CONFERENCE PRESENTATION/WORKING PAPER (rev. Nov 2019). Cite (with caution!) as: Bell, Eamonn. “Abraham Moles Redux: *Théorie de l’information et perception esthétique* (1958) and Its Sources” Conference presentation, Recursions: Music and Cybernetics in Historical Perspective from Edinburgh University, Edinburgh, October 24–25, 2019.

Abraham Moles Redux—Théorie de l’information et perception esthétique (1958) and Its Sources

Eamonn Bell

Nov 2019
rev. ~~July 22, 2020~~

A version of this paper was delivered at the Recursions: Music and Cybernetics conference at the University of Edinburgh, 24–25 October 2019. PLEASE DO NOT DISTRIBUTE THIS WITHOUT PRIOR PERMISSION. Double curly braces indicate interpolations of material written for but not presented on the occasion.

Abstract

M.J. Grant and Jennifer have both identified information theory as one of the primary scientific influences on post-War European avant-garde music. (Grant 2005; Iverson 2019) In his Théorie de l’information et perception esthétique (1958), Moles set out to demonstrate the applicability of information theory to the arts more generally, finding many attentive readers across Europe.

Moles repeatedly returned to musical examples therein

to make his case—despite its intermedial aspirations. This feature of Moles's text attracted the precocious Joel E. Cohen, who prepared an English translation: Information Theory and Esthetic Perception (1966). Cohen's translation might properly be considered a revised edition: small but important changes, additions, and deletions abound, all made with Moles's blessing.

Preparing the Théorie, Moles built upon his doctoral research as well as the practical experience in broadcast engineering that he had gained as an employee of the Centre d'études de la radio-télévision, the research and development arm of the predecessor to the French national broadcaster RTF. Moles also visited the United States during the mid-1950s with the help of financial support from the Rockefeller Institute, on which basis he visited both the Massachusetts Institute of Technology and Columbia University, the latter institution, as a guest of Vladimir Ussachevsky.

Taking the context of its production into account, I revisit the original French text and chart its influence in the interim between its appearance and the publication of Cohen's English translation some eight years later. I conclude by considerings the music examples referenced in the omitted discography. With reference to some of the most striking sounds and music referenced by Moles, I explore the prospects of a sonic rehabilitation of the more idiosyncratic features of Moles's provocative, yet influential, extension of information theory to music.

CONFERENCE PRESENTATION/WORKING PAPER (rev. Nov 2019). Cite (with caution!) as: Bell, Eamonn. "Abraham Moles Redux: *Théorie de l'information et perception esthétique* (1958) and Its Sources" Conference presentation, Recursions: Music and Cybernetics in Historical Perspective from Edinburgh University, Edinburgh, October 24–25, 2019.

Paper

Abraham Moles, born in 1922 and died 1992, was a French polymath, whose forbiddingly large body of writing includes dozens of articles about sound engineering, music, and the sociology of mass culture.[1] Following several years working at a variety of organs of the French government, including the state television broadcaster, Moles set out to extend the reach of information theory to our understanding of the arts. He received two grants from the Rockefeller Foundation to visit the United States in the mid-1950s, spending part of his time at MIT where he met the doyen of communications engineering, Claude Shannon.[2] Moles also visited the Department of Music at Columbia as a guest of Vladimir Ussachevsky; their meeting led to a paper advocating the sonogram as a musical representation greatly superior to "utterly inadequate" conventional notation.[3] Bernard Dionysus Geoghegan writes that the "Rockefeller Foundation saw [cybernetics and information theory] as intertwined aspects of a program for worldwide scientific reform based on the cultivation of expert-driven rational solutions to social and

[1] For a mid-1960s bibliography, see the first issue of BIT INTERNATIONAL, co-authored with Max Bense.

[2] Abraham Moles and Elisabeth Rohmer, "Autobiographie d'Abraham Moles: Le cursus scientifique d'Abraham Moles," 1996, https://www.infoamerica.org/documentos_pdf/moles_autobiografia.pdf, sec. 7.

[3] Abraham Moles and Vladimir Ussachevsky, "L'emploi du spectrographe acoustique et le problème de la partition en musique expérimentale," in *Annales des Télécommunications*, vol. 12 (Springer, 1957), 299–304.

political problems."[4] For Moles, the creation and perception of art was just such a problem.

In his *Théorie de l'information et perception esthétique* (1958), Moles endeavoured to demonstrate that information theory could and ought to be applied to "aesthetic perception". In his "Theory", Moles draws on his practical experience with audiovisual technology and his second (!) doctoral thesis to apply the practices of information theory in order, among other things: to better understand the distinctions between speech and music, to analyse multimedia phenomena such as theatre and ballet, and to posit a quantitative definition for originality based on Claude Shannon and Norbert Weiner's mathematical theory of communication.[5].

Why study Moles's information theory of music? The constellation of strategies that Jonathan Sterne dubbed "perceptual technics" instrumentalise—among other things—information theory, its language of redundancy and channel capacity, and cybernetics' claims to universality in order to characterise the listening subject as a kind of biological processor of auditory information.[6] This position is axiomatic to much psychology since the so-called "cognitive

[4]Bernard Dionysius Geoghegan, "From Information Theory to French Theory: Jakobson, Lévi-Strauss, and the Cybernetic Apparatus," *Critical Inquiry* 38, no. 1 (September 2011): 96–126, https://doi.org/10.1086/661645, 102; 102–104.

[5]cite moles thesis and revues

[6]Jonathan Sterne, *MP3: The Meaning of a Format*, Sign, Storage, Transmission (Durham: Duke University Press, 2012), p. 51–54.

revolution", which commits researchers to more-or-less strong analogies between the mind and a computational machine. As Brian Miller and others are uncovering, music psychology—and the vulgarisations thereof that eventually percolate into mainstream musicology, popular music criticism, and music information retrieval—has made ready use of this model.

{{In musicology, Abraham Moles features as an important figure in both M. J. Grant's review of the music journal *Die Reihe*, as well is in Jennifer Iverson's recent thesis that the discipline of information theory is one of a number of "hidden collaborators" that that fostered the mutual exchange of new musical ideas between the protagonists of the NWDR studios and the Darmstadt nexus.[7] Iverson has pointed out that Meyer-Eppler drew a similar distinction between the "'semantic' aspects of music" and its "emotional-aesthetic qualities" in the article "Statistic and psychologic problems of sound", which appeared in the pages of *Die Reihe*.[8] Meyer-Eppler's article, first prepared in either 1954 or 1955, also notably suggests that statistical methods might be useful not only for the composition of music but also for its analysis.[9].}}

[7] M. J. Grant, *Serial Music, Serial Aesthetics: Compositional Theory in Post-War Europe*, Music in the Twentieth Century (Cambridge: Cambridge University Press, 2001); Jennifer Iverson, *Electronic Inspirations: Technologies of the Cold War Musical Avant-Garde* (New York, NY: Oxford University Press, 2019).

[8] Iverson, XX.

[9] But Meyer-Eppler stops short of realizing this distinction using the apparatus of information theory - CHECK

{{More critically, Robin Maconie has blamed Milton Babbitt's rarified writing about music—sometimes pejoratively but nevertheless accurately described as "scientistic"—on Babbitt's commitment to the principles of "communication science", a term which Maconie understands to include a complex of techniques from electrical engineering, information theory, and even cryptography.[10] Moles earns a passing mention here, being credited by Maconie with the elaboration of an explicitly mathematical, multi-dimensional—that is, parametric—conception of the musical note we sometimes associated with the total-serial theory of Babbitt.[11] More recently, Brian Lennon has argued that the intellectual forebears of positivist literary criticism in the United States are a cadre of philologists whose textualist training recommended them to the attention of the state for use in codebreaking.[12] Provocatively implicating the security state in a process that is contiguous with the ascendance of the digital humanites, Lennon coined the term "cryptophilology" to refer to this text-as-data hermeneutics, which cleverly connotes both its purported home in the *chambres noirs* as well as alludes to the disputed or as-yet-unsubstantiated character of just such an approach to literature.}}

[10] Robin Maconie, "Care to Listen: Milton Babbitt and Information Science in the 1950s," *Tempo* 65, no. 258 (October 2011): 20–36, https://doi.org/10.1017/S0040298211000362.

[11] Maconie, 34.

[12] Brian Lennon, *Passwords: Philology, Security, Authentication* (Cambridge, MA: The Belknap Press of Harvard University Press, 2018).

> In the *Théorie*, Moles outlines a program of research for the information-theoretic study of a natural communication system. The chief concerns of this program are as follows:
>
> 1. Define a "situation of communication," that is, a channel and a level of observation adopted by the experimenter toward the pair: transmitter, receiver. This isa problem of situational psychology.
> 2. Find the nature and state the repertoire (sign-set) corresponding to this situation. This is a problem of behavioral psychology.
> 3. Through statistical study, find the probabilities of occurrence (expectancy) of each element of the repertoire.
> 4. Through experimental modification of the message, compute its redundancy and try to account for redundancy in terms of constraints upon the transmitter's freedom of choice.
> 5. Sum up these various rules constituting the code as the whole of the laws of assemblage known *a priori* to receiver and transmitter.[13]

Moles's agenda underscores the case that an information theory of human communication requires a

[13] Abraham Moles, *Information Theory and Esthetic Perception*, trans. Joel E. Cohen (Urbana, IL: University of Illinois Press, 1966), 55.

conspiracy of disciplines: situational psychology, behavioural psychology, and statistics. So far, so cybernetic.

Moles's text was published by the French publisher Flammarion in 1958. Around the same time, it was being translated into German by Hermann Scherchen; translations into Spanish, English, and Russian followed in the 1960s. An English translation by Joel E. Cohen was published in 1966 as *Information Theory and Esthetic Perception* by the University of Illnois Press.[14] Although this is the version of the text commonly cited in English-language histories of electronic and computer music,[15] Cohen's translation significantly differs from the original. In the Preface, he admits to rewriting and updating some of Moles's proofs, revising his bibliography, and even deleting sentences and paragraphs.[16] All this, it should be said, with Moles's blessing; it is probably best understood as a revised edition rather than a literal translation.

The reception of the English edition was mixed. Moles was accused of dilettantism and dilated prose, of drawing on outdated psychological research (particularly of psychoacoustics), of factual inconsistencies, and, worst of all, of a propensity for faddish jargon.[17] On the other hand, writing in *Leonardo*, Gordon

[14]Moles, Preface.
[15]See Holmes, Roads, Iverson for example
[16]Moles, Preface.
[17]David Kraehenbuehl, "Review of Abraham Moles,

Pask hailed Moles's book as "a pioneering work that is likely to become a classic in this field."[18] The Russian "mathematical biophysicist" N. Rashevsky was similarly praising, seeing parallels between Moles's lines of thinking and his own research into the neural mechanisms of visual perception.[19]

Though he composed little or no music himself, Moles was welcomed into experimental music circles of the late 1950s as the chief Francophone exponent of information theory. Lejaren Hiller, for instance, was enthusiastic about Moles's ideas, first meeting him in Paris in 1957 and sustaining correspondence with him through the early 1960s.[20] By the time Cohen's English translation was published, however, interest in apply-

<It>Information Theory and Esthetic Perception</It>," *Journal of Music Theory* 11, no. 1 (Spring 1967): 149–51; Arthur B. Wenk, "Review of Information Theory and Esthetic Perception, by Abrahm Moles, Trans. Joel E. Cohen," *Notes* 25, no. 2 (December 1968): 249–50. For a particularly devastating though lightly researched take-down by a fellow Harvard man, see Wilson Lyman Keats, "Review of Abraham Moles's <It>Information Theory and Esthetic Perception</It>, Trans. Joel E. Cohen," *The Harvard Crimson*, March 18, 1966.

[18]Gordon Pask, "Review of *Information Theory and Aesthetic Perception* by Abraham Moles," *Leonard* 1, no. 2 (April 1968): 205–6, https://muse.jhu.edu/article/596566/pdf, 205.

[19]N Rashevsky, "Review of *Information Theory and Esthetic Perception*. By Abraham Moles and Joel C. Cohen," *The Quarterly Review of Biology* 42, no. 3 (September 1967): 463–64

[20]Lejaren Hiller and Leonard Isaacson, *Experimental Music: Composition with an Electronic Computer* (New York: McGraw-Hill, 1959), p. 29; Lejaren Hiller, "A Report on Contemporary Music," Technical Report (Urbana, IL: Experimental Music Studio, 1962), https://monoskop.org/File:Hiller_Lejaren_A_Report_on_Contemporary_Music_1961.pdf, 75–76. According to Cohen, Hiller was instrumental in arranging for the publication of his English translation by Illinois University Press.

ing information theory to music was experiencing one of its characteristic temporary nadirs. Robin Maconie avers that "by 1968 official interest in the role of music in information theory and speech recognition research had all but faded away, trailing a small collection of speech-related compositions it its wake."[21]

{{During the last years of the 1950s, Moles's work came to be viewed as a core text in the inchoate area of European "information aesthetics," the short-lived movement in art production and art criticism which sought to adopt information as an empirical and objective measure of artistic content as well as a criterion for its creation.[22] Reflecting on his pioneering career, the influential digital visual artist Frieder Nake identified Abraham Moles along with Max Bense as one of the two main exponents of information aesthetics during the late 1950s.[23]}}

In the "Théorie", Moles uses the results of psychophysical experiments to model the human ear as the receiving apparatus of a natural communications system. To ensure the flow of information from sender

[21]Maconie, "CARE TO LISTEN.". See also Elizabeth Hellmuth Margulis and Andrew P. Beatty, "Musical Style, Psychoaesthetics, and Prospects for Entropy as an Analytic Tool," *Computer Music Journal* 32, no. 4 (November 19, 2008): 64–78, https://doi.org/10.1162/comj.2008.32.4.64.

[22]For an overview of information aesthetics in the context of the New Tendencies movement, see Armin Medosch, *New Tendencies: Art at the Threshold of the Information Revolution (1961–1978)*, Leonardo Book Series (Cambridge, MA: The MIT Press, 2016), 82–87.

[23]Frieder Nake, "Information Aesthetics: An Heroic Experiment," *Journal of Mathematics and the Arts* 6, nos. 2 – 3 (June 2012): 65–75, https://doi.org/10.1080/17513472.2012.679458.

> to receiver, the receiver must be able to discriminate between individual symbols. In artificial communication systems, this is controlled by the careful electrical engineering of the detector. The alphabet of possible symbols used by the communications system, what Moles calls its "répertoire", is determined in advance by the system's designer. A binary receiver, for example, must be designed to distinguish between at least two discrete electrical states or voltage thresholds (high and low, closed and open, zero and one) against a background of line noise.
>
> When the human ear takes in sound from its immediate surroundings in a natural communications system, its sensitivity thresholds are constrained by psychophysiological features of the body. Since the late 19th century, empirical studies of hearing have determined that physiology limits the ear's ability to discriminate pitch; ultrasonics were an obvious case.[24] The pitch sense was deemed educable—but not infinitely so.[25] Classical studies in psychophysics determined how pitch and loudness interact, showing that the

[24] See the review of research in H. Fletcher and R. L. Wegel, "The Frequency–Sensitivity of Normal Ears," *Physical Review* 19, no. 6 (June 1, 1922): 553–65, https://doi.org/10.1103/PhysRev.19.553. For a discussion of research with ultrasonics in particular, David Trippett, "Music and the Transhuman Ear: Ultrasonics, Material Bodies, and the Limits of Sensation," *The Musical Quarterly* 100, no. 2 (April 1, 2018): 199–261, https://doi.org/10.1093/musqtl/gdy001, p. 202–208.

[25] For a discussion of this in the context of the Seebeck–Ohm debate, see Benjamin Steege, *Helmholtz and the Modern Listener* (Cambridge; New York: Cambridge University Press, 2012), p. 51–53.

ability to discriminate pitch varies as a function of a sound's intensity or loudness.[26]

Experiments with timing apparatus during the mid-19th century showed that perception was not a durationless, instantaneous process.[27] Moles repeatedly reprises Hénri Bergson's formulation of the "thickness of the present" to refer to the smallest perceptible unit of duration, a psychological brute fact that quantises the third and final dimension of Moles's model of sound: time.[28] This body of psychological literature furnished Moles with just-noticeable-difference data for the ear-as-receiver: the minimum amounts two stimuli must vary in one or more parameters before they can be reliably distinguished by the average listener.

Taken together, these just-noticeable-difference measures effectively partition a multidimensional field of all possible sounds into a gridded repository of potentially discriminable sound structures: each sound embedded in a manifold of pitch, time, and duration. Moles describes an ear that quantises the incoming stream of pressure fluctuations into individual packets, whose minimum extent is determined in advance by the competencies of the human ear. This

[26] R. R. Riesz, "Differential Intensity Sensitivity of the Ear for Pure Tones," *Physical Review* 31, no. 5 (May 1, 1928): 867–75, https://doi.org/10.1103/PhysRev.31.867

[27] Benjamin Steege, "Janáček's Chronoscope," *Journal of the American Musicological Society* 64, no. 3 (December 1, 2011): 647–87, https://doi.org/10.1525/jams.2011.64.3.647

[28] Abraham Moles, *Théorie de l'information et perception esthétique* (1958; repr., Denoël, Gonthier, 1972), http://books.google.com?id=hxYvAAAAYAAJ, p. 80

> discrete "repertoire" of musical sounds, the set of sounds that may be discriminated from each other by the human ear as messages, is a critical prerequisite for performing the statistical analysis that leads to estimations of the information content in heard musical sounds. {{Moles is not repsonsible for the first "telegraphic" theory of listening—this was, for instance, Helmholtz's favored metaphor for the transmission of neural signals throughout the body—-but he may be responsible, by dint of the quantizing ear that he posits, and his recourse to the discourse of communications theory to characterize it, the first telealphabetic one.[29]}}

Curtis Roads points out that this quantum view on sound influenced Xenakis's conception of statistical form, the principles of granular synthesis, and, ultimately, the late-twentieth century interest in "microsound."[30] As Roads notes, this view on sound was first articulated by the physicist Denis Gabor, who in 1945 developed a mathematical alternative to the Fourier transform that had been directly inspired by recent developments in quantum physics.[31] In a slightly later work, Gabor summarized his speculations about a theory of auditory perception that was suggested to him by the structure of his new mathematical tool.[32]

[29]This could probably be said of Gabor.Steege, Lenoir

[30]Curtis Roads, *Microsound* (Cambridge, MA: MIT Press, 2001)

[31]D. Gabor, "Theory of Communication," *Journal of the Institue of Electrical Engineers* 93/III, no. 26 (1946): 429–57.

[32]D. Gabor, "Acoustical Quanta and the Theory of Hearing," *Na-*

Moles does not cite this research, suggesting instead that Gabor's approach to quantising sound may have been known to Moles indirectly, through Werner Meyer-Eppler, an avid reader of Gabor whom Moles does cite extensively. Whatever the original source of this idea may have been, Moles went beyond Gabor and Meyer-Eppler's analyses by turning explicitly to aesthetics, in an attempt to theorise the apparent surplus information in a vocal or musical utterance in excess of its semantic or sensical content.

Perhaps the most distinctive contribution of Moles's book to information theory literature is his effort to distinguish between two "kinds" of information, what he calls semantic information and aesthetic information. This seems a bold challenge to orthodox information theory, at least as it can be represented by its American progenitors.

Claude Shannon notoriously wrote that although the messages in a communications system have "*meaning*; that is they refer to or are correlated to some system with certain physical or conceptual entities," applying communications theory with a view to modelling meaning was dead on arrival since, in Shannon's words, "these semantic aspects of communication are irrelevant to the engineering problem".[33]

ture 159, no. 4044 (May 1947): 591–94, https://doi.org/10.1038/159591a0.

[33]Claude E. Shannon and Warren Weaver, *The Mathematical Theory of Communication* (Urbana, IL: University of Illinois Press, 1949), 31.

> Moles observes that so far his theory only accounts for linear sequences of stimuli at a single level of complexity, for example: as a sequence of letters or notes drawn from a probabilistic bag. He notes that, in reality, every communication decomposes into several superimposed messages, each at a different level of coherence or complexity. His motivating example considers the marks of ink on a page of newsprint: as read by a child, the basic informational units of the page group in one way, perhaps erring where words are not recognised by memory; as read by the typesetter, the sense data is grouped a different way, perhaps according to the runs of type used in compositing the page. "Each level," writes Moles, "has its own signs, its code, its repertoire, hence its rate of information per sign, and its redundancy."[34]
>
> Recognising the hierarchical nature of information processing, Moles argues, eventually sheds light on why we like to reread novels, memorise poetry, or revisit works of art even though we have already "exhausted" (Moles's word) their content. Human individuals in this case, he reasons, are not looking to extract "logical information in the message"; rather, they seek "an *esthetic originality* which transcends the collection of symbols in order to create an effect."[35] Because every communications process is hierarchical, Moles concludes that these apparently distinct categories of information are really alterna-

[34]Moles, *Information Theory and Esthetic Perception*, p. 125
[35]Moles, p. 128

> tive groupings of the same stream of basic acoustical quanta. Thus, what appears to be a categorical difference between "semantic" and "aesthetic" information is explained away as a difference of "viewpoint", simply two different (and complementary) levels of analysis of a communications system.
>
> In this way, Moles's theory complies with the assumptions of mainline information theory, which was ambivalent—if not outright hostile—towards extensions of the theory beyond communications engineering that did not retain the theory's original ontological parsimony. Though Moles would occasionally refer to "aesthetic information", and "semantic information", at base there was to be but one "kind" of information; these tags were useful shorthand for particular perspectives or viewpoints on the same stream of basic sonic symbols.
>
> Moles's schema of the differences between these two levels is straightforward: semantic information has "a universal logic", is "structured, articulable, translatable into a foreign language" and serves "to prepare actions" or decisions.[36] The semantic information of a recorded spoken sentence is the meaning of that sentence: its *sense*. This is why Moles claims "semantic information" is "translatable"; it is that element of an utterance that remains invariant when transposed to another cognate system of representation. On the other hand, "*esthetic* information,

[36] Moles, p. 129

which is untranslatable refers to the repertoire of knowledge common to the particular transmitter and particular receptor."[37] To take up the example of speech again, for Moles "esthetic" information would be carried by their particular vocal timbre or in minimal variations of their intonation; essentially, all that is excess to understanding the sense of the speaker's utterance.

How, then to separate these two viewpoints? As Moles wrote, "the difference between semantic and aesthetic information, no matter how justifiable logically, has no interest if it is not operationally based, that is, if it cannot be tested experimentally."[38] It is Moles's experiments with recorded sound that attest to the pragmatism of his investigation. Though dependent on the theory of perception, his conclusions about these two viewpoints on musical information were inspired by the manipulation of sound recordings in the studio.

A thematic discography included as an appendix to the original Flammarion edition of Moles's work was excluded from Cohen's English edition. This document plays an essential part in understanding the rhetoric of Moles's text. The discography reminds us that Moles's research program was at base a practical one: it mobilised recordings and the latest studio technology to assert new knowledge about hearing under the broadly cybernetic framework he articulates throughout

[37] Moles, p. 129.
[38] Moles, p. 136

the text.

Moles's experience with recorded musical sounds includes his collaboration with Pierre Schaeffer on an early incarnation of an explicit theory of Schaeffer's *objet sonore*. Moles had been hired by Schaeffer to work at the *Club d'Essai* during the summer of 1951. The final chapter of Schaeffer's *A la recherche d'une musique concrète* (1952) is titled "Equisse d'un solfège concret, en collaboration avec [Abraham] André Molès [*sic*]."[39] In it, Moles develops the notion of the "trihedron of reference", articulating the same multidimensional conception of the basic note, the same quantising ear at the core of his information aesthetics.[40].

{{ Drawing on these particular connections and experiences, and being evidently more familiar with the physiological and psychological features of the ear than with those of the visual or motor systems, Moles repeatedly returns to musical examples in his text. Moles was hardly the first writer to attempt a quantitative and general aesthetics of various forms of art. Moles's forebears in quantitative approaches to aesthetics include the mathematician George Birkhoff (1884–1944) and, before him, the experimental psychologist and psychophysics pioneer Gustav Fechner (1801–

[39]See Thom Holmes, *Electronic and Experimental Music: Technology, Music, and Culture*, Fifth edition (New York, NY ; Abingdon, Oxon: Routledge, 2015), 48–52.

[40]Pierre Schaeffer, Christine North, and John Dack, *In Search of a Concrete Music*, California Studies in 20th-Century Music 15 (Berkeley: University of California Press, 2012), 211

1887).[41] Needless to say, Birkhoff and Fechner were working without the information-theory framework that Moles embraces.[42] His effort can be distinguished from earlier work by both its mathematical specificity (in that it invokes and demonstrates the use of quantiative articulations of Shannon's information repeatedly) and its dependence on music, both notated and sounded. Interestingly, Moles considered musical messages "the epitome of temporal esthetic messages", and his text depends on examples involving music, despite its pretentions to generality.[43] For Moles, the listener hearing a live or recorded performance of art music stands as a paradigm case for the analysis of human esthetic perception more generally.}}

In 1956, Moles published a German summary of his book in the *Gravesano Review*, the periodical publication of Hermann Scherchen's Swiss electronic music studio.[44] This article was accompanied by a recording from Moles's experiments with filters; some with speech and

[41]Fechner's outline of an experimental aesthetics is can be found in Gustav Theodor Fechner, *Vorschule der Aesthetik*, Second edition (1897; repr., Cambridge: Cambridge University Press, 2013). See also, Alexandra Hui, *The Psychophysical Ear: Musical Experiments, Experimental Sounds, 1840–1910*, Transformations: Studies in the History of Science and Technology (Cambridge, MA: MIT Press, 2013), chap. 1.

[42]Like Moles, however, Birkhoff did treat music at some length in George Birkhoff, *Aesthetic Measure* (Cambridge, MA: Harvard University Press, 1933), chapters 5–7

[43]Moles, *Théorie de l'information et perception esthétique*, 107. My translation.

[44]André Moles, "Informationstheorie Und äesthetische Empfindung," *Gravesaner Blätter* 6 (December 1956): 3–9

others with music.[45] Moles used control recordings of speech and music and passed them through the Albis *Terzfilter*, a fixed-bandwidth parametric equaliser, to filter out various audible frequency bands. Here, a male and a female speaker read the first strophe of an Eichendorff poem. Moles included diagrams of the filter configurations, shown here as we listen to a short selection from the processed recordings.

[PLAY]

Moles argues that testing the intelligibility of filtered speech can help estimate the proportions of semantic and aesthetic information in a given recording. The progressive distortion of visual and aural stimuli was a well-established procedure for estimating the redundancy in a given signal, though psychological research to that point emphasised the intelligibility of recorded speech or functional radio transmissions, and not art.[46] {{Moles assumes that when the intelligibility of speech—reported by experimental subjects—is preserved, so must the semantic information. Assuming this, Moles concludes that particular configurations of the bandpass filters point to the regions of the spectrum responsible for bearing the majority of this information.}}

In this connection, Moles was particularly interested in two techniques for distorting recordings: dynamic

[45] Thanks to Kees Tazelaar for posting these here: http://keestazelaar.com/gravesaner-blatter/. Also see the AdK for the printed journals: https://archiv.adk.de/bigobjekt/44596.

[46] George Miller, **??**

range compression (which Cohen translates as "infinite clipping") and reverse playback. These techniques seemed to offer a way to leverage human-subject experiments to disentangle semantic and aesthetic content in recorded music.

Briefly, Moles argued that extreme {{dynamic range}} compression eradicates aesthetic information from musical recordings; the semantic information is preserved chiefly in the durational patternings of the musical events. Think of the opening movement of Beethoven's Fifth Symphony, reduced to a sequence of pips. Would you recognise it as such? Based on the results of similar experiments, Moles believed most trained listeners would. This proved to him that even durational patterning bore enough of a fingerprint of a work's identity that it may be recognised, a criteria he (tactically) conflated with that work's semantic content.

Reverse playback, on the other hand, preserves the overall timbral features of a recorded musical work, while completely distorting its temporal progression. Moles claimed that reverse playback stripped music of semantic information that captured music's progression in time, its moment-to-moment syntax. He even boldly claims "temporal inversion reveals the cultural and social aspect of musical structures."[47] Describing experiments where listeners presumed to be unfamiliar with non-Western music were played "exotic" music,

[47] Moles, *Information Theory and Esthetic Perception*, p. 146.

> "from beyond the Moslem frontier", he reports that no clear aesthetic preference between the straight-ahead and inverted recordings was noted by participants.[48] From this, Moles reasons that listeners naive to the structures of a musical tradition appreciate musical material "directly on the esthetic level."[49]
>
> Moles liked to think of these two studio techniques as a set of "information filters", adding them to the arsenal of laboratory techniques for a new field of investigation he dubbed "experimental esthetics". Moles was especially keen to note that these procedures were already in use by experimental musicians, a fact he knew well from his contacts at Gravesano, as well as from his brief alliance with Schaeffer.[50].
>
> Careful as Moles was to emphasise processual thinking in his account of the sound object, Schaeffer never-

[48] Moles, 147.

[49] Moles, p. 147.

[50] Moles also describes the results of a series tone-masking experiments,following the work of JCR Licklider, Pollack, and Meyer-Eppler in which pitched "pips" are intermittently laid over speech and music. These experiments give insight into second-order psychoacoustic phenomena such as masking, meaning that though certain combinations of elementary sounds are physically possible, and individually theoretically distinct, the ear cannot easily discriminate between them; hence, such a combination of sound elements would collapse into the same symbol from the communications standpoint. And, in yet another experiment reported in 1957, Moles argued that taping and playback of a recording of human speech into to an acoustic space–à la Alvin Lucier–showed how the semantic and esthetic aspects of the information in human speech might be separated by the method of iterated reproduction. Abraham Moles, "Sur L'emploi de La Méthode d'itération En Acoustique Des Salles," *Cahiers d'Acoustique* 87 (1957): 443–44, https://link-springer-com.ezproxy.cul.columbia.edu/content/pdf/10.1007%2FBF03016007.pdf

theless disavowed what he called Moles's "simplistic model" in his later *Treatise on Musical Objects*.[51] Despite this, Moles's pluralistic approach accommodated a Schaeffer-adjacent phenomenological angle that he himself makes explicit in the *Théorie*. Moles asserts the status of information theory as an "inspiration" that serves to defamiliarize the apparently natural act of communication.

Moles glosses his inversion and reverse-playback experiments with tape accordingly, extolling the virtues of reverse playback in particular: "shattering the normal view of the temporal object, [reverse playback] aims to recover an intrinsic appreciation forbidden to us by our mental habits."[52] "[T]he theory [of information] appears as a huge *Gedanken* experiment," continues Moles, "attempting to re-create the strangeness of communication by making evident its material aspect. It was specifically this point of view which led us to the concept of sonic objects."[53] Listeners whose epistemologies of sound remain yoked to symbolic representational schemes of music are to be delivered a shock to wrest them from the specious conflation of music as notated with music as sounded. Moles viewed score-bound music theory a moribund enterprise, "retarded by dogmatism", that could only be revived by helping it-

[51] Pierre Schaeffer, Christine North, and John Dack, *Treatise on Musical Objects: Essays Across Disciplines*, California Studies in 20th-Century Music 20 (Oakland, California: University of California Press, 2017), p. 38–39. See also Brian Kane, "The Fluctuating Sound Object".

[52] Moles, *Information Theory and Esthetic Perception*, 147.

[53] Moles, 208.

self to the fantasies of modelling and prediction for which cybernetics is justifiably renowned.[54]

{{As Moles confidently asserts in the opening pages of the text:

> Notions of *information*, *code*, *repetition*, the *banal/original dialectic*, *foreseeability*, *Background Noise*, must take their place alongside quantum theory, the principles of relativity and uncertainty, and those of the opposition between the microscopic universe and the macroscopic universe.}}

Whether the unfortunate patient was successfully reanimated by Moles's infusion of cybernetic thinking is a matter of continuing debate. In my view, however, the prognosis was ever bleak.

[54]Moles, p. 5. See also Orit Halpern, "Dreams for Our Perceptual Present: Temporality, Storage, and Interactivity in Cybernetics," *Configurations* 13 (2005): 285–321.

Works cited

Birkhoff, George. *Aesthetic Measure*. Cambridge, MA: Harvard University Press, 1933.

Fechner, Gustav Theodor. *Vorschule der Aesthetik*. Second edition. 1897. Reprint, Cambridge: Cambridge University Press, 2013.

Fletcher, H., and R. L. Wegel. "The Frequency–Sensitivity of Normal Ears." *Physical Review* 19, no. 6 (June 1, 1922): 553–65. https://doi.org/10.1103/PhysRev.19.553.

Gabor, D. "Acoustical Quanta and the Theory of Hearing." *Nature* 159, no. 4044 (May 1947): 591–94. https://doi.org/10.1038/159591a0.

———. "Theory of Communication." *Journal of the Institue of Electrical Engineers* 93/III, no. 26 (1946): 429–57.

Geoghegan, Bernard Dionysius. "From Information Theory to French Theory: Jakobson, Lévi-Strauss, and the Cybernetic Apparatus." *Critical Inquiry* 38, no. 1 (September 2011): 96–126. https://doi.org/10.1086/661645.

Grant, M. J. *Serial Music, Serial Aesthetics: Compositional Theory in Post-War Europe*. Music in the Twentieth Century. Cambridge: Cambridge University Press, 2001.

Halpern, Orit. "Dreams for Our Perceptual Present: Temporality, Storage, and Interactivity in Cybernetics." *Configurations* 13 (2005): 285–321.

Hiller, Lejaren. "A Report on Contemporary Music." Technical Report. Urbana, IL: Experimental Music Studio, 1962. https://monoskop.org/File:Hiller_Lejaren_A_Report_on_Contemporary_Music_1961.pdf.

Hiller, Lejaren, and Leonard Isaacson. *Experimental Music: Composition with an Electronic Computer*. New York: McGraw-Hill, 1959.

Holmes, Thom. *Electronic and Experimental Music: Technology, Music, and Culture*. Fifth edition. New York, NY ; Abingdon, Oxon: Routledge, 2015.

Hui, Alexandra. *The Psychophysical Ear: Musical Experiments, Experimental Sounds, 1840–1910*. Transformations: Studies in the History of Science and Technology. Cambridge, MA: MIT Press, 2013.

Iverson, Jennifer. *Electronic Inspirations: Technologies of the Cold War Musical Avant-Garde*. New York, NY: Oxford University Press, 2019.

Keats, Wilson Lyman. "Review of Abraham Moles's <It>Information Theory and Esthetic Perception</It>, Trans. Joel E. Cohen." *The Harvard Crimson*, March 18, 1966.

Kraehenbuehl, David. "Review of Abraham Moles, <It>Information Theory and Esthetic Perception</It>." *Journal of Music Theory* 11, no. 1 (Spring 1967): 149–51.

Lennon, Brian. *Passwords: Philology, Security, Authentication*. Cambridge, MA: The Belknap Press of Harvard University Press, 2018.

Maconie, Robin. "Care to Listen: Milton Babbitt and Information Science in the 1950s." *Tempo* 65, no. 258 (October 2011): 20–36. https://doi.org/10.1017/S0040298211000362.

Margulis, Elizabeth Hellmuth, and Andrew P. Beatty. "Musical Style, Psychoaesthetics, and Prospects for Entropy as an Analytic Tool." *Computer Music Journal* 32, no. 4 (November 19, 2008): 64–78. https://doi.org/10.1162/comj.2008.32.4.64.

Medosch, Armin. *New Tendencies: Art at the Threshold of the Information Revolution (1961–1978)*. Leonardo Book Series. Cambridge, MA: The MIT Press, 2016.

Moles, Abraham. *Information Theory and Esthetic Perception*. Translated by Joel E. Cohen. Urbana, IL: University of Illinois Press, 1966.

———. "Sur L'emploi de La Méthode d'itération En Acoustique Des Salles." *Cahiers d'Acoustique* 87 (1957): 443–44. https://link-springer-com.ezproxy.cul.columbia.edu/content/pdf/10.1007%2FBF03016007.pdf.

———. *Théorie de l'information et perception esthétique*. 1958. Reprint, Denoël, Gonthier, 1972. http://books.google.com?id=hxYvAAAAYAAJ.

Moles, Abraham, and Elisabeth Rohmer. "Autobiographie d'Abraham Moles: Le cursus scientifique d'Abraham Moles," 1996. https://www.infoamerica.org/documentos_pdf/moles_autobiografia.pdf.

Moles, Abraham, and Vladimir Ussachevsky. "L'emploi du spectrographe acoustique et le problème de la partition en musique expérimentale." In *Annales des Télécommunications*, 12:299–304. Springer, 1957.

Moles, André. "Informationstheorie Und äesthetische Empfindung." *Gravesaner Blätter* 6 (December 1956): 3–9.

Nake, Frieder. "Information Aesthetics: An Heroic Experiment." *Journal of Mathematics and the Arts* 6, nos. 2 – 3 (June 2012): 65–75. https://doi.org/10.1080/17513472.2012.679458.

Pask, Gordon. "Review of *Information Theory and Aesthetic Perception* by Abraham Moles." *Leonard* 1, no. 2 (April 1968): 205–6. https://muse.jhu.edu/article/596566/pdf.

Rashevsky, N. "Review of *Information Theory and Es-*

thetic Perception. By Abraham Moles and Joel C. Cohen." *The Quarterly Review of Biology* 42, no. 3 (September 1967): 463–64.

Riesz, R. R. "Differential Intensity Sensitivity of the Ear for Pure Tones." *Physical Review* 31, no. 5 (May 1, 1928): 867–75. https://doi.org/10.1103/PhysRev.31.867.

Roads, Curtis. *Microsound*. Cambridge, MA: MIT Press, 2001.

Schaeffer, Pierre, Christine North, and John Dack. *In Search of a Concrete Music*. California Studies in 20th-Century Music 15. Berkeley: University of California Press, 2012.

———. *Treatise on Musical Objects: Essays Across Disciplines*. California Studies in 20th-Century Music 20. Oakland, California: University of California Press, 2017.

Shannon, Claude E., and Warren Weaver. *The Mathematical Theory of Communication*. Urbana, IL: University of Illinois Press, 1949.

Steege, Benjamin. *Helmholtz and the Modern Listener*. Cambridge; New York: Cambridge University Press, 2012.

———. "Janáček's Chronoscope." *Journal of the American Musicological Society* 64, no. 3 (December 1, 2011): 647–87. https://doi.org/10.1525/jams.2011.64.3.647.

Sterne, Jonathan. *MP3: The Meaning of a Format*. Sign, Storage, Transmission. Durham: Duke University Press, 2012.

Trippett, David. "Music and the Transhuman Ear: Ultrasonics, Material Bodies, and the Limits of Sensation." *The Musical Quarterly* 100, no. 2 (April 1, 2018): 199–261. https://doi.org/10.1093/musqtl/gdy

001.

Wenk, Arthur B. “Review of Information Theory and Esthetic Perception, by Abrahm Moles, Trans. Joel E. Cohen.” *Notes* 25, no. 2 (December 1968): 249–50.