FILM: NEUROSCIENCE

# Piecing Together a Puzzling World

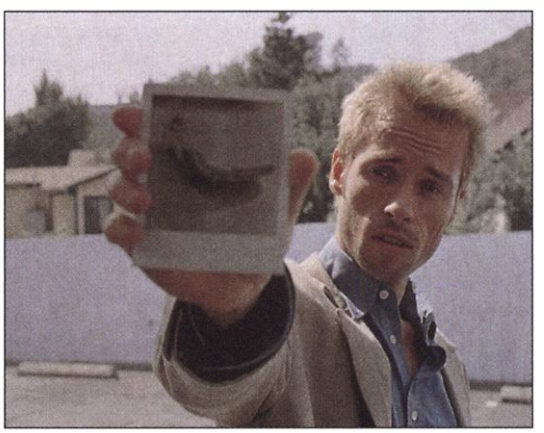
Esther M. Sternberg

What happens to our sense of self, our sense of time, our sense of truth, our knowledge and love of another, or our ability to feel, if our ability to make and store new memories is suddenly cut short? These are the profound questions posed by the movie *Memento*, which is close to a perfect exploration of the neurobiology of memory. In writer and director Christopher Nolan's film, the main character, Lenny, has lost his short-term memory but retains his long-term memory and his ability to reason (along with all his other cognitive and mental faculties). Through him, we learn how important memory is to self. The plot, the dialogue, and the very way that the movie is filmed all explicitly and implicitly expose the different kinds of memory that we take for granted, unless they are suddenly lost.

**Memento**
*Christopher Nolan, Director*
Newmarket Film Group, 2001. See: www.otnemem.com

The film illustrates the ways the brain continuously collects and stitches together sensory inputs from our surroundings and our emotional responses to them to form the memories that create our own unique and constantly evolving identity. *Memento* presents life not according to clock time but with time reflected through memory. If movies were filmed in real time, no one would watch them; the few seminal events would be lost among long, boring sequences when nothing happens. As Oscar Wilde once observed, life is a string of shining moments. Indeed, that is how both movies and memories are constructed: a series of short sequences, stored in separate "boxes," is later strung together to create a whole picture of each character or event. Although one can jumble these short clips together and pull them out in different orders, eventually they form a whole. But in order for that whole to have meaning, the bits and pieces of events must be held together by a glue, and that glue is memory.

In the movie, we learn that Lenny, after a violent accident, has lost his short-term memory because of damage to his hippocampus, the part of the brain that processes short-term memories before they are stored elsewhere. He is perfectly able to recall everything that occurred before the moment of his accident, but since then nothing that happens sticks (*1*). We also discover that Lenny is able to get along in life after the accident only because he has developed a meticulous artificial memory system involving Polaroid pictures, notes written on bits of paper, and even items tattooed on his skin. He has realized that through constant repetition and a form of learning called conditioning (which involves a different part of the brain than the hippocampus), he is able to manage despite his loss of short-term memory. The audience is drawn into the mystery that drives Lenny's life and gives it meaning, the mystery of his wife's horrific death. Together with Lenny, we try to piece together the clues he gathers through pictures and notes, and we try to fit the puzzle together in some meaningful and logical conclusion.



**External memory card.** Lenny uses Polaroid pictures, scraps of paper, and tatoos to compensate for his inability to form new memories.

Without memory, events happen, emotions are felt, and time moves on, but those experiencing the passing show cannot retain any of it. They are doomed, as Lenny is, to live only in the present instant. And if, like Lenny, they previously could form memories, they may constantly re-live the last moment that they truly remember. Their sense of self is frozen in that last moment and stops evolving. For the rest of us, however, our sense of self changes in response to every new experience.

The movie's title refers to the objects that trigger the real kind of memory that provide us with knowledge of things in our physical environment—the only kind of memory that is indisputable, according to the main character. This type of memory is known in neurobiology as "semantic memory." It is the knowledge that when you pick up a thick glass dish, as Lenny illustrates, you know that it will be cold and heavy. Another type of memory is implicit memory: different from words (which are signs of "explicit memory") and hard to express verbally, these associations link an object or a person with a feeling. Lenny closes his eyes when trying to reach into the part of his mind where he has stored his warm feelings for his dead wife. It is only then, when he is not using words, that he is able to remember these feelings. These emotional memories are evoked by smell and touch, memories of a love that is lost. Lenny inhales deeply from the pages of his wife's favorite book, before he burns that memento of her in an effort to forget the horrific event that ended her life. But even the flames that destroy such real-world mementos do not erase the horrible memory of her death nor the wonderful memory of her life and his love for her.

Just like memory, but opposite from real-time life, the plot in *Memento* runs backwards. In the opening scene, the image on a Polaroid picture slowly disappears instead of developing as the photo is shaken. Here and throughout the film, the director's imagery mirrors memory—a likeness that fades with time instead of becoming clearer. And as it fades, and because the actual event that was snapped on film was so fleeting, the viewer is forced to question what, exactly, took place. Also just like memory, events in the film are experienced over and over in tiny, fleeting bits. Each glimpse reveals a little more detail than the previous shot, so that eventually a whole picture emerges. In this way Nolan draws the audience into the process of dredging their own memories of earlier scenes in order to piece together the solution to the mystery.

A psychodramatic mystery, *Memento* asks the ultimate question: what is real? The surprise ending is so fleeting that viewers are forced to replay the final scene over and over in their minds to check the implications of its details. It makes us begin to question our own memory and our interpretation of events based on memory. We must ask ourselves, is anything in memory real? Can we rely on memories and our deduction of the truth if memory is so flawed? This thought-provoking

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thriller is the kind of movie that keeps reverberating in the viewer's mind, and each iteration makes one examine preconceived notions in a different light. *Memento* is a movie for anyone interested in the workings of memory and, indeed, in what it is that makes our own reality.

**References and Notes**

1. These characteristic features of hippocampal memory loss were described in the classic case of the patient H.M.: W. B. Scoville, B. Milner, *J. Neurol. Neurosurg. Psychiatr.* **20**, 112 (1957); S. Corkin, *Semin. Neurol.* **4**, 249 (1984).
2. Thanks to my colleagues R. Desimone and E. A. Murray for their helpful suggestions.

BOOKS: PHARMACOLOGY

# Pathways to Dependency

**Jack H. Mendelson**

This book offers a fascinating, entertaining, and perceptive account of how politics, profit, and pleasure have shaped contemporary attitudes about psychoactive substances. Consider, for example, the history of caffeine consumption in the United States. In 1773, anger about unfair taxation and the control of wholesale tea prices by Britain prompted revolutionary Americans to dump English tea in the waters of Boston harbor. During and after the fight for independence, patriots preferred to get their caffeine from coffee and tea drinking declined. But the replacement of tea also reflected costs: low duties, the proximity of Caribbean and Latin American plantations, and the labor of Brazilian slaves helped coffee consumption rise to eight pounds per person per year by 1859.

David Courtwright, a historian at the University of North Florida, authored an earlier book on opiate addiction in America. In *Forces of Habit* he reviews, with calm reason and humor, histories of the use and abuse of a complete spectrum of psychoactive substances including alcohol, tobacco, caffeine, opiates, cannabis, cocaine, and hallucinogens.

The author notes that connotations of abuse and addiction make the term "drugs" extremely problematic. But, he observes, "For all its baggage the word has one great virtue. It is short." So he uses it as a convenient name for the long list of psychoactive substances (natural, semisynthetic, and synthetic) that he discusses. These drugs can be mild or potent, and they can be used for medical, recreational, religious, or other purposes. Many of them have achieved licit and illicit status with remarkably reversible characterizations or distinctions—interpretations that often reflect local, national, or global political situations. Although Courtwright recognizes that each of these drugs can be abused, he rejects the idea that any are "inherently evil." He observes that "all are sources of profit" for at least some people; thus, they "have become, or at least have the potential to become, global commodities." The author does not ignore individual responses that initiate and sustain drug dependence and abuse, but the emphasis throughout this excellent text highlights the political, economic, and social factors that have enhanced or attempted to reduce such behavior.

**Forces of Habit**
**Drugs and the Making of the Modern World**
*by David T. Courtwright*
Harvard University Press, Cambridge, MA, 2001. $24.95. ISBN 0-674-00458-2.

Courtwright presents a fresh and discerning discussion of contemporary issues and problems surrounding both illicit and legalized drugs. Use of illicit drugs such as heroin and cocaine may lead to severe criminal penalties. In the United States, a considerable portion of the record numbers of individuals currently incarcerated were convicted of illicit drug possession. Nonetheless, the adverse social, economic, and health problems associated with the use of licit substances may be far greater than those due to illegal drugs. The enormous detrimental consequences of alcohol dependence and abuse are evident throughout the world. In some places, such as Russia, alcohol abuse currently poses a major national public health problem. Nicotine offers another example of the heavy medical and social costs of a legal drug. Even though cigarette smoking has noticeably declined in some population groups in the United States, Britain, and western Europe, it continues to cause significant personal health problems such as lung cancer. At present, cigarette smoking among women, particularly younger women, appears to be increasing and the occurrence of fatal health consequences including lung cancer is accelerating. Courtwright addresses these issues with great care and compassion. His helpful discussion of the public health aspects of legal drugs in contemporary society is quite up to date. Indeed, his astute review of the issues concerning cigarettes and women is supported by findings in the U.S. Surgeon General's March 2001 report *Women and Smoking* (see www.cdc.gov/tobacco/sgr_forwomen.htm).

**Fashionable drug use.** When this drawing appeared in the 1920s, smoking was well on its way toward its current position as the world's most widespread and lethal form of addiction.

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I finished reading *Forces of Habit* shortly before the onset of this year's Passover holiday. So I was pleased to read the author's quotation from the Talmud: "wine taken in moderation induces appetite and is beneficial to health...Wine is the greatest of medicines." However, the Old Testament text of Genesis also discusses possible adverse consequences from the consumption of wine.

> And Noah began to be a husbandman, and planted a vineyard: And he drank of the wine, and was drunken; and he was uncovered within his tent. And Ham, the father of Canaan, saw the nakedness of his father, and told his two brethrens without....And Noah woke from his wine, and knew what his youngest son had done unto him. And he said, cursed be Canaan; a servant of servants shall he be unto his brethren. –*Genesis* 9:20–25

It is not clear whether Noah's anger was due to his shame at being naked or to the alcohol abuse that led to his nakedness. Our perception of alcohol and drug abuse in contemporary society continues to reflect ambivalence about responsibility for the causation of problems and about the best procedures for correcting them. *Forces of Habit* enhances our understanding of the numerous conflicting social, economic, psychological, and physiologic processes that shape our use of psychoactive substances—factors that may either increase or, hopefully, attenuate drug dependence and abuse. I enthusiastically recommend the book to both scholarly and lay readers and congratulate Courtwright for his outstanding contribution to our fund of information concerning the causes and consequences of substance abuse.

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