Meta-Xenakis

New Perspectives on Iannis Xenakis's Life, Work, and Legacies

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Cover image: Iannis Xenakis at the C.R. MacIntosh Museum, Glasgow, Scotland, 1987. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

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10. Jean-Étienne Marie and Iannis Xenakis: The Vision of an Artistic Engineer and a Theorist of Microtonal Music

Judith Romero Porras

Jean-Étienne Marie and Sound Installations

Born in the north of France, Jean-Étienne Marie (1917–89) moved to Paris to study at the National Conservatory of Music with Olivier Messiaen (1908–92). In 1947, he founded *Le Cercle Culturel du Conservatoire de Paris* to promote the music of living composers of that time. Beginning in 1949 he worked as an artistic engineer at the Radio Télévision Française.[1] A critical moment in his development was his 1950 meeting with the Mexican composer Julián Carrillo (1875–1965) whose microtonal theory "Sound 13" helped Marie understand the evolution of European music.[2] After having analyzed and carried out a comparative study of the microtonalists Ivan Wyschnegradsky (1893–1979), Alois Hába (1893–1973), and Carrillo, Marie concluded that microtonality was the transition from acoustic instruments to electronics. That is why Marie considered microtonality the common axis of acoustic instruments (the past) and electronics (the future).

After the death of Carrillo in 1965, Marie carried out a first cultural mission in Mexico in 1966. His goal was to restore the microtonal pianos of Carillo and give lectures about his research. He wanted to share Carrillo's music as well as the European avant-garde with the young composers of that time. Specifically, Marie's intention was to make known the importance of microtonal theory in western musical evolution.

1 For a brief biography, cf. "Biographie de Jean-Etienne Marie" (22 May 2018), *CIRM: Centre National de Création Musicale*, https://www.cirm-manca.org/fiche-artiste.php?ar=29

2 Cf. Armando Nava Loya, "Julián Carrillo and the Sound 13" (January 2010), *Sonido13*, https://sonido13.com

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Due to doctoral research later conducted on Marie's life as well as the influence of his teaching on Mexican composers at the end of the 1960s, we are able to understand Marie's knowledge of the post-war European avant-garde. His work as an artistic engineer allowed him to know Iannis Xenakis and Xenakis's music from two different perspectives: from the perspective of sound realization, that is to say, the practical questions of sonorization with respect to *Bohor* (1962), and from the perspective of his micro-intervallic theory contained in *Oresteïa* (1965–6).

Regarding the first perspective, Marie's work as an artistic engineer consisted in solving the problems of music retransmission as it differed from live listening. The music critic, Claude Rostand (1912–70), defines Marie's work as that of someone "who makes sound recording, creating the necessary balance for a good broadcast of a concert. But he is also a musician, who has a musical, scientific, historical and musicological culture."[3]

Thanks to this experience acquired in the radio, Marie began to participate in the sound realization of electroacoustic works from the 1950s. He specialized in sound recordings and their projection through a fundamental pairing: the microphone and the loudspeaker.

As for the second perspective, Marie's interest in microtonal music came from his relationship with Julián Carrillo and his "Sound 13" Theory. Marie alludes to Xenakis and the generalization of the notion of temperament, called "crible," which could be translated into English as "sieve." He compares Xenakis's theoretical process to that of Hába, which results in a certain practice of micro-intervals.

Marie's experience in the field of sound installations dates back to 1952, when he organized two concerts of concrete music at the National Conservatory of Music in Paris, using three recorders linked to three independent circuits. The effect produced was "a spatial relief either preset or instantly calibrated by means of a device, which allowed a sound motion of extreme freedom."[4]

These technological devices gave music a previously unsuspected spatiality. In the *Revue Musicale* of 1968, Marie recounted these first electroacoustic experiences:

> From a single speaker and with two microphones, one close to the sound source, another capturing the reverberations, moving away from the sound source or moving to an echo chamber, effects or spatial structures can be obtained in terms of depth as a continuum of more or less fast *travellings*; discontinuous static planes (comparable to American planes), originating a very elaborate spatial language.[5]

3 Rostand, 1967 [*Les fonctions de musicien-metteur en ondes* […] *désigne le preneur de son qui créé l'équilibre nécessaire à la bonne diffusion du concert mais qui est aussi un musicien, c'est-à-dire, un homme qui a une culture musicale, scientifique, historique, musicologique, etc.*]. All translations are my own, unless otherwise specified. Transcription of fragments of the interview and presentation of the piece *Hommage à Julián Carrillo* by Jean-Étienne Marie.

4 Marie, 1968, p. 129 [*un relief spatial soit préétabli, soit réglé dans l'instant par un dispositif permettant une cinématique du son d'une extrême liberté*].

5 Ibid., p. 130 [*A partir d'un seul haut-parleur et en jouant à l'enregistrement avec un micro de proximité et un micro captant des sons réverbérés, soit par éloignement, soit par passage dans une chambre d'écho, on peut*

Following in this same order of ideas, Marie emphasizes:

> From 3 or 4 speakers placed in a concert hall, we can foresee displacements of sounds, either continuous (thanks to a potentiometer passing the sound of one of the tracks over another), or discontinuous: another possibility of effects or structures. The combination of possibilities on the plane of the cardinal points and the zenith, and those that tend to the depth, offer the composer a true celestial dome [...]. We would be surprised how rudimentary [...] these experiences from 20 years ago are.[6]

In 1954, Marie participated in the sound realization of *Déserts* (1950–4), by Edgard Varèse (1883–1965) at the Théâtre des Champs-Elysées in Paris, where he used four speakers, forming a vertical sound wall from a single track. Varèse himself wrote to Marie several years later, in November 1963, when the work was performed, to give him a more precise idea of *Déserts*: "Please, note that the instrumental parts represent the human side, and the electronic interpolations should suggest the naked, impersonal, inflexible desert... dialogue between human and nature. The speakers must offer the maximum voltage and dynamic level."[7] Marie's idea was to put the orchestra at the center, the audience around, and the last circle would be made up of the loudspeakers.

Marie himself, as a composer, knew the challenges of realization involved in contemporary music. In 1958, during the Paris Music Weeks based in UNESCO, he carried out a concert dedicated to micro-intervals (inherited from Carrillo), electronic music, audiovisual, and concrete music. He premiered his work *Polygraphie Polyphonie* for violin in quartertones (live music), tape (concrete music) and visual rhythms projected on a wall.[8]

In 1961, he premiered *Images Thanaïques*. For this work, the orchestra is divided into three sectors: a two-track tape of five so-called sound domes, music in semitones played by the orchestra, and a tape of concrete music with sounds in thirds, fifths, and fifteenths of a tone, of instrumental origin making the link between the orchestra and the concrete music.

In 1967, Marie premiered *Tombeau de Julián Carrillo*,[9] in honor of the Mexican

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obtenir des effets, ou des structures spatiales dans le sens de la profondeur : continu de travellings plus ou moins accusés et plus ou moins rapides, discontinu de plans statiques (*comparables aux gros-plans, plans-américains...*) *permettent un langage spatial déjà très élaboré*].

6 Ibid. [*A partir de 3 ou 4 haut-parleurs répartis dans une salle de concert, pour un même objet sonore situé dans le même plan de présence dans l'axe de la profondeur, on peut prévoir des déplacements de sons soit continus* (*par un jeu de potentiomètres faisant passer le son d'une des pistes sur une autre*) *soit discontinus : autre possibilité d'effets ou de structures. La combinaison des possibilités sur le plan des points cardinaux et du zénith et de celles qui ont trait à la profondeur offrent au compositeur une véritable voûte céleste* [...]. *On est surpris de voir combien rudimentaires,* [...] *restent toutes les expériences qui ont vu jour au cours de ces 20 dernières années*].

7 Ibid. [*Notez, je vous prie, que les parties instrumentales représentent le côté humain et les interpolations électroniques doivent suggérer le désert nu, impersonnel, inflexible... dialogue entre l'humain et la nature. Les haut-parleurs doivent offrir le maximum de tension et niveau dynamique*].

8 The recording of this work, as well as most of Marie's repertoire, is available at the INAthèque of the National Library of France in Paris.

9 Recording available on the CD *Musiques en tiers et en seizièmes de ton*, Société Nouvelle d'Enregistrement, Quebec, 2009.

composer, for two pianos, one in semitones and the other in thirds of a tone on stage, played along with a recording on which fifths and sixths of a tone had been previously played. The recording was made in Mexico with Carrillo's "metamorphosing" pianos.[10]

In the 1960s, Marie even collaborated with Karlheinz Stockhausen (1928–2007) at the Royan festival for the sound realization of the works *Mixtur* (1964) and *Hymnen* (1966–7). In *Prozession* (1967), Stockhausen uses:

> A piano, a viola with contact microphone, a tam tam [...] amplified by a microphone, and a trautonium[11] connected by a Hohner provided with an echo chamber. The composer can manipulate on his console, by means of filters, the sound effects of the viola and tam tam. This random work was experienced in Royan as an ephemeral performance of great beauty.[12]

In 1967, Marie participated as a musical engineer in the concert of the Ensemble Instrumental de Musique Contemporaine of Paris held in Bordeaux, France. In this concert, works performed included *Volumes* (1960) by François-Bernard Mâche (b. 1935), *Atlas Eclipticalis* (1961–2) by John Cage (1912–92), and *Oresteia* (*1966*) by Xenakis. In this regard, Marie comments that "some fragments need the amplification of metallic sonorities. Thus, Xenakis would have wanted 12 channels of amplification. In a medium-size room, 12 microphones spread over three channels could give a more or less equivalent sound result."[13]

Following this first experience in Bordeaux, Marie invited Xenakis to the Music Weeks festival in Paris in 1968 where the former had the opportunity to be the technician responsible for a concert including *Bohor*. Regarding the work, he points out the following:

> We cannot express sufficiently how remarkable is this attempt to create a music beyond art whose evolution in time is so closely adapted to the curve of a meditation: it begins with the picturesque of indefinite and infinite bells [...]. 16 shells, [producing] 1000 watts; two spheres, two amplifiers: 1000 watts of bells [...]. The ear does not listen anymore, there is no more dynamic: the body becomes intoxicated.[14]

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10 Pianos built by Sauter. Carrillo registered the patent in 1940 for its construction. Carl Sauter and his company, established in Spaichingen, Germany, carried out the project. Information obtained from the auction brochure of the "metamorphoser" piano of sixths of tone and the grand piano of thirds of tone. Private collection of Fernand Vandenbogaerde.

11 Electronic instrument created by Friedrich Trautwein in 1924.

12 Marie, 1968, p. 145 [*un piano, un alto avec micro de contact, l'immense tam-tam* [...] *amplifié par un microphone tenu à la main et un trautonium branché sur amplificateur Hohner muni de chambre d'écho. Le compositeur règle lui-même à son pupitre, muni de filtres, les effets sonores de l'alto et du Tam-tam. Cette œuvre très aléatoire vécut à Royan une réalisation éphémère d'une très grande beauté*]

13 Ibid., p. 140 [*certains fragments nécessitent l'amplification de sonorités métalliques. A cet effet Xenakis aurait souhaité 12 chaînes d'amplification. Dans une salle de moyenne importance, 12 micros répartis sur trois canaux pouvaient donner un résultat sonore à peu près équivalent*].

14 Ibid., p. 147 [*nous trouvions remarquable cette tentative d'une musique au-delà de l'art dont l'évolution dans le temps s'adapte si étroitement à la courbe d'une méditation : On commence dans le pittoresque de cloches indéfinies et infinies* [...]. *16 conques,* [*qui produisent*] *1000 watts ; deux sphères éclatées, deux amplis brûlés : 1000 watts de cloches* [...]. *L'oreille n'entend plus, il n'y a plus de dynamique : le corps s'intoxique*].

Artistic Engineering: The Microphone and Sound Capture

This professional work would not have been possible without the exhaustive study of the technique involved in sound production. In this regard, Marie had extensive knowledge of the microphone as a tool for sound collection, understanding its possibilities and limitations. In his first book *Musique Vivante. Introduction au langage musical contemporain* (Living Music. Introduction to Contemporary Musical Language) (1953), Marie made a distinction between sound perception made by the ear and by the microphone.[15]

The ear	***The microphone***
• Two ears form, two circuits	• The binomial microphone (relay medium) speaker forms a circuit
• The ear creates a steering sensation thanks to both circuits	• The microphone does not give the illusion of a certain direction with respect to itself
• The ear is not very sensitive to distance	• The microphone has a great sensitivity to distance: notion of "sound planes" that determines a certain "color of sounds," typical of the concert hall (creating a certain "environment")
• The ear is versatile in terms of detection faculty	• The microphone is univocal. There are microphones that have different characteristics, thus allowing each to detect the sound in a different way

Table 10.1 Table of the differences in sound perception between the ear and the microphone according to Jean-Étienne Marie.

In this sense, Marie confronted two phenomena. The ear has two circuits that give the human being the sensation of direction. On the contrary, according to Marie, the ear is less sensitive to distance, while, in the microphone, the phenomenon is reversed. In addition, the ear has a determining factor in the capture of sound: the environment. Marie then inferred that the microphone is more sensitive than the ear to the "environment" of a concert hall, since it has a great sensitivity to the distance that separates it from a sound source, and also because of a psychological factor in the mechanism of hearing.

However, Marie also recognized the technical limitations of microphones, such as adapting to the needs of sound pick-up. In this sense, this is where Marie located the role of the artistic musician-engineer: he had to find the sound balance to capture the

15 Marie, 1953, p. 183–4.

music in all its harmonic and sonorous richness, adapting and arranging microphones in the concert hall or studio. This task could only be performed by "an intelligence provided with a sensitivity that gives it this faculty of adaptation: this intelligence, driven by the artistic sensitivity that the microphones need, determines an essential function in the retransmission of music."[16]

With this statement, Marie dissociates himself from the role of sound engineer since:

> A sufficiently astute and sufficiently artistic person must realize *what he wants* in the sound field (i.e. be able *to imagine* a certain color of the room... and do it). Because there are styles for sound pick-up, styles determined mainly by the following factors: the dynamics, the environment, and the relationships of the elements of a musical ensemble.[17]

To create a "sound pick-up style," Marie defined these factors[18] as follows:

- Dynamics is an essential element in transmission: for a given work, it is possible to "collect" sounds, depending on the proximity and location of the microphones, with great sensitivity in terms of intensity. From this point of view, there can be bright, nervous, round, intimate, and warm sound pick-ups. This activity thus implies a great sensitivity of the musician to be able to perceive the almost imperceptible nuances.
- As for the environment, Marie addressed the sound recording methods practiced in France at the time. He called them "mixed method," consisting of a central microphone and other lapel microphones, which give great freedom for sound pick-up. Thus, Marie named the environment "color."
- The third element is calibrated by the sound pick-up console, which determines the *balance of the sound masses*. Marie was convinced that it was the new reference instrument as the first experimental musicians moved from the piano to the console.

Thus, the artistic musician-engineer or musico-technician is a performer, comparable to an instrumentalist or an orchestra conductor, who deals with a certain number of problems such as difficulties imposed by the sound recording where the *dynamics*, i.e. the style of the piece, the *environment*, the style of interpretation, and the *balance*

16 Ibid., p. 186 [*une intelligence* [*munie d'*] *une sensibilité qui lui donne cette faculté d'adaptation : cette intelligence, poussée par les forces affectives de la sensibilité artistique dont le micro a besoin,* [*détermine*] *une fonction essentielle dans la retransmission de la musique*].

17 Ibid., p. 187 [*Le musicien metteur en ondes suffisamment averti et suffisamment artiste* [*doit*] *réaliser ce qu'il veut dans le domaine sonore* (*c'est-à-dire, capable d'imaginer une certaine couleur de salle... et réaliser celle-ci*) [...]. *Car il y a des styles de prise de son, styles déterminés principalement par les facteurs : dynamique, ambiance, rapports des éléments d'un ensemble musical*].

18 Ibid., p. 188–90.

of masses, i.e. the musical temperament of the musician-engineer intervene. Marie concluded by affirming that "the material necessary for sound recording introduces new possibilities of writing and sonorities."[19]

Xenakis and the Aspiration to a "Meta-Music" through the "Cribles"

Marie approached Greek music and the practice of Xenakis's micro-intervals from the perspective of the "crible" (sieve), defined as "the equidistant partition of any reference interval, for example, [...] the octave."[20] In his book *L'homme musical*, published in 1976, Marie pointed out that "Xenakis insists on the fact that Greek music was based, not on octave modes, but on tetrachords. However, it is a hierarchical structure in 4 ranges."[21] The four ranges used by Xenakis based on the *cribles* are:

1. Primary. The tone and its subdivisions: semitone (1/2 tone), thirds (minimum chromatic diesis) and fourths (minimum enharmonic diesis).
2. Secondary. The tetrachord, whose two extreme sounds have a distance of fourth, and whose other sounds are mobile; its place characterizes:
   a. *The enharmonic*. Xenakis defines the intervals in aristogenic segments of a value of a twelfth of a tone. Thus, we have:
      $$3 + 3 + 24 \text{ segments} = 1/4 + 1/4 + 2 \text{ tones}$$
   b. *The chromatic*. Xenakis subdivides it into:
      - Mou: $4 + 4 + 22 = 1/3 + 1/3 + (1/3 + 3/2)$
      - Hemiola: $4{,}5 + 4{,}5 + 21 = 3/8 + 3/8 + 7/4$[22]
      - Tonin, which is subdivided into:
        * Mou: $6 + 9 + 15 = 1/2, 3/4, 5/4$
        * Syntonon: $6 + 12 + 12 = 1/2, 1, 1.$
3. System or assemblage of tetrachords with or without a tone (hence the pentachord).
4. Modo, trope, or particularization of the systems by cadential, melodic formulas.

19 Ibid., p. 196 [*Le matériel nécessaire à une prise de son ou à un enregistrement introduit de nouvelles possibilités d'écritures autant que des sonorités*].

20 Marie, 1976, p. 39 [*une équipartition d'un intervalle de référence quelconque, par exemple* [...] *l'octave*].

21 Ibid., p. 64 [*Xenakis insiste sur le fait que la musique grecque se basait, non sur des modes octaviants, mais sur des tétracordes. Il s'agissait toutefois d'une structure hiérarchisée en 4 rangs*].

22 Marie clarifies, with regard to the indication of alteration of the microtones: "Xenakis did not define writing in the field of micro-intervals, other than the one he needed: 1/4 and 1/3 of tone. To write the examples above, we resort to our writing where the 1/4 of tone are defined by a vertical stripe |, the 1/8 by 2 ||...". Ibid., p. 65 [*Xenakis n'a pas défini d'écriture dans le domaine des micro-intervalles, que celle dont il a eu besoin :* 1/4 *and* 1/3. *Pour noter les exemples ci-dessus, nous avons donc eu recours à notre écriture où les* 1/4 *sont définis par une seule verticale* |, *les* 1/8 *par* 2 ||...].

Subsequently, Marie explains that Xenakis:

> Turns to the study of Byzantine music which amalgamates Pythagorean (multiplicative, division of strings) and Aristogenic (additive, in the manner of musicians) calculus. These additive and multiplicative languages were mixed through the centuries, causing many confusions in interval calculations and theories. Thus arose the supposed scale of Aristogenes, [...] modified by Ptolemy in the third century and characterized by "three tones."[23]
>
> $^{9}/_{8}$ = 12 segments, $^{10}/_{9}$ = 10 segments, $^{16}/_{15}$ = 8 segments, distributed as follows:
>
> 1, $^{9}/_{8}$, $^{5}/_{4}$, $^{4}/_{3}$, $^{3}/_{2}$, $^{27}/_{16}$, $^{15}/_{8}$, 2
>
> 0, 12, 22, 30, 42, 54, 64, 72 segments

By this presentation of the constitutive elements of the micro-intervallic organization or the *cribles*, Marie shows:

> Xenakis's purpose was not musicological. For him it is rather a question of giving new importance to structures "outside of time,"[24] and to do so he seeks a formalizable language capable of accounting for all structures. But under the novelty of language, we find research processes close to those of Wyschnegradsky or Hába... that appear as constants in the discovery of the domain of intervals.[25]

In Xenakis's language, le *hors-temps* (out of time) refers to "essences," that is to say to the attempt to restore the notion of scales. Theorists have always reduced the discussion to this expression because it is simple, quantifiable. In this regard, Makis Solomos (b. 1962), a French-Greek musicologist, considers that Xenakis returns to the teaching and influence of Olivier Messiaen, a period marked by the study of traditional Greek music, but with the aim of creating, constructing his own, original modes.

Regarding the micro-intervallic developed by Xenakis, Marie concluded:

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23 Marie, 1976, p. 65 [*Xenakis passe ensuite à l'étude de la musique byzantine qui amalgame le calcul pythagoricien (multiplicatif, voir plus haut, division des cordes) et aristoxénien (additif, à la manière des musiciens). Ces langages additifs et multiplicatifs se sont mélangés à travers les siècles, créant des confusions multiples dans les calculs d'intervalles et dans les théories. C'est ainsi qu'a vu le jour la prétendue gamme d'Aristoxène,* [...] *et modifié par Ptolomée (IIIe siècle) et caractérisée par "3 tons"*].

24 Marie explains the notion of "scale": "A scale exists independently of the vertical or horizontal combinations that are likely to be used; this is called 'out of time'. Melody and harmony that are derived are 'in time' but do not become temporal until they are inserted into an axis of time, that is, 'during their actual occurrence'".

25 Marie, 1976, p. 66 [*Le propos de Xenakis n'est pas d'ordre musicologique. Il s'agit pour lui de redonner toute leur importance aux structures 'hors temps' et pour ce faire il recherche un langage formalisable susceptible de rendre compte de toutes ces structures. Mais sous la nouveauté du langage nous retrouvons des processus d'investigation proches de ceux de Wyschnegradsky ou de Hába... qui apparaissent comme des constantes dans la découverte du domaine des micro-intervalles*].

> [a] One notes that, in practice, [Xenakis] makes of micro-intervals a desire to integrate Greek and Byzantine music (1/4 and 1/3 of tone) and to apply the *glissando* to instruments little suited to realize them naturally (woodwinds, brass with valves) in Western technique. But these melodic concerns led him to a harmonic exploration in which he is very cautious [with respect to Carrillo].[26]
>
> [b] The chromatic total can be "sieved" in various ways [...]. It is observed then that this notion of module or *crible* is similar to that of the equidistant "division" that we find in Wyschnegradsky,[27] Hába[28] or Carrillo.[29] But Xenakis brings something new through logical operations, starting from these *cribles*, defining any irregular scale.[30]

For Marie,

> the *glissando* was nothing more than a sound effect. Xenakis gave it a structure value, specifying the velocities—starting point, arrival point and *glissando* time at a uniform velocity. Beyond a linear algebra, any mathematical function, or simply its graphical representation, can describe a certain type of continuous evolution of a sound (*glissando*) or visual (travelling – film object) phenomenon.[31]

The idea of the *crible* was later studied by Solomos, who says in this regard:

> With the crible, it is not only a matter of assembling notes of such and such pitches, but they are subjected to an order, to a periodicity. A crible is thus what the musical tradition calls a scale. Its constitution goes through a logical-arithmetic formula [...]. Xenakis' purpose with the crible is not to analyze existing scales but to generate surprising scales, using periodicities other than the octave and even other units beyond the semitone, (for example, the 1/4 of tone). Thus, we can easily imagine that the obtained scales can be very rich in sonorities, respecting the basic idea, i.e., the existence of symmetries—even if they are not detectable to the ear.[32]

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26 Ibid., p. 68. In this sense, Marie recognized in Carrillo, the figure of the creator-researcher, who theorized the "Sound 13," conceived the instruments for the production of micro-intervals, and created and recorded his most representative microtonal works. In addition, Carrillo founded and wrote the magazine *el Sonido 13* to disseminate his own ideas about microtonality.

27 To listen to Wyschnegradsky's music, contact the Ivan Wyschnegradsky Association, which keeps the composer's sound archive: https://www.ivan-wyschnegradsky.fr/en/

28 Regarding Hába, Marie writes: "In Moravia, [his birthplace], he listened to folk songs that constituted 1/4 and 1/6 of tone [...]. [Hába] was very sensitive to the influence of the Vienna School (atonal). It was not until after the Second World War that he turned to the 1/12 of tone." Op. cit., p. 52 [*En Moravie il entendait des chants populaires qui comportaient des intervalles de 1/4 et 1/6 de ton* [...] [*Hába*] *a été très sensible à l'influence de l'école de Vienne* (*atonale*). *Ce n'est qu'après la Deuxième guerre mondiale qu'il se penche véritablement sur le 1/12 de ton*].

29 The French composer and musicologist Francis Bayer analyzes the processes of Wyschnegradsky, Hába, and Carrillo. In the first two, he observes that their theories are harmonic rather than acoustic. Bayer considers Carrillo's process to be more of an empirical study. Bayer, 1981, p. 114.

30 Marie, 1976, p. 66.

31 Ibid., p. 179 [*le glissando n'était qu'un effet sonore. Xenakis lui a conféré une valeur de structure en spécifiant les vitesses* (*point de départ, point d'arrivée, temps de glissement à vitesse uniforme*). *Au-delà de l'algèbre linéaire, toute fonction mathématique, ou plus simplement sa représentation graphique, peut décrire un type déterminé d'évolution continue d'un phénomène sonore* (*glissando*) *ou visuel* (*travelling*)].

32 Solomos, 2004, p. 65 [*avec les cribles, les ensembles de notes ne sont plus une réunion quelconque de hauteurs, ils se plient à un ordonnancement, à une périodicité. Un crible constitue donc ce que la tradition musicale nomme échelle. Leur construction passe par une formule logico-arithmétique* [...]. *Le but principal de Xenakis*

This theory is part of the general logic of the composer's evolution. Xenakis noted in 1988 that "when, in a given piece the problem of scale has been satisfactorily solved, half of the problems of composition have been solved."[33] The theory of scales occupies a preponderant place in the production of the Greek composer. Solomos placed its development in the early 1960s, but this theory was overshadowed by Group Theory. Marie, having had contact with the Greek composer, introduced the theory of scales in his courses at that time.

Solomos mentioned that sieves were already used, along with other techniques, in pieces such as *Akrata* (1964–5), *Nomos Alpha* (1966), *Nomos Gamma* (1967–8), *Anaktoria* (1969), *Metastasis* (1953–4), *Pithoprakta* (1955–6), *Nuits* (1967), *Eonta* (1963), *Psappha* (1975), and *Oresteïa*, among others, considered as "sound halos."[34] The first three, according to Solomos, "are, in general, very complex and often integrate quartertones."[35] In *Embellie* (1981), for viola, Xenakis uses what Solomos called the archaic *cribles*, based on the *pelog*.[36] Solomos noted that Xenakis generalized its use from 1977 with the piece *Jonchaies* (1977), finding its full expression in the works of the 1980s.

Xenakis wrote about the *cribles* in his book *Musique. Architecture* of 1971.[37] This theory was the expression of a fundamental preoccupation of Xenakis throughout his life: the search for the foundations of music; what he will define as "meta-music." For Solomos, the ultimate phase of this search was the *crible*, as an attempt to restore an order, a discontinuity, and a periodicity. Solomos quotes an article by Xenakis, in which he expresses his concerns about the pillars on which music should rest:

> The question of symmetries (spatial identities), or of periodicities (identities in time), plays a fundamental role at all levels, from the sample, for its synthesis by means of the computer, to the architecture of a piece. It is therefore necessary to formulate a theory that makes it possible to construct such complex and desired symmetries and, conversely, from a series of events or objects in space or time, to find symmetries that constitute them. I name this "cribles". All that may be applied to any well-ordered set of sound characteristics or sound structures, and especially to any group provided with

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n'étant pas d'analyser des échelles existantes, la théorie des cribles aura pour tâche de générer des échelles inouïes, en utilisant d'autres périodicités que l'octave et/ou d'autres unités que le demi-ton (par exemple le quart de ton). On l'imagine aisément, les cribles obtenus peuvent être alors très riches, tout en respectant l'idée de base, c'est-à-dire l'existence de symétries – même si celles-ci ne sont pas nécessairement détectables à l'oreille].

33 Ibid., p. 65 [*Quand, pour une pièce donnée on a résolu le problème de l'échelle de manière satisfaisante, on a alors résolu la moitié des problèmes de composition*].

34 Solomos, 2004, p. 64. Solomos explains that "the halos [...] dominate scales and parallel movements over the cribles, homorhythms, as well as dialogues between standard groups of timbres" [*les halos n'occupent qu'une petite partie et dominent des gammes et mouvements parallèles sur cribles, des homorythmies ainsi que des dialogues entre groupes standards de timbre*].

35 Solomos, 2004, p. 69 [*Les premiers cribles* [...] *sont, en général, très complexes et intègrent souvent les quarts de ton*].

36 *Pelog* is one of the two scales of gamelan music native to Bali and Java in Indonesia.

37 Xenakis, 1971, *Musique. Architecture*, Tournai, Casterman; (1976) New enlarged edition: Tournai, Casterman.

> an additional operation and whose elements are multiples of unity, i.e. belonging to the set N of natural numbers. Examples: pitches, instants, intensities, densities, degrees of order…, timbre locally, etc.[38]

Solomos concluded that the ultimate ambition of the *cribles* is to found music; to unify its particular fields thanks to a single axiomatization. As an observation, the musicologist pointed out that Xenakis applied the *crible* more to the pitches. His ultimate, unrealized aspiration was to transfer this theory to the field of sound synthesis. Finally, Solomos distinguishes two periods of the *cribles*:

> In the first one, Xenakis builds complex, highly differentiated (in the sense of a particular succession of intervals) *cribles* […]. Then, at the end of the 1980s, these same *cribles* are increasingly invaded by chromaticism, especially when the strings intervene. Thus, in 1987, in the piece *Tracées* for orchestra, a particular notation makes its appearance and then becomes generalized: with a bar linking two notes, the composer asks the string players to divide themselves to play all the pitches between these notes.[39]

As a tentative conclusion, it should be noted that Marie's work in the 1950s was determined by the sound and visual progress developing around radio and television. Being at the Radio Télévision Française, Marie was able to be at the forefront of musical and scientific innovations of his time, carried out by concrete music, electronics, and electroacoustics. This professional relationship with the great French and foreign composers, among them Xenakis, motivated his scientific and compositional spirit that pushed him to carve his own path, that of research and sound creation, thus undertaking the titanic task of the analysis and theorization of contemporary music.

Thus, his contribution to artistic engineering begins in 1954 when he participated in the Congress on the Sociological Aspects of Music on the Radio, organized by the Center for Radiophonic Studies. Marie exposed his aesthetic concerns with the paper "Broadcasting facing the problem of initiation to contemporary music." In it, he expressed the need for a work of initiation between the neophyte public and the contemporary composer, through the action of a musical connoisseur, so that the work

38 Xenakis, 1976, p. 75, cited in Solomos, 2004, p. 66 [*En musique, la question des symétries* (*identités spatiales*), *ou des périodicités* (*identités dans le temps*), *joue un rôle fondamental à tous les niveaux, depuis l'échantillon, en synthèse des sons par ordinateur, jusqu'aux architectures d'une pièce. Il est donc nécessaire de formuler une théorie permettant de construire des symétries aussi complexes qu'on les désire et, inversement, à partir d'une suite donnée d'événements ou d'objets dans l'espace ou dans le temps, de retrouver les symétries qui la constituent. On nomme ces suites des 'cribles.' Tout ce qui sera dit ici pourra s'appliquer à tout ensemble de caractéristiques du son ou de structures sonores bien ordonné, et spécialement à tout groupe muni d'une opération additive et dont les éléments sont des multiples d'une unité, c'est-à-dire qu'ils appartiennent à l'ensemble N des nombres naturels. Exemples : hauteurs, instants, intensités, densités, degré d'ordre, …, timbre localement, etc…*].

39 Ibid., p. 70 [*Dans un premier temps, Xenakis construit des cribles complexes, hautement différenciés* (*dans le sens d'une succession particulière d'intervalles*) […]. *Puis, vers la fin des années 1980, ces mêmes cribles sont de plus en plus envahis par le chromatisme, notamment lorsque interviennent les cordes. Ainsi, dans Tracées* (*1987, pour orchestre*), *fait son apparition une notation particulière qui se généralise par la suite : avec une barre qui unit deux notes, le compositeur demande aux musiciens à cordes de se diviser pour jouer toutes les hauteurs comprises entre ces notes*].

can be appreciated in its correct creative and performative dimension. In addition, he insisted on the need for an educational musical policy for the public wishing to discover the music of living composers.

His experience at the RTF as an artistic engineer materialized in the creation of the Applied Acoustics and Experimental Music class, to be based at the Schola Cantorum in Paris in 1959.[40] This class was one of the first of its kind, where Marie taught Architectural Acoustics based on the intrinsic relationship of the microphone to the loudspeaker. Starting from traditional writing, Marie questioned its validity, confronting it with experimental music (concrete and electronic music), graphic music, and micro-intervals.

With respect to media, Marie addressed in his classes the conservation, transmission, and reproduction of music, the role of microphones, loudspeakers, the record, and the role of radio and television as means of aural and sonorous diffusion. Marie's concern throughout his life was the lack of preparation of aspiring composers who were constantly being faced with the proliferation of technical and electronic media. For that reason, Marie dedicated his entire life to the proper training of future composers in technical production, the capture of sound, and the study of micro-intervals as a sound initiation with which to approach electronic music. In that sense, Marie taught music and mathematics and their practical application in music through a composer like Xenakis.

With regard to the *cribles*, Marie writes that:

> By means of a succession, arrangement of logical and mathematical structures (notions linked to the transformation group of the cube) catalyzes a triggering of sounds through the confrontation of structures. Each of Xenakis' works thus presents an aspect of meditation on human thought applied to sound. In the Xenakian logic, there is no intention to manipulate sounds, but to elaborate works.[41]

In terms of "knowing how to listen" in the twentieth century, Marie distinguishes three elements:

1. A deferred listening.
2. A new profession that emerges in radio and television: the artistic engineer.
3. Radio listening.

Marie's subsequent research focused on these three elements of communication: the transmitter, the receiver, and the message (whether verbal or not). This musical and technical richness gives him a place in musical teaching and broadcasting. His goal was to bring the neophyte public closer to the new music of that time.

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40 Marie was invited for two months, in 1966 and one month in 1968, to give seminars in Mexico City. His teaching left its mark on the young Mexican composers of that time.

41 Marie, 1976, p. 260 [*par un étagement de structures logiques en mathématiques* (*relié, ici, au groupe de transformation du cube*), *catalyse un déclenchement de sons par le jeu des structures confrontées. Chaque œuvre de Xenakis présente donc un aspect de médiation sur la pensée humaine appliqué au son. Il est dans sa logique d'élaborer des œuvres sans manipuler un seul son*].

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