuroscience* and *Trends in Cognitive Science* (Kuhn et al., 2008; Macknik et al., 2008), and which have led to extensive publicity in both popular science journals and the media more generally (e.g. Callaway, 2009; Fahey, 2009; Kim & Shams, 2009; Lehrer, 2009; Martinez-Conde & Macknik, 2008; Mitchum, 2009; Powell, 2008; Sanders, 2009). Given this recent publicity, and the fact that it seems to be leading to new scientific interest, this may be an opportune moment to consider the topic from a wider perspective. This article argues that a science of magic, in any meaningful sense, is a misguided idea. It seeks to provide a more informed view of the relationship between science and magic, and suggests a more appropriate way forward.

Psychological interest in magic is far from new. In 1897, Joseph Jastrow noted that there was ‘much to interest the student of science in the elaborate performances of the prestidigitateur and the illusionist’ (Jastrow, 1897, p. 851). By then, he had already published on the psychology of magic, based on experiments he had conducted with world famous conjurors, as had Alfred Binet (who had conducted his own experiments with conjurors in Paris), and Norman Triplett was on the point of writing a doctoral thesis on the psychology of conjuring, suggested and supervised by G. Stanley Hall, and published shortly afterwards in the *American Journal of Psychology* (Binet, 1894; Triplett, 1900). Indeed, for over a century, psychologists have periodically recognised the potential value in studying magic, and have made several preliminary attempts to systematize the principles of magic with a view to establishing some sort of science of magic or deception (e.g. Binet, 1894; Ceillier, 1922; Dessoir, 1893; Hyman, 1989; Kelley, 1977; Kuhn et al., 2008; Lamont & Wiseman, 1999; Macknik et al., 2008; Nardi, 1984; Randal, 1982; Triplett, 1900; Wiseman, 1996). Nevertheless, despite regular calls for a proper scientific enquiry into magic, there has never been a sustained program of research on the topic. To date, we have progressed no further than periodically noting our neglect of magic and claiming that there must be some value in studying it, making comparisons between some areas of magic and some recent experiments, then calling for further study with a view to constructing a general scientific theory. The frequency with which this has

happened suggests that our lack of progress is not the result of neglect, but rather follows from the misguided idea that magic should be treated as a distinct subject of scientific enquiry.

This idea has not gone away. However, while the authors of both recent papers argue for a scientific study of magic, they suggest radically different approaches to understanding how magic tricks work, one group calling for a general psychological theory of magic (Kuhn et al., 2008), the other for a neuroscience of magic or ‘neuromagic’ (Macknik et al., 2008; Martinez-Conde & Macknik, 2008). The latter authors argue that ‘future studies of magic should be grounded in neuroscience’, and warrant this ‘shift in focus’ by claiming that ‘the neuroscientific study of magic has already proved more productive ... than previous attempts at psychological magic theory’ (Macknik & Martinez-Conde, 2009). In contrast, we argue that neither of these directions is warranted, and that both lack evidential support and are inherently unsound. We suggest a third way forward that is more appropriate and has actually proven more productive than either.

### **A scientific theory of magic?**

To seek a scientific theory of magic is a misguided endeavor. First, the potential for such a theory has been exaggerated by pointing to apparent similarities between recent scientific research and particular areas of conjuring theory, but based upon a misunderstanding of the latter. To take one example, in an attempt to link conjuring theory to recent psychological research, Kuhn et al (2008) define misdirection as ‘the direction of attention away from the method [how the trick is done]’, and state that ‘[m]any methods involve attentional capture, in which attention is pulled away by an irrelevant task’, citing in support recent experiments in which abrupt visual onsets distracted attention (p. 349). However, while distractions clearly divert attention, this has little to do with misdirection as discussed by magic theorists, who typically make explicit distinctions between crude distraction and effective misdirection (e.g. Lamont & Wiseman, 1999; Ortiz, 1994; Wonder & Minch, 1996). Though scientists may be interested in how attention can be distracted by irrelevant stimuli, magicians seek to direct attention without resorting to such crude distractions, since the audience should

not be aware that their attention is being directed. Indeed, in order for spectators fully to appreciate a conjuring effect, their attention needs to be directed so that it is not distracted by irrelevant stimuli (such as someone passing nearby, or another member of the audience returning to their seat). Studies in inattention blindness, of course, have shown how observers can miss similarly irrelevant events within the visual field (e.g. Simons & Chabris, 1999), but such direction of attention is a part of the observation of any performance, indeed any event, on which observers are closely focussed. In this sense, magic is no different from any live performance. Misdirection, however, is quite different. Far from distracting attention by an irrelevant task such as an abrupt visual onset, misdirection in magic is concerned with directing attention away from the method by naturally directing attention towards what is most relevant to what the audience sees as the trick. To take the simplest of examples, by asking a spectator who has chosen a card to shuffle the deck, and then commenting on how thoroughly the cards are being shuffled, the magician can naturally direct attention towards what is most relevant to what the audience see as the trick (that the chosen card is being lost in the shuffled deck) and, at the same time, away from the method (that the card is actually concealed in the magician's palm). It is precisely this relevance to the effect (what the audience sees as the trick) that allows attention to be directed naturally, and without awareness, because if the observer is naturally attending to what they see as most relevant to the event they are watching, they will not realise that they are, at the same time, being directed away from the method (Lamont & Wiseman, 1999; Wonder & Minch, 1996). To compare misdirection to crude distraction by abrupt visual onsets is a basic misunderstanding that exaggerates the link between misdirection and recent scientific research.

There are, of course, links between some forms of misdirection and some research that scientists have carried out. For example, magicians direct attention by looking in certain places at certain times, and Kuhn et al (2008) understandably link this to recent research that shows how eye gaze leads to shifts in visual attention (p. 349). However, the use of gaze to direct attention is part of many forms of performance, it has been consciously used in theatre for centuries, and is a part of normal human interaction. The only difference in the way it is used by magicians is that by naturally directing attention to one place, they can execute the method in another place without it being seen. However, they direct attention in the same way even when it is not to

conceal the method. To take the above example, the magician might direct attention towards the shuffling of the cards not to direct attention from the method but simply to reinforce the effect (i.e. that the card is truly lost in the deck), since the more convinced the audience is that the card is completely lost, the better the trick (e.g. Tamariz, 1988). In terms of attention direction, this is not so different from an actor (or salesperson) directing attention towards an area of the stage (or a product) and away from other irrelevant areas within the visual field of the audience. In short, how magicians direct attention is much the same as how anyone else might who seeks to focus attention in a certain place at a certain time, and this is deliberate since the point of employing natural direction of attention is that it prevents suspicion that covert action is taking place elsewhere. Thus, it is an exaggeration to make a particular connection between magic and recent scientific research into the effect of gaze, and the idea that a science of magic will provide particular insight into the relationship between eye gaze and attention is misguided.

Another of the attempts to link conjuring theory to recent scientific research, also based on misunderstanding, may help to illustrate the degree to which such an approach is misguided. Both recent papers cite the well known saying in magic that one should 'never repeat a trick', and both link this to recent experiments in visual cognition in which observers spotted on a second viewing what they missed on the first (Kuhn et al., 2008; Macknik et al., 2008). While the basic point is again valid, the idea that it relates to a 'key rule' (Kuhn et al., 2008) or 'principle' (Macknik et al., 2008) in magic is misleading. As one of the papers itself seems to recognise (Macknik et al., 2008), many magic tricks involve a repetition of effect (what the audience sees) but a change in method (how it is done). However, even this is not a 'rule' or 'principle', since many magic tricks rely upon the repetition of a method. For example, Alex Elmsley's 'Four card trick' (Minch, 1991) repeatedly employs the same method to produce different effects, and Tommy Tucker's 'Six card repeat' (Eastman, 1933) repeatedly employs the same method to produce the same effect. These are not esoteric examples but classic magic tricks that have been performed by countless magicians for decades. Indeed, depending upon the context, the same method can be used repeatedly to produce the same effect in such a way that observers do not even spot the effect (we shall discuss this in more detail below). Perhaps more importantly, however, and again depending upon the context, the same

method can successfully be used to produce the same effect several times in such a way that even magicians who already know the method nevertheless fail to spot it (Edmondson, 2001). Furthermore, it is a common practice for magicians to deploy methods and misdirection techniques in ways that deceive fellow magicians who know but simply fail to recognize the particular techniques being used. This is possible because effective deception depends largely upon exploiting the physical and psychological conditions of the performance situation, the latter including not only the knowledge of those present, but also any assumptions they might have about what might be possible, practical or likely in that particular context (Lamont & Wiseman, 1999). Thus, the advisability of repeating a trick, whether effect or method or both, indeed the efficacy of any method or form of misdirection, depends upon how and for whom it is applied in a particular situation. Relying upon what superficially appear to be general rules or principles as a route to a scientific theory of magic is misguided.

Second, the purpose of a scientific theory of magic is far from clear. One suggestion has been that it might be of benefit to magicians (Kuhn et al., 2008), but it is difficult to see the obvious benefit. After all, the vast majority of psychological writings to date have been based almost entirely on what conjurers have written themselves. Even the most recent papers draw heavily upon Lamont & Wiseman (1999), which was itself based on an extensive literature written by magicians. In any case, magicians have always displayed ample competence in drawing upon scientific knowledge when necessary in order to create new types of misdirection and to improve methods (e.g. Dawes, 1979; Steinmeyer, 2003). Indeed, even the early work on inattention blindness, which was not originally presented as relevant to conjuring, was rapidly applied by magicians to the creation of new tricks (Lamont & Wiseman, 2000). More recent experiments explicitly presented as a scientific study of magic, on the other hand, were dismissed by an influential conjuring journal as a ‘fascinating bit of scientific trivia, something we’ve all known through empirical evidence for 100 years’ (Kaufman, 2007, p. 11). New scientific knowledge might well be of interest to magicians, but the latter seem to be quite capable of recognising what is beneficial to them, and what is not.

It is surely the potential benefit to science that makes any science of magic worthwhile, but before any benefits can be gained, we must be clear on what we wish

to achieve. After all, while it has been agreed for over a century that psychologists may have something to learn from studying magic, it is quite another matter to suggest that we should construct a scientific theory of magic. In terms of scientific benefit, Kuhn et al (2008) suggest that by ‘reducing all magic effects to a set of basic operations (such as physical and psychological misdirection)’, we might discover ‘unknown perceptual or cognitive mechanisms’ (p. 353). But this, too, is a misunderstanding of conjuring theory. First, it confuses magic effects with methods, since any effect can be achieved by a variety of quite different methods. One classic text on conjuring theory (Fitzkee, 1945) provides dozens of methods for each effect, and each of these methods, when applied in practice, might employ a variety of quite different forms of physical and psychological misdirection. It is these deeply complex methodological processes that might provide psychologists with some insight into how deception works. Second, physical and psychological misdirection are far from being basic operations. On the contrary, they are general umbrella terms for a range of approaches that are categorized by terms that themselves cover countless more specific ways in which attention and suspicion may be directed in a particular context (depending upon such matters as the nature of the effect, the style of the performer, the type of audience, the size and shape of the venue, and so on). For example, one key approach within psychological misdirection is the ‘false solution’, in which suspicions are diverted by suggesting a method other than the real one, but this might be done in countless ways with varying degrees of subtlety, all of which would in turn involve other kinds of physical and psychological misdirection (Lamont & Wiseman, 1999; Tamariz, 1988). The difficulty of isolating misdirection from any other aspect of magic is such that magicians often cite Jean Hugard’s well-known quote: ‘magic is misdirection and misdirection is magic’ (Polidoro, 2007, p. 36). In short, if we seek to reduce magic to a list of basic operations, then we need to identify rather more basic elements, and if the purpose of a general theory is to discover unknown mechanisms through a process of reduction and exclusion, then we have yet to begin the process. Furthermore, if we consider the purpose and form of conjuring theory so far, we can see that an attempt to identify new mechanisms in this way is itself inherently flawed. The purpose of the many attempts by magicians to systematize what they do has not been to provide any sort of definitive list but simply to offer to magicians another way of understanding their craft. Indeed, there has never been a list that has not been challenged by others in the magic community, who understand that there are various



ways in which one might reduce the performance of magic (e.g. Lamont & Wiseman, 1999; Swiss, 2000). If a science of magic is to mean a scientific theory of how magic works, presumably it must begin by reducing conjuring knowledge in a coherent and systematic way. Yet, while there have been several systematic accounts of magic, there is no reason to regard one as self-evidently superior to, or more accurate than, another. With so many ways of reducing magic to more basic elements, it is hard to see how any unknown mechanisms might be discovered via a process of reduction and exclusion.

Another claim concerning how a science of magic might be useful has been that it could shed light on the study of persuasion and deception (e.g. Kuhn et al., 2008). However, while there may be some insight to be gained into these areas from specific techniques used by magicians, magic itself is fundamentally different from other kinds of deception in that it is uniquely open about its persuasive and deceptive aims. It is not, of course, open about its particular deceptive means, but it is based on the premise that audiences are aware that they are being deceived, and most of the techniques employed, not to mention the way in which they are employed, recognize and regularly exploit this awareness. For example, the ‘false solution’ referred to above, which is a fundamental approach to effective magic, relies upon the assumption that audiences are, at some level, seeking to discover the method. And, while the performance of magic involves a range of other persuasive and deceptive techniques, all of them are deployed within a context in which techniques of persuasion and deception are not only expected but regularly made relevant. There is no reason to believe that those techniques unrelated to the unique context in which magic is performed are any different from those involved in other forms of persuasion and deception.

Indeed, it is notable that even scientists who have called for a general theory of magic have in fact done no more than suggest a few specific areas that might be of potential interest to both magicians and scientists. Even Kuhn et al (2008), though they claim that they seek to reduce magic to ‘basic operations’, merely refer to ‘general methods’ in magic (citing ‘misdirection’, ‘illusion’ and ‘forcing’) – that are, in practice, extremely difficult to tease apart. For example, misdirection is an essential part of forcing (the control of spectator choice), since to control the selection process one

must direct attention and suspicion in some way. Indeed, most of what the authors discuss in relation to forcing could equally apply to misdirection. It is not that these 'general methods' are similar, but rather that they are quite different in type. Indeed, they are less a scientific taxonomy than a Borgesian list, and thus provide no more than some suggestions of themes that might be worth exploring. In short, even those who seek a scientific theory of magic have failed to explain either how or why such a theory might be constructed. On the contrary, what they have written confirms what history has shown so far: that the potential and purpose of a scientific theory of magic is simply unclear; and that neither magic nor its apparent principles should be treated as distinct subjects of scientific enquiry.

### **A science of neuromagic?**

While a more focussed approach to studying magic is clearly advisable, the call for a shift towards a neuroscience of magic is unwarranted. As noted above, Macknik & Martinez-Cohen (2009) have argued that 'future studies of magic should be grounded in neuroscience', warranting a shift in focus by claiming that 'the neuroscientific study of magic has already been more productive ... than previous attempts at psychological theory'. First, what neuroscience may offer to the understanding of magic - indeed, what the authors themselves admit - is the possibility of understanding more about the perception of magic. This restricts the enquiry to a study of the neural response of spectators, not the performance of magic itself, which remains a social phenomenon that relies upon physical and psychological techniques. Thus, while a more focussed approach may indeed be more fruitful, this particular focus would ignore what magicians actually do. Second, while they are correct in claiming that neuroscientific interest in magic is new - indeed, given that magic is now being studied by many disciplines within the academy, it is long overdue - it is so new that it has yet to demonstrate its value. Indeed, as we write, the first empirical study of magic that is neuroscientific rather than psychological has only just been published and, as expected, is simply a study of neural responses to magic tricks (Parris et al., 2009). Furthermore, this paper makes no reference whatsoever to a neuroscience of magic, instead framing its findings in terms of belief, a point to which we will come back shortly. Meanwhile, however, it is important to remember that the

call for a neuroscience of magic itself was based on no more than a conference in which some extremely knowledgeable magicians were invited to explain to neuroscientists how magic works (Macknik et al., 2008). It is easy to forget, following the widely publicized claims about the potential benefits of a new science of neuromagic, that these claims were based on no evidence whatsoever. Thus, the extent of dissemination, and the claim that neuromagic has already been more productive than prior attempts at psychological theory, are difficult to understand.

Again, this is not to say that such research is unworthy of our attention, or that any studies that follow will not lead to greater understanding of cognitive and neural processes. But if it is to do so, we need to be clearer about what we currently know, and what it is we wish to achieve (Lamont & Henderson, 2009). If we are simply looking for the neural bases of basic psychological processes in cognition and perception, such as those related to phenomena like inattention blindness, change blindness, persuasion, deception or belief, then we do not need to look to magic for testable neural hypotheses. Indeed, neuroscientific work on these and related topics are well underway (e.g. Beck et al., 2001; Beck et al., 2006; Fernandez-Duque et al., 2003; Huettel et al., 2001; Klucharev et al., 2008; Pourtois et al., 2006; Turatto et al., 2002). And by presenting the scientific study of magic as an attempt to understand how magic tricks work, we risk missing a rather obvious point. Magicians not only understand how magic tricks work, but also demonstrate the adequacy of their understanding in every performance (which, it might be said, has a rate of successful replication few psychologists and neuroscientists manage to achieve). However, what any experienced magician also understands is that the performance of magic involves an endless range of physical and psychological techniques, the particulars of which continue to grow, and the general categories of which are, and always have been, disputed. And, however we attempt to understand magic performance, it remains a social phenomenon that is located within, and depends upon, the particular circumstances of the performance environment. Within this complex social context, specific psychological and neurological processes are at play, but there is currently no reason to believe that such processes are any different from those that have already been identified, or might be identified, in terms of attention, awareness, persuasion, deception, belief and so on.

### **From a 'science of magic' to science**

There is, however, a more focussed and productive way forward, if we can resist the temptation to talk about a science of magic, and instead recognize that magic is simply another resource from which scientists can draw. This approach will require us to focus on the difficult process of not only fully understanding particular areas of conjuring knowledge but also translating relevant knowledge into ways that advance scientific understanding. Rather than attempting yet another systematic classification of conjuring knowledge, or simply claiming that a neuroscientific approach is somehow more fruitful, we need to recognize that the aims of magic and science are radically different, and that advancing scientific knowledge may mean a radical transformation of conjuring techniques so that what we wish to learn about cognition, rather than magic, is paramount. The practical implications of this can perhaps be seen most clearly by considering the most obvious link between magic and current psychological research, namely, the area of change/inattentional blindness. At a superficial level, both conjurors and psychologists are interested in how observers might miss potentially noticeable events. However, psychologists researching change blindness have focussed on how a significant change in the scene is not noticed from one moment to the next, whereas magicians are primarily concerned with how to maximise the perception of a change in the scene (since the more vivid the vanish, appearance or transformation of an object, the better the trick). Similarly, psychologists researching inattentional blindness have been concerned with how noticeable events within the scene are missed while observers are focussed on an irrelevant task, whereas magicians have been primarily concerned with how to direct attention such that an audience notices a change (such as a vanish, appearance or transformation) but does not think they have been distracted by an irrelevant task (since the more convinced the audience is that they have not been distracted, the better the trick). These are clearly related interests, but the primary interests are different, and roughly analogous to what magicians refer to as effect and method. Roughly speaking, whereas magicians are interested in maximising the effect while making the method invisible, psychologists have focussed on effects that are not seen while the method is visible. Without recognizing this fundamental difference, it is difficult to gain more from a scientific study of magic than further illustrations of

what we already know, for example that observers will miss noticeable events if their attention is directed to elsewhere in the scene.

However, by drawing upon certain areas of conjuring knowledge, but by ignoring the fundamental aims of conjuring in favour of what is of primary interest to psychologists, we can gain new insight into psychological processes. For example, by attempting to direct attention towards the method of a trick, we can see how robust attention direction can be, such that powerful yet irrelevant stimuli fail to attract attention. Indeed, we have recently conducted experiments in our laboratory in which observers of a card trick failed to spot the method, which was in full view, even when abrupt visual onsets were used to direct attention towards it. Similarly, by performing a transformation effect in such a way that it is not noticed, we can see that observers can fail to notice an object change within a dynamic scene even when they are attending to the object as it changes. For example, in other recent experiments we have conducted, observers failed to spot the transformation of one coin into another despite continually attending to the coin throughout the viewing. Neither attempting to direct attention towards the method, nor performing an effect that is not noticed, is an approach that any magician would take, but both can provide new insight into psychological processes. Furthermore, so far as these were magic tricks, in the sense that a transformation of objects did occur, they were performed in a way that involved an unrelated task sufficient to distract viewers from the method of one and the effect of the other. This, as we have noted above, has little to do with misdirection as discussed by magicians but rather is a translation of particular conjuring techniques into an experimental context that focuses on what is of primary interest to psychology.

Perhaps when we realize that we would benefit more from focussing on how certain specific aspects of magic might be used in the advance of scientific understanding, rather than on attempting to understand magic from a scientific perspective, we might finally cease to talk of a science of magic. After all, it is the case that scientists have long drawn upon specific conjuring knowledge and deployed it creatively with a specific purpose in the interests of psychological research (e.g. Besterman, 1932; Hodgson & Davey, 1894; Johansson et al., 2005; Johansson et al., 2006; Jones & Russell, 1980; Wiseman & Greening, 2005; Wiseman & Lamont, 1996; Wiseman &

Morris, 1995). Such an approach has been genuinely productive because, rather than being misdirected by calls for a science of magic, it has simply taken specific techniques from magic in order to carry out scientific research. It is this approach that, we argue, will continue to be the most productive. Indeed, this approach is by no means incompatible with some of what both recent papers argue, since they both explicitly state that this should be done. There is, however, nothing whatsoever new about this, it depends upon focussed understanding and application, and it does not amount to a science of magic in any meaningful sense. The recent heightened interest in magic is only as a result of the grander call for a science of magic, and the claim that it may provide significant scientific and practical benefits. We have argued that this wider endeavor, whether defined as a quest for a scientific theory of magic or as a neuroscientific investigation of spectator's brains during magic, is simply unwarranted. What we can do, of course, is continue to draw upon specific techniques from magic (or anywhere else for that matter) in the interest of advancing scientific understanding. But that is not a science of magic; it is science. To call for a science of magic is a form of misdirection, in that it directs attention towards what is not real, and away from what will provide insight into what is actually going on. The science of magic is, in that very real sense, an illusion.

## REFERENCES

- Beck D. M., Muggleton N., Walsh V., & Lavie N. (2006). Right parietal cortex plays a critical role in change blindness. *Cerebral Cortex*, 16, 712–717.
- Beck, D. M., Rees, G., Frith, C. D., & Lavie, N. (2001). Neural correlates of change detection and change blindness. *Nature Neuroscience*, 4, 645–650.
- Besterman, T. (1932). The psychology of testimony in relation to parapsychical phenomena: report of an experiment. *Proceedings of the Society for Psychical Research*, 40, 363-387.
- Binet, A. (1894) Psychology of prestidigitation. *Annual Report of the Board of Regents of the Smithsonian Institution*. Washington GPO, 555-571.
- Callaway. E. (2009). Magic reveals the brains response to the impossible. *New Scientist*. Retrieved Apr 30, 2009, from

<http://www.newscientist.com/article/dn16407-magic-reveals-the-brains-response-to-the-impossible.html?DCMP=OTC-rss&nsref=online-news>

Ceillier, R. (1922). The psychological and technological problems of illusionism.

*Institut General Psychologique Bulletin*, 21, 1-42.

Dawes, E. (1979). *The great illusionists*. Secaucus: Chartwell Books Inc.

Dessoir, M. (1893). The psychology of legerdemain. *The Open Court*, 12, 3599-3606.

Eastman, C. (1933). *Expert manipulative magic*. Self-published manuscript.

Edmondson, M. (2001). Are you superhuman? *The Young Magician*, 6, 10.

Fahey, J. (2009). The truth in illusions. *Forbes.com*. Retrieved Apr 30, 2009, from

[http://www.forbes.com/2009/02/17/optical-illusions-neuroscience-technology-breakthroughs\\_0218illusions.html](http://www.forbes.com/2009/02/17/optical-illusions-neuroscience-technology-breakthroughs_0218illusions.html).

Fernandez-Duque, D., Grossi, G., Thornton, I.M., & Neville, H.J. (2003).

Representation of change: Separate electrophysiological markers of attention, awareness, and implicit processing. *Journal of Cognitive Neuroscience*, 15, 491–507.

Fitzkee, D. (1945). *The trick brain*. Oakland: Magic Limited.

Hodgson, R., & Davey, S. J. (1894). The possibilities of malobservation and lapse of memory from a practical point of view. *Proceedings of the Society for Psychical*

*Research*, 4, 381-495.

Huettel, S. A., Guzeldere, G., & McCarthy, G. (2001). Dissociating the neural mechanisms of visual attention in change detection using functional MRI. *Journal of Cognitive Neuroscience*, 13, 1006–1018.

Hyman, R. (1989) The psychology of deception. *Annual Review of Psychology*, 40, 133-154.

Jastrow, J. (1897). Magic stage illusions and scientific diversions, including trick photography [book review]. *Science*, 6, 850-851.

Johansson, P., Hall, L., Sikstrom, S., & Olsson, A. (2005). Failure to detect mismatches between intention and outcome in a simple decision task. *Science*, 310, 116-119.

Johansson, P., Hall, L., Sikstrom, S., Tarning, B., & Lind, A. (2006). How something can be said about feeling more than we can know. *Consciousness and Cognition*, 15, 673-692.

Jones, W. H., & Russell, D. (1980). The selective processing of belief disconfirming information. *European Journal of Social Psychology*, 10, 309-312.

Kaufmann, R. (2009). Genii speaks. *Genii*, 70(2), 11.

- Kelley, H. (1977). Magic tricks: the management of causal attributions. *Perspectives on attribution research and theory: the Bielefeld symposium*. Cambridge: Ballinger.
- Kim, R., & Shams, L. (2009). What can magicians teach us about the brain? *Scientific American*. Retrieved Apr 30, 2009, from <http://www.scientificamerican.com/article.cfm?id=magic-neuroscience-cognition-illusions>
- Klucharev, V., Smidts A., & Fernández, G. (2008). Brain mechanisms of persuasion: how 'expert power' modulates memory and attitudes. *Social Cognitive and Affective Neuroscience*, 3(4), 353-366.
- Kuhn, G., Amlani, A., & Rensink, R. (2008). Towards a science of magic. *Trends in Cognitive Science*, 12, 349-354.
- Lamont, P., & Henderson, J. H. (2009). More attention and greater awareness in the scientific study of magic. *Nature Reviews Neuroscience*, 10, 241. Retrieved from <http://www.nature.com.ezproxy.webfeat.lib.ed.ac.uk/nrn/journal/v10/n3/full/nrn2473-c1.html>.
- Lamont, P., & Wiseman, R. (1999). *Magic in theory: an introduction to the theoretical and psychological elements of conjuring*. Hatfield: University of Hertfordshire Press.
- Lamont, P., & Wiseman, R. (2003). Seeing and believing. *Magic*, 13(3), 86-87.
- Lehrer, J. (2009). Magic in the brain: Teller reveals the neuroscience of illusion. *Wired Magazine*. Retrieved Apr 30, 2009, from [http://www.wired.com/science/discoveries/magazine/17-05/ff\\_neuroscienceofmagic](http://www.wired.com/science/discoveries/magazine/17-05/ff_neuroscienceofmagic).
- Macknik, S., & Martinez-Conde, S. (2009). Real magic: future studies of magic should be grounded in neuroscience, *Nature Reviews Neuroscience*, 10, 241. Retrieved from <http://www.nature.com.ezproxy.webfeat.lib.ed.ac.uk/nrn/journal/v10/n3/full/nrn2473-c2.html>.
- Macknik, S., King, M., Randi, J., Robbins, A., Teller, Thompson, J., & Martinez-Conde, S. (2008). Attention and awareness in stage magic: turning tricks into research. *Nature Reviews Neuroscience*, 9, 871-879.
- Martinez-Conde, S., & Macknik, S. (2008). Magic and the brain. *Scientific American*, 299(6), 72-79.
- Minch, S. (1991). *The collected works of Alex Elmsley*. Volume 1. Tahoma,: L&L Publishing.



- Mitchum, R. (2009). Brain scientists turn to magic to learn about perceptions and how mind works. *Chicago Tribune*. Retrieved from [http://macknik.neuralcorrelate.com/pdf/news/chicagotribune\\_090310.pdf](http://macknik.neuralcorrelate.com/pdf/news/chicagotribune_090310.pdf).
- Nardi, P. (1984). Towards a social psychology of entertainment magic. *Symbolic Interaction*, 7, 25-42.
- Ortiz, D. (1994). *Strong magic: creative showmanship for the close-up magician*. Silver Spring, MD: Kaufman & Greenberg.
- Parris, B. A., Kuhn, G., Mizon, G. A., Benattayallah, A., & Hodgson, T. L. (2009). Imaging the impossible: An fMRI study of impossible causal relationships in magic tricks. *NeuroImage*, 45(3), 1033-1039.
- Polidoro, M. (2006). The magic in the brain: how conjuring works to deceive our minds. In S. Della Sala (ed.), *Tall Tales About the Mind and Brain* (36-43). Oxford: Oxford University Press.
- Pourtois, G., De Pretto, M., Hauert, C., & Vuilleumier, P. (2006). Time Course of Brain Activity during Change Blindness and Change Awareness: Performance is Predicted by Neural Events before Change Onset. *Journal of Cognitive Neuroscience*, 18, 2108-2129.
- Powell, D. (2008). Magicology: casting a spell on the mind. *New Scientist*. Retrieved Apr 30, 2009, from <http://www.newscientist.com/article/mg20026872.900-magicology-casting-a-spell-on-the-mind.html>.
- Randal, J. (1982). *The psychology of deception (how magic works)*. Venice, CA: Top Secret Productions.
- Sanders, L. (2009). Specialis revelio!: it's not magic, its neuroscience. *Science News*, 175(9), 22.
- Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: sustained inattention blindness for dynamic events. *Perception*, 58, 1059-1074.
- Steinmeyer, J. (2003). *Hiding the elephant*. New York: Carroll & Graf Publishers.
- Swiss, J. I. (2000). Magic in theory [book review]. *Genii*, 63(1), 68-70.
- Tamariz, J. (1988). *The magic way*. Madrid: Frakson Books.
- Triplett, N. (1900). The psychology of conjuring deceptions. *American Journal of Psychology*, 11(4), 439-510.
- Turatto, M., Angrilli, A., Mazza, V., Umiltà, C., & Driver, J. (2002). Looking without seeing the background change: Electrophysiological correlates of change detection versus change blindness. *Cognition*, 84, B1-B10.

- Wiseman, R. (1996). Towards a psychology of deception. *The Psychologist*, 9, 61-64.
- Wiseman R., & Greening, E. (2005). 'Its still bending': Verbal suggestion and alleged psychokinetic metal bending. *British Journal of Psychology*. 96(1), 115-127.
- Wiseman, R., & Lamont, P. (1996). Unravelling the rope trick. *Nature*, 383, 212-213.
- Wiseman, R., & Morris, R.L. (1995). Recalling pseudo-psychic demonstrations. *British Journal of Psychology*, 86, 113-125.
- Wonder, T., & Minch, S. (1996). *The books of wonder*. Volume 1. Seattle: Hermetic Press.