open fireplaces with the efficient Franklin stove, the fires caused by the sparks from train fireboxes — changed the landscape briefly and dramatically. If change was rapid in the nineteenth century, how much more rapid will it be in the twenty-first? Perhaps Whitney's most useful lesson is that the factors altering the modern rates of tropical deforestation and the conversion of grasslands to agriculture will not only be complicated, but their relative importance is likely to fluctuate dramatically from decade to decade. □

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Mental tunnels

Martin Gardner

Inevitable Illusions: How Mistakes of Reason Rule Our Minds. By Massimo Piattelli-Palmarini. *Wiley: 1995. Pp. 242. £19.99, $27.95.*

COGNITIVE psychologists study how we think and make decisions. In recent decades they have devised a vast array of confusing questions that most people answer incorrectly because of their poor grasp of logic and probability theory. The correct answers are so counterintuitive that they arouse strong emotions of disbelief comparable to those produced by familiar optical illusions.

Massimo Piattelli-Palmarini, a cognitive psychologist at the Massachusetts Institute of Technology, has written a delightful informal survey of what are known as 'cognitive illusions'. They arise, he says, because of curious blind spots, or mental tunnels, in our mind. Moreover, these tunnels often seriously distort our thinking in such areas as law, politics, economics and medical statistics.

The author's example of what he calls a "super tunnel" is a notorious brain teaser involving elementary probability. It generated such a storm of controversy when Marilyn vos Savant published it in her *Parade* magazine column that the *New York Times* (21 July 1991) reported the fuss on its front page. We can model the problem with three playing cards, one of which is an ace. The operator of the game shuffles the cards and places them face down. You put your finger on a card. The probability you have chosen the ace clearly is 1/3.

Suppose the operator, who knows where the ace is, removes a card that is not the ace. Two cards remain. Most people believe that the probability your finger is on the ace has now risen to 1/2. Wrong! It remains 1/3. Even more amazing is the fact that if you shift your finger to the other card, the chances it is the ace doubles to 2/3. Savant was bombarded with thousands of letters, some from leading mathematicians, objecting to her correct answer.

Piattelli-Palmarini has a raft of other instances where intuitions lead one astray. Which is larger, the set of all seven-letter words ending with 'ing' or the set of all such words with 'i' in the fifth position? Obviously the second set is larger because it includes the first, yet on actual tests most people guess the other way.

Consider this statement:

> Steve is very shy and withdrawn, invariably helpful, but with little interest in people or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail.

Which is more likely, that Steve is a librarian or a farmer? Most people pick librarian. Their blind spot is letting a librarian stereotype override the fact that there are far more farmers than librarians.

This neglect of background statistics is involved in other classics of cognitive research. A laboratory test is 79 per cent accurate in detecting a certain disease. The disease is known to affect only 1 per cent of the population. If you test positive, what is the probability you have the disease? The correct answer, which the author says can be established by Bayes' theorem (to which he devotes an informative chapter), is 8 per cent! Our intuition, we are told, is faulty because we have failed to consider the background information.

Are the cognitive psychologists right on this one? Let's raise the accuracy of the test to 100 per cent. Surely the background information is now totally irrelevant. Why would it become relevant if the test were, say, 99 per cent accurate?

The most tireless researchers on cognitive illusions are Amos Tversky, at Stanford University, and Daniel Kahneman, at Princeton. Is Piattelli-Palmarini right in saying their discoveries are so revolutionary that they deserve the Nobel prize in economics? Or should we agree with their leading detractor, the German psychologist Gerd Gigerenzer? He and others argue that the tricky problems posed by cognitive-illusion researchers represent rare, carefully contrived instances where intuitions are indeed unsound, but that their work on such illusions is making mountains out of molehills.

Whatever the case, *Inevitable Illusions* is the best popular book yet in this peculiar field. It will be of as much interest to recreational mathematicians as to psychologists and general readers. □

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Race to the swift

Lawrence Freedman

The Sorcerer's Challenge: Fears and Hopes of the Weapons of the Next Millennium. By David Shukman. *Hodder and Stoughton: 1995. Pp. 256. £20.*

IT has long intrigued me that in the cartoon battles between superheroes and supervillains that sully childrens' television, the villains always seem to have some device to track the heroes and watch their every move (something our military would love) yet when they actually shoot at a hero they invariably miss (which, by and large, our military do not once they have a fix on the target). It would not do, of course, for heroes to be struck down with ease, so much high-tech science fiction ends up by denying a basic feature of modern armed conflict in order to keep the story going.

Away from fantasy worlds, one cannot rely on the enemy being inept with a basic tool, especially an enemy that has demonstrated considerable technological sophistication elsewhere. Indeed, the best line available to a defence scientist worried about resource constraints is to warn of the consequences if the other side makes the crucial breakthrough first. This line served the defence research establishment well during the Cold War years, but has lost some of its appeal with the apparent loss of the former Soviet Union's demonic character, or at least its transformation into a power that has become incapable of mounting a serious non-nuclear threat to the West. Some of the most vivid descriptions in this book have David Shukman and his television crew teasing secrets out of destitute Soviet military laboratories, where grand ideas are kept alive by underpaid scientists, working in rooms with cracked light bulbs and broken locks, dreaming of access to US technology as part of some scheme of strategic cooperation.

The great merit of this account of the ideas and people in the world of defence research and development is that it provides a snapshot of the process of adjustment to the post-Cold War world. The snapshot comes after the euphoria immediately following the breach in the Berlin Wall and the heady days of Desert Shield and Desert Storm, and the frustrations of Somalia and Bosnia. The scientists have no shortage of ideas, but funding is tighter than ever and they must now justify them according to new political criteria, which for the moment seem to demand a virtually painless war.

If we are not fighting for the survival of our way of life, the casualties must be few and far between, methods must be found to provide defences against any