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## **FLOU: A CO-COMPOSITIONAL ATTEMPT AT ALGORITHMIC EMBODIMENT**

**Abstract:** My composition, *Flou* for solo violin, is an attempt at co-composition between the composer and the performer at embodying otherwise unidiomatic machine-learning generated materials. The piece touches on a broader compositional problem where historically, when algorithms were used as a means in itself, composers were often faced with tensions between the algorithm, the composer, and the performer. To contextualize further, Cage, Xenakis, and Boulez each came up with their own algorithmic processes and dealt with these tensions differently. Upon scrutinizing these composers' methods, I observe that these tensions are usually resolved by enabling agency for either side of the humans involved. As in, Boulez deviates from his algorithm to follow his compositional instincts, Cage creates indeterminate scores for performers to interpret, and Xenakis adds 'human touches' to his 'incomplete' algorithm. Considering these kinds of tensions, *Flou* uses an open score with only algorithmic pitch notated, which I ask to be played using an octave-lower scordatura. The open score affords the performer's freedom to react to the instability of the scordatura in non-pitch ways, and it is this tantalizing physical attempt at trying to play the algorithmic pitch that foregrounds the performer's bodily presence in the performance.

**Keywords:** algorithmic music, musical embodiment, phenomenology, acoustic composition, contemporary music.

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## ***Flou*: A Co-Compositional Attempt at Algorithmic Embodiment**

This paper discusses exclusively algorithmic music within the western contemporary classical tradition that is written for acoustic instruments. In order to articulate the research question more clearly, it would be useful to begin by addressing what I mean by algorithmic music, and from there, set up the scope of my research. Borrowing from Karlheinz Essl's definition, the term 'algorithm' in itself means a "predetermined set of instructions for solving a specific problem in a limited number of steps" (Essl 2007, 109). This definition breaks down the conception of an algorithm into three necessary components: 1) a specific problem to be solved; 2) a predetermined set of instructions to follow, and; 3) a finite number of possible outcomes as a result. Following this definition, Schoenberg's serialism, which admittedly uses a formalized procedure, is not technically algorithmic. To be sure, there are fixed sets of instructions in how dodecaphonic materials i.e., the tone row and its transformations are created. There are a finite number of ways in which the 12 notes can be arranged ( $12! = 479,001,600$  possible combinations) and there are limited steps in how each row can be transformed. However, although the series serves as a basic organizing principle for pitch and structure, Schoenberg is very much in intuitive control of how notes are used, while still following the predetermined order. For example, his *Variations for Orchestra* (1926–28) uses pitch quite strictly in the order of his tone row and its retrograde, inversion, and retrograde inversion. But here, Schoenberg has expressive freedom to manipulate parameters around pitch material in terms of orchestral timbre, rhythm, and texture, all of which goes hand-in-hand to create musical expression from dodecaphonic materials (Schoenberg 1950, 118–31). While the serial material in itself is algorithmically generated (in the sense that there are fixed definitions of what a tone row is and that there are limited ways of arranging one), Schoenberg's intuitive command in how he crafts music out of tone rows separates his music from the type of algorithmic music described in Essl's definition. With that said, in a roundabout manner, Schoenberg is still considered a putative pioneer of contemporary algorithmic music in the way his music led to divided reactions among the next generation of composers, namely Boulez, Cage, and Xenakis, all of whom opined differently about serialism and arrived at all sorts of algorithmic experiments for their own reasons. This paper will briefly survey the above composers' reasons for engaging in algorithmic composition in the context of the serial dispute and shed light on the underlying tensions in how they used their algorithms. Specifically, the emphasis will be placed on what they initially hoped to use algorithms for, and how/why they resorted to deviate from them. This will be followed by a final section to explain how these tensions and their deviations inform my recent composition, titled *Flou*.

### **Pierre Boulez: from *Structure Ia* to *Le Marteau sans Maître***

In ‘Schoenberg is Dead’, Boulez openly criticized Schoenberg’s serialism for its lack of critical awareness in its aesthetical implications. He wrote: “Under Schoenberg’s pen, in fact, there abounded – not without producing irritation – the clichés of redoubtably stereotyped writing representing, there too, the most ostentatious and obsolete romanticism” (Boulez 1968, 273). To be sure, at the time of writing, Boulez was not against the idea of dodecaphony in itself. It was specifically Schoenberg’s connection with the ‘old ways’ to use dodecaphony expressively that Boulez was against. For Boulez, serialism paved way for a path that helped him escape pre-established forms and styles from the historical tradition.

Furthermore, though Schoenberg’s serial technique was never intended to be used as an automatic system, Boulez found Schoenberg’s abstracted treatment of pitch to be lacking and wished for it to generate music more comprehensively (Boulez 1968, 275). As a result, Boulez began exploring serial technique that is integrally expanded onto other parameters, such as duration, dynamics, and timbre, along with pitch (ibid, 212). For example, in *Structure Ia* (1951), Boulez wanted to “find out how far automatism in musical relationships would go” and hoped that it would be able “to bring everything into question again”, to “make a clean sweep of one’s heritage” (Boulez 1976, 56–57). *Structure Ia* is a highly automatic algorithmic piece which Ligeti described as a “textbook example” of multiple serialism in his analysis of the piece (Ligeti 1961, 36).

Curiously, Boulez’s enthusiasm in totally automatic systems only lasted briefly, and never quite became Boulez’s main working method moving forward (Idon 2013, 119). Shortly after completing the entire set of *Structures I*, Boulez started adopting a more relaxed, compositionally intuitive approach towards algorithmic material. For example, in *Le Marteau sans Maître* (1955), rather than continuing to follow strict, automated serialization of material like in *Structure Ia*, Boulez embraces a more flexible and relaxed use of serial structures and returns to a more expressive language (Jameux 1991, 78). To be sure, Boulez’s revisit to expression in serialism is still considerably different from Schoenberg’s expressive approach. In fact, in *Le Marteau*, the creation of the work is not any less serial than *Structure Ia*. On writing *Le Marteau*, Boulez said:

There is in fact a very clear and very strict element of control, but starting from this strict control and the work’s overall discipline there is also room for what I call local indiscipline: at the overall level there is discipline and control, at the local level there is an element of indiscipline – a freedom to choose, to decide, and to reject (Boulez 1976, 66).

What Boulez means by “local indiscipline” is that he reserves his rights to make free choices to manipulate the serial organization expressively. In *Le Marteau*, for instance, the predetermined structure alternates between movements that are strictly serial structures and movements with greater compositional freedom (Koblyakov 1993, 1–3). Movements that are meant to be strictly serial use predetermined materials rigidly in a similar fashion as *Structure Ia*. This is contrasted by movements that are permitted by the higher order row to be free, where serial structures are interpreted intuitively and stretched expressively by Boulez. Boulez’s apparent relaxation from automatism seems to be driven by a desire to intervene with the system. As he explained:

I have the sort of temperament that tries to invent rules so as to have the pleasure of destroying them later: it is the dialectical evolution between freedom of invention and the need for discipline... The difficulty is to find a point of balance, or at least a constant interchange, between these extremes (Boulez 1976, 64).

When Boulez speaks of finding this balance between “freedom of invention” and “disciple in invention”, he seems to be implying that there is a certain tension between “what the algorithm wants to write”, and “what his intuition wants to write”. This conflict is resolved, in *Le Marteau*, by giving himself the compositional agency to ‘destroy’ the system by deviating significantly from the original outcome.

### **John Cage: *Music of Changes to Concert for Piano and Orchestra***

After being acquainted with Boulez in 1949, Cage and Boulez stayed friends and continued to exchange ideas on each other’s music (Nattiez 1993, 4–17). Coincidentally, around the same time Boulez finished working on *Structure Ia*, Cage also completed his first algorithmic composition, the *Music of Changes* (1951). Cage described the piece as “an object more inhuman than human, since chance operations brought it into being” (Cage 1961, 36). By that, he meant that *Music of Changes* uses almost exclusively chance operations such that the “[composers] are removed from the activities of sounds they make”. (ibid, 10). In some ways, Cage’s attitude is not too dissimilar from Boulez’s multiple serialism. Boulez’s view, as outlined above, pushed for serial automatism as a means to break away from historical tradition. Here, Cage resorted to algorithms to “let sounds be themselves” rather than “vehicles for man-made theories or expressions of human sentiment” (ibid, 10). This is to say that both composers hoped for a radically new approach for composition that is unconcerned with the musical language of the past, and is removed from personal expression. However, in spite of the friendship between the composers, Boulez criticized such alea-

toric approach (without mentioning any names, but presumably towards Cage). Boulez wrote: “the individual does not feel responsible for his work, but merely throws himself by unadmitted weakness” (Boulez 1964, 42). Mutually, Cage disagreed with Boulez’s experiments in multiple serialism and found that they somewhat “diminish the interest they enjoy”. As Cage wrote: “curiously enough, the twelve-tone system has no zero in it...there is not enough of nothing in it” (Cage 1961, 53–79).

By and large, Cage’s algorithm, or what he called “composing means”, are elaborate and autonomous, perhaps more so than *Structure Ia*. In *Music of Changes*, Cage uses a series of coin flips to make decisions within predetermined charts of various musical parameters. Each chart is magic-square-like with materials filled in 8x8 grids, where eight charts are used to determine sound and silences, another eight are used for durations, eight for dynamics, and single charts for tempi and polyphony (Bernstein 2002, 262–63). Each square on the charts corresponds to the 64 hexagrams of the *I Ching*, where each hexagram is made of different combinations of solid and dotted lines. To select a square, Cage uses three coin tosses to determine the corresponding type of lines: two heads and a tail is a solid line, two tails and a head is a broken line, three tails is a solid line moving to a broken line, and three heads is a broken line moving to a solid line.

*Music of Changes* was by far Cage’s largest and most complex chance-based deterministic work written using precise notation. Curiously, after *Music of Changes*, Cage started experimenting with more open notation, such as in *Concert for Piano and Orchestra* (1957–58). The piece can be played in any order and by any combination of instrumentation ranging from solo to chamber to an orchestra. As analyzed by Iddon and Thomas, the parts have been intricately generated from a fixed set of predesigned instructions based on paper imperfections and *I Ching* castings, but details such as durations, dynamics, pitch, and many more are left unspecified to open up performative freedom for performers (Iddon and Thomas 2020, 1–3).

Notably, Cage’s use of open form and graphic notation enables performers to deviate from the algorithm quite freely under Cage’s, nonetheless, quite confusing performance instructions. In performing the solo piano version of the piece, David Tudor created his own playing score to use in every performance from the second performance onwards (Iddon 2013, 64–82). In this case, Tudor found a balance between the tensions of “what he wants to play”, “what Cage wants to write”, and “what the algorithm wants to write”.

There is an interesting parallel with Boulez in Cage’s discontinued interest in automatism where they both wrote a maximally deterministic piece and then retrenched from it in their own ways. Boulez gave himself greater compositional freedom, and Cage gave his performers greater interpretive freedom. It is also worth noting that Boulez had similar experimentation in open form, albeit in a

much more limited way, in his Third Piano Sonata (1955–57). Similar observations can be made where the openness of the work's structure has given the performer some influence within the tension between “what the composer wants to write”, “what the algorithm wants to write”, and “what the performer wants to play”. To be sure, Boulez's Third Piano Sonata is by no means as open as Cage's, and functions more similarly to multiple ways within the same labyrinth.

### **Iannis Xenakis: *Achorripsis* to *Duel***

Like Boulez and Cage, Xenakis found his own musical ideas to be in opposition with the general impression of how serial music seemed to be developing in the 1950s. For Xenakis, the problem with serialism was that when one listens for polyphony in serial music of the likes of Boulez and Stockhausen, rather than hearing individual threads, one hears “a mass of notes in various registers...[and] there is consequently a contradiction between the polyphonic linear system and the heard result, which is surface or mass” (Xenakis 1992, 8). Xenakis's criticism was that serial structures have gotten so perceptually dense that listeners can no longer hear the method in the music. However, unlike Boulez and Cage, Xenakis was unconvinced of using open forms to give the performer freedom over how the piece is performed. Xenakis found open scores to be problematic because they lead to a “substitution of authors”, where he sees it as a “resignation” of responsibility by the composer (ibid, 38).

With his disinterest in the aleatoric methods of Boulez and Cage, Xenakis nonetheless resorted to using chance-based algorithms to create deterministic works, but in a way that is distinct from Cage's system of coin tosses. In *Formalized Music*, Xenakis describes his concept of “real chance” as a particular “rare thing”, which can only be understood properly through probability theory (ibid, 39). Rather than Cagean chance-based results, Xenakis tried to deal with “chance” itself. For example, *Achorripsis* (1957) applies the Poisson distribution function from probability theory to generate parameters such as speed, density, intervals, durations, and general structure (Gibson 2011, 71).

Contrary to what his advocacy of formalized composition might imply, Xenakis tended to interpret the theories behind his process more loosely than is usually assumed. As Xenakis clarified: “the theory and the calculation define the tendencies of the sonic entity, but they do not constitute a slavery” (Xenakis 1992, 34). In practice, Xenakis sets up his algorithms in a way that leaves certain, admittedly smaller-scale decisions open for himself subjectively. In some ways, this is similar to Boulez's compositional freedom in *Le Marteau*, but here, Xenakis does not necessarily ‘deviate’ from his algorithm. Rather, he left ‘blanks’ in his algorithm for himself to fill intuitively. Where these decisions are made,

Xenakis prioritized faithfulness to the “spirit of the algorithm”, meaning his intervention functions akin to “human touches” to the algorithm. In other words, the tension between “what the algorithm wants to write” and “what Xenakis wants to write” does not exist, but it is at the expense of automatism. Given the deterministic nature of how the rest of the work is generated, Xenakis compromised the comprehensiveness of the system in exchange for the affordance to avoid tension between himself and his algorithm.

Interestingly, Benoît Gibson noted a connection between *Achorripsis* and *Duel* (1958) (Gibson 2011, 14). Perhaps as a reflection on his embark on the evidently more deterministic approach in *Achorripsis*, Xenakis asked:

Now the question is, when heard a number of times, will this music keep its surprise effect? Will it not chance into a set of foreseeable phenomena through the existence of memory, despite the fact that the law of frequencies has been derived from the laws of chance? (Xenakis 1992, 37)

In retrospect, the conception of *Duel* seems to be in contradiction with Xenakis’s initial skepticism towards open works. Gibson noted that *Duel* was written to prevent the foreseeable effect of stochastic music that is written deterministically like *Achorripsis*. In brief, *Duel* functions like a musical game where each orchestra has its own conductor, and they can choose to play from any of the six musical ‘tactics’ predefined by Xenakis. The succession of any two sonic events will produce a score of gain or loss such that eventually, one of the conductors will win (Gibson 2011, 15).

Notably, Gibson found that tactic IV in *Duel*, described as “stochastic percussion sounds”, is a direct quotation from the percussion section in *Achorripsis*. This suggests that despite using the adjective of “stochastic”, Xenakis did not make any new calculations and directly borrowed from his previous piece. In the context of my discussion of algorithmic music, *Duel* is considered algorithmic because there is a finite number of possible combinations between the tactics, notwithstanding the fact that the actual sonic material has been precomposed elsewhere and not strictly systematically. This categorization is made more confusing if it is taken into account that conductors can start and finish any time on the score, as long as each tactic is played for at least 10 seconds. Nonetheless, *Duel* is an interesting case where Xenakis laid down a set of instructions on “how to play the game”, and each performance will be different depending on the choice from both conductors.

Tempting as it may be to draw a similar observation as Boulez and Cage, Xenakis’s shift from using predetermined form to open form (which is to say, from *Achorripsis* to *Duel*) was only a brief experiment. Xenakis’s other works from *Achorripsis* onwards, perhaps with the exception of *Stratégie* (1962) and *Liniaia*

*Agon* (1972), continued to develop this approach to compose with a mathematical basis placed at the forefront of his compositions. For example, his ST algorithm continues to use the stochastic methods from *Achorripsis* for computer composition, *Herma* is based on the Boolean formula in stochastics, *Akrata* is based on sieve theory, and *Analogique* on Markov Chains.

Strikingly, all composers mentioned above have, in one way or another, wrote deterministic work as a reaction against general conceptions of serialism (*Structure Ia*, *Music of Changes*, and *Achorripsis*), and then eventually attempted more intuitive, open-formed, and/or indeterminate works (*Le Marteau*, *Concert*, and *Duel* – but except that Xenakis returned to follow his algorithms quite strictly). My discussion thus far has examined three typical ways composers have worked with (or deviated from) their algorithms. Boulez's *Le Marteau* is just as serially conceived as *Structure Ia*, but Boulez granted himself the freedom to deviate expressively from the generated outcome. Cage's *Concert* also uses strictly predetermined materials, but once the score and instructions are set up, it is up to the performer to interpret the piece freely. Xenakis's *Achorripsis* is ostensibly just as deterministic as *Structures Ia* and *Music of Changes*, all of which were written with the aim to remain 'faithful' to the algorithm, but *Achorripsis* is necessarily not as automatic because smaller-scale decisions are left for Xenakis to fill in.

In the context of the works discussed, there seems to be a conspicuous undertone here that suggests a triangulated tension exist between the composer, the algorithm, and the performer. As seen in the examples, these tensions are generally resolved by enabling agency between the humans involved. The composer's agency gives the composer a chance to 'add human touches' to the algorithmic outcome, while the performer's agency gives the performer an opportunity to engage intuitively with the material. These types of agencies can be of varying extents and used in different ways, as in Boulez grants himself more compositional agency than Xenakis does, where Cage arranges his material to facilitate the performer's agency. If neither the composer nor the performer is given agency, the algorithm will dictate the compositional material. When that happens, the piece will become dangerously close to Adorno's critique for systematic means of music generation, where "apparent objectivity of an overriding devotion to technique is nothing but an atrophied and impaired form of subjectivity" (Williams 2008, 194). It is beyond the scope of this paper to assess the context and the surrounding controversies in Adorno's *The Aging of the New Music*, but for the time being, the composition in question, as explained below, is quite far from the kind of music Adorno was (at least initially) against. See Martin Iddon's *New Music in Darmstadt*, page 110–16 for a more comprehensive overview of what Adorno meant.

## ***Flou* (2022)**

Having surveyed the historical approaches in algorithmic composition by contemporary composers for acoustic instruments, my recent co-composition, titled *Flou* for solo violin, considers the creative tensions explained above and attempts to explore a middle ground where the composer and the performer are both given agency to add ‘human touches’ to embody otherwise unidiomatic materials.

The algorithm uses machine learning to output pitch material in the style of my previous compositions. Since the algorithm does not provide any non-pitch parameter, the material is too ‘basic’ to function as a finished piece in itself. Furthermore, as shown below, the pitch material consists of dyads occasionally, which are not always playable depending on the acoustic instrument. Figure 1 provides a glimpse into what the machine learning generated material look like.



**Figure 1.** Machine Learning Generated Outcome.

In order to turn the material into a finished piece that remains faithful to the algorithm, I decided to give both myself and my performer different agencies to embody the piece. My main concern was that I wanted to use my compositional freedom to open up the algorithmic material in a way such that the violinist, Mira Benjamin, can have interpretive freedom that foregrounds her bodily presence in the performance. I also imagined that it would be alarmingly quite ‘dry’ to have the solo violin play the algorithmic pitch as it is, so I experimented with an octave-lower scordatura to obscure pitch material (hence the title). The octave-lower scordatura results in extremely loose and ‘flabby’ strings on the violin, and this physical phenomenon led to a series of secondary decisions to follow.

For example, due to the looseness of strings, it became physically more challenging to play double stops with the inner two strings without touching the outer strings. This led me to change the voicing, or in some cases the harmony of the dyads, to a perceptually similar sounding alternative that is more playable. Also, I noticed that the timbre and pitch of the violin becomes drastically more unstable in the scordatura. This led me to explore the inclusion of extended bowing techniques to introduce more unpredictability and timbral indeterminacy that come from the materiality of the unstable instrument itself. An excerpt of the final score is shown below.



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**FLOU: A CO-COMPOSITIONAL ATTEMPT AT ALGORITHMIC EMBODIMENT**  
(summary)

This paper is a practice-led investigation on the limited human agencies in algorithmic compositional methods. My piece for solo violin, titled *Flou* (2022), was written in response to a general observation where historically, autonomous usages of algorithms tend to incur a disembodied quality to the music. Through discussing the broader context of contemporary algorithmic repertoire, I explain my approach in algorithmic embodiment where I aim to foreground the performer's bodily presence in her attempt at realizing the algorithmic material to her best ability. I begin by establishing a definition of algorithmic music. Schoenberg's use of dodecaphony, despite being a formalized method for material generation, is not algorithmic because Schoenberg's rows are used expressively and do not strive toward automaticism. Boulez's *Structure Ia*, in contrast, is serial and algorithmic because there are meticulous layers that help Boulez serialize structures without requiring much additional intervention. Cage's *Music of Changes* is also algorithmic because the method in itself is predetermined and automatic. The piece basically 'writes itself' once the system was predesigned and Cage is not required to intervene with the process. Xenakis's *Achorripsis*, is also algorithmic in the way its macro forms are predetermined by a mathematical equation of probability, but his algorithm is not wholly automatic and leaves out the lower-level decisions for himself to 'fill in'. After a brief discussion of the pieces above, this paper observes a curious trend where these composers have coincidentally attempted to write strictly notated, deterministic algorithmic music as a reaction to serialism, and have, in their own ways, eventually experimented with more open-formed, indeterminate scores after. For instance, Boulez grants himself more compositional freedom in *Le Marteau* than in *Structure Ia* to enable a more expressive language to use serial materials. Cage grants his performers interpretive freedom by using graphic notation in *Concert for Piano and Orchestra*, and Xenakis had several open form experimentations such as *Duel*, based on game theory. In contemporary acoustic algorithmic music, I argue that when an autonomous algorithm is rigidly followed in the compositional process, the music becomes more interesting when the humans can afford agencies to facilitate a resolution of the creative tensions between the algorithm and the composer and performers. Having identified these creative tensions and how they are resolved differently by these composers, *Flou* is a co-creation between the composer and the violinist, where the algorithmic outcome is followed rather strictly, but the composer and performer both add 'human touches' by notating/performing a semi-open score. These collaborative interventions and unpredictabilities are welcome, insofar as they are imposed without undermining the 'original spirit of the algorithm.'

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