

ing tribes or to torture crime suspects. In the chapter on the trolley problem, Hauser argues that an abstract rule explaining our intuitions could be that harming people can be justified when the harmful act is not intended, but is rather a bad side effect of an act with good intentions. Again there are counterexamples: Some people feel that it is okay to hurt somebody's leg to save a life or that a physician should be held accountable for bad side effects that he did not intend. Hauser would probably argue that these are all parametric variations, but if so it is then hard to discern the underlying common abstract moral rule.

Although Hauser is not shy about his theoretical preferences, he presents alternative theories in a fair manner. One plausible alternative postulates cultural learning mechanisms (3) that draw on various general capacities, such as our abilities to understand other people as intentional agents and to imitate them—to mention just two of the capacities whose existence in children and some animals Hauser eloquently describes. Moral judgments need not be based entirely on reflective applications of explicit rules. They may draw on unconscious analogical reasoning, simple heuristics, and gut feelings. General cognitive mechanisms, such as attention, may also influence our judgments. For example, different causal representations of similar situations may highlight different aspects of the moral dilemmas (4).

Some of these components may be in part innate, although they need not necessarily be specific to the moral domain. Constraints on moral systems may also have historically developed as a result of cultural evolution. For example, it is hard to imagine a society that would survive if it created a moral system that punishes cooperation. Thus, there is certainly a place for both nature and nurture, and Hauser and his critics would agree that various competencies that are not specific to morality play an important role. Where they part company is on whether a dedicated cognitive system devoted to a moral grammar is also required (5, 6).

Regardless of how convincing Hauser's theory eventually proves, its boldness turns reading *Moral Minds* into a suspenseful experience. Near the end, Hauser reveals that he does not expect a definitive resolution soon and that he considers his theory a framework for future research rather than a summary of a finished project: "By leaning on the linguistic

analogy, however, we open the door to these questions, and wait for the relevant theoretical insights and observations."

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NEUROSCIENCE

The Powers of Rhythm

Pascal Fries

György Buzsáki's *Rhythms of the Brain* is an excellent compendium on the rapidly expanding research into the mechanisms and functions of neuronal synchronization. Buzsáki presents such synchronization as a binding glue that integrates many levels of neuroscientific investigation with one another and with neighboring disciplines. The text refers to more than a thousand articles and books. For many of these, the author provides a mini-review in a few sentences, and he summarizes selected references in informative figures. For this reason, the book might well have been subtitled "everything you ever wanted to know about how the brain works but never found the time to look up and read in the original literature."

All the same, the book is much more than a giant review. Buzsáki (a professor at Rutgers University's Center for Molecular and Behavioral Neuroscience) manages to elegantly integrate insights from physics, engineering, and cognitive psychology with contributions from cellular, systems, cognitive, and theoretical neuroscience. By connecting the pieces, he produces a whole that greatly exceeds the sum of its parts. His narrative begins and ends with neuronal synchroniza-

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Behavior established through synchrony. "If you have seen Luis Bravo's Broadway extravaganza *Forever Tango*, you can picture the qualitative essence of neuronal synchrony: coupling through time by some invisible links."

tion, and he presents that as the key to understanding how everything comes together to make the brain work. The book suggests that Buzsáki has already arrived at integrative neuroscience, currently a much-sought target of funding and research organizations.

The book is organized into 13 chapters, which the author calls "cycles." The first introduces relevant general concepts such as periodicity and prediction. Here Buzsáki also presents his notion that most of the brain's activity is generated from within, whereas external inputs cause perturbations that are only minor albeit essential for rendering the brain's internal operations ecologically useful. He ends the chapter with an excellent summary of *Rhythms of the Brain*:

The topics discussed in this book—emergence of spontaneous order, oscillations, synchrony, structure–function relationships, and representation and storage by cooperating cell assemblies—represent the middle grounds of brain activities between the microscopic mindless neurons and the wise, performing brain. My goal is to disclose how the brain gains its smartness from the organized complexity of its constituents. What follows is a progress report on the fascinating endeavors of neuroscience, a tour of fields that are usually not linked together in a single piece of scientific writing.

After exploring the principles that link structure to function, Buzsáki reviews the essentials of cortical microcircuitry, focusing on the important role that neuronal inhibition plays in functional diversity and the generation of rhythms. Introducing the methods currently used for measuring and analyzing rhythmic brain activity, the author discusses their relation to the underlying cellular and synaptic biophysics. He then presents the phenomenology of rhythms (from the circadian cycle to 600-Hz neuronal oscillations) and considers the fundamental scaling laws that connect them. The chapter “Synchronization by Oscillation” moves from the phenomenology to the underlying physiology and from oscillations to synchronization. Its revealing exploration of the mechanistic consequences of synchronization is one of the book’s highlights.

Following discussions of sleep-related brain rhythms and the role of sleep rhythms for consolidating waking-time experiences, Buzsáki introduces gamma-band synchronization and the theories about its function. A chapter on perceptions and actions reviews the influence of brain states on brain rhythms and in turn on behavior. In “Oscillations in the ‘Other Cortex,’” Buzsáki describes his “home turf”: the hippocampus, its rhythms, and their putative functions for hippocampal coding and memory formation. He then turns to synchronization between hippocampus and neocortex and its putative function for coordination and for memory. Although many of the topics he addresses in these chapters have been reviewed extensively elsewhere, Buzsáki takes the discussions to a new level by assuming a bird’s-eye perspective and integrating observations and concepts that have not previously been brought together. A final chapter offers some thoughts on a sample of remaining “tough problems,” which range from the role of brain rhythms in the cerebellum and basal ganglia to their potential function in consciousness.

All of the chapters have a two-part structure: the main text and very extensive footnotes. Buzsáki reserves the former for an uninterrupted flow of thought. Although full of deep insights, this main text avoids technicalities and expert terminology; therefore, it should be understandable to any curious and open-minded reader. Through this approach, Buzsáki succeeds in following his credo that “discoveries and insights realize their power only when understood by others.”

Even though the book is structured to reward nonspecialists, it is also a must-read for interested neuroscientists. My own

research focuses on neuronal synchronization; nevertheless, I learned something from almost every paragraph. At some places, Buzsáki filled gaps in my knowledge; at others, he made me recognize overarching principles. For the expert neuroscientist, the footnotes add full scientific depth to *Rhythms of the Brain*. Branching from the main text, they provide extensive references, deepened discussions, and various historical anecdotes. There is bias toward Hungary and its scientists, but that becomes fully understandable reading this masterful book.

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NEUROSCIENCE

From the Dark Side to the Bright Side of Drug Addiction

Barry J. Everitt

The timely appearance of this ambitious book emphasizes how rapidly the neurobiology of addiction has emerged and grown as a research field. Some 30 years ago, we knew almost nothing about the neurobiological mechanisms of addiction. The rapid advances in our understanding owe much to the important interplay between animal experimentation and the scientific study of drug addiction in humans. Studies in humans, which allow measurements of subjective experience, have been greatly facilitated by the advent of functional imaging techniques. The text’s authors, George Koob and Michel Le Moal, have made major contributions, both experimental and conceptual, to the field. In *Neurobiology of Addiction*, they review how we have come to understand the specific molecular mechanisms underlying the effects of the major classes of addictive drugs. They describe the cellular and molecular adaptations to chronic self-administration of drugs and discuss the neural systems that mediate the effects of addictive drugs as well as their withdrawal. The authors

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Neurobiology of Addiction

by George F. Koob and Michel Le Moal

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also outline the learning mechanisms engaged (perhaps aberrantly) by these drugs.

Koob and Le Moal first met in the late 1970s in Koob’s lab at the Salk Institute in La Jolla, California; there soon followed a reciprocal visit by Koob to Le Moal in Bordeaux. *Neurobiology of Addiction* is a fitting culmination to the productive, long-term collaboration that grew out of these initial exchanges. This substantial volume succeeds both as a reference work—with chapters devoted to each of five major classes of drug (psychostimulants, opioids, alcohol, nicotine, cannabinoids)—and as a state-of-the-art review of theories of drug addiction. The five chapters on drugs repeat a common structure, which makes them easy to follow. Once one gets used to it, the authors’ approach provides a very helpful framework within which to consider the commonalities and differences among these classes of powerfully addictive drugs.

Koob made some of the fundamental observations showing that the mesolimbic dopamine neurons that innervate the nucleus accumbens mediate the acute reinforcing effects of addictive drugs. Collaborating with Le Moal, he subsequently focused on the “opponent motivational processes” through which addiction is hypothesized to originate (that is, through avoidance of the aversive effects of drug withdrawal). The authors developed their theory in the context of Richard Solomon’s earlier ideas (1), which had suggested that drugs like heroin

