

March 1999, p. 3.

2. "AIDS in Context" International Conference, University of the Witwatersrand, Johannesburg, 4 to 7 April 2001. Opening address by E. Cameron, text available at <http://www.hivnet.ch:8000/africa/af-aids/viewR?987>
3. Panel discussion, "AIDS in Context" International Conference (2).
4. While with the Department of Health under Zuma, Shisana had supported the government's stalling on MTCT prophylaxis.
5. "African Summit on HIV/AIDS, Tuberculosis and Other Related Infectious Diseases," 24 to 27 April 2001, Abuja, Nigeria. Information available at www.unaids.org/whatsnew/speeches/eng/index.html
6. G. Gray, address, South Africa's First AIDS Walk, Johannesburg, 9 September 2000.
7. Z. Achmat, responding to Simelela's address and exit from the panel discussion at the "AIDS in Context" International Conference (2).

DOE's Support of the Sloan Digital Sky Survey

THE U.S. DEPARTMENT OF ENERGY (DOE) rarely gets the credit it deserves for its science programs, and in the case of the Sloan Digital Sky Survey, it deserves a lot of credit. The contributions to the project from Fermilab and Los Alamos National Laboratory that Ann Finkbeiner discusses in her sidebar article "Funding the Sloan" (News Focus, 25 May, p. 1474) came from the DOE. DOE's contribution to the Sloan is considerably larger than that of the traditional astronomy funders, NASA and the National Science Foundation (NSF). That DOE made this contribution is a tribute to the vision of its program officers and laboratory researchers, who recognized the importance of the Sloan data to such topics as the nature of dark matter and the evolution of the early universe, as well as to traditional astronomy.

As for those who will be analyzing the data, I was startled to read that NASA and NSF have not put up funds to allow the builders of the Sloan to have a major shot at this opportunity. The Sloan will be a revolutionary instrument. The people who have spent so many years bringing it into being deserve a chance to use it.

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The Biology of Music

MUSIC WAS AT ONE TIME THE EXPLANATION OF universal order that supported the concept of the harmony of the spheres. From Pythagoras to Kepler, music and mathematics were inseparable and offered a means to understanding the mysterious relation between humans, nature, and the supernatural. In the Perspectives "The music of nature and the nature of music" by P. M. Gray *et al.* (1) and "The music of the hemispheres" by M. J. Tramo (2), the authors discuss recent research into the biological foundations of this unique human

capability; however, they favor a biological and evolutionary origin of musical creativity.

The music produced by whales and birds and the physiology of human cochlea are analyzed and compared with the diatonic scale as if it were a universal and invariable series of musical notes. The diatonic scale is an artificial series of notes that is imperfect by its very nature. The scale we use in modern music was arrived at no more than three centuries ago. The uppermost note of a circle of fifths lands at a slightly higher frequency than the top note of a corresponding span of octaves, and the essential scaffolding of the 12-note scale does not fit the abstract ideal of arithmetic perfection (3). How, then, could evolution have shaped whale and bird songs or cochlear hair cells for specific tones in a recently human-made imperfect musical scale? Consequently, it is astonishing to find that whales might have chosen the same musical intervals and that they compose songs of the length of a symphony. However, to compare the descending cascade of notes of the wren's song with Chopin's "Revolutionary Etude," which differs altogether in tone, key, rhythm, and extension, or to compare part of the "Pastoral



The nature of music—whether from humpback whales, quails, or the mind of Chopin.

Symphony" by Beethoven, which is intended to mimic bird sounds, to the songs of the quail and cuckoo as evidence of the animal capacity to compose music certainly lies beyond scientific demonstration.

Finally, the conclusion by Gray *et al.* (1), that the roots of music lie closer to our ancient brain (lizard brain) than to our neocortex, seems to contradict that of Tramo (2), who describes extensive cortical activity during musical perception. It appears more likely that musical creativity is a unique human quality similar to that of mathematical ability.

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1. P. M. Gray *et al.*, *Science* **291**, 52 (2001).
2. M. J. Tramo, *Science* **291**, 54 (2001).
3. T. Levenson, *Measure for Measure* (Touchstone, New York, 1995).

Response

THE BEGINNINGS OF THE DIATONIC SCALE are impossible to determine. However, ancient Greek theoretical writings on music describe its construction (1), and it also appears as the "Dheera Sankarabharanam," a Mela Raga in the Karnatic system of Indian music. This system is based on the Sanskrit writings known as the "Vedas," dating from 4000 to 1000 BC (2). In addition, we should also consider that practice usually precedes codification.

Benítez-Bribiesca refers to the diatonic scale as an "imperfect" combination of tones. The pleasure or "perfection" of the diatonic scale, however, is not dependent on whether the semitones are 100 cents (well tempered) or 112 cents ("just" tuning), but rather that it is an old, natural division of the octave.

The intonation of this scale is a matter of cultural taste. Bach's Baroque world of keyboard music demanded the creation of an altered tuning system to accommodate the tyranny of thematic transposition through the circle of fifths.

Well-tempered tuning did not create the diatonic scale (and many believe that it was not an improvement).

For many musical cultures still living close to the natural world, there is no distinction made between themselves and the world of the Other. They (the Bayaka, the Kauli, or the Jivaro, for instance) do not care whether scales are well tempered or equal tempered. Their forms of musical expression are not nearly as limited as those of the West. The birds, insects, mammals, and amphibians these people hear in their environments have a range of acoustic expression that extends well beyond the realm of those creatures we in the West would consider "musical" simply because they fit our models of music. Otherwise, why, with so many birds, insects, fish, mammals (marine and terrestrial), have we stuck to emulating and reflecting on only those that fit our particular models of what might seem musical to our limited ears?

In regard to the comparisons of bird song and Chopin's familiar composition, this reference was intended to be an example of the convergence of themes. The thesis is that avian song is a learned tradition, as is human music, and that ways in which music is learned in birds and humans are often similar (3). And as for music perception and the brain, figure 1 in Tramo's Perspective (4) does

CREDIT: (WHALE) IAN KEIR AND ROGER PAYNE/ OCEAN ALLIANCE; (QUAIL) ROBERT MAIER/ANIMALS ANIMALS; (SOURCE FOR MUSIC) LUIS BAPTISTA AND ROBIN KEISTER

propose that emotions (and their visceral concomitants) are generated in phylogenetically ancient structures, including the hypothalamus and midbrain. However, abstract processing of music is subserved by structures, in particular the neocortex, that are not shared by lizards.

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Structures of the Mind and Universal Music

IS THERE "MUSIC PLATONISM"—UNIVERSAL music—awaiting discovery? The Perspectives by P. M. Gray *et al.* (1) and M. J. Tramo (2) are relevant to this question. In searching for music platonism, should we pursue a unified theory of external effects (involving whales, birds, etc.)? Does the key to discovery lie in the analysis of genes and brain structure, or is it embedded in a defined set of abstract structures that governs our response to music?

Natural sounds, such as the communication signals used by whales and birds, are no more than external stimuli that influence compositions and our musical tastes. In addressing the question of why some sounds are accepted as being "musical" and others not, the scientific query should focus on the filtering process of our cognitive system. Much in the same way that birds and whales represent an environmental influence, other sounds dictate formation of music composition and responses just as well. If we consider the impact of urban sounds on our music, external stimuli effects appear unlikely to underlie music platonism.

Alternatively, might music platonism stem from genes and brain structure? Indeed, a good sense of pitch is an inherited trait, and people vary in tonal memory, sense of timbre, sense of consonance, and auditory memory (3). However, neurobiological research suggests that there is no music center in the brain, no dominant brain structure that is activated solely during music cognition, and that

the structures involved in the processing of music can be understood only in their contribution to other forms of cognition.

Platonism is also not likely achieved by analyzing the contents of music. Key objective parameters in the theory of harmony fail to predict some of the outcomes that strive for explanation. For example, the average rate of pitch vibrato and average extent of a step shared by prominent singers such as Caruso, Chaliapin, and Gigli are undistinguishable from other, much less known, singers (3).

Search for universality should gain from analysis of the interplay between external stimuli and internal deep structures or templates (4), already shown to be universal and definable mathematically in creative behavior. It can be shown that Botticelli's Venus rising from the waves, Dali's Christ of Valles, a Bally's shoe ad, and Watt's first steam engine are all primed by a simple underlying structure. Several prominent artists, Stravinsky for one, noticed the advantage of musical rules and adopted self-imposed limitations (5).

The correlation between external stimuli and internal structures stems from two complementing mechanisms. In one direction, information is categorized through surface structures that lead to formation of deep internal structures, serving as the sources for spawning creative ideas. In the other direction, the internal dynamics, based on self-organization rules, form deep structures such as creativity templates into which external stimuli are assigned.

In illuminating the way to discovering music platonism, a distinction should be drawn between the numerous external stimuli that are received and registered, molding the idiosyncratic styles of music, and the well-defined and generalizable templates of creativity that are adaptable in their contents but enduring structurally. Music platonism will emerge by inferring evolution-based templates and by examining how they weld with other templates found in different forms of human creation.

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