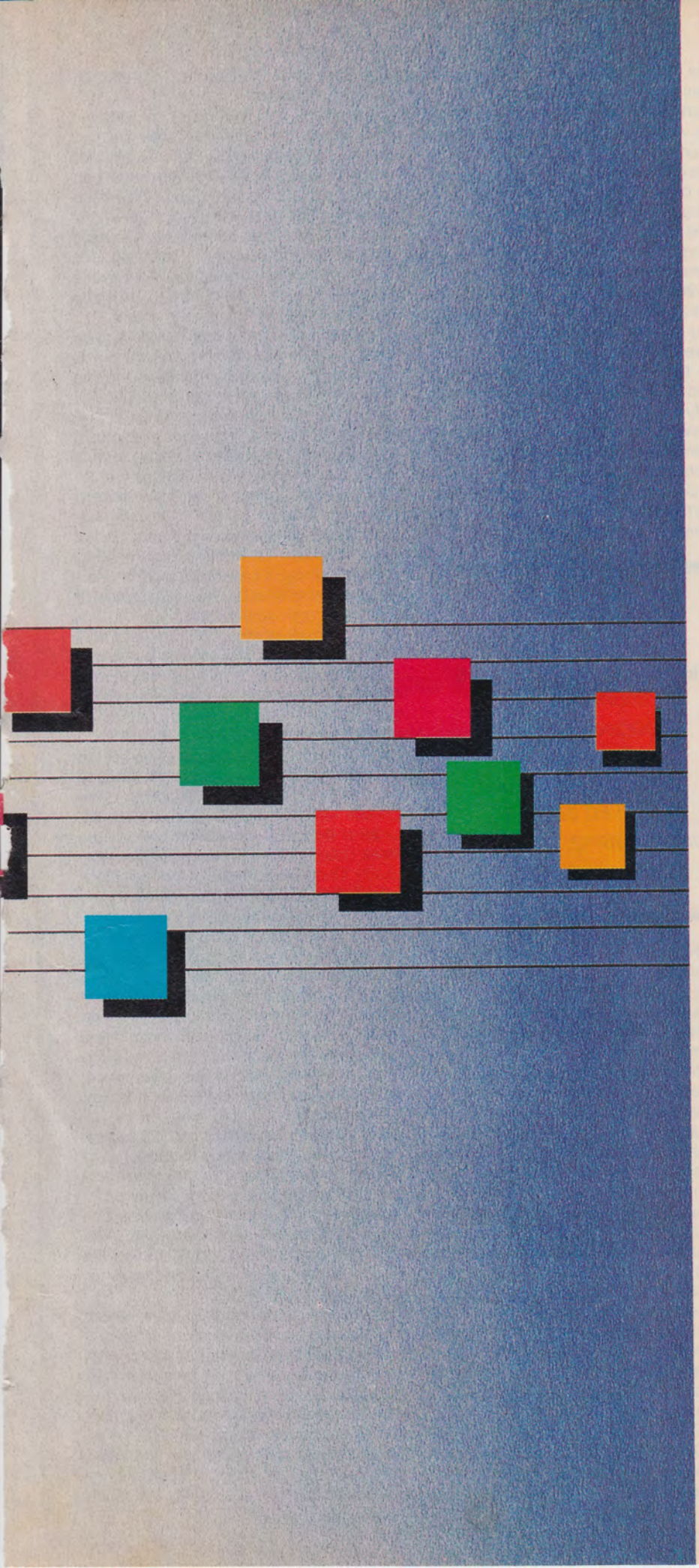

Are we wired to appreciate only certain kinds of music? An emerging science of sounds says yes

KEY NOTES ON THE MIND

BY TERENCE MONMANEY

While he's waiting for a courier to deliver the videotape, Jan Hammer generally gets a little tense and starts prowling around his farmhouse. It's a 200-year-old, white-clapboard place on a hill in eastern New York, and it stands up there like a monument to the proud Yankee disdain of all that's new and trendy.

Yet it could not be more up-to-date. Hammer, an edgy electro-pop star who 15 years ago played keyboards with the jazzy Mahavishnu Orchestra, has rigged two large rooms with music machines so new wave they make a Moog synthesizer seem colonial. Linndrum. Simmons electronic drums. Roland Jupiter-8 keyboard. Lexicon 200 digital delay. Fairlight Computer Music Instrument. Yamaha DX7 digital synthesizer. At least there's one familiar relic—an IBM personal computer.

Once the tape arrives he pops it into a player and begins dreaming up the music that will be heard by millions some two weeks later on *Miami Vice*. Working alone, he'll compose, perform, and record the *Miami Vice* soundtrack, creating sometimes as much as a half hour of original music for an episode—a mind-boggling

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task made agreeable by a fat salary and by an artistic freedom unprecedented in television. The only rules are that the music sound as hot as a stolen pistol and as hip as a silk T-shirt and that he come up with it, God bless him, in five days.

The wailing guitars, pulsating drums, and eerie choruses that Hammer has become famous for do not sound exactly real, but they aren't supposed to. "I like creating collages of sound," he says, "overlaying things so you don't know if it's a horn or a bass. With the new musical technologies we can create sounds that we could never hear otherwise."

But sound doesn't exist in a vacuum. Composer John Cage talks about how incidental events contribute to a work, how the audience completes it, and how the work of art is personalized by the person who experiences it. Fellow composer Philip Glass agrees with Cage: "We shouldn't think of a work of art as an objective reality that exists independently."

Glass is a classically trained musician who is known for his innovative computer-generated music. His ensemble consists of three keyboard players, three reed players, a singer, two speaker stacks, several computers, 50 computer programs, and a conductor who mixes and programs the sounds. "One of the things I'm interested in doing is extending the sound of acoustic instruments with electronic sounds. That's what we do. My ensemble is a perfect laboratory for that. I'll have a saxophone, and I'll double it with a synthesized sound and get a different sound. It's amazing. The refinements we can work with are just beginning to open up."

He's also interested in how the technology is applied on a human scale. "The human being who goes home and puts on his CD, I hope, and listens to the music is, finally, just a person. He's not a robot. No matter how we change our technology, our human technology is not going to change. The biological evolution that allows us to hear in certain ways, we can't upgrade that every year. Everything has to be geared to human physiology."

As composers and engineers are turning the computer into a surprising new instrument, neurologists and psychologists are discovering some things about the ultimate instrument, the brain, and how it makes sense of music.

What effect will those new sounds have on how the human mind processes music? Even an oscilloscope—an instrument that can pinpoint the frequency of every sound wave in a piece of music—cannot tap its foot to the beat, tingle with you, laugh, weep, or feel a rush of memory. That takes brains. Indeed, researchers have shown that we regularly perceive musical tones and pitches that aren't there—tones that an oscilloscope couldn't pinpoint if it tried. The brain, in other words, does not merely process musical sounds but sometimes accompanies the band, supplying the odd pitch, doing a little arranging of its own.

One of the earliest and most revealing studies done in the field showed that the human brain controls musical experiences. A single note struck on a piano gives off a complex signal composed of sound waves of several frequencies that are multiples of the lowest, or fundamental, frequency. The fundamental frequency of middle C, for instance, is 261 cycles per second, but the signal also contains frequencies that are two, three, four, and five times 261 cycles per second. Despite this, a human being perceives the sound as having one pitch—middle C.

More interesting, studies show that even when the fundamental frequency is removed from a complex tone, subjects still identify the pitch as usual—as middle C. The inner ear and brain are capable of recognizing the pattern of the harmonics that surround the missing frequency, calculate their relationship, infer the presence of the fundamental, and identify the pitch. This is true even for six-month-old infants.

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Furthermore, the way humans interpret a single note can vary: Individuals, it seems, can perceive the same note differently, just as they can interpret an event differently or derive several meanings from a poem or story.

In Diana Deutsch's windowless psychoacoustics lab at the University of California at San Diego (UCSD), amps, equalizers, and tape recorders rest on racks against one wall. Waist-high Altec-Lansing speakers occupy the far corners. Two women sit in the center of the room. They are music students—Toshie, an accomplished pianist, and Mamoru, a composition student whose work has been performed at New York City's Lincoln Center. Deutsch loads a digital tape into a player, and a second later computer tones pop from the speakers. *Dingdong*. Pause. *Dingdong*. Pause. The question for Toshie and Mamoru: Does the musical sequence go up or down? *Dongding* or *dingdong*?

They shout their answers. "Up," Toshie says. "Down," says Mamoru. Giggling. Next pair: "Down," Toshie. "Up," says Mamoru. Furrowed brows. This goes on for several minutes. Sometimes they agree. But more often they don't. That's when they start arguing in Japanese.

Each tone is a mixture of six frequencies. When you hear the tone, you can identify the pitch as a C, but you can't tell *which* of six C's it is; without the usual harmonics, the pitch is ambiguous. Therefore, theoretically at least, you shouldn't hear one tone as higher than another. But Deutsch has shown that you do. In her tests, she found that people generally do have a consistent, built-in tendency to perceive certain pitches as higher than others.

Deutsch concedes that her study was limited and employed few tones, but it was done under controlled conditions, and she believes it's relevant to our perception of real music. "This finding is counter to theories of pitch perception, counter to music theory, counter to common sense. I marvel at the fact that two fine musicians can totally disagree about a two-tone pattern going up or down. It's got to be meaningful. It's as if we all have a different kind of color blindness. Do we know we're hearing the same thing? It's an open question. Perhaps we should suspend discussions of aesthetics until we clear this up."

The manner in which we perceive, and then "hear," the song of a thrush or a chord in Beethoven's *Eroica* may have a genetic link. At the University of Toronto psychologist Sandra Trehub has spent a number of years studying how infants respond to musical notes. In a series of experiments with infants, she played musical phrases consisting of three computer tones. Each phrase was repeated over and over (the order of the notes was varied, but only the three notes in any particular phrase were used). Once that pattern had been established, Trehub inserted stray notes to see if the infants would respond. In order to respond, they had to recognize or remember that the stray notes were not part of the sequence. "We thought they'd be able to do it for all tones or for none at all," explains Trehub. "But they could remember only one particular set of notes, and those three notes were the major triad—C, E, G—the most important notes in the major scale, the prototypical notes in Western melody. It surprised us."

For Edward Carterette, a UCLA psychologist who specializes in speech and hearing systems, Trehub's findings represent the neurological bottom line for processing music. "It wouldn't matter what culture you went to," says Carterette. "You would see that children and adults find this triad to be very salient—strong, easily remembered. It stands out."

Carterette, a soft-spoken man whose special passion is the study of cross-cultural perception of music, has found what he believes is convincing evidence that, generally speaking, human musical perception hasn't changed much throughout human history. He, along with Rao Yu-An of the Institute of Physiology in Shanghai, analyzed tape recordings of a collection of 2,400-year-old Chinese bells. He found

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they have a similar—if not identical—tuning system to bamboo flutes made in China today. Apparently without the aid of Pythagorean theory or other such mathematics, the ancient Chinese created a system of harmonics that has stood the test of time. As the researchers conclude in a soon-to-be-published paper, "The strong musical and cultural traditions of China and the biological fixedness of the human ear have conspired to maintain a pure tonal system across two and one half millennia." Although the Eastern scale differs from that found in Western societies, Carterette thinks it's a finding that holds true for other cultures. In other words, the way the human ear perceives sound hasn't changed at all over time. The tones our ancestors liked or found pleasing, so do we.

Similarly, anthropologists have found that the music of nearly all the world's cultures share certain elements—pitches separated by discrete intervals, musical scales of five to seven notes, scales arranged in octaves. Composers are also aware of these commonalities and what they may mean for the creation of new music. "If something pops up in music all over the world the way the fifth, the octave, and some sort of pulsable beat do, then these elements emerge as more than merely national styles," says avant-garde composer Steve Reich. "They become something that's built into the physiology of music and that may not be able to be dispensed with if music is to be effective."

The greatest similarity in all music—its ability to evoke feeling—has also been investigated. Researchers have seen heart rates rise and fall in response to melodies and rhythms. Pennsylvania State University psychologist John Johnson found that an individual's heartbeat can drop a full ten beats per minute from its normal level at the beginning of a song—a dampening effect that Johnson believes "facilitates your ability to listen." During a thrilling passage, however, the opposite can occur: The heartbeat will soar. "I look at it as an interplay between cognitive and emotional factors," Johnson says. "When you're paying close attention, the heart rate decreases, but then when emotions take over, the rate goes up again."

Pitch has a similar effect. People really do respond to high-pitched, up-tempo songs with more pleasure than to lower-pitched, slower music. And preschool children react in the same way as adults. In another experiment conducted by Trehub, preschoolers pointed to a drawing of a happy face when they listened to brisk, high-pitched pieces, and to a sad face when the music was slower and lower pitched. These emotional associations, Trehub believes, come in part from listening to nursery rhymes, lullabies, even a parent's tone of voice. "It's never actually taught to them," says Trehub. "They have an implicit understanding of the emotions our culture attributes to musical patterns."

Though far from understood in the laboratory, the human emotional response to music has been utilized by clinical psychologists as a treatment for autistic patients, cancer victims, and manic-depressives. Consider Alice. She tried committing suicide before ending up at the psychiatric clinic at the University of California at San Francisco, where she met Frances Goldberg, a music therapist. Surly, uncommunicative, always threatening to walk out, Alice made little or no progress until Goldberg put her in a therapy group in which patients assembled and played simple musical instruments. One day, unprovoked, Alice tapped out a slow, mournful "Amazing Grace" on a glockenspiel. The group responded. "It must be bad to feel as sad as the music sounds," someone said.

The next day, moved by this display of concern, she began to talk to therapists about her troubles. She was enrolled in psychotherapy. "Music," Goldberg says, "allowed her to express some feelings she couldn't put into words, feelings she had not even been able to acknowledge. That made her receptive to therapy."

One day psychotherapists may even have a sonic Rorschach test at their disposal. The idea of a UCSD graduate student, the test would be based on a series of intervals, which subjects would interpret. Some passages that generally evoke a quiet and thoughtful response in most people might create a state of anger or anxiety in a psychologically unbalanced individual and reveal unconscious feelings that would aid the therapist.

As scientists delve into the uncharted territory of music and the mind, today's musicians explore another frontier. Computer-generated music challenges the brain with sounds it has never heard. It has also opened up new possibilities for the composer. Rock performer and composer Frank Zappa welcomes the chance to use technology to fashion a music that traditional instruments could never create. "I have a perfect reproduction of a classical guitar on the computer, and I can write notes that aren't on a real guitar. I can also make those notes occur at speeds that humans just can't play. I've written plenty of stupid little songs so human beings could play 'em. Now it's time to take advantage of what technology has to offer and try to do the other stuff."

For better or worse, the computer will be the great shaper of future music. As Jan Hammer says, "It's the third industrial revolution." But how will that revolution change the music we choose to hear?

"It's fair to say," says Carterette, "that even with all the new electronic devices and computer power that is going to let us create bizarre and unheard-of sounds, ultimately the test is going to be the taste of the listener. And his taste will be limited by his nervous system."