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***Music and the making of modern science*, by Peter Pesic. London: MIT Press, 2014; Hardcover ISBN: 9780262027274 (£27.95), eBook ISBN: 9780262324373 ($20.00)**

In his latest book Peter Pesic skillfully frames the interrelationship between music and science in the context of intellectual exploration. He leads the reader from the ancient historical connections of music, arithmetic, geometry and astronomy (the Quadrivium) to concepts that shape our modern understanding of nature by Riemann and Holtz. Importantly, the investigations start from the musical or auditory concept and work towards the related scientific or mathematical idea and not, as is often the case in literature on these subjects, in the other direction. As a composer, my relationship with mathematics, physics and science in general is both explicit in the acoustic properties of the sounds that I want to hear produced, and implicit in the structural and conceptual background work (the pre-composition). I came to this book hoping to find bridges between these two interests.

Pesic carefully balances detailed explanation with swift chronological progression through each of the eighteen chapters (or episodes). Starting with 'Music and the Origins of Ancient Science' and recounting the tale of Pythagoras and the blacksmith, he cements the core concept of mathematical proportion as musical interval and musical interval as mathematical proportion. Even at this early stage

we are invited to consider not only deep, empirically verifiable connections between subjects, but also how music and science were understood both culturally and philosophically during the time period under consideration. Key intellectual developments in history, such as the discovery (or invention) of irrational numbers, had precursors in the arts. Pesic invites us never to underestimate the importance of the philosophical groundwork that music and the arts in general provide society—a concept that today's politicians might well benefit from understanding.

The searchlight of Pesic's enquiry rapidly shines on topics such as 'Descartes's Musical Apprenticeship', 'Mersenne's Universal Harmony', 'Euler: from Sound to Light' and 'Helmholtz and the Sirens'. Within these slightly enigmatic headings lie pivotal points in our collective scientific history such as the motion of heavenly bodies, colour and optics, and quantum theory.

Previous to his current employment as Tutor and Musician-in-Residence at St. John's College, Santa Fe, Pesic was a research assistant and associate at the Stanford Linear Accelerator Center. His deep understanding of both disciplines is apparent in his clarity of writing. Fellow musician and physicist Douglas Hofstadter has also written extensively on understanding one discipline in terms of another and how he believes that analogy-making lies at the core of our cognition. In his foreword to *Gödel's Proof*, Hofstadter (2001, p.xviii) writes:

> Numbers are a universal medium for the embedding of patterns of any sort, and for that reason, statements seemingly about numbers alone can in fact encode statements about other universes of discourse.

This powerful idea is fundamental to how Pesic clearly shows, through example after example, how numbers are integrated into the fabric of our understanding of the natural world. Furthermore, by understanding relationships and patterns in the context of music we are able to build an intuitive relationship with them, one that can be used as another tool in the toolbox of scientific discovery. In turn these discoveries inform and shape our work within the creative arts. Andrei Riabovitchev (2013, p.36) in his introductory chapter to *Art Fundamentals* writes:

> The Theory of (artistic) composition is built upon a scientific base. Mathematics enables us to calculate geometry and perspective; physics determines colour and light; biology and physiology drives our perception of colour and its effect on humans.

The highlight of the book for me was 'Planck's Cosmic Harmonium'. Max Planck's outstanding test compositions integrate certain tuning systems as an essential part of the composition. Through using these systems he plays with our expectations and our perceptions of sounds. Like an Escher print, Planck was able to, for example, slowly shift a tonic up five syntonic commas (about a semitone). As compositional material, *Planck's first test composition* acts as a reminder of how understanding the building blocks of our western harmonic system can be used as the fabric of a compositional process. Similar investigations in *How Equal Temperament Ruined Harmony (and Why You Should Care)* by Ross Duffin (2007) provide a further framework for this type of enquiry. There is fun and beauty in this type of 'what if' investigation. Surely this is as much a common thread between art and science as anything else.

To conclude this wonderful work Pesic summarises music and science as a hybrid enterprise. I would have liked to

have had a little more information on where he sees this enterprise going in the future and also how developments in technology may also have a bearing on this relationship. Above all, on reading this book I have been left with a lasting impression of the sophistication and depth of true interdisciplinary thinking.

The book is available in both hardback and eBook editions. Audio examples are available online to accompany the book, and the eBook edition has these examples as embedded multimedia. I would unreservedly recommend this book to anybody interested in the history of science and music. Educators, students and other interested parties in both disciplines can benefit from thinking of one field in terms of another and thus understand their own more fully.

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About the review author

DR J. HARRY WHALLEY is a tutor at the Reid School of Music at the University of Edinburgh and Tutor Technician in Sound for Moving Image at the University of Creative Arts. His practice-led research focuses on relationships between music and music theory and wider subject areas. His PhD thesis investigated the concept of a tangled hierarchy as outlined in Douglas Hofstadter's 1979 book *Gödel, Escher, Bach* and how this might be mapped onto a music composition process. He is currently working on the use of music and dramaturgy as a means to highlight contemporary issues in bioethics.