

Stochastic composition

Demystifying Xenakis' *Achorripsis* (1957) and
applying his underlying approach in composition

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1. Introduction

Stochastic music is a composition technique which relies heavily on math and probability to steer away from serialism and its deterministic views. This type of music was, among others, created by a composer and architect, who was taught by Le Corbusier and Messiaen; Iannis Xenakis. Until now, I have steered away from delving into this composition technique because of its daunting appearance as it heavily relies on math. Furthermore, stochastic composition always raises to me the question; Isn't music supposed to be written from feelings and thoughts? Shouldn't music come from the heart? Shouldn't it be a way of telling a story which comes from the composer's brain and into a listener's brain? That is why in the piece at hand I will focus on the following question: What story could numbers tell me that any composer or human being could not? I will shed light on this question and answer starting in Chapter 2 where I will give some context to the composition style and the composer Iannis Xenakis. I will explain the foundation of how he composed *Achorripsis* using his book "*Formalized music*". In Chapter 3 I explain how I created my own vector matrix according to Xenakis' rules that I shed light on in Chapter 2. In Chapter 3 I will further share the insights I gained while going through the stochastic composition process. In this paper, I'll exemplify the interesting process a composer can go through while composing in a stochastic method. At the end of Chapter 3 I'll report on my findings from a conversation with an expert composer, Arnold Marinissen, where he elucidates some of my interpretations of Xenakis' and stochastic methods and gives some insight on his own process. I'll report my thought processes and further findings during the creation of stochastic compositions. This way, I also aim to better understand Xenakis' view on stochastic methods of composition by doing so myself. Through this method I was able to answer my question.

2. Stochastic music

2.1 What is stochastic music?

Stochastic music is a form of music where the composer employs probability and rulesets to create his music. Stochastic music was created by Iannis Xenakis because he found the rules of serialism to be too restrictive. Xenakis was seeking indeterminism and ways to organize sound. He would subject sounds to the laws of chance and create interesting new ideas. He would organize the sounds by pitch, durations, dynamics etc in order to create his first stochastic works named '*Free stochastic music*' (1955-57) and '*Markovian stochastic music*' (1958-59). When listening to these pieces the dynamic nature of the composing technique is very clear as the set of rules begin to take over and the composer lets go yet gives in to the sound of the numbers. Stochastic music is not composed by every person in the same way that pop music and jazz are common. However most composers who learn at a university will be confronted with these techniques as they are very eye opening as to what music is, can be and can cater to a whole new way of exploration in sound.

2.2 Iannis Xenakis

Iannis Xenakis (1922-2001) is a Romanian-born Greek-French avant-garde composer, music theorist and architect. Some of his works are: *Pithoprakta* (1957), *Achorripsis* (1956), *Metastaseis for Orchestra* (1954) and the *Philips Pavilion*. Later, he also became a very important influence in the development of electronic and computer music. He developed several computer programs, one of them being UPIC, a computerized musical composition tool completed in 1977 which uses stochastic synthesis, a set of direct sounds synthesis based on probability theory, which is also used by known artists such as Aphex Twin. Xenakis revolutionized his field of composing and is to date one of the most influential creators in stochastic composition and computer music.

3. Stochastic composition

3.1 Achorripsis

The 1957 composition *Achorripsis* (Greek for “jets of sound”) was composed using four different probability distributions, applied over three different organizational domains, during the course of the 7 minute piece. Xenakis did not mean to ‘sonify’ data by any means but instead worked toward a strong vision of rendering mathematical formulations into musical events such as time, timbre, glissando speed, thus the stochastic principles he used.

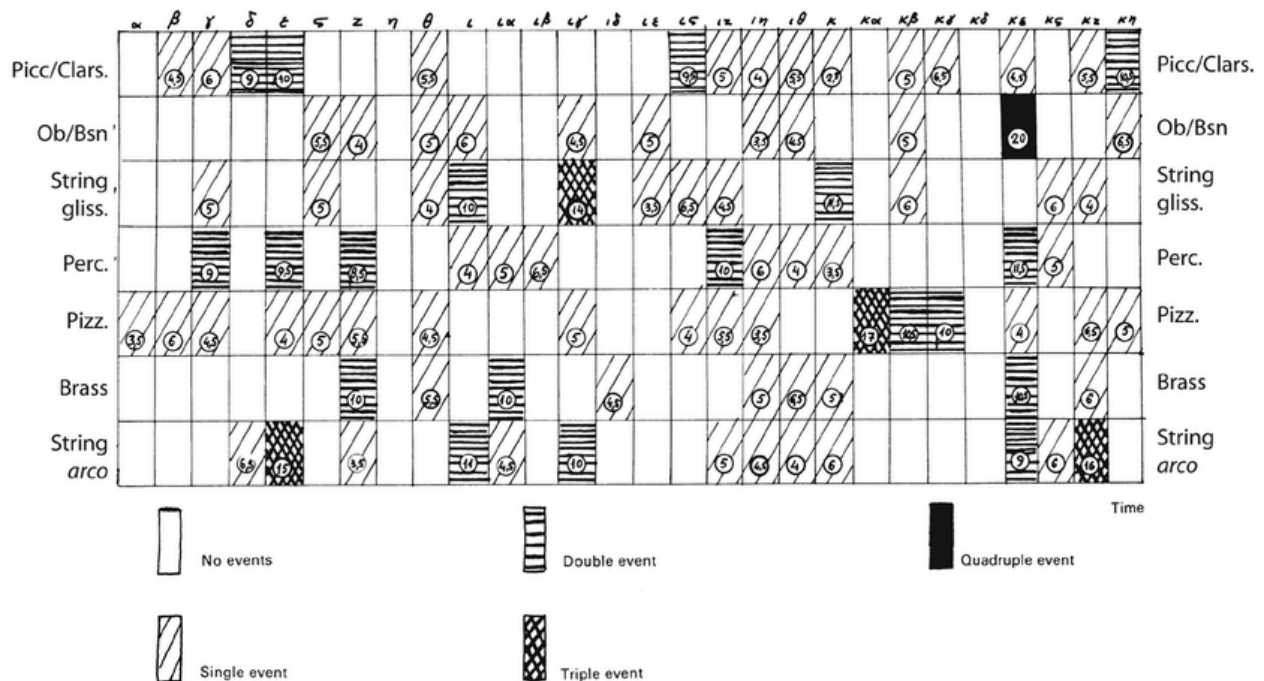


Figure 1 ‘Vector Matrix’, created for Xenakis’ *Achorripsis* from ‘Formalized Music’ by Iannis Xenakis

3.2 The Matrix Game

The Vector matrix (figure 1) is a collection of cells on a horizontal and vertical axis. One of the probability distributions is the Poisson distribution, following the lambda of 0.6, derived from the probability of gas distribution in a space. These cells represent time on the x-axis and instrument/playstyle on the y-axis. Also, the cells have different values ranging from ‘no events’ up to ‘quadruple events’. These values are connected to the amount of notes per second (based on the tempo & count).

Achorripsis is written on a tempo of $\text{♩} = 60$ and a time signature of $2/2$. Before he started to compose Xenakis had decided that the piece would last for 7 minutes, thus containing 182 measures, while also deciding that the y-axis would have 7 cells for timbre & playstyle. These 7 cells would contain oboe,

bassoon, brass section, clarinet & piccolo. The remainder is used for different play styles such as Strings-glissando, strings-pizzicato and strings-arco. What is left now is doing the calculations for the number of events per sort and distribution of the events over the x and y-axis.

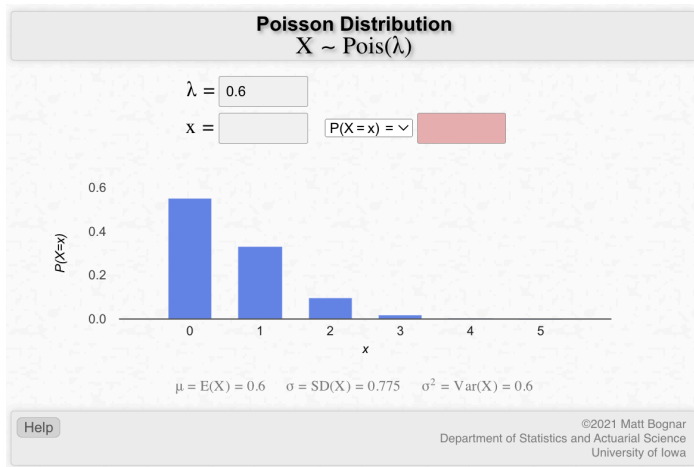


Figure 2. Poisson distribution with $\lambda = 0.6$. [University of Iowa poissoncalculator](#)

For the distribution over the x and y axis, Xenakis used the Poisson distribution of a cloud of gas in a room. The cloud of gas was calculated to have a lambda or a of $\lambda = 0.6$. This number is significant because it is the relevant number of the discrete probability function. Figure 2 shows the Poisson distribution which was used by Xenakis.

With these numbers, he then calculated the amount of events per kind. So for instance a ‘zero-event’ would correlate to the $X = 0$ in the Poisson distribution. Xenakis would then do the calculation of $\text{measures} * P = \text{amount of zero-events}$. So for the P0, it would be $182 * 0.54881 = 99,882$. Telling us that in this composition there will be 99.8 events or “zero events” where nothing will happen out of the total 181 events in the piece. This simple distribution would serve as the basis of the composition. From here on out there will be more calculations such as how to distribute these ‘events’ over the X and Y axis.

3.3 Vector

For my project of learning the stochastic way of composition, I followed Xenakis' approach as read in his book "Formalized Music", a book where he describes some of his works, some more detailed and some less detailed, some even missing important parts of the explanation. I will go over my exact steps, and explain the most important details of my steps.

My piece would last up to 8 minutes containing 1 violin, 1 alt-violin, 1 cello, 1 double-bass, 1 dynamic (pizzicato/staccato), and 1 arco. The tempo is set to a 4/4 meter and the bpm is set to 60. We now know that when using the same calculations as Xenakis the piece will exist of 32 Units of time and because the bpm is set to 60 it will coincidentally also have 32 measures. The setup does not match up exactly with the players that will be playing my piece because the actual piece will be played by 3 violins, 2 alt-violins, 1 cello and 1 double bass. However, with these rules I am setting up I can later compose easily for more players if I wish.

Starting, and following Xenakis', with a lambda of 0.9 (as seen in Figure 3). I noticed immediately that it is really important that this number is not too large. So before I ended up with this exact lambda I tried several others. and concluded that a lambda which is too high will show you a large number of distributions according to the discrete distribution system (as shown in figure 4), however, we do not need as many distributions because in our case, the same as in Xenakis' case, each distribution amounts to a doubling of player speed. As you can now imagine a player having to play 'event 20' and thus having to play 20x the speed as on event 1, would mean that the tempo of the player on event 1 should be very slow when taking further multiplication into account. So a very well-considered initial value is of great importance here.

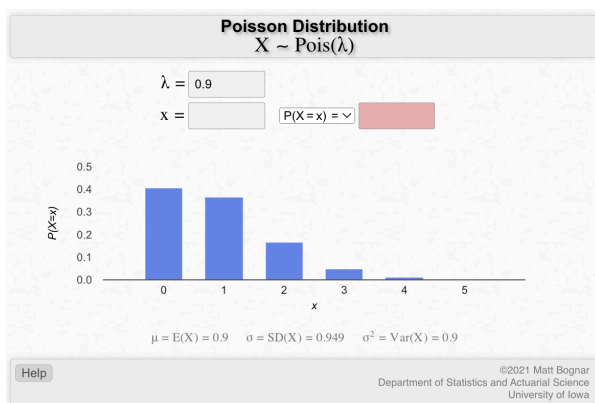


Figure 3, Lambda of 0.9 showing a distribution over 5.

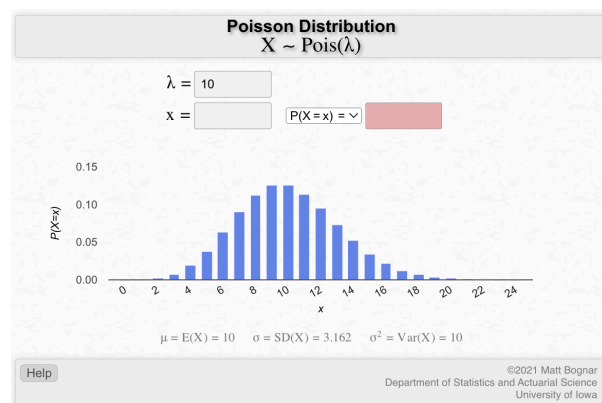


Figure 4, Lambda = 10 showing a great number of discrete distributions. [University of Iowa poisson calculator](https://www.stat.columbia.edu/gelman/poisson-calculator/)

Poisson distribution of $\lambda = 0.9$	
Frequency K	P
P0	0.40657
P1	0.36591
P2	0.16466
P3	0.0494
P4	0.0111

Figure 5, *All data of the distribution as numbers.*

Frequency of K * the total number of cells		
<i>I</i>	<i>Amount of cells</i>	<i>Rounded off</i>
P0 - zero	78,07	78
P1 - single	70,25	71
P2 - double	31,61	32
P3 - triple	9,48	9
P4 - quad	2,13	2
TOTAL	191,54	192

Figure 6, *Calculation of the amounts per event.*

Before going any further more calculations are necessary such as the total amount of events per row. Earlier I explained this is done via the simple formula of *Amount of cells * P* The outcome of this is visible in Figure 6. Furthermore, we need to calculate the number of notes per event according to the bpm (bpm = 60) and the Ut (Ut = 32). This is because of the higher density that will be played which will form the ‘clouds’ of sound. Note how the numbers are not exactly fitting in a measure, being 26.4 or 35.2 in the *Sounds/Measure*. This means that the composing part will need some calculation on getting the exact amount to be played.

amount of notes per event			
Event	Sounds/sec	Sounds/measure	Sounds/cell
P0 - zero	0	0	0
P1 - single	2,2	8,8	33
P2 - double	4,4	17,6	66
P3 - triple	6,6	26,4	99
P4 - quadruple	8,8	35,2	132

Figure 7, *Note density per event.*

In Figure 8, I have calculated the amount of cells for the X-axis. This is a very interesting moment in the process because if the approach to this stochastic composition is according to gas distribution and we are now composing with a strictly scientific and calculus-based method, why and how can we just *round off* these numbers? I discovered that Xenakis would also do this. This gives a very clear message of how this piece of music is not just existing purely because the numbers ‘add up’ but there is also a composer composing the data. This is my personal first eureka of how Xenakis composes his music. Portrayed as the ‘composer using math’. Sure, Xenakis uses math. However, he does have a very distinct idea of his music and how he can make the numbers “work” towards his narrative. To make this more clear we should have a look at the next section of the piece where we will do the Poisson distribution over columns (the X-axis of the vector matrix).

Firstly, I had to calculate a new λ for each event (figure 8). This is necessary because the distribution must be about time and instrumentation.

Poisson for X-axis			
	Amount of cells	Amount of Ut	λ
P0 - zero	78	32	2,44
P1 - single	71	32	2,22
P2 - double	32	32	1
P3 - triple	9	32	0,28
P4 - quad	2	32	0,06

Figure 8, *Lambda per event.*

Now with this data, we can create the distribution of **P0 - Zero events** (figure 9). What is important here is that the *Product col * K* must exactly be the same as the amount of Zero events as calculated earlier. By any means necessary! The amount of Frequencies of K we are using is not the same as the amount of rows we have. Therefore our numbers will not exactly fit into our vector matrix. Drastic action was required so I made the number fitt. This is the second moment where I will ‘compose’ the piece. I already know the order of the instruments/dynamics distributed over the numbers 1 to 5. I can potentially choose which instrument I would like to be silent most often. In this case, number 4 will be silent more often over number 1 which would fit my narrative which is “*I prefer to have the three violins play the higher density of sounds.*”

P0 - no event, $\lambda = 2,44$			
Frequency K	EXACT number of Columns containing K events	ROUNDED number of columns containing K events	Product col * K
0	2,79	3	0
1	7,3	7	7
2	8,46	9	18
3	6,54	7	21
4	3,8	4	22
5	2,01	2	10
Actual total	30,9	32	78

Figure 9, Lambda per event.

Continuing I have repeated this step for every row and every event and for just every one I had a decision to make. The rules I made in the beginning, combined with my knowledge of the ensemble and my personal preferences gave me a very clear path to aim my decisions and compose a piece according to my Vector matrix (Figure 10). Noteworthy is that because of the setup of the matrix, it is possible to swap out each row and column which enabled me to change everything after filling in the vector matrix. I wanted more zero events in the beginning and I also wanted the ending to feel more empty, so I placed the highest-density events more towards the middle by swapping the rows and columns. I was pleasantly surprised by the flexibility in a system like this which was built by rule upon rule.

3.4 Conversation with Arnold Marinissen

Composer and percussionist Arnold Marinissen (1966) studied Classical percussion at the Royal Conservatoire The Hague, where he graduated with distinction in 1991, receiving the prize for the best exam of the year. Since 2008, he has been a principal subject teacher at the Conservatorium van Amsterdam. Arnold Marinissen is Artistic Director of Slagwerk Den Haag. Arnold Marinissen composed works for ensembles and artists including Askō|Schönberg, the Nederlands Kamerkoor, the Storioni Trio, Slagwerk Den Haag and many more. As percussionist Arnold has also performed a lot of pieces composed by Xenakis' which makes him familiar to Xenakis and his works.

Arnold told me about his experience as a composer and performer of playing pieces from Xenakis, saying that as a player, Arnold has experienced that Xenakis was a composer that would always compose towards his own narrative and not the player nor did he compose for the instrument. Xenakis was a composer that would compose his music towards his vision. And in much the same way as John Cage, contrary to popular belief, Xenakis also adapted randomness into his composition. Xenakis was somewhat inspired by John Cage because they knew each other. But Xenakis would still remain the editor of the piece which is really where the 'architect' comes into play. The algorithms would create the 'frameworks' for Xenakis and much the same as a house that needs a roof, walls and windows, how you would actually 'build' the house is completely up to the architect. This was a very good comparison that put my own findings into perspective and changed my view of how I had experienced my own findings up to this point.

For his own compositions Arnold also employs algorithms but also in another way. Led by insights from artists such as John Cage, Messiaen and Xenakis, Arnold focussed on composing minimal music with algorithmic inspiration to shift Arnold's responsibility from composer to the composition itself. In this way it could show Arnold how it can be composed and it gave me the insight that Arnold sees the composition as another performer. For example Arnold would load a predetermined piece of audio into a Digital Audio Workstation (D.A.W.) and would increase and decrease the tempo with automation. This creates a basis for experimentation while he would be able to choose how the piece could interpret itself. After this Arnold would re-analyse the audio with a plethora of analysis' to see what the newly created piece could bring Arnold. His next step would be to compose with the information he gained while also reflecting on his source-audio as a form of mould. Staying close to the framework while reimagining its inner workings much in the same way as a metamorphosis.

4. Conclusion

In this paper, I aimed to answer the question on the topic of stochastic composition: What story could numbers tell me that any composer or human being could not? During this process I have learned that numbers can give meaning to a piece but more importantly that the composer can give meaning to the numbers. This is because a composer can create the key aspect in the stochastic composition of becoming the translation of data to music if they apply themselves to their data as if it were their instrument. In chapter 2 we were able to learn about the problems and strivings of the stochastic method. Why Xenakis' wanted to create his own style of composition and what its potential could be. In chapter 3 we were able to learn how to understand the very specific decision making and reasoning behind these choices, aiming to work towards the narrative of my composition. This completes the story that numbers tell me. They strive to give meaning to my narrative all while the numbers only exist out of the narrative. It's a very symbiotic relation from number to note where the composer intentionally strives to create a flowing translation from one world to the other, number to note. This has led to my Vector Matrix which was completely different from Xenakis' work as it should.

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