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Foreword

Music has, for a very long time, stood at the intersection between the Humanities and the Sciences. The first music was probably the rhythmic sounds that could be made by sticks when struck against hollow objects such as tree logs or coconut shells and then the sustained tonal sounds the could be made by blowing across or through hollow pipes such as pieces of bamboo. These sounds were probably appealing to humans because they introduced simple patterns that could be heard by all members of a tribal or family group and that could be made distinctive to that group. Over the millennia musical instruments were developed – drums, harps, flutes, and so on – and these were gradually refined and extended to produce the musical instruments that we know today.

The interaction between music and science perhaps began in the West with the Greek scholar Pythagoras (570–495 BC) who first discovered that 'harmonious' sounds were produced by strings with integer length ratios, specifically 2:1 and 3:2. This led to development of the Pythagorean tuning system which used just these two ratios. Parallel developments in Asia led to the rather different gamelan tunings of Indonesia and the microtonal shruti of Indian music, along with the more 'Pythagorean' pentatonic tunings of China and Japan. The relation of string length to vibration frequency was not formally discovered, however, until the time of Galileo (1564–1642) nearly 2000 years later. This connection between arithmetic and music then continued to develop as shown by the classification of learning in the Middle Ages into the trivium, consisting of grammar, rhetoric and logic, and the more advanced quadrivium that comprised arithmetic, geometry, music and astronomy.

Even the connection between music and arithmetic turns out to be more complex than Pythagoras imagined, for a tuning based on only the integers 2 and 3 fails to close the 'cycle of fifths' since $(3/2)^{12}$ does not equal 2^7. It also leads to the ratio 81/64 for the major third, which is far from simple – a ratio of 5/4 or 80/64 is what is really needed to eliminate beats between the fourth and fifth harmonics. A 'meantone' system based on perfect thirds and approximate fifths was popular for much of the classical period but many better tuning systems were developed over the years, including the famous Werckmeister III system that influenced Bach in his *Well Tempered Clavier*, though coding on the manuscript title page suggests a slightly different system perhaps developed by Bach himself. The modern solution, however, is a compromise based upon an 'equal-tempered' semitone step with a frequency ratio of $2^{1/12}$ which makes every interval except the octave a bit 'out-of tune' but renders all musical keys equivalent. An almost equivalent practical approach is used in the spacing of frets on guitars and similar instruments with the 'rule of eighteen' specifying that the string length should be reduced by one eighteenth of its current length for each semitone step.

Apart from the underlying physics and acoustics of musical instruments, one of the areas of greatest research interest today is the interaction between musical sounds and structures and human perception, generally termed psychoacoustics. What makes a 'musical' sound? (the answer cannot just be 'a musical instrument'!) and what makes a 'musical' composition? In Western music we are used to 'harmonic' musical sounds in which all the overtone frequencies are integer multiples of the fundamental frequency, and this underlies our tuning systems. Sustained-tone instruments have this characteristic automatically because of nonlinear interactions, but impulsively excited instruments such as bells and gongs can have very different overtone structures. Even plucked or hammered strings differ slightly from ideal harmonic ratios because of their inherent stiffness. This does not mean that non-harmonic sounds cannot be used in musical compositions, but rather that they must be treated in a way that is rather different from harmonic convention. Such sounds will also be perceived by listeners in a rather different manner.

When it comes to the structure of musical compositions a much wider view must be taken, for structures can extend from two notes played simultaneously up to the whole pattern of a composition lasting many minutes. The important thing is that the pattern, whatever it is, must first be perceived by the listener and secondly appreciated, typical classical examples being dances at a short scale and fugues or variations at a much longer scale. Many arguments may develop concerning patterns that are formally imposed upon a musical composition but may only be discovered by careful analysis of the manuscript rather than by listening – they may attract scholars but leave listeners unmoved.

The papers in this volume address many of these questions from widely differing viewpoints, ranging from the sound of bells to the structure of modernist compositions, from digital and electric instruments to pitch perception. These papers were selected from those presented at the Conference on Interdisciplinary Musicology organised by Michele Castellengo and Hughes Genevois and held in Paris in October 2009. They generally examine matters from the viewpoint of a listener, as is appropriate, though in some cases the paper concerns itself with the structure and hidden content of the composition studied. The field itself is very wide and highly multi-disciplinary so that these papers can give only a view of some of the subjects that are currently being examined and of the variety of approaches being used. We hope you will enjoy reading them and that they will expand your own view of the subject.

Neville Fletcher, David Howard
guest editors

Biographies

Neville Fletcher was for twenty years Professor of Physics at the University of New England in Australia, following which he was an Institute Director in CSIRO, Australia's national research organisation. Following retirement in 1995 he has been a Visiting Fellow at the Australian National University in Canberra and a Visiting Professor at the University of New South Wales in Sydney. He has done research work in many fields including transistor design, condensed-matter physics, cloud physics, and nanotechnology, but his main interests have been in musical and biological acoustics. He has published seven books and more than 200 research papers, one of his best known books being "The Physics of Musical Instruments" written in collaboration with Thomas Rossing.

David Howard holds a personal chair in music technology at the University of York, UK where he is Head of the Audio Lab Research Group. A great part of his research inspiration arises from being an organist, choir conductor and choral singer and he has particular research interests in the analysis and synthesis of singing, music and speech, including intonation and pitch shift in a cappella singing, the use of computers in professional voice training and physical modeling digital waveguide synthesis for music and voice. He has published invited chapters in 12 books and 'Acoustics and Psychoacoustics' with Jamie Angus and 'Voice science acoustics and recording' with Damian Murphy. His work in public engagement with science led to him presenting two BBC TV programs – 'Castrato' and 'Voice'.