BOOKS & ARTS

Why music moves us

Daniel J. Levitin enjoys a book that explains how rhythm, pitch and timbre are combined, and why the most delightful compositions balance predictability and surprise.

The question of how music conveys emotion is ancient. Whereas the Pythagoreans focused on the physical properties of music, the Greek philosopher Aristoxenus argued in the fourth century BC that one must look into the mind of the listener to understand the emotion that music elicits. Modern cognitive neuroscientists ask how the brain interprets sensory events and imposes structure and meaning on them. Scientific research on music perception has increased exponentially in recent decades, spawning many research articles (see 'Science of music') and books on the topic, including my own. By focusing on the intersection of music theory and cognition rather than neuroscience, science writer and former *Nature* editor Philip Ball fills a niche.

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Jimi Hendrix and Johann Bach used similar ornamental trills.

The Music Instinct does a great job of explaining rhythm, pitch and timbre and how they combine to make compositions that capture our attention and emotions. Ball demystifies music theory, teasing out statistical patterns in compositional styles that are separated by continents and by centuries. He paints a big picture by bridging interdisciplinary perspectives, working to understand how music is put together by composers and how listeners interpret those parts to form a coherent whole. He is equally in love with the music of Johann Sebastian Bach and Jimi Hendrix, at one point drawing parallels between their use of trills and ornaments; however, it reminded me of a high-school English teacher trying to be cool, wearing sunglasses indoors and reading Stevie Nicks lyrics with studied gravitas.

The Music Instinct: How Music Works and Why We Can't Do Without It
by Philip Ball
Bodley Head: 2010. 464 pp. £20

Why is it that strangers plucking on strings, dragging horse hair over them or blowing into tubes can cause some of the most deeply satisfying moments of our lives? Ball recounts how the German composer Paul Hindemith thought that expectation was central to the aesthetics of music, "but only insofar as we derive pleasure from having our expectations met". Yet this explanation is manifestly untrue: if musical pleasure can be reduced to expectation, we should prefer simple, predictable music — precisely the sort that most people find annoying.

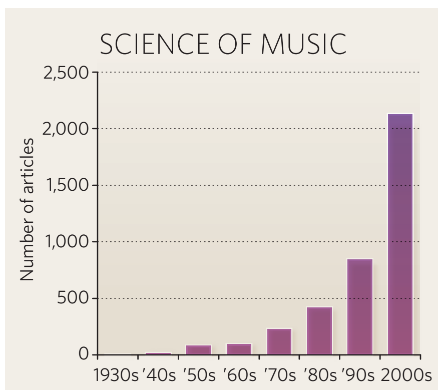
After pages dissecting technicalities — such as Pythagorean scales, Greek modes, various tuning systems and the physical basis for consonance and dissonance in simultaneously sounded notes and chords — the music really starts to play when Ball introduces the US composer and music theorist Leonard Meyer. Meyer argued that music that is too simple or too complex is likely to irritate. The secret to composing a likeable song is to balance predictability and surprise. Because most music has a beat and is based on repetition, we know when the next musical event is likely to happen, but we don't always know what it will be. Our brains are working to predict what will come next. The skilful composer rewards our expectations often enough to keep us interested, but violates those expectations the rest of the time in interesting ways.

If the composer can then invent a musical completion that surprises and satisfies us, we are hooked. The reason why a particular completion can sound good may be analogous to our hunter-gatherer ancestors being shown a new route to the well. The new musical route teaches us that there is more than one way to get from note A to note B, a journey through musical space that traverses pitch, time, memory and emotion.

In neuroscientific terms, the physical world presents our sensory systems with an ambiguity, and the brain — a giant prediction device — uses statistical principles and logical inferences to resolve that ambiguity and to predict what will happen next. Listening to music exercises our neural circuits by simultaneously rewarding them for correct predictions and challenging them to learn new principles for organizing the world. Music engagement might also promote creative, flexible thinking and hone prediction skills.

Ball's account is mostly accurate. However, readers should ignore the publisher's online description of the contents as uniting findings in music psychology and brain science, as few pages address that topic. Ball commits the error of many outside the field when he breathlessly writes that "musical training alters the brain". Well, yes. But so does any form of learning, be it building a model of the SS *Andrea Doria* out of balsa wood, or forming mental representations of geographical terrain — as demonstrated by neuroscientist Eleanor Maguire in her study of the hippocampi of London taxi drivers.

The book does not answer the question posed in its subtitle about why we cannot live without music; recent books such as David Huron's *Sweet Anticipation* (MIT Press, 2008), Steven Mithen's *The Singing Neanderthals* (Harvard University Press, 2007) and Aniruddh Patel's *Music, Language, and the Brain* (Oxford University Press, 2008) come closer. Yet Ball's survey is



SOURCE: D. LEVITIN

Articles on music-related research in the PubMed database have increased rapidly.

commendable. He is at his best describing expectancy theory, the acoustic and physical bases of pitch, consonance and tonality. He explains well the decisions that composers make given the constraints of style, form and tradition. *The Music Instinct* also contains representative, if abbreviated, coverage of seminal and recent research into music cognition.

How far are we today from understanding how music moves us? I suspect that we are close. We know that music activates regions throughout the brain, not just a single 'music centre'. As with vision, music is processed component by component, with specific neural circuits handling pitch, duration, loudness and timbre. Higher brain centres bring this information together, binding it into representations of contour, melody, rhythm, tempo, metre and, ultimately, phrases and whole compositions. Our memory for music is remarkable and melody recognition is robust. Listening to music activates reward and pleasure circuits in brain regions such as the nucleus accumbens, ventral tegmental area and amygdala, modulating production of the neurotransmitter dopamine.

We now need to learn how simple manipulations of acoustic parameters — such as pitch, intonation, timing, timbre and loudness — give rise to changes in our mental and emotional perception of a performance. For example, I can play all of the same notes that pianist Arthur Rubinstein played — even on the same piano he used to record Beethoven's *Moonlight Sonata* — but no one is going to mistake me for him. Critics call it his touch, but cognitive psychologists would reduce the difference to the interactions of the five dimensions above (or four in the case of the piano, in which intonation is fixed). How can so much emotional nuance come from these factors? Why do some people become master musicians, whereas others with equivalent training and practice do not? And what might be the genetic, personal, neural and social components of this difference? We still do not know much about why people like the music they do, or about aesthetic tastes in general.

The Music Instinct offers an expansive and high-level overview of a complex field. Ball is both an enthusiastic writer about music and a passionate listener engaged with its emotional meaning as much as with its intellectual puzzles — an Aristoxenus for his time. ■

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Social skills: Hawaiian cleaner fish (right) have learned to cooperate.

Once more into the animal mind

Cognition, Evolution, and Behavior
by Sara J. Shettleworth
Oxford University Press: 2010 (2nd edn). 720 pp. $59.95, £40
First edition published 1998

The study of the mental lives of animals — comparative cognition — is relatively new. Although Charles Darwin suggested in the nineteenth century that mental, as well as morphological, characteristics are subject to natural selection, the study of animal cognition did not take off until the 1970s, the offspring of a partnership between the fields of comparative psychology and animal behaviour. In the latest edition of *Cognition, Evolution, and Behavior*, experimental psychologist Sara Shettleworth provides a scholarly synthesis of current thinking in this fast-moving field.

The book is much more than a revision, reflecting the developments that have transformed the field in the decade since the first edition. Whereas topics such as spatial cognition — exploring how animals navigate and what they remember about their spatial environment — have seen incremental advances, others have exploded. The chapters on numerical and social cognition, covering how animals assess quantities and what they know about their social world, now extend beyond primates to species as diverse as dogs, goats, ravens, jays and cleaner fish. Shettleworth also discusses newly founded areas of study, including episodic-like memory, future planning and an animal's self-knowledge of what it knows (metacognition).

By taking a broad overview, Shettleworth resolves two critical conundrums within comparative cognition. The first is a tension between behaviouristic and mentalistic explanations of complex behaviour — namely whether the presence of a stimulus simply triggers a behavioural response or whether it engages a set of cognitive inferences. By adopting the critical stance of the behaviourist and acknowledging the theoretical concepts of the mentalist, Shettleworth integrates both perspectives in an informed way.

A second tension is whether comparative cognition should be viewed as a suite of adaptive specializations — from spatial skills to social smarts — or whether general-purpose processes, such as associative learning, have greater explanatory power. Here, too, she argues that both processes play a part in explaining how cognitive abilities arise. Shettleworth's analysis will catalyse the development of an overarching, integrated theory of comparative cognition.

Shettleworth's second edition provides considerable synthesis and a greater theoretical amalgamation with other disciplines, such as child development, cognitive science and neuroscience. The result is a detailed, nuanced and biologically informed view of how and why the cognitive capacities of various species can be the same yet different. ■

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