Start making sense.
AI, Automata and the Conquest of Space

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The rapid development of artificial intelligence tools during the last years, and more importantly, the availability and ease of use of such tools for architects, designers and artists have raised questions about the ways in which they affect current creative practices. Opinions of course vary, from understanding AI as just another set of tools at the disposal of the designer to desperate warnings that generative AI tools could signify the death of the creative process as we know it. The use of automated processes however is not something new; on the contrary, tools that automate a smaller or larger part of the creative process have a long history within which we can find examples that might help us to better understand current processes as they are formed with the proliferation of AI tools.

Xenakis and Automata

In 2005, Makis Solomos, one of the most prominent scholars of Iannis Xenakis' work, publishes his article "Cellular Automata in Xenakis Music. Theory and Practice[1]" . Iannis Xenakis, who apart from being an accomplished musical composer had been educated as an engineer and worked for more than ten years with Le Corbusier, has employed several times computational models as part of his compositional methods. In fact, it would be reasonable to argue that even those of his compositions that predated the use of computers are following approaches that are in essence algorithmic. In his article however, Solomos is analyzing two of Xenakis' later compositions, namely Horos[2] and Ata[3], where cellular automata are utilized to generate part of the musical score.

Xenakis himself notes in a very brief passage from the Preface to the Pendragon Edition of his 'Formalized Music' book: "It is on the basis of sieves that cellular automata can be useful in harmonic progressions which create new and rich timbric fusions with orchestral instruments"[4]. Solomos' article, as he states in the introduction, has three main aims. The first is to try and locate the reasons behind Xenakis' decision to use cellular automata in the first place. The second is to analyze the implementation of cellular automata in one specific example, namely that of Horos. And finally, the third part is a reflection on the notion of theory, as one that has an important place in the body of Xenakis' work. Concerning the first aim, Solomos is locating two main reasons that might explain why Xenakis makes use of cellular automata. The first one is rather practical. It is their ability to generate complex and rich output that can be used to generate sound qualities, from very basic and simple rules: "They are very simple rules which can create structures on very large surfaces […] I was also attracted by the simplicity of it: it's a repetitious, a dynamic procedure which can create a very rich output". Therefore, Xenakis is using cellular automata as a tool that helps him generate variability and complexity. One can easily identify a reasoning very similar to the one behind the use of AI tools today. AI tools can indeed provide a starting point for any creative process and generate an abundance of ideas in a relatively small amount of time. The second reason identified by Solomos, however, is more interesting and is based on the idea of the automaton: "It is well known that Xenakis took a great interest in automata. […] The idea is related to 'formalization', which has several meanings in Xenakis' thought and practice. One of its meanings is the idea of 'mecha-

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[1]*Makis Solomos, "Cellular Automata in Xenakis' Music. Theory and Practice.," in Definite Proceedings of the International Symposium Iannis Xenakis (International Symposium Iannis Xenakis, Athens, 2005).*

[2]*Iannis Xenakis, Horos, Orchestral Works, Vol. 3, 1986.*

[3]*Iannis Xenakis, Ata, Orchestral Works, Vol. 4, 1987.*

[4]*Iannis Xenakis, Formalized Music: Thought and Mathematics in Composition, 2nd edition (Stuyvesant, NY: Pendragon Pr, 2001), xii.*

[5]*Solomos, "Cellular Automata in Xenakis' Music. Theory and Practice."*

nism'.[5] Particularly, Xenakis employs the term 'mechanism' when he comments on the use of computers: "everything that is rule or repeated constraint is part of the mental mechanism. […] Just as the wheel was once one of the greatest products of human intelligence, a mechanism which allowed one to travel faster and faster with more luggage, so is the computer, which today allows the transformation of man's ideas"[6] . For Xenakis therefore, the automaton is something that operates like a mechanism that carries the ability to transform (ideas, sounds, etc). Solomos continues his analysis by employing Varela's distinction between Von Neumann's and Wiener's approach to computation, and consequently their different understanding of the concept of the automaton. The first is based on the idea of the command, of the black box. The second is based on the idea of autonomy.[7] Solomos concludes this part by stating that in principle, Xenakis' conception of the automaton is closer to the idea of autonomy.

In the second part of the article Solomos analyzes Horos and the ways in which cellular automata were used during its composition. After a thorough analysis of the score and of the role that cellular automata played in its generation, Solomos verifies that Xenakis used cellular automata to generate sieves. However, in the end of the process Xenakis takes great liberties at manipulating the results of the automata, by altering them, making local changes, and smaller or larger manual adjustments to the automatically generated score. Indeed, this is something that characterizes Xenakis' approach to composition at large: "All the Xenakis' specialists, when working in the field of the concrete analysis of works using formal procedures, have noted that the composer takes liberties with formal models, and introduces 'licenses', 'gaps'. In other terms, his use of formalization is mediated through manual interventions. These interventions […] affect not only the musical implementation of the formal system, but also its construction".[8] Xenakis' approach to the usage of models like cellular automata in composition, is always mediated by his manual interventions. That holds true for all the different procedures that he employed throughout his career: whether stochastic processes or game theory, group theory or sieve theory, Xenakis was always having the last (manual) word. He intervenes and adjusts or transforms the results, usually employing his musical criteria, in such a way that he undermines the integrity of the generative processes. The adjustments he makes to the output generated by the cellular automaton, not only differentiates and alters it, but in effect goes against the internal rules of the system he uses. In other words, it would appear that the autonomy of the system is compromised.

Solomos describes Xenakis' common practice to deliberately alter the results of the formal models that he employs as bricolage. Bricolage is a term that, as analyzed by Claude Levi-Straus,[9] refers to an intermediate condition between what he calls the mythical and the rational. The 'space' that exists between the magical and the scientific. In fact, Levi-Straus claims that art is always an operation through bricolage. In the case of Xenakis, bricolage is a technique that combines the output of the formal model that he employs, in the case of Horos the cellular automata, (the rational or scientific) with his intuition or musical intention (the mythical or magical). Or, to be more precise, it is not so much a combination, as it is a transformation, or a modulation, of the output of the formal model through the personal and of course highly subjective filters of the composer. Solomos is based on Xenakis' use of bricolage to justify his first conclusion: The composer's process cannot fulfill the concept of autonomy because of the manual interventions that he performs: "Xenakis' manual interventions are very important; sometimes they destroy the nature of cellular automata. And, of course, they are far away from the idea of something that works alone, of an automaton, from which an autonomous meaning emerges".[10]

The Importance of 'Comprehension'
One would be tempted to draw quick conclusions by observing the obvious parallels between Xenakis' use of cellular automata and bricolage, and the ways in which we are employing AI tools today as part of creative processes. Indeed, what for Solomos is Xenakis' compromise of the idea of autonomy, namely bricolage, could be seen as a creative way to deal with AI tools while at the same time keeping control over them and imposing the personal 'vision' of the creator. Various tools that employ artificial intelligence can become part of that process of bricolage; in other words, they can be subordinated to the will of the artist/designer/creator. Let us, however, consider a different approach before we draw any such conclusions.

In 1962, Hannah Arendt wrote an article that was taking part in the at the time current discussion concerning the 'conquest of space'; the ability of man to travel beyond the limits of the earth. The article, which was published a year later as part of the collection of essays under the title "Between past and future",[11] is a much more general reflection upon the concepts of science and technology. In it, Arendt explores the implications of space exploration on human society and individual identity. She argues that while the conquest of space represents a remarkable achievement of human intellect and technology, it also poses significant challenges to our understanding of human existence, as well as to our understanding of non-human entities. She argues that modern science has changed the meaning of notions like life, man, science, or knowledge to "such an extent that they no longer make sense".[12] Modern science for Arendt "has changed and reconstructed the world we live

[6]*Xenakis, Formalized Music, 132.*
[7]*For more details on the two opposing directions that defined the development of computation at its early stages and which are represented by John Von Neumann and Nobert Wiener see Gourdoukis, D. "Variability: Architecture and its Fightagainst Chaos and Opinion" in ArchiDOCT 15, vol 8(1), July 2020.*
[8]*Solomos, "Cellular Automata in Xenakis' Music. Theory and Practice.".*
[9]*Lévi-Strauss, The Savage Mind.*
[10]*Solomos, "Cellular Automata in Xenakis' Music. Theory and Practice."*
[11]*Arendt, Hannah. Between Past and Future: Six Exercises in Political Thought. New York: Penguin Classics, 2006.*
[12]*Ibid. p.268*

in so radically that it could be argued that the layman and the humanist, still trusting their common sense and communicating in everyday language, are out of touch with reality"[13]. In other words, common people (ie non-scientists) can understand only appearances; they can comprehend the results of scientific processes and not the principles behind them. That idea of comprehension is very important for Arendt. She goes on to explain that machines that supplant human brain power are no different than those that support labor power and she supports that claim by quoting a letter from John Gilmore: "During the last several years we have in fact succeeded in writing computer programs that enable these machines to exhibit behavior that anyone not familiar with the makeup of the programs would unhesitatingly describe as intelligent, even highly intelligent. Alex Bernstein, for example, has devised a program that enables a machine to play spectacular good checkers. In particular, it can play better checkers than Bernstein. This is an impressive achievement; but it is Bernstein's and not the machine's."[14] In other words, according to Gilmore (and Arendt) the intelligence exhibited by machines that can mimic the function of the human brain, even when doing so much more efficiently than humans, is in fact intelligence related and attributed to the one that created the machine and not to the machine itself. For Arendt that stems from being able to understand how the machine works: We know the rules behind checkers, we know that to play checkers we need to follow those rules and anticipate future actions that derive from them, and we fully understand that the computer is doing the same, albeit faster and more efficiently.

For Arendt however, there is a break in this line of thinking when 'understanding' is absent: "There are, however, scientists who state that computers can do "what a human brain cannot comprehend," and this is an altogether different and alarming proposition; for comprehension is actually a function of the mind and never the automatic result of brain power. If it should be true and not simply a case of a scientist's self-misunderstanding-that we are surrounded by machines whose doings we cannot comprehend although we have devised and constructed them, it would mean that the theoretical perplexities of the natural sciences on the highest level have invaded our everyday world."[15] The problem arising from the above observation "is that man can do, and successfully do, what he cannot comprehend and cannot express in everyday human language."[16] The lack of the ability to comprehend and express through human language (which for Arendt is the same thing since she believes that we can only comprehend what we can express through language) is what takes automated computational tools to a different level that moves beyond what is essentially human.

In Xenakis' example and his use of cellular automata, comprehension is still in place. He fully understands the rules of the cellular automaton. Xenakis programed his computer to follow those rules, and even when the calculations are too complex to carry out without a computer, he can still understand and follow them. However, is that true for generative AI tools? One could argue that the users of such tools cannot really comprehend everything that they do. That is certainly true when one

uses tools that do not give access to the code that supports them. Most tools that we employ today fall in this category. However, AI might be moving beyond our comprehension even when we have access to the code or for that matter even when we are using tools that we trained or created ourselves. AI tools are operating through references; an almost infinite number of references that are then used to generate something new. However, while using references is a very old and common creative process, in the case of AI tools we can't trace those references back, and we can't see how they are combined and altered. In other words, we cannot fully understand how the results are produced, even if we know the general principle or the rules that the AI model follows in order to learn.

Xenakis Revisited

Going back to Solomos' article on the work of Xenakis with cellular automata, it is interesting to see his conclusion. While he determines that Xenakis' approach does not follow the model of autonomy, because of bricolage as we explained above, he also claims that his approach does not follow the model of 'command' either. He uses the concept of 'theory' in Xenakis' approach to justify the later observation: "if cellular automata are comprehended as 'theory' [...] as independent, in the musical level, of a practice, then they are working as black boxes: they are only used to produce interesting sonorities, and it is why there are a lot of manual interventions. But if they are comprehended as theoria, something remains from the model of autonomy to which they are related by their nature."[17] Solomos is using the word 'theoria' here to signify the etymological meaning of the word 'theory', through its Greek origin. Theoria in this sense can be 'translated' as point of view.[18] For Solomos, Xenakis' theories are never theories in the 'traditional' sense of the word: that of "a system of rules, procedures, and assumptions used to produce a result"[19] which are coherent and are operating autonomously within themselves. Instead, theory for Xenakis is theoria, a point of view, and as such is always related to a practice. It is not an attempt to create a generalized theory that can achieve a universal status. It is instead a specific point of view in relation to the specific case that is at hand. In other words, Xenakis' theories are processes created and employed in specific applications, and they work only in the context of those applications. In the case of Horos for example, the cellular automaton is a point of view towards the

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[13]*Ibid.*
[14]*Ibid.*
[15]*Ibid.*
[16]*Ibid.*
[17]*Solomos, "Cellular Automata in Xenakis' Music. Theory and Practice."*
[18]*"From Middle French théorie, from Late Latin theōria, from Ancient Greek θεωρία (theōría, "contemplation, speculation, a looking at, things looked at"), from θεωρέω (theōréō, "I look at, view, consider, examine"), from θεωρός (theōrós, "spectator"), from θέα (théa, "a view") + ὁράω (horáō, "I see,look")." "Theory - Wiktionary," accessed March 7, 2016, https://en.wiktionary.org/wiki/theory.*
[19]*"Theory," Collins English Dictionary – Complete and Unabridged, 1994, 1998, 2000, 2003 1991, http://www.thefreedictionary.com/theory.*

production of sieves. But then, if we adopt this attitude towards the concept of theory, we cannot dismiss Xenakis' approach as unrelated to the model of autonomy. The productive system in Xenakis' compositional methods does not consist solely of the formal model used, in the case of Horos the cellular automaton, but instead includes the composer as part of the system. The cellular automaton becomes an autonomous generative system only when understood as a point of view, through Xenakis' eyes. The manual interventions performed by Xenakis allow the closed, self-referential nature of the computational model to open up and become part of a larger assembly that includes the composer. Equally, if we understand AI supported processes as 'theorias', as points of view, we might be able to understand them. While the users still don't have access to the references that the AI models used for the specific result that they produce each time, they make them part of a larger system that includes the users and therefore becomes able to produce subjectivity.

Aesthetics and the Making-sense of the World
Comprehension therefore might be a concept that will help designers navigate the creative landscape formed by AI tools. Which will in turn render the concept of aesthetics equally important: "Aesthetics thus concerns the experience of the world. It involves sensing – the capacity to register or to be affected, and sense-making – the capacity for such sensing to become knowledge of some kind"[20] . It is the latter – sense-making – that is crucial, and currently lacking, when we deal with AI powered tools. When we find ways to use those tools in order to transform the sensations that they produce into processes that produce knowledge and subjectivity, we might be able to re-establish our own creative processes and generate novice and liberating points of view.

Reference List

Arendt, H. (2006). *Between Past and Future: Six Exercises in Political Thought*. New York: Penguin Classics.

Fuller, M., Weizman, E. (2021). *Investigative Aesthetics: Conflicts and Commons in the Politics of Truth*. London: Verso.

Gourdoukis, D. (2020) Variability: Architecture and its Fight against Chaos and Opinion. *ArchiDOCT 15, vol 8*(1).

Solomos, M. (2005). Cellular automata in Xenakis's music. Theory and Practice. In *International Symposium Iannis Xenakis* (Athens, May 2005) (pp. 11-p).

Xenakis, I. (1992). *Formalized music: thought and mathematics in composition (No. 6)*. Pendragon Press.

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http://www.thefreedictionary.com/theory.
[20]*Fuller, Matthew, and Eyal Weizman Investigative Aesthetics: Conflicts and Commons in the Politics of Truth. London: Verso, 2021*