Computer, Formalisms, Intuition and Metaphors. A Xenakian and Post-Xenakian Approach

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ABSTRACT

Xenakis played an outstanding role as a pioneer in the development of algorithmic and computer music. His theoretical approaches and interviews often link those aspects of his career with philosophical and cognitive topics: these clues reveal an attitude far away from a blind use of technology. The aim of this paper is to discuss how intuition is fruitful to set the necessary and sufficient conditions in order to hold up a robust modeling of certain compositional practices aided with technological tools. We will support our arguments with the help of logics, epistemology of sciences, contemporary theories of metaphor –rather from a cognitive perspective than a hermeneutic one– and pragmatic philosophy. Some examples borrowed from Xenakis will be summoned from a critical point of view for this purpose, specially his personal exploitation –both electronic and instrumental– of Brownian motion. The paper will also finish with a genetic criticism of a post-xenakian approach: we've assisted Alberto Posadas (Valladolid, 1967) with an eye to help him out to transpose the Bezier curves from computer-aided design into musical patterns.

1. INTRODUCTION: INTUITION IN XENAKIS'S PRACTICES

Xenakis contributions to algorithmic and computer music are overwhelming in theoretical, technological and artistic terms. It would take too much place to enumerate all of them, same thing for the countless times he was roughly criticized due to it. One of the main arguments pleaded in the quarrel has been an alleged will to transfer a mathematical coherence into musical consistency. Nevertheless, a supposed context-insensitive 'isomorphism' between music and science seems to be far away from the composer's thoughts.

On the one hand, Xenakis has often invoked a possible parallelism between compositional practices and scientific activities. His definition of an "*artiste-concepteur*" [1] –one who would need a widespread training (or at least curiosity) in sciences and technology– sharply takes this road. He has even asserted that "artists are experimentalist scientists" [2]. On the other hand, he refined in the same interview that the parallelism is not at all trivial. Xenakis has in fact recognized an essential role of intuition in his theoretical and compositional practices, linked to mathematics and technology. This idea has been largely expressed in several ways throughout his writings: "The ear, the eye, and the brain unravel sometimes inextricable situations with what is called intuition, taste and intelligence", "The sonic result [form an stochastic process] thus obtained is not guaranteed a priori by calculation. Intuition and experience must always play their part in guiding, deciding and testing", "When scientific and mathematical thought serve music, or any human creative activity, it should amalgamate dialectically with intuition", or even "To make music means to express human intelligence by sonic means. This is intelligence in its broadest sense, which includes not only the peregrinations of pure logic but also the 'logic' of emotions and of intuition" [3].

From the perspective of computer epistemology, Xenakis's practical use of technologies is not free or independent from preceding questionings. The Greek composer has also criticized a blind use of informatics, and claimed for an intuitive orientation of computer tools with the aim of avoiding "haphazardly a combination of formulae, of systems" [4]. In fact, he considered the computer programs as "the phantasmal appearance of the real thing, the incarnation" [5]. These quotations bring to light the tension between a formal abstraction and a tangible practice. Moreover, the embodied mind focuses on a material purpose –the 'incarnation'– in order to produce artwork.

2. IDEAL VS MATERIAL: THE INTUITIVE BRIDGE

2.1 The Gaps during the Creative Process

It is often easier to measure the divergence between a formal theory and a musical result in Xenakis's instrumental music than in electronic one. For that purpose, professor Solomos has coined the term '*écart*' –'gap'– to generically assess the distance between Xenakis auto-analysis and the score data [6]. He has spotted for example a great deviation – bigger than 20%– in *Nomos Alpha* (for violoncello, 1966) pitches while implementing his sieves.

Nevertheless, the smattering of ‘gap’ as a musicological tool could spread out, touching other phases or stages of a compositional act beyond its mere materializations. In addition to the data contrast of divergence –what Solomos detected in Xenakis’s piece, a category that could be considered in isolated terms as ‘*singular* gaps’–, deviations may adopt other forms. On the one hand, the way a composer understands and conceives a formal or a technical aspect of a particular science or technology does not always fit with the consensual yardsticks the scientific community accepts to draw upon it. This situation can be analogically related to the difference between ‘concepts’ and ‘conceptions’ Hilary Putnam made explicit to criticize Thomas Kuhn epistemology [7]. We will define the ‘*conceptual* gaps’ as the deviations of an artist’s conception from a concurred scientific concept. On the other hand, sometimes a compositionally formalized strategy –for example a computer model– does not cover all creative needs, decisions and choices during the creative process. In that case, the composer often drops it out in favor of other –maybe arbitrary– artistic criteria or makes them all to cohabit. We will define these last cases as ‘*functional* gaps’.

Both new sorts of gaps can be reported from Xenakis’s compositional practices. Conceptual ones are summarized in an interview assertion: “I don’t grasp Mathematics in the same way mathematicians do” [8]. Moreover, some of his most formalized pieces also include several non-formalized passages that could be considered as functional gaps. It is the case for example of his mixed work *Analogique A et B* (for nine strings and tape, 1958-59), where Agostino Di Scipio has discriminated both compositional paths. The balance between them has been described by the Italian composer in two statements: “intuitive elements are only possible after enormous efforts in formalization have been made” and “the enormous efforts in formalization are only possible because the composer is confident that intuition will complete the job whenerever [sic] formalization will reveal insufficient” [9].

2.2 The Role of Intuition: Necessary and Sufficient Conditions

Di Scipio’s statements about Xenakis’s work hold up a clear dialectic dualism between intuition and formalization. Nonetheless, both poles are even more interdependent than asserted. A formal abstraction is indeed led by intuition: even in strictly scientific activities a former heuristic role of intuition cannot be overlooked or denied. Coming back to music, it does not only touch therefore the area of functional gaps but the conceptions that guide compositional formalisms.

From this point of view, we are going to rethink Di Scipio‘s dualism. Let us consider before the activities summoned to formalize or to compute music analogous to Model Theory, i.e. “the relation between the formulas of a formal language and their interpretations or models” [10]. This analogy needs to be deemed from a materialistic epistemology of Model Theory –like Alain Badiou’s [11]– for an efficient transfer into music. Furthermore, it is justified in a computational framework through the concept of ‘metamodel’. In such a context, we may formulate a new dual scope –a practical definition– of intuition, as the cognitive guarantor of a robust modeling construction leading algorithmic and computer music. On the one hand, intuition preserves the sufficient conditions –the formal ones– during modeling processes, and it even helps to fill in the gaps derived from the conception and the use of the model. On the other hand, it sets up the necessary conditions –the metaphorical ones– that cement the cognitive mainstays of the model. In short, intuition will be considered as the bridge to distend the conflict between formal an informal ideas and practices during composition. We will discuss those necessary and sufficient conditions throughout the next paragraphs.

3. FORMAL AND METAPHORICAL FOUNDATIONS

3.1 Music and Formal Languages: an Intuitive Intersemiosis

Algorithmic and computer music invoke the presence of formal languages in order to build up their compositional strategies. The existence of such a support entails a prickly issue: music is not actually a linguistic entity, albeit its syntactical categorization of patterns and its semantic-evocative puissance are both true in cognitive terms [12]. More specifically, formal languages own an axiomatic corpus and several sentence transformation rules that music does not have, even accepting the redoubtable conceptualizing effort some music theory authors made to build a multi-stratified chain of axioms in order to describe music [13].

The transfer from formalisms towards artistic practices is therefore not trivial in epistemological terms. It seems to need an intersemiotic translation –replacing ‘formal’ instead of ‘verbal’ in Roman Jakobson’s definition as “an interpretation of verbal signs by the means of signs of nonverbal sign systems” [14]– to lead the process. Thus, the passage between formalisms and music could be considered partially analogous to metalinguistic stratifications in Model Theory. Anyway, and calling back again Putnam’s pragmatics, this sort of lectures requires a wider “standards of logical acceptability” scope, where intuition could nourish and preserve its “adequacy and perspicuousness [sic]” [7].

A crucial role of intuition at this point is the arrangement of a logical openness. It is obvious that programming in computer music or the development of calculations in algorithmic music must inherit an important logical framework from formal languages. In return, the material application of these tools or environments leading the production of artwork does not necessarily reclaim the pillars of such a severe or polarized logic. It does not mean however that further decisions over formalized stages as well as the appearance of functional or singular gaps– are allogical choices. They may be led by wider –

more intuitive– protocols, that could be better described with the support of inductive and abductive reasoning, alternative modal logics or even fuzzy logics.

3.2 Mental Categorizations: Computer Models and Metaphors

Formalizing music is not an *ex nihilo* activity. It is supported by mental categorizations of music that allow abstractions. Many of them could seem to be 'natural' due to habit, but they are intimately related to cultural conventions and to embodied cognition. A trivial example can be evoked right off: a musical or a sound representation in the real plane that confronts time against pitches or frequencies looks rather obvious for a computer composer, engineer or musicologist. In fact, it is deeply rooted within the evolution of Western music notation. Nevertheless, it cannot be regarded as a universal in cognitive terms at all. Ethnomusicology has already shown how mental categories of music or social activities incorporating sound practices strongly differ among cultures.

Composers can even conceive more complex and personal categorizations with the purpose of developing their own creative practices. All them are often carried through intuition, and metaphorical thinking appears as one of the best hypothesis to argue for it. We will rather privilege the term 'metaphor' than 'analogy' –profiting its etymological connection with the notion of 'metamodel'– but emphasizing the cognitive feedback between them [15]: metaphors make proliferate analogies, and vice versa. Metaphor must be contemplated in this context not from a hermeneutic angle, but from a cognitive one. Linguistics researchers in cognition have postulated several contemporary theories about metaphor over the last decades: it is the case of Conceptual Metaphor Theory (CMT) [16] or Conceptual Blending (CB) [17]. In short, they propose that metaphor is not just a single and rhetorical identification between terms but a deep and intensive comparative between mental structures that we activate unconsciously on a daily basis. These linguistic theories may also be transposed into music theory, as professor Lawrence Zbikowski has fruitfully done [18].

Computer music environments operate as optimal places to develop and to exploit original and rewarding music metaphors inspired by scientific transfers. Even science itself often shadows a metaphorical cognitive framework from a heuristic perspective, a sooner step anticipating its formal developments [19]. In fact, "computer science metaphors […] seem to be paradigm examples of the constructivist approach to the relationship of language and our knowledge of reality. They expand the ontological framework of our language for talking about computational processes" [20]. Just a mere replacement of 'language' by the term 'music' in the last quotation can illustrate the metaphor scope over computer music in intuitive terms. Specifically, it impresses its encompassed potential in Human-Computer Interaction (HCI) and helps to preserve structures [21], as well as it is fructiferous for pedagogical purposes [22].

4. A XENAKIS'S ILLUSTRATION: HIS USE OF BROWNIAN MOTION

Xenakis did not use the expression 'metaphor' to describe any of his intuitive arguments. He rather liked the term 'parable' –that etymologically becomes more related to analogy– to describe them. He has thus enumerated three essential parables linked to his compositional practices: the space parable where *glissandi* become the elementary straights to generate sonic surfaces, the numbers parable as the impasse between auditory and formal facts, and the gas parable that compares sound masses with gaseous cinematic [23]. His work *Pithoprakta* (for orchestra, 1956) arises as the best synthetic achievement of them.

The last two parables are crucial to catch his interest on Brownian motion (Bm). He clearly described in an article that a waveform generated by it as "the pressure variations produced by a particle capriciously moving around equilibrium positions along the pressure ordinate in a non-deterministic way" [3]. He added later in the text two methods to compute it, as he did at his CMAM and at Indiana University. On the one hand, the erratic trajectory of the evoked particle leads to the classic definition of Bm about suspended specks in a fluid. The parallel between fluid and gaseous dynamics is evident, convoking thus the gas parable. On the other hand, the numbers parable is activated by the use of Wiener-Lévy processes in order to formalize the transfer. Both paths, the conceptual metaphor –gas– and its formal interpretations –numbers–, get intertwined in order to develop the quoted computer sound synthesis method. His first work containing these sounds is *La Légende d'Eer* (electronic music for his *Diatope*, 1977).

The algorithmic artifice works on a microscopic level, but Xenakis also proposed to broaden his reasoning onto a macroscopic one. As Bm is a stochastic process, obtained computer sounds could be injected into macrostructure tools like his ST program. This approach denotes a unitary will, and it could also be *a posteriori* tied together to a fractal metaphor of music[1]. Anyway, this unitary dream –a supposed musical wholeness imitating the stochastic self-similarity of Bm, conceived by cognitive analogy [24]– is ideologically overcharged and denotes an evident conceptual gap.

But the question of unity around Brownian motion in Xenakis' compositional practices also touches another aspects of his catalogue like instrumental ones. It is the case for example of *Mikka* (for violin, 1971), the first piece where Xenakis applied this method for an acoustic instrument. As Solomos says, "doing this transfer is very easy. Taking the graphs of probabilistic sound curves, the only thing to do is to change their coordinates: the horizontal axis will be allocated to the time of instrumental

[1]We have to underscore that a fractal metaphor of music is exogenous to Xenakis's arguments: no explicit reference to this geometry can be found in his theoretical texts. We propose anyway this extemporaneous metaphor because Bm pertains to fractal objects. Moreover, the term 'fractal' was coined by Benoit Mandelbrot, one of the best disciples of Paul Lévy. This latter has been one of the most influential mathematician in Xenakis's career. Although the concept of 'self-similarity' was not developed yet, Lévy was conscious of the strong relationships between micro and macrostructure in Bm.

music and the vertical axis will indicate the pitches" [25]. This sentence automatically leads to a precedent representation we have evoked when we were discussing mental categorizations. In fact, this conception is akin to Xenakis's graphic *glissandi* experiences he began to develop in the 50's. But this gesture is however problematic in metaphorical terms. It seems that Xenakis tried to represent the Bm analytical continuity with them, but a Bm trail is not a differentiable curve. A *glissando* stands however –in iconic terms– for a differentiable curve, even the sinuous and wandering ones we find in *Mikka.* In short, Xenakis's space parable provides a practical solution to cover an idiomatic shortage the formal Bm cannot resolve. *Glissandi* settling shall be considered thereupon as a conceptual gap during the transfer.

5. A POST-XENAKIAN CASE: POSADAS ON BEZIER'S CURVES

5.1 Alberto Posadas' Models

Xenakis had no disciples in a strict sense. In return, his immense legacy has touched many composers, and they are sometimes incorporated in xenakian studies. An Iberian branch of that influence can be pointed out: Francisco Guerrero (1951-1997) has often been considered as the 'Spanish Xenakis' due to his interests in algorithmic and computer music. Some of his last pupils, like Carlos Satué (1958) or Alberto Posadas (1967), have somehow continued this path he opened up.

Posadas's theoretical and aesthetical foundations are widely supported by three modeling branches. First, scientific models have often stimulated his imagination to try to transpose in music some regulatory systems of Nature or several algorithmic methods to construct mathematical objects. Fractal geometry has been his most exploited source. The second modeling path is introduced by visual arts in order to transpose spatial elements into music parameters. In this regard and so far, painting and ancient architecture have been the two most attractive disciplines to him [26]. Finally, the last family of models is supported by the acoustical scrutiny of musical instruments and their extended techniques.

5.2 The Genesis of `Beziers.m`

In the last years, Posadas has paid attention to Bézier curves, a smooth geometric model –a case of B-spline [27]– often harnessed in computer-aided design. It may give the impression of a contrast in his career if we compare their geometry with the chaotic fractals. Nevertheless, even B-splines can be modeled with L-systems [28], one of the most beloved and exploited fractal by Posadas.

His first attempt to transpose Bézier curves into music appears first in *Elogio de la sombra* (for string quartet, 2012). 'Sombra' means 'shadow' in Spanish, and a vast crucible of elements underlays the metaphor leading his compositional practices. The two most important ones stand out in the opening of the piece (see Figure 1). On the one hand, it comes up with the fictive recreation of an 'acoustic shadow'. The idea is simple: he reproduces a previous passage drastically attenuating dynamics and employing extended techniques with the purpose of evoking a sort of distorted sonic halo. It is quite explicit in the quoted passage: both violins repeat at bar 2 the same melodic pattern from the end of bar 1, but in *mezzopiano*, with *flautando* bowing and harmonic pressure to obtain extremely high overtones. On the other hand, the link with Bézier curves is definitely revealed. Projective shadows of the same object with several foci acting jointly create topologically related shapes, as rational Bézier curves with common nodes deform the trajectory of a standard one via homotopy. Thus, the composer metaphorically interprets those transformations as tiny polyphonic deviations: the melodic profile of both violins conjures up the analogy.

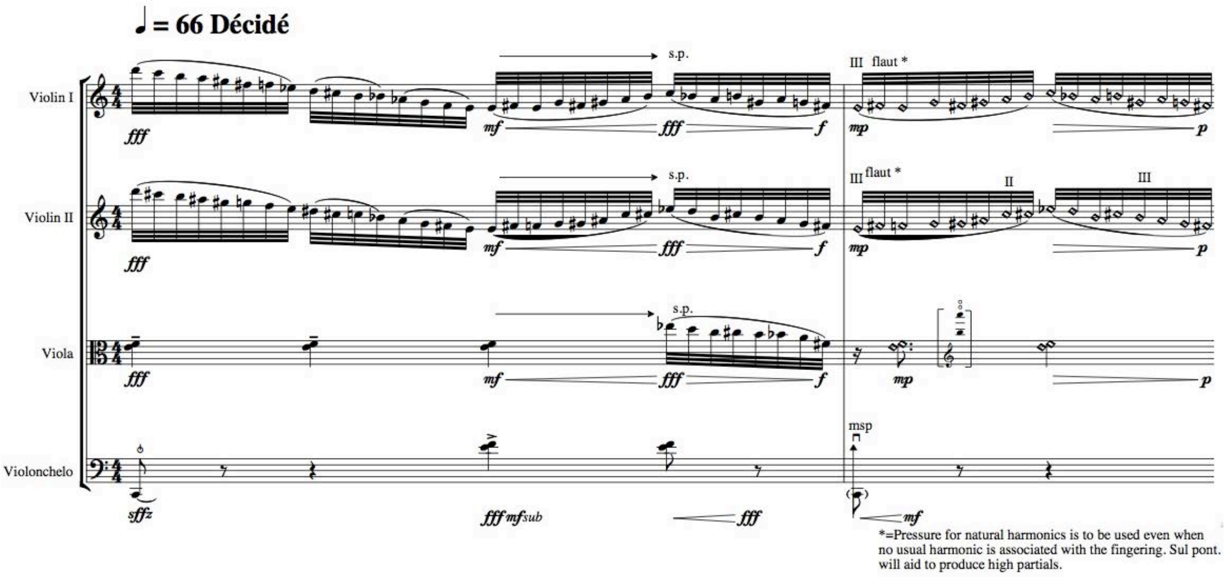

Figure 1. *Elogio de la sombra* (bars 1-2 [partially]).

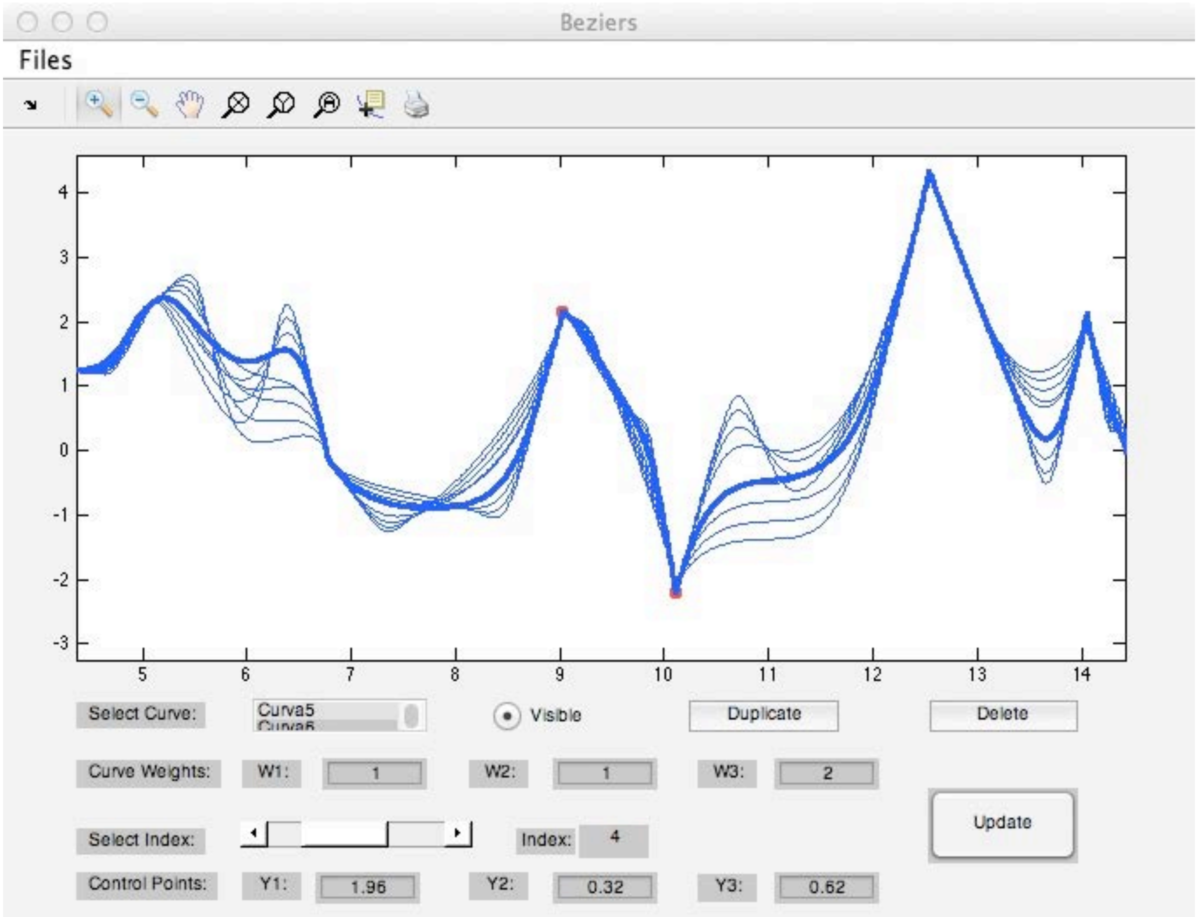

Figure 2. Capture of the tool 'Beziers' developed with `Matlab`.

In spite of this metaphor, the transposition of Bézier curves into music has been merely performed in iconic terms –with no previous formalizations– in the string quartet. For subsequent works, we have assisted Posadas with an eye to make the computerized transfer, developing `Beziers.m` tool. The program allows the composer to introduce several fixed and control points in order to enchain connected sections of Bézier splines. They can later on be transformed by moving the control points or by changing their control weights –non-negative values– (see Figure 2), which creates their topological variations. It contains a second extra utilization: the actual tool can even exploit those curves to interpolate Bm –Posadas composes with them as well– as they were its smoothers. Obtained data with `Beziers.m` are subsequently exported and interpreted as music patterns like melodic profiles, pitch reservoirs, related aggregates or time and rhythmic structures.

6. CONCLUSIONS

The two examples we have given are somewhat dual from the point of view of compositional practices. On the one hand, Xenakis extrapolated a computer sound synthesis technique into instrumental music supported by a geometric categorization and his spatial parable –metaphor – of *glissandi*. On the other hand, Posadas formalized his shadow metaphor with a computer-aided music tool in order to exploit a large set of music patterns, and not only in an iconic way. That shows that formal and metaphorical relationships during composition are not univocally oriented and the context determines the balance between them. Moreover, it highlights than instrumental and computer composition practices build closer frameworks than usually claimed: transfers between them can take both paths, and feedback leads to original and emergent creative acts.

Cognitive metaphors and formalisms are not independent stages of algorithmic and computer music. The leading role of intuition should not be undervalued –from a musicological perspective– in these cases. It allows a proliferation of mental categorizations and steers towards a logical openness while formalizing music. Thereby, it sets the necessary and sufficient conditions for a robust computer or algorithmic modeling of music. Moreover, it may help to understand the reasons of several conceptual and functional gaps of formalized processes.

For a deeper understanding of this process, we should claim for more intense research about computer music epistemology from a cognitive point of view. Metaphor theories have turned out to be quite fruitful in more traditional analysis of music. To ban this perspective in computer music musicology would only be a prejudice. An adaptation of epistemocritic methodologies –the study of literary and scientific mutual borrowings– into those musicological studies could even be a useful grasp.

Acknowledgments

I am grateful to professor Makis Solomos at Paris 8 University for comments and encouragement during the redaction this paper**.**

I am also grateful to Alberto Posadas for allowing me to reproduce an excerpt of his last string quartet, and to PhD Eva Besada Portas for helping out with the user interface of `Beziers.m`.

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