# Noise in the Composition of 2458208

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A variety of perspectives about noise serves as a framework for the development of structures and techniques in the composition of *2458208*, for ensemble and electronics (2018). Thinking about noise promptly reveals its paradoxes. Noise may present itself opposed to concepts like signal or pitch. Noise can be seen as the genesis and backdrop of all there is. But how do these concepts reflect on the practical problem of creating a musical work? This text offers a personal perspective, along with the discussion of software tools and techniques, illustrated with code examples.

## Contents



## 1 Noise and Noises in the Composition Process

The word "noise" is polysemic. Together with its wide variety of related meanings, the idea of noise interests multiple disciplines, where it is conceptualized differently. I kept some of those concepts in my mind when composing *2458208*. They matter to me as part of the writing process, but I did not intend to make a either "noisy piece" or a piece of "noise music". The ideas themselves are not embodied in the piece—I also didn't intend for it to have a "conceptual art" component. Lastly, it's perfectly acceptable to me if in the end no idea of noise comes through to the listener. It belongs more to the means than to the results of the composition, it's a tool, an inspiration, comfort and guidance to overcome the hardship of the white page.

Of the multiple faces that noise presents us, I was being particularly mindful of noise as the anti-pole of pitch. This will be expanded in Section 4. Just as a mere illustration of the tools and techniques that I used with the purpose of bringing forward that idea in the electronic generation of very specific sonic material, Section 6 provides some computer programming examples. I would say that the techniques are perhaps mundane and their implementation unnoteworthy, but I believe that the tools used are a little out of ordinary, enough to warrant a mention in this text, and offer some promise for all with the predisposition to use them.

There are multiple aspects involved in the creation of a musical piece. Some are a product of systematic intentional reflexion by the composer, while others are unconscious and/or intuitive. Generally, I aim to keep the former in the preliminary phases of composing, to populate the imagination with musical ideas. But after that, having experimented with rigorous things like algorithms and formal processes, I prefer to be unconstrained by the results and proceed "by ear" as much as possible. All in all, this text is concerned with just a small cross-section of the more intentional and reflective aspects.

## 2 Signal and Noise

Other than that particular aspect (but clearly not unrelated), noise is an interference, a perspective put forth by information theory. Noise obscures the signal on its transit, from the emitter to the receiver, through the communication channel (Shannon, 1948). This conception was then extended from a strictly communicational problem and incorporated in the realm of aesthetics. For example, Abraham A. Moles—philosopher, engineer and collaborator with Pierre Schaeffer—understood noise as the destruction of the elements of sensation, and gave it a central role on the development of an experimental methodology for aesthetics (Moles, 1957):

> Ainsi, l'un des procédés de découverte les plus généraux de l'es-

> thétique consiste, sur la base de la matérialité de l'oeuvre d'art, à détruire progressivement celle-ci par quantités connues, et à suivre les variations de sensations esthétiques, de valeur, de connaissance de l'oeuvre en fonction de cette destruction (p. 239).

The break-up produced on the unrolling of the aesthetic message generates a kind of filtering that brings forward its semantic aspects.

This advantageous aspect of noise, perhaps surprisingly, finds an echo in the inner workings of the human brain itself. Noise in this domain is connected to imprecisions of cellular operations within an ensemble of neurons, or transmission timing fluctuations that affect the synchronism between ensembles of neurons. Some researchers argue that this inherent noise is beneficial for the cognitive and behavioral functions of the brain (Rolls & Deco, 2010). A related phenomenon is that of *stochastic resonance*, where the presence of noise in a nonlinear system is better for the output signal quality than its absence. It's a matter of debate the exact identification of the mechanisms through which the brain exploits randomness provided by noise, and what is the functional role of noise in the brain, nervous system and other areas of biology (McDonnell & Abbott, 2009).

The counter-intuitive idea of adding noise to a system in order to improve its output is also useful in many other domains. Notably, it's part of the process of *dithering*, where adding noise reduces the impact of quantization errors in the digital processing of an audio signal (Vanderkooy & Lipshitz, 1984).

Coming back to the abstract model proposed by information theory, and specifically to the problem of music making, the interference, fluctuations, affection or destruction of the signal are achieved through the injection of elements that don't belong to the ecology of the original material. But at the receiver's terminal, less signal will be present overall. Paradoxically, noise is at the same time a *plus* and a *minus*, corresponding both to an additive and to a subtractive procedure. Moreover, if noises are extraneous entities, they are warmly invited *into* the music, where they finally belong. In the end, the noise *is* the signal. This is archetypal of our relationship with noise, whose paradoxes are aptly summarized in the title (and content) of a book by Garret Keizer, *The Unwanted Sound of Everything We Want: A Book About Noise* (2010).

Here are some of the practical techniques that I used when composing *2458208*, and that in my view are informed by this idea of noise:

- added elements: appending unrelated pitches to a harmony, clustering tones to produce complex spectra, accreting new subdivisions to a stable/regular rhythmic figure;

- editing as a process: very dense gestures from which numerous individual particles are then removed or obfuscated;
- mash-up of layers; partial or integral superposition of material that was initially thought out to be sequential, and, reciprocally, temporal chopping of simultaneities;
- algorithmic noise: small mutations on the workings of simple formal operations (e.g. transpositions, rotations, etc); for instance, certain quantities are added or taken from the final or intermediate results—the quantities can either be fixed or changing dynamically, according to a particular logic; oftentimes I ended up with very large collections of algorithmically generated musical material, encompassing many or all potential mutations, from which a smaller humanly apprehensible set of results had to be selected, again using automatic processes;
- interjections that break up the flow of musical discourse.

## 3 Acoustic Noise / Electronic Noise

The concept of noise is also used as a sound's attribute or to signify an entire category of sounds. Some instruments produce a noisier timbre than others, or can be made noisier through specific playing techniques. Of course, noise can also stem from the flexibility awarded by the electronic manipulation of audio. In addition, noise is not only abrasive, harsh, tumultuous sound, but also any sound removed from the range of sonic phenomena that nature and the quotidian present us, or unusual enough that cultural associations in the domain of music-making are hard to establish. By allowing the generation of this second type of sonorities, the electronics function as a potentially contrasting element in relation to instrumental sounds and gestures.

As tempting as it can be to see both acoustic instruments and electronic sources played through loudspeakers as belonging to the same general category of sound-producing artifacts, the point of departure for the conjugation (the *orchestration*) of acoustic and electronic sounds must account for their different semiotics, and even more when performance aspects are considered. It's clear that "conventional musical instruments and gestures forcibly reintroduce musical style into a work that might otherwise be free to construct extramusical meaning" (Demers, 2010, p. 38). This, however, is not a fatality, because the composer remains in control of the effect, up to the point where most conventionality is bypassed.

*2458208* uses mostly standard instrumental techniques, and the electronics part is to be seamlessly integrated in the ensemble. The integration generally follows one of three modes: (a) several instruments and electronics are interleaved to contribute tone colors to a compound whole texture, in which there is to be no semantic different between sound sources—the listener may even remain unsure if a sound is being produced by an acoustic instrument or by electronic means; (b) electronics present a "noisier" commentary on an acoustic gesture, taking in account the sonic character of the gesture; and (c) electronics provide a backdrop against which the timbre of acoustic instruments is transfigured.

## 4 Pitch-Noise Continuum

Noise, especially when taken as an infinite multiplicity—e.g. as in *white noise*—has the nature of an abstraction encompassing all sounds. Like a raw marble block in the sculptor's studio, it exhibits the potential for generating all creations, that have to be carved *out of it*, filtered from the endless cacophony of other unwanted materialities.

As noted by Hainge (2013):

> White noise is a plane (that does not exist in actuality) composed of the sum total of all possible sonic frequencies emitted simultaneously. Any sonic expression is then necessarily the contraction into actuality of a zone of this plane or the conjugation of different points on this plane. Every expression is therefore born out of noise and carries noise within it. As expression passes into actuality, however, it is all to easy to forget this and to imagine that that expression is a discrete and autonomous object that exists independently of a greater whole, to concentrate on its content or identity as opposed to the process by which that content or identity comes to be expressed. It is, however, impossible for the content of expression to separate itself from the immanent plane out of which it is formed and the differential process through which it comes to be—'meaningful' expression becoming such only by contracting noise into a form that no longer seems noisy. (p. 18)

This idea finds its maximal expression in the thought of philosopher

Michel Serres, who argues for a perspective of noise as indeed the foundation, the primordial force, and the pervading background of the cosmos (Serres, 1982). All meaning is thus born out of noise: "Comme Aphrodite, mère de toute beauté, naquit d'un coup de l'écume et du ressac, émerge soudain de la mer chaotique du bruit: la Musique. Elle en lisse les épines et en intègre les signaux." (Serres, 2011, p. 20).

If, on one side, noise represents the cosmos, one the other side pitch represents the atom. Pitch, the minimum constituent of noise, is a pure tone, a single sine waveform, as obtained through a sinusoidal oscillator. Between noise and pitch there's an infinite continuous gradient of possibilities. Pitches accumulate and, given a large enough number of them, progressively start being perceived as noise. And noise, progressively removed of its constituents, acquires the impression of pitch.

There's nothing new in the establishment of a continuum between pitch and noise. For decades composers have been resorting to additional roles of pitch, including contrasting it to noise (Roads, 2015, pp. 208-212). Developments in electronic music prompted new ways of approaching sound materials and musical structures. In this context, e.g., Smalley (1986) introduces a spectral typology of sound, encompassing a continuum between note, node and noise. Regarding the specific techniques to peruse the continuum, Wishart (1994, p. 33) notes that it is possible to process initially unpitched sounds in order to give them pitch qualities, and one of the approaches to that effect involves narrow filters that "can single out narrow ranges of partials from a spectrum. A very narrow fixed filter can thus impose a marked spectral peak on the noisiest of sounds, giving it a pitched quality." He also observes: "Noisiness can be a matter of degree, particularly as the number of heard components in an inharmonic spectrum increases gradually to the point of noise saturation" (1994, p. 37). Furthermore, when considering the problem of integrating pitched and unpitched "architectures", he proposes an approach where "the imposition of stable resonant structures on complex (and noise-based) objects through, for example, filtering techniques may be a way of achieving a mediation between a morphologically-based and a lattice-based architecture in the musical structure" (Wishart, 1996, p. 107).

For *2458208*, I used the pitch-noise continuum as a major force in the unrolling of the musical narrative. In particular, many sounds present in the electronics part were created by starting with the recording of a noisy source, and then applying a bank of variable band-pass filters (or resonators) that could be extremely narrow if needed. The precision required to obtain the final effect demanded that filtering had to be done in the frequency domain, through analysis from the output of Fourier transforms and subsequent resynthesis. I found white noise or other distributions of energy in the sound spectrum ("red noise", etc.) uninteresting as initial sounds to be filtered, because they are too balanced and perfectly static in time. Instead, I recorded and used the sound from electric appliances, motors, traffic, street noise and other prosaic sources that surround us. This way, inherent dynamics in the spectrum of the original sources, changing constantly through time, would excite different bands of the filter, itself set up to periodically change the central frequencies of each band, according to a pre-established harmonic sequence. In addition, by increasing and decreasing the width of each band, the sound would resemble more either the original recording or a chord of pure sine waves. I set up a technical solution that allowed me to experiment and perform with these settings (see details in Section 6). The results were recorded and further processed to be played live, together with the ensemble.

## 5 Noise and Time

A periodic sound will be perceived as rhythm or pitch depending on the duration of each cycle. At the same time, and as observed by Stockhausen (1989, p. 93), "the continuum between sound and fixed pitch is nothing more than that between a more and a less stable periodicity: the noisiest noise being the most aperiodic".

It's possible to establish an analogy for the pitch-noise continuum in the temporal domain. A pure pitch is equivalent to a sequence of periodic onsets, and then as the conformance to a regular grid is progressively abandoned, through a myriad of techniques like syncopation, metrical ambiguity, tempo distortion, etc., the resulting sounds approach the pole of maximum irregularity, i.e. noise.

There is an *isomorphism between pitch and time* when the structures present in one of the domains can be mapped into structures of the other domain, thus preserving the relations between elements. It remains an ongoing debate whether the two domains interact or, on the contrary, function independently on listeners' musical perception (Costa, 2017, p. 32, and references therein). In any case, the transposition of musical ideas that deal with pitch into ideas that deal with time, and vice-versa, has been, for a long time, of great interest to musicians. Even when the analogy is not to be conceptually embodied in the musical work, or if the connection may remain elusive to the listener, it works as a tool in the composition process and as a catalyst of musical creativity.

In *2458202* I played with the gradient between rhythmic regularity and irregularity in a way that mirrors the gestures of the pitch layer.

# 6 Technical Implementation

## 6.1 Software and Motivation

The realization of the electronics part was accomplished using SuperCollider[1] together with a project called cl-collider[2], written in the programming language Common Lisp.

SuperCollider is a platform for audio synthesis and algorithmic composition, encompassing three components: (a) a synthesis server (scsynth), (b) a programming language (sclang), and (c) a development environment (scide). Of these, I only use the synthesis server, and communicate with it through messages exchanged in OSC protocol, sent and received by the cl-collider library. This library works as an alternative client to the server, replacing the "built-in" language. There's nothing wrong with sclang, though. It's fully-featured and offers useful abstractions for common tasks in the field of music. However, I had already invested significant time and energy learning Common Lisp, and wanted to benefit from my previous undertakings with it.

Lisp (a family of programming languages of which Common Lisp is a dialect) has a rich history in the development of musical systems. Examples of current projects written in Lisp and/or that rely on it are: PWGL[3], OpenMusic[4], Common Music[5], Slippery Chicken[6], Opusmodus[7], Incudine[8], and Lilypond[9]. Other than historical reasons—Lisp was one of the first high-level programming languages, once prevalent in academia, particularly in artificial intelligence research—some of its features may explain why it has been favored in the musical domain. It offers ample support for the linked list as a basic data structure, which is convenient to use in conjunction with symbolic music materials, like short sets, series, chords, scales, rhythmic figures, etc. Lisp simplifies many aspects of computer operation

[1]https://supercollider.github.io/
[2]https://github.com/byulparan/cl-collider
[3]http://www2.siba.fi/PWGL/
[4]http://repmus.ircam.fr/openmusic/home
[5]http://commonmusic.sourceforge.net/
[6]http://www.michael-edwards.org/sc/
[7]http://opusmodus.com/
[8]http://incudine.sourceforge.net/
[9]http://lilypond.org/

through automatic memory management, dynamic typing, first class functions, and a uniform syntax. It's flexible, multi-paradigm, and extensible through a state-of-the-art macro facility. Coding in Lisp is associated with an interactive, incremental style of development that mimics the process of exploring and progressively furthering musical ideas practiced by many composers and musicologists. This said, it must be stressed that various languages may offer the same or other advantages. In the end, language choice is first and foremost a matter of personal preference.

Cl-collider is an open-source library created by Park Sungmin, with contributions from others. It's still classified by the author as an experimental project, currently under active development. Despite some rough edges, it's advantageous for those willing to erect customized systems over basic building blocks, combining a powerful general-purpose programming language with a synthesis server loading ready-made unit generators. This tooling combination enabled me to work in a text-based environment, as is my preference, using abstractions that hide away the intricacies of low-level digital sound processing, all in a subjectively efficient, flexible, expressive and scalable manner.

## 6.2 Controlling Resonances

What follows is a partial illustration of how cl-collider helped in creating a bank of very narrow band pass filters, with continuously-controllable bandwidth, that processes an original sound, while automatically sequencing a predefined set of harmonic fields.

The code in Listing 1 defines a brick-wall band pass filter using the output of a fast Fourier transform (FFT) and subsequent resynthesis through the inverse FFT.

```
(defsynth band ((in-bus 0) (out-bus 0)
                (freq 440) (q 20) (q-mod-depth 0))
  (let* ((in (in.ar in-bus 2))
         (q (+ q (mouse-x.kr (- 0 q-mod-depth) q-mod-depth)))
         (chain (fft (local-buf '(8192 8192)) in))
         (chain (pv-brick-wall chain
                               (* (sample-dur.ir) (+ (- freq q)))))
         (chain (pv-brick-wall chain
                               (- (* (sample-dur.ir) (+ freq q)) 1)))
         (out (ifft.ar chain)))
    (out.ar out-bus out)))
```

Listing 1: Defining the FFT band pass filter.

By adjusting `q` it's possible to expand or contract the width of frequencies allowed to pass through. As it nears zero, the sound will approximate a sine wave with a frequency of `freq`. Larger values will open the bandwidth—still centered on `freq`—thus producing more and more of the original noisy sound. By mapping this value to the horizontal position of the mouse cursor on screen, I had a straightforward way to perform along the pitch-noise continuum in real time.

Code Listing 2 shows the functions that create the filter bank and that add a number of overtones to each of the pitches in a chord. The second function (`harmonics`) contains a basic example of leveraging previously written code, assembled in a personal library for algorithmic composition, TROCADOLIB[10].

```
(defun multi-band (in-bus out-bus freqs q)
  (make-array (length freqs)
              :initial-contents (mapcar (lambda (x)
                                          (synth 'band :in-bus in-bus
                                                       :out-bus out-bus
                                                       :freq x
                                                       :q q
                                                       :q-mod-depth 50
                                                       :to *fx-group*))
                                        freqs)))

(defun harmonics (chord harm)
  (loop :for n :in chord :append (trocadolib:harmonic-series n harm)))
```

Listing 2: Functions to produce an array of filters and to add overtones.

In Listing 3, the function `new-freqs` iterates over all the active filters and simultaneously changes their center frequencies, introducing a new chord. Then `chord-changes` is responsible for scheduling the progression of chords, over time, in the harmonic sequence.

```
(defun new-freqs (synth-array freqs)
  (when (= (length synth-array) (length freqs))
    (loop :for s :across synth-array
          :for f :in freqs
          :do (ctrl s :freq f))))

(defun chord-changes (time synths changes)
  (if changes
      (let ((next-time (+ time 10)))
        (at time (new-freqs synths (first changes)))
        (callback next-time #'chord-changes
                  next-time synths (rest changes)))
```

[10] https://github.com/ntrocado/trocadolib

```
      (progn
        (free-all synths)
        (stop))))
```

Listing 3: Changing the center frequency of all active filters.

Finally, the code in Listing 4 sets everything up. The function `play-through` accepts a chord sequence, which is computed elsewhere in the program. I used sequences with nine chords, or harmonic fields, each of them with eight voices, and a variable number of added pitches, between two and ten, for each of the voices (the `overtones`). The loading of an audio recording into a buffer (`*wav*`) and the mechanisms for sample playback and processing are also defined elsewhere in the program.

```
(defun play-through (chord-seq overtones)
  (let* ((f-chords (mapcar (lambda (chord)
                              (mapcar #'midicps
                                      (harmonics chord overtones)))
                            chord-seq))
         (bands (multi-band *fx-bus* 0
                             (mapcar #'midicps
                                     (harmonics (first chord-seq)
                                                overtones))
                             52))
         (sound (synth 'play-wav
                       :bufnum *wav*
                       :rate 1
                       :start 0
                       :amp 0.5
                       :out-bus *fx-bus*)))
    (declare (ignore sound))
    (chord-changes (now) bands f-chords)))
```

Listing 4: Playing through the harmonic progression.

## 7 Conclusion

Beyond the abrasive, the cacophonous, the subversive, we find under the umbrella of noise a number of distinct ideas that may serve as a framework for musical creation, from morphological aspects to the development of sonic narratives. And beyond instrumental techniques, the use of electronic sound sources and audio processing provides ample opportunity for reflection on the concept of noise and its semantic implications among a taxonomy of sounds. I've been mindful of these ideas in recent works, and they were clearly present in a variety of forms during the composition of *2458202*.

## References

Costa, N. A. P. T. da (2017). *Interacção humano-máquina no processo composicional* (Master's thesis, Escola Superior de Música, Artes e Espectáculo, Porto, Portugal).

Demers, J. (2010). *Listening through the noise*. doi:10.1093/acprof:oso/9780195387650.001.0001

Hainge, G. (2013). *Noise matters: Towards an ontology of noise*. New York, NY, United States: Bloomsbury.

Keizer, G. (2010). *The unwanted sound of everything we want: A book about noise*. New York, NY, United States: Public Affairs.

McDonnell, M. D., & Abbott, D. (2009). What is stochastic resonance? definitions, misconceptions, debates, and its relevance to biology. *PLoS Computational Biology*, *5*(5), e1000348. doi:10.1371/journal.pcbi.1000348

Moles, A. A. (1957). Théorie de l'information et perception esthétique. *Revue Philosophique de la France et de l'Étranger*, *147*, 233–242.

Roads, C. (2015). *Composing electronic music*. doi:10.1093/acprof:oso/9780195373233.001.0001

Rolls, E. T., & Deco, G. (2010). The noisy brain: Stochastic dynamics as a principle of brain function. doi:10.1093/acprof:oso/9780199587865.001.0001

Serres, M. (1982). *Genèse*. Paris, France: Grasset et Fasquelle.

Serres, M. (2011). *Musique*. Paris, France: Le Pommier.

Shannon, C. E. (1948). A mathematical theory of communication. *Bell System Technical Journal*, *27*(3), 379–423. doi:10.1002/j.1538-7305.1948.tb01338.x

Smalley, D. (1986). Spectro-morphology and structuring processes. *The Language of Electroacoustic Music*, 61–93. doi:10.1007/978-1-349-18492-7_5

Stockhausen, K. (1989). Four criteria of electronic music. In *Stockhausen on music* (pp. 88–111). London: Marion Boyers.

Vanderkooy, J., & Lipshitz, S. P. (1984). Resolution below the least significant bit in digital systems with dither. *Journal of the Audio Engineering Society*, *32*(3), 106–113.

Wishart, T. (1994). *Audible design: A plain and easy introduction to practical sound composition*. York, UK: Orpheus the Pantomine.

Wishart, T. (1996). *On sonic art*. doi:10.4324/9781315077895