Music Theory is for the Birds

Emily Doolittle

In 1997 I moved to Amsterdam, and shortly after I arrived I heard a bird singing outside my window. I was fascinated by the way small bits of what it sang sounded a lot like human music—clear, pure notes, repeated motifs, scale-like passages, and so on—but the whole of what it sang would never be mistaken for human music. I found out the next day that this was a Eurasian Blackbird (*Turdus merula*), not related to the Red-winged Blackbird (*Agelaius phoeniceus*) with which I was familiar, but part of the thrush family, more closely related to the American Robin (*Turdus migratorius*). I decided to explore Eurasian Blackbird song through writing a piece of music. I began by making a list of the differences between the ways I thought a blackbird and a human might arrange the same motifs. Here are a few:

Figure 1
Blackbird and Human Motif Arrangements

Blackbird	**Human**
• Motives repeated unvaried • No harmonic relationship between different motives • Continuous song, no overarching structure • Arbitrary alternation of sound and silence • Rhythm but no meter	• Motives developed as piece progresses • Harmonic relationship between adjacent motives • "Goal-oriented" structure • Mostly sound, silence used as punctuation • Rhythmic and metric

At that time I was studying with the composer Louis Andriessen. When I showed him my list, he looked at the blackbird side and said, "That sounds like Stravinsky!" Of course, he was right: that while blackbird song might not

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sound much like "common practice era" western classical music, there are many kinds of music that do sound like birdsong.

Birdsong can sound like music too, and is often described in musical terms. Some of these comparisons seem irrelevant: a birdsong may have a "flutey sound," but so does a tea kettle whistling, which would only be considered "music" under the broadest of definitions. And some often-repeated comparisons are wrong. For example, Canyon Wrens (*Catherpes mexicanus*) are frequently described as singing "in the chromatic scale,"[1] which they do not.[2] But other comparisons may point to deep-seated similarities in structure or function. Indeed, a growing body of zoomusicological literature explores these similarities. The term "zoomusicology," typically defined as the study of the musical aspects of sound communication in animals, was first used by composer François-Bernard Mâche in his 1983 book.[3] Zoomusicology and related fields such as biomusicology and ecomusicology are gradually increasing in prominence. Since the late 1990s, Dario Martinelli has been actively developing zoomusicological methodologies, drawing on his experience as a musicologist and semiotician.[4, 5] Hollis Taylor[6] comes to zoomusicological research from a performing background, while David Rothenberg[7] brings his experience as a performer and a philosopher to the

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[1] Charles Hartshorne, *Born to Sing: An Interpretation and World Survey of Bird Song* (Bloomington, IN: Indiana Univ. Press, 1973), 84.

[2] I analyzed two Canyon Wren songs. One consisted of 11 sliding-pitch notes unequally distributed over a minor 13th (1956 cents), and the other of 15 notes distributed over an 11th (1678 cents). Neither approximated a chromatic scale. [Cents are a logarithmic unit used to describe musical intervals.—Editor] See www.xeno-canto.org.

[3] François-Bernard Mâche, *Musique, Mythe, Nature, ou les Dauphins d'Arion* [Music, Myth and Nature or the Dolphins of Arion], French original 1983; published in English as *Music, Myth and Nature,* trans. Susan Delaney (Philadelphia: Harwood Academic Publishers, 1992).

[4] Dario Martinelli, *How Musical is a Whale? Towards a Theory of Zoömusicology* (Helsinki: International Semiotics Institute/Hakapaino, 2002).

[5] Dario Martinelli, *Of Birds, Whales and Other Musicians: An Introduction to Zoomusicology* (London: Univ. of Scranton Press, 2008).

[6] Hollis Taylor, "Towards a Species Songbook: Illuminating the Vocalisations of the Australian Pied Butcherbird *(Cracticus Nigrogularis)*" (Ph.D. dissertation, University of Western Sydney, 2008).

[7] David Rothenberg, *Why Birds Sing: A Journey into the Mystery of Bird Song* (New York: Basic Books, 2005).

field. Others, including Tecumseh Fitch,[8] approach the relationship between animal songs and music from a more scientific perspective.

For me, some of the most relevant points of comparison between animal songs and human music are those that occur in relation to learning processes, cultural transmission, individual variation, pattern creation, and change over time.[9]

Learning

Though all humans are born able to learn music, we must do so from other members of our species, our "conspecifics." Songbirds (oscine passerines), too, learn their song from older conspecifics. Just as humans practice music, young songbirds sing fragments of adult song in a flexible, variable form of singing called "subsong."[10] Humans are the only primate to use vocal learning to any large extent, but a small number of non-human mammals also learn their songs from other members of their species,[11] including whales, bats, seals, and elephants.[12]

Culture

Children learn to make the music around them, rather than the music of their genetic ancestors. This is true for vocally learning animals as well. Birds of the same species in different regions may sing different versions of their songs, called "dialects." Humpback Whales (*Megaptera novaeangliae*) in the same ocean basin sing the same, constantly changing song, but are capable of learning a different song if they come into contact with whales from another ocean basin.[13]

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[8] Tecumseh Fitch, "The Biology and Evolution of Music: A Comparative Perspective," *Cognition* 100, no. 1 (2006): 173-215.

[9] The following summarizes some ideas first presented in Emily Doolittle, "Other Species Counterpoint: An Investigation of the Relationship Between Human Music and Animal Songs" (Ph.D. dissertation, Princeton University, 2007).

[10] Clive K. Catchpole and Peter J. Slater, *Bird Song: Biological Themes and Variations*, 2nd edition (Cambridge: Cambridge Univ. Press, 2008), 49-84.

[11] Vincent M. Janik and Peter J.B. Slater, "Vocal Learning in Mammals," *Advances in the Study of Behavior* 26 (1997): 59-99.

[12] Joyce H. Poole, Peter L. Tyack, Angela S. Stoeger-Horwath, and Stephanie Watwood, "Animal Behaviour: Elephants are Capable of Vocal Learning," *Nature* 434, no. 7032 (2005): 455-56.

[13] Michael J. Noad, Douglas H. Cato, M. M. Bryden, Micheline N. Jenner, and K. Curt S.

Individual Variation within a Recognizable Style

Two human musicians, trained in the same tradition and performing the same piece, will nonetheless perform it differently. The same holds true for vocally learning birds and non-human mammals. Species-specific stylistic patterns, such as number of repeats, types of sounds used, range, timbre, and so on—mean that despite individual variation, the species identity of the song is rarely in doubt.

Play with Pattern and Noise

In both human music and animal song, there needs to be enough repetition to create a sense of expectation, and enough variety to hold the listener's interest.[14] The unexpected may be heard in relation to what has come previously in a given piece or song, or in relation to what is expected for a particular musical style, or species, or both.[15]

Functional Identity with Non-functional Stylistic Change

While variation sometimes exists only in an individual song, it may also lead to cumulative change over time. According to cultural theorist Morse Peckham, an object may be considered aesthetic if "a chronologically arranged sequence of such objects shows both functional identity and non-functional stylistic dynamism."[16] In human music, style continually varies, even when the performance context remains the same. Humpback Whale song, too, continually changes, but its context—performed by males, primarily during breeding season—stays constant.[17]

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Jenner, "Cultural Revolution in Whale Song," *Nature* 408, no. 6812 (2000): 537.

[14] Hartshorne, *Born to Sing*, 9.

[15] Alexander Goehr, "Music as Communication," in *Ways of Communicating*, ed. D. H. Mellor (Cambridge: Cambridge Univ. Press, 1990), 141.

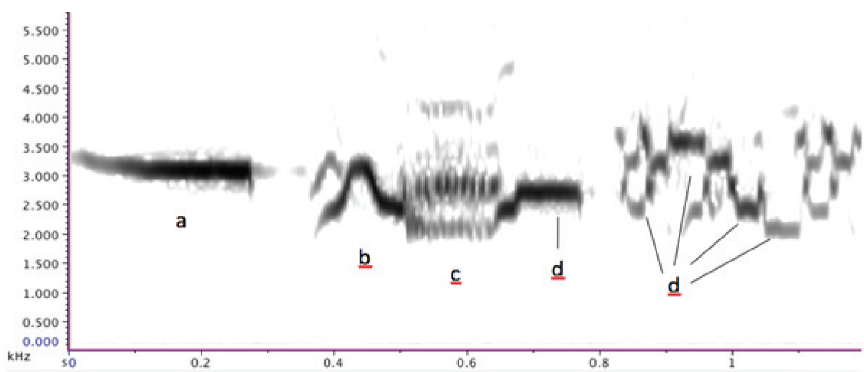
[16] Morse Peckham, *Man's Rage for Chaos: Biology, Behavior and the Arts* (New York: Schoken Books, 1967), 71.

[17] Katherine Payne, Peter Tyack, and Roger Payne, "Progressive Changes in the Songs of Humpback Whales (*Megaptera novaeangliae*): A Detailed Analysis of Two Seasons in Hawaii," in *Communication and Behavior of Whales*, ed. Roger Payne (Boulder, CO: Westview Press, 1983), 9-57.

Of course this is only a partial list, and other writers might emphasize other aspects. As a young researcher, I wanted to convince everyone that some animal songs should be considered music, but I no longer feel this is important. What is clear to me is that there are enough similarities between some animal songs and some human music that we can use some of the same theoretical tools to look at both. Using the example of the Hermit Thrush (*Catharus guttatus*), I will discuss some of the pitfalls and possibilities of looking at birdsong through a music theoretical lens.

The Hermit Thrush is a small songbird, widespread across North America. Each male sings about six to ten different song-types, separated by silence. Each song-type consists of a long "introductory whistle," followed by a series of cascading shorter notes (see Figure 2). The song may also contain trills, slides, and multi-pitches, but steady pitch notes predominate.[18]

Figure 2
A Hermit Thrush Song-type:
a) introductory whistle, b) slide, c) trill, d) some steady-pitch notes



Hermit Thrush song was a favorite of 19th and early 20th-century North American naturalists. F. Schuyler Mathews, who transcribed the

[18] Emily L. Doolittle, Bruno Gingras, Dominik M. Endres, and W. Tecumseh Fitch, "Overtone-based Pitch Selection in Hermit Thrush Song: Unexpected Convergence with Scale Construction in Human Music," *Proceedings of the National Academy of Sciences* 111, no. 46 (2014): 16616-21.

songs of more than 100 North American birds into musical notation in his *Field Book of Wild Birds and Their Music* (1904), wrote that Hermit Thrush song is "brilliant in execution beyond description, as versatile in melody as a genius, and as pure in [its] tones as refined silver."[19] He further believed that the Hermit Thrush had a sense of harmonic progression: "Not content with a single key, he deliberately chose several in major and minor relationship. . . ."[20] Theodore Clarke Smith (1903) also noted that the "keys" of the bird's song "form part of the scale of A flat major."[21] Henry Oldys (1913) described one song that "completely satisfies the requirements of human music" with a "harmonic progression—from B to E minor, then to A . . . which leads naturally into D. . . ." Oldys contended that "we must discard the untenable theory of coincidence and declare that the bird expresses itself in human music." [22]

A recurrent idea in early descriptions is that Hermit Thrush songs are based on the pentatonic scale. Such thinking is explicit in an unsigned 1922 *Scientific American* article, which stated that "The Hermit Thrush has the distinction, above all other birds, of having developed the Scotch, or pentatonic scale."[23] This fit neatly with the notions often held then that the pentatonic scale was "the musical mode instinctively adopted by primitive man"[24] and that birds make a sort of primitive music.

Naturalist Anne Wing elaborated on the idea that Hermit Thrush song follows the pentatonic scale in her 1951 article "*Notes on the Song Series of a Hermit Thrush*," claiming that some songs are "minor [pentatonic]," some "major [pentatonic]."[25] Demonstrating this involved some remarkable musical acrobatics (see Figure 3).

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[19] F. Schuyler Mathews, *Field Book of Wild Birds and Their Music* (New York: G. P. Putnam's Sons, 1904), 258.

[20] Ibid., 261.

[21] Theodore Clarke Smith, "A Hermit Thrush Song," *The Ohio Naturalist* 3, no. 4 (1903): 371-73.

[22] Henry Oldys, "A Remarkable Hermit Thrush Song," *Auk* 30 (1913): 540-41.

[23] "Wild Birds and Their Music," *Scientific American* 127 (1922): 42.

[24] Ibid.

[25] Anne Hinshaw Wing, "Notes on the Song Series of a Hermit Thrush," *Auk* 68 (1951): 189-93.

Figure 3
Wing's Transcription of Five Hermit Thrush Songs and the Pentatonic Scales on Which She Believes Them to be Based[26]

Even setting aside the questions of whether any collection of five notes can be considered a "pentatonic scale," whether the pentatonic scale is really a human universal, or why a Hermit Thrush would follow culturally-specific human music theory, it is a stretch to say that all these songs have five notes in them. One uses six pitches (though this includes an octave repetition), two use three pitches, and one was un-notatable, leaving only one that actually uses five notes!

Going to such lengths to find pentatonic scales in Hermit Thrush song suggests that Wing started by presupposing that this birdsong must be based on those scales, rather than by simply transcribing and analyzing the pitches she heard. Despite the tenuousness of Wing's findings, her paper captured the imagination of several subsequent generations of researchers. For instance, her research was cited in work by Charles Hartshorne (1973),[27] Luis Baptista and Robin Keister (2001),[28] and Patricia Gray et al. (2001).[29] This latter article, "The Nature of Music and the Music of Nature," published in the prestigious journal *Science*, lent new credibility to the myth of the Hermit Thrush pentatonic scale. Subsequent writings, such as articles by Natalie Angier (2001)[30] and by Terry Bossomaier and Allan Snyder

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[26] Ibid., 191.

[27] Hartshorne, *Born to Sing*, 95.

[28] Luis C. Baptista and Robin A. Keister, "Why Birdsong is Sometimes Like Music," *Perspectives in Biology and Medicine* 48, no. 3 (2005): 426-43.

[29] Patricia Gray, Bernie Krause, Jelle Atema, Roger Payne, Carol Krumhansl, and Luis Baptista, "The Music of Nature and the Nature of Music," *Science* 291, no. 551 (2001): 52-53.

[30] Natalie Angier, "Sonata for Humans, Birds, and Humpback Whales," *New York Times*, January 9, 2001.

(2004),[31]attribute the pentatonic Hermit Thrush song idea to Gray et al. without reference to Wing's original paper. The pentatonic theory is thus well on its way to becoming "common knowledge," despite there being no substantiated evidence for its veracity.

In the days before recording equipment and analysis software, musical transcription was perhaps the best option for recording birdsong, although the twelve-tone equal temperament bias of western notation meant songs had to be fitted into interval structures that may not have been appropriate. Early naturalists thus mapped what they heard onto what they knew, in a way that may have subjectively evoked the experience of hearing the song but did not necessarily represent accurately what the birds were singing. Perhaps in reaction to the enthusiastic but not very precise approach of the earlier generation of ornithologists and naturalists, many more recent biologists have avoided musical comparisons in their descriptions of birdsong. Here is an example from a 2012 paper about Hermit Thrush song:

> Overall, introductory note frequencies… ranged from 1617-5062 Hz. However … there was a distinct gap in the distribution of introductory note frequencies (ranging between about 3000-3400 Hz), such that introductory note frequencies were not normally distributed throughout their range.[32]

This is objectively true, but it gives much less of an impression of what the song sounds like than papers that use musical terminology. Ornithologist Donald Kroodsma has written about Hermit Thrushes alternating between song-types that start with a higher and lower introductory whistles, without examining the exact relationship between the frequencies of the introductory whistles.[33] Other recent writing has avoided the analysis of pitch relationships entirely.

It is understandable that scientists wish to avoid describing birdsongs

[31] Terry Bossomaier and Allan Snyder, "Absolute Pitch Accessible to Everyone by Turning off Part of the Brain?" *Organised Sound* 9, no. 2 (2004): 181-89.

[32] Sean P. Roach, Lynn Johnson, and Leslie S. Phillmore, "Repertoire Composition and Singing Behaviour in Two Eastern Populations of the Hermit Thrush (*Catharus guttatus*)," *Bioacoustics* 21, no. 3 (2012): 239-52.

[33] Donald Kroodsma, *The Singing Life of Birds: The Art and Science of Listening to Birdsong* (Boston: Houghton Mifflin, 2005).

in culturally-specific, human music theoretical terms. However, to abandon any consideration of the relationships between pitches in birdsong risks ignoring an important aspect of how birds may organize their songs. Indeed, there may be a rich area of analysis that involves using scientific means to insure, on the one hand, that one is not merely projecting the familiar onto birdsongs, and, on the other, to better understand what the birds are doing.

In 2008 I embarked on a collaborative research project with evolutionary and cognitive biologist Tecumseh Fitch, music theorist and cognitive biologist Bruno Gingras, and computational psychologist Dominik Endres, to examine Hermit Thrush song. We began by listening as a musician might, slowing recordings by a factor of 6 to bring them into a comfortable frequency range and tempo for human auditory processing. To our amazement, we heard immediately that many of the song-types seemed to follow the overtone series. The birds never sang the fundamental of the series—which would be too low for a bird of that size to produce—but for most of the song-types, there was an imagined fundamental, above which they sang exclusively pitches drawn from the harmonic series, usually from harmonics 3 through 12.[34]

In order to move beyond the exciting, but thus far only anecdotal, experience of hearing the overtone series in Hermit Thrush song, we gathered recordings of 14 Hermit Thrushes from the Borror Laboratory of Bioacoustics at Ohio State University, Kevin Colver, and Bernie Krause. These birds sang a combined total of 114 different song-types. Using Praat sound analysis software,[35] we measured the frequencies of all the steady-pitch notes in each of the 71 song-types that had 10 or more such notes. Song-types with fewer than 10 notes were excluded because their following the overtone series could not be determined with as much certainty. We then used both a Bayesian generative model created by Endres and a linear regression model created by Gingras to analyze the frequencies in each song. Both models independently confirmed our aural impression that about 70 percent of the song-types follow the overtone series.

The Hermit Thrush songs included sliding pitches and some song-

[34] Doolittle et al., "Overtone-based Pitch Selection in Hermit Thrush Song."
[35] Paul Boersma and David Weenink, *Praat* 5.1.29 (1992-2010), www.praat.org, accessed June 18, 2012.

types that did not follow the overtone series. This strongly suggests that the birds were selecting the overtone-based pitches from a much wider range of possibilities. They are thus not like a bugle that is capable only of producing pitches from the overtone series, but like a human singer who might choose to sing in imitation of the bugle's overtone-derived pitches. The overtone series is rooted in physics, not in culturally-specific human music theory, so it makes sense that it might be found in some non-human species as well. Because many scales can be derived from this series, it is understandable that earlier listeners, without recording equipment or analysis software, mapped what they heard onto what they knew. Harder to grasp is why the myth of Hermit Thrush pentatonic scales continues to be perpetuated, now that it can be so readily falsified!

Many other aspects of Hermit Thrush song remain to be studied. Musical analysis may help us make sense of rhythms, timbres, or the trills, slides, and other noises that are part of the song. Biological observation may help us figure out which birds sing which songs and under what circumstances. A combination of both might help us figure out why this bird sings songs based on the overtone series. Beyond the Hermit Thrush, there are thousands of other species of song-learning birds, and dozens of species of song-learning mammals, whose songs might be better understood by combining music theoretical and biological methods. Indeed, several individuals and groups with interdisciplinary training are beginning to shed light on the internal structures of various animal songs. Hollis Taylor has conducted perhaps the most extensive zoomusicological research to date on a single species, the Pied Butcherbird (*Cracticus nigrogularis*),[36, 37] while an interdisciplinary team consisting of David Rothenberg and four scientists has recently explored the song of the Thrush Nightingale (*Luscinia luscinia*).[38]

I certainly would not propose that there is a cross-species, universal music. The idea of a universal music is problematic even within the human species. However, given that we share similar biology, similar physics,

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[36] Taylor, *Towards a Species Songbook.*

[37] Hollis Taylor and Dominique Lestel, "The Australian Pied Butcherbird and the Natureculture Continuum," *Journal of Interdisciplinary Music Studies* 5, no. 1 (2011): 57-83.

[38] David Rothenberg, Tina C. Roeske, Henning U. Voss, Marc Naguib, and Ofer Tchernichovski, "Investigation of musicality in birdsong," *Hearing Research* 308 (2014): 71-83.

and similar environments with other species, it is not surprising that we sometimes come up with similar ways of organizing the sounds we make.

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