Cognition 154 (2016) 169–173

Contents lists available at ScienceDirect

Cognition

journal homepage: www.elsevier.com/locate/COGNIT

Short Communication

Magicians fix your mind: How unlikely solutions block obvious ones

Cyril Thomas, André Didierjean

Laboratoire de Psychologie de l'Université de Franche-Comté, UFR SLHS, 30 rue Mégevand, 25030 Besançon, France

ARTICLE INFO

Article history:
Received 30 March 2016
Revised 1 June 2016
Accepted 10 June 2016

Keywords:
Magic
Fixing effect
Einstellung
Problem solving
Illusion

ABSTRACT

In everyday life, several factors limit the human capacity to think differently. The present study shows that implanting an unlikely and unfamiliar idea in the mind can prevent participants from finding a more obvious one. To demonstrate this, we used a technique often adopted by magicians to misrepresent the method of a trick: the false solution. Our results reveal that a single exposure to an unlikely false solution (the magician can influence the spectator's choice with his gesture) before the presentation of a card trick can prevent participants from finding the real (more obvious) secret of a trick, even if they are invited to search for an alternative solution.

1. Introduction

Although most of our everyday activities can be performed using established routines, it is sometimes useful to step outside of normal thought patterns to produce innovative ideas. What factors limit the human capacity to think differently? Among the obstacles to creative thinking, some are well known, such as the limits of working memory that prevent the simultaneous consideration of all the parameters of a given problem (e.g., Newell & Simon, 1972; Swanson & Sachse-Lee, 2001), or the existence of judging biases that lead to prioritizing erroneous reasoning (e.g., Kahneman & Frederick, 2005). Another major limiting factor to creative thinking is the fact that, when confronted with a problem, the presence of a familiar idea prevents the discovery of an alternative solution (Bilalić, McLeod, & Gobet, 2010). This phenomenon has been shown in studies of creativity, and named the *design fixation* (Chrysikou & Weisberg, 2005), and in studies of problem solving, and named the *einstellung effect* (Luchins, 1942).

The first investigation into this latter effect was conducted by Luchins (1942) who exposed participants to a series of water-jar problems that could be solved by a fixed solution, which was quickly learned. Then, participants were exposed to a new water-jar problem that could be solved by the same fixed solution or by a new one that was simpler and shorter. Results showed that the majority of participants failed to find the shorter solution and persisted with the fixed solution that they previously learned. Participants who were not exposed to the first series of problems were all able to find the simpler solution. In a second condition, called the *extinction problem*, participants had to solve a new water-jar problem in which the fixed solution did not work. In this extinction problem, the majority of participants declared that the problem was unsolvable. According to Luchins (1942), participants failed to find the correct solution because the pervasiveness of the familiar solution is enhanced by the similarity between the new problem and the previous one, making them blind to the alternative shorter solution.

More recently, Bilalić, McLeod, and Gobet (2008a, 2008b) conducted several studies of the einstellung effect on chess experts. These authors gave participants a series of chess problems and asked them to find the shortest way to win. For each problem, there were two solutions, one of which was well-known and took five moves and one of which was less familiar and took three moves. The expert players found the familiar solution very quickly, but most failed to find the shortest way to win, even if they actively looked for this alternative solution. Participants who failed to find the shortest solution were exposed to a similar problem with a slight modification that made the familiar solution impossible, leaving only the optimal one. In this single-solution problem, all the players quickly found the shorter and less familiar solution they had not managed to see in the first version of the experiment, showing that it was indeed the salience of the well-known solution that "fixed" their mind and prevented them from finding the less familiar but shorter one.

To better understand the mechanisms responsible for this phenomenon, Bilalić et al. (2008a) recorded participants' eye movements. They noted that players who had found the familiar solution to the two-solution version were unable to dissociate

E-mail addresses: cyril.thomas@univ-fcomte.fr (C. Thomas), andre.didierjean@univ-fcomte.fr (A. Didierjean)

http://dx.doi.org/10.1016/j.cognition.2016.06.002
0010-0277/

from it. It was as if their eyes were irresistibly attracted to the elements involved in the first solution, and this prevented them from seeing the second. These results suggest that when a familiar solution suffices to solve a problem, it is difficult to stop focusing on it and consider alternatives.

Despite some methodological differences between previous studies on the einstellung effect, it is interesting to highlight three common points that link them all. Firstly, it is a familiar solution that prevents participants from finding a less familiar one. This familiarity can be caused by being exposed to a fixed solution previously (Luchins, 1942) or by an expert knowledge of the participant concerning this solution (Bilalić et al., 2008b).

Secondly, there is no doubt about correctness of both the fixed solution and the alternative (because participants can easily test them). Thirdly, the context (e.g., water-jar problem) and the elements (e.g., water-jars) required to find the familiar solution are similar to those required to find the alternative one.

In the present article, we show that the phenomenon is even more general than previously thought. It can appear even when these three common points do not apply: a single exposure (oral presentation) to an unfamiliar and unlikely solution can prevent participants from finding a more obvious and contextually different one. To demonstrate this, we used the topic of magic. For centuries, magicians have been manipulating beliefs and psychological subtleties in order to fool the spectator's mind. As such, the art of magic offers psychology an original and rich research field for gaining insight into certain cognitive processes, such as attention, perception, memory, and reasoning (for reviews, see, for example, Kuhn, Amlani, & Rensink, 2008; Rensink & Kuhn, 2014, 2015; Thomas, Didierjean, Maquestiaux, & Gygax, 2015). In this article, we focus on a promising and yet unexplored psychological property often used in magic: the *false solution* (Tamariz, 1988). The false solution (FS) corresponds to any method other than the one actually used to achieve the magical effect. During magic tricks, magicians often highlight false solutions (e.g., "I can read your mind") to divert a participant's suspicion away from the real secret of the trick (e.g., "I collected information about your private life from social networks").

In this vein, the aim of our experiment was to find out whether a single exposure to an unfamiliar and unlikely false solution could prevent participants from finding a more obvious and contextually different one, even if participants are invited to search for an alternative solution.

2. Method

2.1. Participants

Ninety students (mean age: 20 years, SD: 1.6) from the University of Franche-Comté, France, participated in the experiment. All participants had normal color vision, had normal or corrected-to-normal visual acuity and provided informed consent.

2.2. Stimuli and procedure

Three versions of a magic trick were presented live by the same performer. Each participant was individually exposed to one of these versions.

One third of the participants (30 participants) were exposed to the first version of the magic trick, called the *original trick*. In this version, the performer presents to the participants a brown-backed card surrounded by six red-backed cards (the cards are face down) (see Fig. 1a). He explains that the brown-backed card is a prediction that will be revealed at the end of the trick. He randomly touches the back of the six red-backed cards and asks the participants to freely choose one of the six red-backed cards. The performer turns the chosen card face up, revealing a jack of hearts. He then turns the brown-backed card face up, revealing another jack of hearts and showing that the prediction matches the freely chosen card (see Fig. 1b). Then, he asks the participants to orally give one answer to the following *First question*: "what is the secret of the trick?"[1] The correct answer is "all the cards are the same" (see Fig. 1c).

One third of the participants (30 participants) were exposed to the second version, called the *false solution (FS) conditional trick* (see Fig. 2). This version is similar to the original trick version, with a false solution explicitly introduced before the beginning of the trick. Before the trick, the performer explains to the participant that magicians can influence the spectator's choices thanks to some physical suggestions. Then, the performer explains that he will try to influence the participant's choice through a physical suggestion achieved by a specific move of his hand. After the trick, the performer asks the participants to orally respond to the first question: "what is the secret of the trick?" If the participant finds the correct solution (all the cards are the same), the trick ends here. If the participant does not find the correct solution, the performer asks the following *conditional test questions*: "if your solution was not the correct one, could you find another solution to explain the trick?" and "if yes, what would this solution be?"[2]

One third of the participants (30 participants) were exposed to the third version, called the *false solution (FS) extinction trick* (see Fig. 2). This version is exactly the same as the FS conditional trick with the exception of the conditional test question, which is replaced by the following *extinction test questions*: "I did not use this solution (the performer reformulated the solution given by the participant), can you find another solution to explain the trick?" and "if yes, what is this solution?"[3]

3. Results

Results from the first question of the original trick, without providing a false solution, show that 83% (25/30) of the participants found the correct solution (all the cards are the same), and none proposed the *physical influence* false solution. These results confirm that the correct solution of the trick is far more obvious than the physical influence false solution.

As shown in Fig. 3a (see also Appendix A), there was a clear effect of the exposure to the false solution in the percentage of participants who discovered the correct solution after the first question. Results of chi-square tests showed that the percentage of participants who found the correct solution in the original trick group (83%) was significantly greater than both the percentage in the FS conditional trick group (17%, $\chi^2 = 26.67$, $p < 0.001$) and the percentage in the FS extinction trick group (13%, $\chi^2 = 29.43$, $p < 0.001$). Furthermore, for the two FS groups, participants who did not find the secret of the trick typically found solutions related to the false solution (e.g., "the card that the magician touched longer"). There is no significant difference between the percentage of participants who found the correct solution in the FS conditional trick group (17%) and the percentage in the FS extinction trick group (13%, $\chi^2 = 0.13$, $p = 0.72$).

We next examined participants who did not initially solve the problem but then received the conditional or extinction test questions. Their results are shown in Fig. 3b (see also Appendix A). Results showed that the percentage of participants who found

[1] In French: Quel est le secret de ce tour?

[2] In French: si votre solution n'était pas la bonne, pourriez-vous trouver une autre solution pour expliquer le tour? Si oui, quelle serait cette solution?

[3] In French: je n'ai pas utilisé cette solution, pouvez-vous trouver une autre solution pour expliquer le tour? Si oui, quelle-est cette solution?

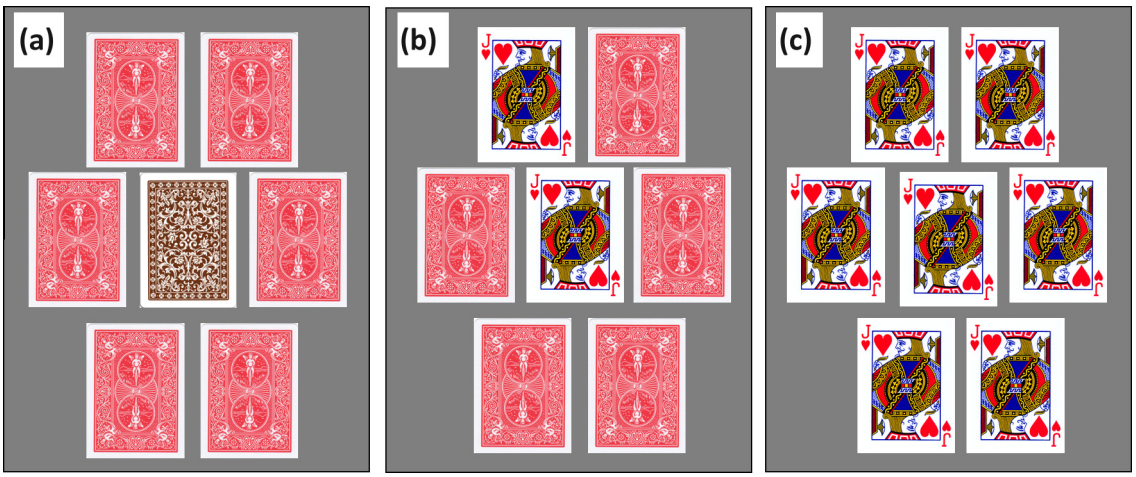

Fig. 1. Configuration of the seven face down cards (a). A chosen card and the matching prediction (b). Secret of the trick (c).

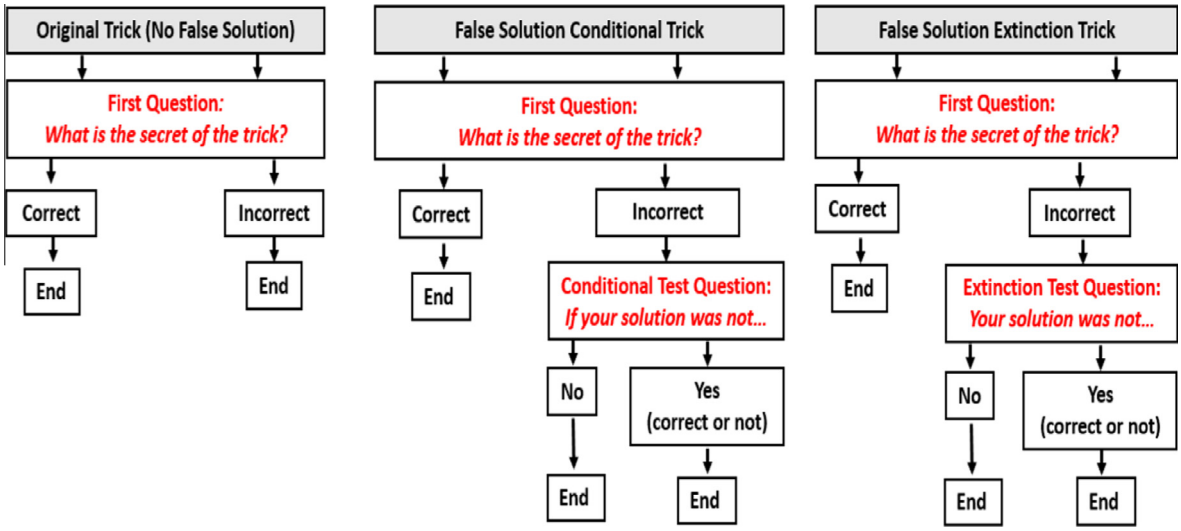

Fig. 2. Description of each condition (original trick, false solution conditional trick and false solution extinction trick).

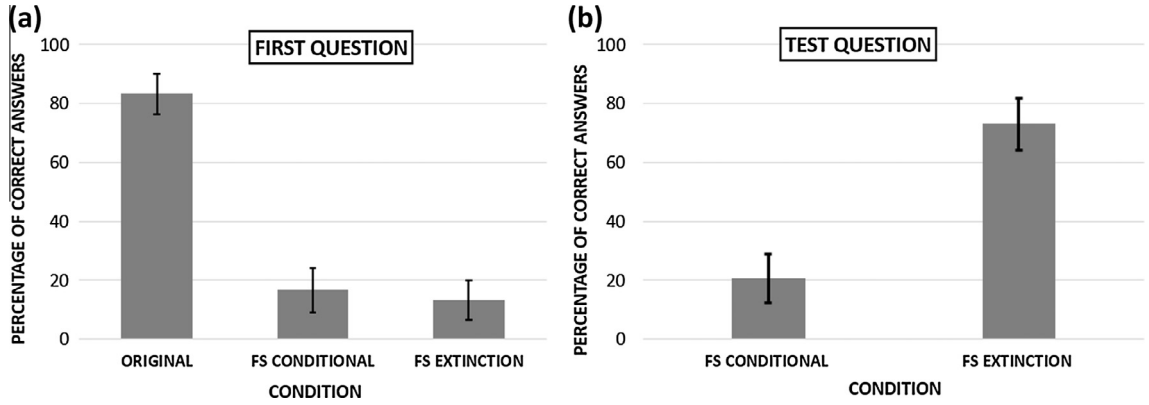

Fig. 3. Percentage of participants who found the correct solution (all the cards are the same) as a function of the condition (original trick (a), FS conditional trick and FS extinction trick) and the question (first question (a) or test question (b)). Error bars represent the standard error of the mean.

the correct solution in the conditional test question (20%) was significantly different from the percentage in the extinction test question (73%, $\chi^2 = 14.41$, $p < 0.001$) (for each condition, all the participants who answered "yes" for the first part of the test question found the correct solution).

4. Discussion

Previous research on the einstellung effect showed that the presence of a familiar solution to a given problem fixes participants' mind and prevents them from finding a less familiar (but

contextually similar) alternative (Bilalić et al., 2008a, 2008b, 2010; Luchins, 1942). The aim of our study was to show that this mind fixing phenomenon is much more general than what previous studies have shown. We tested the hypothesis that, during a magic trick, a single exposure (oral presentation) to an unfamiliar and unlikely false solution (namely, that the magician can influence the spectator's choice with his gesture) can prevent participants from finding a more obvious and contextually different one (all the cards are the same). Our results confirm this hypothesis. Moreover, results from the FS conditional trick show that, even if the performer invites the participants to actively search for an alternative solution to that already given (the false solution), the majority of them (80%) fail to discover it and assume that the trick can't be performed any other way. As long as the false solution is not explicitly exposed as a false one by the performer, most of the participants will close their mind to alternatives.

One hypothesis to explain these results could be that, when the human mind is confronted with an insight problem, it may be more efficient to focus attention on a given and potentially correct solution (even if it is an unlikely and unfamiliar one) than to spend time and attention on finding a hypothetical alternative one (see Simon, 1990). According to Slovic and Fischhoff (1977), the conditional presentation of a problem may activate simultaneously and in parallel the probability that the prior solution (here the FS) is incorrect and the probability that it is correct. Moreover, when participants are confronted with an unnatural event (e.g., a magic trick), the conflict between what they see (e.g., levitation) and what they know about the laws of the nature (e.g., gravity laws) could create an uncomfortable mental state that they try to resolve with the most accessible solution (the FS) (Danek, Fraps, von Müller, Grothe, & Öllinger, 2014; Parris, Kuhn, Mizon, Benattayallah, & Hodgson, 2009). It is only when the magician verbally excludes a particular solution that spectators are forced to abandon the FS by deactivating its representation as a probable solution.

Another phenomenon that may be involved in the present effect is the confirmation bias (Bilalić et al., 2010; Wason, 1960; for a review, see Nickerson, 1998): the tendency to look for evidence that confirms a preexistent belief or hypothesis rather than evidence that might disprove it. Unlike in previous research, in the present study, the prior FS appeared before a problem (the magic trick) was presented. Thus, the confirmation bias could mainly focus on the memory of the elements relative to the FS, misdirecting attention away from the elements of the present scene required to find the correct solution. Moreover, according to Luchins (1942), the pervasiveness of the prior solution is enhanced by the similarity between the new problem and the previous one. Our results contradict this assumption by showing that a fixing effect can also occur when the context of the FS (before the magic trick) is different from the context surrounding the correct one (throughout the magic trick).

Taken together, our results contradict what most magicians believe about FS. According to the magician Tamariz (1988; see also Kuhn, Caffaratti, Tezka & Rensink, 2014), the FS should prevent spectators from discovering the correct solution of the trick, even once this FS is ruled out. The difference between our results and magicians' common assumptions may be due to the fact that, in the present paper, we used an unlikely FS while magicians often use obvious ones (e.g., thanks to a pantomimic action, the performer can convince spectators that a card (that does not exist) is secretly concealed in the palm of his right hand). It is likely that an obvious FS might lead to an *Aha! experience* (a feeling of surprise and obviousness that appears when a solution suddenly comes to mind), which might facilitate the retention and the activation of the FS in long-term memory, increasing the robustness of the fixing effect (see Danek, Fraps, von Müller, Grothe, & Öllinger, 2013; Danek et al., 2014; Thomas et al., 2015).

Finally, our results raise an important question: If a complete stranger (the magician) can fix spectators' minds by convincing them that he/she can control their individual choice with his own gesture, to what extent can an authority figure (e.g., policeman) or someone that we trust (e.g., doctors, politicians) fix our mind with unsuitable ideas?

Appendix A

Summary of the results for the three conditions.

	ORIGINAL TRICK (NO FS)		FS CONDITIONAL TRICK			FS EXTINCTION TRICK		
FIRST QUESTION « WHAT IS THE SECRET OF THE TRICK? »	CORRECT 25/30 (83%)	INCORRECT 5/30 (17%)	CORRECT 5/30 (17%)	INCORRECT 25/30 (83%)		CORRECT 4/30 (13%)	INCORRECT 26/30 (87%)	
TEST QESTIONS « ... ANOTHER SOLUTION? »				NO 20/25 (80%)	YES 5/25 (20%)		NO 7/26 (27%)	YES 19/26 (73%)
« IF YES, WHAT ...? »					CORRECT 5/5 (100%)			CORRECT 19/19 (100%)

Appendix B. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.cognition.2016.06.002.

References

Bilalić, M., McLeod, P., & Gobet, F. (2008a). Why good thoughts block better ones: The mechanism of the pernicious Einstellung (set) effect. *Cognition, 108*, 652–661. http://dx.doi.org/10.1016/j.cognition.2008.05.005.

Bilalić, M., McLeod, P., & Gobet, F. (2008b). Inflexibility of experts—Reality or myth? Quantifying the Einstellung effect in chess masters. *Cognitive Psychology, 56*, 73–102. http://dx.doi.org/10.1016/j.cogpsych.2007.02.001.

Bilalić, M., McLeod, P., & Gobet, F. (2010). The mechanism of the Einstellung (set) effect: A pervasive source of cognitive bias. *Current Directions in Psychological Science, 19*, 111–115. http://dx.doi.org/10.1177/0963721410363571.

Chrysikou, E. G., & Weisberg, R. W. (2005). Following the wrong footsteps: Fixation effects of pictorial examples in a design problem-solving task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*, 1134–1148.

Danek, A. H., Fraps, T., von Müller, A., Grothe, B., & Öllinger, M. (2013). Aha! Experiences leave a mark: Facilitated recall of insight solutions. *Psychological Research Psychologische Forschung, 77*, 659–669. http://dx.doi.org/10.1007/s00426-012-0454-8.

Danek, A. H., Fraps, T., von Müller, A., Grothe, B., & Öllinger, M. (2014). Working wonders? Investigating insight with magic tricks. *Cognition, 130*, 174–185. http://dx.doi.org/10.1016/j.cognition.2013.11.003.

Kahneman, D., & Frederick, S. (2005). A model of heuristic judgment. In K. J. Holyoak & R. G. Morrison (Eds.), *The Cambridge handbook of thinking and reasoning* (pp. 267–293). New York: Cambridge University Press.

Kuhn, G., Amlani, A. A., & Rensink, R. A. (2008). Towards a science of magic. *Trends in Cognitive Sciences, 12*, 349–354.

Kuhn, G., Caffaratti, H. A., Teszka, R., & Rensink, R. A. (2014). A psychologically-based taxonomy of misdirection. *Frontiers in Psychology, 5*, 1392. http://dx.doi.org/10.3389/fpsyg.2014.01392.

Luchins, A. S. (1942). Mechanization in problem solving: The effect of Einstellung. *Psychological Monographs, 54*(6, Whole No. 248).

Newell, A., & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Nickerson, R. S. (1998). Confirmation bias: A ubiquitous phenomenon in many guises. *Review of General Psychology, 2*, 175–220.

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*, 1033–1039.

Rensink, R. A., & Kuhn, G. (2014). A framework for using magic to study the mind. *Frontiers in Psychology, 5*, 1508.

Rensink, R. A., & Kuhn, G. (2015). The possibility of a science of magic. *Frontiers in Psychology, 6*. http://dx.doi.org/10.3389/fpsyg.2015.01576.

Simon, H. A. (1990). Alternative visions of rationality. In P. K. Moser (Ed.), *Rationality in action: Contemporary approaches* (pp. 189–204). New York: Cambridge University Press.

Slovic, P., & Fischhoff, B. (1977). On the psychology of experimental surprises. *Journal of Experimental Psychology: Human Perception and Performance, 3*, 544–551.

Swanson, H. L., & Sachse-Lee, C. (2001). Mathematical problem solving and working memory in children with learning disabilities: Both executive and phonological processes are important. *Journal of Experimental Child Psychology, 79*, 294–321.

Tamariz, J. (1988). *The magic way*. Madrid, Spain: Editorial Frankson Magic Books.

Thomas, C., Didierjean, A., Maquestiaux, F., & Gygax, P. (2015). Does magic offer a cryptozoology ground for psychology? *Review of General Psychology, 19*, 117–128.

Wason, C. P. (1960). On the failure to eliminate hypotheses in a conceptual task. *Quarterly Journal of Experimental Psychology, 12*, 129–140.