Years:	Karlheinz Stockhausen (1928 - 2007)	Iannis Xenakis (1922 - 2001)		John Cage (1912 - 1992)		Curtis Roads	
Affiliations:	**Composer,**	**Engineer, Composer, Architect**		**Composer, & Musician**	**UCLA, USC**	**Composer, Writer**	**CALARTS (72), UCSD (74)**
Article:	**The Concept of Unity and Electronic Music: (1962)**	**Formalized Music: Thought and Mathematics in Music: Ch. 10 Concerning Time, Space and Music (1963)**	**Xenakis on Xenakis (1987)**	**Silence: Composition as Process (1961)** Foreword (ix) Manifesto (xii) The Future of Music: Credo (3) Experimental Music (7) Experimental Music Doctrine (13) **I. Changes (18)** **II. Indeterminancy (35)**	**Silence: Composition as Process (1961)** **III. Communication (41)** **Composition (57)** - To describe the Process of Composition Used in Music of Changes and Imaginary Landscapes No. 4 (57) - To Describe the Process of Composition Used in Music for Piano 21-52 (60)	**Microsound: Ch. 01: Time Scales of Music (2001)**	**Composing Electronic Music Che. 08: Articulating Space (2013)**
Concept:	Using Sound Waves and acceleration to generate all types of sounds. Using the composition process to create moment forms.	Stochastic Laws and Probability	Stochastic Laws and Probability. Integrating Architecture, Mathematics & computer science to composition	Cage is deconstructing the medium of Music/composition by asking questions that fundamentally challenge the field	Cage Uses Chance operations to open the opportunities to create and reach a deeper meaning that goes beyond ego.	Mircosound: Granular Synthesis	Mircosound: Spatializing Sound
Main Works:	Kontakte (1958 - 62) Gesang der Jünglinge (1955 - 56) Klavierstücken I,II,III,IV Momente (1962 - 1969)	Pythoprakta (1956) Concerte PH (1958) Metastaseis (1953-54) Achorripsis (1957)	ST/4, for String Quartet (1956-62) Nomos Alpha (1966) Polytope de Cluny, (1972) UPIC (1979) (Interface that translated graphical images into musical results) Mycenea Alpha (1978)	Dream: (1958) Prepared Piano Works: Sonatas and Interludes (1946-48) Music of Changes (1951) 4' 33" (1952) Landscape # 4 (1951) for 24 performers 12 radios Speech (1955) For 5 performers and 5 radios Water Walk(1959) Variations II (1961)	Dance: Minutiae: (1954) Variations V w/ Merce Cunningham	Purity (1994) Half Life (1999) Point Line Cloud: Eleventh Vortex (2005) Fluxon (2005) Nanomorphosis	
Spatialization:	*Osaka Pavillion* *Worlds Fair Osaka, Japan (1970)*	*Phillips Pavillion* *Worlds Fair, Brussels, Germany (1958)* *(Architecture, & Music Composition)*					
Research: Key Points	*Electronic Music* *Moment Form* *Aleatory (Conrolled Chance) in Serial Composition* *Music Spatialization*	*Pioneer in Mathematical Models in Music* *Set Theory, Stochastic Processes,* *Game theory* *Computer Music* *Integrating Architecture and Music* *Composition and Performance*		*Indeterminancy in Music* *Electroacoustic Music* *Non-standadrd use of musical instruments* *Conceptual Art, Happenings* *Modern Dance (w/ Merce Cunningham)*		*Granular Synthesis* *Electronic Music* *Music Spatialization*	Editor (1978 - 2000) of the Computer Music Journal)
Inspiration	*Nature,* *Science* *Human Physiology*	*Nature,* *Mathematics* *Science: Physics* *Human Physiology*		*Nature, (Conceptual Art)* *I Ching (1951)* *Human Physiology*		*Nature,* *Mathematics* *Science: Physics,* *Human Physiology*	*Dennis Gabor* *(Nobel Prize Physics: Hologrphy)*
Collaborators:	-	*Le Corbusier, Varese*		*Marchel Duchamp,* *Robert Rauchenberg* *Merce Cunningham*		*Alberto Campo*	
Teachers:	*Oliver Messiaen*	*Oliver Messiaen*		*Arnold Schoenberg* *Henry Cowell*	*Dr. D.T. Suzuki*	*Iannis Xenakis*	
Additional References:							
Summary:	**A.**	**B.**	**C.**	**D.**	**E.**	**F.**	**G.**
Quotes:							

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Years:				
Affiliations:	**Composer,**	**Engineer, Composer, Architect**		**Composer, & Musician**
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Granular Synthesis
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Nature,
Mathematics
Science: Physics,
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Dennis Gabor
(Nobel Prize Physics: Hologrphy)

G.

Formalized Music: Thought and Mathematics in Music Ch. 10 Concerning Time, Space and Music pp. 255-267 by Iannis Xenakis (1963) **Links:**

- ☐ _a Date:
- ⊟ _Article Summary:
  - ☑ Presented/Published:
  - ☑ Author: Iannis Xenakis
  - ☑ ***Formalized Music: Thought and Mathematics in Music*** Ch. 10 Concerning Time, Space and Music pp. 255-267
  - ☑ Year: 1963
  - ☑ Publisher: Original Pendragon Press 2nd Edition 2001
  - ☐ Source:
  - ☑ Source: Background Information
- ☐ _Art Works (Examples)
  - ☐ Architecture: (Working with Le Corbusier)
    - ☐ Le Couvent De La Tourette (window detail) www.youtube.con
    - ☐ Philips Pavilion (1958) www.archdaily.co
  - ☐ Music Composition:
    - ☐ **Achorripsis (1957)** www.youtube.con
    - ☐ **Akrata (Groups) (1965) - [Groups]** www.youtube.con
    - ☐ **Nomos Alpha (1966) - [Groups]** www.youtube.con
    - ☐ **Metastasis (1954)** www.youtube.con
    - ☐ **Mycenae Alpha (1978)** www.youtube.con
    - ☐ **Pithoprakta (1956)** www.youtube.con
    - ☐ **ST/4 (1962) - [ST Algorithm]** www.youtube.con
- ☐ _Bibliography (Alternative Format)
- ☐ _Concepts:
  - ☐ Terms
    - ☐ Probability, Stochastic en.wikipedia.org–
- ☐ _Glossary
  - ☐ Definitions:
    - ☐ Probability:
    - ☐ Stochastic:
- ☐ _Objectives
- ⊟ _Outline (Notes)
  - ☐ **Chapter X: Concerning Time, Space and Music**
  - ☐ WHAT IS A COMPOSER?
  - ☐ A few points of convergence in relation to time and space between the sciences and music:
  - ☐ First point:
    - ☐ In 1954, I introduced probability theory and calculus in musical composition in order to control sound masses both in their invention and in their evolution.
    - ☐ *Question:* *What are sound masses?*
    - ☐ *Vocabulary:* -
    - ☐ *Probability Theory, Calculus*
    - ☐ This inaugurated an entirely new path in music, more global than polyphony, serialism or, in general, "discrete" music. From hence came stochastic music.
    - ☐ *Question:* *-What is stochastic music?*
    - ☐ *Vocabulary:* -
    - ☐ *Stochastic Music*
    - ☐ But the notion of entropy, as formulated by Boltzmann or Shannon,] became fundamental.
    - ☐ Indeed, much like a god, a composer may create the reversibility of the phenomena of masses, and apparently, invert Eddington's "arrow of time."2
    - ☐ Today, I use probability distributions either in computer generated sound synthesis on a micro or macroscopic scale, or in instrumental compositions.
    - ☐ But the laws of probability that I use are often nested and vary with time which creates a stochastic dynamics which is aesthetically interesting.
    - ☐ This procedure is akin to the mathematical analysis of Liouville's equation on non-unitary transformations proposed essentially by I. Prigogine;3
    - ☐ *Vocabulary:* -
      - ☐ *Liouville's equation on non-unitary transformations*
    - ☐ namely, if the microscopic entropy M exists, then M = A2, where A acts on the distribution function or the density matrix. A is non-unitary which means that it does not maintain the size of probabilities of the states considered during the evolution of

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the dynamic system, although it does maintain the average values of those which can be observed. This implies the irreversibility of the system to the equilibrium state; that is, it implies the irreversibility of time.

- ☐ *Ask JKM about the above*
- ☐ *Summary :* -

- ☐ **Second point:**
  - ☐ This point has no obvious relationship to music, except that we could make use of Lorentz-Fitzgerald and Einstein transformations in the macroscopic composition of music.[4]
  - ☐ Voc: Lorentz-Fizgerald and Einstein transformations; macroscopic compositions
  - ☐ We all know of the special theory of relativity and the equations of Lorentz-Fitzgerald and Einstein, which link space and time because of the finite velocity of light.
  - ☐ Voc: -
  - ☐ space and time
  - ☐ From this it follows that time is not absolute. Yet time is always there. It "takes time" to go from one point to another in space, even if that time depends on moving reference frames relative to the observer. There is no instantaneous jump from one point to another in space, much less "spatial ubiquity"-that is, simultaneous presence of an event or an object in two sites in space. On the contrary, one posits the notion of displacement. Within a local reference frame, what then does displacement signify? If the notion of displacement were more fundamental than that of time, one could undoubtedly reduce all macro and microcosmic transformations to extremely short chains of displacement. Consequently (and this is an hypothesis that I freely advance), if we were to adhere to quantum mechanics and its implications accepted now for decades, we would perhaps be forced to admit the notion of quantified space and its corollary, quantified time. But then, what could a quantified time and space signify, a time and space in which contiguity would be abolished? What would tile pavement of the universe be if there were gaps between the paving stones, inaccessible and filled with nothing? Time has already been proposed as having a quantic stucture by T. D. Lee ofColumbia University.
  - ☐ *Vocabulary:* -
  - ☐ *macro and microcosmic transformations, Quantum mechanics, Quantified Space, Quantified time,*
  - ☐ Let us return to the notion of time considered as duration. Even after the experimental demonstration of Yang and Lee which has abolished tile parity symmetry P,5 it seems that the CPT theorem still holds for tile symmetries of the electron (C) and of time (T), symmetries that have not yet been completely annulled. This remains so even if the "arrow of time" appears to be nonreversible in certain weak interactions of particles. We might also consider the poetic interpretation of Feynman,6 who holds that when a positron (a positively charged particle created simultaneously with an electron) collides with an electron, there is, in reality, only one electron rather than three elementary particles, the positron being nothing but the temporal retrogression of the first electron. Let us also not forget the theory of retrograde time found in Plato's Politicos-or in the future contraction of the universe. Extraordinary visions!
  - ☐ Quantum physics will have difficulty discovering the reversibility of time, a theory not to be confused with the reversibility of Boltzmann's "arrow of entropy." This difficulty is reflected in the explanations that certain physicists are attempting to give even today for the phenomenon called the "delayed choice" of the two states--corpuscular or wave - o f a photon. It has been proven on many occasions that the states depend entirely on observation, in compliance with the theses of quantum mechanics. These explanations hint at the idea of an "intervention of the present into the past," contrary to the fact that casuality in quantum mechanics cannot be inverted. For, if the conditions of observation are established to detect the particle, then one obtains the corpuscular state and never the wave state, and vice versa. A similar discussion on non-temporality and the irreversibility of the notion of causality was undertaken some time ago by Hans Reichenbach.'
  - ☐ Vocabulary: -
    - ☐ corpuscular state, delayed choice
  - ☐ Thoughts : -
    - ☐ Xenakis is drawing corollaries with the known fundamental knowledge of science and contrasting it with the rules of composition. Composition and the rules that govern it in western music is limited to the arc of human imagination. The natural world and its interweaving systems of layers reality create new territories of compositional process.
  - ☐ Another fundamental experiment has to do with the correlation of the movement of two photons emitted in opposite directions by a single atom. How can one explain that both either pass through two polarizing films, or that both are blocked? It is as if each photon "knew" what the other was doing and instantaneously so, which is contrary to the special theory of relativity.
  - ☐ Now, this experiment could be a starting point for the investigation of more deeply seated properties of space, freed from the tutelage of time. In this case, could the "nonlocality" of quantum mechanics perhaps be explained not by the hypothesis of "hidden variables" in which time still intervenes, but rather by the unsuspected and extravagent properties of nontemporal space, such as "spatial ubiquity," for example?
  - ☐ Let us take yet one more step. As space is perceptible only across the infinity of chains of energy transformations, it could very well be nothing but an appearance of these chains. In fact, let us consider the movement of a photon. Movement means displacement. Now, could this displacement be considered an autogenesis of the photon by itself at each step of its trajectory (continuous or quantized)? This continuous auto- creation of the photon, could it not, in fact, be space?
  - ☐ *Ask JKM - about the above*
    - ☐ *Xenakis seems to be talking about the transfer of energy as a function of space-time metaphors in composition? Is that correct?*
  - ☐ *Vocabulary:* -
    - ☐ *duration, tile parity symmetry, autogenesis*

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- ☐ *Summary : (Section) -*
  - ☐ *Xenakis speculates on how time and space are unified. Time fills space. Time structures space. But the formal structure and language breaks down at different scales. The micro scale of quantum mechanics and the macro scale and Einsteins conception of space-time are metaphorically correlated to tiles and the gaps in-between. Xenakis speculates that if the building blocks of space at different scales are not connected then space space time is also a function that can be parameterized.*
- ☐ *Insights : (Section) -*
  - ☐ *This notion of time as duration, the material quality of space time are relative at different scales and can be described through the mathematics of probability and calculus. Nature and Natural systems are fundamentally chaotic and probabilistic, The evolution of time structures a determined mathematical evolution of entropy and an ecology of different systems creating a fractal interconnected states of reality.*
- ☐ **Third point: Case of creating something from nothing**
  - ☐ In musical composition, construction must stem from originality which can be defined in extreme (perhaps inhuman) cases as the creation of new rules or laws, as far as that is possible; as far as possible meaning original, not yet known or even forseeable. Construct laws therefore from nothing, since without any causality.
  - ☐ But a construction from nothing, therefore totally engendered, totally original, would necessarily call upon an infinite mass of rules duly entangled. Such a mass would have to cover the laws of a universe different from our own. For example: rules for a tonal composition have been constructed. Such a composition therefore includes, a priori, the "tonal functions." It also includes a combinatory conception since it acts on entities, sounds, as defined by the instruments. In order to go beyond this slight degree of originality, other functions would have to be invented, or no functions should exist at all. One is therefore obliged to conceive of forms from thoughts bearing no relation to the preceeding ones, thoughts without limits of shapes and without end. Here, we are obliged to progressively weave an unlimited web of entangled rules-and that alone in the combinatory realm which itself excludes, by definition, any possible continuums of sound. However, the insertion of continuity will consequently augment the spread of this web and its compacity. Furthermore, if one cared to engender the unengenderable in the realm of sound, then it would be necessary to provide rules other than those for sound machines such as pipes, strings, skins, etc. which is possible today thanks to computers and corresponding technologies. But technology is both but a semblance of thought and its materialisation. It is therefore but an epiphenomenon in this discussion. Actually, rules of sound synthesis such as those stemming from Fourier series should not be used any more as the basis of construction. Others, different ones, must be formulated.
  - ☐ *Ask JKM -- about the above*
  - ☐ Another perspective: We have seen how construction stems from an originality which is defined by the creation of rules and laws outside of an individual's or even the human species' memory. However, we have left aside the notion of rules or laws. Now the time has come to discuss this notion. A rule or law signifies a finite or infinite procedure, always the same, applied to continuous or "discrete" elements. This definition implies the notion of repetition, of recurrence in time, or symmetry in realms outside time (hors temps). Therefore, in order for a rule to exist, it must be applicable several times in eternity's space and time. If a rule were to exist but once , it would be swallowed up in this immensity and reduced to a single point, therefore unobservable. In order for it to be observable, it must be repeatable an infinite number of times.
  - ☐ *Insights : (Thesis) --*
    - ☐ *In the discussion of rules, Xenakis formulates a language were he sees the continuity of science and nature and universal laws as a basis of composition through existing patterns of life.*
  - ☐ Subsidiary question: Can one repeat a phenomenon? (cf. Herakleitos: "It is impossible to step twice into the same river," and Kratylos: "not even once.")

    But the fact remains that the universe:
    a) seems, for the time being, to be made up of rules-procedures; b) that these rules-procedures are recurrent.

    It is as though the Being (in disagreement with Parmenides), in order to continue existing, is obliged to die; and once dead, is obliged to start his cycle again. Existence, therefore, is a dotted line.
  - ☐ Can one, at last, imagine an infinitesmal microscopic rule that is engendered from nothing? Even if physics has yet to discover anything resembling this, despite "Lamb's shift" (which sees each point in space in our universe as seething in virtual pairs of particles and anti-particles), we can imagine such an eventuality which would, by the way, be of the same nature as the fact of pure chance, detached from any causality.
  - ☐ It is necessary to depend on such a conclusion of a Universe open to the unprecedented which relentlessly would be formed or would disappear in a truly creative whirlwind, beginning from nothingness and disappearing into nothing. The same goes for the basis of art as well as for man's destiny.
  - ☐ Here, below, is the thesis of a few astro physicians such as Edward Tryon, Alexander Vilenkin, Alan Guth, Paul Steinhardt, adherents to the Big Bang theory:

    If grand unified theories are correct in their prediction that baryon number is not conserved, there is no known conservation law that prevents the observed universe from evolving out of nothing. The inflationary model of the universe provides a possible mechanism by which the observed universe could have evolved from an infinitesimal region. It is then tempting to go one step further and speculate that the entire Universe evolved from literally nothing. (cf. *Scientiflc American,* May, 1984)
  - ☐ The multiplicity of such universes according to Linde[s] from Moscow is also quite intriguing.
  - ☐ Here, below, is an alternative to the Big Bang scenario. These studies have been followed by the physicists of the University of Bruxelles; namely R. Brout, E. Giinzig, F. Englert and P. Spindel:

    Rather than the Universe being born of an explosion, they propose that

it appeared exnihilo following an instability of the minkonskian quantum void, meaning that space-time was devoid of any matter, therefore flat or yet-without any curvature." (cf. Coveney, Peter V., "L'irreversibilite du temps," La Recherche, Paris, February, 1989).9

- ☐ What is extraordinary is that both propositions, Big Bang or not, admit a beginning, an origin from nothing, or nearly nothing with, however, cycles of re-creation! With a most extreme modesty, I would like to compare, especially the last hypothesis, with a scientific-musical vision I had made in 1958. At that time, I wanted to do away with all of the inherited rules of composition in order to create new ones. But the question that came to my mind at that time was whether a music could still have meaning even if it was not built on rules of occurence. In other words, void of rules. Below are the steps in this thought process:

  "For it is the same thing to think and to be" (The Poem, Parmenides)

  and my paraphrase

  "For it is the same thing not to be and to be"

  Ontology:

  In a Universe of Void. A brief train of waves whose beginning and end coincide (nil Time), perpetually triggering off.

  Nothingness resorbs, creates. It is the generator of Being.

  Time, Causality.
- ☐ This text was first published in Gravesaner Bliitter, N° 11/12, 1958, the revue published by the great conductor, Hermann Scherchen. At that time, I had temporarily resolved this problem in creating music uniquely through the help of probability distributions. I say "temporarily" since each probability function has its own finality and therefore is not a nothing. *
  *Cf. also page 24 for a slightly different rendition of the same material (S.K.)
- ☐ *Summary: (Section)* -
  - ☐ *Xenakis outlines the arguments that the universal laws that govern our perceptions of reality are naturally repeating. These patterns transcend human understanding, but we intuit them through universal laws outlined in physics.*
  - ☐ *Insights : (Thesis)* -
    - ☐ *In this section Xenakis uses the laws of physics to inspire is departure from existing models of composition and oppose serialism.*
    - ☐ *Conceptual: (Insight)* -
      - ☐
      - ☐ *Standard Model:*
      - ☐ *Standard Model: (Particle Physics): 4 Forces: Long Range: Gravity , Electromagnetism Short Range: Strong Nuclear Force & Weak Nuclear Force*
      - ☐ *Long Range: Gravity (Governs the path of the sky & stars), Electromagnetism (light, force that binds electrons to atomic nuclei, responsible for all of chemistry) Short Range: Strong Nuclear Force (Ties quarks together) & Weak Nuclear Force*
      - ☐ *Strength of forces: Strong Force (1), Electromagnetic Force (1/100), Weak Force (1/100,000), Gravity (1/10,000,000,000,000,000,000,000,000,000,000,000,000,000,000)*
      - ☐ *Definition:*
        - ☐ The **Standard Model** of particle physics is a theory concerning the electromagnetic, weak, and strong nuclear interactions, which mediate the dynamics of the known subatomic particles. …The Standard Model falls short of being a complete theory of fundamental interactions because it makes certain simplifying assumptions. It does not incorporate the full theory of gravitation[2] as described by general relativity, or predict the accelerating expansion of the universe (as possibly described by dark energy). en.wikipedia.or

- ⊟ **Another question**
  - ☑ The actual state of knowledge seems to be the manifestation of the evolution of the universe since, let us say, some fifteen billion years.IO By that, I mean that knowledge is a secretion of the history of humanity, produced by this great lapse of time. Assuming this hypothesis, all that which our individual or collective brain hatches as ideas, theories or know-how, is but the output of its mental structures, formed by the history of the innumerable movements of its cultures, in its anthropomorphic transformations, in the evolution of the earth, in that of the solar system, in that of the universe. If this is so, then we face a frightening, fundamental doubt as to the "true objectivity" of our knowledge and know-how. For if, with bio-technologies already developing, one were to transform these mental structures (our own) and their heredity,therefore the rules for the functioning of the brain based on certain premises today, on logic or systems of logic, and so on ..., if one were to succeed in modifying them, one would gain, as if by sort of a miracle, another vision of our universe, a vision which would be built upon theories and knowledge which are beyond the realm of our present thought.
  - ☐ Let us pursue this thought. Humanity is, I believe, already on this path. Today, humanity, it seems to me, has already taken the first step in a new phase of its evolution, in which not only the mutations of the brain, but also

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the creation of a universe very different from that which presently surrounds us, has begun. Humanity, or generalizing, the species which may follow it, will accomplish this process.

- ☐ Music is but a path among others for man, for his species, first to imagine and then, after many, many generations, to entail this existing universe into another one, one fully created by man. Indeed, if man, his species, is the image of his universe, then man, by virtue of the principle of creation from nothingness and disappearance into nothingness (which we are forced to set), could redefine his universe in harmony with his creative essence, such as an environment he could bestow upon himself.
- ☐ *Summary : (Section)* -
  - ☐ *Xenakis is summarizing human knowledge as a totality of our species existence. Music is a creation that has originated from humanities imagination and can redefine our perceptions of existence.*

- ⊟ **IN MUSIC**
  - ☑ In the following comments, the points of view on time are taken from music in gestation or under observation. This is not to say that my preceding comments do not concern the musician. On the contrary, if it is incumbent on music to serve as a medium for the confrontation of philosophic or scientific ideas on the being, its evolution, and their appearances, it is essential that the composer at least give some serious thought to these types of inquiry.
  - ☐ Furthermore, I have deliberately not approached the psychological apprehension of time from higher levels, for example, the effects of the temporal dynamic experience while listening to a symphony or to electronic music.
  - ☐ What is time for a musician? What is the flux of time which passes invisibly and impalpable? In truth, we seize it only with the help of perceptive reference-events, thus indirectly, and under the condition that these reference-events be inscribed somewhere and do not disappear without leaving a trace. It would suffice that they exist in our brain, OUT memory. It is fundamental that the phenomena-references leave a trace in my memory, for if not, they would not exist. Indeed, the underlying postulate is that time, in the sense of an impalpable, Heraclitian flux, has signification only in relation to the person who observes, to me. Otherwise, it would be meaningless. Even assuming the hypothesis of an objective flux of time, independant from me, its apprehension by a human subject, thus by me, must be subject to the phenomena-reference of the flux, first perceived, then inscribed in my memory. Moreover, this inscription must satisfy the condition that it be in a manner which is well circumscribed, well detached, individualized, without possible confusion. But that does not suffice to transform a phenomenon that has left traces in me into a referential phenomenon. In order that this trace-image of the phenomenon become a reference mark, the notion of anteriority is necessary. But this notion seems to be circular and as impenetrable as the immediate notion of flux. It is a synonym. Let us alter our point of view, if only slightly. When events or phenomena are synchronic, or rather, if all imaginable events were synchronic, universal time would be abolished, for anteriority would disappear. By the same token, if events were absolutely smooth, without beginning or end, and even without modifications or "perceptible" internal roughness, time would likewise find itself abolished. It seems that the notion of separation, of bypassing, of difference, of discontinuiity, which are strongly interrelated, are prerequisite to the notion of anteriority. In order for anteriority to exist, it is necessary to be able to distinguish entities, which would then make it possible to "go" from one to the other. A smooth continuum abolishes time, or rather time, in a smooth continuum, is illegible, inapproachable. Continuum is thus a unique whole filling both space and time. We are once again coming back to Parmenides. Why is space included among those things that are illegible? Well, because of its non-roughness. Without separability, there is no extension, no distance. The space of the universe would find itself condensed into a mathematical point without dimensions. Indeed, Parmenides' Being, which fills all space and eternity, would be nothing but an absolutely smooth "mathematical point."
  - ☐ *Insights : (Thesis)* -
    - ☐ *Xenakis discusses the nature of time. He discusses the material quality of time as elusive and immaterial. Xenakis however sees music as away to define time as reference-events. How music depending on events and pattern can define time? His definition does not incorporate time and human perception, it postulates how music can leave traces of definition and form. How these traces form the building blocks describing the mechanics of time?*
    - ☐ *Referential Phenomenon, Reference-events, Trace-image, Reference mark*
    - ☐ *Xenakis seems to draw the conclusion that Music composition will to draw interior images that reference nature and that will be formulated by the alien sounds that contradict human constructed compositional rules*
    - ☐ *The association with memory and space are drawn clear and the anteriority will need to be marked through a pattern of separation, bypassing, difference and discontinuity.*
  - ☐ *Vocabulary:* -
  - ☐ Let us get back to the notion of separability, first in time. At the least, separability means non-synchronisation. We discover once again the notion of anteriority. It merges with the notion of temporal ordering. The ordering anterioity admits no holes, no empty spaces. It is necessary for one separable entity to be contiguous with the next, otherwise, one is subject to a confusion of time. Two chains of contiguous events without a commmon link can be indifferently synchronous or anterior in relation to each other; time is once again abolished in the temporal relation of each of the universes represented by the two chains. On the contrary, local clocks serve as chains without gaps, but only locally. Our biological beings have also developed local clocks but they are not always effective. And memory is a spatial translation of the temporal (causal) chains. We will come back to this.
  - ☐ *Important : (Concept)* -
    - ☐ *Separability means non-synchronization.*
  - ☐ I have spoken of chains without gaps. At the moment and to my knowledge, local gaps have not yet been discovered in sub-atomic physics or in astrophysics. And in his theory of the relativity of time, Einstein tacitly

accepts this postulate of time without gaps in local chains, but his theory also constructs special chains without gaps between spatially separable localities. Here, we are definitely not concerned with the reversibility of time which was partially examined above in light of recent discoveries in sub-atomic physics, for reversibility would not abolish time.

- ☐ Let us examine the notion of separability, of discontinuity in space. Our immediate consciousness (a mental category?) allows us to imagine separated entities which, in turn, necessitate contiguity. A void is a unity in this sense, contrarily to time, in which our inherited or acquired mental notions bar us from conceiving the absence of time, its abolition, as an entity sharing time, the primordial flux. Flux either is, or is not. We exist, therefore it is. For the moment, one cannot conceive of the halting of time. All this is not a paraphrase of Descartes or better yet, of Parmenides: it is a presently impassable frontier. (But certainly, by using Parmenides once more, passable: -- See Article : -- .
- ☐ *Ask JKM - about the above*
  - ☐ *What is the notion of flux for Xenakis? How does he define it? Having simultaneity of matter & time?*
- ☐ To get back to space, the void can be imagined as a dwindling of the entity (phenomenon) down to an infinitesimal tenuousness, having no density whatsoever. On the other hand, to travel from one entity to another is a result of scale. If a person who voyaged were small, the person would not encompass the totality of entities, the universe at once. But if this person's scale were colossal, then yes. The universe would offer itself in one stroke, with hardly a scan, as when one examines the sun from afar.
- ☐ The entities would appear, as in a snapshot, reunited in a dense network of nontemporal contiguities, uninterrupted, extending through the entire universe. I said, in a snapshot. This is to say that in the snapshot, the spatial relations of the entities, the forms that their contiguities assume, the structures, are essentially outside time (hors-temps). The flux of time does not intervene in any way. 'That is exactly what happens with the traces that the phenomenal entities have left in our memory. Their geographical map is outside time.
- ☐ Music participates both in space outside time and in the temporal flux. Thus, the scales of pitch; the scales of the church modes; the morphologies of higher levels; structures, fugal architectures, mathematical formulae engendering sounds or pieces of music, these are outside time, whether on paper or in our memory. The necessity to cling against the current of the river of time is so strong that certain aspects of time are even hauled out of it, such as the durations which become commutable. One could say that every temporal schema, pre-conceived or post-conceived, is a representation outside time of the temporal flux in which the phenomena, the entities, are inscribed.
- ☐ Due to the principle of anteriority, the flux of time is locally equipped with a structure of total order in a mathematical sense. That is to say that its image in our brain, an image constituted by the chain of successive events, can be placed in a one-to-one correspondance with the integers and even, with the aid of a useful generalization, with real numbers (rational and irrational). Thus, it can be counted. This is what the sciences in general do, and music as well, by using its own clock, the metronome. By virtue of this same structure of total order, time can be placed in a one-to-one correspondence with the points of a line. It can thus be drawn.
- ☐ This is done in the sciences, but also in music. One can now design temporal architectures-rhythms-in a modern sense. Here is a tentative axiomatization of the temporal structures placed outside of time:

  1. We perceive temporal events.

  2. Thanks to separability, these events can be assimilated to *landmark points* in the flux of time, points which are instantaneously hauled up outside of time because of their trace in our memory.

  3. The comparison of the *landmark points* allows us to assign to them distances, intervals, durations. A distance, translated spatially,

  can be considered as the displacement, the step, the jump from one point to another, a nontemporal jump, a spatial distance.

  4. It is possible to repeat, to link together these steps in a chain.

  5. There are two possible orientations, one by an accumulation of steps, the other by a de-accumulation.

- ☐ From here, we can construct an object which can be represented by points on a line, evenly spaced and symbolized by the numeral 1 with index zero: 10 = (..., -3,-2,-1,0,1,2,3,...). This is the regular rhythm, corresponding to the whole numbers. As the size of the step is not defined in the preceding propositions (recalling Bertrand Russell's observation concerning Peano's axiomatic of natural numbers[II]), we can affix to the preceding object the following objects which I call "sieves," by using solely proposition 4:

  20 = {...,-4,-2,O,2,4,6,...} or 2} = {...,-3,-1,1,3,5,...} or 3_0 = { ...,-3,O,3,6,9,...} or 3} = { ...,-5,-2,1,4,7,...} or 3_2 = {...,-4,-1,2,5,8,...}etc...
- ☐ From these objects and their modular nature, and with the help of these three logical operations:

  union, disjunction ; intersection, conjunction ; complementarity, negation --See Article : --
- ☐ we can construct logical functions L-that is to say, very complex rhythmic architectures which can even go as far as a random-like distribution of points on a line-if the period is sufficiently long. The interplay between complexity and simplicity is, on a higher level, another way of defining the landmark points, which certainly plays a fundamental role in aesthetics, for this play is juxtaposed with the pair release/tension.

Formalized Music: Thought and Mathematics in Music Ch. 10 Concerning Time, Space and Music pp. 255-267 by Iannis Xenakis (1963)

Links:

Example of a logical function *L:* --*See Article :* --

The upper-case letters designate moduli and the subscripts designate shifts in relation to a zero point of reference.

- ☐ Up to this point, we have examined time perceived by means of our faculties of attention and conscious thought-time on the level of forms and structures of an order ranging from tens of minutes to approximately one twenty-fifth of a second. A stroke of the bow is a referrential event that can define durations of a fraction of a second. Now, there are some subliminal events found on several even lower levels. Such an example is that of the temporal segmentation produced by a very choppy amplitude envelope on the sound of an unvarying sinusoidal wave form. If the duration of the note is long (about one minute), we perceive the rhythms of the beats as pleasant. moving vibratos. If the duration is relatively short (three seconds), the ear and the brain interpret it as a timbre. That is to say that the result of subliminal, unconscious counting is different in nature and is recognized as timbre.
- ☐ *Important : (Concept)* --
  - ☐ *Xenakis outlines factual understanding of sound events and the differences in human perception ranging from minutes (beats are pleasant) to seconds (the brain recognizes it as timbre). A precursor to microsound.*
- ☐ Let us take a brief moment to consider the mechanism of the internal ear coupled with the brain which recognizes the wave form-that is to say, the timbre-and the frequency of a sound. On the one hand, it seems that the points of deformation of the basilar membrane playa fundamental role in the recognition; but, on the other hand, a sort of temporal Morse code of electrical discharges of neurons is taken statistically into account for the detection of tone. A remarkably complex subliminal counting of time is taking place. But knowledge of acoustics in this domain is still very limited.
- ☐ On this subliminal level, here is another disconcerting phenomenon. It is the result of a new theory on the synthesis of computer sounds which circumvents the harmonic synthesis of Fourier, practiced everywhere today, a theory which I introduced now more than fifteen years ago.12 It is a question of beginning with any form whatsoever of an elementary wave, and with each repetition, of having it undergo small deformations according to certain densities of probabilities (Gauss, Cauchy, logistic,...) appropriately chosen and implemented in the form of an abstract black box. The result of these deformations is perceptible on all levels, microstructure (= timbre), ministructure (= note), mesostructure (= polyrhythm, melodic scales of intensities), macrostructure (= global evolution on the order of some tens of minutes).
- ☐ If the rate of sampling had been 1,000,000 or 2,000,000 samples per second instead of approximately 44,100 (commercial standard), one would have had an effect of sounding fractals, with a sonorous effect which is impossible to predict.
- ☐ *Important : (Concept)* --
  - ☐ *Xenakis re emphasizes his conceptualizing of sound structures through deformations in the densities of probabilities (Gauss, Cauchy, logistic). The results of these deformations are perceived at all levels of the composition (microstructure (= timbre), ministructure (= note), mesostructure (= polyrhythm, melodic scales of intensities), macrostructure (= global evolution on the order of some tens of minutes).*
- ☐ We see to what extent music is everywhere steeped in time: (a) time in the form of an impalpable flux or (b) time in its frozen form, outside time, made possible by memory. Time is the blackboard on which are inscribed phenomena and their relations outside the time of the universe in which we live. Relations imply architectural structures, rules. And, can one imagine a rule without repetition? Certainly not. I have already treated this subject. Besides, a single event in an absolute eternity of time and space would make no sense. And yet, each event, like each individual on earth, is unique. But this uniqueness is the equivalent of death which lies in wait at every step, at every moment. Now, the repetition of an event, its reproduction as faithfully as possible, corresponds to this struggle against disappearance, against nothingness. As if the entire universe fought desperately to hang on to existence, to being, by its own tireless renewal at every instant, at every death. The union of Parmenides and of Heraclitus. Living species are an example of this struggle of life or death, in an inert Universe launched perhaps by the Big Bang (is it really inert, that is, without any changes in its laws?). This same principle of dialectical combat is present everywhere, verifiable everywhere. Change-for there is no rest-the couple death and birth lead the Universe, by duplication, the copy being more or less exact. The "more or less" makes the difference between a pendular, cyclic Universe, strictly determined (even a deterministic chaos), and a nondetermined Universe, absolutely unpredictable and chaotic. Unpredictability in thought obviously has no limits. On a first approach it would correspond to birth from nothingness, but also to disappearance, death into nothingness. At the moment, the Universe seems to be midway between these two chasms, something which could be the subject of another study. This study would deal with the profound necessity for musical composition to be perpetually original-philosophiocally, technically, aesthetically.13
- ☐ In what follows and as a consequence of the preceeding axioms, we will study in greater detail the practical questions of how to create a sieve (= series of points on a line), beginning from a logical function of moduli (periods), or inversely, from a series of points on a line, how to create a logical function of moduli which should be able to engender the given series. This time, we shall use series of "pitches" taken from musical space.
- ☐ *Summary : (Section)* --
  - ☐ *Xenakis discusses music in relation to space-time. His assertion that time holds everything together and the ways one can inscribe meaning in time through composition creates a contrast of what is actually manufacture red outside of the natural laws. The creation of works in the compositions process is the ability to use all elements of sound, time and the biological knowledge of the mechanics of hearing. Human perception is constructed by space-time, and the imbedding of sound entities that distrust the continuity of space.*

- ⊟ _Outline (Summary)
- ☐ _References (Additional)
  - ☐ Book:
    - ☐ Online Resources:
      - ☐ Iannis Xenakis: His Life in Music by James Harley [online supplement]

Formalized Music: Thought and Mathematics in Music Ch. 10 Concerning Time, Space and Music pp. 255-267 by Iannis Xenakis (1963)

Links:

- ☐ Interviews
  - ☐ Xenakis:
    - ☐ Iannis Xenakis English interview with German subtitles. Includes extracts of interviews with Volker Banfield Heinz Otto Peitgen.
    - ☐ Part 1: www.youtube.con
    - ☐ Part 2: www.youtube.con
- ☐ Symposiums:
  - ☐ Random Walks Music of Xenakis and Beyond: 2013
    - ☐ The Random Walks Festival celebrates the works and ideas of Iannis Xenakis, who was a pioneer of electronic and computer music. His work in music composition and architectural design integrates techniques from probability and game theory.
  - ☐ Speakers:
  - ☐ Sharon Kanach: The Era of Scientific and Philosophical Arts has Begun www.fields.utoron
    - ☐ Sharon Kanach — "The era of scientific and philosophical arts has begun."— Iannis Xenakis www.youtube.con

      Iannis Xenakis (1922–2001) is one of the most protean creators of the past century: trained as a civil engineer, turned architect under Le Corbusier, composer of music that deliberately turned its back on tradition, pioneer in electronic and computer-generated music, and trailblazer for the philosophy and realization of trans-disciplinary art. In addition, his past as an active Resistance fighter and leader during the Greek Civil war and World War II left indelible traces not only on his handsome face but also on his psyche, shifting his personal battle into the field of ideas. This talk aims to show how this “ancient Greek born in the XXth century” has transformed/influenced the evolution of music through his integration of subjects generally considered outside of composition (including mathematics) into his works. An ulterior motive of this talk is to bring a human face to the author of titles such Formalized Music and Arts/Sciences: Alloys by one of his closest collaborators during the last twenty years of his life.
  - ☐ James Harley: Xenakis: Stochastics to Sieves to Random Walks www.fields.utoron
    - ☐ Early in his compositional activity, Iannis Xenakis applied “stochastics” to music, applying probability functions adapted from engineering analysis to generative processes (1955-1962). After developing his Fundamental Phases of Music Composition he programmed a computer algorithm to generate musical score data where most decisions were generated by stochastic processes. After producing a series of “ST” compositions, he turned his attention to deterministic processes (1963-1967). Xenakis pursued two main areas of theoretical research: sieves, and groups. The application of sieves to music provided him with the means to create ordered values to form a pitch scale or a rhythmic pattern. He used logical operations to generate the materials and to transform them (metabolae). Group theory provided a basis for organizing musical form, generating successions of defined elements by means of pre-determined relationships. www.youtube.con

      While continuing to draw upon both stochastic and deterministic processes in his music, Xenakis turned to “random walks” (based on Brownian motion) as a new means of generating melodic material or linear structures based on glissandi. As an extension of the random walk, he used transformation processes to create related linear structure, sometimes bundled into ensemble he termed “arborescences.” From the early 1970s, Xenakis drew upon all of these mathematically-derived compositional techniques throughout the rest of his career (his last works date from 1997). The only new procedure he explore later was the application of cellular automata to music (1986).
  - ☐
  - ☐ Daniel Hambleton — Simulation as Inspiration: The Interdisciplinary Work of Iannis Xenakis www.fields.utoron
    - ☐ The simulation of scientific phenomena, visual or otherwise, can often yield crucial insights into the relationship between seemingly disparate sets of data. As useful as this is for scientific purposes, the act of simulation itself can also be extraordinarily beautiful. Throughout the work of Xenakis, architect and engineer, mathematician and composer, such technical simulations are instrumental in achieving the “formalized” music that Xenakis was dedicated to developing. In this talk, we will focus on following the interdisciplinary threads of Xenakis’s career by identifying and experimenting with ruled surfaces, stochastic methods, and game theory. Xenakis's representation of these scientific phenomena in his compositions and structures will then emerge as a balancing act between freely creative gestures and technically rigorous underpinnings; a combination that has resulted in a truly remarkable body of work. www.youtube.con
  - ☐ Symposium Summary:
    - ☐ In each of the lecture Iannis Xenakis's history, process, methodology and music were explained in detail. The subjects ranged from History and techniques to the application / translation using current technologies (software).

      The links of Art, Science and Technology are credited with Xenakis as a seminal figure to combining the interdisciplinary arts. Xenakis started his studies as an structural engineer and then studied composition, programming while working for Le Corbusier. The methodology of using probability functions to solve structural problems in form was incorporated in the compositional process. His use of mathematical principles as the generator of compositions and sound forms unified his practice to the study of natural phenomenon. The unification of time and space is also collapse with his analysis / experimental with the material of the instrument with its limitation and the material of sound. Sound is used not only as individual accents to a musical work but also in combination to create unified sound forms that reflect that dynamic sound quality of movement and flow of the work. The timbre, pitch (frequency), intensity and duration are used to create a new order of sound that is beyond serialism and that mimics and reflects natural processes found in nature. Mathematics and science drives the reaffirmation of the theory that goes beyond human invention and tries to create a parallel mimicry of universal laws that define the perceived universe.
- ☐ Advisor/Committee Member (Notes) - JKM
  - ☐ Instructions:
    - ☐ To factually understand the content of the articles.
    - ☐ Have a command of the facts
    - ☐ Be able to site examples.
  - ☐ Meeting Summary:
- ☐ Global Outline Summary: Final Draft

Composing Electronic Music: A New Aesthetic: 08: Articulating Space by Curtis Roads **Links**

- ☐ Date:
  - ☐ 050114
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  - ☐ Terms
    - ☐ Vector Base Amplitude Panning: (VBAP) www.acoustics.hu
    - ☐ Ambisonics: en.wikipedia.org–
    - ☐ High Order Ambisonics flo.mur.at—HOA-i
    - ☐ Wave field synthesis www.holophony.n
    - ☐ en.wikipedia.org–
    - ☐ Holophony: www.syntheticwa
- ☐ _Glossary
  - ☐ References
- ☐ _Objectives
- ⊟ _Outline: (Notes)
  - ⊟ **Introduction: (pg. 03)**
    - ☑ To project in space is to choreograph sound: directing sources and animating movement.
    - ☐ Recorded sounds articulate the space in which they were captured, but we can also compose virtual spatial characteristics for sound.
    - ☐ Reasoning about spatial relationships is fundamental to human intelligence (Piaget and Inhelder 1967).
    - ☐ Spatial perception is tightly integrated in the mind with both thought and action (Blauert 1997; Kendall 2010)
    - ☐ Our body moves in space and must be aware at all times of tis position in accordance with everything around it. Our mind needs to be able to recall (through spatial memory) the location of innumerable things, whether in physical space (e.g., our home) or virtual space(e.g., the location of a file).
    - ☐ We not only compute space, we feel it. Spatial experiences can be emotionally moving,
    - ☐ We react to choreography, the movement of sound reconnects us to the ream of Kinesthetic experiences.
    - ☐ Decades of experimentation have proven that spatial choreography is intrinsically interesting and meaningful to audiences. As a result, spatialization in the 21st century has assumed a newfound significance. Indeed, the spatial structure of a composition may be of equal or greater aesthetic importance than its organization in terms of pitch, rhythm, or timbre. As James Dashow (2013) observed:

      One could say that up to now, musical composition has been largely a question of What happens When. With spatialization, composition now becomes What happens When and Where. As more work is done to refine spatialization concepts and discover new modes of musical thinking in terms of space, it becomes clear that spatialization is our genuinely new contribution to musical art
    - ☐ Although a formal theory of spatial relations remains to be developed, the practice of spatialization is becoming more sophisticated. This is due to increased awareness of the importance of spatial presentation of electronic music. Out of this awareness has come greater investment in pluriphonic sound systems, and increasingly elaborate software for spatial sound manipulation.
  - ☐ **History of spatialization in instrumental/vocal music** (pg. 4)
    - ☐ The earliest published works using space as a compositional element date from 1599's Willaert's works for two spatially separated organs and choirs at the Basilica San Marco in Venice).
    - ☐ ...polychoral music, in which an ensemble or chorus is divided into two or more groups (Apel 1972).
    - ☐ Little documentation of spatial techniques in composition until the post - WW!I era.
    - ☐ Henry Brant .. Starting in 1950, … began writing instrumental music in which the position of the performers in the hall, as well as on stage, was an essential factor in the composing scheme. Bryant's Antiphony I (1953) called for five spatially separated orchestras. His catalog comprises over one hundred such works, each for a different instrumentation, each requiring a different spatial deployment in the hall, and with maximum distances between groups prescribed in every case (Jaffe 2005).
    - ☐ (Brant 1967); Harley 1998), and I paraphrase, spatialization serves fundamental compositional functions:

Composing Electronic Music: A New Aesthetic: 08: Articulating Space by Curtis Roads **Links**

- ☐ Spatial separation clarifies the texture; this is particularly important if the music consist of several different layers located in the same pitch register.
- ☐ Spatial separation is equivalent to the separation by register or timbre. That is, just as one can hear separately layers of music that are located in different registers, one can also differentiate layers that originate from different points in space.
- ☐ Spatial separation facilitates greater complexity in the music; more unrelated elements can be heard simultaneously.
- ☐ Other composers, such as Stockhausen, Xenakis, and Serocki occasionally deployed spatially separated instrumentalists in the 1950's and 1960's (Harley 1998).
- ☐ For example, Stockhausen's Gruppen (1957) and Carré (1960) featured three and four spatially separated orchestras, respectively. Gérard Grisey's Tempus ex machina (1979) featured six spatially separated percussionists (Grisey 1987). These experiments were exceptional, however. Composed spatialization remains something of a novelty in instrumental/vocal literature, and was never absorbed into pedagogy or common practice.
- ☐

- ☐ **History of spatialization in electronic music** (pg. 5)
  - ☐ When we record a sound source, we inevitably capture the spatial environment in which it is recorded. This is because recorded sound is a double convolution; it represents the convolution of an acoustic event with the impulse response of the space in which the event takes place, further convolved by the impulse response of the microphone setup and recording device (Roads 1997b). Early recordings were monaural; today, stereo and surround recording are the norm. (1) Suffice it to say that the choice of where and how to record a given sound allows many technical and aesthetic options. Thus a recording can be spatially composed through the choice and placement of microphones (Barrett 2008).
  - ☐ Dual to the microphone is the loudspeaker. The invention of the loudspeaker in the 1920s can be compared to the invention of the electric light bulb. Suddenly it was possible to project sonic energy in spaces small and large, at any angle or intensity. But the use of loudspeakers, in movie theaters, stadiums, railroad stations, phonographs, and home radios, remained plain and functional. Only by the 1950s, with the dawn of the first theories of electronic music, did composers begin to exploit the aesthetic possibilities of sound projection via loudspeakers.
  - ☐ Electroacoustic technology (amplifiers, loudspeakers, tape recorders, etc.) greatly expanded the potential of sound spatialization, permitting recorded spaces to be convolved with loudspeaker projection in physical halls. This section gives capsule descriptions of historically important examples of spatialization in electronic music, from the 1950s to the present.
  - ☐ **Artificial reverberation by mechanical means** (pg. 6)
    - ☐ The lush spatial effect of artificial reverberation is characteristic of the electronic medium. Early recordings used a real physical space as a natural reverberation chamber. Spring reverberators in electric organs date to the 1940s (Hammond 1941) and were later common in guitar amplifiers. In the 1950s, Elektro-Mess-Technik (EMT) introduced the massive (2.4 meters long, 200 kg) model 140 plate reverberator, a much higher quality reverberator, renowned for its concert hall characteristics. Plate reverberators consist of a large thin piece of sheet metal suspended from a steel frame by springs at each corner. An electrical transducer mounted on the center of the suspended plate induces plate movement, which creates the effect. Pickups mounted on the plate capture the effect. Equipped with vacuum tube electronics, these units were installed in early electronic music studios such as the historic WDR studio in Cologne, where Stockhausen realized many of his electronic pieces, and the Columbia-Princeton Electronic Music Studio. Many of the early pieces from the Columbia-Princeton Studio are suffused with plate reverberation, which was then an exotic technique. A typical example is Out of Into (1972) by Bulent Arel and Daria Semegen.

      --See Figures : --

      The classic EMT 140 impulse response is still modeled by software reverberation emulators and marries well with electronic sonorities.
  - ☐ **Artificial reverberation by digital means:**
    - ☐ Dr. Manfred R. Schroeder of the Bell Telephone Laboratories was the first to implement an artificial reverberation algorithm on a digital computer (Schroeder 1961, 1962; Schroeder and Logan 1961). His designs used a combination of multiple time delays, filters, and mixing to achieve the illusion of sound scattering within a room. Schroeder (1970) later extended his original reverberation algorithms to incorporate a multitap delay line to simulate the early reflections that are heard in a hall before the outset of the fused reverberant sound. Thus to simulate a particular concert hall, a straightforward way to improve the basic model is to graft the measured early reflection response of the hall onto the generic global reverberator.
    - ☐ In the 1960s and 1970s, reverberation algorithms soaked up hours of computation time on the behemoth mainframe computers of the epoch. Modern algorithmic reverberators based on Schroeder's model run in real time. (The Lexicon line of products such as the 300L and the PCM96 are classic examples of Schroeder-type reverberators.) Control knobs and buttons on their front panels let musicians dial up a variety of effects.

      Convolution reverberators **********
  - ☐ **Spatialization of musique concrète (1951-52):**

- ☐ The first concert of musique concrète in 1950 resembled we might call live electronics, using multiple turntables mixed in real time (Harrison 1998). By 1951, Pierre Schaeffer and his colleagues shifted to the medium of magnetic tape for concert playback. However, even in this "fixed" medium of tape playback, a device called a *space potentiometer* introduced a live spatialization element. The space potentiometer consisted of four metal hoops manipulated by a sound projectionist (Pierre Henry) onstage, which distributed a sound track to any of the four loudspeakers in the hall (Poullin 1957). This spatially moving track accompanied another four tracks that were distributed to individual loudspeakers (Manning 2004).

- ☐ **Cage and Tudor's sound installations (1951-1973):**
  - ☐ In the 1950s, John Cage created a number of installations involving multiple sources of sound. In these sound art installations, spatialization is achieved by having each member of the audience navigate freely through the gallery; in effect, each visitor creates their own performance. For example, Cage's Imaginary Landscape No. 4 (1951) deploys twelve radio receivers. Williams Mix (1952), realized at the New York studios of Louis and Bebe Barron, featured eight monaural tapes, each playing through its own loudspeaker (Zvonar 2005). Together with David Tudor, Cage realized Variations IV (1965) in which multiple tape machines played back from locations inside and outside a Los Angeles gallery. Other multiple- source installations included Cage's HPSCHD (1969) and Tudor's Rainforest (1973), which featured multiple sound transducers in settings in which the audience circulated freely.
- ☐ **Stockhausen's *Gesang der Jünglinge* (1956) and *Kontakte* (1960):**
  - ☐ Karlheinz Stockhausen's composition *Gesang der Jünglinge* was projected in a 1956 concert over five groups of loudspeakers in the auditorium of the West German Radio (Stockhausen 1961). His opus *Kontakte*, realized in 1960, was performed with the world's first commercial four-track tape recorder, the Telefunken T9 (Stockhausen 1968).
- ☐ **The Philips Pavilion, Brussels (1958):**
  - ☐ **CEM_Figure_8_1_CRoads**
  - ☐ In 1958 Edgard Varèse's classic tape music composition *Poème Electronique* and Iannis Xenakis's *Concret PH* were projected over 400 loudspeakers (2) through an eleven-channel sound system installed on the curved walls of the Philips Pavilion (Figure 8.1). In a letter to Xenakis, Varèse (1958) observed:

    Since my music is based principally on the movement of unrelated sound masses, I have always sensed the need to move them simultaneously at different speeds and always hoped for this effect. And yet such a thing is possible. The very complex electronic [spatializer] device of the Philips Pavilion has demonstrated this in a striking way

    The Philips Pavilion was designed by Xenakis for Le Corbusier at the Brussels World's Fair (Xenakis 1971, 1992, 2008; Treib 1996). (Remarkably, the shape of the building is a direct mapping of the glissandi in the score of Xenakis's *Metastasis* (1954) for string orchestra.) For the spatialization of sounds, Philips engineers built a switching system so that the sounds would travel on programmed "sound routes" during the performance (Figure 8.2).
  - ☐ Edgar Varese - Poeme Electronique — www.youtube.con
  - ☐ Iannis Xenakis - Concret PH — www.youtube.con
  - ☐ VEP - Phillips Pavillion documentary — www.youtube.con
  - ☐ CEM_Figure_8_2_CRoads
  - ☐ The *Poème Electronique* was accompanied by a film of images chosen by Le Corbusier. Some two million visitors experienced this sound-and-light spectacle (Ouelette 1989).
- ☐ **Vortex Concerts, San Francisco and Brussels (1957-59):**
  - ☐ The Vortex Concerts (1957-1959) at the Morrison Planetarium in San Francisco featured visuals by Jordan Belson and music by Stockhausen, Ussachevsky, Takemitsu, Berio, and others projected via 38 loudspeakers (Horton 1996; Zvonar 2005).
  - ☐ *The elements of Vortex are sound, light, color, and movement in their most comprehensive theatrical expression. These audio-visual combinations are presented in a circular, domed theater equipped with special projectors and sound systems. In Vortex there is no separation of audience and stage or screen; the entire domed area becomes a living theater of sound and light. With the thirty-eight high-fidelity speakers, actual movement and gyration of sound was made possible by means of a special rotary console. Utilizing the elaborate Planetarium lighting system along with special projectors, coordinated full-scale visual effects gave promise of an exciting new form of theater. The premiere of Vortex on May 28, 1957 to a capacity audience established this audio-visual experiment as a true theater of the future with a potential for directly reaching an audience with unique sensory experiences not based on the customary*

> *story, music, or entertainers. Vortex is direct. There is no age, linguistic nor aesthetic barrier to experiencing Vortex. – Program notes for Vortex 4 (quoted in Horton 1996)*

For the visuals, several projectors of various types were operating simultaneously so images from a variety of sources could be superimposed. Vortex ran for 100 performances including a stint at the 1958 Brussels World's Fair (Brougher 2005).

- ☐ **AUDIUM Theater, San Francisco (1960s-present):**
  - ☐ In the 1960s, Stanley Shaff and Douglas McEachern mounted a series of concerts based on the notion of the space audium: "An electronic music concert...conceived and executed as movement through space." This eventually led to the construction of a special AUDIUM Theater in San Francisco that has been giving regular spatial music concerts since 1967 (AUDIUM 2008).
- ☐ **Spatial music at EXPO 70 Osaka:**
  - ☐ EXPO 70 featured three major spatial sound systems. First, Karlheinz Stockhausen played his electronic music for 183 days over 55 Siemens loudspeakers distributed in seven rings on the interior surface of the geodesic dome of the German pavilion at EXPO 70 in Osaka (Stockhausen 1971a). Meanwhile, over in the Japanese Steel pavilion, Iannis Xenakis performed his twelve-channel electroacoustic composition Hibiki Hana Ma on a system of 800 loudspeakers distributed in 250 groups around the audience, over their heads, and under their seats (Matossian 1986; Xenakis 2008). At the same time, the Pepsi Cola pavilion at EXPO 70 featured a dome with 37 loudspeakers that could be driven by up to 32 sources: 16 line sources and 16 microphones. The project was curated by Experiments in Art and Technology (EAT), an organization promoting collaborations between artists and engineers.
- ☐ **Martirano's Sal-Mar Construction (1971-72):**
  - ☐ Beginning in 1969, the composer Salvatore Martirano and a team of engineers at the University of Illinois built a complex apparatus out of digital circuits (not a general-purpose computer in the conventional sense) called the Sal-Mar Construction. This interactive device controlled a custom analog synthesizer and distributed the sound in 24 channels to up to 250 Poly-Planar (styrofoam) loudspeakers suspended at various heights from the ceilings of venues.
- ☐ **Xenakis's *Polytope de Cluny*, Paris (1972-73)**
  - ☐ A twelve-channel sound system animated Xenakis's computer-controlled sound-and-light spectacle Polytope de Cluny, projected on the interior of the ancient Cluny Museum in Paris (Xenakis 1975, 1992; 2008). The spectacle ran for sixteen months and was experienced by over 200,000 people, including the author of this book, upon whom it made a deep impression. (3)
  - ☐ CEM_Figure_8_3_CRoads
- ☐ **The orchestra of loudspeakers (1973-1974):**
  - ☐ In early concerts of electronic music, the design of the theatrical presentation and spatial projection were often neglected. As François Bayle (1989) observed:

    > *A theater, an empty stage, unflattering lighting, a few loudspeakers placed sadly in the corners, an accumulation of heterogeneous technical equipment, this is the caricature of an acousmatic concert on a small budget, thrown together hastily the day of the concert, thus revealing the difficulty of being true to experimental initiatives, as well as the mediocrity of the dialog between art and technique.*

    Recognizing the need for more organized design of public concerts, Christian Clozier and his colleagues at the Groupe de Musique Expérimentale de Bourges (GMEB), developed the idea of projecting sound over an orchestra of dozens of loudspeakers on stage and around the audience (Clozier 1997, 2001). This concept was first realized in the elaborate Gmebaphone, an orchestra of loudspeakers first heard in concert in 1973, with spatial projection performed manually by composers. The first concert of a similar configuration called the Acousmonium– an assemblage of dozens of "sound projectors" on stage by the Groupe de Recherches Musicales (GRM)–took place at the Espace Cardin, Paris, in 1974 (Bayle 1989, 1993). As we see in the next section, the idea of an orchestra of loudspeakers has since taken hold around the world.
- ☐ **Computer-controlled spatialization (1971-present):**
  - ☐ Edward Kobrin's HYBRID synthesizer consisted of a digital computer controlling an analog synthesizer. As early as 1971, it was distributing sound to sixteen independent loudspeakers in the composer's living room in Urbana, Illinois (Kobrin 1977). John Chowning (1971) was the first to develop software for spatialization with Doppler shift (simulation of angular velocity as a sound moves around a listener) in conjunction with a purely digital reverberator modeled after Schroeder's original design (Schroeder 1962). Chowning showcased 360-degree quadraphonic spatialization in his composition Turenas (1972), which also pioneered the use of frequency modulation (FM) synthesis.

    The first hardware digital synthesizer to exploit pluriphony was the SSSP sound distribution system at the University of Toronto (Federkow et al. 1978). In 1987, researchers at Luciano Berio's Tempo Reale studio (Florence) developed a computer-based sound distribution system called Trails that could distribute sound to up to 32 audio channels, combining preprogrammed and real-time spatial patterns (Bernardini and Otto 1989). Since then, a variety of other computer-controlled multichannel sound spatialization systems have been developed, including the Halaphon (Freiburg) used by Luigi Nono, GRAME's Sinfonie (Lyon), the BEAST (Birmingham), Simon Fraser University's AudioBox, the Recombinant Media Lab's Cinechamber (San Francisco), the ZKM Klangdom (Karlsruhe), our own Creatophone and Allosphere (Santa Barbara) among many others.

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The market for spatial sound systems continues to grow and a multitude of software applications and plugins are available. At the same time, spatial sound has invaded the world of electronic art; it is now common to find gallery installations and sculptures that deploy distributed loudspeakers. The physicality of spatial sound is often a theme in these works. Multichannel sound systems have also become integral to many popular entertainment spectacles. For example, some cinemas are installing immersive sound systems to complement their 3D video projection systems (Jackson 2010). In outdoor venues, pluriphonic sound has been featured theatrically with accompanying light and water spectacles (McLean 1999).

- ☐ **Michel Redolfi's underwater concerts (1981-present):**
  - ☐ In the late 1970s, the Center for Music Experiment and the Scripps Institute of Oceanography at the University of California, San Diego sponsored research by Michel Redolfi on broadcasting music underwater, a unique spatial environment. In 1981, he presented Sonic Waters in the Pacific, the first concert in history where music was played underwater for a large audience floating on the surface or submerged with scuba gear. Sound behaves differently in the medium of water, traveling 4.3 times faster, and waves within the water modulate the sound. Since that time, Redolfi and others have continued to conduct musical experiments in aquatic spatial environments such as pools, coves, and lakes.

- ☐ **Spatialization on multiple time scales** (pg. 15):
  - ☐ In early electronic music, many compositions were characterized by a global spatial perspective, such as a uniform blanket of reverberation applied to the entire composition. The lushly reverberated Elektronische Impressionen (1978) of the composer Oskar Sala comes to mind. In other works, the spatial impression is more variegated, with reverberation added more selectively, following the contours of particular meso structures. For example, Stockhausen's Kontakte (1960) contrasted sounds in foreground/background relationships on a time scale of phrases.

    Going further, each and every sound can occupy a unique space. Compare the flat perspective of series of monaural electronic tones to a cascade of sounds, each emanating from a unique three- dimensional space, adding the dimension of depth to a phrase. As a phrase unfolds, the position of each sound object articulates a varying topography. Functional oppositions between stationary and moving objects articulate contrapuntal relations.
  - ☐ Spatial organization can be extended … down to the micro layers of sonic structure. For example, our Cloud Generator program fro granular synthesis (Roads and Alexander 1995) positioned each grain in a cloud of hundreds at an individual point in space. This enabled a new and interesting musical effect. Which can be called granular spatial scattering or granular decorrelation. This effect sprays a sound spatially in granular form, while leaving all other aspects of the sound (pitch, duration, timbre) intact. The resulting sound has a three-dimensional width, depth, and spaciousness.
  - ☐ Our Creatovox synthesizer (De Campo and Roads 2003) not only scattered each grain to a unique location, it also reverberated each grain individually (with different reverberation times) over an octophonic sound system in real time. Per-grain reverberation is effective when grain densities are low (no more than a few grains per second). However, as the grain density increases, the texture tends to fuse into a gestalt impression of global reverberation.
  - ☐ **New methods of spatialization based on analysis:** *(pg.16)*
    - ☐ …spatializing sound on multiple time scales. These rely on spectrum analysis techniques that decompose a given sound into a time-frequency (TF) representation. … features in the TF representation, transient events, specific frequency bands, harmonically related components, loud components, short components. The events are then spatialized according to a script of rules.
    - ☐ For example, dictionary based pursuit (DBP) decomposes a sound into a TF representation– essentially a collection of grains that are localized in time and frequency (Sturm et al. 2006, 2008, 2009).
    - ☐ We can parse the TF representation in many ways according to the different properties of the grains, and each parsing provides a basis for a novel spatialization. For example, all transient grains could be scattered in one way, while long grains could be scattered in another. Our Scatter application (Figure 8.3) was an initial proof of concept of spatialization based on TF analysis (Mcleran et al. 2008)
    - ☐ CEM_Figure_8_3b_CRoads
    - ☐ Another analysis technique that could enable such a strategy is the tracking phase vocoder and its extension, spectral modeling synthesis (SMS) (Serra and Smith 1990; Serra 1997; Roads 1996a). SMS reduces the analysis data into a deterministic component (modeled by sine waves) and a stochastic component (modeled by filtered noise). Like DBP, the TF representation generated by SMS can be parsed according to audio features that can be spatialized independently according to a script.

- ☐ **Virtual spaces** (pg. 17)
  - ☐ Sound spatialization presents two facets: the virtual and the physical. In the studio, composers spatialize sounds by imposing delays, spectral filters, phase shifts, convolutions, granulations, panning, Doppler shift and reverberation.
  - ☐ These transformations lend the illusion of sounds inhabiting and moving in imaginary virtual environments.
  - ☐ The spatial possibilities introduced by the technique of convolution are especially intriguing. Specifically, we can take a sound portrait of an existing space such as a concert hall, and through convolution, impose its partial characteristics on any sound, creating the illusion of sound paling in the portrayed space (Roads 1993, 1997z). In the theory of convolution, a sound portrait of a physical space is sampled by recording the response of a room to a sharp impulse. The impulse response of any space, or anything that can make sound for that matter, can be captured and convolved in a in like manner. Digital audio software companies sell collections of hundreds of sampled places, devices, and objects.

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- ☐ **Artificial impulse responses**:
  - ☐ A potent extension of sampling impulse responses is to generate artificial impulse responses by means of particle synthesis techniques (Roads 2001b) This opens the path to an infinite territory of virtual spaces. Many of virtual spaces created in this manner would be difficult or impossible to realize in the physical world. Such as spaces with time-varying echo densities, or the simultaneous presence of different qualities of ambience.
  - ☐ The inverse problem is the auralization of virtual spaces.
  - ☐ What does a given virtual world sound like? How do we derive the impulse response of a virtual environment? Being able to recreate sound propagation in virtual worlds is useful in the design of concert halls as well as synthetic spaces found in games.
  - ☐ Methods drawn from physics can create realistic simulations using beam or ray tracing, which calculate the path of waves in spaces as they encounter absorbing and reflecting surfaces.
- ☐ **Physical spaces** (pg. 18)
  - ☐ A composer works in a specific studio, a physical space with particular dimensions and loudspeaker setup. We must hope that compositions realized in that room will be performed in other physical spaces, from living rooms to concert halls.
  - ☐ The projection of sound in physical space, called spatialization, sound projection, or diffusion is fundamental to the present-day art of electronic music (Clozier 2001; Manning 2004).
  - ☐ The diffusion of sound in a hall intersects virtual spaces in the music with a physical space and a specific playback system.
  - ☐ This intersection creates interplay between the static architecture of the hall and the dynamic virtual acoustics of the music
  - ☐ Physical architecture colors the virtual sound.
  - ☐ The composers need to be aware of these factors:
  - ☐ Room resonances
  - ☐ Room reflections
  - ☐ Room reverberation
  - ☐ Background noise
  - ☐ Loudspeaker type and configuration
  - ☐ Room Resonate at frequencies that depend on their size and geometry.
  - ☐ When projected sound energy hits surfaces, some of it is reflected, some is absorbed, and some is transmitted through the surface. The human body tends to scatter sound like an ellipsoid of same volume; only our clothing absorbs sound (Conti et al. 2003)
  - ☐ ..thus the acoustics of a concert hall can vary depending on the number of spectators and , … their attire.
  - ☐ Besides the direct sound emanating from the loudspeakers, every space imposes its own room sound through its pattern of sound reflections. Critical listening environments, such as mastering studios, are designed to absorb sound, neutralizing the room sound. Good concert halls tend to have diffuse, random reflections, scattering reverberant energy equally to all areas of the listening space. Bad halls tend to have focused reflection patterns, resulting in echoes and uneven resonances in various locations. For example, domes cause reflections to be focused rather than dispersed. Parallel surfaces create an acoustical problem called standing waves–a fluttering echo between two surfaces.
  - ☐ Room sound through its pattern of sound reflections. Critical listening environments, such as mattering studios, are designed to absorb sound, neutralizing the room sound. Good concert halls tend to have diffuse, random reflections, scattering reverberant energy equally to all areas of the listening space.
  - ☐ Please see section for further details on how to look at physical materials design impact on sound.
- ☐ **Foreground and background in virtual soundscapes** (pg. 21)
  - ☐ Like a landscape, a soundscape integrates the notion of perspective or depth. We We want to be able to place sounds anywhere within this spatial perspective-from extremely close to extremely far- and use this opposition (i.e., contrasts in proximity) in our composition methodology. (Examples Ken Fields)
  - ☐ Spatial metaphors of sound.
  - ☐ Starting from the edge of the conventional loudspeaker, we can treat different sounds so that they appear to emanate from specific depths from behind the loudspeaker. This leads to one of the more interesting possibilities in electronic music: the possibility of a counterpoint between foreground and background elements, where the perceived depth of each element is a function of its virtual acoustic properties. A lowpass filtered sound–bathed in reverberation and diminished in amplitude–recedes into the background, while a bright, present, loud sound jumps to the foreground.
  - ☐ Spatial depth is not the only determinant of a background texture, however. Any omnipresent, unobtrusive, or repeating figure tends to recede from our attention when strongly accented ephermeral elements intercede. Here the meaning of “background” is more abstract, referring to perceptually dominant and subordinate structural elements. Just as the background canvas of a painting need not be neutral shade, the canvas of electronic music need not be silence.
  - ☐ In Horacio Vaggione's compositions Nodal (1997) and Agon (1998), for example, a low-level granulose background texture “fills in the dots” to maintain tension between widely-spaced foreground explosions.
  - ☐ Insights : (Thesis) -
    - ☐ This section summarizes how soundscapes can be produced by physical equipment and how they should be thought about as a strategy to create layering metaphors in both real and virtual spaces.
- ☐ **Cinematic use of space** (pg. 22)

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- ☐ Some composers use microphone techniques and spatial processing in a manner similar to the cinematic use of camera angle, lens perspective (width), and depth of field.
- ☐ Accordingly, a trend toward cinematic use of space is seen in compositions that feature dramatic contrasts between sounds that are captured close in proximity and those that are distantly reverberated.
- ☐ Examples: Luc Ferrari's presque Rin no. 1 & Sud (1985) by Jean Claude Risset.
- ☐ The sonic equivalent of zooming in on an image can be achieved by several means, most directly by a microphone in proximity to an acoustic source.
- ☐ Zooming out methods.
- ☐ Changes of lighting correspond to changes in audio filter settings, and changes of camera angle correspond with directional microphone techniques and spatial signal processing.
- ☐ By means of all these methods, sound objects can be localized precisely in the soundscape of a work.

- ☐ **Pluriphonic sound projection** (pg. 23)
  - ☐ in a concert of electronic music, where pluriphonic sound projection (also called multi loudspeaker diffusion) means that each listener may experience a unique spatial perspective.
  - ☐ Pluriphonic spatial impressions experienced by listeners can be classified according to dimensional atrribues such as direction, distance, and extent (where extent means the size of the impression in terms of depth, width and height), and immersive attributes such as presence(experiencing the sound of an eclipsed space) and envelopment (being surrounded by sound (Rumsey 2002; Kendall 2010)
  - ☐ One can extend the pluriphonic concept to project sounds from a variety of positions above, below, and even within the audience. The sound sources need not be limited to fixed positions, but can emanate from rotating loudspeakers or mobile performers.
  - ☐ The art of pluriphony is based on three principles:
  - ☐ a. The experience of an electronic music composition can be greatly enhanced by a spatial performance in concert, whether diffused by a musician in real time, or pre-planned and algorithmically generated.
  - ☐ b. The sound projection system can offer a variety of contrasting spatial images through the arrangement of multiple loudspeakers around the audience, across the front stage, above, within, and below the audience. Thus each listener has a unique perspective, and there is not necessarily a "correct" position from which to hear the music. Not all loudspeakers are used at all times. There performer selects particular spatial images to highlight certain aspects of their work, choreographs transitions from scene to scene. Deploying multiple loudspeakers on stage makes it possible to project a sound image dialing the complexity of an orchestra.
  - ☐ c. While a single type of loudspeaker guarantees a uniformity of sound quality, it is also possible to mix different types of loudspeakers in the same pluriphonic system. Each type offers a particular voicing that may be useful in articulating a specific musical texture.
  - ☐ Let us elaborate point (a) above. The sound projection can be realized manually by a sound projectionist working at a mixing console in the hall. This can add a spontaneous and virtuoso element to the concert. (5) When I project my music, it is not so much a matter of physical skill but rather of intimate knowledge of the music being diffused, i.e., a sense of timing that enables one to anticipate and execute spatial gestures precisely on cue.
  - ☐ **Projection of spatial chords:**
    - ☐ The most important discovery I found when projecting sound from a stereo source to a pluriphonic sound system was the idea of using spatial chords. I would cue these chords to change a critical structural junctures in the unfolding of a work. There the spatial architecture coincides with the musical structure.
    - ☐ A spatial chord deploys a combination of sources not to reproduce a "naturalistic" sound field, but to present a unique spatial geometry.
    - ☐ This can be extended to three dimensions in the case of a space like the UCSB Allosphere with its hundreds of loudspeakers. (We In this case, a dozen or more loudspeakers can be used to articulate a three-dimensional geometry.
    - ☐ Changes in this geometry can be controlled in real-time using spatial software that allows the composer to stipulate:
    - ☐ 1. The number of loudspeakers sources in the chord
    - ☐ 2. The spacing of the points, whether in a closely-spaced cluster or scattered widely in three dimensions.
    - ☐ 3. Tilt or rotating selection (0 + no tilt or rotation)
    - ☐ 4. Tilt angle
    - ☐ 5. Rotation speed
    - ☐ 6. Transition time from one chord to another, from sudden to smoothly interpolated.
    - ☐ The composer manipulates these parameters and initiates these changes in performance at key structural junctures (Roads 2011)
  - ☐ **Generative upmixing:**
    - ☐ Certain spatial gestures multiple rotations at different speeds and angles, for example-are too complex to be controlled manually in real time.
    - ☐ Another possibility is an interactive diffusion application that lets the musician control the up mixing in real time using high - level controls. Such a spatializer is based on a generative or algorithmic approach to spatialization. Generative up mixing is a wee open filed with considerable potential.
    - ☐ One approach is to generate copies of the input tracks that are decorrelated in some way. The time-frequency analysis methods discussed previously would be one way of generating decorrelated copies, but even basic techniques as filter banks, phase shifts, or delay lines can be applied.

- ☐ A primary aesthetic challenge of pluriphonic diffusion is to articulate musical structure through its spatial projection.

- ☐ **Vertical projection in virtual and physical spaces** (pg. 27)
  - ☐ Vertical sound sources offer a novel effect. Artistic experimentation with vertical projection of sound began in the early 1950s. Pierre Schaeffer's studio for musique concrète featured a loudspeaker mounted in the ceiling, and his group's performances featured live diffusion. Another pioneering configuration, for Stockhausen's Gesang der Jünglinge (1956), involved projection in five channels, with four loudspeakers in the corners of the performance hall, and a fifth loudspeaker suspended above the audience. We have already shown an image of the Phillips Pavilion with its loudspeakers mounted above the audience.
  - ☐ A simple but effective configuration for vertical sound projection is the tetrahedral ambiphony layout invented by Michael Gerzon (1973)
  - ☐ Overhead loudspeakers suspended above the audience make an even more striking effect. This contrasts with the virtual acoustic illusion that has been popularized in so-called three- dimensional (3D) sound systems in recent years…..In general, vertical 3D sound systems are based on research that shows that high-frequency sound (greater than about 6 kHz) reflecting off the outer ears (pinnae) and shoulders provides a critical cue to vertical localization. These reflections impose short time delays that manifest in the spectrum as a comb filter effect. (See Roads 1996.)
  - ☐ The virtual vertical illusion is however, fragile and signal dependent. Not all people perceive the illusion well, since it requires that the listener's pinnae bear an anatomical similarity with a model subject.
  - ☐ Thus a robust and definitive solution to the vertical dimension can be provided only by a system that places physical loudspeakers in the vertical dimension, including one or more loudspeakers suspended above the audience. Another advantage of a physical acoustic approach is that it is not limited to sounds above 6 kHz; lower frequencies are perceived as a vertical source by means of the intensity cue.
  - ☐ Kendal (2010) points out, we are not as sensitive to the precise location of the sound images coming form elevated loudspeakers as we are in the lateral plane.
- ☐ **Rotating sound sources** (pg. 28)
  - ☐ Rotating sound sources open another dimension of spatial sound.
  - ☐ To be in a room with a rotating speaker is to be surrounded by ever-changing reflections, like a spotlight on a rotating mirrorball.
  - ☐ The physical rotation of a loudspeaker enlivens sounds, animating them with time- varying spatial and spectral qualities.
  - ☐ The original rotating loudspeaker mechanism was the Leslie Tone Cabinet, which routed an incoming signal into two separate rotating mechanisms: a spinning horn for high frequencies and a rotating baffle (blocking and unblocking a stationary woofer) for low frequencies (Leslie 1949, 1952). A remote control for motor speed let musicians adjust the speed of rotation. The Leslie Tone Cabinet was designed to enrich the static sound emitted by electric organs such as the famed Hammond B3 tone-wheel organ. But musicians discovered that any sound could be enriched this way, including voice and electric guitar.
  - ☐ In the late 1950s, engineers working Hermann Scherchen's Experimental Studio Gravesano in Switzerland developed a spherical loudspeaker that rotated both horizontally and vertically (Loescher 1959; 1960; see a photograph in Roads 1996).
  - ☐ Karlheinz Stockhausen manually rotated a loudspeaker affixed to a turntable to create the spinning sounds in his compositions Kontakte (1960) and Hymnen (1967; see a photograph in Roads 1996). As he stated:

    I naïvely started to rotate any sound I produced, but it didn't work at all. I found that only certain rhythms can be moved in rotation or at certain speeds...I say that in general the sharper the sound, the higher the frequency, the better it moves and the clearer its direction. But I would also say that the more a sound is chopped [amplitude modulated]–let's say in the region between three and twelve pulses per second, the better it moves in space. And the sharper the attack of each segment of a sound event, the better it moves. (Cott 1973).
  - ☐ (Note that "sound chopping" by low-frequency square wave AM is a signature of Stockhausen's electronic technique and markedly enhances the spatial salience of any broadband sound, whether rotated or merely panned.)

    Physically rotating speaker systems are available in the marketplace, and software plugins and effects units attempt to simulate this effect. The quest to model the complex effects of loudspeaker rotation involve Doppler shift vibrato, time-varying filtering, phase shifts, distortions caused by air turbulence, and echo reflections from adjacent surfaces–not to mention the transfer characteristics of the amplifiers and loudspeakers used. Much progress has been made in recent years in simulating these complicated and interacting acoustical and electronic effects. The effect recorded in stereo, however, is not the same as being in the same room as a rotating loudspeaker, which is a three-dimensional immersive experience due to room reflections.
  - ☐ As an alternative to physically rotating loudspeakers, electronic rotation can also be realized on spherical loudspeaker systems with dozens of drivers around the surface (e.g., Avizienis et al. 2006). In this case, software generates a separate stream of audio for each driver. Such technology has also been used to emulate the radiation patterns of acoustic instruments, or to generate an omnidirectional radiation pattern. However, there is no reason why spherical speakers cannot be used more creatively to generate arbitrary radiation patterns–including rotations at various angles–adapted to specific pieces of electronic music (Hulen 2008).
- ☐ **Superdirectional sound beams** (pg. 29)

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- ☐ The directionality or dispersion pattern of a loudspeaker is a design feature, and can vary from omnidirectional to superdirectional. Most conventional loudspeakers are broadly directional, i.e., they typically project sound forward through a horizontal angle spanning 80 to 90 degrees. So- called “narrow coverage” loudspeakers feature dispersion in the 50 degree range (Meyer Sound Laboratories 2010).
- ☐ CEM_Figure_8_5_CRoads
- ☐ By contrast, loudspeakers that act as superdirectional sound beams are an extreme case. Superdirectional sound beams behave like an audio spotlight, focusing sound energy on a narrow spot, typically about 15 degrees in width (Figure 8.5). One person, for example may hear the sound, while someone outside the beam does not.
- ☐ CEM_Figure_8_6_CRoads
- ☐ A more recent technology for superdirectional sound beams employs ultrasound–the domain of high frequencies above the range of human audibility. Ultrasonic superdirectional loudspeakers are based on the scientific principle of acoustic heterodyning (Pompei 1999; American Technology Corporation 1998), first observed by Helmholtz. When two sound sources are positioned relatively closely together and are of a sufficiently high amplitude, two new tones appear: one lower than either of the two original ones and a second one that is higher than the original two. The two new combination tones correspond to the sum and the difference of the two original ones. For example, if one were to emit two ultrasonic frequencies 90 kHz and 91 kHz into the air, with sufficient energy, one would produce the sum (181 kHz) and the difference (1 kHz), the latter of which is in the range of human hearing. Helmholtz argued that the phenomenon had to result from a nonlinearity of air molecules, which begin to behave nonlinearly (to heterodyne or intermodulate) at high amplitudes. Unlike regular loudspeakers, acoustical heterodyning loudspeakers project energy in a collimated sound beam, analogous to the beam of light from a flashlight. One can direct the ultrasonic emitter toward a wall and the listener perceives the sound as coming from a spot on the wall. For a direct sound beam, a listener can stand anywhere in an acoustical environment and point to the loudspeaker as the source.
- ☐ At the time of this writing, there has been little experimentation which such loudspeakers in the context of electronic music. But one could imagine coupling such a loudspeaker with a robot arm. to create precisely controlled sound beams that are synchronized to a musical structure.

- ☐ **Immersive sound** (pg. 32)
  - ☐ One trend in music performance is moving away from the traditional stage-centered experience toward immersive audiovisual environments in virtual and augmented realities (Hollerweger 2001). Immersive sound systems extend the reach of spatialization to a three-dimensional enclosure.
  - ☐ The realm of immersive sound or sound field synthesis is an active area of research and experimentation, with a number of experimental approaches in competition.
  - ☐ Among these are three techniques that have fascinating musical potential. These are: vector base amplitude panning, high-order ambisonics, and wave field synthesis. All combine a physical infrastructure with spatial signal processing. The physical infrastructure consists of a regular array of many loudspeakers surrounding the listener in three dimensions. Spatial signal processing diffuses a potentially unique audio signal to each loudspeaker in the system to create an immersive spatial impression.
  - ☐ **1. Vector Base Amplitude Panning VBAP**
    - ☐ is a three-dimensional extension of strophic techniques (Pulkki 1997). Instead of projecting a signal from a stereo field with a phantom source between two loudspeakers, VBAP projects from triples of loudspeakers arranged in triangles, allowing for vertical as well as horizontal panning(Figure 8.7).
    - ☐ A typical VBAP configuration has regularly spaced loudspeakers around and above the audience. VBAP provides a simple but effective way to pan sound around the inner surface of a half-sphere, for example. VBAP produces virtual sources that are as sharp as is possible, since it uses the minimum number of loudspeakers needed, from one to three.
    - ☐ CEM_Figure_8_7_CRoads
    - ☐ High-order ambisonics and wave field synthesis go beyond this to focus on the reproduction of coherent wavefronts rather than isolated phantom sound sources. A wavefront consists of all points in space that are reached at the same instant by a wave propagating through a medium. This approach is sometimes called holophony by analogy to acoustical holography (Jessel 1973). (6) The aim of these systems is the reconstruction of the acoustic sensations that a listener would perceive around them in a real immersive environment.
  - ☐ **2. Higher-Order Ambisonics**
    - ☐ (HOA) generates a periphoic sound field emanating from the edge of a sphere toward the listener in the center of the sphere. A solution of the wave equation decomposes the sound field into a series of spherical harmonic functions (Malham and Myatt 1995; Malham 1998).
    - ☐ Since the spherical harmonics form a set of orthogonal base vectors, they can be used to describe any function on the surface of a sphere. An HOA encoder takes a monaural sound and a virtual source position and generates a multichannel signal. (“High-order” refers to greater than four channels.)
    - ☐ In HOA reproduction, all speakers generally used to localize a sound, as opposed to techniques that use only adjacent speakers such as VBAP.
    - ☐ Scalibiltiy to multiple moving sources and multiples loudspeakers is one of the major advantages of the HOA approach, which also enables unique operations on the encoded sound field, such as rotation and soon (emphasizing sounds in the front).

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- ☐ Rotation matrices have been defined for rotation about the x axis (tilt or roll), the y axis (tumble or pitch), the z axis (rotate or yaw), or any combination of these; these rotations capabilities are clearly of compositional interest.
- ☐ **3. Wave Field Synthesis (WFS)**
  - ☐ is based on the Huygens Principle, which states that any wavefront can be regarded as a superposition of elementary spherical waves (Berkhout 1988), Berkhout et al. 1993).
  - ☐ CEM_Figure_8_8_CRoads
  - ☐ The special feature of WFS is that it can create the impression of a 2D virtual point source located inside the listening area between the loudspeakers and the listener. To achieve this effect, a computer controls a very large array of tightly -spaced loudspeakers (typically hundreds) and actuates each one in exactly the same instant when the desired virtual wavefront would pass through it. All loudspeakers contribute to the reproduction of a single virtual source.
  - ☐ However, translating the 3D illusion from theory to practice requires tightly controlled conditions. Imperfections in the system tend to diminish the 3D effect, which in any case is not as robust as a real source.
  - ☐ There is, of course, much more to the theory of immersive spatialization than we can delve into here. For technical details on VBAP see Pulkki (1997). For more on HOA and WFS, see Gerzon (1973), Hollerweger (2006), Malham (1998, 2003), Malham and Myatt (1995), and Rumsey (2001).
- ☐ **Summary:**
  - ☐ All combine a physical infrastructure with spatial signal processing. The physical infrastructure consists of a regular array of many loudspeakers surrounding the listener in three dimensions. Spatial signal processing diffuses a potentially unique audio signal to each loudspeaker in the system to create an immersive spatial impression.
  - ☐ High-order ambisonics and wave field synthesis go beyond this to focus on reproduction of coherent wavefronts rather than isolated phantom sound sources.
  - ☐ A wavefront consists of all points in space that are reached at the same instant by a wave propagating through a medium. This approach is sometimes called homophony by analogy to acoustical holography (Jessel 1973). The aim of these systems is to reconstruction of the acoustic sensation that a listener would perceive around them in a real immersive environment.
- ☐ CEM_Figure_8_9_CRoads
- ☐ **Musical potential of immersive sound systems:**
  - ☐ The musical potential of immersive sound systems has inspired a genre of music in which the spatial structure is the central narrative of the composition. All other elements serve the spatial organization.
  - ☐ The most obvious game one can play with an immersive spatialization system is the illusion of presence. : putting the listener inside a 3d soundscape, either from a real source or a virtual generated source.
  - ☐ Second, the ability to move multiple sources in three dimensions opens up the possibility of elaborate choreography, far beyond the ability of a musician to control direct in real time.
  - ☐ Third, in wave field synthesis, a sound can potentially emerge from the loudspeaker and occupy a defined physical space within a room. It can circulate within a room being heard only when it meets a listener in a specific location.
  - ☐ In 3D immersive soundspaces, sound morphology becomes a palpable presence. One can, in theory walk through or around a sound, whose size, shape and radiation pattern may vary in time. Silent areas can be sculpted within a sound field.
  - ☐ CEM_Figure_8_10_CRoads
- ☐ **Articulating space** (pg. 37)
  - ☐ Music is a play of attracting and opposing forces. Attracting forces articleting similarities, while opposing forces articulating contrasts.
  - ☐ The art of spatialization plays out through specific tactics of attraction and opposition. Sonic space has multiple dimensions: lateral position, vertical position, image width, and image depth, all of which can vary on different time scales and in different frequency bands.
  - ☐ As in all aspects of music, the density of voices is a prime structural element: the spatial trajectory of a single source contrasts with a texture consisting of 200 divisi elements, each emanating from it own unique point in space.
  - ☐ CEM_Table_8_1_CRoadsFin
- ☐ **Conclusion** (pg. 40)
  - ☐ CEM_Figure_8_11_CRoads
  - ☐ The choreography of sounds is intrinsically fascinating and meaningful to audiences.…in electronic music, spatial strategy has become an integral facet of composition strategy.
  - ☐ Stockhausen (1958) observed concerning his composition Gesang der Junglinge (song of the youths):
  - ☐ from which side, with how many loudspeakers, whether which rotation to left or right, whether motionless or moving, how the sounds and sound groups should be projected into space; all this is decisive for the understanding of the work.
  - ☐ …the art of spatialization has emerged as one of the most important topics in composition today.
  - ☐ ..a formal theory of spatial relations remains to be developed, the compositional organization of sound spatialization is becoming increasingly elaborate, often assisted by sophisticated software.
  - ☐ The combination of pluriphonic spatialization and 3D imagery creates strong perceptual impressions of presence, of total immersion in world that seems physical and palpable.

- ☐ The continued proliferation of pluriphonic sound systems fosters the development of ever more effective spatial techniques and serves as a showcase for electronic music performance to the public.

- ☐ **Notes** (pg. 42)
  - ☐ 1. Immersive recording using arrays of dozens or hundreds of microphone are in the experimental stage and may eventually become commonplace.

    2. Various historical sources estimate from 300 to 450 loudspeakers. Some drivers were clustered, which could be a source of confusion.

    3. In January 2011, I had the privilege of projecting Xenakis's Polytope de Cluny at the REDCAT Theater, Disney Hall, Los Angeles.

    4. An alternative method of capturing the impulse response is to play a sine wave that sweeps the audible frequencies (Farina 2000).

    5. The presence of a performer imbues a virtuosic aspect to the concert. Performance of spatial diffusion requires two types of expertise: expert knowledge of the piece being spatialized–so that changes in scene occur on cue, and expert knowledge of the sound system and the performance space. The composer has an advantage in the first case, while an experienced sound engineer may have an advantage in the latter case. For example, I can recall an experience in Bourges with their unique Cybérnophone system (Clozier 2001) in which I was given a five-minute lesson and fifteen minutes of rehearsal on a complex and unique spatial distribution system that clearly required more time to master.

    6. The scientific term holophony (Jessel 1973) should not be confused with HolophonicsTM , a trademark of H. Zuccarelli (1983).

- ⊟ _Outline (Review)
- ☐ Additional Reference Material:
- ☐ Advisor/Committee Member (Notes)
- ☐ Global Summary: (Draft)
- ☐ Global Summary: Final Drafts

The Philips Pavilion, Brussels (1958)

Figure 8.1. View, looking upward, of the inside of the Philips Pavilion. The objects on the surfaces are high-frequency loudspeakers in clusters, the patterns designed by Xenakis. Low-frequency loudspeakers were installed on the ground. (From Treib 1996.)

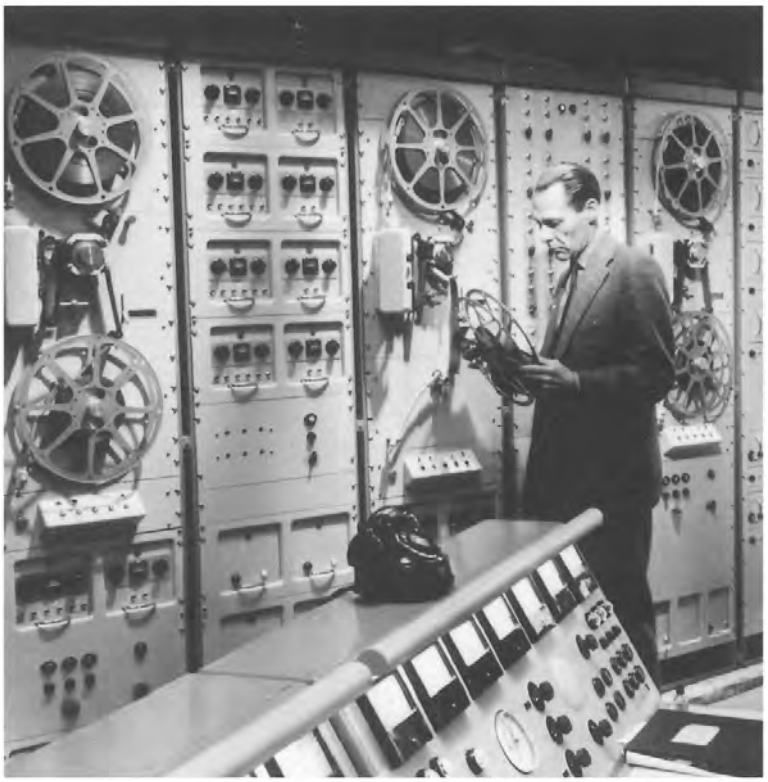


Figure 8.2 Playback and spatial switching system in the Philips Pavilion control room based on 35 mm sprocketed magnetic tape.

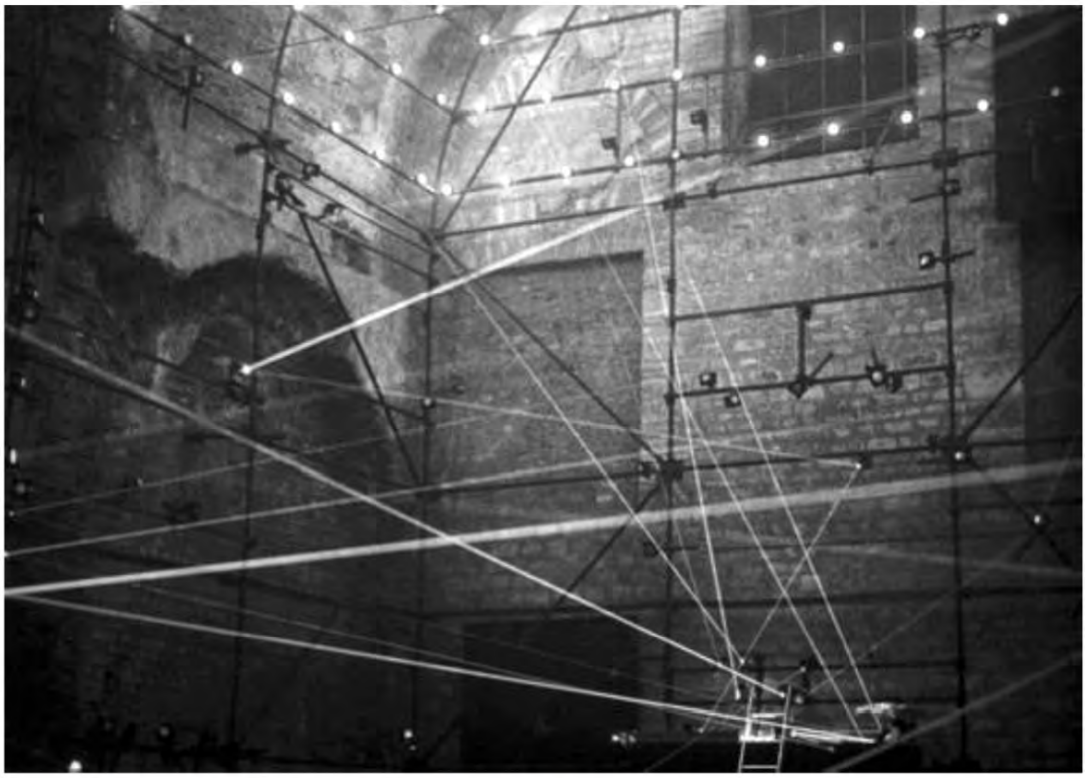


Figure 8.P. Laser projections and flash light scaffolding of the Polytope de Cluny.

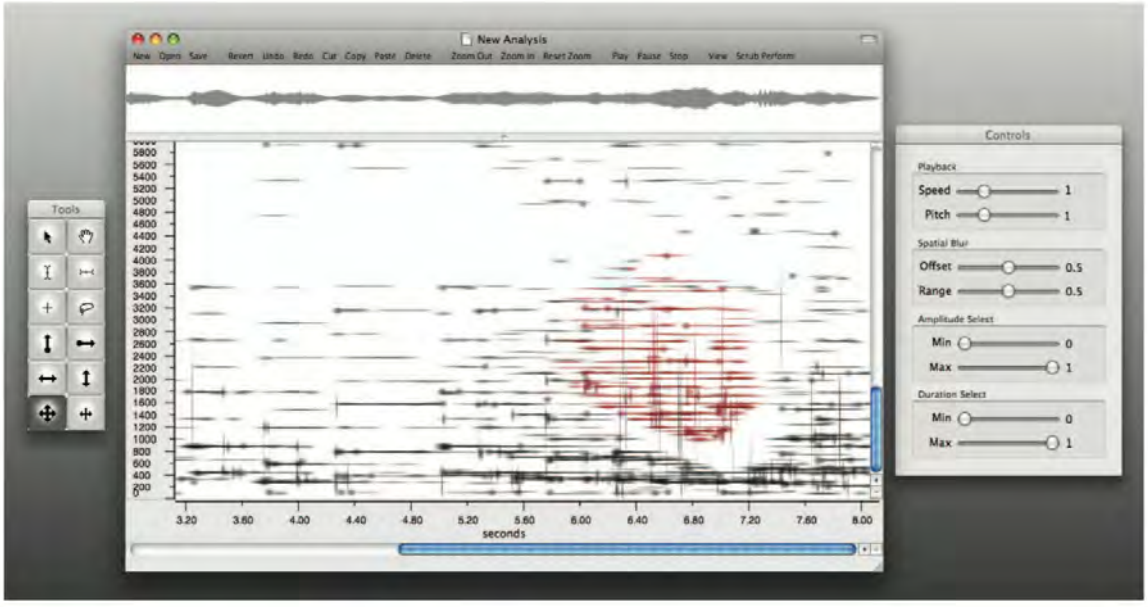


Figure 8.3. Screenshot from Scatter created to provide an interface for visualization and real-time transformation using dictionary-based TF decompositions. The time-domain resynthesis is shown at top, and the model wivigram is shown below this. A palette of tool icons on the left allows one to select groups of atoms for transformations including spatial "scattering."

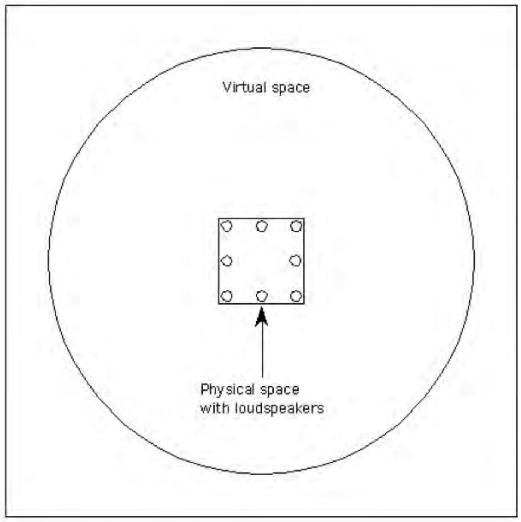


Figure 8.4. View of virtual and physical space from above. The perimeter of phantom images in virtual space is much larger than that of the physical space, due to the possibility of reverberation and other distancing cues. REDO FIGURE.

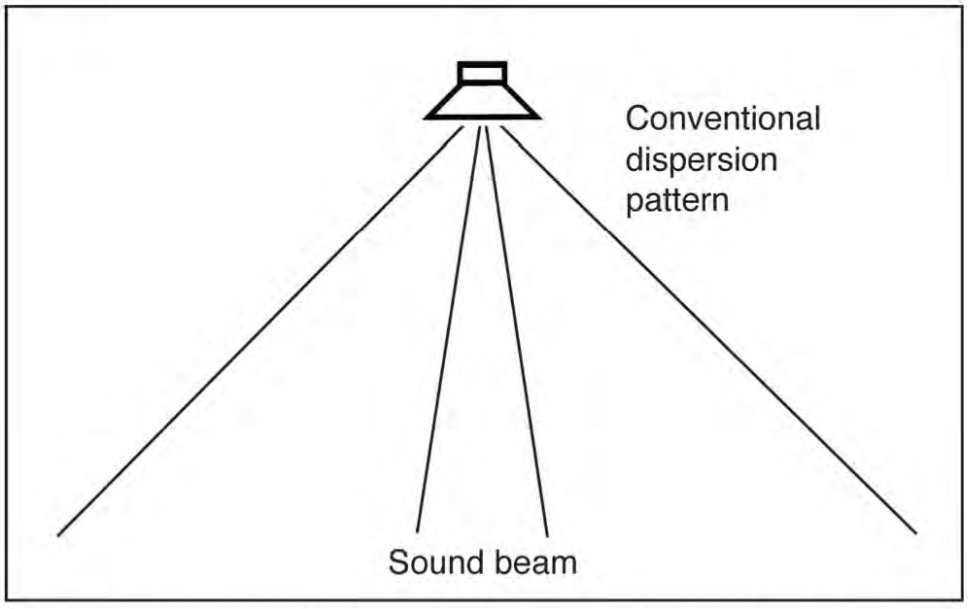
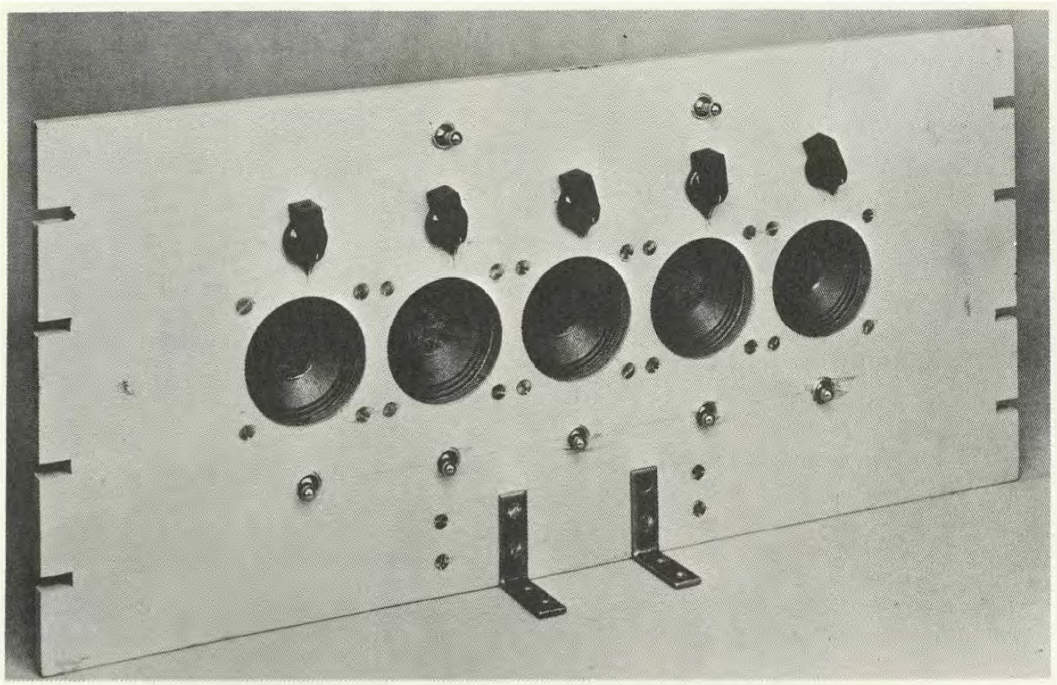


Figure 8.5. The conventional dispersion pattern of a loudspeaker is broad, whilst a superdirectional sound beam is narrow.



8.6. An early superdirectional loudspeaker array. (After Kock 1971)

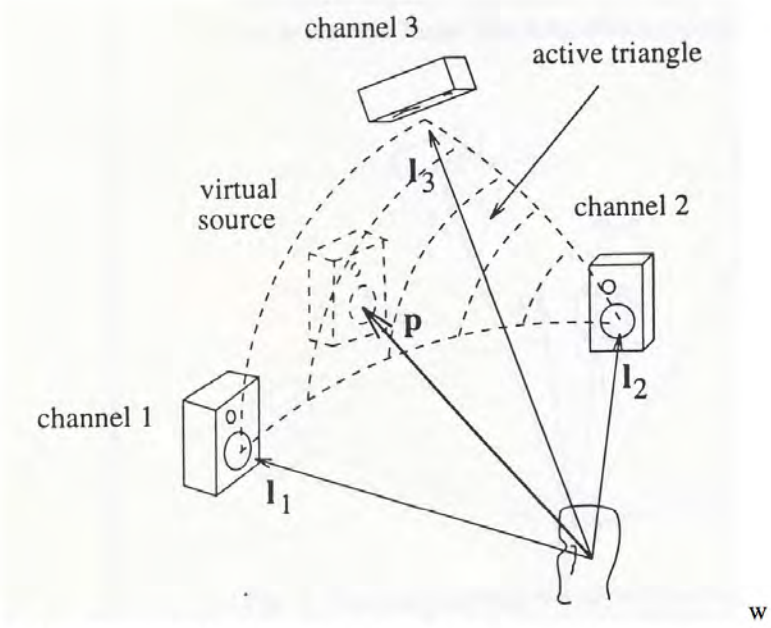


Figure 8.7. Vector base amplitude panning. The three-dimensional unit vectors $\mathbf{I}_1$, $\mathbf{I}_2$, and $\mathbf{I}_3$ define the directions of loudspeakers 1, 2, and 3. The virtual sound source **p** is a linear combination of the gain factors of $\mathbf{I}_1$, $\mathbf{I}_2$, and $\mathbf{I}_3$. Using these three loudspeakers, virtual sources can be created anywhere within the active triangle shown. This can be generalized to arbitrary spatial configurations. After Pulkki (1997).

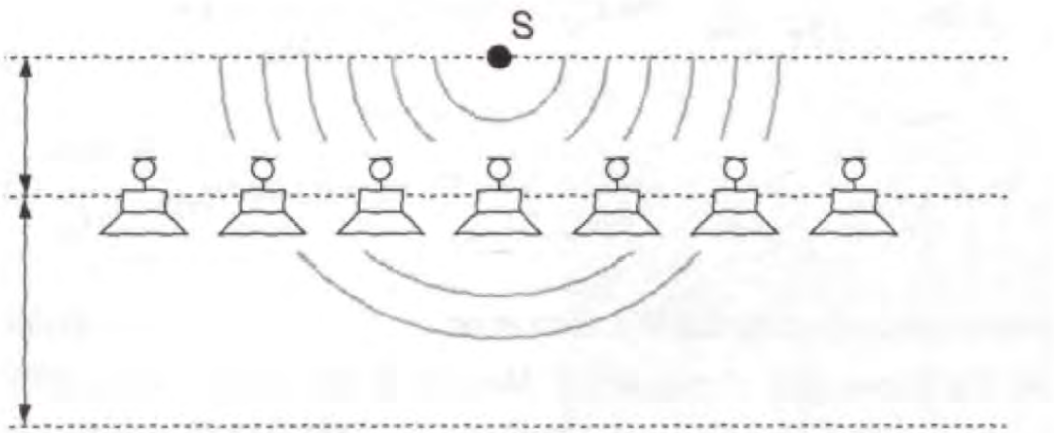


Figure 8.8 Multiple loudspeakers synthesizing a wavefront.

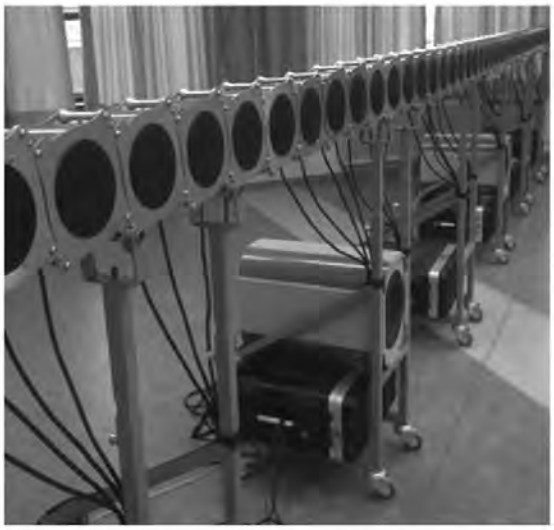


Figure 8.9. A wave field synthesis loudspeaker array in Eindhoven, The Netherlands, 2007 owned by Arthur Sauer. (Photograph by Raviv Ganchrow, who designed the loudspeakers. Permission of Wouter Snoie.)

Figure 8.10. Acoustic chandelier, La Casa della Musica, Parma, Italy.

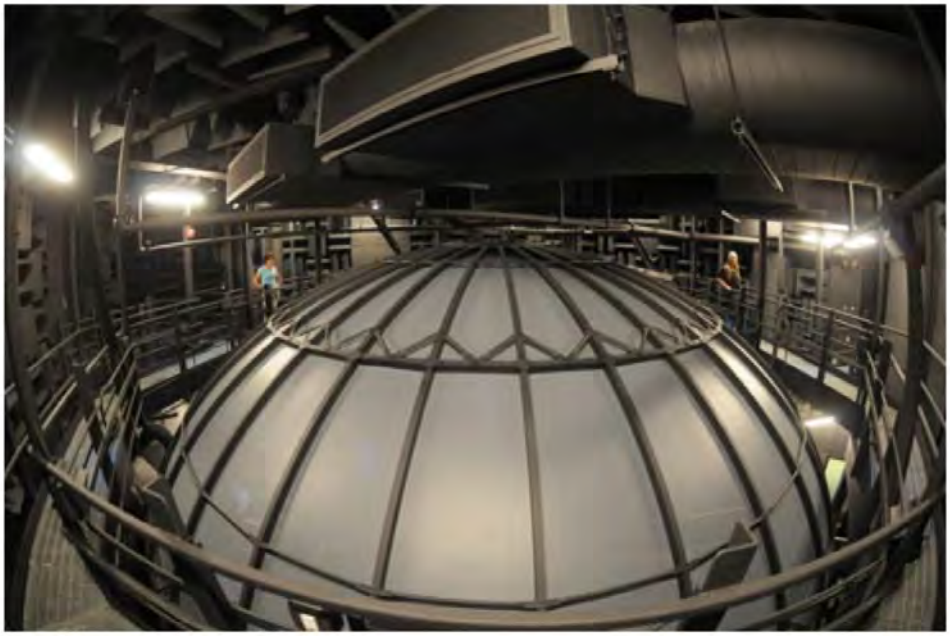


Figure 8.11. The UCSB AlloSphere viewed from outside and above. TheAlloSphere is a three-story high laboratory instrument for 3D immersive visual and audio projection with a multichannel Meyer sound system (Amatriain et al. 2007, 2008, 2009). Photograph by Paul Wellman.

Table 8.1 Spatial oppositions.

Foreground (present)	Background (obscured or reverberated)
Sole position in space	Multiple positions in space (spatial chords)
Positioning and panning by related pairs of loudspeakers, e.g., from front left and right to rear left and right	Positioning and panning by arbitrary pairs of loudspeakers, creating *spatial chords,* e.g., from upper front left and lower rear right to lower middle left and upper front right, generalized to N channels
Fixed position in space	Moving position in space
Fixed position in space	Scattered position in space (through granular decorrelation)
Fixed dispersion pattern	Variable dispersion pattern (changes of apparent source width, possibly modeling the dispersion pattern of an acoustic instrument, horn, lens, or other source)
Fixed source geometry	Rotating source geometry
Slow motion	Fast motion
Periodic movement (sinusoidal, pulse, linear pan, exponential pan, logarithmic pan)	Random movement
Spatialization is organized as an independent parameter, apart from pitch, rhythm, timbre, etc.	Spatialization is linked to mesostructural musical function in coordination with other parameters; the spatial design helps to articulate structural transitions and "changes scene" on musical phrase boundaries. These changes can be linked with any of the oppositions in this table. For example, a transition from one phrase to another could be tied to a transition from one spatial chord to another.

Global spatialization, such as global reverberation	Multiscale spatialization: phrases, objects, microsounds can be all given individual spatial characteristics
Spatialization is independent of frequency band and formant structure	Spatialization by spectrum, i.e., applying spatial filters that pan sounds depending on their frequency band (Wenger and Spiegel 2004; Sturm et al. 2008, 2009) or formant (as in pulsar synthesis, see Roads 2001, 2002)
Spatialization is independent of sound duration and amplitude	Spatialization by grain size and/or amplitude (Sturm et al. 2008, 2009)
Linear motions, from loudspeaker to loudspeaker	Coordinated geometric rotations at different speeds and directions (circular, elliptical, Lissajous, etc.)
Unidirectional rotation	Multidirectional rotation, including contrary motion (e.g., two sounds spinning in opposite directions)
Horizontal panning	Vertical panning (above and below the listener)
Panning without Doppler shift	Panning with Doppler shift
Spatial movement of multiple sounds with swarming behavior (sounds loosely follow one another)	Spatial movement of multiple sounds with independent trajectories
Fixed spatial perspective of virtual sounds	Variations in perspective ("cinematic" use of virtual space so that certain sounds appear to be recorded very closely while others appear to be distant)
Conventional loudspeaker dispersion pattern	Superdirectional sound beams
For fixed position sounds, fixed width of the sound image across multiple loudspeakers	Variations in the width of the image across multiple loudspeakers
Conventional spatial projection bounded on its inner surface by a perimeter of loudspeakers	Wavefield synthesis in which the sound emerges from the loudspeaker perimeter and comes into the room

Microsound_The Scales of Music Chapter 01 Curtis Roads. **Links:**

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    - ☐ Telharmonium en.wikipedia.org–
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  - ☐ Terms
    - ☐ Dennis Gabor en.wikipedia.org–
    - ☐ Gabor Atom en.wikipedia.org–
    - ☐ Gabor Filter en.wikipedia.org–
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    - ☐ Wave: en.wikipedia.org–
    - ☐ Optics:
    - ☐ Mechanical wave motion:
    - ☐ Electromagnetic wave motion:
- ☐ _Glossary
  - ☐ Vocabulary:
    - ☐ Mircrosound en.wikipedia.org-
    - ☐ Infinite Time Scale
    - ☐ Supra Time Scale
    - ☐ Macro Time Scale
    - ☐ Meso Time scale
    - ☐ Micro Time Scale
    - ☐ infinitesimal Time Scale
    - ☐ Signal Processing: en.wikipedia.org-
    - ☐ Nyquist frequency: mathworld.wolfrar
    - ☐ pitch en.wikipedia.org-
    - ☐ transcient events.
  - ☐ References
- ☐ _Objectives
  - ☐ Questions:
    - ☐
- ⊟ Outline (Notes):
  - ☐ **Introduction: (pg. 02)**
    - ☐ The evolution of musical expression intertwines with the development of musical instruments.

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- ☐ This was never more evident than in the twentieth century.
- ☐ Beginning with the gigantic Telharmonium synthesizer 1906,
- ☐ research that ushered forth a steady stream of electrical and electronic instruments.
- ☐ The most precise and flexible electronic music instrument ever conceived is the digital computer.
- ☐ …the computer's power derives from its ability to … model phenomena.
- ☐ The models of the computer take the form of symbolic code. Thus it does not matter whether the phenomena being modeled exist outside the circuitry of the machine, or whether they are pure fantasy.
- ☐ .. This makes the computer an ideal testbed for the representation of musical structure on multiple time scales.

- ☐ **Time Scales of Music: (pg. 03)**
  - ☐ Music theory has long recognized a temporal hierarchy of structure in music compositions. A central task of composition has always been the management of the interaction amongst structures on different time scales. Starting from the topmost layer and descending, on can dissect layers of structure, arriving at the bottom layer of individual notes.
  - ☐ This hierarchy, however, is incomplete. Above the level of an individual piece are the cultural time spans defining the oeuvre of a composer or a stylistic periodic. Beneath the level of the note lies another multilayered stratum, the micro sonic hierarchy. Like the quantum world of quarks, leptons, lions, and bosons, the microsonic hierarchy was long invisible. Modern tools let us view and manipulate the micro sonic layers from which all acoustic phenomena emerge.
  - ☐ Beyond these physical time scales, mathematics defines two ideal temporal boundaries -- the infinite and the infinitesimal-- which appear in the theory of musical signal processing.
  - ☐ …nine time scales of music
  - ☐ 1. Infinite: The ideal time span of mathematical durations such as the infinite sine waves of classical Fourier analysis
  - ☐ 2. Supra: A time scale beyond that of an individual composition and extending into months, years, decades and centuries.
  - ☐ 3. Macro The time scale of overall musical architecture or form, measured in minutes or hours, or in extreme cases, days.
  - ☐ 4. Meso Divisions of form. Groupings of sound objects into hierarchies of phrase structures of various sizes, measured in minutes or seconds.
  - ☐ 5. Sound object. A basic unit of musical structure, generalizing the traditional concept of note to include complex and mutating sound events on a time scale raining from a fraction of a second to several seconds.
  - ☐ 6. Micro Sound particles on a time scale that extends down to the threshold of auditory perception (measured in thousandths of a second or milliseconds)
  - ☐ 7. Sample The atomic level of digital audio systems: individual binary samples or numerical amplitude values, one following another at a fixed time interval. The period between samples is measured in millionths of a second (microseconds).
  - ☐ 8. Subsample Fluctuations on a time scale too brief to be properly recorded or perceived, measured in billionths of a second (nanoseconds) or less.
  - ☐ 9. Infinitesimal The ideal time span of mathematical durations such as the infinitely brief delta functions.
  - ☐ *Important : (Concept) -*
    - ☐ *9 Time Scales: Infinite, Supra, Macro, Meso, Sound Object, Micro Sound, Sample, Subsample, Infinitesimal. --->(The Now)*
  - ☐ --See Figures : --
  - ☐ [redacted]
  - ☐ Figure 1.1 portrays the nine time scales of the time domain. Notice in the middle of the diagram, in the frequency column, a line indicating " Conscious time, the present (~600 ms)." This line marks off Winckel's (1967) estimate of the "thickness of the present." The thickness extends to the line at the right indicating the physical NOW. This temporal interval constitutes an estimate of the accumulated lag time of the perceptual and cognitive mechanisms associated with hearing. Here is but one example of the disparity between chronos-physical time, and tempus-- perceived time (Kupper 2000).

- ☐ **Boundaries between Time Scales: (pg. 04)**
  - ☐ As sound passes from one time scale to another it crosses perceptual boundaries.
  - ☐ It seems to change quality.
  - ☐ This is because human perception processes each time scale differently.
  - ☐ Consider a simple sinusoid transposed to various time scales (1 used, 1 ms, 1 sec, 1 minute, 1 hour). The waveform is identical, but one would have difficulty classifying these auditory experiences in the same family. In some cases the borders between time scales are demarcated clearly; ambiguous zones surround others. Training and culture condition perception of the time scales.
  - ☐ Digital audio systems… operate at a fixed sampling frequency. …makes it easy to distinguish the exact boundaries separating the sample time scale from the subsample time scale. This boundary is the Nyquist frequency, or the sampling frequency divided by two. The effect of the crossing this boundary is not always perceptible.
  - ☐ The border between other time scales is context dependent. Between the sample and micro time scales… is a region of transient events---too brief to evoke a sense of pitch but rich in timbral content.
  - ☐ Between the micro and the object time scales is a stratum of brief events such as short staccato notes.
  - ☐ Another zone of ambiguity is the border between the sound object and the meso levels, exemplified by the evolving texture.

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- ☐ Time scales interlink. A given level encapsulates events on lower levels and is itself subsumed within higher time scales. Hence to operate on one level is to affect other levels. The interaction between time scales is not, however, a simple relation. Linear changes on a given time scale do not guarantee a perceptible effect on neighboring time scales.

- ☐ **Zones of Intensity and Frequency: (pg. 06)**
  - ☐ Sound is an alternation in pressure, particle displacement, or particle velocity propagated in an elastic material (Olson 1957)
  - ☐ …"sound" refers not only to phenomena in air responsible for the sensation of hearing but also "whatever else is governed by analogous physical principles" (Pierce 1994).
  - ☐ Sound can be defined in a general sense as mechanical radiant energy that is transmitted by pressure waves in a material medium.
  - ☐ Thus besides the airborne frequencies that our ears perceive, one may also speak of underwater sound, sound in solids, or structure-borne sound. Mechanical vibrations even take place on the atomic level, resulting in quantum units of sound energy called phonons.
  - ☐ The term "acoustics" likewise is independent of air and of human perception. it is distinguished from optics in that it involves mechanical rather than electromagnetic, wave motion.
  - ☐ …sound is a very wide range of transient, chaotic, and periodic fluctuations, spanning frequencies that are both higher and lower than the human ear can perceive. The audio frequencies, traditionally said to span the range of about 20 Hz to 20 kHz are perceptible to the ear. The specific boundaries vary depending on the individual.
  - ☐ Vibrations at frequency to low to be heard as continuous tones can be perceived by the ear as well as the body. These are the infrasonic impulses and vibrations, in the range below about 20 Hz.
  - ☐ Ultrasound includes the domain of high frequencies above the range of human audibility. The threshold of ultrasound varies according to the individual, their age, and the test conditions. Science and industry use ultrasonic techniques in a variety of applications, such as acoustic imaging (quate 1998) and highly directional loudspeakers (pompei 1998).
  - ☐ Subsonic intensities.. sounds are to soft to be perceived by the human ear. … such as a caterpillar's delicate march across a leaf.
  - ☐ Perisonic intensities (from the Latin periculos meaning :"dangerous"). Other sounds are so loud that to perceive them directly is dangerous, since they are destructive to the human body. Sustained exposure to sound levels around 120 dB leads directly to spin and hearing loss. Above 130 dB, sound is felt by the exposed tissues of the body as a painful pressure wave (Pierce 1983). This dangerous zone extends to a range of destructive acoustic phenomena. The force of an explosion, for example, is an intense acoustic shock wave.
  - ☐ The audible intensities fall between these two ranges. Figure 1.2 depicts the zones of sound intensity and frequency. The _ zone in the center is where audio frequencies intersect with audible intensities, enabling hearing. Notice that the _zone is but a tiny fraction of a vast range of sonic phenomena.
  - ☐ --See Figures : --
  - ☐ [redacted]

- ☐ **Infinite Time Scale: (pg. 07)**
  - ☐ Complex Fourier analysis regards the signal sub specie aeternitatis. (Gabor 1952)
  - ☐ The human experience of musical time is linked to the ticking clock. it is natural to ask: when did the clock begin to tick? Will it tick forever? At the extreme upper boundary of all time scales is the mathematical concept of an infinite time span.
  - ☐ …The idea of infinite duration is implicit in the theory of Fourier analysis, which links the notion of frequency to sine waves of infinite duration.

- ☐ **Supra Time Scale: (pg. 09)**
  - ☐ The supra time scales spans the durations that are beyond those of an individual composition. It begins as the applause dies out after the longest compositions, and extends into weeks, months, years, decades and beyond (figure 1.3).
  - ☐ [redacted]
  - ☐ Musical cultures are constructed out of supra temporal bricks: The eras of instruments, of styles , of musicians, and of composers. Musical education takes years; cultural tastes evolve over decades. There perception and appreciation of a single composition may change several times within a century. The entire history of music transpires within the supra temporal scale, starting from the earliest known musical instrument, a Neanderthal flute dating back some 45, 000 years (Whitehouse 1999).
  - ☐ Composition is itself a supra temporal activity. Its a results last only a fraction of the time required for its creation. A composer may spend a year to complete a ten-minute piece. Even if the composer does not work every hour of every day, the ratio of 53,560 minutes passed for every 1 minute composed is still significant.
  - ☐ Some music spans beyond the lifetime of the individual who composed it, through published notation, recordings and pedagogy. Yet the temporal reach of music is limited. Many compositions are performed only once. Scores, tapes and discs disappear into storage, to be discarded sooner or later.
  - ☐ Music making .. has always been part of the experience of Homo sapiens, who it is speculated came into being some 200,000 years ago. Few traces remain of anything musical older than a dozen centuries.
  - ☐ Modern electronic instruments and recordings media, too, are ephemeral.
  - ☐ Summary: The last section discussed how the time scale has influenced how things are created. The notion of time of creation is a small fraction of the entire effort of human history and the contribution to society.

- ☐ **Macro Time Scale: (pg. 11)**

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- ☐ The macro level of musical time corresponds to the notion of form, and encompasses the overall architecture of a composition.
- ☐ It is generally measured in minutes.
- ☐ The upper limit of this time scale is exemplified by such marathon compositions. Japanese Kabuki theater, Jean-Claude Eloy's evening-long rituals, and Karlheinz Stockhausen's Opera Lictht (spanning seven days and nights).
- ☐ The literature of opera and contemporary music obtains many examples of music on a time scale that exceeds two hours.
- ☐ .. the vast majority of music compositions realized in the past century are less than a half-hour in duration.
- ☐ The average duration is … in the range of a kilo second (16 min 40 sec). Complete compositions lasting less than a hectosecond (1 min 40 sec) are rare.
- ☐ **Perception of the Macro Time Scale:**
  - ☐ Unless the musical form is described in advance of performance (through program notes, for example), listeners perceive the macro time scale in retrospect, through recollection.
  - ☐ It is common knowledge that the remembrance of things past is subject to strong discontinuities and distortions.
  - ☐ We cannot recall time as a linearly measured flow.
  - ☐ As in everyday life, the perceived flow of musical time is linked to reference events or memories that are tagged with emotional significance.
  - ☐ Classical music (Bach, Mozart, Beethoven, etc.) places reference events at regular intervals (cadences, repetition) to periodically orient the listener within the framework of the form. Some popular music takes this to an extreme, reminding listener repeatedly on a shorter time base.
  - ☐ Subjective factors play into a distorted sense of time.
  - ☐ A composition that we do not understand or like appears to expand in time as we experience it, yet vanishes almost immediately from memory.
  - ☐ The perception of time flow also depends on the objective nature of the musical materials.
  - ☐ Repetition and a regular pulse tend to carry a work efficiently through time, while an unchanging, unbroken sound (or silence) reduces the flow to a crawl.
  - ☐ The ear's sensitivity to sound is limited in duration. Long continuous noises or regular sounds in the environment tend to disappear from consciousness and are noticed again only when they change abruptly or terminate.
- ☐ **Macroform:**
  - ☐ Just as musical time can be viewed in terms of a hierarchy of time scales, so it is possible to imagine musical structure as a tree in the mathematical sense. Mathematical trees are inverted, that is, the uppermost level is the root symbol, representing the entire work. The root branches into a layer of macrostructure encapsulating the major parts of the piece. Below the level of form is a syntactic hierarchy of branches representing mesostructures that expand into the terminal level of sound objects (Roads 1985d). mathworld.wolfrar
  - ☐ To parse a mathematical tree is straightforward. Yet one cannot parse a sophisticated musical composition as easily as a compiler parses a computer program. A compiler references an unambiguous formal grammar.
  - ☐ By contrast, the grammar of music is ambiguous --subject to interpretation, and in a perpetual state of evolution. Compositions may contain overlapping elements (on various levels) that cannot be easily segmented.
  - ☐ The musical hierarchy is often fractured. Indeed, this is an essential ingredient of its fascination.
- ☐ **Design of Macroform:**
  - ☐ The design of macro form takes one of two contrasting paths: top-down or bottom-up.
  - ☐ A strict top-down approach considers macrostructure as a preconceived global plan or template whose details are filled in by later stages of composition. This corresponds to the traditional notion of form in classical music, wherein certain formal schemes have been used by composers as molds (Apel 1972).
  - ☐ Music theory textbooks catalog the generic classical forms whose habitual use was called into question at the turn of the twentieth century.
  - ☐ Claude Debussy…, discarded what he called "administrative forms" and replaced them with fluctuating mesostructures through a chain of associated variations.
  - ☐ …while musical form has continued to evolve in practice in the past century, the acknowledged catalog of generic forms has hardly changed.
  - ☐ The practice of top-down planning remains common in contemporary composition. Many composers predetermine the macrostructure of their pieces according to a more-or less formal scheme before a single sound is composed.
  - ☐ By contrast, a struct bottom-up approach conceives a form as a result of a process of internal development provoked by interactions on lower levels of musical structure.
  - ☐ This approach as articulated by Edgard Varese (1971), who said, "Form is a result--the result of a process."
  - ☐ In this view, macrostructure articulates processes of attraction and repulsion (for example, in the rhythmic and harmonic domains) unfolding on lower levels of structure.
  - ☐ Serial or germ-cell approaches to composition expand a series of a formula through permutations and combinations into larger structures.
  - ☐ In the domain of computer music, a frequent technique for elaboration is to time-expand a sound fragment into an evolving sound mass,

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- ☐ John Cage… A different bottom-up approach in conceptual and chance composers.
- ☐ Cage (1973) often conceived of form as arising from a series of accidents--random or improvised events occurring on the sound object level.
- ☐ For Cage, form (and indeed sound) was a side-effect of a conceptual strategy. Such an approach often results in discontinuous changes in sound structure. This was not accidental:
- ☐ Cage disdained continuity in musical structure, always favoring juxtaposition: " Where people had felt the necessity to stick sounds together to make a continuity, we felt the necessity to get rid of the glue so that sounds would be themselves. (Cage 1959)
- ☐ The debate over the mergence of form is ancient. Musicologists have long argued whether, for example a fugue is a template (form) or a process of variation.
- ☐ This debate echoes an ancient philosophical discourse pitting form against flux, dating back as far as the Greek philosopher Heraclitus.
- ☐ In computer science, the concept of constraints does away with this dichotomy (Sussman and Steele1981). A form is constructed according to a set of relationships. A set of relationships implies a process of evaluation that results in a form.

- ☐ **Meso Time Scale: (pg. 14)**
  - ☐ The mesostructural level groups sound objects into a quasi hierarchy of phrase structures of durations measured in seconds. This local as opposed to global time scale is extremely important in composition, for it is most often on the mess level that the sequences, combinations, and transmutations that constitute musical ideas unfold.
  - ☐ Sequence - Whishart (1994) - In the context of electronic music, he identified two properties of sequences:
  - ☐ the field (the material, or set of elements used in the sequence), and the order.
  - ☐ The field serves as a lexicon--the vocabulary of a piece of music.
  - ☐ The order determines thematic relations--the grammar of a particular piece. ...
  - ☐ …Whishart observed, the field and the order must be established quickly if they are to serve as the bearers of musical code.
  - ☐ In electronic music, the meso layer presents timbre melodies, simultaneities (chord analogies), spatial interplay, and all manner of textural evolutions.
  - ☐ …Many of these precesses are described and classified in Denis Smalley's theory of "spectromorphology"---A taxonomy of sound gesture shapes (Smalley 1986, 1997).
  - ☐ **Sound Masses, Textures and Clouds:**
    - ☐ Edgard Varese predicted that the sounds introduced by electronic instruments would necessitate new organizing principles of mesostructure.
    - ☐ *" When thew instruments will allow me for write music as I conceive it, taking the place of linear counterpoint, the movement of sound masses, or shifting planes, will be clearly perceived. When these sound masses collide the phenomena of penetration or repulsion will seem to occur.* (Varese 1962)
    - ☐ A trend toward shaping music through the global attributes of a sound mass began in the 1950's. One type of found mass is a cluster of sustained frequencies that fuse into a solid block. In a certain style of sound mass composition, musical development unfolds as individual lines are added to or removed from this cluster.
    - ☐ Gyorgy Ligeti's Volumina for organ 1962
    - ☐ Particles make possible another type of sound mass: Statistical clouds of micro events (Xenakis 1960's)
    - ☐ Whishart (94) ascribed two properties to cloud textures.
    - ☐ As with sequences, their field is the set of elements used in the texture, which may be constant or evolving.
    - ☐ Their second property is density, which stipulates the number of events within a given time period, from sparse scatterings to dense scintillations.
    - ☐ Cloud textures suggest a different approach to musical organization. …clouds encourage a process of statistical evolution.
    - ☐ Cloud evolutions can take place in the domain of amplitude (crescendi/decrecendi), internal tempo (accelerando/rellentando), density(increasing/decreasing), harmonicity (pitch/chord/cluster/noise, etc.), and spectrum (high/mid/low, etc.).
    - ☐ Xenakis's Tape compositions concret PH (1958), Bohor 1 (1962) and Persepolis (1971) feature dense, monolithic clouds, as do many of his works for traditional instruments. (Please see other examples)
    - ☐ Varese spoke of the interprenetration of sound masses. The diaphanous nature of cloud structures makes this possible. A crossfade between two clouds results in a smooth mutation. (Mesostructural processes such as disintegration and coalescence can be realized through manipulations of particle density.
    - ☐ Density determines the transparency of the material An increase in density lifts a cloud into the foreground, while a decrease causes evaporation, Dissolving a continuous sound band into a pointillist rhythm or vaporous background texture.
  - ☐ **Cloud Taxonomy:**
    - ☐ To describe sound clouds precisely, we might refer to the taxonomy of cloud shapes in the atmosphere:
    - ☐ Cumulus - Well-defined cauliflower-shaped cottony clouds
    - ☐ Stratocumulus - blurred by wind motion
    - ☐ Stratus - a thin fragmented layer, often translucent
    - ☐ nimbostratus - a widespread gray or white sheet , opaque
    - ☐ Cirrus - isolated sheets that develop in filaments or patches.

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- ☐ In another realm, among the stars, outer space is filled with swirling clouds of cosmic raw material called nebulae.

  The cosmos, like the sky on a turbulent summer day, is fllled with clouds of dfferent sizes, shapes, structures, and distances. Some are swelling cumulus, others light, wispy cirrus--all of them constantly changing colliding, forming, and evaporating. (Kaler 1997)

  Pulled by immense gravitational fields or blown by cosmic shockwaves, nebulae form in great variety: dark or glowing, amorphous or ring-shaped, constantly evolving in morphology. These forms, too, have musical analogies. Programs for sonographic synthesis (such as MetaSynth [Wenger and Spiegel 1999]), provide airbrush tools that let one spray sound particles on the time- frequency canvas. On the screen, the vertical dimension represents frequency, and the horizontal dimension represents time. The images can be blurred, fragmented, or separated into sheets. Depending on their density, they may be translucent or opaque. Displacement maps can warp the cloud into a circular or spiral shape on the time-frequency canvas. (See chapter 6 on sonographic transformation of sound.)
- ☐ Summary: The sounds are using natural phenomena as sound metaphors for compositional work.
- ☐ *Insights : (Thesis)* -
  - ☐ *Natural phenomenon are inspirations initially to understand the form. The models generated by experiment and the rigor of the investigative questions in art led to alternative results or scenarios. New discoveries and questions need to be asked in the work to lend to other possible multi relational outcomes.*

- ☐ **Sound Object Time Scale: (pg. 16)**
  - ☐ The sound object time scale encompasses events of duration associated with the elementary unit of composition in scores: The note. A note usually lasts from about 100 ms to several seconds, and is played by an instrument or sung by a vocalist. The concept of sound object extends this to allow any sound, from any source. The term sound object comes from Pierre Schaeffer, the pioneer of musique concrete.
  - ☐ Any sound within stipulated temporal limits is a sound object. Xenakis (89) referred to this as the "mini structural" time scale.
  - ☐ **The Sensation of Tone:**
    - ☐ The sensation of tone--a sustained or continuous event of definite or indefinite pitch--occurs on the sound object time scale. The low frequency boundary for the sensation of a continuous sound--as opposed to a fluttering succession of brief microsounds--has been estimated at anywhere from 8 Hz (Savart) to about 30 Hz.
    - ☐ Helmholtz, the nineteenth century German acoustician, investigated this lower boundary.

      In the First place it is necessary that the strength of the vibrations of the air for very low tones should be extremely greater than for high tones. The increase in strength . . . is of especial consequence in the deepest tones. . . . To discover the limit of the deepest tones it is necessary not only to produce very violent agitations in the air but to give these a simple pendular motion. (Helmholtz 1885)
    - ☐ Helmholtz observed that a sense of continuity takes hold between 24 to 28 Hz, but hat the impression of a definite pitch does not take hold until 40 Hz.
    - ☐ Ptich and tone are not the same thing. Acousticians speak of complex tones and unpitched tones. Any sound perceived a continuous is a tone. This can, for example include noise.
    - ☐ Between the sensation of a continuous tone and the sensation of metered rhythm stands a zone of ambiguity, an infrasonic frequency domain that is too slow to form a continuous tone but too fast for rhythmic definition. Thus continuous tone is possible quality, but not a necessary property, of a sound object. Consider a relatively dense cloud of sonic grains with short silent gaps on the order of tens of milliseconds. Dozens of different sonic events occur per second, each unique and separated by a brief intervals of zero amplitude. yet such a cloud is perceived as a unitary event-- a single sound object.
    - ☐ **Homogeneous Notes versus heterogeneous Sound Objects:**
      - ☐ The sound object time scale is the same as a traditional notes.
      - ☐ What distinguishes sound objects from notes?
      - ☐ The note is a homogeneous brick of conventional music architecture. Homogeneous means that every note can be described by the same four properties:
      - ☐ pitch, generally one of the twelve equal-tempered pitched classes
      - ☐ timbre, generally ones of about twenty different instruments for a full orchestra, with two or three different attack types for each instrument.
      - ☐ dynamic markings,
      - ☐ duration.
      - ☐ The notions of equivalence and distance lead to the notion of invariants, or interval distances that are preserved across transformations.
      - ☐ Limiting material to a static homogeneous set allows abstraction and efficiency in musical language.
      - ☐ Summary: Description of Homogeneous notes and characteristics.
      - ☐ …heterogeneous sound objects. …sound object generalizes the note concept in two ways:
      - ☐ 1. It puts aside the restriction of a common set of properties in favor of a heterogeneous collection of properties. Some objects may not share common properties with other objects Certain sound objects may function as unique singularities.

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- ☐ 2. It discards the notion of static, time-invariant properties in favor of time varying properties (Roads 1985b).
- ☐ Transformations applied to objects in one class may not be effective in another class.
- ☐ In traditional western music, the possibilities for transition within a note are limited by the physical properties of the acoustic instrument as well as frozen by theory and style.
- ☐ Unlike notes, the properties of a sound object are free to vary over time. This opens up the possibility of complex sounds that can mutate from one state to another within a single musical event.
- ☐ In the case of synthesized sounds, an object may be controlled by multiple time-varying envelopes for pitch, amplitude, spatial position, and multiple determinants of timbre.
- ☐ We can subdivide a sound object not only by its properties but also by tis temporal states. These states are com posable using synthesis tools that operate on the microtime scale.

- ☐ **Sound Object Morphology:**
  - ☐ In music, as in other fields, the organization is conditioned by the material. Schaeffer 1977, p.680)
  - ☐ The desire to understand the enormous range of possible sound objects led Pierre Schaeffer to attempt to classy them, , beginning in the early 1950's (Schaeffer and Moles 1952).
  - ☐ Book V of his Traite des objets musical (1977), entitled Morphologie and typology des objets son ores introduces the useful notion of sound object morphology-- the comparison of the shape and evolution of sound object morphology--The comparison of the shape and evolution of sound objects.
  - ☐ Schaeffer borrowed the term morphology from the sciences, where it refers to the study of form and structure (of organisms in biology, of word-elements in linguistics, of rocks in geology, etc.).
  - ☐ … he diagrammed sound shape in three dimensions: harmonic (spectrum), dynamic (amplitude), and melodic (pitch).
  - ☐ He observed that the elements making up a complex sound can be perceived as either merged to form a sound compound, or remaining separate to form a sound mixture. His typology, or classification of sound objects into different groups, was based on acoustic morphological studies.
  - ☐ The idea of sound morphology remains central to the theory of electroacoustic music (Bayle 1993), in which the musical spotlight is often shone on the sound object level.
  - ☐ In the electroacoustic music, the morphology of an individual sound may play a structural role, and transitions can occur within an individual sound object. This ubiquity of mutation means that every sonic event is itself a potential transformation.

- ☐ **Micro Time Scale: (pg. 20)**
  - ☐ … micro time scale is the main subject of this book.
  - ☐ It embraces transient audio phenomena, a broad class of sounds that extends from the threshold of timbre perception (several hundred microseconds) up to the duration of short sound objects (~100 ms). It spans the boundary between the audio frequency range (approximately 20 Hz to 20 kHz) and the infrasonic frequency range (below 20 Hz). Neglected in the past owing to its inaccessibility, the microtome domain now stands at the forefront of compositional interest.
  - ☐ Summary: Description of Microsounds in nature. Microsounds in instruments and microsounds in mathematics.
  - ☐ **Perception of Microsound:**
    - ☐ Microevents last only a very short time, near to the threshold of auditory perception. Much scientific study has gone into the perception of microevents. Human hearing mechanisms, intertwine with brain functions, cognition, and emotion, and are not completely understood.
    - ☐ One cannot speak of a single time frame, or a time constant for the auditory system (Gordon 1996). Our hearing mechanism invoke many different agents, each of which operates on its own time scale (see figure 1.1).
    - ☐ The brain integrates signals sent by various hearing agents into a coherent auditory picture.
    - ☐ Ear-brain mechanisms process high and low frequencies differently. Keeping high frequencies constant, while inducing phase shifts in lower frequencies, causes listeners to hear a different timbre.
    - ☐ Determining the temporal limits of perception has long engaged psychoacousticians.
    - ☐ The pioneer of sound quanta, Dennis Gabor, suggested that at least two mechanisms are at work in micro event detection:
    - ☐ 1. that isolates events
    - ☐ 2 that ascertains their pitch.
    - ☐ Human beings need time to process audio signals. Our hearing mechanisms impose minimum time thresholds in order to establish a firm sense of identity and properties of a microevent.
    - ☐ ..Audition (1992) Buser and Imbert summarize a large number of experiments with transitory audio phenomena.
    - ☐ The general result from these experiments is that below 200 ms, many aspects of auditory perception change character and different modes of hearing come into play.
  - ☐ ***Microtemporal Intensity Perception:***
    - ☐ In the zone of low amplitude, short sounds must be greater in intensity than longer sounds to be perceptible.
    - ☐ …subjective loudness diminishes with shrinking durations below 200 ms.
  - ☐ ***Microtemporal Fusion and Fission:***

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- ☐ *In dense portions of the Milky Way, stellar images appear to overlap, giving the effect of a near-continuous sheet of light… The effect is a grand illusion. In reality … The nighttime sky is remarkably empty. Of the volume of space only 1 part in 10 (to the 21st) [one part in a quintillion] is filled with stars. (Kaler 1997)*
- ☐ Circuitry can measure time and recognize pulse patterns at tempi in the range of a gigahertz. Human hearing is more limited. If one impulse follows less than 200 ms after another, the onset of the first impulse will tend to mask the second, a time-lag phenomenon known as forward masking, Which contributes to the illusion that we call continuous tone.
- ☐ The sensation of tone happens when human perception reaches attentional limits where micro events occur to quickly in succession to be heard as discrete events.
- ☐ The auditory system, which is nonlinear, reorganizes these events into a group.
- ☐ Example: When a fast sequence of pitched tones merges into a continuous tone. When a fast sequence of pitched tones merges into a continuous "ripple," the auditory system is unable to successfully track its rhythm.Instead, it simplifies the situation by interpreting the sound as a continuous texture. The opposite effect, tone fission, occurs when the fundamental frequency of a tone descends into the infrasonic frequencies.

- ☐ The theory of auditory streams (McAdams and Bregman 1979) aims to explain the perception of melodic lines.
- ☐ An example of a streaming law is: the faster a melodic sequence plays, the smaller the pitch interval needed to split it into two separately perceived ``streams.'' One can observe a family of streaming effects between two alternating tones A and B. These effects range from coherence (the tones A and B form a single percept), to roll (A dominates B), to masking (B is no longer perceived).

  The theory of auditory streaming was an attempt to create a psychoacoustic basis for contrapuntal music. A fundamental assumption of this research was that ``several musical dimensions, such as timbre, attack and decay transients, and tempo are often not specified exactly by the composer and are controlled by the performer'' (McAdams and Bregman 1979). In the domain of electronic music, such assumptions may not be valid.

- ☐ ***Microtemporal Silence Perception:***
  - ☐ In intermediate tones, between a sine and noise, micro temporal gaps less than 10 ms sound like momentary fluctuations in amplitude or less noticeable transient pops.
- ☐ ***Microtemporal Pitch Perception:***
  - ☐ Studies by Meyer-Eppler show that pitch recognition time is dependent on frequency, with the greatest pitch sensitivity in the mid-frequency range between 1000 and 2000 Hz,
  - ☐ …Doughty and Garner (1947) divided the mechanism of pitch perception into two regions. Above about 1 kHz, they etimated, a tone must last at least 10 ms to be heard as pitched. Below 1 kHz, at least two to three cycles of tone are needed.
- ☐ ***Microtemporal Auditory Acuity:***
  - ☐ *We feel impelled to ascribe a temporal arrangement to our experiences. …At first sight it appears obvious to assume that a temporal arrangement of events exists which agrees with the temporal arrangement of experiences. This was done unconsciously until skeptical doubts made themselves felt. For example, the order of experiences in time obtained by acoustical means can differ from the temporal order gained visually (Einstein 1952)*
  - ☐ Green (1971) suggested that temporal auditory acuity (the ability of the ear to detect discrete events and to discern their order extends down to durations as short as 1 ms. Listeners hear micro events that are less than about 2 ms in duration as a click, but we can still change the waveform and frequency of these events to vary the timbre of the click. Even shorter events (in the range of microseconds) can be distinguished on the basis of amplitude, timbre, and spatial position.
- ☐ ***Microtemporal preattentive Perception:***
  - ☐ *When a person glimpses the face of a famous actor, sniffs a favorite food, or hearts the voice of a friend, recognition is instant. Within a fraction of a second after the eyes, nose, ears, tongue or skin is stimulated, one knows the object is familiar and whether it is desirable or dangerous. How does such recognition, which psychologists call pre attentive perception, happen so accurately and quickly, even when the stimuli are complex and the context in which they arise varies? (Feeman 1991)*
  - ☐ One of the most important measurements in engineering is the response of a system to a unit impulse. It should not be surprising to learn that auditory neuroscientists have sought a similar type of measurement for the auditory system. The impulse response equivalents in the auditory system are the auditory evoked potentials, which follow stimulation by tone pips and clicks.
  - ☐ The first response in the auditory nerve occurs about 1.5 ms after the initial stimulus of a click, which falls within the ream of pre attentive perception stimulus of a click, which falls within the realm of pre attentive perception (Freeman 1995). The mechanisms of preattentive perception perform a rapid analysis by an array of neurons, combining this with past experience into a wave packet in its physical form, or a percept in its behavioral form. The neural activities sustaining preattentive perception take place in the cerebral cortex. Sensory stimuli are preanalyzed in both the pulse and wave modes in intermediate stations of the brain. As Freeman noted, in the visual system complex operations such as adaptation, range compression, contrast enhancement, and motion detection take place in the retina and lower brain. Sensory stimuli activate feature extractor neurons that recognize specific characteristics. Comparable operations have been

described for the auditory cortex: the final responses to a click occur some 300 ms later, in the medial geniculate body of the thalamus in the brain (Buser and Imbert 1992).

- ☐ ***Microtemporal Subliminal Perception:***
  - ☐ …subliminal perception, or perception without awareness.
  - ☐ Psychological studies have tested the influence of brief auditory stimuli on various cognitive tasks. In most studies these take the form of verbal hints to some task asked of the listener. Some evidence of influence has been shown, but the results are not clear-cut. Part of the problem is theoretical: how does sub- liminal perception work?
  - ☐ How does subliminal perception work?
  - ☐ …cognitive theory of Reder and Gordon (1997), for a concept to be in conscious awareness, its activation must be above a certain threshold.
  - ☐ Magnitude of activation is partly a function of the exposure duration of the stimulus. A subliminal micro event raises the activation of the corresponding element, but not enough to reach the threshold.
  - ☐ The brain's ``production rules'' cannot ®re without the elements passing threshold, but subliminal micro event can raise the current activation level of an element enough to make it easier to fire a production rule later.
  - ☐ The musical implications are, potentially, significant.
  - ☐ If the subliminal hints are not fragments of words but rather musical cues (to pitch, timbre, spatial position, or intensity) then we can embed such events at pivotal instants, knowing that they will contribute to a percept without the listener necessarily being aware of their presence.
  - ☐ …this is one of the most interesting dimensions of micro sound, the way that subliminal or barely perceptible variations in the properties of a collection of microevents--their onset time, duration, frequency, waveform, envelope, spatial position, and amplitude--lead to different aesthetic perceptions.
- ☐ **Viewing and Manipulating the Microtime level:**
  - ☐ Microevents touch the extreme time limits of human perception and performance. In order to examine and manipulate these events fluidly , we need digital audio "microscopes"--software and hardware that can magnify the microtome scale so that we can operate on it.
  - ☐ …serious researcher, the most precise strategy for accessing the micro time scale is through computer programming. Beginning in 1974, my research was made possible by access to computers equipped with compiler software and audio converters. Until recently, writing one's own programs was the only possible approach to microsound synthesis and transformation.
  - ☐ Many musicians want to be able to manipulate this domain without the total immersion experience that is the lifestyle of software engineering. Fortunately, the importance of the micro time scale is beginning to be recognized. Any sound editor with a zoom function that proceeds down to the sample level can view and manipulate sound microstructure (figure 1.4).
  - ☐ [redacted]
  - ☐ …Cloud Generator (Roads and Alexander 1995) offer high -level controls in the micro time domain. .. interface directly manipulates the process of particle emission, controlling the flow of many particles in an evolving cloud. PulsarGenerator described in chapter 4, is another example of a synthetic particle generator.
  - ☐ The perceived result of particle synthesis emerges out of the interaction of parameter evolutions on a micro scale. It takes a certain amount of training to learn how operations in the micro domain translate to acoustic perceptions on higher levels.
  - ☐ The grain duration parameter in granular synthesis, for example, has a strong effect on the perceived spectrum of the texture.
  - ☐ This situation is no different from other well-known synthesis techniques. Frequency modulation synthesis, for example, is controlled by parameters such as carrier-to-modulator ratios and modulation indexes, neither of which are direct terms of the desired spectrum. Similarly, physical modeling synthesis is controlled by manipulating the parameters that describe the parts of a virtual instrument (size, shape, material, coupling, applied force, etc.), and not the sound.

    One can imagine a musical interface in which a musician specifies the desired sonic result in a musically descriptive language which would then be translated into particle parameters and rendered into sound. An alternative would be to specify an example: ``Make me a sound like this (soundfile), but with less vibrato.'' This is a challenging task of parameter estimation, since the system would have to interpret how to approximate a desired result. For more on the problems of parameter estimation in synthesis see Roads (1996).
- ☐ **Do the Particles Really Exist?**
  - ☐ In the 1940's, the physicist Dennis Gabor made the assertion that all sound even continuous tones--can be considered as a succession of elementary particles of acoustic energy. (Chpt 2) The question then arises: do sound particles really exist, or are they merely a theoretical construction?
  - ☐ In certain sounds, such as the taps of a slow drum roll, the individual particles are directly perceivable. IN other sounds, we can prove the existence of a granular layer through logical argument.
  - ☐ Consider the whole number 5. This quantity may be seen as a sum of sub quantities, for example 1 + 1 + 1 + 1 + 1, or 2 + 3, or 4 + 1, and so on. If we take away one of the sub quantities, the sum no longer is 5. Similarly, a continuous tone may be considered as a sum of subquantities--as a sequence of overlapping

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grains. The grains may be of arbitrary sizes. If we remove any grain, the signal is no longer the same. So clearly the grains exist, and we need all of them in order to constitute a complex signal. This argument can be extended to explain the decomposition of a sound into any one of an infinite collection of orthogonal functions, such as wavelets with different basis functions, Walsh functions, Gabor Grains, and so on.

- ☐ This logic, though becomes tenuous if it is used to posit the preexistence (in an ideal Platonic realm) of all possible decompositions within a whole. For example, do the slices of a cake preexist, waiting to be articulated? The philosophy of mathematics is littered with such questions (Castonguay 1972, 1973).

- ☐ **Heterogeneity in Sound Particles:**
  - ☐ The concept of heterogeneity or diversity of sound materials, which we have already discussed in the context of the sound object time scale,also applies to other time scales.
  - ☐ Many techniques that we use to generate sound particles assign to each particle a unique identity, a precise frequency, waveform, duration, amplitude morphology, and spatial position, which then distinguishes it from every other particle.
  - ☐ …as certain sound objects may function as singularities, so may certain sound particles.

- ☐ **Sampled Time Scale: (pg. 29)**
  - ☐ Below the level of microtome stands the sampled time scale (figure 1.5).
  - ☐ [redacted]
  - ☐ The electronic clock that drives the sampling process establishes a time grid. The spacing of this grid determines the temporal precision of the digital audio medium. The samples follow one another at a fixed time interval of 1/fs, where fs is the sampling frequency. When fs = 44.1 kHz (the compact disc rate), the samples follow one another every 22.675 millionths of a second (usec).
  - ☐ The atom of the sample tie scale is the unit impulse, the discrete-time counterpart of the continuous-time Dirac delta function. All samples should be considered as time-and-amplitude-transposed (delayed and scaled) instances of the unit impulse.
  - ☐ The interval of one sample period borders near the edge of human audio perception. … a good audio system one can detect the presence of an individual high-amplitude sample inserted into a silent stream of zero-valued samples.
  - ☐ Like a single pixel on a computer screen, an individual sample offers little.
  - ☐ Its amplitude and spatial position can be discerned, but it transmits no sense of timbre and pitch. Only when chained into sequences of hundreds do samples float up to the threshold of timbral significance. And still longer sequences of thousands of samples are required to represent pitched tones.
  - ☐ **Sound Compositions with Individual Sample Points:**
    - ☐ User's of digital audio systems rarely attempt to deal with individual sample points, which , indeed, only a few programs for sound composition manipulate directly.
    - ☐ *for some time now it has become possible to use a combination of analog and digital computers and converters for the analysis and synthesis of sound As such a system will store or transmit information at the rate of 40,000 samples per second, even the most complex waveforms in the audio-frequency range can be scanned and registered or be recorded on audio tape. This … allows, at last, the composition of timbre, instead of with timbre. In a sense, one may call it a continuation of much which has been done in the electronic music studio, only on a different scale. The composer has the possibility of extending his compositional control down to elements of sound lasting only 1/200,000 of a second. (Brun 1970)*
    - ☐ … Users of these programs stipulated sets of individual time and amplitude points, where each set was in a separate file. They then specified logical operations such as linking, mingling, and merging, to map from a time-pint set to an amplitude-lint set in order to construct a skeleton of a waveform fragment. Since these points were relatively sparse compared to the number of samples needed to make a continuous sound the software performed a linear interpolation to connect intermediate amplitude values between the stipulated points.
    - ☐ Koenig was explicit about his desire to escape from the traditional computer- generated sounds:

      My intention was to go away from the classical instrumental definitions of sound in terms of loudness, pitch, and duration and so on, because then you could refer to musical elements which are not necessarily the elements of the language of today. To explore a new ®eld of sound possibilities I thought it best to close the classical descriptions of sound and open up an experimental ®eld in which you would really have to start again. (Roads 1978b)
    - ☐ Iannis Xenakis proposed a related approach (Xenakis 1992; Hoffmann 1994, 1996, 1997). This involves the application of sieve theory to the amplitude and time dimensions of a sound synthesis process. As in his Gendyn program, the idea is to construct waveforms from fragments. Each fragment is bounded by two breakpoints. Between the breakpoints, the rest of the waveform is filled in by interpolation. Whereas in Gendyn the breakpoints are calculated from a nonlinear stochastic algorithm, in sieve theory the breakpoints would be calculated according to a partitioning algorithm based on sieved amplitude and time dimensions.
    - ☐ Summary: The creation of a new paradigm of music and interest in Set Theory, Sieve Theory and the building of waveforms through interpolation.
  - ☐ **Assessment of Sound Composition with Samples:**
    - ☐ To compose music by means of logical operations on samples is a daunting task. Individual samples are subsymbolic--perceptually indistinguishable from one another. It is intrinsically difficult to string together samples into meaningful music symbols. Operations borrowed from set theory and formal logic do not take into account the samples' acoustical significance.

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- …to compose intentionally a graceful melodic figure, a smooth transition, a cloud of particles, or a polyphonic texture requires extra ordinary effort, due to the absence of acoustically relevant parameters for building higher-level sound structures.

- **Subsample Time Scale: (pg. 31)**
  - A digital audio system represents waveforms as a stream of individual samples that follow one another at a fixed time interval (1/fs, where fs is the sampling frequency). The subsample time scale supports functuations that occur in less than two sampling periods. Hence this time scale spans a range of minuscule durations measured in nanoseconds and extending down to the ream of infinitesimal intervals.
  - To stipulate a sampling frequency is to fix a strict threshold between a subsample and the sample time scale.
  - Frequencies above this threshold the Nyquist frequency (by definition: $f_S/2$)--cannot be represented properly by a digital audio system. For the standard compact disc sampling rate of 44.1 kHz, the Nyquist frequency is 22.05 kHz. This means that any wave fluctuation shorter than two samples, or 45 msec, is relegated to the subsample domain. The 96 kHz sampling rate standard reduces this interval to 20.8 msec.
  - The subsample time scale encompasses an enormous range of phenomena.
  - Here we present five classes of subsample phenomena, from the real and perceptible to the ideal and imperceptible: aliased artefacts, ultrasounds, atomic sounds, and the Planck interval.
  - **Aliased Artefacts:**
    - In comparison with the class of all time intervals, the class of perceptible audio periods spans relatively large time intervals. In a digital audio system, the sample period is a threshold separating all signal fluctuations into two classes: those whose frequencies are low enough to be accurately recorded and those whose frequencies are too high to be accurately recorded. Because a frequency is too high to be recorded does not mean that it is invisible to the digital re- corder. On the contrary, subsample fluctuations, according to the theorem of Nyquist (1928), record as aliased artefacts. Specifically, if the input frequency is higher than half the sampling frequency, then:

      aliased frequency = sampling frequency - input frequency

      Thus if the sampling rate is 44.1 kHz, an input frequency of 30 kHz is rejected down to the audible 11.1 kHz. Digital recorders must, therefore, at- tempt to filter out all subsample fluctuations in order to eliminate the distortion caused by aliased artefacts.

      The design of antialiasing ®lters has improved in the past decade. Current compact disc recordings are efectively immune from aliasing distortion. But the removal of all information above 22.05 kHz poses problems. Many people hear detail (referred to as air) in the region above 20 kHz (Koenig 1899; Neve 1992). Rigorous scienti®c experiments have confirmed the effects, from both physiological and subjective viewpoints, of sounds above 22 kHz (Oohashi et al. 1991; Oohashi et al. 1993). Furthermore, partials in the ultrasonic region interact, resulting in audible subharmonics and air. When the antialiasing filter removes these ultrasonic interactions, the recording loses detail.

      Aliasing remains a pernicious problem in sound synthesis. The lack of frequency headroom in the compact disc standard rate of 44.1 kHz opens the door to aliasing from within the synthesis algorithm. Even common waveforms cause aliasing when extended beyond a narrow frequency range. Consider these cases of aliasing in synthesis:

      1. A band-limited square wave made from sixteen odd-harmonic components causes aliasing at fundamental frequencies greater than 760 Hz.

      2. An additive synthesis instrument with thirty-two harmonic partials generates aliased components if the fundamental is higher than 689 Hz (approximately E5).

      3. The partials of a sampled piano tone A-sharp2 (116 Hz) alias when the tone is transposed an octave and a ®fth to F4 (349 Hz).

      4. A sinusoidal frequency modulation instrument with a carrier-to-modulator ratio of 1:2 and a fundamental frequency of 1000 Hz aliases if the modulation index exceeds 7. If either the carrier or modulator is a non-sinusoidal waveform then the modulation index must typically remain less than 1.
         As a consequence of these hard limits, synthesis instruments require preventative measures in order to eliminate aliasing distortion. Commercial instruments filter their waveforms and limit their fundamental frequency range. In experimental software instruments, we must introduce tests and constrain the choice of waveforms above certain frequencies.

      The compact disc sampling rate of 44.1 kHz rate is too low for high-®delity music synthesis applications.

Fortunately, converters operating at 96 kHz are becoming popular, and sampling rates up to 192 kHz also are available.

- ☐ Summary: Discussion about the details of signals of signal phenomenon of high and low frequencies. This phenomenon that does exist and can be sensed depending on the file fidelity and sampling rate.

- ☐ **Ultrasonic Loudspeakers:**
  - ☐ inaudible energy in the ultrasonic frequency range can be harnessed for audio use.
  - ☐ heterodyning: this principle is based on a phenomenon observed by Helmholtz. When two sound sources are positioned relatively closely together and are of sufficiently high amplitude, two new tones appear. one lower and one higher thant either of the original tones.
  - ☐ Reporting that he could also hear the summation tones (whose frequency is the sum, rather than the difference, of the two fundamental tones), Helmholtz argued that the phenomenon had to result from a nonlinearity of air molecules. Air molecules begin to behave nonlinearly (to heterodyne) as amplitude increases.
  - ☐ Unlike regular loudspeakers, acoustical heterodyning loudspeakers project energy in a collimated sound beam, analogous to the beam of light from a flashlight. One can direct an ultrasonic emitter toward a wall and the listener will perceive the sound as coming from a spot on that wall.
- ☐ **Atomic Sound: Phonons and Polarons:**
  - ☐ 1907, Albert Einstein predicted that ultrasonic vibration could occur on the scale of atomic structure (Cochcran 1973). The atoms in crystals he theorized, take the form of a regular lattice.
  - ☐ A one-dimensional lattice resembles the physical model of a taut string--a collection of masses linked by springs. Such a model may be generalized to other structures, for example three-dimensional lattices. Lattices can be induced to vibrate ultrasonically, subjected to the proper force, turning them into high-frequency oscillators. This energy is not continuous, however, but is quantized by atomic structure into units that Einstein called phonons, by analogy to photons the quantum units of light. It was not until 1913 that regular lattices were verified experimentally as being the atomic structure of crystals.
  - ☐ Scientists determined that the frequency of vibration depends on the mass of the atoms and the nature of the interatomic forces. Thus the lower the atomic weight, the higher the frequency of the oscillator (Stevenson and Moore 1967).
  - ☐ Ultrasonic devices can generate frequencies in the trillions of cycles per second.
  - ☐ Complex sound phenomena occur when phononic energy collides with other phonons or other atomic particles. When the sources of excitation are multiple or the atomic structure irregular, phonons propagate in cloud-like swarms called poltroons (Pines 1963).
  - ☐ Thus optical photons can scatter acoustic phonons. For example, laser-induced lattice vibrations can change the index of refraction in a crystal, which changes its electromagnetic properties. On a microscopic scale, optical, mechanical, and electromagnetic quanta are interlinked as elementary excitations.

    Laser-induced phonic sound focuses the beams from two lasers with a small wavelength difference onto a crystal surface. The difference in wavelength causes interference, or beating. The crystal surface shrinks and expands as this oscillation of intensity causes periodic heating. This generates a wave that propagates through the medium. The frequency of this sound is typically in the gigahertz range, with a wavelength of the order of 1 micron. Because of the small dimensions of the heated spot on the surface, the wave in the crystal has the shape of a directional beam. These sound beams can be used as probes, for example, to determine the internal features of semiconductor crystals, and to detect faults in their structure.
  - ☐ One of the most important properties of laser-induced phononic sound is that it can be made coherent (The wave trains are phase-aligned), as well as monochromatic and directional.
  - ☐ This makes possible such applications as acoustic holography (the visualization of acoustic phenomena by laser light).
  - ☐ en.wikipedia.org-
- ☐ **At the Physical Limits: The Planck Time Interval:** *(pg. 35)*
  - ☐ Sound objects can be subdivided into grains, and grains into samples. How far can this subdivision of tim continue? Hawking and Penrose (1996) have suggested that time in the physical universe is not infinitely divisible.
  - ☐ …that no signal fluctuation can be faster than the quantum changes of state in subatomic particles, which occur at close to the Planck scale.
  - ☐ The Planck scale stands at the extreme limit of the known physical world, where current concepts of space, time and matter break down, where the four forces unify.
  - ☐ It is the exceedingly small distance, related to an infinitesimal time span and extremely high energy, that emerges when the fundamental constants for gravitational attraction, the velocity of light and quantum mechanics join (Hawking and Penrose 1996)
  - ☐ How much time does it take light to cross the Planck scale? <----------
  - ☐ Light takes about 3.3 nanoseconds ($3X3 \times 10^{-10}$) to traverse 1 meter. The Planck time interval is the time it takes light to traverse the Planck scale. Up until recently, the Planck scale was thought to be 10^{-33} meter. An important new theory puts the figure at a much larger 10^{-19} meter (Arkani-Hamed et al. 2000). Here, the Planck time interval is 3.3×10^{-28} seconds, a tiny time interval.
  - ☐ One could call the Planck time interval a Kind of "sampling rate of the universe,: since no signal fluctuation can occur in less than the Planck interval.

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- ☐ If the flow of time stutters in discrete quanta corresponding to fundamental physical constants, this poses an interesting conundrum, recognized by Iannis Xenakis:
- ☐ *Isn't time simply an epiphenomenal notion of a deeper reality?*
- ☐ *There is no instantaneous jump from one point to another in space, much less spatial ubiquity--that is, the simultaneous presence of an event or object everywhere in space.*
- ☐ *… one posits the notion of displacement. Within a local reference frame, what does displacement signify? If the notion of displacement were more fundamental than that of time, one could reduce all macro and micro cosmic transformations to weak chains of displacement. Consequently … if we were to adhere to quantum mechanics and its implications, we would perhaps be forced to admit the notion of quantified space and its corollary, quantified time.*
- ☐ *But what could a quantified time and space signify, a time and space in which contiguity would be abolished. What would the pavement of the universe be if there were gaps between the paving stones, inaccessible and filled with nothing? (Xenakis 1989)*

- ☐ **Infinitesimal Time Scale: (pg. 36)**
  - ☐ Besides the infinite-duration sinusoids of Fourier theory, mathematics has created other ideal, infinite-precision boundary quantities. One class of idea phenomena that appears in the theory of signal processing is the mathematical impulse of delta (d) function.
  - ☐ [redacted]
  - ☐ Delta functions represent infinitely brief intervals of time.
  - ☐ Physically this means that the pulse's height grows and the interval of integration (the pulse's duration) becomes very narrow. … This shows that the pulse becomes an infinitely high spike of zero width, incited as , the Diract Delta function.
  - ☐ The two significant properties of the d function are:
  - ☐ 1. it is zero everywhere except at one point,
  - ☐ 2. it is infinite in amplitude at this point, but approaches infinity in such a way that its integral is unity-- a curious object.
  - ☐ The most important is the Dirac delta function, formulated for the theory of quantum mechanics.
  - ☐ In other words, the spectrum of an infinitely brief impulse is infinite (Nahin 1996)
  - ☐ We see here a profound law of signal processing, …that duration and spectrum are complementary quantities.
  - ☐ The delta functions are de®ned over a continuous and in®nite domain
- ⊟ **Outside Time Music: (pg. 38)**
  - ☐ Musical structure can exist, in a sense, "outside" of time (Xenakis 1971, 1992).
  - ☐ By this, we mean abstract structuring principles whose definition does not imply a temporal order.
  - ☐ A scale, for example, is independent of how a composer uses it in time. Myriad pre compositional strategies, and databases of material could also be said to be outside time.
  - ☐ A further example of an outside time structure is a musical instrument.
  - ☐ Aleatoric compositions of the 1950's 1960's which left various parameters, including the sequence of events to chance, were also outside time structures.
  - ☑ Today we see installations and ritual environments in which sounds occur in an order that depends on the path of the person interacting with the system, In all of these cases, selecting an ordering the material places it in time.
- ☐ **The Size of Sounds: (pg. 39)**
  - ☐ Sounds form in the physical medium of air-- a gaseous form of matter. Thus sound waves need space to form. Just as sounds exist on different time scales, so they take shape on different scales of space. Every sound has a three dimensional shape and size. Which is its diffusion or dispersion pattern over time. Since the wavelength of a high frequency sound is short, high frequencies form in small spaces. A low frequency waveform needs several meters to unfold. The temporal and the spatial morphologies of sound intertwine. A sounds duration, frequency, amplitude, and pattern of radiation from from its source all contribute to its physical form, as does the space in which the sound manifests.
  - ☐ The duration of a sound is an important determinant of physical shape, especially in the open air. a long -duration sound is long in spatial extent, spanning the entire distance from the source to the point at which its energy is complete absorbed. Short duration sounds on the contrary, are thin in spatial extent, disappearing from their point of origin quickly. The wave of a short duration sound occupies a thin band of air, although the fluctuations that it carries may travel great distances if it is loud enough.
  - ☐ Today we have accurate measurements of the speed of sound waves in a va-riety of media (Pierce 1994). The accepted value for the speed of sound in dry air is 331.5 meters/second. Thus a 20 Hz acoustical wave requires no less than 16.5 meters (54.13 feet) to unfold without obstruction.
  - ☐ Obstructions such as walls cause the wave to reflect back on itself, creating phase cancellation effects.
  - ☐ A high-frequency waveform at 20 kHz has a period of only 1/20,000th of a second. This takes only 1.65 cm to form.
  - ☐ The ear is very sensitive to the time of arrival of sounds from different spatial positions. Thus, even a minor difference in the distance of the listener from two separate sources will key the spatial images.
  - ☐ The most important determinant of a sound's size is its amplitude. Very loud sounds (such as atmospheric thunder and other explosions) travel far. As they travel, the air gradually absorbs the high frequencies, so that only the low frequencies reach great distances.
- ☐ **Summary: (pg. 40)**

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- ☐ *Particle physics seeks to find a simple and orderly pattern to the behavior of matter on the atomic and subatomic level. To this end Large particle accelerators are build, acting like giant microscopes that zoom down through the atom … Astronomers build equally complex devices-- Telescopes and observatories. These gather data from distance clusters of galaxies, all the way out to the rim of the cosmos… We are seeing here a convergence between particle physics and cosmology. The instruments, and even the stated objectives ,a re different, but the languages draw closer. The laws of nature that control and order the microscopic world, and those that determined the creation and evolution of the universe, … are beginning to look identical. (Lederman and Schramm 1995)*
- ☐ Projecting time horizontally, and amplitude vertically, the concept of nil duration corresponds to a zero-dimensional point on the time-amplitude plane. This point zero is mute: no flux of energy can occur in the absence of a time window. In that ideal world experienced only by the gods of mathematics, the delta function q(t) --Find Equation: -- breaks the monotony with an instantaneous impulse that is born and dies within the most infinitesimal window beyond point zero.
- ☐ Our mundane digital domain is a discrete approximation to the ideal realm of infinitesimal time. In the digital domain, the smallest event has a duration equivalent to the period of the sampling frequency. This sound atom, the sample period, is the grid that quantizes all time values in an audio signal. Any curve inscribed on the amplitude-versus-time plane must synchronize to this grid. Individual samples remain sub symbolic. Like the woven threads of canvas holding paint in place, their presence is a necessity, even if we can see them only in the aggregate.
- ☐ As the window of time expands, there is a possibility for chaotic fluctuation, periodic repetition, echoes, tone, noise, and measured silence. Each additional instant of time accrues new possibilities.
- ☐ Microsonic particles can be likened to molecules built from atomic samples. To view this level of detail, we rely on the tools of sound analysis and display. Under this scrutiny, remarkable patterns emerge and we gain new insight into sound structure.
- ☐ Moluecular materials alter the terrain of composition. Plain globules can be molded into arbitrary object morphologies. The presence of mutating sound objects suggests a fluid approach to compositional mesostructure, spawning rivulets, streams, and clouds as well as discrete events. The package of all these musical structures, the macro form, can be tailored with high flexibility and precision in a sound mixing program.
- ☐ it is necessary to see music over a broad range of time scales, from the infinitesimal to the supra scale (Christensen 1996). Not all musicians are prepared to view musical time from such a comprehensive perspective
- ☐ [redacted]

- ⊟ _Outline (Review)
- ☐
- ☐ Additional Reference Material:
  - ☐ **Curtis Roads: Bringing music down to the micro sound level. (2009) On Vice** **www.vice.com—**
  - ☐ **Curtis Roads: Sounds + Science - Gabor's Sonic Model (2009) UCLA.** **vimeo.com—271**
    - ☐ Summary:
      - ☐ Curtis Roads of UC Santa Barbara Department of Media Art & Technology presents "Gabor's Sonic Model: A Research Review" as part of the Sound + Science Symposium at UCLA, March 5th, 2009.
    - ☐ **Introduction:**
      - ☐ University of Illinois. Electronic Music
      - ☐ Took course with Iannis Xenakis - Indiana University.
      - ☐ 1972 - Cal Arts: learning to program scores
      - ☐ 1974 - Transferred to UCSD had a computer that could generate sound
      - ☐ Point Line Cloud (CD DVD)
      - ☐ Book: Microsound: 2001
      - ☐ Book: Composing Electronic Music
      - ☐ Revised Edition: Computer Tutorial (Update)
      - ☐ Talk is about. Aesthetic Ideas and Technical Research.
      - ☐ Aesthetic reflection: Teaching, Writing and Research are related to the process of composition
      - ☐ Example: Tushpa - (Touch not) - Using space as a cadence. Dedicated to Morton Subotnick en.wikipedia.org—Morton_Subotnick
    - ☐ Electronic Music can sound like an acoustical music performance. Reproducing acoustical music.
    - ☐ **How does electronic music change the "rules of the game"**
    - ☐ **Nine (9) Characteristics that sets apart electronic music:**
      - ☐ **One.**
        - ☐ Electronic music opens the domain of composition from a closed homogeneous set of notes to an unlimited universe of heterogenous sound objects.
        - ☐ Varese called this openning" the liberation of sound."
        - ☐ The notes in traditional music are a homogenous system. Each note can be described by the same 4 properties: Pitch, dynamic, duration, and instrument timbre.

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- ☐ Pitch, dynamic, duration, and instrument timbre is functionally equivalent to another notes with the same properties, so the properties of a pair of notes, the properties can be compared and at a distance or interval and can be measured. The notion of distance and equivalence leads to the concept of invariance or intervalic distances that are preserved among transformations.
- ☐ By contrast heterogeneity implies that diverse musical materials may not share common properties we cannot calculate a simple distance between two sounds. We allow the possibility of time varying morphologies and even mutations of identity. They are not static and fixed. They are evolving and mutating. A sound can begin like one thing and evolve into something different.
- ☐ We can extent heterogeneity even further to micro sound for which each constituent grain of sound can be unique. Granular Representation. However the diversity of sound made available in electronic music comes at a price. Comes with the lost of note homogeneity. The loss of a standardized symbolic language common music notation.
- ☐ To enter into the universe of heterogenous sound objects, is to be cast in a strange new land without conventional language.

- ☐ **Two.**
  - ☐ Electronic music extents the temporal domain of composition to the level of microsound.
  - ☐ Particles defined in Microsound (grains, wavelets, pulsars, grain lets, translates and microarchs). Using detailed knowledge of sound, we can edit a micro sound till it has just the right timbre, weight, proportion and shape within a phrase.
  - ☐ Electronic instruments unify the time field between the audio or intone frequencies above 20 Hz (for example that have pitch) and the infrasonic rhythmic of frequencies that are below this thresh hold.
  - ☐ This means we can compose through and in-between these thresholds were rhythms morph into tones and vs. versa. (Curtis has developed software that exploits that condition.)
- ☐ **Three.**
  - ☐ Sound spatialization has evolved into an integral component of composition.
  - ☐ Presenting two facets,the virtual and the physical. In the virtual reality of the studio composers spatialize sounds through techniques that lend the illusion of sound immersing from imaginary environments.
  - ☐ For example: Through convolution we can take a portrait of an existing space and impose its acoustical signature on any sound.
  - ☐ (Example: Plug in: Impulse verb. Existing Space Trinity Church to any sound)
  - ☐ PHD. Thesis, (Curtis Roads: suggestion) translate a synthetic sound portrait into a 3d image of a space that could have produced that sound portrait.
  - ☐ **(Creation of a synthetic sound and to generate a method of creating a virtual space.)
  - ☐ As a compliment to the Virtual approach
  - ☐ Trend: In the physical concert halls we see a pluriphonic or multi loudspeaker sound projection systems. Around the audience. Occupying the entire front stage. Positioned vertically. Positions within the audience.
  - ☐ The convergence of the virtual and the physical make it possible to paint detail sonic landscapes with an interplay between foreground and background elements in three dimensions.
  - ☐ The convergence of the virtual and the physical make it possible to paint detailed sonic landscapes with an interplay of foreground and background elements in three dimensions.
  - ☐ The composer is called upon to perform this spatial projection of the work.
- ☐ **Four.**
  - ☐ New materials and tools mean new organizational strategies.
  - ☐ Not only pitch and time but timbre and space are morphophoric. (capable of conveying structure)
  - ☐ Compositional processes can be based on timbral mutations.
  - ☐ Expansions on the concept of counterpoint to include timbral and spatial interplay.
  - ☐ Detailed control of sound masses.
  - ☐ Juxtapositions of virtual and real soundscapes. Sound coalesce. Sound disintegration.
  - ☐ Interplay with the microtome scale and other time scales that cannot be realized by acoustical instruments.
- ☐ **Five.**
  - ☐ The composer is the performer in the electronic music studio.
  - ☐ Varese observed, " On an instrument played by a human being you have to impose musical thought through notation. And much later a player must prepare himself what will emerge from the notated sound."
  - ☐ This process is indirect compared to electronics, where a sound can appear and disappear unpredictably.
- ☐ **Six.**
  - ☐ The notation of electronic music is graphical rather than symbolic.
  - ☐ We see an increasing tendency of software to portray sound structure graphically.
  - ☐ Example: Sonigraphic or frequency vs. time plane. (Miller Pucket)
  - ☐ In some cases the interface resembles a painting or drawing program for sound.
  - ☐ The representation of sound spectra is increasingly explicit rather than hidden by the note symbol.
- ☐ **Seven.**

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- ☐ The frequency precision of the medium opens up possibilities for pitch organization
- ☐ Such as (examples)
- ☐ an unlimited array of micro tonal scales,
- ☐ the combination of scales in polytonal constructions
- ☐ and the exploitation with the continuum between pitch and noise.
- ☐ At the same time dependance on pitch as an organizing principle is reduced to expanded control over other dimensions.

- ☐ **Eight.**
  - ☐ The temporal precision of the medium makes it possible to realize mathematically exact rhythmic structures and poly rhythms.
  - ☐ At the same time the dependence at the grid of metro which is necessary to synchronize players in instrumental music is reduced to an optional structuring principle in electronic music.
  - ☐ Example: Periodic pulsation. Using in the maritime level. to create tones.
- ☐ **Nine.**
  - ☐ Memorized control or playback from a stored function or sequence and algorithmic control according to a set of logical rules lets a composer organize more layers and dimensions of music then can be handled manually. Greatly expand the capabilities of interactive performance.

- ☐ **Microsound:**
  - ☐ The research is based on a scientific model of sound. Initially proposed by the physicist Dennis Gabor in 1946. Gabor won the Nobel Peace prize in 1971 (Holagrapy). All sounds can be considered acoustic quanta or grains.
  - ☐ Specific to the granular model is the focus on the micro sonic time scale between 100 ms 1/10th of a second and 1 millisecond or 1/1000 of a second.
  - ☐ Time scale of micro sound is pertinent to auditory perception. As It corresponds to the range of several auditory difference thresholds.
  - ☐ Example the smallest time scale which psycho acoustic such as pitch, timbre spatial position, and temporal order are still perceptually salient. (Example 1) 8 grains at 100 milliseconds
  - ☐ Reduction of the duration of the grains by a factor of 100 to 1 imilsecond we cross a perceptual threshold. We no longer hear pitch intervals, but only differences in sound color or timbre. (Example 2)
  - ☐ Crossing the 1 mili second threshold. The sensation of timbre is completely lost. All the grains sound like a click. The difference we hear between them is their amplitude and their position. (Example 3)
  - ☐ Thus the granular thresholds limit a zone of morphosis where the perceptual quality of the experience changes. such zones are extremely important in electronic music. The perceptual threshold between what are perceived as individual events at a continuous stream is of great interest from an aesthetic point of view. Discrete melodies when speed up lose their melodic quality and morph into continuous timbres rhythms sped up morph into tones. Steering around these thresholds is intrinsically exciting and fascinating.
  - ☐ **Example: 10th Vortex. 3 minutes.** **www.youtube.co**
    - ☐ Continuum unfolds and breaks apart. It is full of micro sonic articulations. Every grain has been projected to a random point in space. This piece is made as granular synthesis of thousands of grains, each one projected to its own location in space.
  - ☐ **Background History: Dennis Gabor & Iannis Xenakis**
    - ☐ As Gabor showed all sound can be scene as a combination of acoustic particles.
    - ☐ Iannis Xenakis read Gabor's papers, he proposed a granular synthesis sound in 1960.
    - ☐ Example: Philips pavilion is a direct translation into space, glissandi pitch curves in Xenaki's Metastasis composition for 61 instruments. A composition that is derived from mathematical algorithms.
    - ☐ He used mathematical algorithms to compose a piece of music and then translated it into the Philips Pavillion (Brussels Worlds Fair of 1958)
    - ☐ Description of the components of the Philips Pavilion (Hi Frequency Loudspeakers. The music played inside was electronic. The music was made by Xenakis and Varese. Inside the pavilion was 400 loudspeakers.
    - ☐ 1972, Curtis attended the course Formalized Music with Iannis Xenaki's.
    - ☐ Curtis programmed the computer to realize granular synthesis.
    - ☐ Music can be seen as a pattern of energy sketched on the canvass of time vs frequency. Granular models provide a flexible spray jet for the distribution of energy of sound particles.
    - ☐ Using such tools extends the realm of composition. into the internal structure of individual sounds. (Composition inside the sound, not only the units of larger sounds)
    - ☐ As Gabor observed, all sounds can be bounded by frequency and time. Through new analysis methods we can make atomic representations. to transform sounds in new ways that elucidates and illustrates its internal structure.
  - ☐ Software:
    - ☐ Software: Microsound in Space. Pulsar Synthesis. Pulsar Generator with Mathias del Campo. (Example)
      - ☐ Seperation of Formants. Cannot be done with Acoustical instruments. Going between tone and rhythm.
    - ☐ Emission Control. A synthesize granular equipment. (Reviewed extensively)
  - ☐ Scientific Research:

Microsound The Scales of Music Chapter 01 Curtis Roads. **Links:**

- ☐ 2004 investigation of time frequency and spectrum analysis. (Atomic decomposition and dictionary pursuit.) Can be seen as analytical counterpoints to granular synthesis.
- ☐ The idea is that the implementation of Gabor's theory that all sound is an agglomeration of individual grains . We have an analysis methods that breaks all sound to particles or grains. Professor John Sanken (Electrical and Computer Engineering UCSB) & Professor Roads received an NSF grant to investigate and improve methods.
- ☐ Dictionary based methods. analyze sounds. Analyzes sounds by trying to find matchess between the energy of the signal with a predefined dictionary of micro sonic grains. Comparison between the Short time Fourier transform and discrete wavelet transform.
- ☐ Chart Examples (38 min :38 sec)
- ☐ Short Fourier Transform:
- ☐ Discrete Wavelet Transform:
  - ☐ It is good at localizing high frequency energy and time but terrible in localizing low energy and time.
- ☐ Roads /Shanken Method:

- ☐ **Spatialization:**
  - ☐ Microsound in space.
  - ☐ The invention of the loudspeaker in the 1920's can be compared to the invention of the light bulb. It was possible to project sonic energy.
  - ☐ The use of the loudspeaker was utilitarian before the 1950's.
  - ☐ In the 1950's with the development of the first theories of electronic music the exploiting of sound projection via loudspeakers.
  - ☐ Electro acoustics greatly expanding sound spatialization. (Virtual Spaces recorded on tape were convolved and transmitted through loudspeakers in physical halls.)
  - ☐ To deploy space is to choreograph sound. Directing sources and animating movement.
  - ☐ Spatialization in the 21st century has assumed the position similar to the art of orchestration in the 19th century.
  - ☐ The spatial structure of the work maybe of equal aesthetic importance as its organization in terms of pitch, timbre or rhythm.
  - ☐ With the increasing use of pluriphonic or loudspeaker projection systems. Sounds can articulate a spatial architecture.
  - ☐ Example: (44:13)Recombinant media lab. Image spatialization and sound spatialization. (with Brian Orielly)
  - ☐ New spatialization techniques such as wave synthesis brings sound dimensions into three dimensions.
  - ☐ Sounds can be focused on a three dimensional space.
  - ☐ Example: (44:38) - Acoustical Chandelier.
  - ☐ Example: Tushpa
- ☐ **Question & Answer Session:**
  - ☐ Question 1:
    - ☐ Particle and Wave Duality:
    - ☐ Perceptual Phenomenon and wave phenomenon.
    - ☐ Work out phase relationship.
  - ☐ Question 2:
    - ☐ How do you isolate Ferrari Noise?
    - ☐ Identified the stochastic parts of the noise?
    - ☐ Throwing away particles that have to do with the engine.
  - ☐ Question 3:
    - ☐ Arup has sound. Combination with a virtual piece.
    - ☐ Design an impulse response and see the building.
    - ☐ Siesmologists - Importance
  - ☐ Question 4:
    - ☐ What is the shape of the drum? Mark Kac.
    - ☐ Eigen values of the laplacian of the space is the same on similar shaped drums

- ☐ **Curtis Roads:(2009) Southern California Institute of Architecture.** **sma.sciarc.edu–**
  - ☐ Roads discusses the relation of electronic music with acoustic music, and plays some samples of classical music generated by a computer. He describes electronic music as the liberation of sound. By paying attention to sound spatialization can generate synthetic portraits of imaginary spaces. Besides playing several sound samples, Roads discusses sound visualization, showing some scientific and artistic examples. Roads concludes by stating that his work is all about awakening consciousness through perception.
- ☐ **Curtis Roads: Teoria de síntese granular e pulsar - (2001)** **vimeo.com—271**
- ☐ **Max Mathews & John Chowning - Music Meets the Computer - Moderated by Curtis Roads (2001)** **www.youtube.co**
  - ☐ Computers have revolutionized music making. Two of the most important pioneers of computer music, Max Mathews and John Chowning, stand at the epicenter of this musical revolution. Research led by Mathews at Bell Laboratories, beginning in

Microsound The Scales of Music Chapter 01 Curtis Roads. **Links:**

the 1950s, created a series of programming languages that are the direct precursors of today's software synthesizers. Max Mathew's many contributions to interactive music systems, algorithmic composition, and psychoacoustics (with Jean-Claude Risset) are equally seminal. Stanford's legendary Center for Computer Research in Music and Acoustics (CCRMA) led for many years by Chowning, has long been a hotbed of innovation. After groundbreaking research in sound spatialization, Chowning's invention of frequency modulation (FM) synthesis led to the most successful synthesizer of all time: the Yamaha DX7. In this video, Chowning and Mathews are in conversation with Curtis Roads, composer and music historian. The video also includes a performance by pianist Chryssie Nanou performing "Duet for One Pianist."

- ☐ Advisor/Committee Member (Notes)
- ☐ Global Summary: (Draft)
- ☐ Global Summary: Final Drafts

Xenakis on Xenakis by Iannis Xenakis (1987) **Links:**

- ☐ Article Summary:
- ☐ _a Date: 041614
- ⊟ _Article Summary:
- ☐ _Art Works (Examples)
  - ☐ Architecture: (Working with Le Corbusier)
    - ☐ Le Couvent De La Tourette (window detail) www.youtube.con
    - ☐ Philips Pavilion (1958) www.archdaily.co
  - ☐ Music Composition:
    - ☐ **Achorripsis (1957)** www.youtube.con
    - ☐ **Akrata (Groups) (1965) - [Groups]** www.youtube.con
    - ☐ **Nomos Alpha (1966) - [Groups]** www.youtube.con
    - ☐ **Metastasis (1954)** www.youtube.con
    - ☐ **Mycenae Alpha (1978)** www.youtube.con
    - ☐ **Pithoprakta (1956)** www.youtube.con
    - ☐ **ST/4 (1962) - [ST Algorithm]** www.youtube.con
- ☐ _Bibliography (Alternative Format)
- ☐ _Concepts:
  - ☐ Terms
    - ☐ Probability, Stochastic en.wikipedia.org–
- ☐ Glossary:
  - ☐ Definitions:
    - ☐ Plato's Cave en.wikipedia.org–
    - ☐ Stochastic Music: en.wikipedia.org–
    - ☐ UPIC www.youtube.con
    - ☐ Aleatoric music en.wikipedia.org–
    - ☐ Sisyphus en.wikipedia.org–
    - ☐ Tantalus en.wikipedia.org–
    - ☐ fugue en.wikipedia.org–
    - ☐ Hieratic en.wikipedia.org–
    - ☐ Combinatorics en.wikipedia.org
    - ☐ Graph theory en.wikipedia.org–
    - ☐ Exegesis en.wikipedia.org–
- ⊟ Outline:
  - ☐ **Introduction: (pg. 16)**
    - ☐ ITS IT BECAUSE he was born in Greece? That he went through the doors of the Poly technic University before those of the Conservatory? That he thought as an architect before he heard as a musician? Iannis Xenakis occupies an extrordinary place in the music of our time.

      He is compared to the sages of Greek Antiquity, to the painters of the Renaissance, to the Encyclopedists of the Century of Enlightenment. Occasionally one is tempted to scoff at his theoretical positions on the merging of music, architecture, and science.

      Iannis Xenakis responds as an artist: through his philosophic questioning and the directions of his research, he gives expression to the torment that dwells within him: his violent poetry of the galaxies, his mortal wars of atom-sounds echo the primitive chaos and immortalize it in a ceaseless storm.
    - ☐ Who, really, is the creator Iannis Xenakis? He reveals himself to us in the interview which opens this article. Why has Iannis Xenakis emerged as one of the most important composers in instrumental music of our time? How do the preoccupations of the composer, developed for example in Metastasis (1955), meet the approach of the architect?

      Iannis Xenakis is revolutionizing the relation between music and the computer. His first works with computer (ST/4, ST110, ST/48, conceived at IBM)go back m the years1955-60. Since then, he has been inventing a new way to think music-from a drawing: he created the UPIC system (Uniti Polyagogique Informatique de CEMAMu) in 1977at the CEMAMu (the research center that he directs in Paris). What need led him to the confrontation between science and music?

      To each of these questions, the interview here with Iannis Xenakis and the excerpts from his own

writings will provide us with an initial response: a partial approach to the composer's highly complex, constantly evolving universe.

- ☐ ***Summarized Points:***

- ☐ **I. Portrait of Iannis Xenakis: (pg. 18)**
  - ☐ ***Why music?***
    - ☐ It thrilled me. It carried me away. When I was twelve or thirteen years old, I was practicing the piano, I was reading Astronomy by Flammarion for hours on end. I was doing mathematics and archaeology: I didn't like life. I had all kinds of failures.
      The power of music is such that it transports you from one state to another. Like alcohol. Like love. If! wanted to learn how to compose music, maybe it was to acquire this power. The power of Dionysus.
    - ☐ Section Points : --
  - ☐ ***And at a certain point you chose to go into science?***
    - ☐ No. I wanted to do everything at the same time. Earn my living, learn math and physics: the only really serious place was the Polytechnic University in Athens. The entrance exams were difficult and I worked hard to pass them. I made it. But at the same time, I was doing music, archaeology, and law.
    - ☐ Section Points : --
  - ☐ ***Did you consider music as a discipline among others?***
    - ☐ Absolutely. Things were scattered. Each subject was a domain. I wasn't trying to make any connection. If my professors had really taught me, in the true sense of the word, they would have made the connection: they would have shown me music combinatorics which would have opened up for me a more abstract vision of harmony, of contrapuntal polyphony, of form. They didn't do it. They were speaking as musicians.
      At that time, I was working with private teachers. I didn't think about the Conservatory. I thought music should be learned like that.
    - ☐ Section Points : --
  - ☐ ***Like how?***
    - ☐ Without going to school. It's strange. I had the impression that music, like painting, escaped academics. My desire to study music was intense. But, at the same time, I was ashamed that I wanted to, as if it were a weakness
    - ☐ Obviously, the milieu in which I lived was not very favorable for music: few milieus are! I was very young when my mother died. I was five. She was a musician. She played the piano. She wanted me to play the violoncello; maybe it was for that reason that I eventually wrote for the cello. As for myself, I didn't want to learn the cello. So I played the piano.
    - ☐ When I was seventeen years old, all of a sudden I realized that I wanted to make music, that is, that I wanted to write it myself. I looked for professors capable of teaching me the rudiments of composition. But the decision to do only that, to be a musician exclusively, came later.
    - ☐ I was twenty-five years old, and I was in a hopeless situation. There had been the war. I had fought in the Resistance. All the marvelous universe that I had imagined, first by myself, then in reading The Republic of Plato (another way of life in which art would have a fundamental place in behavior, dress, language,- everything that had pushed me to join the Communist Party suddenly collapsed. I decided to withdraw into myself. In this innermost recess, there was no science. But there was music.
    - ☐ Either I committed suicide. Or I started out on a new foot. I had the choice of continuing on the same course that I had followed for years with all the force and strength that youth has and that distress gives-to be a political activist (but this was no longer possible in Greece because the authorities were looking for me,-or to withdraw into music. This was the decision that I made in coming to France. Actually, I had left to go to the United States: France had been defeated. I thought it would be chaos there. I wasn't mistaken. But I had friends there. I stopped there.
    - ☐ The strange thing is that I never thought about going to the USSR! I have to say that I climbed on the bandwagon when the Allies became so friendly with the Russians in order to win the war. Roosevelt and even Stalin were saying how much different life would be on the planet after the war. This went right along with my militant beliefs and with reading Plato and Marx. This was the instant solution for a richer life. But all this had been shattered.
    - ☐ Section Points : --
  - ☐ ***By Stalin?***
    - ☐ Not only byStalin. Stalin betrayed the Greek resistance, which was essentially a communist movement. But the English also betrayed the resistant fervour of that really ruined country. And even the Americans, with Truman. If Roosevelt had remained in government, there would not have been the Cold War. Truman was a simple little man from the right wing who brought to the presidency all the paltriness and the racism of his clan.

      1947, in France, marked the beginning of a period of moving about from place to place that lasted until l952. I had heard of Nadia Boulanger, and I went to see her-I was still looking for someone who could guide me. She told me that I had talent but that she was too old to take a beginner like me. For that matter, she was only sixty years old then. But she still could choose her students.

Xenakis on Xenakis by Iannis Xenakis (1987) **Links:**

- ☐ By chance, I found work with the architect, Le Corbusier, whose team included a number ofGreeks, and who took me with him as engineer. For me, architecture had stopped at Antiquity. All architecture-Byzantine, Roman, Gothic and modern-was nonexistent.
- ☐ Section Points : -
- ☐ ***That of Le Corbusier as well?***
  - ☐ No. I realized his importance as soon as I saw him working. When an artist is not a fool, he creates around him a field of very sensitive forces. This was his case. One day, I told him that I wanted to work at architecture. He responded, "Why not?" He, himself, had not come out of a school. He had not been admitted to the School ofFine Arts, and in the end, he did his architecture as he understood it. It was a good example.

    He detested all music except that of Varese, whom he had known personally. It should be said that his mother was a great pianist (by dint of hearing Men- delssohn all the time, he must have gotten fed up!) and that one of his brothers, the darling of the family, was a composer. *As* for himself, he made his way all alone, starting by engraving watch-backs at La-Chaux-de-Fonds.

    I wanted to work in those days in the electronic studio of Pierre Schaeffer. This music interested me a lot. I was going to the concerts at the "Petit Conservatoire" where there were never more than three people in the audience.

    I wrote to Schaeffer. He never answered me. Finally, I brought him a score, *Sacrifice* for eight instruments. Since he couldn't read music, he gave it to Pierre Henry, who, very kindly, showed it to Scherchen, who was rehearsing Deserts by Varese. They were interested.

    What counted above all was the row I had with Honegger. I was enrolled in his composition class at the Ecole Normale. The students would bring their works, and he would critique them in front of everyone.

    I went there. I showed him a score. He played it and said,

    "There, you have got parallel fifths." "Yes, but I like them."

    "And there, parallel octaves."

    "Yes, but I like them."

    "But all this, it's not music, except for the first three measures, and even those..."

    And the madder he got, the madder I got. I thought that he was a free- thinking man. How could he make athing out of parallel fifths, especially after Debussy, Bartok, and Stravinsky?

    So I left Honegger-hardened. I learned that I should no longer look to someone else for what existed in me.

    The class of Messiaen was a different matter: he analyzed scores, also his own. It was he that made me discover the possibilities of abstraction starting with Beethoven and Stravinsky. I said to myself-they're crazy, those guys.

    Why don't they really do everything? What criteria dictated their choices? Tradition? But what is tradition? So I deduced that, theoretically, one could do everything. This was what clicked into place in my head.
  - ☐ Section Points : -
- ☐ ***What pushed you to adopt, early on, compositional methods that were absolutely new?***
  - ☐ My development was that of sleepwalker. It's difficult for me to explain it. A posteriori, I think that drawing came easy to me: I was drawing, and my drawing' represented musical symbols. I knew traditional solfege. But freedom of thought, for me, could not come from there. I was convinced that one could invent another way of writing music. I set myself to imagining sound phenomena, using drawing' to help me: a spiral, intersecting planes. . . .
    And then, I always adored the sound of nature, the sea, crickets. During the Occupation, the demonstrations against the enemy brought together hundreds of thousands of people in Athens who shouted slogans, who planted mines. Apart from these scenes which marked me politically, the sound phenomena are engraved in me . During the street fighting of December 1944 there were scattered explosions, tracer bullets, bombings: extraordinary sounds.
  - ☐ Section Points : -
  - ☐ *Insights : (Thesis)* -
    - ☐ *Xenakis saw the limitations of music notation. He used drawing as a medium to imagine sound phenomena. His interests in drawing was to represent the natural structure and to evolve music notation for each respective phenomenon.*

Xenakis on Xenakis by Iannis Xenakis (1987) **Links:**

- ☐ ***Your critics conclude that your ideas are not specifically musical.***
  - ☐ Those who say that have a conception of music based on polyphony and tonal harmony. Berlioz, in the same way, thought that Chinese music wasn't music .
  - ☐ Insights : (Thesis) -
    - ☐ Xenakis was also following the evidence that existing music from other countries were not apart of the western canon. This also validated his intuition to proceed with developing his own style.
  - ☐ Section Points : -
- ☐ ***Didn't you think immediately of using electronic music techniques?***
  - ☐ That was private ground. I wasn't admitted into the "Groupe de Recherche" at the French Radio until l957, and even then-at a time when Schaeffer was ill! For me it was too late. What I had to do I did in the instrumental domain.

    Besides, I think that the instrumental realm is richer than the electronic: an orchestra is made up of individuals, and each individual can transmit an infinity of sounds. The composer can obtain the greatest configurations that he could hope for. It suffices to imagine them, then to transcribe them onto paper. The human orchestra machine thus lends itself to the most complex, abstract speculations.

    On the contrary, if you use magnetic tape, you must record each sound, manipulate it, and mount it: this is an enormous amount of work. Successive mixings degrade the sound and cannot be multiplied.

    Electronic music obtained from frequency generators is even worse-the sounds are all the same kind. That's what happens at least when one limits one's self-like at the studio at Stanford in the States or at IRCAM-to juxtapositions of pure sounds. When one approaches the computer with new music-theoretical thought, one will make music that will go further than that of today's orchestra.
  - ☐ Thoughts : (Experiments) -
    - ☐ Xenakis privileges the natural phenomenon of sound through the orchestra machine. This machine has the richness of the natural phenomenon that cannot be replicated by the computational machinery of the time. But this did inspire other methods and tests cases that used the strengths of both methods and deconstructed the approaches to both as formal languages composition.
  - ☐ Section Points : -
- ☐ ***The progress in music will therefore always go, according to you, towards a greater complexity?***
  - ☐ At a given moment, yes. But not necessarily all the time. Because from complexity to complexity, it can happen that you no longer know what you're doing. There are examples of enormous simplifications: serial music makes a simplification in harmonic relations and in tonal functions. It was because of this that it had to reintroduce the complex polyphony of the Renaissance. When Einstein formulates the equivalence of energy and matter in a short multiplication, he makes a fantastic simplification.

    But all this is relative: what you find to be simple are the signs for extremely complicated realities. To get across quicksand, you have to hold onto branches. Abbreviations, names, formulae play the role of branches.

    The problem is not one of complexity but of power and of freedom of action. A bad composer, a bad artist does only what he has been taught. He is incapable of making a creative blunder. To make such blunders-maybe even brilliant ones!-one cannot have mental rails. Freedom then means total responsibility. One can go everywhere. One chooses to go there and not elsewhere.
  - ☐ *Insights : (Section)* -
    - ☐ *Xenakis discusses his notion of mental rails. The limitation that is found in bad composer's or art that limits the exploration of the medium and the formal language of style of the time. Xenakis finds that the artist mind can be changed if the limitations are removed and self determination is emphasized through exploration in all forms within or outside the discipline.*
  - ☐ Section Points : -
- ☐ ***Using the computer is a way of being freer?***
  - ☐ The computer should be used not only for sound synthesis but also for macro-structures, large-scale constructions. Technology still had to follow, and as for that, I was waiting with no success (since the beginning of the 1960s). Finally, thanks to grants from the Gulbenkian Foundation and the National Center of Telecommunications Studies of France, we built a first system for computer sound synthesis in 1971.[1]

    The obstacle stood on the side of the computer: how to transmit to the machine a notation and concepts that the musician learns in the conservatories. The solution was the hand: the musician gives his commands to the computer through drawings, and not punch cards or programs.

Xenakis on Xenakis by Iannis Xenakis (1987) **Links:**

So we have made the UPIC.[2] This is a graphic table, a drawing table, like an architect's. Equipped with a special pen, the musician traces lines on the table. The computer interprets these signs and reconstructs them in the form of isolated sounds or of music.

The interest for the composer is that all this should happen in real time. When he writes a score, he has to wait for it to be copied and executed. With this system, he writes and the result is immediate. Moreover, he can go hunt- ing for timbres and instruments by drawing-no need for symbols, nor for solfege. Nothing but lines having a certain relationship-which one learns very quickly-with the sound.

The pedagogic interest is obvious: with the UPIC, music becomes a game for the child. He writes. He listens. He has everything in his reach. He corrects immediately. He is not forced to become initiated to instruments. He can imagine the timbres. And, above all, he can devote himself right away to composition.

- ☐ *Insights : (Thesis)* --
  - ☐ *Xenakis with his development of the UPIC, he wanted a formal realtime system to be attached to the language of drawing. For the real-time elements of a 2 dimensional figurative line drawing to be represented in sound. This ability to free the artist from within and releases the user's constraint of knowing the existing formal symbolic language of music. The rules that are established in the system can be learned quickly by immersion in the tool and hearing realtime results (the playing of the instrument).*
- ☐ Section Points : --

- ☐ ***Is it important that the hand be involved?***
  - ☐ Yes. What is obtained by calculation always has limits. It lacks inner life, unless very complicated techniques are used. Mathematics gives structures that are too regular and that are inferior to the demands of the ear and the intelligence. The great idea is to be able to introduce randomness in order to break up the periodicity of mathematical functions, but we're only at the beginning.

    The hand, itself, stands between randomness and calculation. It is both an instrument of the mind- so close to the head-and an imperfect tool.

    The products of the intelligence are so complex that it is impossible to purify them in order to submit them totally to mathematical laws. Industrialization is a forced purification. But you can always recognize what has been made industrially and what has been made by hand. Industrial means are clean, functional, poor. The hand adds inner richness and charm.
  - ☐ Thoughts : (Experiments) --
  - ☐ Section Points : --
- ☐ ***You mean, that this is art?***
  - ☐ Not necessarily. But there is a greater chance. Only one set of my works, the *ST,* came out of computer programs. All the others are mostly handiwork, in the biological sense: adjustments that cannot be controlled in their totality. If God existed He would be a handyman.

    Music, today, must go through the stages that the sciences encountered in the nineteenth century. Sounds must be likened to signs and symbols. The significance of music is found in them, in their physical relation, and not in the psychological conditionings that are submissive to passing fashions. Whence my idea of symbolic music.
  - ☐ Section Points : --
- ☐ ***Do you deny that music be mystic?***
  - ☐ Music cannot lead to mysticism. The imbeciles who listen to it that way are the mystics. Mysticism is a drug. One thinks that one is making mysticism- look at Messiaen!-but the high value of his music is elsewhere: Religious sensitivity evolves so quickly that before long this mysticism takes on the appearance of superficial froth, linked to the color of the times.

    That is why I like Bach. What interests me in him, in spite of all the years separating us, are the relations among the notes. A certain number of relations, the more abstract ones, remain. The proportions and the forms are the hard body of the work.

    The architecture of ancient times was swept away by a female form of Byzantine art, the dome. Then it reappeared in the Renaissance era. Likewise, mathematics has withstood millennia thanks to its inner force. This force is both rational and intuitive: A machine is able to compute, but it does not under- stand mathematics. A work of art, it too, remains thanks to its hard yolk. It is neither the perfumes of an era nor the mysticism which gives it this power.

    I appear perhaps very optimistic: Finally, maybe, nothing lasts. And yet, paleontology shows that biological data three billion years old lives on in us without our being aware of it. All of our fundamental chemistry dates back to that era. And it goes even further: According to certain theories, life on earth comes from the cosmos. In the artistic sphere, we ourselves are also no doubt

rooted in the cosmos.

-Remarks noted by Pascal Dusapin and Anne Rey

- ☐ *Conceptual : (Insight) -*
  - ☐ *Xenakis does not empower style and the arts ability to do anything other than operate on its own internal mechanisms of existence. Similar to an experiment, but the art is thus created by the relationship of the artist to the medium and the interaction of ideas that transcend the discipline through the exploration of concepts. The process is therefore privileged of the symbolic significance of how the artwork operates within culture. Xenakis demystifies the medium so that it can be deconstructed and analyzed for what it is.*
- ☐ Section Points : -
- ☐ *Summary : (Section) -*
  - ☐ *This previous section demonstrates Xenakis evolution of the conceptual framework of his compositional work and his development of the UPIC system. His work is generated not only by tool, but by the understanding of the fundamental value of the complexity of the instrument and its expressive representation of its own nature.*

- ☐ **II. The Instrumental Music of Iannis Xenakis (pg. 18)**
  - ☐ Xenakis continually explores new territories in stochastic music. In the years 1965-70, several totally spatialized works appeared: with Terretektorh (1965) for eighty-eight musicians scattered throughout the audience, Nomos Gamma (1969) for an orchestra of ninety-eight musicians spread through rmt the audience, and Persephassa (1969)for six percussionists surrounding the audience, he becomes the first composer to confront a new auditive and sonorous space.

    During the last ten years, a period when a certain burn-out is being felt among the musicians of his generation, and when many are speaking of a general crisis in contemporary esthetics, Iannis Xenakis is establishing his style of composition. No trace of vacillation marks his most recent compositions.

    He develops various kinds of research. Thus, in Mikka (1976) for violin solo, we find his discoveries in (random walks),from the same lines of research as in N'Shima (1975) for ensemble and voices. Jonchaies (1977), for full orchestra, stems directly from his theoretical work on sound synthesis and computer music-accomplishments leading as well to the electroacoustical piece La Ugende d'Er, performed within the architectural structure he created in Paris for the inauguration of the Centre Beaubourg: the Diatope (1978).

    With his most recent Image scores, Cendrees (1973) for orchestra and chorus, AiS (1980) for orchestra, amplified baritone, and percussion, Nekuia (1981) for orchestra and chorus, he is working to further develop some of his theoretical findings: He works in several directions, making a sort of of stochastic music and of tree structures of melodic lines. He also concerns himself with melodic scales, pitch, and time in a .systematic way. From these perhaps a new style will develop in his current compositions.

    -L.B.
  - ☐ Section Points : -
  - ☐ *Summary : (Section) -*
    - ☐ *Xenakis work is classified by different periods of research of mathematical principles through the expressive nature and use of the orchestra. His methodology does integrate the fundamentals of music, melodic scales, pitch and time.*

- ⊟ **III. Iannis Xenakis: Music and Computers (pg. 25)**
  - ☐ *In the following interview, Iannis Xenakis explains why he introduced the computer into his compositional work. He wrote Achorripsis in 1956-57 with the assistance of his slide rule. Then he automated this approach, which led to compositions such as ST4, STIO, ST48. In 1966, Xenakis founded the EMAMu (Equipe de Mathe-matique et Automatique Musicales) which in 1972 became CEMAMu (Centre d'Etudes de Mathematique et d'Automatique Musicales). established at the CNET (Centre National d'Etudes des Telecommunications) in Paris, and underwritten by the Ministry ofCulture.*

    In1977, CEMAMu set up UPIC1, the first generation of the Unite Polyagogique Informatique of the CEMAMu. UPIC 2 came in1983. Since then the CEMAMu has been collaborating with Hewlett-Packard and IBM and is presently installing under UPIC a system of real-time sound synthesis.

    -L.B.
  - ☐ ***Introduction: Xenakis:***
    - ☐ The fundamental problem is that a musician is not necessarily a computer expert, an engineer or a mathematician (that will change, for a new category of musicians is appearing); it is therefore necessary to provide tools for the user that are simple and elegant. The difficulty is thus to conceive well-adapted interfaces between thought and music. When I founded CEMAMu in 1966, I wanted primarily to construct something that would allow musicians and composers to produce music by graphic design, using a micro-computer. The result was UPIC, signifying Uniti Polyagogique Informatique de CEMAMu. This computer

system allows one to compose music directly by means of a graphic design, even without knowledge of music or computer science. As you can see, it is a matter of immediate access and of making complete use of computer science. A child can use it.

- ☑ Section Points : --
- ☑ ***What does the child do with the machine?***
  - ☑ He draws houses, flowers, suns, then he coordinates what he hears with what he draws.
- ☑ ***You mean that he modifies his design according to what he hears?***
  - ☑ Yes, that's it… and the youngest children are the most inventive. That is why this mechanization, if it is fun and appealing, can radically change the practice of composing music. In addition, it allows us to discover things that the books on acoustics don't tell us.
- ☑ ***What things for example?***
  - ☑ The importance of modifying the tone and the color of the sound by contraction of time. The same sounds, heard in different time frames, produce unexpected timbral effects: The ear perceives them in another way. To summarize, with this type of computer system, creativity interatcs intimately with all of the physico-mathematical apparatus.
- ⊟ ***For you, is the physico-mathematical apparatus an aid to creation?***
  - ☑ …it is a basis for my compositional work. As for computer science, it provides the necessary equipment, the hardware as the Anglo-saxons call it. However music is the sonorous rendering of thought. If this thought is limited to veins of feeling, it does not go very far; but if it is molded by philosophic and mathematical procedures, then music becomes a part of fundamental research.
  - ☐ Important : (Concept) --
    - ☐ The purpose of the artworks that directly effects the decision making is the research.
- ⊟ ***What are you alluding to? Particle physics?***
  - ☑ Yes, as an example. What goes on in particle physics? One defines sub particles by the symmetries what they breed. Now, music is steeped in the problem of symmetry, and symmetry is made accessible by the theory of groups. Among other examples, we could take genetics, where one find permutation groups. What is music, if not very often a set of structures made from the permutations of notes, of sounds? I believe that with this type of scientific approach, we could have another perspective on music, even on that of the past-- and that we could create the music of the future.
  - ☐ Important : (Concept) --
    - ☐ Xenakis is looking for equivalent relationships towards science and cites both particle physics and genetics and areas of research.
- ☑ ***This is thus the perfect marriage between artistic creation and technique?***
  - ☑ Yes, almost perfect, but beware, technique can submerge the user: We must defend ourselves; it is good to use techniques, but we have to dominate them, to stay on the alert. Technology allows the exploration of new domains proposed by theoretical thought and esthetics; but once these domains are explored, we must push further. In fact, computer science is a product of simple rationality; as a composer, I unceasingly bring complexity, sometimes irrational, to this rationality.
- ☑ ***How do you envisage the evolution of music and computers in the years to come?***
  - ☑ First of all, the development of microprocessors will allow the multiplication of systems like the UPIC. The introduction of such machines at universities, at conservatories, and at all the cultural centers will open tremendous perspectives, not nobly for research, but also for pedagogy. Secondly, this is the first time in the history of humanity when man can have direct access to composition. He no longer needs to know the symbolism of solfeggi, or have to play and instrument. In the years to come with the development of computer networks and of individualized computer science-- the computer in the home-- and individual will be able to create alone at home, with an electromagnetic table connected to peripherals. I think that in a certain way, the social foundation of art could also be resolved by computer science. Finally, the man on the street will be able to think in terms of music.
  - ☑ Pour la Science, November (1982)

- ⊟ **IV. Iannis Xenakis The Architect: (pg. 28)**
  - ☐ *In 1947, Iannis Xenakis exiled in France. He was brought into the office of the architect Le Corbusier and while there, produced some of the most recognized works of modern art: the Couvent de la Tourette (at Evreux on the Arbresle, from 1953 to 1957), the Philips Pavilion at the Brussels International Exposition (1956 to 1958) . . . where he executed some choices of a "musical" nature. The facade of the Couvent de la Tourette displays immense plates of glass- "screens of musical glass"-arranged vertically in superimposed layers of irregular densities and intervals. Thus we once again find the composer has these concerns: simultaneous layers of durations, complex and rhythmic polyphony. 3 Le Corbusier testifies to this collaboration:*

    These two solutions are static. We have therefore adopted a third one, provisionally named 'musical glazed panels.'

    Here, the dynamics of the Modulor are given free reign. The elements are set face to face, in masses, in the two cartesian directions, horizontal and vertical. Horizontally, we obtain variations in the densities of membranes in a continuous manner, after the fashion of the undulations of elastic media. Vertically we create a harmonious counterpoint of variable densities. The two scales of the Modulor, the red and the blue, are used either separately or together, thus creating a subtle balance, using the whole of the two Moduloric processes.

    (In the end, for fear of being bitten by snakes or adders, we adopted for this invention the name of 'undulatory

glazed panels.')

- Le Corbusier, Modulor II, translated by Peter de Francia and Anna Bostock (London: Faber and Faber, 1958), 323-26.

- ☐ --See Figures : --
- ☐ *Section Points :* --
- ☐ ***Philips Pavilion (pg. 30)***
  - ☐ Philips Pavilion

    A two minute interval, and an eight minute show. First decision: the container will be a sort of stomach with a separate entrance and exit for five hundred people. Second decision: to use two almost vertical, con- cave walls allowing the audience, standing and looking forward, to see above the heads of their neighbors.

    We had at first considered a construction of plaster- which is the basic, fragile material used for temporary exhibitions-a bottle suspended in a cage of tubular scaffolding. But Xenakis, who was put in charge of the study, quickly abandoned the plaster. After having considered timber and concrete, Xenakis, who had known Bernard Lafaille well, turned towards self-supporting, curved surfaces. Having made his draft, Xenakis constructed a first model with wire and sewing thread. Then a second model that he covered with cigarette wrappers.

    -L e Corbusier, "La Poeme electronique," in Lcs Cahiers Forces Vives (Paris: Editions de Minuit 1958), 24.
  - ☐ --See Figures : --
- ☐ ***Polytopes de Cluny (pg. 30)*** ***www.youtube.co***
  - ☐ First adventure: the Polytope de Montreal, in 1967. Within the French pavilion, a structure of steel cables, curved into hyperbolae, 1200 flashes, 35 programmed stages, and 90,000 changes of light in six minutes! As a contrast, giant loudspeakers broadcast continuous, smooth music, in uninterrupted glissandi comprised of four recorded orchestras.

    In order to assimilate the medium of sound and light, Xenakis pursued this exploration in Persepolis (1971), in Paris, with the Polytope de Cluny (1972), the first show to be totally organized and controlled by computer. At Beaubourg, in 1978, for the inauguration of the Centre Georges Pompidou, his Diatope-a structure with three curved apices- marks a decisive step: the realization of a tridimensional composition (architecture, light and sound). For the musical part, La Ugende d[1]Er, the tape combines recordings of African or Asian instruments with microsounds created with converters, a supernaturally strange effect. All these researches, conducted for years in his Parisian studio of the CEMAMu, have led him to the invention of the UPIC machine.

    (author unknown)
  - ☐ --See Figures : --
- ☐ ***On the subject of this Diatope: Iannis Xenakis himself comments upon his experience. (pg. 32)***
  - ☐ La Ugende d'Er (first version): Song of Light and Sound of the Diatope at the Georges Pompidou Center
  - ☐ Music is not a language. Every musical piece is like a highly complex rock with ridges and designs engraved within and without, that can be interpreted in a thousand ways without a single one being the best or the most true. By virtue of this multiple exegesis, music sustains all sorts of fantastic imaginings, like a crystal catalyst. Myself, I wanted to deal with the abysses that surround us and among which we live. The most formidable are those of our destiny, of life or of death, visible and invisible universes. The signs that convey these abysses to us are also made of the lights and sounds that provoke the two principal senses that we possess. That is why the Diatope would like to be a place for the condensation of those signs from the many worlds. Rational knowledge coalesces with intuitive knowledge, or revelation. It is impossible to dissociate one from the other. These abysses are unknowable, that is to say, knowledge of them is an eternal and desperate flight, composed of milestones-hypotheses across the epochs. It is difficult and probably not necessary to attempt to explain the light-show and the music of the Diatope on all levels. The sense of these acts of light and sound will be glimpsed in the extracts of significant texts published elsewhere.[5] This spectacle and its music form multiple resonances with the texts, a sort of sonorous string held by humanity in cosmic space and eternity, a string composed of ideas, sciences, revelations. This spectacle is created from the harmonics of that cosmic string. These texts explain it better than any other discourse. They form the argument for the spectacle.

    I chose in a sort of panorama some o f the epochs which were significant and particularly rich in ideas and poetics, and I present here in a group the few texts that appear to me to be the summits, those of course that I preferred among others. I gave the generic title "La Ugende d'Er" to these texts, because this legend which paradoxically completes the Republic of Plato, incorporates ideas of morality, of destiny, of the physical and extraphysical, of death, of life, in a system which is closed but highly poetic due to its apocalyptic visions.

    Opposite Plato's grandiose poetics and rational realism, I place the hermetic text, "Poimandres" of Hermes Trismegiste. Then the admirable text of Blaise Pascal, a universal thinker possessing extraordinary philosophical and scientific intuitions. Then the vision of]ean-Paul Richter in "Siebenkiis" where man is alone in the black of the universe. Ultimately, our universe as seen by modem astrophysics.
  - ☐ --See Figures : --
  - ☐ Section Points : --

Xenakis on Xenakis by Iannis Xenakis (1987) **Links:**

- ⊟ **Some Principles of Composition: (pg. 34)**
  - ☐ ***Architectural:***
    - ☐ The form of the plastic shell of Diatope is a materialisation of a project which I have had in mind for more than twenty years. It is a response to the perennial, never-resolved question: What architectural form is to be given to musical or visual performances? I say that there is no unique answer. But I also say that the effect of architectural forms has a quasi-tactile influence on the quality of the music or show that is performed there. This apart from all considerations of acoustics or of optimal proportions for seeing or hearing. Architectural forms, their types, are an element which is generally neglected or scorned. Whence we get halls that are cubical or rectangular polygons, that is, vertically cylindrical or conical as the case may be. Architects are inhibited when it is a matter of giving free rein to the imagination of new and rich forms which contort three-dimensional space.

      I wanted to give a different solution comparable to that which I conceived and executed for Le Corbusier with the Philips Pavilion at Expo '58 in Brussels. But the form of Le Diatope, because of the laser trajectories, had to conform to the following principle: a maximum of free volume for a minimum of enclosing surface. The classical answer is the sphere. But the sphere, beautiful in itself, is bad for acoustics and less tangibly rich than some other, double- curved, warped or skewed forms. Whence the current configuration, which makes use of hyperbolic paraboloids, thus shaping a kind of enveloping form, closed and opened to the world at the same time by the convergence of its geometrical construction.
  - ☐ ***Musical:***
    - ☐ The music of La Legende d'Er is made of the following families of sounds:

      a) instrumental,for example, the sonorous shooting stars of the beginning and the end, or the sounds of the African jew's harps, or of the Tzuzumis (small Japanese hourglass drums).

      b) noises, for example, clapping special blocks, scrapings against cardboard. ...

      c) realised by mathematical functions on a computer and converted from digital to analog at the Centre d'Etudes de Mathematique et d'Automatique Musicales (CEMAMu).

      Here, I have inaugurated a new approach to the production of sounds, different from and even opposed to the methods of the electronic music studios and laboratories using computers and digital-to-analog conversion. It is no longer a matter of starting from analysis and of Fourier synthesis, which permits the generation of sound by means of bundles of sine-tone harmonics or partials. This new method constructs and acts directly on the pressure-time curve which itself acts on the tympanum of the ear. (See my text, "New proposal in microsound structure," Chapter 9 of Formalized Music.) I have used probability functions to generate the pressure-time curves, that is, I worked directly with the l/40,000 of a second. Nothing remains of the traditional approach except the notion of periodicity, but taken in its more general sense, that is, the stochastic renewal of equiv- alence classes of values for pressure and values for duration. The functions used here are, essentially, Cauchy functions (t/((t**2 + X**2)*pi)) and the famous "logistic" alpha*exp(- alpha*X - beta)/(exp(- alpha*X - beta ** (-2)), as well as functions of these functions. It is then a means of controlling Brownian motion (random walk).

      These families of sounds, some of them realized at WDR (West Deutsche Radio), are then treated by filtering, reverberating, transpositions of speeds, and various mixings at the electronic music studio of WDR, which has also commissioned this music and which has financed all its processing. The music is on a seven-track tape. Each track is distributed over the eleven high-quality loudspeakers arranged under the shell of Diatope. This static or cinematic distribution is realized by means of a special computer program.
    - ☐ --Find Equation: --
  - ⊟ ***Visual:***
    - ☐ The visual acts are built from mobile configurations, either of points (electronic flashes) or of lines (laser beams) . The 1680 flashes form galaxies in movements, thanks to the rapid turning on of the flashing lights (every l/25 second), and all kinds of interpenetrating, disappearing, rebounding, transforming figures. It goes without saying that the organization of these light gestures in their continuity or their discontinuity is regulated by angles of mathematical functions ranging from functions of imaginary (complex) numbers to probability distributions. The beams of the four lasers are taken in charge by some four-hundred special mirrors as well as by optics designed for the intended effects. In short, just as our universe is formed from grains (of matter) and straight lines (photon radiation) ruled by stochastic laws (probability), this spectacle offers a reflection of it which is miniature but symbolic and abstract. So music and light unite together. In some sense, this is a kind of cosmic "harmony of the spheres" which, by means of art, becomes one with that of thought.
    - ☑ *Important : (Concept) --*
      - ☑ *Xenakis is combining all aspects of creating a world. He is using architecture, sound, lights to create his works.*
  - ☐ ***Architecture and the hearing of music***
    - ☐ ***Finally, on the occasion of the debate recently provoked by new theaters in Paris (Bas- tille Opera and La Vilette, Iannis Xenakis expresses his notions about architecture and the hearing of music.***
    - ☐ By removing the main floor seating, one can arrange the audience on bleachers while accentuating frontality, which is the most effective procedure from the point of view of visibility. One can imagine

planes, platforms that rise and descend, differentiated reliefS. This is unlike traditional opera, where space is always expected to remain oriented toward the place of action, of drama, toward the scene. It is possible to imagine the multiplication of places of action, such as Mnouchkine in the Theatre du Soleil. Space can even be occupied up above: Look at the acrobats of the Peking Circus! The physical presence of singers, of the choristers, of the constraints imposed by the drama, with the unities of place, occasionally of time, mark the limit of an eventual reform of the traditional building. It will always be necessary to construct a place where the characters play, meet one another. . . . The presence of musicians is also a constraint. One can remove the orchestra from the pit, place it on the stage or elsewhere, but its presence in a given spot is inescapable.
Opera is an object of art in itself, one which tells the thought and the mentalities of an epoch. No theatre will never be staged in French! The constraint that I am evoking is of the same order; it is a question of language.
Today we have at our disposal more numerous technical means than before, such as electricity, instruments for programing the lighting, the possibility of changing the scene more rapidly. One can find acoustical solutions other than the orchestra pit. That's an easy change to make.
On the other hand, with present audio-acoustical procedures and the computer, we can create spectacles where neither the action nor the voice are necessarily localized. One can think in terms of human voice, human presence, and no longer do opera. Artistic creation is no longer done in the same context as before and we can imagine new spaces.

- ☐ At La Villette, free experimental space will be created. I have proposed in my architectural project some ideas for the future edifice. First of all, there will not be a single floor, but rather platforms, perhaps mobilized, arranged in space so that one can look in all directions. The spectator, suspended in space like a spider at the end of its filament, should no longer have the feeling of liv- ing on one plane, but rather in all three dimensions. These floors resemble little islands, clouds on which one could place the spectators, the performers, the equipment. Light must be designed to come from all directions, including from below. Technically it is entirely possible to construct transparent floors which allow light and sound to filter through. It would also be necessary that the sound sources be spread throughout the space, something that is never anticipated in halls. The mixing consoles would be situated in the hall, and not in a recording room where one hears nothing. This space, empty and capable of being filled, is never oriented either for seating, for viewing, or for listening. Music, spectacle, contrary to that which happens in traditional opera, does not favor one particular type of orientation.

  This has nothing to do with a polyvalent hall. I do not believe in mobile systems, in an infinitely adjustable frame structure. The designer must anticipate a distribution of elements in space. In what sense? That liberty, that neutrality must be handled in such a way that the diversity created will be interest- ing. There are technical questions bearing on distances. . . but that all belongs to the domain of the study. As far as the forms are concerned, we do not have an infinite number. They must withstand the construction. We had many problems when constructing the Philips Pavilion, due to the extreme thinness of the concrete, warped shells. Mobile architecture is nothing but garbage, because no one is able to replace an architect of worth. As an artist, I prefer to use something fixed, interesting, captivating, rather than leaving total liberty of structuring the space with each use. Polyvalence is proof of the absence of taste, of will, of the architect's reflection. One must create a space which is strong, rigid, but which nevertheless allows for a richness in arrangement, in the permutation of things and events.
- ☐ This space, it would at first be like an envelope which would serve as a sonorous shelter, as thermal insulation. The envelope could have certain sonorous qualities based on forms and volumes, and not on correcting panels, as usually happens. Acoustics is bound to the conformation of space, to the shape of the covering. The architectural form need not be conventional. The sphere, the right angle, level surfaces are absolutely to be avoided. I would use instead a contour surface, a sail. That is what I did with the Philips Pavilion. The contoured surface had the advantage of better reflecting and diffusing the sound. At the polytope of the Pompidou Center we used a fabric that had no sonorous inertia, but that nevertheless reflected a part of the sound, and there was no untimely echo, rather a satisfying diffusion of the sound.

  The envelope need not be unique because there are many things arranged around the periphery. What? Sources of lighting, eventually sources of sound, and then the direct contact of the production department with the space. . .. To allow for the most liberty, we need a sort of metallic net on which to hang all sorts of things, like islands fastened to the envelope. Behind the cloud of these objects, there is the shell, the actual cover. What form should it assume? What material might be used?

  Just as the first membrane, the netting, is open and pierced, it is this second membrane, this shell, which will serve as reflector. While visible forms always play a role, we can also be sensitive to invisible forms . The human eye and ear are sufficiently skilled and cunning to sense the proximity of forms from afar. Finally, we must connect this closed space with the exterior. Now and then, one must be able to leave the events of the interior.

  The edifice gains nothing in being weighed down by a conventionally thick, useless shell. The elegance of the material is found in its effectiveness. The shell of the Philips Pavilion was five centimeters thick, no more. The limit of the non-constructible is continually pushed further.

  To realize something different from the traditional building implies a rediscovery of fundamental questions, of lines of force, abandoning certain architectural prejudices.
- ☐ Identical elements are too frequently multiplied, repeating a rhythm, a module:pilotis, posts, orders... . The utilization of repetitive elements com- plies with simple motives, firstly economic-those of

industrialization-the ease, the rentability-the peace of mind. Secondly, repetition is very strong, it is also the architectural tradition of the discrete. The shell, the sail on the contrary represents an aspect of continuity in construction, in space. It is naturally more expensive to construct. In a final analysis, all will depend on the ultimate controller, the State, which must decide if it wants to leave its name in contemporary architecture.

There are prejudices concerning the purpose of the edifice, its function. Even here things are not simple. Function can be considered in several ways. I remember, when the apartments of Marseilles were being designed, Le Corbusier spoke about women's liberation with respect to the opening out of the kitchen toward the living room and thus toward the exterior. A woman was certainly no longer shut away in the kitchen, but she was still subservient for the simple reason that she always did the cooking, even if she had a lovely countryside view.

- ☐ One must invent this architectural space and not choose it as if it were already in existence. It is a place to be discovered according to the fundamental necessities that face us. There are things that one cannot imagine, and yet that must be discovered and created. This is an entirely different, dynamic attitude. It is not a question of permutations or of combinations of existing things, that is what I want to say. . ..

  There is no automatic rationality that can in itself bring one to an interesting solution. First one must consider the needs and the initial functions, and from there, search and invent. In everything that we do, in architectural matters or anything else, we inevitably manipulate certain concepts, certain structures. It is thus necessary to work in the theoretical domain, without which we are slaves, trapped by cliches, by inherited structures that we manipulate without knowing them perfectly. Theoretical exploration avoids making such unfortunate mistakes. A theoretical effort starts in any case from premises which are intuitive, esthetic, from an idea; it then explores and uses tools: logic, other knowledge coming from other sciences. For example, if you compose music on the computer that you consider bad, it is not necessary to respect that music on the pretext that it is the result of a computer, as do certain contemporary musicians. On the contrary, one frees oneself from such a theory in order that the result may be interesting. Theory and the machine are not a criterion. Music is the final criterion.

- ☐ Thus, you set down the basic necessities, then you discover the elements that correspond to the emotions, to the imagination. If you succeed for example in creating a space that gives the impression of flying, that is tremendous. At Saint Sophia in Constantinople, one has this impression. ... It is only in this way that you manage to create something that is universal. These aims are inevitable. Great artists are those who attain the universal. In reality, the universal is not so far removed; it is found in you since you are human. To find the difference between that which is of value diachronically and synchronically-across the ages and on the planet-and that which is not, provides solutions, expressions that are not petty. To get beyond pettiness is not easy. To say that women were going to be " liberated" in the new apartments of Marseilles is an example of such small-mindedness. But at that particular moment, no one realized it. In opera music there are universal aspects which remain and which certainly will remain, because they are present much in the same way as are certain Egyptian bas reliefs. The bas reliefs of the masters of ancient Egypt are not confused with those of the copyists who spread them throughout the realm....

  -remarks noted by Stephane Galzy and Grucon

- ☐ *Important : (Concept) -*
  - ☐ *Xenakis is giving examples cases of how both architecture and music are interrelated. The impact of style and the investigation of form should be solely based on research. Considerations to the medium must be equated to the final outcome if and only if the final artwork requires it.*
  - ☐ *Quote: Theoretical exploration avoids making such unfortunate mistakes. A theoretical effort starts in any case from premises which are intuitive, esthetic, from an idea; it then explores and uses tools: logic, other knowledge coming from other sciences. Theory and the machine are not a criterion. Music is the final criterion.*

- ☐ **V. The Mind of Iannis Xenakis Today: (pg. 43)**
  - ☐ ***In these two articles recently published in France, Iannis Xenakis develops some of his favorite themes for reflection., notably his lofty philosophical preoccupations: the composer joins the mathematician, the physicist and the astrophysicist.***
  - ☐ ***The Source of the Human Experience:***
  - ☐ ***First Proposition: rules can only be imposed by the work itself.***
    - ☐ one always comes back to the same question--what is true or what is false in artistic maters? or to the only response worth considering, to refuse all rules outside the work is to refuse to be cripple, blind, and deaf.
    - ☐ All philosophical thought, all rules are provided in an original way by the actor, by the artist. We touch here upon the foundation of art: what is originality.
    - ☐ The analysis will certainly bring us back to genetics. It suffices already to remark that though man's original acts are numerous (as in daily life, the event of walking..), the more they are rare and symbolic the stronger is their degree of originality.
  - ☐ ***Second Proposition: nothing is born from nothing.***

Xenakis on Xenakis by Iannis Xenakis (1987) **Links:**

- ☐ - To speak of our originality is to speak of our constitution, and as a consequence of the making of the universe and of its process. It is the same for art as for the destiny of humans and of the universe. The preoccupations of the musician join those of the astrophysicist.
- ☐ For centuries, scientific tradition has predicted that nothing can come from nothing. It has viewed the universe as an automation, continuing to exist without a point of return, without a new creation.
- ☐ I am not an astrophysicist, but, for a long time, I have thought that music is nothing but a path among others, permitting humankind first to imagine, then , after long generations, to lead the existing universe to another, entirely created by humanity.
- ☐ Since 1958, I have been writing on the subject of originality of art and music: ….
  --See Figures : --
  "for it is the same to think as to be" (Poem by Parmenides); and my paraphrase,
  "For it is the same to be as not to be." In a universe of nothingness. A brief train of waves, so brief that its end and beginning coincide (time in nothingness) disengaging itself endlessly.

  Nothingness resorbs, creates. It engenders being.

  Still today, through lack of conceptual and suitable experimental tools, astrophysicists are unable to respond to this question, to this captivating notion of a universe open to spontaneous creation, which could form or disappear without respite, in a truly creative vortex. From nothingness, A disappearance into nothing.

- ☐ ***Third Proposition: the universe is in perpetual creation.***
  - ☐ According to Plato, God creates the universe, builds it and leaves it. The automaton deregulates itself and becomes increasingly chaotic (this could be the current epoch…), to the point where the Creator takes it in hand again and reconstructs the universe.
  - ☐ Transcribed to a scientific level, the anecdote assumes its true force: Because of gravitation, the universe could stop dilating and could commence to contract until it becomes an implosion towards nothingness. This pendulum movement creates the state of perpetual creation.
  - ☐ Again, we are referred back to the foundation of art. You often hear it said: To construct, it is necessary to destroy. In my opinion, this assertion is false. It suffices to put the proposition: The contribution of an individual depends on his originality, his own distinctiveness, even though he is caught in a global and general flux. Einstein would not exist without the breakthroughs of Lorentz. We could extrapolate forever.
  - ☐ Thus opens before us the reason for certain remarkable works, sort of unsurpassable paradigms (Egyptian bas relief…); What is done is an absolute. Likewise in music, the architecture of a work, its performance, depend on technique, but also on factors which are impossible to name- the life of him who composes it, of him who performs it, the instrument, the acoustics. Richness elaborates upon itself by stages, to the point of the highest universal preoccupations.
  - ☐ Thought is nothing but a part of doing whence the absence of archetypes, and the different existence each time. This is, in effect, at least partly, the theory of probabilities: a flux of aleatoric functions.
- ☐ *Insights : (Thesis) -*
  - ☐ *The works inner logic demand scrutiny. The work, the motivations to make and the evidence left behind from the work is built not in a vacuum but by all that precedes the medium.*
  - ☐ *Quotes:*
  - ☐ *… the composer joins the mathematician, the physicist and the astrophysicist.*
  - ☐ *…The Source of the Human Experience: First Proposition: rules can only be imposed by the work itself.Second Proposition: nothing is born from nothing. Third Proposition: the universe is in perpetual creation.*
- ☐ * * *
  - ☐ It is in fact the inner initiative, the transfer to a deed which engenders fulfilment. I am not speaking of happiness, which is a myth, for nothing is absolute. They exist, of course, the joys, the tears. But that is not what should count: They are nothing but epiphenomena of that which one does, suffers, or lives. Death, for example, a supreme misfortune, is a part of life. We sense it, we anticipate it. But we prudently avoid speaking about it, as if it were a guest that we must avoid. Nevertheless, it is there, omnipresent, at our sides. Our organism, degenerating every second, knows it. Now, this definitive disappearance can be transposed in the domain of work: the choices that I make when I compose music, for example. They are distressing, for they imply renouncing something. Creation thus passes through torture. But a torture which is sane and natural. That is what is most beautiful: to decide at any moment, to act, to renounce, to propose something else. It's great. The joy is the fulfilment of living. That's what it means to live.

    This tormented life is necessary. Everywhere, at all times. Only, one does not live with it, one refuses it. We surround ourselves with references, politeness, taboos, ethics, for ourselves as well as for others. Or, as a last resort, we spread butter on the psychoanalyst's bread, but what a myth it is to believe that in remembering something, we delve more profoundly into ourselves! The subconscious also forgets. Like memory, it is putrescible. It is not a veil one can lift from the shadow cast by a long abandoned planet. A sort of Hades from Antiquity. In our life, there are entire patches of the past which have completely disappeared, or that we will never find again. It is illusory to think that the subconscious can retain the fantastic quantity of impressions, of suggestions, of fascinations experienced at such and such a moment in our existence.

    I can nevertheless ponder: Is it because I no longer remember it that a particular thing no longer exists? The fact that I do not remember it does not mean that the thing no longer exists in my subconscious, certainly. However, I cannot maintain that these memories exist, since they are inaccessible. And if anyone claims that

they are accessible, I would very much like to possess the methods for access to them. Because it would be fascinating to explore them, if only in order to turn one's past into a cinema.

The inaccessibility of this memory thus implies that we cannot prove its existence. That is the theory. In addition, practically speaking, it is unthinkable, impossible that the human brain conserve intact, and not degraded, traces or prints of the past. Which are extremely fine and subtle. Let's take the example of our most recent recollections. When we remove them from memory's drawer, we damage them like pinned butterflies. In fact, we replace them with others. And, if we go back further, we realize that memory, if it still exists somewhere, is still more inaccessible, tucked away more deeply. Because it is covered with new traces. Starting from the oldest, yes, but completely restructured. We are speaking of a theoretical view. For me, psychoanalysis is a sub- conscious view. Moreover Gust as other disciplines) it has suffered from an abusive extrapolation; people have wanted to see it as a panacea.

Paleontologist, geneticist, biologist, physician, chemist, mathematician, historian and expert in human sciences. These qualifications comprise the identification card of tomorrow's musician. Of him whom I call the conceiving artist. Who searches after the secret order that rules the universal apparent disorder. Who considers a new relation between art and science, notably between art and mathematics. Since Greek Antiquity and right up to our twentieth century, moreover, certain conquests in music and several discoveries in mathematics spring forth almost at the same moment. And, contrary to what we often think, there have been interactions, osmosis, reciprocal influences. In 500 B.c., for example, the relation between the pitches and the lengths of string; had been established. Music thus gives a serious impetus to the theory of numbers (positive rational) and to geometry. Later (eleventh century), the bi-dimensional spatial representation o f pitches as a function o f time by the use of staves and puncta undoubtedly influenced Descartes' analytical geometry, proposed six centuries later. Direct influence? I do not know, not knowing Descartes in person at all! But ideas cross one another like currents of air. And sometimes very little suffices for the spark to burst forth.

Another interesting example: the fugue. A fixed structure, and fixed if there ever was one, when speaking of school work, the fugue is an abstract automatism, which was utilized two centuries before the birth of the theory of abstract automata. It was the first automaton. And what is an automaton if not the expression of mankind's profound need to reproduce? To project worlds, universes, to create himself in his proper image?

In constructing robots, man took the place of gods. For he felt that the latter were nothing but his own reflection. And now, we are constructing biological robots which tomorrow will give birth to little robots: The dreams of the gods are materialized!

Yet, we always live in the shadow of Sisyphus and Tantalus. Because everything around us moves, shifts, is in constant turmoil. We are not moving through an epoch of certitudes: Cosmonauts in a swarm, we navigate in the provisional, we must reconsider each thought at every instant. This isn't all bad, moreover, for our life thereby becomes much more complicated, more complex, more alive, finds itself all the more enriched. We live more intensely when we must confront swarms of problems, when we must decipher this growing complexity, which is here, before our eyes, hieratic, even if we try to ignore it. That which we live is a bloody hand-to-hand with nature. Which engenders anguish. But, luckily, when we are afraid of something, when it becomes bitter, acidic, we immediately erect defenses. We cannot live without defenses, anyway, at the risk of being immediately annihilated. And our defense is to refuse to see, is to deny the complexity that surrounds us. It is also to create beliefs, myths, good or bad gods. Or elegant theories of physics, which structure our spiritual environment and reassure us, be they legitimate or not. These are our bunkers, our mental machines, veritable automata inter- connected with our defensive tactics, with our lines of conduct, with our physical and mental self-protection. So that we can act, know how to act and what to do.

I was about to forget memory, which is forgettable, we all know that. Fortunately. It is even made to be forgotten, it is perishable. For, if we should remember, what with the acuity of reality, of all the past instants, marvels and transformations, we could never take the shock. Memory, nothing but the trace of these instants, equalizes, cushions, lulls. Another self-defense.

But in other respects, one must avoid the trap of becoming imprisoned in memory. It is good to look around, to risk shock, to keep a critical spirit, a power of constant renewal. In brief, a fresh outlook. This risk, for there is one, comprises a part of our existence, just as defense, survival. It is our fate to be destiny.

Society, which stifles us, constitutes an additional risk. It is thus in self- defense that we try to participate as little as possible. So that we can judge it from the exterior. For it rubs off on us, just as history taints the present. Thus, I would rather be outside-putting on the decals-than within-being plastered with decals. Everyone of us tries, according to our ability, to pull away from society and from the work it implies. Work which, for many, is synonymous with slavery. Yet another proof-if one were wanting-that servitude always exists. For if one does not find in his work the possibility of being oneself, the joy-or anguish-of existing, then one is enslaved. And one buys moments of release time-but which are not free-liquified instants of real life, which one doesn't know how to live anyway. Because one doesn't know, one no longer knows.

In his Republic, Plato says that a society is just when its citizens do what they like to do. This amounts to saying that all present societies are unjust. In spite of social or socializing theories which seek to liberate humans, to render them creative, to lead them to make decisions in their own interior solitude. And not to impose them from the outside. If only that were practiced since child- hood! When I was at school, we were set one against the other, creating an idi- otically competitive spirit, a superficial emulation. For what reason? Perhaps one day to obtain recompenses, glory, fortune, privileges ... material things. Thus, from the very beginning, we do not

Xenakis on Xenakis by Iannis Xenakis (1987) **Links:**

act according to our own, pro- found individuality. We must recognize that this aberration, that this false route is a powerful arm of society.

The force of a work is in its truth. And truth is that which can exist without crutches. Those crutches which are often sentimentality, sensitivity, "emotional filth," as Kundera says. Sentiments, understood in this sense, are the alibi of cruelty, of barbarity, of blackmail. Me, I again find myself in that which I do. In movements outside of creation, in the strings which hold it as if in perpetual expectation. Movements of clouds, of galaxies, of crowds, of ourselves within ourselves. All truly creative people escape this foolish side of a work, the exaltation of sentiments. They are to be discarded like the fur surrounding meat before it is cooked. This blubber which envelops the work can also be secreted by our own way of seeing, now: Thus, when one listens to the "Ride of the Valkyries," for example, we should make an effort to abstract ourselves from all the mythology which surrounds these viragos, from all that which Wagner and his crowd have found to say about this music. So as to listen only to the music, to have it within us. That is what confers its value, its perennity, independently of the sentiments of the time. That is also why we listen to it.

It is the same for African, Hindu, Chinese, or Egyptian art. Why am I so sensitive to them without ever having studied them? Because I appreciate them just as I appreciate the curl of a leaf, the photograph of a galaxy or of a cosmic dust cloud lighted by the stars. For in these sorts of things there exist signs made by mankind. Signs that we must see, not as representations, but as relations among them, without any romanticism. If these relations are sufficiently rich, necessary, and elegant, then the piece is a work of art.

The greatest work is thus that which invokes the highest level of abstraction. That which presents the fewest possible references to representation. In this sense, Altdorfer's The Battle of Alexander, with its myriads of soldiers advancing under the vault of heaven, immense, is a much more abstract painting than a Mondrian or a Malevitch, because it implies an effort of abstraction on our part, of enormous reduction to nothingness. We must cleanse it from the historical time that clogs it. There is the true festival of the imaginary: to construct abstractions from that which is the most scrupulously concrete. There also is the force of humanity, which is in its power of generalization, of universality. To see reality with new eyes, that is reality, that is life itself.

- ☐
- ☐ *Summary : (Section)* -
  - ☐ *Xenakis outlines his philosophical views on the origins of art and its relationship to the mathematical language of nature.*
  - ☐ Quotes:
  - ☐ ...But ideas cross one another like currents of air. And sometimes very little suffices for the spark to burst forth.
- ☐ *Conclusion : (Article)* -
  - ☐ *The description of the new art is to follow science. An art that is the science of feeling and seeing process through research. The methodology of the artist is to find discovery through using art/ music as a tool to create and discover reality. Art must mimic and to confront what exist in our own reality to find contrast to the simplified realities that are constructed by man. Physical and existential understanding of life is found through the motivations to make work and the material of the artworks. A new artist that understands and find nature a muse will discover complexity as a language of mathematical symmetry.*
- ☐ Section Points : -

- ☐ **Notes:**
  - ☐ *1. CEMAMu: Centre d'Etudes de Mathematique et d'Automatique Musicales.)*

2. *Unite Polyagogique et Informatique de CEMAMu (realized with grants from the Ministry of Culture in France).*

3. *See the text by Iannis Xenakis in Le Corbusier, La Tourette and Other Buildings and Profects 1955-1957 (New York: Garland Publishing, Inc., and Paris: Fondation le Corbusier, 1984).*

4. *See Francoise Choay, L'Urbanisme: Utopies et realites (Paris: Editions du Seuil, 1965).*

5. *In the booklet printed by the Centre Georges Pompidou, to accompany the production o f le Diatope.*

The Concept of Unity in Electronic Music by Karlheinz Stockhausen (1962) **Links**

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  - ☐ Color (music)
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  - ☐ Rhythm (music)
  - ☐ Dynamics (music)
  - ☐ Form (music)
  - ☐ sound
  - ☐ noise
  - ☐ sine tone
  - ☐ Square Wave
  - ☐ saw tooth generators
  - ☐ Periodic Oscillations
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  - ☐ Timbre (music) en.wikipedia.org–
  - ☐ frequency-bands
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  - ☐ Pitch (music) en.wikipedia.org–
  - ☐ Intensity (music)
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  - ☐ Aleatoric en.wikipedia.org–
  - ☐ Frequency: (sound) en.wikipedia.org–
  - ☐ Pulse: en.wikipedia.org–
  - ☐ Pulse wave: en.wikipedia.org–
  - ☐ Sine wave en.wikipedia.org–
  - ☐ Harmonic Analysis mathworld.wolfra
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  - ☐ Fourier Analysis en.wikipedia.org–
  - ☐ Fourier Transform: en.wikipedia.org·
  - ☐ Spectrum en.wikipedia.org–
  - ☐ Spectral Music en.wikipedia.org–
  - ☐ aperiodic
  - ☐ dissonance
  - ☐ syncopation
  - ☐ Movements
  - ☐ Compositions
- ☐ _Objectives
- ⊟ _Outline (Notes)
  - ⊟ (pg. 39)
    - ☐ On several previous occasions, when I have been asked to explain the composition of electronic music, I have described four characteristics that seem important to me for electronic composition as distinguished from the composition of instrumental music:

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1) the correlation of the coloristic, harmonic-melodic, and metric- rhythmic aspects of composition

2) the composition and de-composition of timbres

3) the characteristic differentiation among degrees of intensity

4) the ordered relationships between sound and noise

Here, I would like to discuss only the correlation of timbre, pitch, intensity, and duration. In the past, it has been customary to regard these correlative properties of sound as mutually independent, as belonging to fundamentally distinct spheres. They have appeared increasingly separate as our acoustical perception developed along such lines.

Similarly, the means employed for the production of sound, as well as the compositional process itself, were consequent upon this conceptual separation. To generate sound-events having single perceptible pitches, we used the so-called sine tone, square-wave, or saw-tooth generators, which produce periodic oscillations. Sound-events of indeterminate pitch, those that are more or less noise-like, were produced by means of noise generators.

We varied such sound- or noise-colors by means of electrical filters, with which one can strengthen, attenuate, or suppress entirely individual partials or whole frequency-bands-the so-called formants, or bands of noise-of the spectra.

- ☐ Intensity was controlled by regulating, with the aid of a voltmeter, the voltages recorded on tape (whereby the spectrum itself automatically varied with the variations in intensity), whereas duration was determined simply by the length of tape on which a sound was recorded.

Compositionally, in terms of the production and manipulation of sound, these individual sound-properties had to be dealt with separately. But, on the other hand, we perceive a sound-event as a homogeneous phenomenon rather than as a composite of four separate properties. At a relatively early stage of my work in electronic composition, I had already considered the possibility of equating this unity of perception with an analogous unity in composition itself. In the preparatory work for my composition Kontakte, I found, for the first time, ways to bring all properties under a single control. I deduced that all differences of acoustic perception can be traced to differences in the temporal structure of sound waves. These temporal relations enable us to distinguish the many different manifestations of pitch, timbre, simultaneity, sound-mixture, and noise: their speed of oscillation, their particular intervals-either equal and regular or more or less irregular-their density, and the frequency with which pulsations reach the ear. It seemed to me that the differences in intensity among sounds ultimately derive from the latter property: when pulsations of equal value follow one another in closer temporal succession, the over-all intensity increases; to effect this, the density would, in fact, have to be so great that the individual pulses were no longer conveyed as a succession of equal perturbations of the atmosphere but rather as mutually interfering sound-waves: the particles of air agitated by the initial pulses would thus be reactivated by further pulses before they have become quiescent and are, so to speak, "shaken up," so that the impression given is of an increase in over-all intensity. The total complex thus appears as a single greater wave rather than several smaller ones. The faster the succession of pulses, the stronger will be the appearance of the resultant wave.

A periodic sound wave, such as a simple tone, fluctuating regularly in intensity, would thus be the result of a succession of pulses that alternately accelerate and decelerate within each period. The difference between the fastest and slowest rates of speed of the pulses in each period would define the direction of its intensity (its "intensity envelope") and its amplitude. The distance between periodically recurring equal rates of speed would determine the pitch.

- ☐ *Ask JKM -- about the above*
  - ☐ *Is Sockhausen a seminal figure in serialism? What did Xenakis think of his work? or of his way of creating compositions?*
  - ☐ *Ask JKM about the specifics of this passage. What I gather from this passage is that waves increase in complexity overtime when additional wave information is added. It decreases depending on what is subtracted. Filters change the type of wave that is created to form different sounds.*
  - ☐ *Timbre, Pitch, Duration, Intensity*
- ☐ *Quotes : (Section) --*
  - ☐ *These are the 4 characteristics that Stockhausen outlines that electronic composition as distinguished from the composition of instrumental music:*
  - ☐ *1) the correlation of the coloristic, harmonic-melodic, and metric- rhythmic aspects of composition*

    2) the composition and de-composition of timbres

    3) the characteristic differentiation among degrees of intensity

    4) the ordered relationships between sound and noise
  - ☐ *At a relatively early stage of my work in electronic composition, I had already considered the possibility of equating this unity of perception with an analogous unity in composition itself.*

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- ⊟ Section Points : --
- ☐ pg. 41 - 46
  - ☐ If a succession of pulses of this kind were to be accelerated so that between the periodic recurrences of the highest speed there were a time interval of, say, 1/440 sec., one would hear a simple tone with the pitch of A-440.
  - ☐ If the rate of speed of the pulse-succession did not fluctuate regularly--See Figures : -- Ex. 1 but consisted instead of periods of several unequal parts within each equal time-span (as, for example,--See Figures : --, the so-called "color" of a steady sound would II vary according to the wave crests. A "period" divided into two parts would be represented as follows: --See Figures : -- Ex. 2
  - ☐ In a more or less noiselike sound-event the periods would no longer be regular; i.e. the time intervals between recurrences of equal rates of speed would not remain constant but would vary irregularly between a given fastest and slowest speed. These extremes determine the limits of a frequency band, a so-called "colored noise" band. If the rate of speed of the pulse succession were so widely varied that the smallest interval between pulses were ca. 1/16,000 sec., and the longest ca. 1/20 sec., occurring at regular time-intervals, and every- thing between these extremes occurred in a highly aperiodic fashion (in a manner that one might term "aleatoric") the result would be "white noise."
  - ☐ *Ask JKM -- about the above*
    - ☐ *If the wave is irregular depending on noise characteristics, how does the filtering and additional noise timbres and frequencies add to the wave?*
  - ☐ For most musicians, these considerations may seem specifically related to acoustics rather than to music. Actually, however, a musical composition is no more than a temporal ordering of sound events, just as each sound event in a composition is a temporal ordering of pulses. It is only a question of the point at which composition begins: in composing for instruments whose sounds are predetermined, a composer need not be concerned with these problems. On the other hand, in electronic music, one can either compose each sound directly in terms of its wave succession, or, finally, each individual sound wave may be determined in terms of its actual vibration, by an ordering of the succession of pulses.
  - ☐ If, in fact, all of the experiential properties of sound could be traced to a single principle of ordering-such temporally composed successions of pulses-compositional thought would have to be radically reoriented. The distinction between the "acoustical prearrangement" within the material and "musical ordering using this material would now have to be discarded. The prevailing additive, or "synthetic" compositional procedure, in which the different properties are bound together, would now be expanded through a protogenerative and more unified approach. One would not proceed from sound properties that had already been experienced and then allow these to determine temporal variations; instead, one would compose the temporal arrangements of pulses themselves, and discover their resultant sound properties experimentally.
  - ☐ After my first, relatively simple, attempt at such a procedure, I was able to predict roughly the particular temporal orderings of the pulses. I then proceeded to record fixed successions of pulses on tape within a relatively low speed range (using pulsation intervals of between 1/16 and 16 secs.) and then increased the speed until I arrived at the "field" of frequencies and color that I desired. This was done by means of a pulse generator with which the speed of the pulse succession was regulated by hand. Thus, for example, if I wished to generate a periodic wave-that is, a sound of constant pitch-from a succession of pulses lasting eight seconds whose speed variations are fixed, I would have to accelerate the rhythmized eight-second succession 1,024 times, that is, transpose it ten octaves upwards, reducing its duration from eight to 1/128 sec. In order to sustain this pitch of 128 cps. for 10 sec., I would have to re-record the original succession 128 X 10, or 1,280 times, which can easily be done by means of a tape loop. The "color" of the resulting sound would be determined by the variations of speed among the pulses of the original succession, which are now determined by the periodic duplications and accelerations of the wave form within each time span-i.e. the "intensity envelope."
  - ☐ With such a compositional procedure, then, one must proceed from a basic concept of a single, unified musical time; and the different perceptual categories, such as color, harmony and melody, meter and rhythm, dynamics, and "form," must be regarded as corresponding to the different components of this unified time, as follows:
  - ☐ 1. Harmony and melody correspond to periodic waves (that is, to sound-events of constant pitch) whose individual periods should not be greater than ca. 1/16 or less than ca. 1/6,000 sec. because beyond these limits they are no longer audible as "pitches."
  - ☐ 2. The color of harmonic spectra corresponds to the whole number fractions which, as "fundamentals," refer to periods of between ca. 1/13,000 and ca. 1/16 sec.; the color of nonharmonic or noiselike spectra corresponds to more or less aperiodic successions of periods.
  - ☐ 3. Between ca. 1/30 and 1/16 sec. our perception of duration gradually changes into perception of meter and rhythm; i.e., periodic periods may then be considered as meters, and the internal interoallic relationships of the distances between pulses within any given meter- that which determines the tone color for periods shorter than ca. 1/16 sec.-may here be considered as "rhythm."

    Aperiodic relationships of periods, which are considered "noises" in the sphere of color, correspond, when the periods are longer than ca. 1/16 sec., to aperiodic rhythms having no recognizable meters- i.e. no recognizable periodicity (just as a deviation from simple periodicity in the sphere of frequency-"dissonance"-corresponds, in the sphere of duration, to syncopation).

    Although many of the new compositions have been criticized for their alleged "lack of rhythm," they may actually be considered to have "pure rhythm" without meter. This objection, moreover, is exactly analogous to that directed against the use of aperiodic sound waves, i.e. against "noises."
  - ☐ 4. Meter and rhythm correspond to the time intervals whose order of magnitude is between ca. 1/8 and ca. 8 secs. At about 8 secs. our ability to distinguish durational relationships gradually breaks down. With values of greater length we are no longer able to remember the exact lengths of durations or perceive their proportions

as accurately as we can those that lie between ca. 1/8 and ca. 8 secs.

"Form" in a special sense-the time relationships of longer events-corresponds to durations of the order of magnitude of from several seconds to about 15-60 minutes (for "movements" or whole "compositions").

The transitions and overlappings between all the time spheres are quite flexible, but this is especially so with reference to "form," which is most obviously an approximation (in the literature of music, of course, the durations of "movements" or continuous works vary from several minutes to ca. one hour).

Perhaps I should mention here that each of the three large musical time-spheres-frequency duration, rhythm duration, and form duration-are of approximately equal size: each has a compass of about seven "octaves" (where "octave" signifies a relation of 1:2).Between the highest note on the piano, whose fundamental wavelength is ca. 1/4,200 sec. and the lowest, whose wavelength is ca. 1/27 sec., there are just over seven octaves. Below this point sound waves gradually become audible as rhythms (a good illustration of this is the audible effect of the lowest notes on the organ), and from ca. 1/16 sec. to ca. 8 sec.-the span of rhythm durations-there are again seven octaves, as follows:

--See Figures : --

- ☐ The sphere of form duration, from ca. 8 sec. to between ca. 900 secs. (1 5 minutes, the approximate traditional duration of single movements of a work) and ca. 3,600 secs. also includes seven-nine octaves, as follows:

--See Figures : --

- ☐ Thus, the total musical time sphere encompasses the durations between ca. 1/4,200 sec. and ca. 900 secs., that is, 22(-24) "octaves," or 22-24 progressions of 1:2.

At this point I would like to demonstrate, with an example from my composition Kontakte, a continuous overlapping between the time sphere of "frequencies" ("sounds" and their "colors" and the sphere of "rhythms" (individually audible pulses within given time intervals). This overlapping will take place in the zone between ca. 30 and ca. 6 pulses/sec. To begin with, I fed a periodic succession of 16.6 pulses/sec. into a very narrow-band filter. This succession emerged as a sound wave of clear, recognizable pitch. Then, within one min- ute's duration, I continuously varied the frequency position of this filter from 40 cps to 300 cps-that is, over a span, from low to high, of about 3 octaves-in an ascending zigzag glissando pattern:

--See Figures : -- Ex 3

- ☐ These variations in filtering are heard as variations in the pitch resulting from the pulse-succession.

Next, I subjected this result to a tenfold acceleration, until 166 pulses/sec. sounded instead of 16.6 pulses/sec.; that is, one heard a steady pitch having a frequency of 166 cps (between Eb, and E,). The pitch variation between $0 and 300 cps, heard at the first stage, now appears as an intensification of the tone color of the 166-cps tone (now 6 secs. in duration). Because of the high speed, this pattern is no longer heard as an ascending "melodic line."

For the continuation of this sound, I generated a thirty-second suc- cession of pulses whose speed decreased from 16.6 pulses/sec. to 4 pulses/sec. according to a zigzag pattern. Simultaneously, the filter was continuously varied downwards from 300 cps to 40 cps and then upwards again to 300 cps.

--See Figures : -- Ex 4

- ☐ During the next 45 secs., the speed was lessened from 4 pulses/sec. to 1 pulse/sec. according to a pattern of 4 zigzag alterations of the filter in the range between 300 and 54 cps. After 27 secs., the filter remained level at 54 cps.

--See Figures : -- Ex 5

- ☐ In the third part of the pulse succession the speed was decreased regularly from 1 pulse/sec. to 1/4pulse/sec. (within 45 secs. dura- tion); the position of the filter remained constant at 54 cps for the first 15 secs., and then, suddenly, with each individual pulse, it was varied seven times in a fixed up-down, up-down "melodicn pattern, and then held constant at 44 cps.

--See Figures : -- Ex 6

- ☐ Next, I connected the resultant parts, and the overall diminution of the speed amounted to 6 octaves (from 16.6 pulses/sec. to 1/4 pulse/sec., along with the above mentioned pitch variations between 300 and 44 cps). (60" +30" +45" +45")

For the last pulses, I gradually altered the filter feedback time so that, at the end, the duration of each individual pulse is increased, and the "color" becomes somewhat "metallic."

At this point, I subjected the total result to an acceleration, which amounted, at the beginning, to a tenfold acceleration from 16.6 to 1 6 6 pulses/sec., and, by virtue of the continuous alterations, to a 2.5-fold acceleration at the end, so that the intervals between the final pulses amount to ca. 1.5 secs. The pitch of the final pulses is then steady at 160cps, which is approximately the same as that with which the event began. Whereas the accelerated form of the original frequency variation is heard chiefly as tone-color variation, we gradually perceive it again as a succession of individual pulses, as pitch, because of the continuous dissolution of the sounds. The initial sound of 166 cps slides (in 6" +32") about 7% octaves downwards, pass- ing through the zone where perception of pitch modulates into perception of rhythm, where perception of "tone color" merges

The Concept of Unity in Electronic Music by Karlheinz Stockhausen (1962) **Links**

into that of 'melody," and thus the "color" is dissolved into a succession of individual "pitches."

At the conclusion of this pulse succession, the intervals between the individual pulses correspond to 45.5 cm., 48.5 cm., 52 cm., and 57 cm. of the tape (where 38.1 cm. = 1 sec.). I then added three more pulses with a pitch of 1 6 0 cps, between which the intervals were 89 cm. and 140 cm. This continued the gradual retardation and lengthening of the pulses. The third and final pulse was protracted into a continuous sound once again (by means of overmodulating the filter feedback). By means of amplification I made this sound increasingly "overtone-rich" and in five stages filtered continuously from the lowest to the highest portions of the sound. As a result, within 48 secs., its color first gradually brightened, then passed out of the range of audibility, "over the top," as it were.

- ☐ OPPOSITE AND OVERLEAF:

  Stockhausen, Kontakte, pp. 19 and 20

  --See Figures : --
- ☐ Section Points : --

- ☐ pg. 47
  - ☐ Beginning 200-300 cps

    450-600 cps (after 8")

    800-1,000 cps (after 17")

    FILTER: 1,500-3,000 cps (after 26")

    5,000-10,000 cps (after 35")
  - ☐ The entire process of temporal transformation, as it was applied in Kontakte, is schematically represented in the score between the time coordinates 16'56.5" (highest layer) and 18'26.5" (pp. 19-20 in the score). Most of the events in Kontakte, like the one in the example, were composed by means of many temporal transformations of pulse structures.

    I have already affirmed my belief that any drastic separation between acoustics and music is no longer meaningful where composition includes the synthesis of the sound waves themselves. The temporal process ,by which a sound is transformed into a rhythm can, without doubt, take a musical form. The aesthetic judgment of the listener can determine if the result of this process is successful, if it is significantly congruent with the total work, and if it has been accomplished with originality and imagination.
  - ☐ It is understandable that, in traditional Western music, where the spheres of harmony and melody dominate, only those sound-events were used that have periodic waves and clear, recognizable, constant "pitch." The way in which the laws of harmonic and melodic union of such tones, whose harmonic sound spectra are based on whole- number divisions of the sound waves of the fundamentals, corresponds precisely to the definition of consonant and dissonant intervals and their function, indicates the necessity of excluding noise from this kind of music. Similarly, in the sphere of duration, the meters, i.e. periodic time intervals (or measures) were filled in with rhythms- consequently, by whole-number divisions of the meters (tone color is to a fundamental as rhythm is to a meter) -and all of the variations and disruptions of the metrical periodicity were regulated according to the definition of syncopated and regular time intervals and their function. Correspondingly, in the sphere of form, such metrical successions were formed periodically into units of 2, 4, 8, 16 measures with "irregular" (or, better, "syncopated") variants of 3-, 5-, 7-, or 9-measure periods. All of musical time was unified under a common principle, and it was unnecessary to include in this scheme the actual sound wave structure of instrumental tones, since this was guaranteed in advance by the selection and construction of instruments of fixed pitch. If nowadays, on the other hand, it has become necessary to take into account factors such as those discussed here, to bring all the spheres of electronic music under a unified musical time, and to find one general set of laws to govern every sphere of musical time itself, this is simply a result of the condition imposed by electronic music that each sound in a given work must be individually composed.

    (Translated by Elaine Barkin)
  - ☐ Section Points : --

- ☐ _Outline (Summary)
- ☐ _References (Additional)
  - ☐ Karlheinz Stockhausen: The British Lectures - February 13th 1972 at the Institute of Contemporary Arts, London.
    - ☐ Lecture 1: Musical Forming
    - ☐ Lecture 1: Musical Form Part [1/4] www.youtube.con
    - ☐ Lecture 5: Four Criteria of Electronic Music
    - ☐
    - ☐ Lecture 5: Four Criteria of Electronic Music [Part 2/3] www.youtube.con
  - ☐ Tuning In - Karlheinz Stockhausen 1981 www.youtube.con
  - ☐ Interview: BBC www.youtube.con
- ☐ Advisor/Committee Member (Notes) - JKM
- ☐ Global Outline Summary: Final Draft

Silence: Lectures and Writings: Composition as Process (John Cage) pp. 18-62 (43); foreword pp. ix- 17 (19) **Links**

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- ⊟ _Article Summary:
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    - ☐ Foreword (ix)
    - ☐ Manifesto (xii)
    - ☐ The Future of Music: Credo (3)
    - ☐ Experimental Music (7)
    - ☐ Experimental Music Doctrine (13)
    - ☐ Composition as Process (18)
      - ☐ I. Changes (18)
      - ☐ II. Indeterminancy (35)
      - ☐ III. Communication (41)
    - ☐ Composition (57)
    - ☐ To describe the Process of Composition Used in Music of Changes and Imaginary Landscapes No. 4 (57)
    - ☐ To Describe the Process of Composition Used in Music for Piano 21-52 (60)
  - ☐ +*1 Silence: Lectures and Writings (John Cage)
    Composition as Process pp. 18-47 (29)
  - ☐ +*2 "Silence: Lectures and Writings (John Cage)"
    Composition as Process pp. 48-62 (14)
- ☐ _Concepts:
  - ☐ Terms
    - ☐ Indeterminancy: en.wikipedia.org–
    - ☐ Electroacoustic Music: en.wikipedia.org–
    - ☐ Prepared Piano: en.wikipedia.org–
    - ☐ Modern Dance: en.wikipedia.org–
    - ☐ Aleotoric Music en.wikipedia.org–
    - ☐ Chance Operations howcreativeswork
    - ☐ Music
    - ☐ Composition
    - ☐ Conceptual Art
    - ☐ Timbre
    - ☐ Dynamics
    - ☐ Pitch
    - ☐ Duration
- ☐ _Glossary
  - ☐ References
    - ☐ Merce Cunninghanm: en.wikipedia.org–
    - ☐ Henry Cowell en.wikipedia.org–
    - ☐ Arnold Schoenberg: en.wikipedia.org–
    - ☐ IChing: en.wikipedia.org–
    - ☐ Pierre Boulez
    - ☐ Fuge
- ☐ _Objectives
  - ☐ Questions:
    - ☐ The understanding of the compositional process.

Silence: Lectures and Writings: Composition as Process (John Cage) pp. 18-62 (43); foreword pp. ix- 17 (19) **Links**

- ☐ To understand the use of chance in compositions.
- ☐ To determine the origins of silence as sound.

- ☐ _Outline (Notes)
  - ☐ Foreword (ix)
  - ☐ Manifesto (xii)
    - ☐ Please see diagram
  - ☐ The Future of Music: Credo (3)
    - ☐ 1 BELIEVE THAT THE USE OF NOISE
      Wherever we are, what we hear is mostly

      noise. When we ignore it, it disturbs us. When we listen to it, we find it fascinating. The sound of a truck at fifty miles per hour. Static between the stations. Rain. We want to capture and control these sounds, to use them not as sound effects but as musical instruments. Every film studio has a library of "sound effects" recorded on film. With a film phonograph it is now possible to control the amplitude and frequency of any one of these sounds and to give to it rhythms within or beyond the reach of the imagination. Given four film phonographs, we can compose and perform a quartet for explosive motor, wind, heartbeat, and landslide.

      TO MAKE MUSIC

      If this word "music" is sacred and reserved for eighteenth- and nineteenth-century instruments,

      we can substitute a more meaningful term: organization of sound.

      WIl.L CONTINUE AND IN- CREASE UNTIL WE REACH A MUSIC PRODUCED THROUGH THE AID OF ELECTRICAL INSTRUMENTS

      Most inventors of electrical musical instruments have at- tempted to imitate eighteenth- and nineteenth-century instruments, just as early automobile designers copied the carriage. The Novachord and the Solovox are examples of this desire to imitate the past rather than construct the future. When Theremin provided an instrument with genuinely new possibilities, Thereministes did their utmost to make the instrument sound like some old instrument, giving it a sickeningly sweet vibrato, and per- forming upon it, with difficulty, masterpieces from the past. Although the instrument is capable of a wide variety of sound qualities, obtained by the turning of a dial, Thereministes act as censors, giving the public those sounds they think the public will like. We are shielded from new sound experiences.

      The special function of electrical instruments will be to pro- vide complete control of the overtone structure of tones (as opposed to noises) and to make these tones available in any frequency, amplitude,

      and duration.

      WHICH WILL MAKE AVAILABLE FOR MUSICAL PURPOSES ANY AND ALL SOUNDS TIIAT CAN BE HEkRD. PHOTOELECTRIC, FILM, AND MECHANICAL MEDIUMS FOR THE SYNTHETIC PRODUCTION OF MUSIC

      It is now possible for composers to make music directly, without the assistance of intermediary performers. Any design repeated often enough on a sound track is audible. Two hundred and eighty circles per second on a sound track will produce one sound, whereas a portrait of Beethoven repeated fifty times per second on a sound track will have not only a different pitch but a different sound quality.

      WILL BE EXPLORED. WHEREAS, IN THE PAST, THE POINT OF DISAGREEMENT HAS BEEN BETWEEN DISSONANCE AND CONSONANCE, IT WILL BE, IN THE IMMEDIATE FUTURE, BETWEEN

      NOISE AND SO-CALLED MUSICAL SOUNDS.

      THE PRESENT METI:IODS OF WRITING MUSIC, PRINCIPALLY THOSE WHICH EMPLOY HARMONY AND ITS REFERENCE TO P ARTICULAR STEPS IN THE FIELD OF SOUND, WILL BE INADEQUATE FOR THE COMPOSER, WHO WILL BE FACED WITH THE ENTIRE FmLD OF SOUND. THE e composer (organizer of sound) will be faced not only with the entire field of sound but also with the entire field of time. The "frame" or fraction of a second, following established film technique, will probably be the basic unit in the measurement of time. No rhythm will be beyond the composer's reach.

      NEW METHODS WILL BE DISCOVERED, BEARING A DEFINITE RELA TION TO SCHOEN- B~G'S TWELVE-TONE SYSTEM

      Schoenberg's method assigns to each material, in a group of equal materials, its function with respect to the group. (Harmony assigned to each material, in a group of unequal materials, its function with respect to the fundamental or most important material in the group.) Schoenberg's method is analogous to a society in which the emphasis is on the group ruad the integration of the individual in the group.

      AND PRESENT MEmODS OF WRITING PERCUSSION MUSIC

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Percussion music is a contemporary transition from keyboard-influ- enced music to the all-sound music of the future. Any sound is acceptable to the composer of percussion music; he explores the academically forbidden "non-musical" field of sound insofar as is manually possible.

Methods of writing percussion music have as their goal the rhythmic structure of a composition. As soon as these methods are crystallized into one or several widely accepted methods, the means will exist for group improvisations of unwritten but culturally important music. This has already taken place in OrieDtal cultures and in hot jazz.

AND ANY OTHER METHODS WHICH ARE FREE FROM mE CONCEPT OF A FUNDAMENTAL TONE.

THE PRINCIPLE OF FORM WILL BE OUR ONLY CONSTANT CONNECTION W im THE PAST. ALmOUGH THE GREAT FORM OF mE FUTURE WILL NOT BE AS IT WAS IN mE PAST, AT ONE E TIME THE FUGUE AND AT ANOTIIER THE SONATA, IT WILL BE RELATED TO THESE AS THEY ABE TO EACH OTIIER:

Before this happens, centers of experimental music must be established. In these centers, the new materials, oscillators, turntables, generators, means for amplifying small sounds, film phonographs, etc., available for use. Composers at work using twentieth- century means for making music. Performances of results. Organization of sound for extra-musical purposes (theatre, dance, radio, film).

THROUGH THE PRINCIPLE OF ORGANIZATION OR MAN'S COMMON ABILITY TO THINK.

- ☐ ….
  - ☐ It was a Wednesday. I was in the sixth grade. I overheard Dad saying to Mother, "Get ready: we're going to New Zealand Saturday." I got ready. I read everything I could find in the school library about New Zealand. Saturday came. Nothing happened. The project was not even mentioned, that day or any succeeding day.
  - ☐ M. C. Richards went to see the Bolshoi Ballet. She was delighted with the dancing. She said, "It's not what they do; it's the ardor with which they do it." I said, "Yes: composition, performance, and audition or observation are really different things. They have next to nothing to do with one another." Once, I told her, I was at a house on Riverside Drive where people were invited to be present at a Zen service conducted by a Japanese Roshi. He did the ritual, rose petals and all. Afterwards tea was served with rice cookies. And then the hostess and her husband, employing an out-of-tune piano and a cracked voice, gave a wretched performance of an excerpt from a third-rate Italian opera. I was embarrassed and glanced towards the Roshi to see how he was taking it. The expression on his face was absolutely beatific.
  - ☐ A young man in Japan arranged his circumstances so that he was able to travel to a distant island to study Zen with a certain Master for a three-year period. At the end of the three years, feeling no sense of accomplishment, he presented himself to the Master and announced his departure. The Master said, "You've been here three years. Why don't you stay three months more?" The student agreed, but at the end of the three months he still felt that he had made no advance. When he told the Master again that he was leaving, the Master said, "Look now, you've been here three years and three months. Stay three weeks longer." The student did, but with no success. When he told the Master that absolutely nothing had happened, the Master said, "You've been here three years, three months, and three weeks. Stay three more days, and if, at the end of that time, you have not attained enlightenment, commit suicide." Towards the end of the second day, the student was enlightened.
- ☐ Experimental Music (7)
- ☐ Experimental Music Doctrine (13)
- ☐ Composition as Process (18)
  - ☐ I. Changes (18)
    - ☐ Section Points : -- (Initial reading)
      - ☐ … The music is not superimposed on the speech but is heard only in the interruptions of the speech- which, like the lengths of the paragraphs themselves, were the result of chase operations.
      - ☐ ...Structure and method
      - ☐ …By "structure" was meant the division of the whole into parts;
      - ☐ … by "method," the note-tonote procedure.
      - ☐ …"material"--the sounds and silences of a composition.
      - ☐ .. Composition, …an activity integrating the opposites, the rational and the irrational, bringing about ideally a freely moving continuity within a strict division of parts, the sounds, their combination and succession being either logically related or arbitrarily chosen.
      - ☐ The strict division of parts, the structure, was a function of the duration aspect of sound, since, of all the aspects of sound including frequency, amplitude and timbre, duration, alone was also a characteristic of silence.
      - ☐ The structure, then was a division of actual time by conventional metrical means, meter taken as simply the measurement of quantity.
      - ☐ The materials, the piano preparations were chosen as one chooses shells while walking along a beach.
      - ☐ .. by the later work, the deduction might be made that there is a tendency in my composition means from ideas of order towards no ideas of order.
      - ☐ .. the note-to-note procedure, the method, is the function of chance operations.
      - ☐

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- ☐ .. chance operations determined stability or change of tempo. Thus, buy introducing the action of method into the body of the structure, and these two opposed in terms of order and freedom, that structure became indeterminate; It was not possible to know the total time-length of the piece until the final chance operation, The last toss o coins affecting the reate of tempo had been made.
- ☐ Being indeterminate, though still present, it became apparent that structure was not necessary, even though it had certain uses.
- ☐ One of these uses was the extermination of density, the determination, that is, of how many of the potentially present eight lines, each composed of sounds and silences, were actually to be present within a given small structural part. Another use of the structure affected the charts of sounds and silences, amplitudes, durations, potentially active in the continuity.
- ☐ These twenty-four charts, eight for sounds and silences, eight for amplitudes, eight for durations, were throughout the course of a single structural unit, half of them mobile and half of them immobile.
- ☐ Mobile meant that once any of the elements in the chart was used it disappeared to be replaced by a new one. Immobile meant that through an element in a chart had been used, it remained to be used again.
- ☐ At each unit structural point, a chance operation determined which of the charts, numbers one, three, five , seven air tumors two four six and eight, were mobile and which of these cahrsts were immobile not changing.
- ☐ The structure, therefore was in these respects useful. Furthermore, it determined the beginning and ending of the compositional process.
- ☐
- ☐ … structure is not longer a part of the compositional means. The view taken is not of an activity the purpose of which is to integrate the opposites, but rather of an activity characterized by process and essentially mind, through stripped of its right to control, is till present.
- ☐ What does it do, having nothing to do?
- ☐ What happens to a piece of music when i is purposely made? What happens , for instance, to silence? How does the minds's perception of it change? Formerly, silence was the time lapse between sounds, useful towards a variety of ends, among them that of tasteful arrangement, where by separating two sounds or two groups of sound their differences of relationships might receive emphasis or that of expressivity, where silences in a musical disourse might provide pause or punctuation.
- ☐ … Where non of these or other goals is present, silence becomes something else-not silence at all, but sounds, the ambient sounds. The nature of these is unpredictable and changing. These sounds are called silence only because they do not form part of a musical intention Maybe depended upon to exist.
- ☐ He who has entered an anechoic chamber, a room made as silent as technologically possible, has heard there two sounds, one high , one low the high the listener's nervous system in operation, the low his blood in circulation. There are demonstrably sounds to be heard and forever, given ears to hear.
- ☐ Where these are in connection has nothing to do that the mind is free to enter into the act of listening and hearing each sound just as it is not as a phenomenon more or less approximating a preconception.
- ☐
- ☐ What's the history of the changes in my composition with particular reference to sounds?
- ☐
- ☐ One may conclude from this that in the Music of Changes the effect of the chance operations on the structure (making very apparent its anachronistic character was blanked by a control of the materials.
- ☐
- ☐ The question "How do we need to cautiously proceed in dualistic terms?" was not consciously answered until the Music for Piano. In that piece notes were determined by imperfections in the paper upon which the music was written the number of imperfections was determined by chance.
- ☐
- ☐ …I have affirmed the absence of the mind as a ruling agent from the structure and method of the composition means its presence with regard to material is made clear on mexaming the sounds themselves:
- ☐ … The limited nature of this universe of possibilities makes the events themselves comparable to the first attempts at speech of a child or the fumbling about of a blind man. The mind reappears as the agent which established the boundaries within which this small play took place.
- ☐
- ☐ Something more far-reaching is necessary: a composing of sounds within a universe predicated upon the sounds themselves rather than up on the mind which can envisage their coming into being.
- ☐ Sounds… have frequency, amplitude, duration, timbre and in a composition, an order of succession. five lines representing these five characteristics may be drawn in India ink upon transparent plastic squares.
- ☐
- ☐ In this situation the universe within which the action is to take place is not preconceived. Furthermore, as we know, sounds are events in a field of possibilities, not only at the discrete points conventions have favored.

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- ☐ pg 29. (segmentations of durations) …this segmentation was a pratical measure taken to avoid the writing of an impossible situation which mint arise during a high density structural area due to the chance operations.
- ☐
- ☐ Pg 30. Though each page is read from left to right conventionally, the combination is unpredictable in terms of succession. The history of changes with reference to timbre is short.
- ☐ .. giving up the personal taste about timbre.
- ☐
- ☐ .. The early works have beginnings middles and endings. The later ones do not. They being anywhere, last any length of time and involve more or fewer instruments and players. They are therefore not preconceived objects and to approach them as objects is to utterly miss the point. They are occasions for experience and this experience is not only received by the ears but by the eyes too. An ear alone is not a being. I have noticed listening to a record that my attention moves to a moving object or a play of light,
- ☐ .. It becomes evident that music itself is an ideal situation, not a real one. The mind may be used either to ignore ambient sounds, pitches other than the eighty-eight, durations which are not counted, timbres which are unmusical or distasteful, and in general to control and understand an available experience. Or the mind may give up its desire to improve on creation and function as a faithful receiver of experience.
- ☐

- ☐ II. Indeterminancy (35)
  - ☐ The Art of the Fugue by Johann Sebastian Bach pg. 35
    - ☐ The Art of the Fugue by Johann Sebastian Bach is an example. In The Art of the Fugue, structure, which is the division of the whole into parts; method, which is the note-to-note procedure; and forrn, which is the expressive content, the morphology of the continuity, are all determined.
    - ☐ Frequency and duration characteristics of the material are also determined. Timbre and amplitude characteristics of the material, by not being given, are indeterminate. This indeterminacy brings about the possibility of a unique overtone structure and decibel range for each performance of The Art of the Fugue. In the case of the Klavierstuck X/, all the characteristics of the material are determined, and so too is the note-to-note procedure, the method. The division of the whole into parts the structure, is determinate. The sequence of these parts, however, is indeterminate, 1 bringing about the possibility of a unique form, which is to say a unique morphology of the continuity, a unique expressive content, for each performance.
    - ☐ Klavierstuck XI Karlheinz Stockhausen pg. 35
    - ☐ The indetenninate aspects of the composition of the KlavierstUck XI do not remove the work in its performance from the body of European musical conventions. And yet the purpose of indeterminacy would seem to be to bring about an unforeseen situation. In the case of KlavierstUck XI, the use of indeterminacy is in this sense unnecessary since it is ineffective. The work might as well have been written in all of its aspects determinately. It would lose, in this case, its single unconventional aspect: that of being printed on an unusually large sheet of paper which, together with an attachment that may be snapped on at several points enabling one to stretch it out flat and place it on the music rack of a piano, is put in a cardboard tube suitable for safekeeping or distribution through the mails.
  - ☐ Intersection 3 by Morton Feldman pg. 36
  - ☐ Indlces by Earl~Brown pg. 37
  - ☐ The 4 System1 by Earle Brown pg. 37
  - ☐ Duo II for Pianists by Christian Wolff pg. 38
  - ☐ Conclusion: pg. 39 - 40
    - ☐ This is a lecture on composition which is indeterminate with respect to its performance. That composition is necessarily experimental. An experimental action is one the outcome of which is not forseen. Being unforseen•.t!tis action is not concerned with its excuse. Like the land, like the air, it needs none. A performance of a compoSition which is indeterminate of its performance is necessarily unique. It cannot be repeated. When performed for a second time, the outcome is other than it was. Nothing therefore is accomplished by such a performance, since that performance cannot be grasped as an object in time. A recording of such a work has no more value than a postcard; it provides a knowledge of something that happened, whereas the action was a non-knowledge of something that. 1lad not yet happened.
    - ☐ There.,are certain practical matters to discuss that concern the performance of music the composition of which is indeterminate with respect to Its performance. These matters concern the physical space of the performance. These matters also concern the physical time of the performance. In connection with the physical space of the performance where that performance involves several players (two or more), it is advisable for several reasons to separate the performers one from the other, as much as is convenient and in accord with the action and the architectural situation. This separation allows the sounds to Issue from their own centers and to interpenetrate in a way which is not obstructed by the conventions of European harmony and theory about relationships and interferences of sounds. In the case of the harmonious ensembles of European musical history, a fusion of sound was of the essence, and therefore players in an ensemble were brought as close together as possible, so that the!' actions, productive of an object in time, might be effective. In the case, however, of the

performance of musc the composition of which is indeterminate of its performance so that the action of the players is productive of a process, no harmonious fusion of sound is essential. A non-obstruction of sounds is of the essence. The separation of players in space when there is an ensemble is useful towards bringing about this non-obstruction and interpenetration, which are of the essence. Furthermore, this separation in space will facilitate the independent action of each performer, who, not constrained by the performance of a part which has been extracted from a score. has turned his mind in the direction of no matter what eventuality. There is the possibility when people are crowded together that they wUI act like sheep rather than nobly. That.is why separation in ~pace is ~poke'.' of as facilitating independent action on the part of each performer. Sounds will then anse from actions, wh1ch w1ll then ar1se from their own centers rather than as motor or psychological effects of other actions and sounds in the environment. The musical recognition of the necessity of space is tardy with respect to the recognition of space on the part of the other arts, not to mention scientific awareness. It is indeed astonishing that music as an art has kept perform- ing musicians so consistently huddled together in a group. It Is high lime to separate the players one from another! in order to show a musical recognition of the necessity of space, which has already been recognized on the part o the other arts, not to mention scientific awareness. What is indicated, too, is a disposition of the performers, in the case of an ensemble in space, other than the conventional one of a huddled group at one end of a recital or symphonic hall. Certainly the performers in the case of an ensemble in space will be disposed about the room. The conventional architecture is often not suitable. What is required perhaps is an architecture like that of Mies van der Robe's School of Architeclure at the Illinois Institute of Technology. Some such architecture will be useful for the performance of composition which is indeterminate of its performance. Nor will the performers be huddled together in a group in the center of the audience. They must at least be disposed separately around the audience, if not, by approaching their disposition in the most radically realistic sense, actually disposed within the audience itself. In this latter case, the further separation of performer and audience will facilitate the independent action of each person, which will include mobility on the part of all.

- ☐ There are certain practical matters to discuss that concern the performance of music the composition of which is indeterminate with respect to Its performance. These matters concern the physical space of the performance. These matters also concern the physical time of the performance. In connection with the physical time of the performance, where that performance involves several players (two or more), it is advisable for several reasons to give the conductor another function than that of beating time. The situation of sounds arising from actions which arise from their own centers will not be produced when a conductor beats lime in order to unify the performance. Nor will the situation of sounds arising from actions which arise from their own centers be produced when several conductors beat different times in order to bring about a complex unity to the performance. Beating time Is not necessary. All that is necessary is a slight suggestion of time, obtained either from glancing at a watch or at a conductor who, by his action, re_presents a watch. Where an actual watch is used, it becomes possible to foresee the time, by reason of the steady progress from second to second of the second hand. Where, however, a conductor is present, who by his actions represents a watch which moves not mechanically but vari- ably, it Is not possible to foresee the time, by reason of the changing progress from second to second of the conductor's indications. Where this conductor, who by his actions represents a watch, does so in relation to a part rather than a score-to, in fact, his own part, not that of another-his actions will interpenetrate with those of the players of the ensemble in a way which will not obstruct their actions. The musical recognition of the necessity of time Is tardy with respect to the recognition of time on the part of broadcast communications, radio, television, not to mention magnetic tape, not to mention travel by air, departures and arrivals from no matter what point at no matter what time, to no matter what point at no matter what time, not to mention telephony. It is indeed astonishing that music as an art has kept performing musicians so consistently beating time together like so many horseback riders huddled together on one horse. It is high time to let sounds issue in time independent of a beat In order to show a musical recognition of the necessity of time which has already been recognized on the part of broadcast communications, radio, te]evision, not to mention magnetic tape, not to mention travel by air, departure. and arrivals from no matter what point at no matter what time, to no matter what point at no matter what time, not to mention telephony.
- ☐ Section Points : -- (Initial reading)

- ☐ III. Communication (41)
  - ☐ Section Points : -- (Initial reading)
    - ☐
    - ☐ pg. 44. When we separate music from life what we get is art (a compendium of Masterpieces). With contemporary Music, When it is actually contemporary, we have no time to make that separation (Which protects us from living), and so contemporary music is not so much art as it is life...
    - ☐ … Returning to the book of Changes: The hexagram of Grace (which is the hexagram on Art) Discusses the effect of a work of Art as though it were a Light shinning on top of a Mountain penetrating to a certain extent the surrounding Darkness, that is to say , art is described as being illuminating, and the rest of life as being Dark.
    - ☐
    - ☐ pg 46.
    - ☐ Here's a little information you may find informative about the information theory:
      - ☐ Fourier analysis allows a function of time (or any other independent variable to be expressed in terms of periodic (frequency) components. The frequency components are over all properties of

the in tire signal. By means of a fourier analysis one can express the value of a signal at any point in terms of the over all frequency properties of the signal; or vice versa, one can obtain these over-all properties from the values of the signal at its various points.

- ☐ ...Part of the vast range of vibrations including radio waves, light, cosmic rays.

- ☐ WE"RE PASSING THROUGH TIME AND SPACE. OUR EARS AilE IN EXCELLENT CONDITION. pg. 49
- ☐ The Belgians asked me about the avant-garde in America and this is whot I told them: pg. 52
- ☐ I must read a little from an article by Christian Wolff. Here's what he says: pg. 54
  - ☐ NOTABLE QUALITIES OF ThiS MUSIC, WHETHER ELECTRONIC OR NOT, ARE MONOTONY A WTHEII\RIT A TIONTHA T ACCOMPANIES IT. THE MONOTONY MAY LIE IN SIMPLICITY OR DELICACY, STRENGTH OR COMPLEXITY. COMPLEXITY TENDS TO REACH A POINT OF NEUTRALIZATION: CONTINUOUS CHANGE RESULTS IN A CERTAIN SAMENESS. THE MUSIC HAS A STATIC CHARACTER. IT GOES IN NO PARTICULAR DIRECTION, THERE IS NO NECESSARY CONCERN WITH TIME AS A MEASURE OF DISTANCE FROM A POINT IN THE PAST TO A POINT IN THE FUTURE, WITH LINEAR CONTINUITY ALONE. IT IS NOT A QUESTION OF GETTING ANYWHERE, OF MAKING PROGRESS, OR HAVING COME FROM ANYWHERE IN PARTICULAR, OF TRADITION OR FUTURISM. THERE IS NEITHER NOSTALGIA NOR ANTICIPATION. OFTEN THE STRUCTURE OF A PIECE IS CIRCULAR: THE SUCCESSION OF ITS PARTS IS vARIABLE, AS IN PoussEuR's Exercises de Piano AND STOCKHAUSEN's Klavierstuck XI. IN CAGE'S RECENT WORK THE NOTATION ITSELF CAN BE CIRCULAR, THE SUCCESSION OF NOTES ON A STAVE NOT NECESSARILY INDICATING THEIR SEQUENCE IN TIME, TIIAT IS, THE ORDER IN WHICH THEY ARE PERFORMED. ONE MAY HAVE TO READ NOTES ON A CIRCLE, IN TWO "vOICES" GOING IN OPPOSITE DIRECTIONS SIMULTANEOUSLY. AN ASPECT OF TIME DISSOLVES. AND THE EUROPEANS OFTEN VIEW ORGANIZATION AS "GLOBAL," WHEREBY BEGINNINGS AND ENDS ARE NOT POINTS ON A LINE BUT LIMITS OF A PIECE's MATERIAL (FOR EXAMPLE, PITCH RANGES OR POSSIBLE COMBINATIONS OF TIMBRES) WHICH MAY BE TOUCHED AT ANY TIME DURING THE PIECE. THE BOUNDARIES OF THE PIECE ARE EXPRESSED, NOT AT MOMENTS OF TIME WHICH MARK A SUCCESSION, BUT AS MARGINS OF A SPATIAL PROJECTION OF THE TOTAL SOUND STRUCTURE.

    AS FOR THE QUALITY OF II\RIT A TION, THAT IS A MORE SUBJECTIVE MA TTER. ONE MIGHT SAY TIIA T IT IS A T LEAST PREFERABLE TO SOOTHING, EDIFYING, EXALTING, AND SIMILAR QUALITIES. ITS SOURCE IS, OF COURSE, PRECISELY
    IN MONOTONY, NOT IN ANY FORMS OF AGGRESSION OR EMPHASIS. IT IS THE IMMOBILITY OF MOTION. AND IT ALONE, PERHAPS, IS TRULY MOVING.
- ☐ And now I have to read a story from Kwang-Tse and then I'm finished: pg. 54
  - ☐ Y un Kiang, rambling to the East, having been borne along on a gentle breeze, suddenly encountered Hung Mung, who was rambling about, slapping his buttocks and hopping like a bird. Amazed at the sight, Yun Kiang stood reverentially and said to the other, "Venerable Sir, who are you? and why are you doing this?" Hung Mung went on slapping his buttocks and hopping like a bird, but replied, " I'm enjoying myself." Yun Kiang said, "I wish to ask you a question." Hung Mung lifted up his head, looked at the stranger, and said, "Pooh I" Yun Kiang, however, continued, "The breath of heaven is out of harmony; the breath of earth is bound up; the six elemental influences do not act in concord; the four seasons do not observe their proper tim.s. Now I wish to blend together the essential qualities of those six influences in order to nourish all living things. How shall I go about it?" Hung Mung slapped his buttocks, hopped about, and shook his head, saying, "I do not know; I do not know!"

    Y un Kiang could not pursue his question; but three years afterwards, when again rambling in the East, as he was passing by the wild of Sung, he happened to m.et Hung Mung. Delighted with the rencontre, he hastened to him, and said, "Have you forgotten me, 0 Heaven? Have you forgotten me, 0 Heaven?" At the same time, he bowed twice with his head to the ground, wishing to receive his instructions. Hung Mung said, "Wandering listlessly about, I know not what I seek; carried on by a wild impulse, I know not where I am going. I wander about in the strange manner which you have seen, and see that nothing proceeds without method and order-what more should I !mow?" Yun Kiang replied, "I also seem carried on by an aimless influence, and yet people follow me wherever I go. I cannot help their doing so. But now as they thus imitate me, I wish to hear a word from you." The other said, "What disturbs the regular method of Heaven, comes into collision with the nature of things, prevents the accomplishment of the mysterious operation of Heaven, scatters the herds of animals,
    makes the birds sing at night, is calamitous to vegetation, and disastrous to all insects; all this is owing, I conceive, to the error of governing men." "What then," said Yun Kiang, "shall I do?" "Ah," said the other, "you will only injure them I I will leave you in my dancing way, and return to my place." Y un Kiang rejoined, "It has been difficult to get this meeting with you, 0 Heaven I I should like to hear from you a word more." Hung Mung said, "Ah Iyour mind needs to be nourished. Do you only talce the position of doing nothing, and things will of themselves become transformed. Neglect your body; cast out from you your power of hearing and sight; forget what you have in common with things; cultivate a grand similarity with the chaos of the plastic ether; unloose your mind; set your spirit free; be still as if you had no soul. Of all the multitude of things, every one

returns to its root, and does not know that it is doing so. They all are as in the state of chaos, and during all their existence they do not leave it. If they knew that they were returning to their root, they would be consciously leaving it. They do not ask its name; they do not seek to spy out their nature; and thus it is that things come to life of themselves."

- ☐ ….
  - ☐ One day when I was across the hall visiting Sonya Sekula, I noticed that she was painting left-handed. I said, "Sonya, aren't you right-handed?" She said, "Yes, but I might lose the use of my right hand, and so I'm practicing using my left." I laughed and said, "What if you lose the use of both hands?" She was busy painting and didn't bother to reply. Next day when I visited her, she was sitting on the floor, painting with difficulty, for she was holding the brush between two toes of her left foot.
  - ☐ Morris Graves introduced Xenia and me to a miniature island in Puget Sound at Deception Pass. To get there we traveled from Seattle about seventy-five miles north and west to Anacortes Island, then south to the Pass, where we parked. We walked along a rbcky beach and then across a sandy stretch that was passable only at low tide to another island, continuing through some luxuriant *woods* up a hill where now and then we had views of the surrounding waters and distant islands, until finally we came to a small foot- bridge that led to our destination-an island no larger than, say, a modest home. This island was carpeted with flowers and was so situated that all of Deception Pass was visible from it, just as though we were in the best seats of an intimate theatre. While we were lying there on that bed of flowers, some other people came across the footbridge. One of them said to another, "You come all this way and then when you get here there's nothing to see."
  - ☐ A composer friend of mine who spent some time in a mental rehabilitation center was encouraged to do a good deal of bridge playing. After one game, his partner was criticizing his play of an ace on a trick which had already been won. My friend stood up and said, "If you think I came to the loony bin to learn to play bridge, you're crazy."
- ☐ Composition (57)
  - ☐ To describe the Process of Composition Used in Music of Changes and Imaginary Landscapes No. 4 (57)
    - ☐ My recent work (Imaginary Landscape No. N for twelve radios and the Music of Changes for piano) is structurally similar to my earlier work: based on a number of measures having a square root, so that the large lengths have the same relation within the whole that the small lengths have within a unit of it. Formerly, however, these lengths were time-lengths, whereas in the recent work the lengths exist only in space, the speed of travel through this space being unpredictable.
    - ☐ What brings about this unpredictability is the use of the method established in the 1-Ching (Book of Changes) for the obtaining of oracles, that of tossing three coins six times.
    - ☐ Three coins tossed once yield four lines: three heads, broken with a circle; two tails and a head, straight; two heads and a tail, broken; three tails, straight with a circle. Three coins tossed thrice yield eight trigrams (written from the base up): chien, three straight; chen, straight, broken, broken; kan, broken, straight, broken; ken, broken, broken, straight; kun, three broken; sun, broken, straight, straight; Zi, straight, broken, straight; tui, straight, straight, broken. Three coins tossed six times yield sixty-four hexagrams (two trigrams, the second written above the first) read in reference to a chart of the numbers 1 to 64 in a traditional arrangement having eight divisions horizontally corresponding to the eight lower trigrams and eight divisions vertically corresponding to the eight upper trigrams. A hexagram having lines with circles is read twice, first as written, then as changed. Thus, chien-chien, straight lines with circles, is read first as 1, then as kun-kun, 2; whereas chien-chien, straight lines without circles, is read only as 1.

      Charts are made of an equal number of elements (sixty-four) which refer to (one chart) (how many events are happening at once during a given structural space); Tempi (one chart); Durations (n, the number of possible superpositions, in these works, eight charts); Sounds (eight charts); Dynamics (eight charts).

      Where there are eight charts, four at any instant are mobile and four immobile (mobile means an element passes into history once used, giving place to a new one; immobile means an element, though used, remains to be used again). Which charts are which is determined by the first toss at a large unit structural point, an odd number bringing about a change, an even number mamtaining the previous status.

      The Tempi and Superpositions charts, however, remain unchanged through the entire work.

      In the charts for sounds thirty-two of the elements (the even numbers) are silences. The sounds themselves are single, aggregates (cf. the accord sometimes obtained on a prepared piano when only one key is depressed), or complex situations (constellations) in time (cf. the Chinese characters made with several strokes). Sounds of indefinite pitch (noises) are free to be used without any restriction. Those of definite pitch are taken as being twelve in number. In any chart for sounds (there being thirty-two sounds) two squares (four times four) exist, one above the other. Reading horizon- tally or vertically, one reads all twelve tones. In the case of the mobility of sounds (disappearance into history) four in succession also produce the twelve tones, with or without noises and repetitions. In the case of "interferencen (the appearance of a sound having characteristics in common with the characteristics of the previously sounded situation) the characteristics that produce the interference are omitted from the newly appearing sound or cut short in the situation that has previously sounded. In the radio piece, numbers on a tuning dial are written instead of sounds, whatever happens being acceptable (station, static, silence).

In the charts for dynamics only sixteen numbers produce changes (one, five, nine, etc.); the others maintain the previous status. These are either dynamic levels or accents (in the piano piece); levels, diminuendi, and crescendi in the radio piece. In the piano piece, combinations of dynamic levels (e.g. fff>p) indicate accents; in the case of a sound complex in time this become a diminuendo or (by retrograde interpretation) a crescendo, or derived complex.

- ☐ In the charts for durations there are sixty-four elements (since silence also has length). Through use of fractions (e.g. Ya; Ya + % + Yz) measured following a standard scale (2Y:! em. equals a crotchet), these durations are, for the purposes of musical composition, practically infinite in number. The note stem appears in space at a point corresponding to the appearance of the sound in time, that is if one reads at the tempo, or chang- ing tempo indicated. Given fractions of a quarter, half, dotted half and whole note up to Ya, simple addition of fractions is the method employed for the generating of durations. Because addition is the generating means employed, the durations may be said to be "segmented." These segments may be permuted andfor divided by two or three (simple nodes). A sound may then express the duration by beginning at any one of these several

  points.
  A way of relating durations to sounds has been thought of in the course

  of this work but not in it utilized: to let four durations equal a specified length (on the chart, horizontally or vertically and in mobility four in suc- cession)-this specified length being subject to change.

  The chart for Tempi has thirty-two elements, the blanks maintaining the previous tempo.

  Each one of the events one to eight is worked from the beginning to the end of the composition. For instance, the eighth one is present from beginning to end but may sound only during a structural space that has been defined by a toss (for Superpositions) of fifty-seven to sixty-four. It is then not only present but possibly audible. It becomes actually audible if a sound is tossed (rather than a silence) and if the duration tossed is of a length that does not carry the sound beyond the structural space open to it.

  It is thus possible to make a musical composition the continuity of which is free of individual taste and memory (psychology) and also of the literature and "traditions" of the art. The sounds enter the time-space centered within themselves, unimpeded by service to any abstraction, their 360 degrees of circumference free for an infinite play of interpenetration.

  Value judgments are not in the nature of this work as regards either composition, performance, or listening. The idea of relation (the idea: 2) being absent, anything (the idea: 1) may happen. A "mistake" is beside the point, for once anything happens it authentically is.

- ☐ To Describe the Process of Composition Used in Music for Piano 21-52 (60)
  - ☐ 1. Given ink, pen, and sheets of transparent paper of determined dimensions, a master page (without notations) is made, having four total systems. "Total" here means having enough space above and below each staff to permit its being either bass or treble. Thus, there being the conventional two staves (one for each hand) , each has enough space above it to accommodate nine ledger lines (as equidistant as those of the staves) and below it to accommodate six ledger lines plus (leaving room for the extreme low piano key and string). Between the two there is a narrow space, bisected by a line, allowing for the notation of noises produced by hand or beater upon the interior (above the line) or exterior (below the line) piano construction. Measurements are such that theentire sheet (within margins) is potentially useful.
  - ☐ 2. Laying the master page aside, chance operations derived from the *1-Ching* and channeled within certain limits (1-128 for *21--J6;* 1--32 for *37-52)* (which are established in relation to relative difficulty of performance) are employed to determine the number of sounds per page.
  - ☐ 3. Ablanksheetoftransparentpaperisthenplacedsothatitspointalimperfectionsmayreadily be observed. That number of imperfections corresponding to the determined number of sounds is intensified with pencil.
  - ☐ 4. Placing the penciled sheet in a registered way upon the master page, first the staves and interline and then the ledger lines where necessary are inscribed in ink. Secondly, conventional whole notes are written in ink wherever a penciled point falls within the area of staves or ledger lines, inked-in notes (crotchets without stems) being written wherever such a point falls within the space between the two staves. This operation is done roughly, since, through the use of conventional lines and spaces, points falling in the latter are in the majority . Thus it is determined that a point, though not on a line, is actually more nearly so than it is at the center of the adjacent space.
  - ☐ 5. Eight single coin tosses are made determining the clefs, bass or treble, and inscribed in ink. 6. The sixty-four possibilities of the *1-Ching* are divided by chance operations into three groups relative to three categories: normal (played on the keyboard); muted; and plucked (the two latter played on the strings) . For example, having tossed numbers *6* and 44, a number 1 through 5 will produce a normal; *6* through 43 a muted; 44 through 64 a plucked piano tone. A certain weight of probability exists in favor of the second and third categories. Though this has not appeared to be of consequence, it indicates a possible change in "technique." The categories having been determined, notations (M and P) are conveniently placed in reference to the notes.
  - ☐ 6. The sixty-four possibilities of the *1-Ching* are divided by chance operations into three groups relative to three categories: normal (played on the keyboard); muted; and plucked (the two latter played on the strings) . For example, having tossed numbers *6* and 44, a number 1 through 5 will produce a normal; *6*

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through 43 a muted; 44 through 64 a plucked piano tone. A certain weight of probability exists in favor of the second and third categories. Though this has not appeared to be of consequence, it indicates a possible change in "technique." The categories having been determined, notations (M and P) are conveniently placed in reference to the notes.

- ☐ A similar procedure is followed to determine whether a tone is natural, sharp, or Hat, the procedure being altered, of course, for the two extreme keys where only two possibilities exist.
- ☐ 7. The notation of the composition is thus completed. Much that occurs in performance has not been determined. Therefore, the following note is fixed at the head of the manuscript: "These pieces constitute two groups of sixteen pieces (*21--36; 37-52)* which may be played alone or together and with or without *Music for Piano 4--19.*• Their length in time is free; there may or may not be silence between them; they may be overlapped. Given a programed time length, the pianists may make a calculation such that their concert will fill it. Duration of individual tones and dynamics are free."

- ⊟ _Outline (Review)
- ☐ ArtWorks:
- ☐ Additional Reference Material:
  - ☐ Opus 20 Modern Masterworks: "John Cage"
    - ☐ www.youtube.co
    - ☐ www.youtube.co
    - ☐ Details:
      - ☐ documentary film (Uplink Factory, Japan, 2006)

        music by John Cage, Ingo Metzmarcher, Hermann Ktetzschmar, David Tudor, Ensemble modern

        film by Klaus Lindemann

        presented by the Alte oper Frankfur
      - ☐ Summary:
        - ☐ John Cage Interviewed:
          - ☐ Everything in the world of interesting.
          - ☐ Our minds tend to narrow the possibilities
          - ☐ Chance operations open up the possibilities
        - ☐ Narrator:
          - ☐ It frustrates expectation of order and logical constructions.
          - ☐ Freeing it from normative convention.
          - ☐ Discovering music then vehicles of man made theories
          - ☐ A refusal of psychology and history.
          - ☐ Chance and open experience.
        - ☐ Composition as Process:
          - ☐ Composition as process - attending to sound as they emerged. (Charles Ives)
        - ☐ Composition by Chance Procedures:
          - ☐ Chance and open experience. (Not ordering or personal expression)

            Sound and Process over Structure

            Composition by chance procedures:

            Prepared piano (Free Timbre) - Invented by Henry Cowell

            - He transformed the piano into a palette of sounds.

            Timbre mutates along the piece.

            First steps towards indeterminacy.

            Liberated Timbre from the conventions of musical tradition.

            Other elements were liberated:

            Pitch, duration, intensity, (From rigorous control)

            Method - John Cage created composition by chance procedures
        - ☐ John Cage Analysis: The Four Causes:
          - ☐ The Four Causes:
          - ☐ 1 Material cause: (Knowledge of Material, Process , origins)

            Example: Music/Composition: (Sound and Silence are Co Equal)

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- ☐ 2 Formal cause: (What is it? The creation of the actual thing? Discipline? Type of work?)

  Example: 4' 33" , Water walk
- ☐ 3 Efficient cause: (Artist needs to make it: Artist decisions, experience, instincts, process)

  Chance Procedures: To invert the concerns of meaning and personal choice in music. To operate and imitate nature.
- ☐ 4 Final cause: (What questions does it ask/have? What is it for?)

  What is being a Musician? What is it being a composer? What is it being a listener?

  What is Music in the Twentieth Century?
- ☐ Important: Point: John Cage pondered the meaning of composition of the twentieth century. Writing music for this time and this society.

- ☐ Chance Procedures Defined:
  - ☐ JC Questions: Why would one write music in this society:

    The function of art is not to communicate ones own art or ideas or feelings but to Imitate nature of her manner of operation.

    Chance is not randomness but a method/process to

    pose musical questions of the four elements of music

    Pitch, Duration, dynamics, timbre.
  - ☐ (The answers were obtained by chance combinations read off carefully set up charts of possibilities.)

    In the early years tossing coins. In the later years by computer.
- ☐ Music Composition Philosophy
  - ☐ My choices consist in choosing what questions to ask.

    (Chance was not away of giving up choices.)

    In avoidance of any kind of logical control of sound and discipline submission to chance

    lay the way to Liberation of personal taste and memory. (Spirit of Zen Buddism)

    1946. Became of student of D. Suzuki.

    Meditation on emptiness.

    John Cage:

    One new idea since Bethooven:

    That Sound and Silence are co equal.

    Late 40's and forward.

    Structured by units of time, not patterns or harmonic systems.

    Quote:

    I want to keep from interrupting the silence that's already there.

    Music is made of sound and silence.

    Composing is connecting the two in succession not progression.

    Listening is opening ones ears.

    And hearing a sound suddenly before thinking turns it into something logical, abstract or symbolical.

    Quote:

    No one can have an idea once he really starts listening.

Silence: Lectures and Writings: Composition as Process (John Cage) pp. 18-62 (43); foreword pp. ix- 17 (19) **Links**

Important:

John Cage reposed for the twentieth century the question.

How the act of composition stands to the material of music.

- ☐ Quotes:
  - ☐ My choices consist in choosing what questions to ask.
  - ☐ I want to keep from interrupting the silence that's already there.

- ☐ John Cage: 22708 Types Part 1, 2, 3, 4, & 5
  - ☐ Details:
    - ☐ Film By: Henning Lohner
  - ☐ Summary:
    - ☐ John Cage Reading: www.youtube.con
      - ☐ The purpose of music is to sober and quite the mind, thus making it supseptinle to devine influences

        The responsibility of the artist is to imitate nature in its manner of operation.

        Our view of that operation changes with our scientific awareness, our scientific awareness in recent years includes Chaos, (The Butterfly effect)

        There is nothing free of the network of cause and effect.

        Everything causes everything else. Everything results in everything else.

        A sober and quite mind to philosophy, is free of its like and dislikes.

        Audience: comes to hear music because he is well known. But when they realize what it is they become disappointed, and they have ideas on how it should be. Those are the sounds don't seem to many people musical. The Sounds that don't change, so frequent in our environment, then we can enjoy all sounds, then we can enjoy life.

        Position of having music.
    - ☐ Interview: 1 - (He is using flow, The algorithm to create ideas) www.youtube.con
      - ☐ Keep me from doing into the same thing. Old habits.
      - ☐ The profound questions that are asked to make good chance operation compositions.
      - ☐ Notions of Buddist creation
      - ☐ Process to asking questions, continuing to ask radical questions.
      - ☐ Anarchy in music. Music that cannot be controlled.
    - ☐ Interview: 2- www.youtube.con
      - ☐ Music is an example of society.
      - ☐ Music is a social activity. Can follow a model of society or not.
      - ☐ Analyzing the form.
      - ☐ Music is society rather than individual and acceptance of the past.
      - ☐ He does not cultivate memory.
      - ☐ Marcel Duchamp to reach the impossibility of transference one night image to another, transferring memory imprint. Coke bottle example. Remaining a tourist through great duplication. Coke bottles in different points of space and time. No two coke bottles look the same.
    - ☐ Interview: 3 - www.youtube.con
      - ☐ Digital Age:
      - ☐ Getting closer to nature. Technology is to disappear and without technology. When technology improves get smaller. Carrying out logically it will disappear entirely.
      - ☐ If technology goes to nowhere - where are human being going.
      - ☐ Technology according to MuCluhan is an extension to the central nervous system.
      - ☐ so we are in a situation of greater number of ideas and interconnection of ideas. McCluhan said that rubbing ideas against ideas.
      - ☐ The future: we get to a point that everyone gets to live has he wishes.
      - ☐ The division of the world. Those that have and have not.
      - ☐ How do we operate with conscious
      - ☐ Everyone is a master of
      - ☐ He was homeless. In New York. Didn't have money, or a place to live, he would lie down on the street to sleep. During the depression.
      - ☐

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- ☐
- ☐ Interview: 4 - www.youtube.con
  - ☐ What is music?
  - ☐ It is one of the arts. It is a way to paying attention. Attention is paid to sound.
  - ☐ What is art?
  - ☐ The same thing. Visual art is to looking and seeing.
  - ☐ What is Love?
  - ☐ We don't know? We think it is loving someone, but we suspect that it is loving ourselves.
- ☐ American Masters: John Cage http://www.youtu
  - ☐ Quotes:
    - ☐ When Schoenberg asked me whether I would devote my life to music, I said, "Of course." After I had been studying with him for two years, Schoenberg said, "On order to write music, you must have a feeling for harmony." I explained that I had no feeling for harmony. He then said that I would always encounter an obstacle, that it would be as though I came to a wall through which I could not pass. I said, "In that case I will devote my life to beating my head against that wall."
    - ☐ I have come through my music to enjoy the music in my environment.
    - ☐ The first question that I ask. Why do I think it is not beautiful. Conclusion, there is no reason. If we conquer that dislike then the world is more open. That path of increasing ones enjoyment of life, that is the path that we should all best take. To use art not as self expression but to self alteration (for more openness).
  - ☐ Narrator:
    - ☐ Composer, Musician, philosopher, visual artist and writer.
    - ☐ Ideas are seminal. International artist.
    - ☐ International Artist.
    - ☐ Innovative, experimental, controversial.The originator of the multimedia happening. Pioneer in electronic music. and leading figure in indeterminacy in ,music using chance operations.
    - ☐ Challenged the way we perceive experience. Reshaped aesthetic thought in the 20th century.
    - ☐ The music of cage in in everyones subconscious.
    - ☐ He wants everyone to respond intensely to everyday life.
    - ☐ Laurie Anderson: Encouraging other to tweak up sensibility.
    - ☐ I want to be free without being foolish.
    - ☐ All of Cage's pieces are highly structured.
    - ☐ The giving up the ego of self to the work.
    - ☐ Influence Duchamp. Readymades.
    - ☐ Philosophical point of view centered on doubt. Man is not the center of the universe. Taste: Bad, good and indifference.
    - ☐ Performance work, how nature naturally work.
    - ☐ Physicist notion of randomness.
    - ☐ 1948. Cage and Merce went to Black Moutain school. many visits. Faculty. Josef Albers and Buckminster fuller. Faculty and students performed together in experimental productions. They med robert Rauchenberg.
    - ☐ They collaborated together. First work Dance minutia 1954. Composition by cage, Dance choreography from Merce and Rochenberg made the set and costume design.
  - ☐ John Cage:
    - ☐ Conference of the The subject of reality. Dr. Suzuki didn't say anything all the time. In what sense the table was real, Suzuki said that in every sense.
    - ☐ Why do I ask questions? I have nothing to say and I am saying it.
    - ☐ Merce Cunningham 1938. Piano prepared pieces (1938)
    - ☐ Cowell, Plucking them, muting them. He extended the idea using a pie plate. Then he had to fix it nail. It slipped. Then he put a wood screw and then it stayed in position. Bolts are close together to the string.
    - ☐ Sound coming into its own. What does it mean? Noises are useful to music as musical tones for the simple reason that they are sounds.
    - ☐ What is more musical? A truck driving by a factory or a truck driving by a music school.
    - ☐ All of the work is determined but all decisions are from chance operations. Derived from imperfections and from tossing coins. Multiple of 64. Given structural Chance operations. Took the place of pshycho analysis.
    - ☐ In the mushrooms not to eat one that is deadly.
    - ☐ In music, no sounds are deadly.
    - ☐ Zen statement. Everyday is a beautiful day. Everything is pleasing if you don't have the notion of pleasing or displeasing.
    - ☐ It is difficult to get rid of ones instincts of order and taste.
    - ☐ I use the IChing as a method and a discipline.

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- ☐ In Zen they say if it is boring in 2 minutes then try more 4, 8, 16, 32, then eventually you will find it interesting.
- ☐ 4' 33":
  - ☐ Sounds are continually taking place. In the environment all things experience (cough is as audible is interesting as any sound)
  - ☐ The material of music is sound and silence. Composing them is music.
  - ☐ I am not interesting in learning but in changing my mind. That has changed. All of us have changed. We have less confidence in time as we go into the future. How long the future will be. We wonder if we have ruined the silence (Society)
  - ☐ Simply waking up to the way the life worth living. Let's life act in its own accord.
- ☐ Video:
  - ☐ In the name of the Holocaust. Prepared piano piece.
  - ☐ Collaborator with Merce Cunningham. Allowing music and dance to act independently from each other. Music does not support the dance and vice a versa. It is just to things happening. Two separate things happening.
- ☐ Works:
  - ☐ Percussion Music
  - ☐ Prepared Piano Pieces
  - ☐ Chance Operation Music
  - ☐ Visual Arts
  - ☐ Writing
  - ☐ Performance Art / Happenings.
  - ☐ Individual Works:
    - ☐ Water Music
    - ☐ Radio Works
    - ☐ Video piece collaboration. Duchamp and Cage.
    - ☐ Chess Piece. Determined piece reenacting a work with Marcel Duchamp. (Want to work from chance operations.)
      - ☐ He is cutting, splicing and directing the shoot for each scene using chance operations.
    - ☐ Minutae: Rauschenberg, Merce and Cage.
    - ☐ Speech 1983: Radio works moving around in an auditorium space. 5 performers.
    - ☐ 1952. 4' 33" using chance operations instructing the performer to do nothing. The sound is the ambient sound around them. Perceive life as art. He wrote it with all notes silent with different lengths. (After seeing a white painting by Robert Rauchenberg)
- ☐ Biography:
  - ☐ (Born in LA. 1912.
  - ☐ Attended LA high school. Travelled Europe.
  - ☐ Took courses at UCLA with Schoonberg.
  - ☐ Mother was a writer for a local newspaper.
  - ☐ Father was an inventor.
- ☐ John Cage Interview: 1985
- ☐ For The Third Time (1978) www.ubu.com—c
- ☐ 19 QUESTIONS www.youtube.con
- ☐ Lectures from Other Academics:
  - ☐ Is John Cage's 4'33'' music?: Prof. Julian Dodd at TEDxUniversityOfManchester www.youtube.con
- ☐ Quotes:
  - ☐ “When you start working, everybody is in your studio- the past, your friends, enemies, the art world, and above all, your own ideas- all are there. But as you continue painting, they start leaving, one by one, and you are left completely alone. Then, if you are lucky, even you leave.”
    — John Cage
  - ☐ “Every something is an echo of nothing”
    — John Cage
  - ☐ “There is no such thing as an empty space or an empty time. There is always something to see, something to hear. In fact, try as we may to make a silence, we cannot.”
    — John Cage
  - ☐ “The highest purpose is to have no purpose at all. This puts one in accordance with nature, in her manner of operation.”
    — John Cage
  - ☐ “What is the purpose of writing music? One is, of course, not dealing with purposes but dealing with sounds. Or the answer must take the form of a paradox: a purposeful purposeless or a purposeless play. This play, however, is an affirmation of life--not an attempt to bring order out of chaos nor to suggest improvements in

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creation, but simply a way of waking up to the very life we're living, which is so excellent once one gets one's mind and one's desires out of its way and lets it act of its own accord."
— John Cage, *Silence: Lectures and Writings*

- ☐ "Which is more musical, a truck passing by a factory or a truck passing by a music school?
  Are the people inside the school musical and the ones outside unmusical?
  What if the ones inside can't hear very well, would that change my question?"
  — John Cage, *Silence: Lectures and Writings*
- ☐ "Whether I make them or not, there are always sounds to be heard and all of them are excellent."
  — John Cage
- ☐ "Value judgments are destructive to our proper business, which is curiosity and awareness."
  — John Cage
- ☐ "A 'mistake' is beside the point, for once anything happens it authentically is."
  — John Cage
- ☐ "The first question I ask myself when something doesn't seem to be beautiful is why do I feel it's not beautiful? And very shortly you discover there is no reason."
  — John Cage
- ☐ "If you develop an ear for sounds that are musical it is like developing an ego. You begin to refuse sounds that are not musical and that way cut yourself off from a good deal of experience."
  — John Cage

- ☐ Advisor/Committee Member (Notes)
- ☐ Global Summary: (Draft)
- ☐ Global Summary: Final Drafts