Manual and algorithmic procedures in soundscape composition

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ABSTRACT
A new electroacoustic composition — *Travessia* (2020) — relies on a well-known urban soundscape of Lisbon: the sound radiated from the 25 de Abril bridge. As with many soundscape compositions, the sonic reality captured *in situ* serves as the basis for subsequent manipulative procedures. Although exploring those procedures, the focus of this article is on the human/machine interface, especially important in electroacoustic music composition. Building on previous research on the use of algorithms in music-making, an analysis of compositional processes is carried out in connection with their associated aesthetic decisions and implications, providing new insights into composing with computers.

1 INTRODUCTION

1.1 Research Aims and Methodology

A new soundscape composition — *Travessia* (2020) — was recently composed, embodying creative practice as research (PaR) to address contemporary issues in computer-assisted composition (CAC). PaR "involves a research project in which practice is a key method of inquiry" (Nelson, 2013: 8). Only by creating can the artist-researcher investigate topics related to his/her craft. In the field of CAC, there is a need to continue researching the human/machine interface, so that a more detailed picture of how composition takes place can be obtained, especially by reporting individual practices and their contextualization in wider discussions. This includes both the technicalities of algorithm design and how they're balanced with manual procedures, but also the thought processes occurring in the composer's brain and how they guide the actual creative process. We arrive at an important research question: how does the use of algorithms affect creative thought and action in computer-assisted compositional practice? By using a specific example of electroacoustic composition in the soundscape domain this article offers new insights.

1.2 Algorithmic and Computer-Assisted Composition

An algorithm is a process or a set of rules that must be followed to carry out a given task. The word is usually applied to calculations and other problem-solving operations performed inside a computer. In the context of musical composition, the way sounds

are generated and manipulated can also be described by algorithms: "every rule of composition that can be formulated can also be programmed and carried out by a computer", wrote Koenig (1967). Rules are systematic compositional procedures, which can either be strict and univocal — programmable by using deterministic algorithms, outputting the same result each time they're fed with the same initial parameters — or have a degree of randomness — programmable by using indeterministic/stochastic algorithms, outputting a different result each time they run.
Instances of what we can call algorithmic composition predate computers. Arrangements of tubes blown by the wind — called aeolian harps — can be considered the most ancient forms, even if a little limited in their generative capacity. What is controlled in these instruments is the selection of tube lengths and their associated fundamental frequencies. Curiously, first examples of real algorithmic composition were the musical dice games (*Musikalisches Würfelspiel*) that became popular in the eighteenth century, the first example of which is the *Der allezeit fertige Menuetten - und Polonaisencomponist* (1757) by Johann Philipp Kirnberger (a student of Bach). Haydn's and Mozart's name appear on later dice games although their attribution has not been proven (Nierhaus, 2009: 36–38). After the invention of the modern computer in the 40s, scientists soon began exploring the automation of processes involved in musical composition. The *Illiac Suite* (1957), for string quartet, composed by LeJaren Hiller, was the first computer-assisted composition. Hiller and Leonard Isaacson demonstrated at the time how compositional techniques could be handled by computer programming. Various composers followed, along with different approaches towards automating composition.
It is important to distinguish manual from algorithmic composition. Manual composition is any procedure used to create (or transform) music materials without automation, i.e., *doing by hand*. Algorithmic composition takes place when we programme and automate the process of generating new sounds or new combinations. Those processes can be, for instance, a particular kind of counterpoint, a variation technique, or any form of digital sound synthesis or signal processing. We are composing sounds indirectly by programming the computer.
Nowadays, composing electroacoustic music usually, and naturally, involves combining manual and algorithmic procedures. The manual/machine interface is at the core of CAC. Anders and Miranda write that:

> *When doing computer-aided composition, composers apply or even develop certain technical means, but these technical means are not the actual purpose; the main result of their work is the artistic output. Composers decide which compositional parts or aspects of the music the computer generates, and which parts are composed manually. (2009: 134)*

Explorations in CAC have continued for more than half a century. In the recent book *The Oxford Handbook of Algorithmic Music*, the editors point to some of the ongoing issues:

> *(1) what benefit the algorithm, especially when computational (deterministic or stochastic), provides to the music creator; (2) whether the algorithm can become a genuine partner in the creative process; (3) whether it can make contributions which are equivalent*

in utility to those potentially emanating from another (human) music creator; and finally, (4) whether it can provide meta-human outputs, which we ourselves currently could not achieve but which may in the short to medium time frame become just as accessible cognitively and socially as musical outputs that we can make now. (Dean and McLean, 2018: 10)

1.3 Soundscape Composition

The term 'soundscape' was first used by Michael Southworth (1969) and later developed by Murray Schafer (Schafer, 1973, 1977). 'Soundscape composition' is a term coined by the composers working with the World Soundscape Project at Simon Fraser University in the late 60s and early 70s (Truax, 1984). Barry Truax proposed a definition and set limits to what should be included in the genre: in contrast to pure electroacoustic music, the sounds used should keep an environmental context. Throughout time, the creative practice of composers continuously pushed those limits, mostly by exploring 'abstracted sound'. Truax writes:

The soundscape composition always keeps a clear degree of recognizability in its sounds, even if some of them are in fact heavily processed, in order that the listener's recognition of and associations with these sounds may be invoked.
(...)
Of course, many composers like to create an imaginary world with processed sounds of various origins, and if the result is heard as a coherent soundscape, even if unrealistic in its details, one can make a connection to the soundscape composition approach. *(2002: 6)*

Soundscape composition, being based on environmental sound, also touches on important fields such as acoustic ecology, architecture (including landscape), sociology, and politics. As Hildegard Westerkamp writes: "to compose with environmental sound implies a relationship — a dialogue — between composer and recorded materials, just as there is a relationship between soundscape and listener in daily life" (2002: 53). This last relationship widens the scope of soundscape recording and manipulation beyond composition. Throughout time, it's no surprise that a series of cross-disciplinary approaches have also emerged (Martin, 2018).
The work discussed in this article — *Travessia* (2020) — starts with the real environmental sound captured close to Lisbon's 25 de Abril bridge (which traverses the Tagus river) — what Truax calls 'found sound' — and takes the listener on a journey of transformations and layering — progressing towards 'abstracted sound'. In doing so, it transcends the initial sonic reality to build up new artificial soundscapes. This is achieved mainly by using wind-like, thunder-like, and storm-like sounds. The title of the piece translates as 'crossing', and indeed the piece embodies a series of crossings: from real to imaginary, from known to unknown, from natural to artificial and from analogue to digital. Both the 25 de Abril bridge and the Tagus river are also deeply associated with the country's historical developments — which also imply crossings — namely the discoveries and the transition from dictatorship to democracy. Furthermore, and in purely sonic terms, the bridge is as iconic of Lisbon as it is noisy.

2 COMPOSING WITH ALGORITHMS

2.1 Algorithm Design, Output, and Incorporation into Pieces

Algorithm design is at the core of computer-assisted composition. How we design algorithms, what we choose to automate and, finally, the space we leave for manual control, all constitute important subjects in CAC. It is useful to introduce specific terminology which can help clarify how the composing process actually takes place (see Gato, 2016: 39–40).

Algorithms usually output a musical/sonic result,[1] which the composer accepts after assessment. It can then be either manually or automatically incorporated into a piece. *Manual incorporation*[2] means writing a passage in a score by hand using the algorithm output as a reference/source — for instance, writing a given passage based on an algorithm-generated harmonic progression. *Automatic incorporation*, on the other hand, requires results which can be placed directly on a developing score, usually *copied* automatically. This is the most common case in electroacoustic composition, the score being a timeline-based window inside a DAW where one places sound files. The balance between automated and manual procedures is an important aspect of how a particular composer works, but also of how composers in general interact with computer technology while creating music. If an algorithm output is automatically incorporated (copied into the score), then subsequent *manual intervention* can take place, which comprises modifications carried out by hand (adaptations or corrections, for instance). Finally, algorithm-generated materials can either be manually *elaborated* — that is, developed — and/or manually *complemented* — joined by, or superimposed with materials of different conception, prepared by hand.

2.2 Generating, Assessing and Selecting Material

An algorithm automates a particular compositional technique and, in doing so, embodies aesthetic principles. These principles underlie *aesthetic decisions*, which are the basis of authorship (see Meyer, 1998: 17). Aesthetic decisions influence algorithm design where they are joined by *coding decisions*:[3] purely technical choices tied to programming.

Once an algorithm starts to output results, judgment can begin, which should include listening. The next step can be either *algorithm redesign* or *manual control* of the algorithm's initial parameters/arguments. A testing cycle usually takes place until a refinement of the algorithm's structure and/or parameters is achieved. That is the time at which the composer starts to become satisfied with the material he/she is getting. Various assessment criteria can assist the composer in selecting a result and what ends up in the score or in the final sound file of the composition is the result of a series of choices made by one particular person. The following feedback loop is quite frequently at work when a composer begins to be stimulated by an algorithm's output:

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[1] Alternatively, an algorithm can output a non-musical result which will, in some way, be used by a composer to make music.

[2] The author previously used the term 'implementation' but later found that 'incorporation' is clearer.

[3] The author previously used the term *operational decisions.* (Gato, 2016: 45)

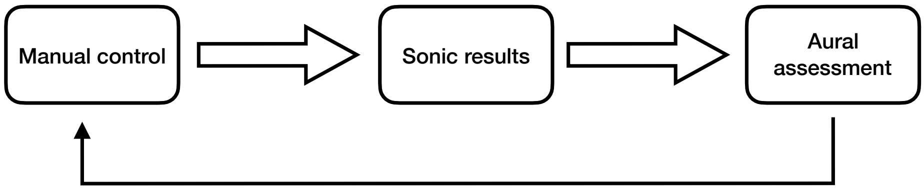

Figure 1 - Manual control of an algorithm pictured as a feedback loop.

2.3 Discovery and Automatism

To discover, and to acquire new knowledge, implies, at the outset, knowing that one does not know something.[4] In the preface of the recent book *On Not Knowing: How Artists Think* the authors write: "artists often begin something without knowing how it will turn out. In practice, this translates as thinking through doing" (Fisher and Fortnum, 2013: 7).

Used as creative research devices, algorithms allow a composer to discover new sonic materials, especially those that would be hard to formulate *ab initio*. Furthermore, an algorithm can have various degrees of unpredictability of results, especially if stochastic in nature. A closely related idea is automatism, which refers to "the avoidance of conscious intention in producing works of art, especially by using mechanical techniques or subconscious associations" (Oxford University Press, 2013).[5] This avoidance of conscious intention became quite popular among the surrealists of the twentieth century, but its influence reached art music. Ligeti called this the unconscious method in his influential article on Boulez's *Structures Ia* (1952), saying that "elements and operations . . . are, as it were, fed into a machine, to be woven into structures automatically" (1960: 36). Ligeti was referring to the serial method applied to all musical parameters: a kind of (unautomated) algorithm used to obtain new music uninfluenced by a given composer's thinking habits. Composition was a mere abstraction controlled by the dodecaphonic matrix. The following experimentalism of 60s, 70s, and onwards owes a great deal to different forms of automatism. CAC remains an important context for its application.

2.4 Limitations of CAC and Exclusively Human Aspects

In a 2009 interview given to Rozalie Hirs, Tristan Murail said:

> *Creating musical structures merely through algorithms doesn't work for me, because I need objects that have a meaning: expectation, closure, opening, or whatever. (Murail, 2009: 11)*

It's important to be aware that some aspects of artistic creation are exclusively human and can't, or shouldn't, be automated. This can, of course, be challenged by those who carry out research in the most advanced forms of artificial intelligence (AI). Here's a definition of AI by two experts of the field:

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[4] This is the precondition for acquiring knowledge according to Socrates, whose thought was transmitted to us by Plato's writings.

[5] Historically, automatism is mostly associated with the Surrealist movement beginning in the 20s.

> *Very generally, artificial intelligence (AI) is a cross-disciplinary approach to understanding, modeling, and replicating intelligence and cognitive processes. (Frankish and Ramsey, 2014: 1)*

How we define both intelligence and cognitive process concisely, and what aspects of human creativity we include remains an ongoing issue. Perhaps the term *intelligence augmentation* is more useful, especially in CAC where machines are only assistants of a specific author while he/she makes music.

Cognitive faculties seem to condition each other in various, complex ways, and do not exist entirely independently, something known as *interdependence*. For instance, despite the apparent distance, emotion is known to condition reasoning (see Damásio, 2008). The composer is the source of what we can call *personal bias* — specific ways of thinking and approaching composition influenced by his/her biographical and genetic factors — currently far beyond the reach of available AI tools. This bias certainly underlies intuitive processes, so fundamental to many composers. Choice should also be re-stressed in this context: a composer can simply choose not to automate parts of the composing process because he/she doesn't want to or feels he/she needs to be directly involved with the developing materials. Finally, there are limitations in the available algorithmic tools: they simply can't handle all aspects of composition. This is due to the way in which each tool is designed, its specificity and scope.

Automating compositional procedures creates a contrasting scenario to carrying them out manually and that contrast can help us better understand the creative process. A parallel can be drawn between AI and CAC research: both can help us better understand human nature.

3 SOUNDSCAPE CAPTURE AND COMPOSITIONAL PROCEDURES

The soundscape explored in *Travessia* has two main features, or elements:

1. Pitched element: the sound radiated from the 25 de Abril bridge which connects the two margins of the Tagus River in Lisbon. The noise cars make as they move through the bridge on top of a gridded roadway is a continuous time-varying pitched sound. Listening to it close by, one can use a metaphor and say that the bridge 'is singing'.
2. Waves element: the sound of the waves the Tagus river creates as it undulates and repeatedly crashes into its margins.

Element 1 is man-made, product of human activity. It arises from the interaction of the bridge structure with the tires of the cars rolling on top of it. Element 2 is a natural source although influenced by its man-made context: the waves crash both into a small shore and into the concrete platform where people stand (and where I stood to capture sound, see Figure 2 below).

3.1 Recording

Capturing a soundscape is usually a manual procedure relying on *in loco* aural assessment via headphones. The recordist continually explores the possibilities of the capture by varying both the location and the direction of microphones.[6] Here lies the

[6] Many more factors can be varied such as the type of microphone, windshields, interface, use of baffles (Jecklin or Schneider disc), among other things.

first aesthetic decision which will impact subsequent compositional actions taken in the studio.

Figure 2 - Mic placement for direction 2: capturing the sound of the waves by pointing towards the river. The bridge is located above the mics (not shown).

The soundscape was captured in stereo using the NOS technique (see King, 2016: 38–39): two cardioids with windshields are placed on a stereo bar, 30 cm apart (capsule to capsule), at an angle of 90°. Two directions were used at the same location under the bridge near the Tagus river. Direction 1 pointed upwards towards the bridge. Direction 2 pointed towards the river in parallel with the bridge's elongated body and captured the sound of small waves as they crash into the river margins (Figure 2). Previous recordings were attempted by using the XY stereo technique, but I later found that NOS creates a more open stereo field, more suitable for large ambiences. All recordings were checked for remaining low-frequency wind noise and city background noise, eliminated by using a low-cut filter.

3.2 Max Algorithms

Algorithmic composition procedures were programmed using the software Max (Zicarelli, 1999). The application was used to programme both synthesis and signal processing methods applied to the captured soundscape. Three algorithms and associated compositional techniques will be analysed.

3.2.1 Determinism and manual control: fundamental tracking and additive synthesis

The idea behind this process was to create a synthetic version of the pitched element featured in the captured soundscape. The musical aim was to create both a comparison between found and synthetic sound and a way to migrate from the natural/environmental to the artificial domain. Also, an important aim was to highlight the 'singing' quality of the pitched element that constitutes a melody.
A mono sound file containing one of the channels from the stereo soundscape recording with mic direction 1 was fed into a Max algorithm for polyphonic additive

synthesis. In this algorithm, the sound is continuously analysed with the *fzero~* object (fundamental frequency estimator), the frequency output of which is used as the fundamental for synthesis (see Figure 3). A *metro* object (not shown) triggered the notes with a fixed 50 ms spacing, and a duration of 2000 ms, chosen to create a good overlap between subsequent tones. No amplitude changes were transmitted to the additive synthesizer over time and the frequency was filtered by using the *split~* object. This filtered out frequencies that were outside the perceived frequency range of the pitched element in the soundscape, heard as artifacts. The interval 150-500Hz was obtained by adjusting the *split~*'s arguments and comparing the pitch range of the additive synthesizer with the original soundscape. Finally, the wave function could be selected among three types: sinusoidal, triangular, and rectangular. No stochastic processes were involved so this algorithm is deterministic.
Although strongly algorithmic in nature, this compositional process showcases some important aspects of computer-assisted composition. Once the initial raw, deterministic, algorithm was programmed, manual control and redesign occurred concurrently. Then, manual control gradually took over so that Max could start generating desirable sounds. The following list of parameters was arrived at by continuous experimentation and aural assessment (see Figure 1 above):

1. Size in samples to estimate the fundamental frequency: 2048.
2. Range of frequencies to select: 150-500 Hz.
3. Time interval between notes: 50 ms.
4. Duration of notes: 2000 ms.
5. Wave function for each component of the additive synthesis: triangular.

It is important to note that setting these parameters does not equate to manual composition. It is just manual *control* of the algorithm's parameters. All sound is generated algorithmically, and no manual shaping takes place at this stage.

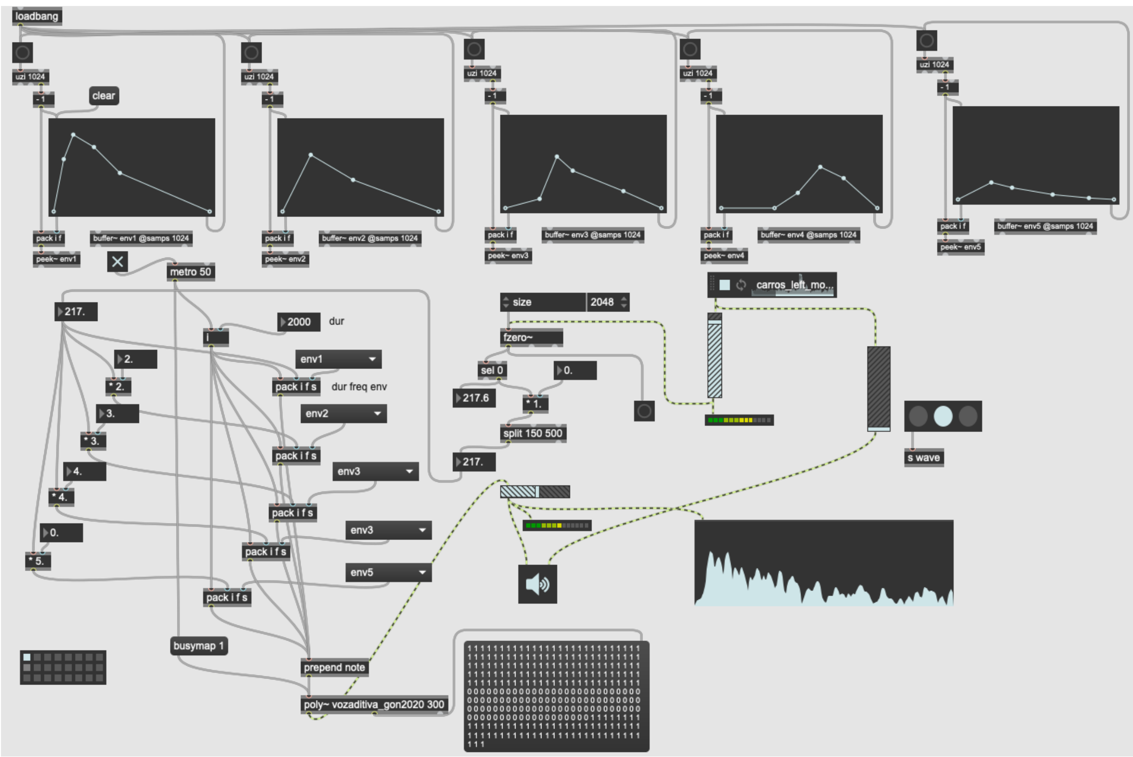

Figure 3 - The fundamental tracking and additive synthesis algorithm.

3.2.2 Discovery, unpredictability, and intuition: granulation

Granular synthesis is a good example of how an algorithm can help a composer discover new sounds. Many times, the sonic result is not easily predictable, something that, no doubt, lies behind the popularity of this technique. The enormous diversity of sounds that can be obtained by submitting a sound sample to granulation arises from Gabor's theory that states that "a granular representation can describe any sound" (Roads, 1996: 169). Thus, producing grains from a given sound sample can yield an immense variety of sonic results. It is interesting to note that the unpredictability potential of the technique does not fundamentally arise from algorithmic indeterminism: one can programme a deterministic granulation algorithm and still find it difficult to predict its sonic output. It surely depends on how well acquainted the composer is with the technique, but, essentially, it arises from limitations in human calculation capacity, given both the sound sample to granulate and the number of parameters to take into consideration.

> *One purpose for which [algorithms] have been used is to go beyond the known, and help generate something that cannot be directly envisioned, thanks to our limited predictive capacity. (Dahlstedt, 2018: 56)*

Synchronous methods are, in general, more predictable than asynchronous ones. An asynchronous granular synthesizer was programmed in Max allowing control over a set of individual grain parameters which could be randomized within a defined range: duration, pitch and location in the stereo field — in Figure 4 one can see the generic (unweighted) random number generator utilized. The amplitude envelope was adjustable and affected all grains while producing output files. Grain density could randomly fluctuate within a certain range. Finally, a sound file containing the captured soundscape was fed as input. A time selection within the file could be defined and allowed to progress forwards at a set speed.

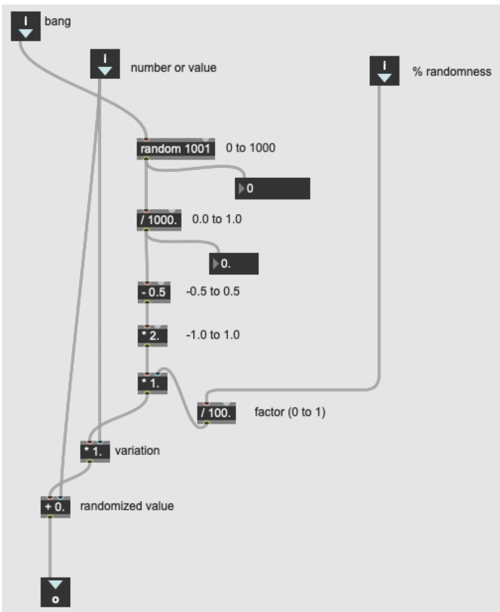

Figure 4 - The random number generator Max patcher.

The granulator was switched on and manually controlled to generate various kinds of sound textures out of two sound files. The first was obtained by filtering the soundscape recording to isolate the pitched element (see intro to section 3 above). The other sound file was obtained by filtering the soundscape recording to isolate the waves element. The piece *Travessia* starts with the captured environmental sound, gradually drifting away towards the creation of an artificial/synthetic soundscape. Many sounds that make up this artificial environment were produced by granulation. I continuously experimented with new sets of parameters to get new sonorities: some of them more continuous, some more fragmented. As I progressed, I was both getting new results and envisaging a compositional path for the piece, aided by aesthetic choices. These choices, in this particular context, can hardly be analysed as they were based on personal bias, or individual taste. Intuition is a useful term: a guiding principle that is more instinctive than rational, assisting the experimentation. And so, granulation, as used creatively while composing the piece, constituted an important instance of human/machine interaction. Although algorithmic composition is at work, a set of exclusively human aspects came into play. The algorithm, by creating novel and unpredicted sonorities, enabled new possibilities, stimulated new thought, and suggested new compositional directions. To conclude, one can say that the algorithm interacted strongly with the personal cognitive processes at work during creation.

3.2.3 Indeterminism as variation: ring modulation

The idea behind using ring modulation was to create yet another form of abstracted sound based on the captured environmental sound. Ring modulation is a way to modify what one calls the carrier signal source, while keeping some characteristics of both carrier and modulator sources.

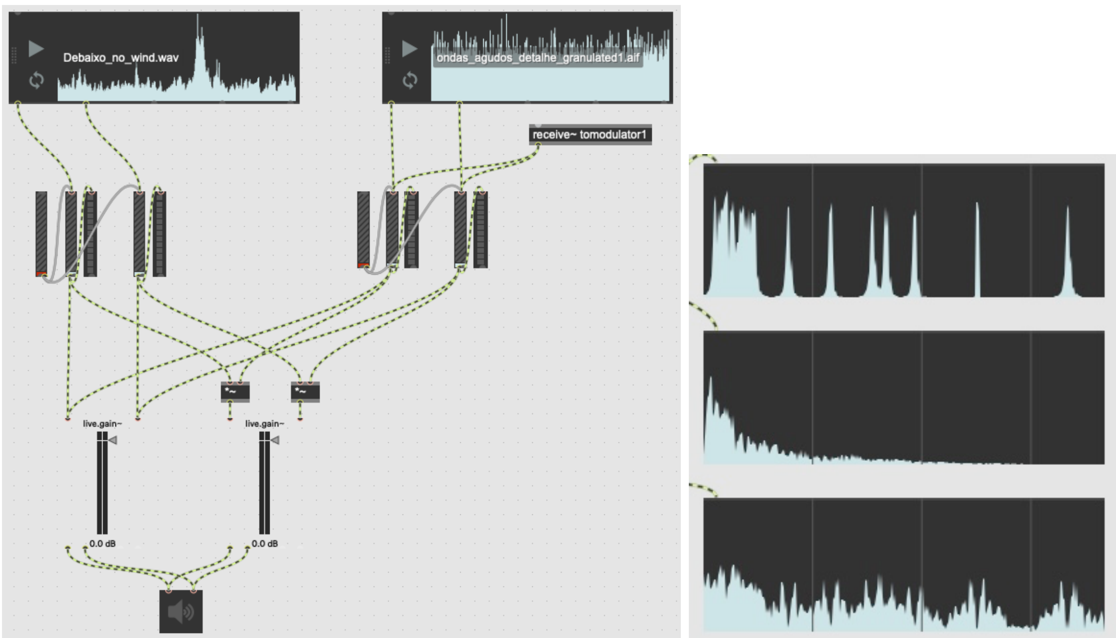

Figure 5 - Left: the ring modulation algorithm. At the *live.gain~* fader at bottom left one can listen to a mix of sources. At the bottom right fader, the modulation can be monitored. Right: spectra of the process of multiplication of sound sources (ring modulation). Top: additive synthesis. Middle: captured soundscape. Bottom: multiplication.

A simple algorithm for modulation was used, based on the multiplication of sound sources. This is the digital equivalent of ring modulation (Roads, 1996: 216). As shown in Figure 5, sound files or audio received from other Max patchers could be used, and the gain of each source could be controlled. I used the sound recording of the soundscape, which was multiplied by the output of an additive synthesizer. Given that multiplication in the time domain equals convolution in the frequency domain (law of convolution), the resulting sound is spectrally richer (see Figure 5, right).[7] Because the soundscape recording is already very rich in frequency components and is also dynamically very agitated, ring modulation with an additive synthesizer produced a coloured, fragmented, noise-like sonority which I found very interesting. The frequencies and durations of the notes created by the additive synthesizer were each controlled by a random number generator as pictured in Figure 4 above, so that diverse, but related, sounds could be produced.
For each instance of sound generation by the additive synthesizer, three random frequencies were used to form a chord, together with one random and common duration. I proceeded by starting a recording of the modulation output, triggering the additive synthesizer while the soundscape file was playing back into the modulator. These note triggers created a chain of individual sonorities of short duration. Although manual control was important to set the centre values and ranges of randomness of both frequency and duration, once they were set, they remained fixed. The aleatoric nature of the algorithm allowed for the easy production of similar but different sounds, much like a variation technique works in instrumental music. This was very useful, quickly generating a whole realm of interconnected sounds. Their reiteration seemed to constitute a feature of an artificial soundscape (many real soundscapes have persistently repeating sounds). Formally, this chain of sonorities worked like a sonic development process, sharing some aspects with musical discourse coherence. This idea comes from the language analogy, which has gained an increasing scientific support in recent years. In his book *Music, Language and the Brain*, A. Patel asks:

> *If there are general cognitive processes underlying the perception of coherence in linguistic discourse, might these same processes apply to the perception of coherence in music? (2008: 337)*

And so, one can say that the interaction between algorithm and the mind that programmed it is fundamental.

3.3 DAW Editing and Mixing

Editing and mixing sound inside a Digital Audio Workstation (DAW) are manual procedures which reshape and combine the sonic outputs of algorithms. Although every step relies on algorithms which are running continuously — and constitute the DAW application itself — they do not comprise algorithmic composition. That is because they are not specifically programmed by the composer to generate sound. The operations applied to the sounds are kept and saved — thus constituting a kind of score — and can be played back. But they are not fundamentally generative.

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[7] Every component of the carrier (C) spectrum is now replaced by C+M and C-M, where M is each component of the modulator.

The output files from the Max algorithms were all imported into tracks on a DAW software, a process we can call automatic incorporation. The placing of the files in a specific order is known as montage, carried out manually. Manual interventions were needed for some of the algorithm-generated materials such those coming from the fundamental tracking-led synthesis, which had to be time-aligned with the original environmental sound. Furthermore, the balance between the real sound recording and the sound produced by the synthesizer was shaped by hand through automation curves. This reshaping took place on virtually every sound file imported into the DAW software and can be classified as manual elaboration. The same applies to panning through automation curves. Manual elaboration procedures were, thus, very limited in scope while composing the electroacoustic piece *Travessia*, something that can differ sharply from a score-based composition process.

Most of the layering procedures can be considered complementations. Manual complementations contain environmental sound (a manually produced material via recording), while the others constitute algorithmic complementations. These procedures are, fundamentally, mixing and involve manual balance of track volumes.

4 CONCLUDING REMARKS

In this article, a series of manual procedures plus a series of sound-based algorithmic procedures were described, together with their aesthetic implications in the context of CAC. Answering the research question stated at the outset is not a straightforward task because the interaction between humans and machines can be complex and idiosyncratic, especially in the context of creative practice. Although demonstrable truths are present in that practice — such as how to programme effective algorithms or how to formalize compositional processes — we should really answer artistic research questions by remaining close to the creative journey involved in completing an artwork. Section 3 described compositional procedures — mostly the technical and aesthetic aspects of doing — complemented by more general remarks in this section.

It's safe to say that newly programmed algorithms not only affect the creative process in various ways but can often be a necessity when carrying out sonic research according to specific demands. Especially in the field of digital audio, only algorithms can articulate a very peculiar investigation which might not be explorable with available pre-programmed tools (i.e., 'ready-to-use' software applications). This articulation can be found in the code itself and helps the composer draw relationships between idea/technique and resulting sound (the output). These techniques can easily be refined by searching for the right combination of parameter values.

In CAC, the formalization and automation of compositional processes is only part of a much bigger story. We need to discuss how programming algorithms can influence creative thought either by providing contrast to purely manual procedures, or by stimulating further thinking and discovery. This was a concern of this article and is, perhaps, one of the most fascinating topics to investigate, as it impacts both CAC and pure composition, let alone artmaking.

As terminology helps us identify specific procedures so that their inter-relationships and potential implications can be investigated, some terms were defined and utilized to analyse compositional stages. We should hypothesize that perhaps new terminology is needed to capture the nuances of how algorithms interact with the creative minds that use them.

Several procedures in electroacoustic composition remain manual, despite being performed on computers. The experience of doing something *by hand* — as opposed to automating via programming — remains an important part of the fruition composers derive from the act of creation. The experience of field recording, for instance, features acoustic site explorations, equipment selection and many trials-and-errors. Automating these tasks would, perhaps, render them less pleasurable and disembodied. Pleasure is central to many human activities, and it is a necessity of the human body. Perhaps a link to psychology can also be envisioned, not focusing on perceptive and cognitive processes associated with listening but on those associated with *doing*.

To conclude, we should note that electroacoustic music composition can (and frequently does) rely heavily on algorithmic procedures and part of the advancement of the state-of-the-art is linked to the technicalities of sound programming. Although not the focus of this article, some contributions can be found within it.

5 REFERENCES

Anders, T. and Miranda, E. (2009) 'Interfacing Manual and Machine Composition' In: *Contemporary Music Review* 28 (2) pp.133–147.

Dahlstedt, P. (2018) 'Action and Perception; Embodying Algorithms and the Extended Mind' In: Dean, R.T. and McLean, A. (eds.) *The Oxford Handbook of Algorithmic Music*. New York: Oxford University Press. pp.41–65.

Damásio, A. (2008) *Descartes' Error: Emotion, Reason and the Human Brain*. London: Random House.

Dean, R. T. and McLean, A. (2018) 'Musical Algorithms as Tools, Languages, and Partners: A Perspective' In: *The Oxford Handbook of Algorithmic Music*. New York: Oxford University Press.

Fisher, E. and Fortnum, R. (2013) *On Not Knowing: How Artists Think*. London: Black Dog Publishing Limited.

Frankish, K. and Ramsey, W. M. (2014) *The Cambridge Handbook of Artificial Intelligence*. Cambridge: Cambridge University Press.

Gato, G. (2016) *Algorithm and Decision in Musical Composition*. [Doctoral thesis] City University London / Guildhall School of Music and Drama. At: http://openaccess.city.ac.uk/17292/

King, R. (2016) *Recording Orchestra and Other Classical Music Ensembles*. New York: Taylor & Francis.

Koenig, G. M. (1967) *The Use of Computer Programmes in Creating Music*. At: http://www.koenigproject.nl/Computer_in_Creating_Music.pdf (Accessed 17/06/2014).

Ligeti, G. (1960) 'Pierre Boulez: Decision and Automatism in Structure Ia' In: *Die Reihe (Translated by Alexander Goehr from the original German edition of 1958)* 4 pp.36–62.

Martin, B. (2018) 'Soundscape Composition: Enhancing our understanding of changing soundscapes' In: *ORGANISED SOUND* 23 (1) pp.20-20–28.

Meyer, L. B. (1998) 'A Universe of Universals: Evolution and Choice' In: *The Journal of Musicology* 16 (1) pp.16–17.

Murail, T. (2009) 'Interviewed by Rozalie Hirs in April 10, 2007' In: Hirs, R. and Gilmore, B. (eds.) *Contemporary Compositional Techniques and OpenMusic*. (s.l.): Editions DELATOUR FRANCE/Ircam-Centre Pompidou. pp.7–14.

Nelson, R. (2013) *Practice as Research in the Arts: Principles, Protocols, Pedagogies, Resistances*. (s.l.): Palgrave Macmillan.

Nierhaus, G. (2009) *Algorithmic Composition: Paradigms of Automated Music Generation*. (s.l.): Springer.

Oxford University Press (2013) 'Oxford Dictionary of English' definition. (s.l.): Oxford University Press.

Patel, A. D. (2008) *Music, Language and the Brain*. New York: Oxford University Press.

Roads, C. (1996) *The Computer Music Tutorial*. (s.l.): MIT Press.

Schafer, R. M. (1973) *The Music of the Environment*.

Schafer, R. M. (1977) *The Tuning of the World*. New York: Alfred Knopf.

Southworth, M. (1969) 'The sonic environment of cities' In: *Environment and Behavior* 1 (1) pp.49–70.

Truax, B. (1984) *Acoustic Communication*. (s.l.): Ablex Publishing Corporation.

Truax, B. (2002) 'Genres and techniques of soundscape composition as developed at Simon Fraser University' In: *Organised Sound* 7 (1) pp.5–14.

Westerkamp, H. (2002) 'Linking soundscape composition and acoustic ecology' In: *Organised Sound* 7 (1) pp.51–56.

Zicarelli, D. (1999) *Max*. Cycling ’74. At: https://cycling74.com/products/max/