Music Theory's Other Nature: Reflections on Gaia, Humans, and Music in the Anthropocene

ALEXANDER REHDING

When the edited volume *Music Theory and Natural Order* came out two decades ago, the humanities had only a vague inkling that climate change, then still known as global warming, was going to be a defining topic for our times.[1] That is not to say, of course, that the environment was not a matter of concern. On the contrary, in the years leading up to the new millennium the world breathed a collective sigh of relief as acid rain lightened up and the ozone hole stopped growing. These victories appeared as a triumph of applied science and of policy-making, which identified the specific problems and offered workable solutions: human life had overstepped the boundaries of what was good for nature, and a worldwide reversal of industrial practices paved the way for betterment.

The place for the humanities in this discussion was less clear. *Music Theory and Natural Order* therefore did what the humanities were best at doing then: it interpreted and historicized. This was a fairly novel idea in the field of music theory at the time, which was freshly emerging from a period determined by scientific posturing, a much-professed love of logical positivism, and a search for objectivity. The volume showed how the master signifier of nature was employed at various points in time, in a variety of guises, to garner authority for whatever pronouncements a given theory made about music.

Re-reading *Music Theory and Natural Order* twenty years later, what seems most striking is how the human was mostly left out of

[1] *Music Theory and Natural Order from the Renaissance to the Early Twentieth Century*, ed. Suzannah Clark and Alexander Rehding (Cambridge: Cambridge University Press, 2001). The title of the conference on which the volume was based had been *Music Theory's Nature* (1998), but the publisher objected to the genitive form of a lifeless object and pulled out the eventual title from the introduction of the volume. As this article will deny precisely the claim of lifelessness, I hope I may be permitted to deviously reinstate this grammatical form in the title. This title is also a tip of the hat to my coeditor Suzannah Clark. All translations in this article are my own.

19th-Century Music, vol. 45, no. 1, pp. 7–22. ISSN: 0148-2076, electronic ISSN: 1533-8606 https://doi.org/10.1525/ncm.2021.45.1.7.

the equation. The arguments for "nature" deliberately sought an anchor for music-theoretical principles that removed human capriciousness from the equation. Nature was figured, as it were, as a disinterested third party. Those historical music theories that piggybacked on the objectivity—in all its senses—of natural science were the ones that appeared to offer the most instructive examples.[2]

On reflection, this kind of nature was never the only game in town. Starting perhaps with Rousseau's heroic efforts to wrest music from Rameau's all-too-scientific claws, music had always also had an anthropological kind of nature. Rousseau, who was always a political theorist in the first place, knew what he was talking about: "human nature" was the starting point of all political theorizing in the wake of Thomas Hobbes. Against Hobbes's dystopian vision of a dog-eat-dog (or, in Hobbes's case, wolf-eat-wolf) world locked in perpetual war against everybody, Rousseau painted a rosier picture of noble savages living in peaceful harmony—that is, before the invention of property ruined everything. As he detailed in his *Essay on the Origin of Languages*, Rousseau's happy individuals famously sang to each other to communicate their rich emotional lives through the infinitely fine gradations of their *Ur*-melodies. Sad to say, these specific ideas never got very far within the formal framework that music theory prized: Rousseau offered very little that could be abstracted and generalized here, very little that could be mapped onto the structures of the musical scores that music theory was best at handling.[3]

But there are other approaches that attempted to work a human element into music theory and nature that might perhaps lead further. After C. F. Michaelis and others adopted the Kantian sublime for music, a number of nineteenth-century (mostly German) music theorists tentatively sought to adapt these insights to their purposes.[4] The sublime is, after all, a thought figure that places the human in extreme opposition to nature. Edmund Burke highlighted the apt image of watching a person in a dinghy fighting the waves during a storm—only the person who observes this spectacle from a safe distance, Burke explained, can have a sublime experience; the person cast around in the waves is simply afraid of drowning. No matter which philosopher's particular brand of sublime we choose, this concept is typically figured as an aesthetic experience of sensory overload, in which the perceiving subject begins to grasp the limitations of the very capacity to make sense. The first insight of the sublime is incomprehension—the psychological response to this insight is fear. The second insight may be either Burke's pleasantly cathartic buzz, as the subject realizes that the aesthetic experience cannot directly harm its body, or Kant's triumphant affirmation of a reason that is greater still than the unleashed forces of nature.[5]

In the hands of a small group of German music theorists, the "musical sublime" was typically transformed into sounds that deviate significantly from the musical capacities of the human body.[6] The trombone is a good example here—much louder and much lower than the average human voice. (It is useful to bear in mind, for instance, that the German version of the bible speaks of the "trombones" of

[2]See above all Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 1998).

[3]Nathan Martin's *Rameau and Rousseau: Harmony and History in the Age of Reason* (PhD diss., McGill University, 2009) is the most sustained recent exploration of his music-theoretical ideas. My "Rousseau, Rameau, and Enharmonic Furies in the French Enlightenment," *Journal of Music Theory* 49, no. 1 (2005): 141–80, may count as an attempt to open up a modern music-theoretical arena for Rousseau's ideas.

[4]On Michaelis, see *Music and Aesthetics in the Eighteenth and Early Nineteenth Centuries*, ed. Peter le Huray and James Day (Cambridge: Cambridge University Press, 1981), 286–92. For a recent reconsideration of the musical sublime, see *Music and the Sonorous Sublime in European Culture 1680–1880*, ed. Sarah Hibberd and Miranda Stanyon (Cambridge: Cambridge University Press, 2020).

[5]For influential reconsiderations of the sublime, see above all Jean-François Lyotard, *Lessons on the Analytic of the Sublime*, trans. Elizabeth Rottenberg (Stanford: Stanford University Press, 1994), and Christine Pries, *Übergänge ohne Brücken* (Berlin: DeGruyter, 2015).

[6]Among them, Adolf Zeising, *Aesthetische Forschungen* (Frankfurt am Main: Meiglinger, 1855), Arthur Seidl, *Vom Musikalisch-Erhabenen: Prolegomena zur Ästhetik der Tonkunst* (Leipzig: Kahnt, 1887), and Hermann Stephani, *Das Erhabene, insonderheit in der Tonkunst, und das Problem der Form im Musikalisch-Schönen und -Erhabenen* (Leipzig: Hermann Seemann, 1903).

Jericho.) Or take tempos that are much slower than MM=60, that is to say, tempos that stay far below the average human heart beat.[7] Of course, these suggestions do nothing so much as to reinforce the notion that man is the measure of all things, even for those sounds that are designated specifically to fall far outside of the norm. But this conclusion may easily overshadow a more important insight: all these approaches start not with abstract structures but with the sensory perception of concrete sound. This is a relatively unusual position for music theory to be in but, as we will see, it is an important facet in this discussion.

None of these approaches were central to *Music Theory and Natural Order*. By and large, the human appeared as a messy and mostly irrelevant complication; it seemed less urgent than an understanding of "nature" itself.[8] (Or maybe that should be nature "itself.") The stakes have risen exponentially since then. Back then, the term *Anthropocene* had not yet imprinted itself on the collective consciousness. The realization that the root problem was not just the bad practices of big industry, but that our entire collective existence was instrumental in the shaping (and destruction) of the environment had not yet sunk in. Modern life itself is at fault.[9] The Anthropocene forces us to come to terms with the terrifying fact that the way we imagined our power relations, as weak human individuals against an all-powerful nature (that is to say, the starting point of the sublime), got it badly wrong. In the traditional image, nature will strike back a hundredfold at those who trespass against her.[10] The Anthropocene teaches us, by contrast, that humans have in fact been much more potent than we would allow ourselves to imagine even in our wildest philosophical fantasies. But insidiously, human impact is slow and much less immediate than the fantasies of nature's retribution would lead us to believe. When we notice it, it is already too late.[11]

This requires a radical reshifting in the way in which we imagine the power relations between humans and nature. Humans and nature are not oppositional forces; their fates are inextricably intertwined. Instead of observing nature's violence from the safe shore, we find that we are actually sitting inside Burke's dinghy. Not only do we die when nature suffers, but nature will die with us, at our hands.[12] We find ourselves sitting on the proverbial branch that we are busy cutting off. We need to find ways in which human actions can be thought as *part* of nature.

A Gaia for Music Theory

Put differently, the Anthropocene forces us to rethink the subject-object relationship on a fundamental level. And this is a topic to which the humanities have a lot to contribute. The Anthropocene, typically defined as the period when human action had a decisive influence on the climate conditions of the planet, has forced us to do the hard work of reorienting our entire thinking. Certain models that promise to break down the old barriers have come to the fore.

The Gaia hypothesis, proposed by James Lovelock and Lynn Margulis in the 1970s and which views the entire planet Earth with all its inhabitants as one gigantic organism, has been one such galvanizing force.[13] The easiest way

[7]See Hugo Riemann, *Die Elemente der Aesthetik* (Berlin: Spemann, 1900), 61, 80, 159.

[8]One reason for the scant attention to humans is bound up with efforts of music scholars, starting in the nineteenth century, to regard music as a life force in its own right. See Holly Watkins, *Musical Vitalities: Ventures in a Biotic Aesthetics of Music* (Chicago: University of Chicago Press, 2018) and *Music Theory and Natural Order*, 9–13.

[9]There is considerable discussion about when exactly the Anthropocene began. While a geological case is to be made for the detonation of the atomic bombs at Hiroshima and Nagasaki in 1945, which left a measurable impact on the geological record, I tend to side with those who push the starting point back to the industrialization of the late eighteenth century.

[10]If anyone has the Disney movie *Moana* on their mind as they read my gendered prose, then they have read my mind. Furthermore, if that was your immediate association, you are probably a parent of small children.

[11]This is a point of contention, of course. Rhetorically it is dangerous to make this claim, which runs the risk of inspiring further inaction. But pessimists, such as Roy Scranton, may indeed turn out to be pragmatists; see his *Learning to Die in the Anthropocene* (New York: City Lights, 2015).

[12]This point may also cause resistance: Planet Earth will of course continue to exist even when humans no longer populate it, and many will argue that the planet will be better off for it. But what I mean here are two things, one metaphorical, the other practical: the figure of nature has always been a human projection, and the consequences of human action will affect many species besides *homo sapiens*.

[13]It is probably useful to point out that there are important structural disanalogies here. The Anthropocene serves as a

to explain the hypothesis is to begin smaller: we typically imagine the human body as a unitary object, but in fact it is a complex system in which all sorts of microorganisms do essential work. Without the trillions of bacteria, archaea, and microfunghi inside and around us, the body would not survive for long. Now imagine this kind of symbiosis on a planetary scale: the planet is a similarly complex macroorganism, Lovelock and Margulis argue, in which everything and everybody plays a part.[14]

Given the prospect of planetary warming that affects all of life on earth indiscriminately, in which human action comes back to haunt the possibility of human life (and all other), it makes sense to start from a position where everything is connected and, crucially, where the human is no longer the measure of all things. Viewed from this towering perspective, the long-standing binaries human/nonhuman, nature/culture, and subject/object break down. In the face of the entire planet, the humanities must become posthumanities.

For a situation in which the human is no longer simply subject to nature but in turn controls nature (albeit on borrowed time), what we need is a postsublime aesthetics that manages to get us out of this bind. In regarding the entire planet as one singular organism, canceling the very division between human and nonhuman other, each is only a component within one vast network. Readers of contemporary theory should prick up their ears at this key term. It should surprise no one that Bruno Latour, of Actor-Network-Theory (ANT) fame, has become interested in this model.[15] For him, the Gaia hypothesis is the most glorious application of ANT on the largest scale. Most importantly, it elides the differences between human agents and nonhuman actants. While this maneuver, which is essential to Latour's ANT, has continually raised eyebrows in humanistic circles, it is in fact part and parcel of the Gaia hypothesis.[16]

We—I use the first-person plural to indicate both the community of scholars and humankind at large—can only make progress when we look beneath the façades of the passive, dispassionate concept of nature and the active scientists laboring in the service of truth (as well as prudent political goals),[17] and recast their symbiosis within a network in which all components are engaged as actors—no matter whether they are things or peoples. This is no less true for the Gaia hypothesis than it is, on a more limited scale, for a network such as music theory.

We need to let go of the traditional image of the music theorist as the "natural scientist" who impartially proclaims timeless, objective truths about music. We already know that this model is untenable—whenever a Schenker or a Riemann felt his conception of music under attack, he would very quickly drop his dispassionate attitude and issue dire threats to composers unwilling to toe the line. An ideology critique of these figures is one thing, but proposing a different model is another. One important

historiographic device, while the Gaia hypothesis models a certain form of behavior. As Erle C. Ellis and others have pointed out, the Gaia hypothesis offered an answer to the conundrum of the long-term stability of Earth's climate during the last four billion years while the sun heated up considerably; see Ellis, *Anthropocene: A Very Short Introduction* (Oxford: Oxford University Press, 2018), 18–20. Isabelle Stengers has recently taken up the Gaia hypothesis in the context of a critique of capitalist society; see *In Catastrophic Times: Resisting the Coming Barbarism* (Lüneburg: Open Humanities Press, 2015).

[14]In his *Gaian Systems* (Minneapolis: University of Minnesota Press, 2020), Bruce Clarke highlights specifically Lynn Margulis's perspective on the Gaia hypothesis, inspired by systems theory.

[15]This argument goes back to Latour's *We Have Never Been Modern* (Cambridge, MA: Harvard University Press, 1993) and its critique of Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton: Princeton University Press, 1985), in which he calls to balance the social with the natural and to grant nature agency, which then leads him to formulate ANT. Thanks go to Emily Dolan for pointing to the *longue durée* in Latour's thinking.

[16]Benjamin Piekut, "Actor-Networks in Music History: Clarifications and Critiques," *Twentieth-Century Music* 11, no. 2 (2014): 191–215.

[17]Latour is, of course, also known—and often criticized—for his relativistic stance on scientific knowledge. This is a problem in his foray into climate change. After all, climate change is itself subject to a pseudo-debate, a delaying tactic whose only purpose is to cast doubt on the validity of the scientific consensus in order to prevent any meaningful action being taken. The irony is that this attempt to muddy the waters is precisely premised on the relativist epistemology of the 1990s, which counts Latour among its intellectual fathers. In a situation where no less than our collective survival depends on a clear distinction between right and wrong, Latour is in need of defending his own position. He argues that his position has not changed, and that it is incumbent upon science to recognize its inherently political nature.

starting point is to think of music theory as a network in which the differences between all the actors are leveled. In this network the rules that make up the body of the theory are one agent, the composer who complies with (or disobeys) these rules is another, and the music they compose is a third. Yet, while these elements are clearly different in kind, ANT resists a hierarchical order among them. They all exercise a certain kind of agency within the network, which presents a flat ontology.[18] From the perspective of ANT, there is no structural difference between a living, breathing composer, a book of rules, and a musical composition (in performance, score, or otherwise).

This flat ontology that levels distinctions between things and people may sound counterintuitive, and from a certain perspective it clearly is. But this non-hierarchical approach is the foundation of everything that follows, whether it is the Gaia superorganism in the Anthropocene or the workings of music theory. This view collapses the binaries between nature and culture, and between human and material.[19] There is no center or periphery, no up or down: humans are actants just as are objects and principles. It is a whole without holism, all that exists are connections between elements.[20]

The exclusion of the human element, within a largely mechanistic conception of the nature of music, was the nineteenth-century mainstream of music theory in the shadow of Rameau. But it was never an inevitable choice. When we dig a little deeper, it is possible to find alternative music-theoretical conceptions that reveal a striking affinity to our contemporary values. The little-known composer-scholar Jean-Georges Kastner (1810–67) erected such a model in his treatise *La harpe d'Éole et la musique cosmique* (1856). As it turns out—and this lesson might be straight out of Jakob von Uexküll—once you place the human within the greater network, everything else around it must change too.

Epistemic Tsunamis and Other Music-Theoretical Catastrophes

When one opens the pages of Kastner's book, which is ostensibly about the Aeolian harp, it first appears as a rambling hodgepodge of disconnected topics that all somehow relate to sound. The Aeolian harp seems to be little more than a fig leaf covering an impressive but unsystematic display of learning, mostly presented in summaries of articles and treatises on any number of topics, ranging from Pythagorean harmony of the spheres to explorers' reports on natural phenomena from distant parts of the world, from recent scientific controversies in the physics community to fairy tales featuring supernatural sounds. All this is topped with an original composition, a lyric monologue in the style of French compositions for the annual conservatory competition, describing the ethical powers of music. "Bizarre" is a descriptive term that is found every few pages of this treatise, and one can see why.

But there is method behind the madness; Kastner is expansive rather than strategic. As a gentleman of leisure—he married rich—he had no need to be succinct or goal-directed in his writing. An Alsatian musician who studied composition with Antoine Reicha in Paris, Kastner specialized in writing *livres-partitions*, a hybrid genre of his own coinage that assembled a learned treatise on a topic from the cultural history of music and concluded with an original large-scale composition on the same topic. Kastner felt especially drawn to themes that invoked the supernatural powers of music, such as the sirens, dances of death, or military music (alternately inspiring fear and valor in the warring forces). A specialist in orchestration admired by Hector Berlioz, Kastner was always interested in using these compositions as test sites for new, often extravagant, instrumental sonorities—his symphony *Les cris de Paris* requires an ensemble of some forty saxhorns for one passage, which are never again used elsewhere in the piece. As Philip

[18]The term *flat ontology* brings us to object-oriented ontology (OOO), which regards itself as the heir to ANT. While OOO is not without its critics (see especially Alexander Galloway), Graham Harman offers an excellent summary of ANT in his book *Object-Oriented Ontology* (Basingstoke: Penguin, 2018).
[19]Latour, *Facing Gaia: Eight Lectures on the New Climatic Regime* (Cambridge: Polity Press, 2017), 68.
[20]Ibid., 97–98.

Spitta observed, none of Kastner's works had ever been performed.[21] Given Kastner's financial independence, it seems that performability was simply not a relevant consideration.

Characteristically, Kastner was intellectually omnivorous to the point of being self-indulgent. All his *livres-partitions* indiscriminately review every last scrap of paper ever written on a given topic of musical culture without much concern about truth or relevance. But *La harpe d'Éole*, dubbed a "meditation on the essential character of musical sound,"[22] stands out among his *livres-partitions* as a full-fledged theory of music. In it, Kastner sought to establish a new paradigm—one that replaces the "sound of nature" with the "voice of nature"—and he therefore had to start with fundamentals: *Quid sit musica?* What might music be?

Significantly, Kastner focused this query specifically on sound: where does noise end and tone begin? The standard definitions of Kastner's age held that "tone" (*son musical*) is that which "produces a continuous sensation in which one can perceive musical value" whereas "noise" is "a sound of too short duration to be well perceived or . . . a confusing mix of various discordant sounds."[23] Behind these distinctly unscientific explanations we can recognize the textbook definitions of periodic and aperiodic soundwaves.[24] Kastner rejected these old definitions as inadequate. A more accurate definition, instead, would have to take the specific physiology of the listener into account. For Kastner, this was not simply a question of injecting an element of anthropology; rather, he insisted that the difference between music and noise "principally depends on the organization of the *individual*."[25] Beauty, so to speak, is firmly placed in the ear of the beholder.

Music theory typically builds on the generalizability of its propositions. From this perspective, Kastner's atomization of the listening experience is a startling position for any attempt at theorizing music. With this gambit, he effectively threw down the gauntlet to the mechanistic paradigm that ruled over most of the eighteenth century and that sought music-theoretical explanation in the immutable, static principles of sound, epitomized by the overtone series. Kastner's position holds that the *corps sonore* cannot be dissected on the operating slab but must be vivified. Insofar as it builds on insisting that sound does not exist by itself but only in our ears, Kastner's approach amounts to an ecological model: it is individual variation that determines what is music and what is not. If there is a science that is the lodestar here, it would be human physiology, which Kastner seemed, admittedly, to treat more as a mystery than as a science.[26]

What brought about Kastner's clarion call for the need to rethink the fundamental categories of music and listening? Discernible beneath his proposal are the aftershocks of an epistemological tsunami that flooded the foundations of music only a few years previously: Cagniard de la Tour's siren. Presented in 1819, the siren turned the old certainties about theories of sound upside down.[27] In fact, Kastner spends a significant part of his treatise explaining the mechanism of the siren in great detail—even though ostensibly the physics of the siren has little to do with the Aeolian harp. What mattered to Kastner was the upheaval that the siren had caused in the world of acoustics.[28]

[21]See Philip Spitta's untitled review of Hermann Ludwig's three-volume biography of Kastner in *Vierteljahrsschrift für Musikwissenschaft* 4 (1888): 436–49. And, as far as I can tell, this has not changed, other than some short excerpts of his works, which typically appear in arrangements.

[22]Kastner, *La Harpe d'Éole et la musique cosmique* (Paris: L. Martinet, 1856), 7 (trans. mine).

[23]Ibid. Examples of noise that Kastner lists here include a cannon shot, thunder, and the lapping of waves.

[24]Kastner has more scientific definitions for these traditional approaches to offer, as he reveals later on. Tone is "a musical sound for which the number and duration of vibration can be calculated," whereas noise is characterized by "vibrations that lack regularity" (ibid., 90).

[25]Kastner, *La Harpe d'Éole*, 8 (emphasis added).

[26]Ibid., 8–9.

[27]Charles Cagniard de la Tour, "Sur la sirène, nouvelle machine d'acoustique destinée à mesurer les vibrations de l'air qui constituent le son," *Annales de chimie et de physique* 12 (1819): 167–71.

[28]See Stephen Turner, "The Ohm-Seebeck Dispute, Hermann von Helmholtz, and the Origins of Physiological Acoustics," *British Journal for the History of Science* 10 (1977): 1–24, and my "Opelt's Siren and the Technologies of Musical Hearing," in *Testing Hearing: The Making of Aurality*, ed. Viktoria Tkaczyk, Mara Mills, and Alexandra Hui (Oxford: Oxford University Press, 2020), 131–57.

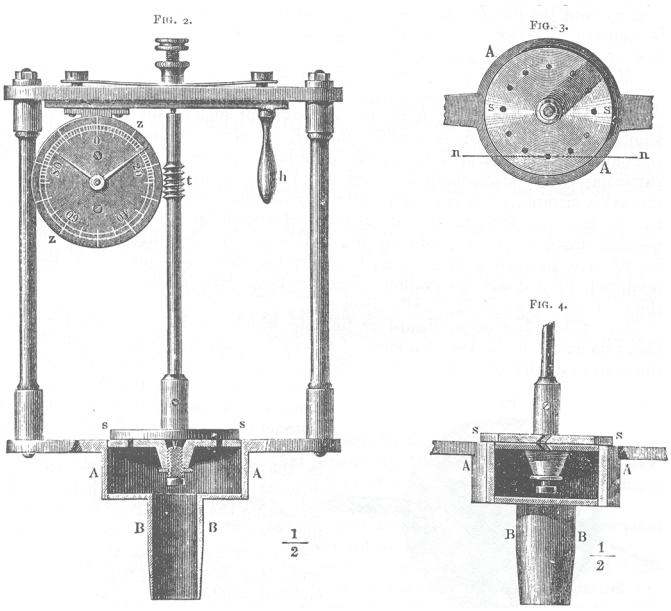


Plate 1: Cagniard de la Tour's siren (from Helmholtz, *On the Sensations of Tone*).

Cagniard de la Tour's mechanical siren (named *sirène*, or mermaid, because it could operate in air and under water) was originally conceived as a device to test and challenge existing theories of sound. If musical sound, Cagniard queried, is based on the pulsating airwaves passed on from instruments, would it be possible to generate sounds by stirring the air directly?[29] In other words, the siren was conceived as a non-instrument, a mechanism that would bypass traditional musical instruments, to test the minimum requirements of sound production.

Cagniard's mechanism of the siren was distinctly simple. As shown in plate 1, reproduced from Helmholtz's *On the Sensations of Tone*, the device consists of a rotating round metal disc with holes punched in regular intervals, laid on top of a fixed disc of the same size with holes in the same places. A bellows is attached at B. The cross section of disc S (along secant n) shows how two diagonal bores in opposite directions direct the air flow. When air is pumped through a chamber (A) below the fixed disc the air pressure begins to rise, causing the top disc to start rotating. Each time air passes through both holes, a gentle air puff, *choc* or *secousse*, is heard.[30] At slow rotation speed these air puffs will be distinct, but as the rotation speed accelerates beyond twenty impulses per second (20Hz), they blend into a unified pitch that rises depending on the rotation speed. The siren begins to sing—a musical tone arising out of noise.

At the time, this mechanism shattered all certainties about the nature of sound.[31] The siren produces noise, individual pulses, *chocs*, air puffs—or, in Kastner's earlier definition, "a sound of a duration that is too short to be able to be appreciated." But this static definition is clearly insufficient, because given

[29]Cagniard de la Tour, "Sur la sirène," 167–68. "Si le son produit par les instruments est dû principalement, comme le croient les physiciens, à la suite régulière des chocs multipliés qu'ils donnent à l'air atmosphérique par leurs vibrations, il semble naturel de penser qu'au moyen d'un mécanisme qui serait combiné pour frapper l'air avec la même vitesse et la même régularité, on pourrait donner lieur à la production du son."

[30]Kastner prefers the term *secousse* for this phenomenon.

[31]Even Ernst Chladni, the principal authority in the field of acoustics in the early nineteenth century, agreed that the siren posed a deep challenge to the understanding of sound; see "Ueber Töne bloß durch schnell aufeinander folgende Stöße, ohne einen klingenden Körper," *Annalen der Physik* 84 (1826): 21–48.

sufficient speed, the individual air puffs of the siren flip into continuous sounds that must be defined as musical tones. The quiet *chocs* that the siren emits resonate as profound shocks to the system: the difference between noise and tone cannot be demarcated within the soundwave. That is why, Kastner concludes, it must be located in the listener's ear.

It is hard to underestimate the wider importance of this controversy for the field of acoustics as a whole. Kastner did not participate in the scientific debates that moved the phenomenon of the siren sound to different territory and laid the foundation for modern acoustics, with Ohm's adoption of Fourier spectra for the analysis of soundwaves.[32] Kastner was simply struck, shaken to his core, by the siren's ability to lay bare the inadequacy of our prior understanding of sound. The reason the siren looms so large in Kastner's cosmological imagination, put simply, is this: if the siren shattered our old certainties about the nature of sound, what else might we not know? A new paradigm, a new basis on which a better understanding of music could be erected, was urgently necessary.

Toward a Chemical Music

In a world in which all that was solid had melted into air, there was a distinct need for a new music-theoretical instrument with which the new principle could be brought to life. In the ancient world, the monochord had fulfilled that purpose.[33] It had been used to sonify the universal mathematical ratios underlying the basic musical intervals. But this device was inadequate for the complexities that the new conception of music and sound required. After all, the siren—another music-theoretical instrument—had just disproved all the theories that had been erected on the basis of the monochord. But the siren's effect had primarily been negative: it had shown, with apparently inexorable logic and incontrovertible sonification, that the old paradigm had been inadequate, but it had relatively little to offer in the way of alternative hypotheses. There was clearly a need for a new instrument that would exemplify—or better yet, offer sonic proof of—the new musical paradigm that was needed in this situation. Enter the *harpe d'Éole*. Not dissimilar from the siren, the Aeolian harp was an acoustical marvel that defied standard explanations of sound. This mysterious instrument, which enjoyed great popularity in the eighteenth and nineteenth centuries, had long been a favorite with the European Romantics.[34] Described in detail by the Jesuit polymath Athanasius Kircher in the seventeenth century, the Aeolian harp was not a harp in a standard sense of the word, but rather a chamber with an opening through which the wind could move large strings stretched across the chamber.[35] The number of strings could vary, typically between three and twelve, all tuned in unison. But inexplicably, when the wind stirred the strings, they did not sound pitches and timbres that human hands could elicit from them, but a changing kaleidoscopic array of unpredictable chords and melodies. Perhaps the Aeolian harp might just hold the key to understanding the hidden secrets of the acoustical world. What is more, the sound of nature is not the consonant triad, as the Rameauian tradition had claimed, but distinctly dissonant

[32]On this important chapter, see especially Bernhard Siegert's magisterial *Passage des Digitalen* (Berlin: Brinkmann und Bose, 2003).

[33]I explore the concept of the music-theoretical instrument especially in "Three Music-Theory Lessons," *Journal of the Royal Musical Association* 141, no. 2 (2016): 251–82, and "Instruments of Music Theory," *Music Theory Online* 22, no. 4 (2016), http://mtosmt.org/issues/mto.16.22.4/mto.16.22.4.rehding.html.

[34]Kastner evokes explicit Romantic tropes here: "The effect that [the Aeolian harp] made *on us* by means of its strange chords, imprinted from the feeling of the infinite, gave me the idea of a poetic conception in which this instrument played the principal role" (*Harpe d'Éole*, 64). The important role of the Aeolian harp in the Romantic imagination is underscored in M. H. Abrams's epochal *The Mirror and the Lamp: Romantic Theory and the Critical Tradition* (Oxford: Oxford University Press, 1953), 51–52. For specific musicological considerations, see Carmel Raz, "The Expressive Organ within Us: Ether, Ethereality, and Early Romantic Ideas about Music and the Nerves," this journal 38, no. 2 (2014): 115–44; Emily Dolan, "E. T. A. Hoffmann and the Ethereal Technologies of Nature Music," *Eighteenth-Century Music* 5, no. 1 (2008): 7–26; and Francesca Brittan, "Berlioz and the Pathological Fantastic: Melancholy, Monomania, and Romantic Autobiography," this journal 29, no. 3 (2006): 211–39.

[35]See Thomas L. Hankins and Robert J. Silverman, *Instruments and the Imagination* (Princeton: Princeton University Press, 1995), 86–112.

formations such as seventh or even ninth chords, seen in ex. 1b—all sounded without resolution. In some cases extremely dissonant formations can be heard. Note the layered dynamic levels that the transcription captures.

The sounds of the Aeolian harp were distinctly not those of plucked strings but ones that could vary in *all* dimensions. Throughout his treatise Kastner deployed several musical examples with which he tried to convey various aspects of the specific sound of the Aeolian harp in notation. First of all, the harp refused, in ex. 1a, to make a clear distinction between harmony and melody: it could sound individual tones of the overtone series successively or simultaneously, or anything in between. This example transcribes snippets of an Aeolian harp at the castle in Baden (Germany) that Kastner considered worthy of transcription. The final, more elaborate transcription shows how in some cases this fluidity takes on textural character. It seemed clear to Kastner that the continually changing dynamics of the Aeolian harp, in ex. 1c, were not an incidental feature but conveyed something essential about its sound. Kastner notes especially also that the harmonies do not resolve as voice-leading rules argue they should.

Occasionally the ghostly hand that excited the strings seemed to be able to vary the fundamental pitch, in direct contradiction of the old acoustical certainties that saw a linear relationship between the string (given constant tension, thickness, and length) and the sound produced—though Kastner underlined that this was not common. All these phenomena crystallized in Kastner's mind into a new certainty: the old mechanical causalities, the if-then relationship between string and sound, were no longer tenable.[36] The notated music examples Kastner included here can only convey an incomplete impression; much of what made the Aeolian harp special was precisely what notation could not convey: timbre and constant change. To make any progress in the search for the voice of nature, then, we have to stop thinking about notes as the irreducible elements of music and break down these sounding molecules into their atomic particles.

This musical chemistry required a whole new approach. If there existed some natural acoustic force distinct from human experimentation, then it was imperative to study the sounds of nature. This is why the reports of acoustical marvels from remote corners of the world—reverberating caves, howling noises at night, sighing mountains—took on a strategic significance in Kastner's model. He did not offer an explanation of these phenomena, and probably could not have done so. But their potential importance clearly rises in the epistemic vacuum that the rejection of the mechanistic model, along with the old certainties, brought with it. If the search for the voice of nature had to start again from scratch, no stone could be left unturned. Even the old myths, such as the Wild Hunt (*la chasse nocturne*), the subject of various European fairy tales, might be worth combing through again for nuggets of some higher truth. In this aspect of his work especially, Kastner appears of a piece with nineteenth-century scholarship that sought fundamental truths in mythology. The important archeologist Heinrich Schliemann, who sought to locate the ancient city of Troy based on information from Homer's *Iliad* (which he read as a historical document), may be the closest analogy here. If this particular brand of literalism, Kastner's faith in myth's attempt to understand the natural world through the supernatural, seems hopelessly Romantic to us, then it is because that is exactly what it is.

What if nature were not giving us raw material for composition, as mechanical theories held, but *performing* music for us—and on us? Much of Kastner's search for the voice of nature was guided by Novalis's famous pronouncement: "Nature is an Aeolian harp, a musical instrument, whose tones are in turn keys of higher strings within us."[37] Following the

[36]Kastner, *Harpe d'Éole*, 94. See also p. 135: "The most striking fact is that at the hands of the wind, one and the same string can produce multiple simultaneous sounds, without any visible agent dividing the string or changing its length."

[37]Novalis, *Fragment* 2232. Kastner, *Harpe d'Éole,* quotes this on p. 66.

German Romantic poet's lead, Kastner expressed a particular fascination with sounds that have no external physical cause but only exist in our hearing. He was especially taken by combination tones (then known as Tartini tones), which emerge in the ear as the result of specific interferences between two different sounds.[38] He went on to speculate whether higher-order combination tones could be generated as the product of two combination tones—a true virgin birth in the sound world.[39]

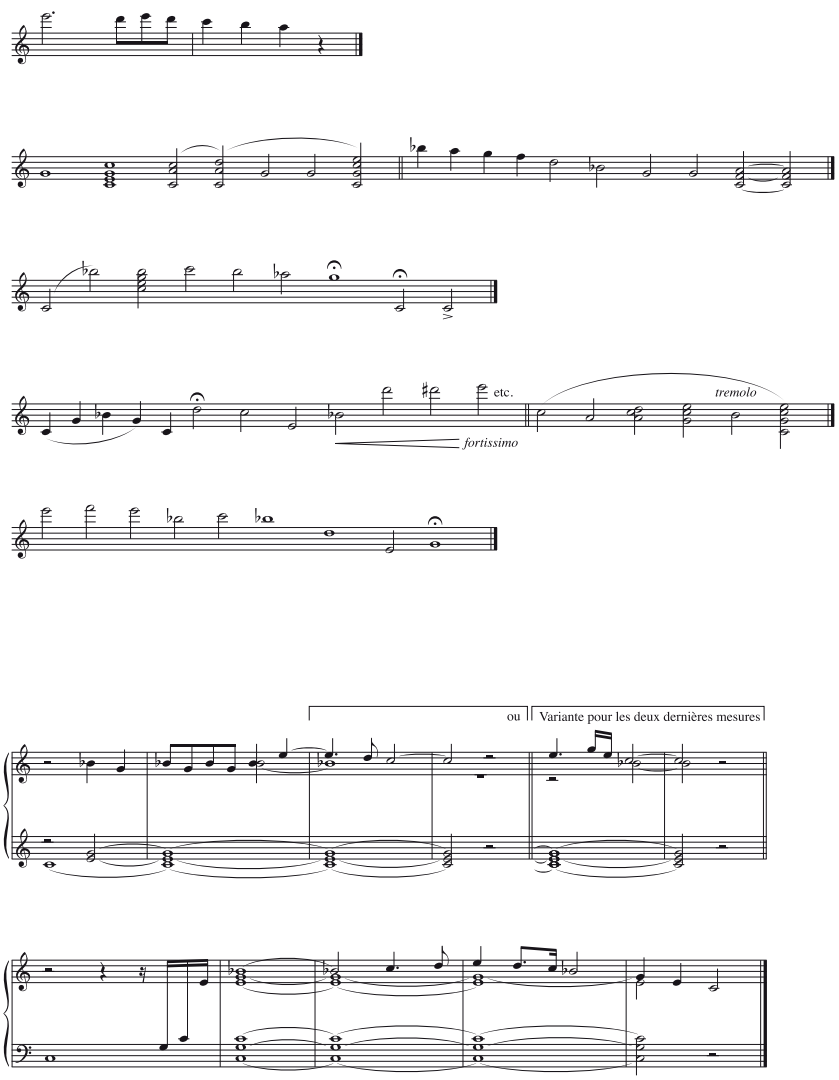
For the Romantic poets, the Aeolian harp was the entrance to the spirit realm; for Kastner, it was an invitation to write the human into music theory and to individualize the mechanistic model. The ideas that filtered into sonic reality through the Aeolian harp sounded the death-knell for the neat divisions into objective and subjective factors on which the theories of Chladni and Rameau had rested.[40] The harp raised new pressing questions: what if the factors that had been considered secondary—timbre, dynamics, articulation—were in fact essential? Kastner did not offer a firm definition of timbre, but he did gesture toward an ecological model in which this musical parameter "seems to depend on the nature of the sounding body [*corps sonore*] and that of surrounding bodies."[41] So eager was Kastner to stress the subjective, physiological-psychological import of timbre that he resorted to an exoticizing flourish when he speculated that the "ear of the Orientals"[42] may be best attuned to the fractional details of sound. It seems that the main purpose of Kastner's use of nineteenth-century racial stereotypes here is to undercut the purported universality of the mechanistic model and the "physical music" of previous generations, in the spirit of *ex oriente lux*.

The music of Kastner's time was, he felt, quite inadequate for capturing the infinite subtleties of nature. This is because Western listeners have not fully learned to listen: "The coarseness or, put more circumspectly, the imperfection of our senses has hindered us from grasping this music in all its delicate nuances and all its mysterious combinations. It is no doubt richer and more extensive than the one whose laws were fixed by our ear."[43] It is a music that lies beyond—Kastner briefly introduces the notion of a "chemical music"[44] (*musique chimique*), which he contrasts with the "physical music" of the previous generation. The notion of chemistry would have resonated with Kastner's nineteenth-century readers as a new science on the rise that picked up precisely where Newtonian mechanics left off. The main thrust of chemistry, in the Romantic mindset, was to explore the dynamism of forces, to focus on the productive power behind organic structures.[45] Kastner put his hope in various ongoing acoustical and musical experiments that built on vapor, electricity, and fire—these constituted hints of the new "chemical music" he envisioned. These explorations may still be tentative, Kastner conceded, but "in these attempts, no matter how bizarre they may appear, there are germs of completely new instrumental combinations that only await the efforts of a man of genius before they can burst forth" in the artistic world.[46]

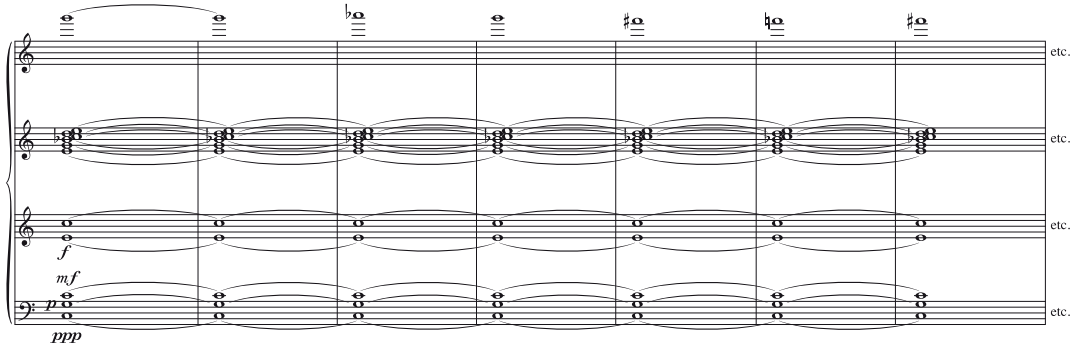
Especially the idea that the new musical paradigm must be built up from harmonics, from the elementary particles of musical sound, and not from ready-made chords as the old mechanics

[38]Helmholtz offered the most thoroughgoing scientific explanation in "Ueber Combinationstöne," *Annalen der Physik und Chemie* 99 (1856), 523–29. Kastner may well have read about the speculative connection between the Aeolian harp and Tartini tones in William Jones's *Physiological Disquisitions* (1781).
[39]Kastner, *Harpe d'Éole*, 131.
[40]Ibid., 65.
[41]Ibid., 90. This approach is surprisingly close to modern models. See Nina Fales, "The Paradox of Timbre," *Ethnomusicology* 46 (2002): 56–95.
[42]Kastner, *Harpe d'Éole*, 141. The arabesque seems to be the unspoken guiding metaphor here.
[43]Ibid., 125.
[44]Ibid., 93. Kastner explores a variety of recent developments such as "vapor music"—Doppler's (falsely called "Dappler" by Kastner) adaptation of the mechanism of the siren for steam engines—as well as various other sound experiments involving explosions and electricity. He considers all these to be "chemical music."
[45]On Romantic chemistry and music, see Daniel Chua, *Absolute Music and the Construction of Meaning* (Cambridge: Cambridge University Press, 1999), 199. See also, more broadly, Richard C. Sha, *Imagination and Science in Romanticism* (Baltimore: Johns Hopkins University Press, 2018); and Jeremy Adler, *Eine fast magische Anziehungskraft: Goethes 'Wahlverwandtschaften' und die Chemie seiner Zeit* (Munich: C. H. Beck, 1987).
[46]Kastner, *Harpe d'Éole*, 102.

a. Sound of the Aeolian harp in notation, from pp. 79 and 145.

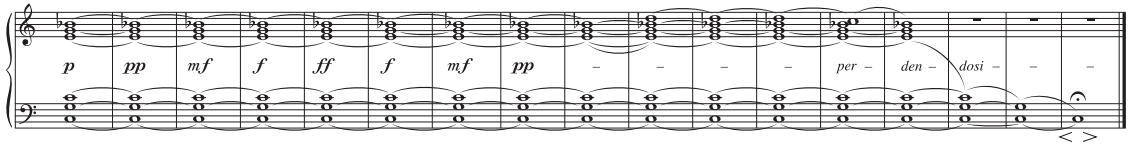


b. Seventh and ninth chords, from p. 142.



Example 1: Jean-Georges Kastner, *La harpe d'Éole et la musique cosmique* (1856), transcriptions.

c. Changing dynamics of the Aeolian harp, from p. 139.



Example 1 (*continued*)

had insisted, was Kastner's paragon of chemical music.[47] Thus he was convinced that "harmonics [*sons harmoniques*], which can barely be obtained in the artistic realm, by means of highly artificial procedures, arguably constitute natural music *par excellence*."[48] This, finally, is the nut that needs to be cracked.

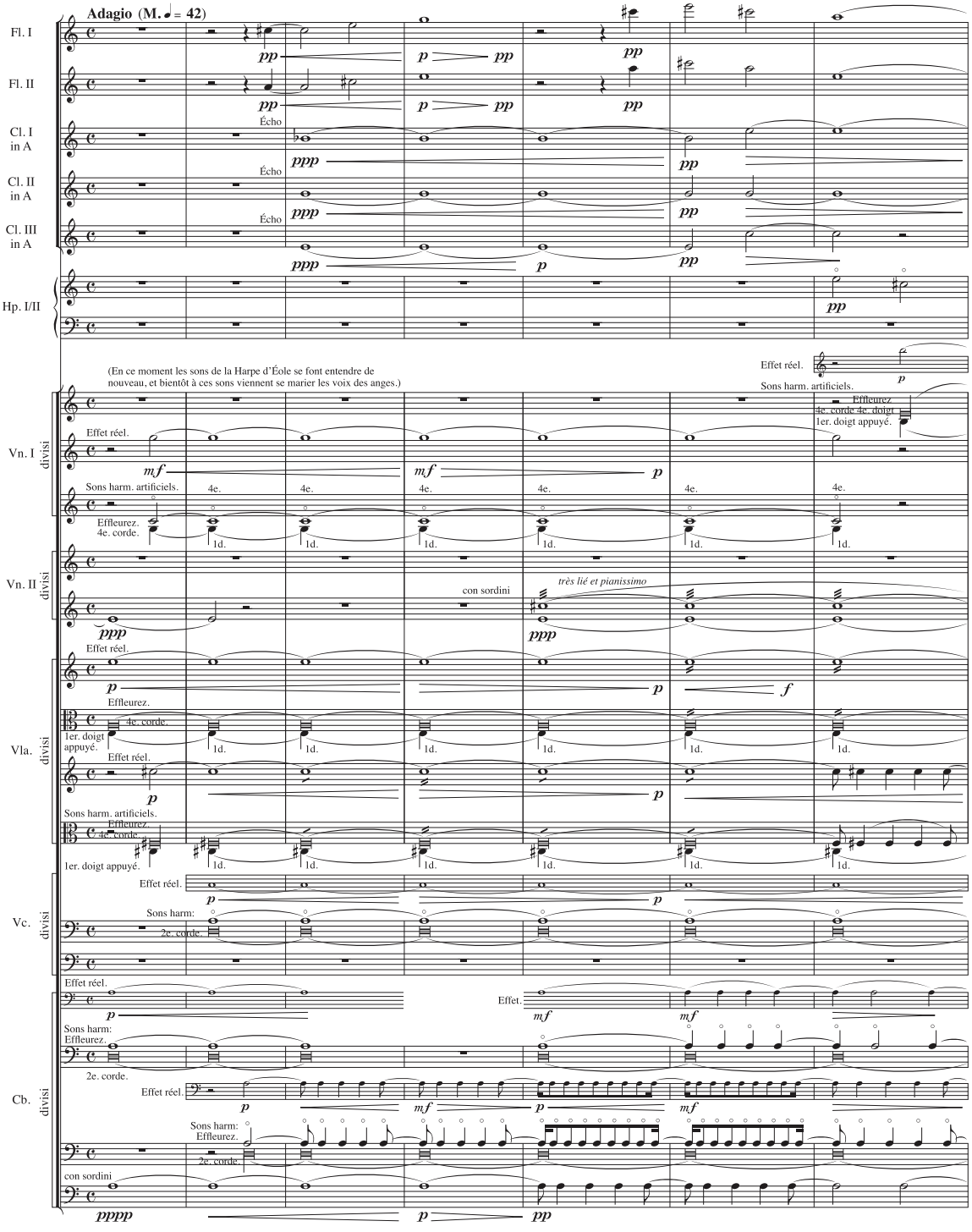
Absent the "man of genius" he called for, Kastner felt compelled to act himself. His research culminated in a compositional *simulation* that took all the different parameters into account, where the transcriptions of exs. 1a–c had fallen short. Simulation seemed the only way forward for Kastner, since words and theoretical principles had failed. The unprecedented complexity of the orchestral parts, in ex. 2, from Kastner's lyric monologue *Stéphen ou la harpe d'Éole*, show infinitely fine-shaded nuances of the sea of individual voices, iridescent harmonics in changing constellations, fading in and out in crescendos and diminuendos. The detailed articulation markings, the layered dynamics, and use of special techniques such as tremolo and harmonics in the strings indicate that Kastner composed the sound of the Aeolian harp in all its sonic complexity. His score reaches the limits of what is possible to convey in notation. A single G played ***mf*** in the Violins 1 stands out. The upper woodwinds, flutes and clarinets, playing ***ppp***, fill out the sonority, while the lower strings come in softly, down to an impossibly silent ***pppp***. Each string group is divided, with some playing harmonics, and others half muffling their sounds with a mute. Over time the strings introduce slow-moving repetitive rhythmic figures, while the woodwinds and flutes begin to intone short melodic fragments at glacial pace. When part of the violas crescendo to a momentary ***f***, the harps punctuate this subdued climax by sprinkling slowly plucked harmonics across the texture. This incomparably fine-tuned sonority has almost no harmonic meaning—technically, it is a dominant seventh, which is also a good approximation of the most important components of the harmonic series. This sound remains sustained, shimmering and almost unmoving, over what seems to be a never-ending length of time. Kastner's simulation-transcription conveys one thing above all: the conventional wisdom about music no longer holds. The voice of nature simultaneously held the promise of a music of the future. And, following nineteenth-century ideas of progress, the future is more complex, more nuanced, and much of its mystery lies beneath the surface. Although he cautioned that his orchestral impression was still an imperfect rendition of the voice of nature, Kastner's score may well be the first example of chemical music in notation.

Learning to Think with Gaia

Kastner found himself unable to supply an explanation of the mechanism of the Aeolian harp. He juxtaposed the three ruling theories of his time—by Athanasius Kircher (1650), Matthew Young (1784), and Carl Emil Pellisov (1830). He was especially taken by the young scientist Pellisov, whose explanation leaned on longitudinal waves. We now know this hypothesis to be false, but it is easy to see why Kastner would have been attracted to it: Pellisov took great care to explain harmonics, which Kastner intuited at the core of chemical music.[49] It seems that

[47]Ibid., 116.
[48]Kastner, *Harpe d'Éole*, 125. See also p. 62.

[49]Carl Emil Pellisov (pseud. for Karl Emil von Schafhäutl), "Andeutungen zur Begründung einer Theorie der Aeolsharfe," *Poggendorffs Annalen der Physik und Chemie* 19 (1830): 237–59. The theory first proposed by Vincenc



Example 2: From Kastner's lyric monologue *Stéphen ou la harpe d'Éole*.

longitudinal waves were just sufficiently different from transverse waves, just sufficiently enigmatic, to provide an explanation that still retained enough mystery for the supernatural wonder of the Aeolian harp to continue casting its spell.

In other words, Kastner not only failed to supply a scientific explanation for the mechanism of the Aeolian harp, but he also bet on the wrong horse. But this is fairly irrelevant here. After all, an acoustical explanation would have stood in the way of the marvel that fed so much of Kastner's fascination with this instrument. In fact, an *inability* to explain motivates the fundamental reconfiguration of actants within the network that characterizes his theory of "chemical music." The starting point of Kastner's network, after all, was a call to assign a place to the human listener, to mark the threshold between noise and tone. This new, integrated function of the listener then also required a new approach to the raw sound material: the "sound of nature" of mechanical theory was deemed insufficient and replaced with the mysterious "voice of nature" that had been described in myriad natural (and supernatural) phenomena and found its most concrete expression in the enigmatic Aeolian harp. This new "voice of nature" was almost impossible to pin down: its essence was not one *thing* but constant change. Insofar as it could modify itself in multiple dimensions simultaneously, this sound could not be fully explained, but it could be (partially) represented. That is why the simulation given in Kastner's orchestral score must count as a vital part of his theory. Whatever this sound was, Kastner was convinced, it had to be built up from individual harmonics. What is more, it called for a completely different kind of music, a music that did not as yet exist but whose traits Kastner associated with "chemical" qualities—that is, a music that replaces solid matter with dynamic changes. In the end, it behooves the human listener to grow better ears to become more attuned to this music. Kastner suspected that examples of the subtler kind of hearing that he thought appropriate for this music could be found in the fine-tuned ears of unspecified "Oriental" people. This final speculation closes the circle: the network, in which no element is superior to another and everything is contingent on everything else, is a theory in which human and nonhuman actants operate, as it were, hand in hand.

But how does that conclusion tie in with our overriding topic, the Anthropocene? Some might argue that looking for the right music is not the same as looking for a solution to climate change. They would not be wrong. On the one hand, climate change was not a known issue in Kastner's time, and on the other, music theory cannot hope to solve global warming. But the concern for listening to nature and the urgent call for a shift in thinking testify to the underlying connections. The Gaia hypothesis, especially in Latour's reading, can help explicate the link between them.

In the end, the Aeolian harp is an interface.[50] It can be thought of as a Chladni plate that represents the impalpable processes of nature in sensorily appreciable form.[51] But whereas Chladni plates presented standing waves as arrangements of grains of sand in visually arresting but motionless patterns, Kastner's Aeolian harp added a temporal dimension to the representation of sound. The constant change of the sound of the Aeolian harp, the ceaseless crescendos and decrescendos, pointed for Kastner to a dynamic nature that was never static but always in flux. Kastner's Aeolian harp is a gateway that unlocks sensory access to nature that would otherwise be

Strouhal, "Ueber eine besondere Art der Tonerregung," *Annalen der Physik und Chemie* 241, no. 10 (1878): 216–51, and promoted by Lord Rayleigh, "Æolian Tones," *Philosophical Magazine* (6th series) 29, no. 172 (1915), 433–44, is now accepted as correct. Strouhal explains that the sounds are created by turbulences ("frictional sounds") behind the strings.

[50]See Emily Dolan, "Toward a Musicology of Interfaces," *Keyboard Perspectives* 5 (2012): 5–12. For thinking about interfaces in a media-theoretical context, see Alexander Galloway, *The Interface Effect* (Cambridge: Polity, 2012).

[51]Romantic critics like Johann Wilhelm Ritter had already held up Chladni's sound figures as a repudiation of analytical—"dead"—science in favor of a science of beauty that marvels at the mysteries of nature. See his *Fragmente aus dem Nachlass eines jungen Physikers* (Heidelberg: Mohr und Zimmer, 1810), II, 227.

foreclosed and that includes humans in its purview. Once this necessity is grasped, Kastner's argument continues, it might even be possible to give the idea of *musica mundana* another shot—perhaps the world, the cosmos, really does provide hints about a deeper reality revealed to our ears through and by nature. We human listeners do not understand it, Kastner concludes, but we know that *we* are integrated parts of the network—we are actants linked to the wider system, though pointedly not in privileged positions with respect to it.[52]

Considering the history of sound art, Thomas Patterson and Emily Dolan urge us to think of Aeolian harps as the earliest sound installations.[53] The blurred line between noise and tone that characterizes the Aeolian harp has also been identified as a key feature of sound art.[54] Not coincidentally, since the 1970s Aeolian harps have featured prominently in environmental art by such artists as Max Eastley, Douglas Hollis, Alan Lamb, and Juan Duarte Regino. Hollis, for one, conceives of his sound work as a translation, highlighting ephemeral sounds that would otherwise be ignored. His works are "sensors of natural activity—or the lack thereof."[55] Such contemporary installations may possess the fierce urgency of the present that Kastner's Aeolian Harp lacked—unsurprisingly perhaps, as the nineteenth century did not have the same catastrophic environmental concerns that our age faces (and against which it has consistently failed to take meaningful action). But even without an explicit outlook on the climate, Kastner's model holds some important lessons for the Anthropocene.[56] The profound epistemic crisis that first gave rise to Kastner's new theory underscores that "business as usual" is no longer an option. Kastner firmly believed, as stipulated by the Gaia hypothesis, that everything is connected, from the smallest to the largest elements. Having understood that the old system had failed by leaving the human contribution out of the picture, Kastner's most important exhortation to us is to listen carefully.

Abstract.
The new historical paradigm ushered in by the Anthropocene offers a timely and urgent opportunity to rethink the relationship of humans and nature. Bruno Latour's take on the Gaia hypothesis, which rejects the traditional subject/object divide, shows how the human can be inscribed into the work of music theory. This turn toward Latour's Actor-Network Theory, which erases the categorical difference between human and nonhuman agents, now dressed up in cosmic garb under the banner of the Gaia hypothesis, appears to be distant from traditional music-theoretical concerns, but the connection is in fact less far-fetched than it seems. J. G. Kastner's music theory, taking its cue from the sound of the Aeolian harp, serves as a test case here: the Aeolian harp, played by wind directly, had long served as a Romantic image of the superhuman forces of nature, but Kastner argues that the Aeolian network only becomes complete in human ears. By unraveling the various instances and agencies of Kastner's theory, this article charts a novel approach to music and sound that sidesteps the conceptual problems in which the nineteenth-century mainstream habitually gets entangled. Kastner's work is based on a fundamental crisis in the conception of sound, after the invention of the mechanical siren (1819) tore down any certainties about the categorical distinction between noise and musical sound. Seeking to rebuild the understanding of sound from the ground up, Kastner leaves no stone unturned, from the obsolete Pythagorean tradition of *musica mundana* to travelers' reports about curious

[52]There is one final twist of irony: the wishful projections that Kastner heaps upon the Aeolian harp are less an accurate description of the instrument than an expression of a desire for a new music with scintillating timbres, entirely composed out of harmonics fading in and out. In a word, what Kastner compiles is a wishlist for an additive synthesizer *avant la lettre*.

[53]Thomas Patterson and Emily Dolan, "Ethereal Timbres," in *Oxford Handbook of Timbre*, ed. Emily Dolan and Alexander Rehding (New York: Oxford University Press, 2020).

[54]Christoph Cox, "Sound Art and the Sonic Unconscious," *Organised Sound: An International Journal of Music Technology* 14, no. 1 (2009): 19–26. Aeolian harps also play an important part in Timothy Morton's *Ecology without Nature* (Cambridge, MA: Harvard University Press, 2007).

[55]"Pet Sounds," *SF Weekly*, 14 February 1996, https://www.sfweekly.com/news/pet-sounds/.

[56]Kastner's ideas clearly resonate with ecomusicological questions. I have explored another early ecomusicological contribution by Kastner, from his *Les Voix de Paris* (1857), in "Brauchen wir eine Ökomusikwissenschaft?" *Archiv für Musikwissenschaft* 69/3 (2011): 187–95.

sonic environmental phenomena from distant parts of the world. Where the old mechanistic paradigm was built on a "physical music" (and a static "sound of nature" based on the harmonic series), Kastner proposes a new "chemical music" that is based on the dynamic, ever-changing sonority of the Aeolian harp. This chemical music does not (yet) exist, but Kastner gives us some clues about its features, especially in his transcription/simulation of the sound of the Aeolian harp scored for double symphony orchestra. Kastner's "chemical music" finally closes the music-theoretical network that he builds around his new conception of the supernatural sound of the Aeolian harp and its human and nonhuman agents. Keywords: Actor-Network Theory, Aeolian harp, Jean-Georges Kastner, chemical music, crisis of sound

IN OUR NEXT ISSUE (FALL 2021)

RALPH LOCKE: The Exotic in Nineteenth-Century French Opera, Part 1: Locales and Peoples

JACEK BLASZKIEWICZ: *Chez Paul Niquet*: Sound, Spatiality, and Sociability in the Paris Cabaret

STEPHEN ARMSTRONG: Bellini's *Il pirata* as Virtual Tourism in Late Georgian London