

this book was written just after the basic algorithmic and physical tools of the field had reached a standard form. And so the text contains essentially all of the material that might be covered in a course on quantum information.

I used it as a textbook for an introductory course in quantum computation at my institute. At the end of the term, the class was polled on various aspects of the book. The response was uniformly positive: the book received ratings of 5 out of 5 for comprehensiveness, 4 out of 5 for clarity, and 4 out of 5 for problems and exercises. Within the first week, the students had bestowed on it a nickname, “Mike ‘n’ Ike”, after the authors’ first names.

A rigorous, comprehensive text on quantum information is timely. The study of quantum information and computation represents a particularly direct route to understanding quantum mechanics. Unlike the traditional route to quantum mechanics via Schrödinger’s equation and the hydrogen atom, the study of quantum information requires no calculus, merely a knowledge of complex numbers and matrix multiplication. In addition, quantum information processing gives direct access to the traditionally advanced topics of measurement of quantum systems and decoherence.

Finally, understanding information in a quantum-mechanical context is crucial for the development of the next generation of quantum technologies, such as nanoscale circuits, sensors, motors and timing devices. At the nanoscale and below, information has as important a role as energy in the functioning of such devices. *Quantum Computation and Quantum Information* is a must-read for the generation of budding quantum-mechanical engineers who will build the technologies of the future. ■

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Notes on a cultural theme

**Beethoven’s Anvil: Music in Mind and Culture**

by William Benzon

Basic Books: 2001. 352 pp. \$27.50, £19.99

**David Juritz**

Here’s an analogy that will live with me for ever — the comparison of the finale of Beethoven’s ninth symphony to a troop of baboons. This striking idea is to be found in *Beethoven’s Anvil*, which describes “the workshop in which human culture was first

forged and which continues to sustain us as we evolve into the future”.

William Benzon, a cognitive scientist and musician, draws on research from a wide range of disciplines. Although his preface describes the book as “an exercise in speculative engineering”, with the caveat that many of his speculations “must surely be wrong”, he succeeds in building a convincing, though not compelling, case.

Arguing that musicality is an adaptive feature that evolved in hominids alongside speech, Benzon initially focuses on the mechanisms by which participants in musical activity coordinate their neural states. He believes that, in such states, the brain operates in a mode similar to that of dreaming, with the attendant changes in its neurochemical processes. In this state, the reduced levels of the neuromodulators serotonin and noradrenaline inhibit the laying down of long-term memories.

The sceptic in me couldn’t help observing that the author nevertheless seems to have near-perfect recall of many of his own such ‘ecstatic’ experiences. However, he then presents compelling evidence from, among others, psychologist Jaak Panksepp (who discovered in a delightful experiment that chickens are affected by music, showing a particular affinity for Pink Floyd), that some music has a direct effect on levels of the neuropeptide oxytocin. This hormone is known to mediate bonding between individuals and may also have an enhancing role in the laying down of new memories. If these statements are contradictory, Benzon is the first to admit that further research is required.

Starting with the observation that the hypoglossal nerve controlling the tongue reached its present size 300,000 years ago, Benzon takes up the argument proposed

by zoologist Valerius Geist that the ability to mimic animal calls while hunting is an adaptive advantage that offsets the biological expense of our sophisticated vocal apparatus. (Recall President George W. Bush’s recent encounter with a pretzel.) These imitative calls would then have been incorporated into ritual activity, evolving in time into a protomusical form of communication.

Hence music as a memetic phenomenon. Using Richard Dawkins’ and Susan Blackmore’s concept of the meme, the behavioural or cultural equivalent of a gene, Benzon shows how musical ideas and fragments that are ‘successful’ tend to replicate as musical language as a whole evolves.

Next, he explores music as an agent of social cohesion in hunter-gatherer and small-scale communities. He maintains that it acts to dissipate tension or to enhance the sharing of pleasure, and allows social reprogramming to occur during rites of passage. Benzon suggests that during rituals, such as a marriage between individuals from neighbouring communities, the simultaneous changes induced in the collective brain chemistry allow relatively large groups of people to adjust quickly to changes in the status of the individuals who are marrying. He argues that groups possessing the means to maintain collective harmony in this way function more smoothly, thus securing a selective advantage.

Other sections of the book address rhythm, cognitive processes, learning processes, ethnography and some music history, with a wealth of examples as illustration.

Benzon’s book covers a vast area, albeit in a rather rambling fashion. But there are weak points. *Beethoven’s Anvil* drops with a resounding clang at the ridiculous analogy between a troop of baboons and Beethoven’s ninth symphony. Apparently, at the opening of the finale, “distinctly different ideas [for which read pseudopods formed by young males] mill about until one of them, the Ode to Joy [yes, you guessed it, a dominant male] takes charge”. And they move off. A glance at the CD’s sleeve notes, or the vaguest knowledge of Beethoven’s compositional process, should have disabused him of such an assertion. When, in the final chapter, 300,000 years of music-making (Benzon prefers to use the painful construct “musicking”) is reduced to a diatribe about racism in contemporary America and — I kid you not — the burning issue of where ‘hip-hop’ should go from here, my exasperation reached a level where I feared I had developed late-onset Tourette’s syndrome.

This book stimulated as intensely as it irritated me. It has great scope but a lack of focus, poorly chosen examples and some weak analysis which served to alienate rather than convince. I recommend it with caution, but not as a present for Beethoven lovers. ■

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A world of music: these Ladakhi musicians at Leh Gompa in Tibet emphasize music’s ubiquity.

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