Why did the ability to carry a tune evolve? At an unusual, high-level meeting, researchers pondered whether music helped our ancestors survive and reproduce or whether it is merely a happy evolutionary accident

Seeking the Key to Music

READING, ENGLAND—On a recent fall evening, the lobby of the archaeology building at the University of Reading was the scene of a strange ritual. Twenty-five researchers danced in a circle while blowing on the ends of differing lengths of rubber tubing. Pedro Espi-Sanchis, a music educator based in South Africa, had cut the tubing such that the notes produced by the pieces spanned two full octaves. Espi-Sanchis encouraged everyone to toot to his or her own inspiration, but to try not to repeat what others were doing. After several minutes, to everyone's delighted surprise, the individual notes coalesced into a single pleasing melody to which the dancers swayed and dipped in rhythm.

This spontaneous musical performance, a highlight of a recent workshop on the evolution of music and language,* illustrated one of the meeting's key themes: Music, like language, can be a form of communication and coordination among people. Moreover, music is an exquisitely powerful way of conveying emotion, a task at which language all too often falls short.

Yet although few researchers question that human language arose by means of natural selection, presumably because more accurate communication helped early humans survive and reproduce, the evolutionary significance of music has remained open to debate. The meeting, organized by Reading archaeologist Steven Mithen and music educator Nicholas Bannan, was intended as a first step in setting a research agenda to explore the evolution of music.

In 1997, cognitive scientist Steven Pinker, then of the Massachusetts Institute of Technology, threw down the gauntlet in his book *How the Mind Works*, when he suggested that music itself played no adaptive role in human evolution. Rather, Pinker argued, music was "auditory cheesecake," a byproduct of natural selection that just happened to "tickle the sensitive spots" of other truly adaptive functions, such as the rhythmic bodily movements of walking and running, the natural cadences of speech, and the brain's ability to make sense of a cacophony of sounds. Music, Pinker maintained, is what the late paleontologist Stephen Jay Gould called a "spandrel," after the highly decorative but nonfunctional spaces left by arches in Gothic buildings.

Scientific bonding. Researchers at a meeting danced and played in step.

But many researchers disagree, arguing that music clearly had an evolutionary role. They point to music's universality and the ability of very young infants to respond strongly to it as evidence that music itself is hardwired into our brains. "A predisposition to engage in musiclike activities seems to be part of our biological heritage," says Ian Cross, a psychologist of music at Cambridge University. He and others point to the work of University of Montreal neuroscientist Isabelle Peretz, whose studies of musically challenged neural patients, which suggest that distinct regions of the brain specialize in music processing, have made her a leading opponent of the Pinker viewpoint (*Science*, 1 June 2001, p. 1636). Indeed, Cambridge University anthropologist Robert Foley argues that the evidence is suggestive enough that "an adaptive model for music should be the default hypothesis."

All the same, many researchers agree that Pinker's argument represents the key challenge to be met: If music is the result of Darwinian natural selection, how did it evolve, and in what way did it make humans more fit? At the interdisciplinary meeting, many talks focused on music's ability to cement social bonds. Some researchers argued that the roots of music could perhaps be traced back to "performance spaces" created by earlier species of human. Others see music as a way of getting high with one's peers, again to lubricate human bonding. And new studies focus attention on mothers and infants, suggesting that music might have evolved as a way for parents to soothe babies while foraging for food.

By the end of the meeting, says Peretz, "I felt a consensus around the idea that music is not only distinct from language but also has biological foundations." Yet there was also broad agreement that Pinker's challenge had not been fully answered.

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Sociability versus sex

Like language, most musical behavior leaves no trace in the archaeological record. The earliest undisputed instruments are flutes made from bird bones found at Geissenklösterle cave in Germany and Isturitz cave in France, created and played by modern humans a scant 32,000 years ago. But the first instruments were probably made of perishable materials such as bark or bamboo and are not preserved, says Bannan. And given the universality of music today, most researchers assume that its origins extend back much further, possibly even before modern humans arose some 150,000 years ago. "If there is a strong genetic basis to musicality, then for it to be universally present in the human population it must have been in place more than 150,000 years ago," says Foley.

In the workshop's opening talk, Foley pointed out that Charles Darwin himself was hard put to explain how music made humans better adapted to their environment. In the end, Darwin concluded that music was the result of "sexual selection," the elaboration of traits—such as the peacock's tail—designed to attract a mate and thus ensure reproductive success. Just as some songbirds sing as part of the courtship process, Darwin proposed that humans evolved the ability to sing to each other to express emotions such as love and jealousy.

That theory has some leading proponents today, including University of New Mexico evolutionary psychologist Geoffrey Miller, author of *The Mating Mind*. Miller notes that in some bird species, such as marsh warblers and nightingales, the male signals his supposed genetic fitness to the female by the sheer number of songs he can sing and can reach a repertoire of more than 1000 numbers. He argues that music might have evolved as a way for humans to show off their reproductive fitness. But the sexual selection hypothesis continues to be a minority view among music evolution researchers. "If it was sexual selection, [music] would be a lot more restricted," says Foley. "We would see it more in courtship and less in other activities. Musical ability and activity are too widespread."

Foley and others favor another hypothesis, which holds that in humans, music plays an important role in maintaining social cohesion—critical to mounting coordinated actions—which was essential for hominid survival. Experts in primate behavior have long assumed that cooperation among members of a group boosted the survival rates of early hominids and their offspring, thus selecting for genes that enhance social bonding. But direct evidence has been lacking—until last year, when anthropologist Joan Silk of the University of California, Los Angeles, and her co-workers published a study in *Science*. After 16 years of observing wild baboons, they demonstrated that infants of more sociable female baboons had a higher survival rate (*Science*, 14 November 2003, p. 1231).

Foley points out that the apparent fitness benefit of social cohesion is also the current leading hypothesis for why language itself evolved. "So it makes sense to extend it to music and indeed most other activities," he says. The evening performance led by Espi-Sanchis was a good example of music's "ability to be used in group bonding," adds psychologist Helen Keenoo of the Open University in Milton Keynes, U.K. "Many people seemed to come away from this experience on an emotional high."

First flutes. These 32,000-year-old flutes are the oldest undisputed evidence of music.

CREDIT: FRANCESCO D'ERRICO

But others, including Pinker, say the social-cohesion hypothesis suffers from circular reasoning. Björn Merker, an expert in animal vocalizations at Uppsala University in Sweden who attended the meeting, says that the hypothesis "takes for granted that which it needs to prove, namely why music is needed for bonding and where it got its group-stimulating powers." Merker prefers a hypothesis that "is driven exclusively by the individual advantage of sexual selection." Pinker, who was not at the meeting and is now at Harvard University, adds that "universality and early development don't show that music is an adaptation. It just shows that music is innate. That's a necessary condition for something being an adaptation but not a sufficient one."

Music for the masses

For social-cohesion theorists, the challenge is to explain why singing or dancing enhanced social bonding—and why that in turn fosters greater fitness and survival. Robin Dunbar, a psychologist at the University of Liverpool, U.K., has suggested that music might have put groups of hominids into a collective endorphin high, making them feel more positively disposed toward their fellow hominids—and thus more likely to cooperate and survive. Researchers have long known that listening to music can trigger the production of endorphins, natural opiates that are produced in response to pain or other stress. In a frequently cited 1980 study by Stanford University neuroscientist Avram Goldstein, volunteers who received injections of an endorphin-receptor blocker reported getting considerably less pleasure when they listened to normally moving musical pieces.

Dunbar is well known for his "social brain" hypothesis of human evolution, which holds that larger hominid brain sizes and language both evolved as a response to increasing group sizes in our primate ancestors (*Science*, 14 November 2003, p. 1160). He argues that the endorphin release from music may enhance the subjective feeling of bonding, creating stronger social cohesion. He told the attendees of the meeting about a pilot study that he and his students recently carried out in English churches. In the study, which aimed to look at the effects of music in a social setting, the endorphin levels of churchgoers who attended Anglican services with and without singing were monitored by indirect methods that measured tolerance to pain. (Measuring endorphins directly requires an invasive lumbar puncture.) After services, parishioners who had sung were able to endure having a fully inflated blood pressure cuff on their arms for significantly longer than those who had not sung.

Dunbar stressed that although his own study is very preliminary, the overall evidence suggests that group singing and dancing might have helped bridge what he calls the "endorphin gap" between the nonverbal grooming activities of our primate ancestors and the later development

of language. A number of studies have shown that grooming, which is the social glue of monkeys and many other primates, raises endorphin levels. "Humans are good at finding things that trigger the sensations they like," Dunbar says. And in a social context, he says, "endorphin surges create a very strong sense of bondedness and belonging that seems difficult to create any other way."

One way to support the social-cohesion hypothesis might be to find archaeological evidence of such group interactions in humans' evolutionary past, but such evidence has been hard to come by. In an imaginative talk, archaeologist Clive Gamble of the University of London proposed that group singing and dancing might be traceable back as far as half a million years ago, by seeking evidence for "performance spaces" where such activities might have taken place.

He drew on a recent visit to a village of the Makuri people of northern Namibia, where he watched a performance in which women sat around a fire while men, wearing rattles on their legs and striking sticks, danced around them. The next morning, Gamble could see the circle in the sand made by the male dancers. He compared those circles to several circles, 8 meters in diameter and marked by anvils of bone and stone, unearthed at the 400,000-year-old hominid site of Bilzingsleben in Germany, which he suggested represented gathering and performance areas of these early humans. He also pointed to an unusual concentration of 321 hand axes, many of them unused and all located far from a butchering area, at the 500,000-year-old site of Boxgrove, in Sussex, U.K. Gamble suggested that this possibly symbolic deposit of hand axes may have represented a space where early humans gathered to sing and dance.

Although Gamble's evidence is scant, "I am sure that the hominids at Boxgrove were communicating in a musical and dancelike fashion," says Mithen, who feels that such speculations "give us a perceptive understanding of [early humans'] lifestyle."

Music and motherese

If music did evolve to facilitate a sense of belonging among early hominids, it's possible that a very specific human relationship—that of mothers and infants—was involved, says University of Toronto psychologist Sandra Trehub. She suggested at the meeting that music was crucial to both bonding with and soothing babies, as well as allowing mothers to get on with other tasks that boosted survival.

For years Trehub and her colleagues have studied how mothers talk and sing to their infants. Maternal speech has a number of features that can be considered musical, including higher pitch than normal speech—which is associated emotionally with happiness—and a slower tempo, which is associated with tenderness. Trehub and others have demonstrated that infants prefer maternal cooing to normal adult speech in studies that monitor "infant gaze," or how long a baby spends looking in one direction, considered a measure of attention.

Music to his ears. A mother's song captures her baby's attention.

In a more recent study, in collaboration with Takayuki Nakata of the Nagasaki Junshin Catholic University in Japan, Trehub measured the responses of 6-month-old infants as they watched videos of their mothers. Infant gaze times were even longer during episodes of maternal singing than during normally melodic maternal speech. In another recent study, Trehub and Nakata asked volunteer mothers to talk to their infants for 2 minutes at a time. During one session, the mothers were allowed to touch their babies as much as they wanted; in a second session, they were told not to touch their babies. Trehub and Nakata found that the women markedly increased the pitch of their voices—that is, made them much more musical—when they could not touch their infants. The infants, for their part, responded to their mothers' efforts to compensate for the no-touch rule with even longer gaze times.

Trehub and her co-workers did not try to measure endorphin levels in their infant subjects, but they did measure the cortisol levels in the saliva of babies before and after their mothers spoke or sang to them. Higher blood cortisol levels are a reliable indicator of higher arousal levels, and the hormone passes easily from the bloodstream to saliva. Mothers themselves took the saliva samples by gently swabbing their infants' mouths with a cotton roll. The results were striking: Maternal singing caused a marked decrease in cortisol levels that was maintained for at least 25 minutes after the singing stopped. Maternal speech, on the other hand, caused an initial drop in cortisol levels, which then quickly rebounded to normal. "The function of maternal singing seems to be to regulate the arousal level of the infant," Trehub concluded.

Of course, this is rather obvious to anyone who has ever sung a baby to sleep. But for Trehub, that's the whole point. "Every culture in the world has lullabies," she told the meeting. "And they sound very similar across cultures. They are emotive: The pitch goes up and the tempo goes down." The universality of lullabies, Trehub said, is strong evidence that they have an evolutionary origin. As for what their adaptive function might be, Trehub favors a speculative new idea, called the "putting down the baby hypothesis," recently proposed by anthropologist Dean Falk of Florida State University in Tallahassee.

Falk's hypothesis, in press at the journal *Behavioral and Brain Sciences*, is based on comparisons of the mother-infant interactions of chimpanzees and modern humans as well as data from fossils. She argues that as the brain size of early hominids increased—thus making it more difficult for infant heads to pass through the birth canal—natural selection favored females who gave birth to more immature infants. Unlike baby chimps, who can cling to their mothers at a very young age, human infants are too helpless to do so. The hominid female responded to this situation, Falk argues, by developing melodious vocalizations, or "motherese," so that she could calm and reassure her baby, if not actually put it to sleep, while foraging for food. These vocalizations, Falk concludes, were the prelinguistic forerunner to true language. And although Falk's hypothesis is controversial—not everyone agrees that "motherese" is universal—Trehub says that it is consistent with the notion that maternal singing, and thus early forms of music, also had an adaptive function.

Despite this range of suggestions for music's adaptive functions, Pinker, for one, says his challenge has not been met. "The idea that music evolved to soothe babies might explain why mothers sing to their babies," he says, "but it doesn't explain why older children and adults listen to music." But he adds that whether music was essential to the survival of modern humans has little bearing on its value to us today: "Some of the things that make life most worth living are not biological adaptations."

—MICHAEL BALTER

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