



PSYCHOLOGY  
**Why  
Good  
Thoughts**



**Block  
Better  
Ones**

**While we are working through a problem,  
the brain's tendency to stick with familiar ideas  
can literally blind us to superior solutions**

*By Merim Bilalić and Peter McLeod*

# In

A CLASSIC 1942 EXPERIMENT, AMERICAN PSYCHOLOGIST ABRAHAM LUCHINS

asked volunteers to do some basic math by picturing water jugs in their mind. Given three empty containers, for example, each with a different capacity—21, 127 and three units of water—the participants had to figure out how to transfer liquid between the containers to measure out precisely 100 units. They could fill and empty each jug as many times as they wanted, but they had to fill the vessels to their limits. The solution was to first fill the second jug to its capacity of 127 units, then empty it into the first to remove 21 units, leaving 106, and finally to fill the third jug twice to subtract six units for a remainder of 100. Luchins presented his volunteers with several more problems that could be solved with essentially the same three steps; they made quick work of them. Yet when he gave them a problem with a simpler and faster solution than the previous tasks, they failed to see it.

This time, Luchins asked the participants to measure out 20 units of water using containers that could hold 23, 49 and three liquid units. The solution is obvious, right? Simply fill the first jug and empty it into the third one:  $23 - 3 = 20$ . Yet many people in Luchins's experiment persisted to solve the easier problem the old way, emptying the second container into the first and then into the third twice:  $49 - 23 - 3 - 3 = 20$ . And when Luchins gave them a problem that had a two-step solution—but could not be solved using the three-step method to which the volunteers had become accustomed—they gave up, saying it was impossible.

The water jug experiment is one of the most famous examples of the *Einstellung* effect: the human brain's dogged tendency to stick with a familiar solution to a problem—the one that first comes to mind—and to ignore alternatives. Often this type of thinking is a useful heuristic. Once you have hit on a successful method to, say, peel garlic, there is no point in trying an array of different techniques every time you need a new clove. The trouble with this cognitive shortcut, however, is that it sometimes blinds people to more efficient or appropriate solutions than the ones they already know.

Building on Luchins's early work, psychologists replicated

**Merim Bilalić** is a professor of cognitive science at the University of Klagenfurt in Austria and a senior research fellow at the University of Tübingen in Germany. His research on the *Einstellung* effect won the British Psychological Society's Award for Outstanding Doctoral Research Contributions to Psychology in 2008.



**Peter McLeod** is an emeritus fellow at Queen's College at the University of Oxford. He is chair of the Oxford Foundation for Theoretical Neuroscience and Artificial Intelligence.



the *Einstellung* effect in many different laboratory studies with both novices and experts exercising a range of mental abilities, but exactly how and why it happened was never clear. Recently, by recording the eye movements of highly skilled chess players, we have solved the mystery. It turns out that people under the influence of this cognitive shortcut are literally blind to certain details in their environment that could provide them with a more effective solution. New research also suggests that many different cognitive biases discovered by psychologists over the years—those in the courtroom and the hospital, for instance—are in fact variations of the *Einstellung* effect.

## BACK TO SQUARE ONE

SINCE AT LEAST THE EARLY 1990s, psychologists have studied the *Einstellung* effect by recruiting chess players of varying skill levels, from amateur to grand master. In such experiments, researchers have presented players with specific arrangements of chess pieces on virtual chessboards and asked them to achieve a checkmate in as few moves as possible. Our own studies, for instance, provided expert chess players with scenarios in which they could accomplish a checkmate using a well-known sequence

### IN BRIEF

The *Einstellung* effect is the brain's tendency to stick with the most familiar solution to a problem and stubbornly ignore alternatives.

Psychologists have known about this mental phenomenon since the 1940s, but only now do they have a solid understanding of how it happens.

In recent eye-tracking experiments, familiar ideas blinded chess players to areas of a chessboard that would have provided clues to better solutions.

called “smothered mate.” In this five-step maneuver, the queen is sacrificed to draw one of the opponent’s pieces onto a square to block off the king’s escape route. The players also had the option to checkmate the king in just three moves with a much less familiar sequence. As in Luchins’s water jug studies, most of the players failed to find the more efficient solution.

During some of these studies, we asked the players what was going through their mind. They said they had found the smothered mate solution and insisted they were searching for a shorter one, to no avail. But the verbal reports offered no insight into why they could not find the swifter solution. In 2007 we decided to try something a little more objective: tracking eye movements with an infrared camera. Which part of the board people looked at and how long they looked at different areas would unequivocally tell us which aspects of the problem they were noticing and ignoring.

In this experiment, we followed the gaze of five expert chess players as they examined a board that could be solved either with the longer smothered mate maneuver or with the shorter three-move sequence. After an average of 37 seconds, all the players insisted that the smothered mate was the speediest possible way to corner the king. When we presented them with a board that could be solved only with the three-sequence move, however, they found it with no problem. And when we told the players that this same swift checkmate had been possible in the previous chessboard, they were shocked. “No, it is impossible,” one player exclaimed. “It is a different problem; it must be. I would have noticed such a simple solution.” Clearly, the mere possibility of the smothered mate move was stubbornly masking alternative solutions. In fact, the *Einstellung* effect was powerful enough to temporarily lower expert chess masters to the level of much weaker players.

The infrared camera revealed that even when the players said they were looking for a faster solution—and indeed believed they were doing so—they did not actually shift their gaze away from the squares they had already identified as part of the smothered mate move. In contrast, when presented with the one-solution chessboard, players initially looked at the squares and pieces important for the smothered mate and, once they realized it would not work, directed their attention toward other squares and soon hit on the shorter solution.

### BASIS FOR BIAS

THIS PAST OCTOBER, Heather Sheridan of the University of Southampton in England and Eyal M. Reingold of the University of Toronto published studies that corroborate and complement our eye-tracking experiments. They presented 17 novice and 17 expert chess players with two different situations. In one scenario, a familiar checkmate maneuver such as the smothered mate was advantageous but second best to a distinct and less obvious solution. In the second situation, the more familiar sequence would be a clear blunder. As in our experiments, once amateurs and master chess players locked onto the helpful familiar maneuver, their eyes rarely drifted to squares that would clue them in to the better solution. When the well-known sequence was obviously a mistake, however, all the experts, and most of the novices, detected the alternative.

The *Einstellung* effect is by no means limited to controlled experiments in the lab or even to mentally challenging games like chess. Rather it is the basis for many cognitive biases. Eng-

lish philosopher, scientist and essayist Francis Bacon was especially eloquent about one of the most common forms of cognitive bias in his 1620 book *Novum Organum*: “The human understanding when it has once adopted an opinion ... draws all things else to support and agree with it. And though there be a greater number and weight of instances to be found on the other side, yet these it either neglects or despises, or else by some distinction sets aside and rejects.... Men ... mark the events where they are fulfilled, but where they fail, though this happen much oftener, neglect and pass them by. But with far more subtlety does this mischief insinuate itself into philosophy and the sciences, in which the first conclusion colours and brings into conformity with itself all that comes after.”

In the 1960s English psychologist Peter Wason gave this particular bias a name: “confirmation bias.” In controlled experiments, he demonstrated that even when people attempt to test theories in an objective way, they tend to seek evidence that confirms their ideas and to ignore anything that contradicts them.

In *The Mismeasure of Man*, for example, Stephen Jay Gould of Harvard University reanalyzed data cited by researchers trying to estimate the relative intelligence of different racial groups, social classes and sexes by measuring the volumes of their skulls or weighing their brains, on the assumption that intelligence was correlated with brain size. Gould uncovered massive data distortion. On discovering that French brains were on average smaller than their German counterparts, French neurologist Paul Broca explained away the discrepancy as a result of the difference in average body size between citizens of the two nations. After all, he could not accept that the French were less intelligent than the Germans. Yet when he found that women’s brains were smaller than those in men’s noggins, he did not apply the same correction for body size, because he did not have any problem with the idea that women were less intelligent than men.

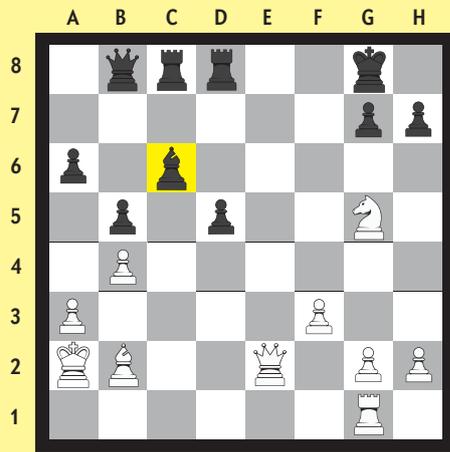
Somewhat surprisingly, Gould concluded that Broca and others like him were not as reprehensible as we might think. “In most cases discussed in this book we can be fairly certain that biases ... were unknowingly influential and that scientists believed they were pursuing unsullied truth,” Gould wrote. In other words, just as we observed in our chess experiments, comfortably familiar ideas blinded Broca and his contemporaries to the errors in their reasoning. Here is the real danger of the *Einstellung* effect. We may believe that we are thinking in an open-minded way, completely unaware that our brain is selectively directing attention away from aspects of our environment that could inspire new thoughts. Any data that do not fit the solution or theory we have already clung to are ignored or discarded.

The surreptitious nature of confirmation bias has unfortunate consequences in everyday life, as documented in studies on decision making among doctors and juries. In a review of errors in medical thought, physician Jerome Groopman noted that in most cases of misdiagnosis, “the doctors didn’t stumble because of their ignorance of clinical facts; rather, they missed diagnoses because they fell into cognitive traps.” When doctors inherit a patient from another doctor, for example, the first clinician’s diagnosis can blind the second to important and contradictory details of the patient’s health that might change the diagnosis. It is easier to just accept the diagnosis—the “solution”—that is already in front of them than to rethink the entire situation. Simi-

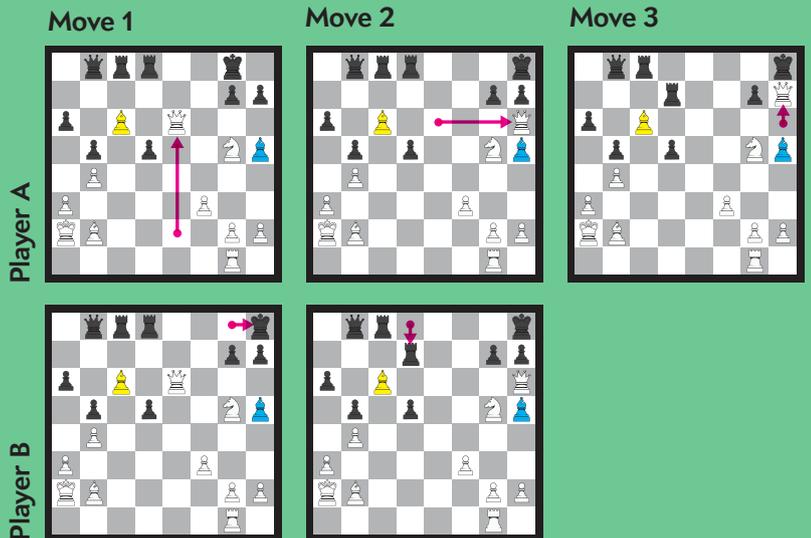
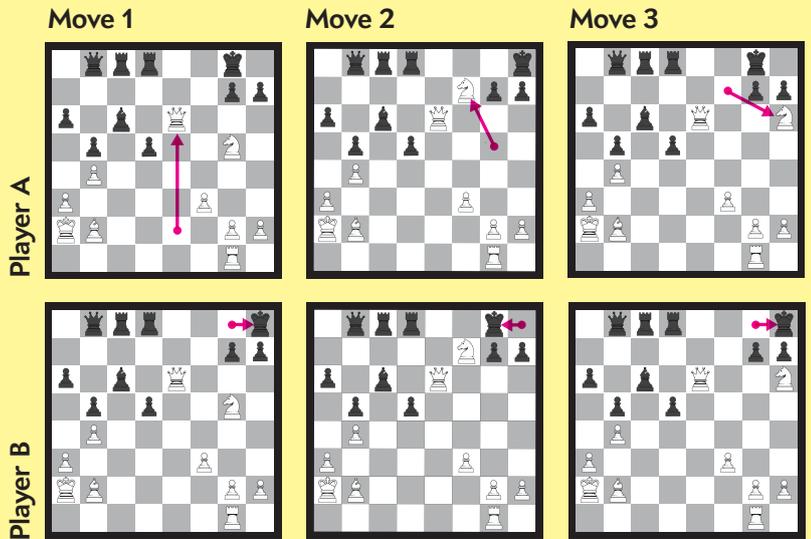
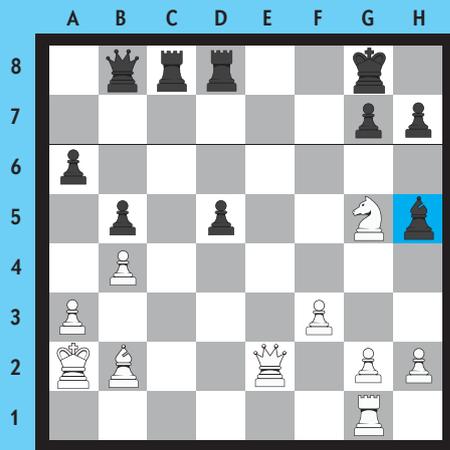
# Much More Than Meets the Eye

The intellectually demanding game of chess has proved a wonderful way for psychologists to study the *Einstellung* effect—the brain’s tendency to stick with solutions it already knows rather than looking for potentially superior ones. Experiments have shown that this cognitive bias literally changes how even expert chess players see the board in front of them.

## Two-Solution Problem



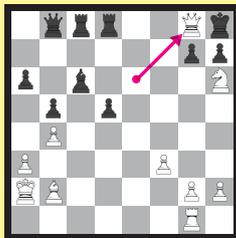
## One-Solution Problem



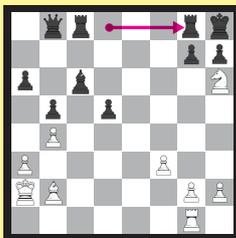
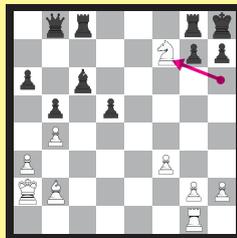
### Chess Masters Fail to See the Quickest Path to Victory

In a well-known five-sequence move called smothered mate (*top, yellow*), player A begins by moving his queen from E2 to E6, backing player B’s king into a corner. Player A then repeatedly threatens to take B’s king with a knight, forcing player B to dodge. As an act of deliberate sacrifice, player A moves his queen adjacent to B’s king, allowing player B to take the queen with a rook. To end the game, player A moves his knight to F7, boxing in B’s king with no chance of escape. In recent experiments, psychologists presented master chess players with the two-solution board shown above, which could be won using either the smothered mate or a much swifter three-step solution (*middle, green*). The players were told to achieve checkmate as quickly as possible, but once they recognized the smothered mate as a possibility, they became seemingly incapable of noticing the more efficient strategy. When presented with a nearly identical board on which the position of one bishop had shifted (*bottom, blue*), eliminating the smothered mate as an option, the players did recognize the speedier solution, however.

### Move 4



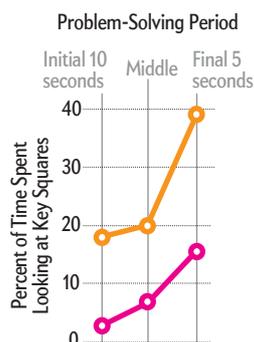
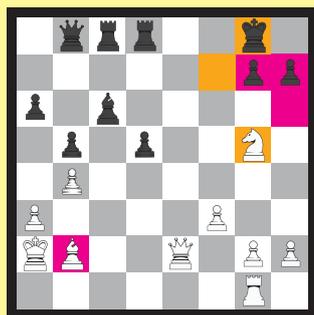
### Move 5



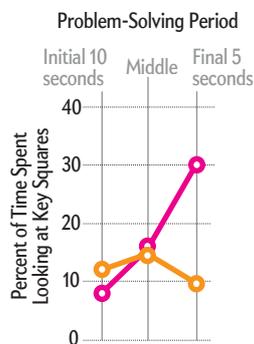
### The Explanation: Tunnel Vision

Eye-tracking devices revealed that as soon as chess players hit on the smothered mate as a solution, they spent far more time looking at squares relevant to that familiar maneuver (orange) than at squares pertinent to the more efficient three-step sequence (magenta), despite insisting that they were searching for alternatives. Conversely, when the smothered mate was not viable, the players' gaze shifted to regions of the chessboard crucial to the swifter strategy.

### Two-Solution Problem



### One-Solution Problem



larly, radiologists examining chest x-rays often fixate on the first abnormality they find and fail to notice further signs of illness that should be obvious, such as a swelling that could indicate cancer. If those secondary details are presented alone, however, radiologists see them right away.

Related studies have revealed that jurors begin to decide whether someone is innocent or guilty long before all the evidence has been presented. In turn, their initial impressions of the defendant change how they weigh subsequent evidence and even their memory of evidence they saw before. Likewise, if an interviewer finds a candidate to be physically attractive, he or she will automatically perceive that person's intelligence and personality in a more positive light, and vice versa. These biases, too, are driven by the *Einstellung* effect. It is easier to make a decision about someone if one maintains a consistent view of that person rather than sorting through contradictory evidence.

Can we learn to resist the *Einstellung* effect? Perhaps. In our chess experiments and the follow-up experiments by Sheridan and Reingold, some exceptionally skilled experts, such as grand masters, did in fact spot the less obvious optimal solution even when a slower but more familiar sequence of moves was possible. This suggests that the more expertise someone has in their field—whether chess, science or medicine—the more immune they are to cognitive bias.

But no one is completely impervious; even the grand masters failed when we made the situation tricky enough. Actively remembering that you are susceptible to the *Einstellung* effect is another way to counteract it. When considering the evidence on, say, the relative contribution of man-made and naturally occurring greenhouse gases to global temperature, remember that if you already think you know the answer, you will not judge the evidence objectively. Instead you will notice evidence that supports the opinion you already hold, evaluate it as stronger than it really is and find it more memorable than evidence that does not support your view.

We must try and learn to accept our errors if we sincerely want to improve our ideas. English naturalist Charles Darwin came up with a remarkably simple and effective technique to do just this. "I had ... during many years, followed a golden rule, namely, that whenever a published fact, a new observation or thought came across me, which was opposed by my general results, to make a memorandum of it without fail and at once," he wrote. "For I had found by experience that such facts and thoughts were far more apt to escape from memory than favourable ones." ■

#### MORE TO EXPLORE

**Why Good Thoughts Block Better Ones: The Mechanism of the Pernicious *Einstellung* (Set) Effect.** Merim Bilalić, Peter McLeod and Fernand Gobet in *Cognition*, Vol. 108, No. 3, pages 652–661; September 2008.

**The Mechanism and Boundary Conditions of the Einstellung Effect in Chess: Evidence from Eye Movements.** Heather Sheridan and Eyal M. Reingold in *PLOS ONE*, Vol. 8, No. 10, Article No. e75796; October 4, 2013. [www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0075796](http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0075796)

#### FROM OUR ARCHIVES

**The Expert Mind.** Philip E. Ross; August 2006.

**The Science of Genius.** Dean Keith Simonton; *Scientific American Mind*, November/December 2012.