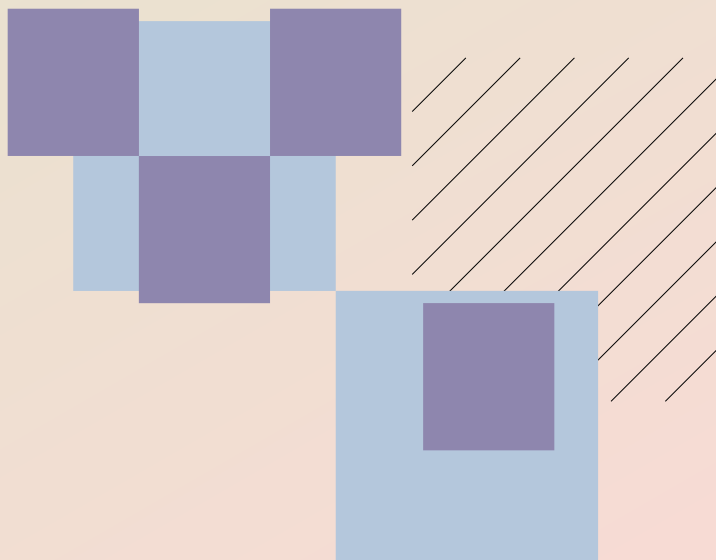


The cognitive algorithm a music listening model and tool for music analysis

Joséphine Calandra, PhD Student (3rd year)
supervised by Jean-Marc Chouvel (IReMus)
and Myriam Desainte Catherine (LaBRI)

November 10th 2021



Numerical tools for music analysis

A little bit of history

- Information Theory

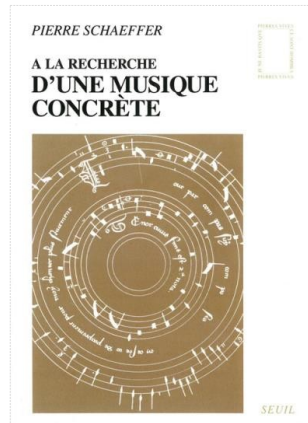
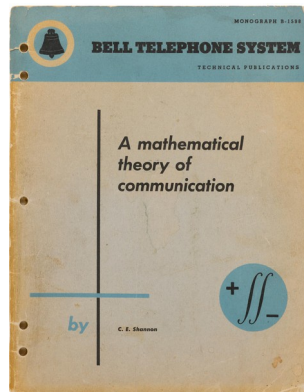
Shannon, C.E. *A Mathematical Theory of Communication*, The Bell System Technical Journal, vol.27, p 379-423, 1948.

- Concrete Music (P. Schaeffer, 1949)

→ **Objet sonore (acoustic object)** : *acoustic event which is isolated from its original context and examined for its natives characteristics, excluded from the normal temporal continuum.*

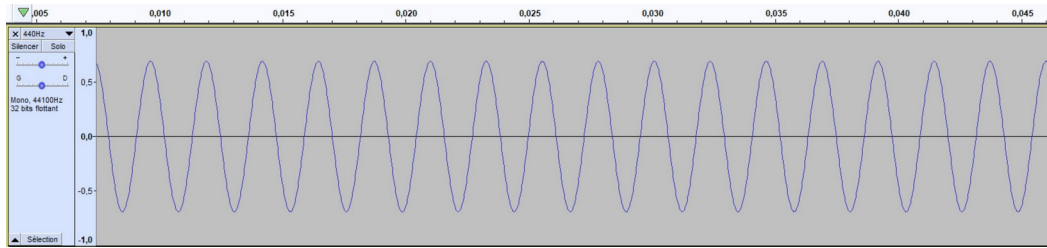
Schaeffer, P. *A la recherche d'une musique concrète*, Éditions du Seuil, Paris, 1952.

- Creation of the *Groupe de Recherches Musicales* (GRM - Musical Researches Group, 1958)

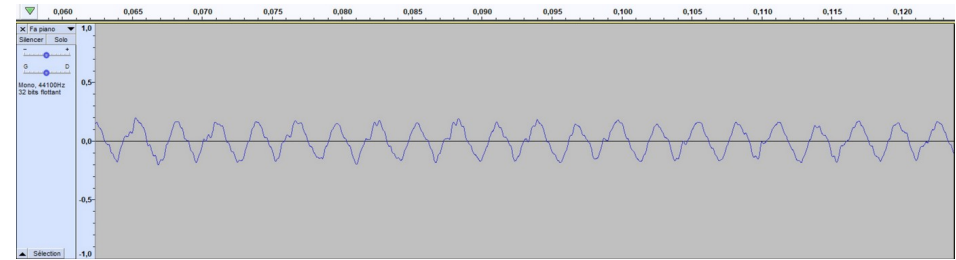


<https://inagrm.com/fr>

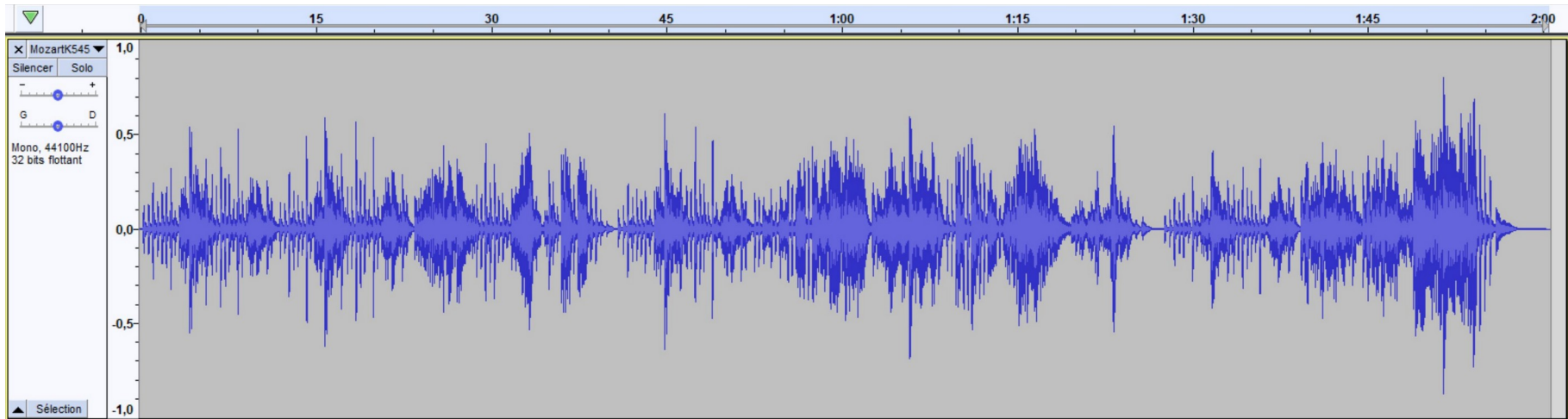
The waveform



Pure sinusoid, 440Hertz

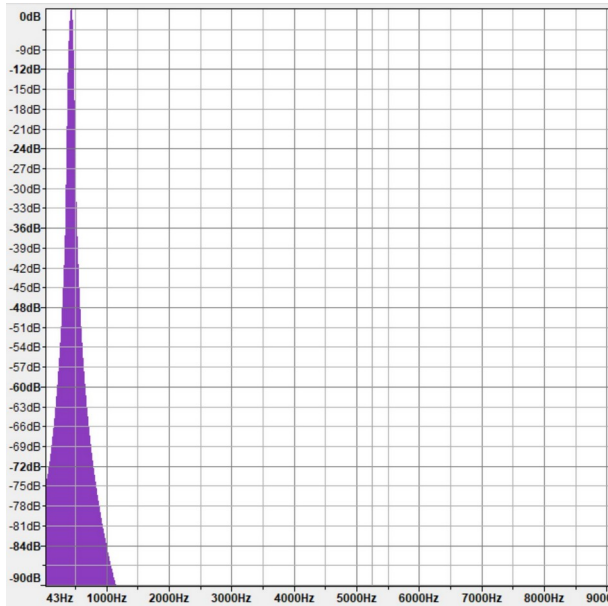


Piano, 349.23Hertz

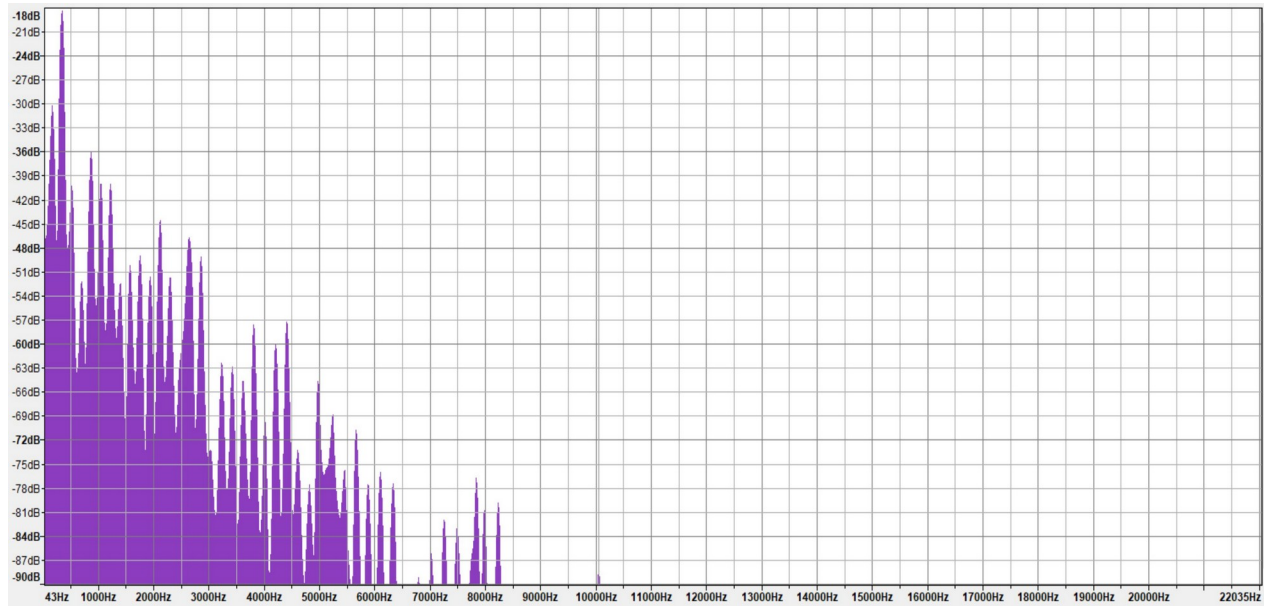


Sonata n° 16 for piano, rondo, Wolfgang Amadeus Mozart.

The frequency spectrum

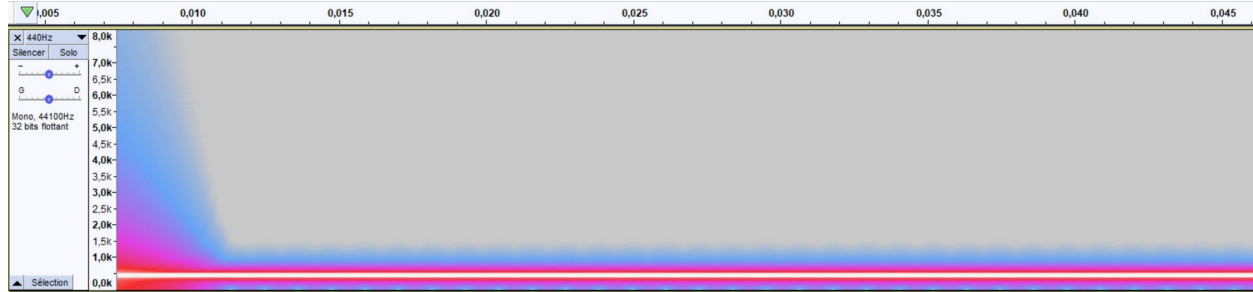


Pure sinusoid, 440Hertz

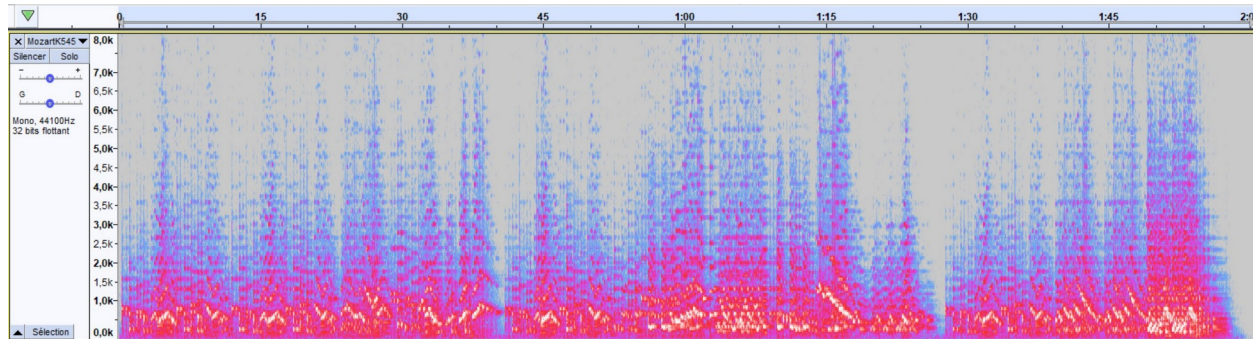


Piano, 349.23Hertz

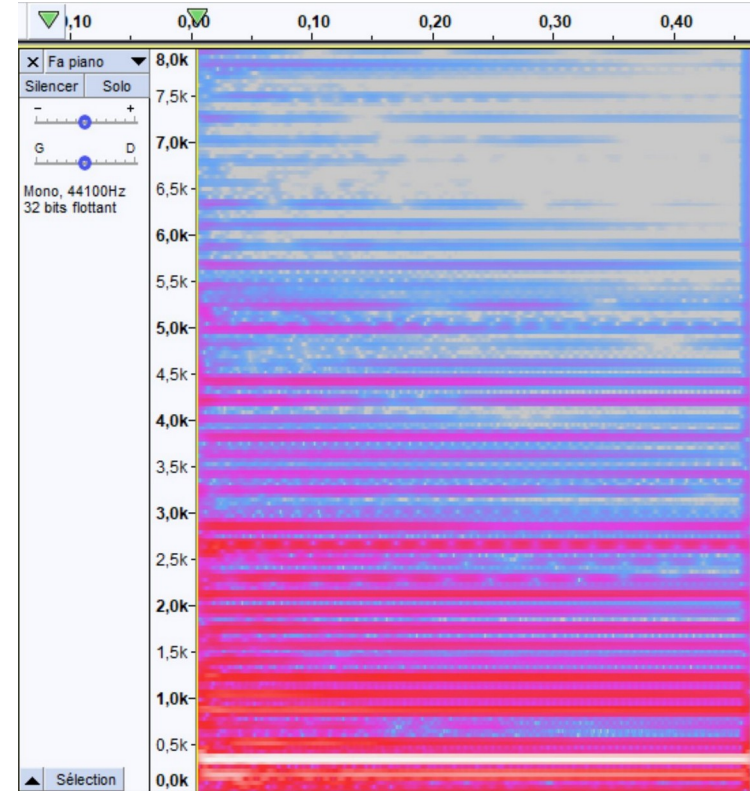
The sonagram



Pure sinusoid, 440Hertz

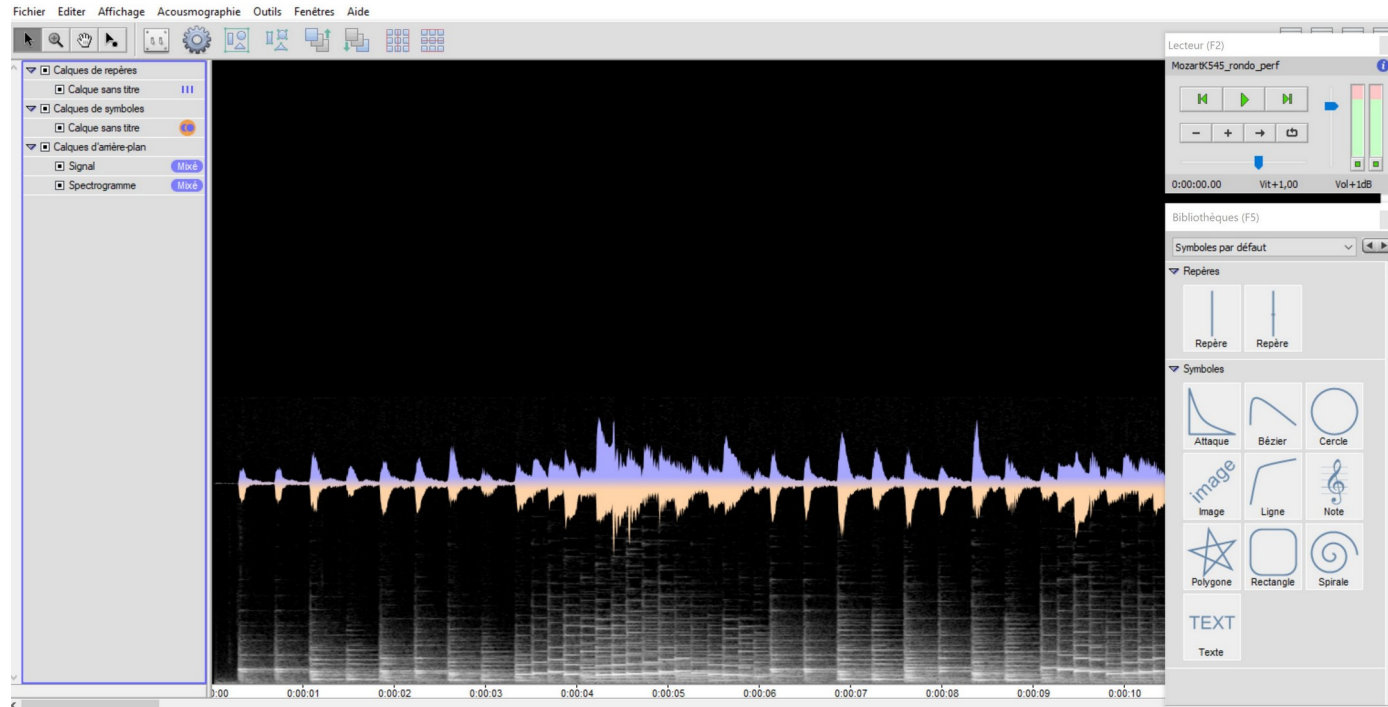


Sonata n° 16 for piano, rondo, Wolfgang Amadeus Mozart.



Piano, 349.23Hertz

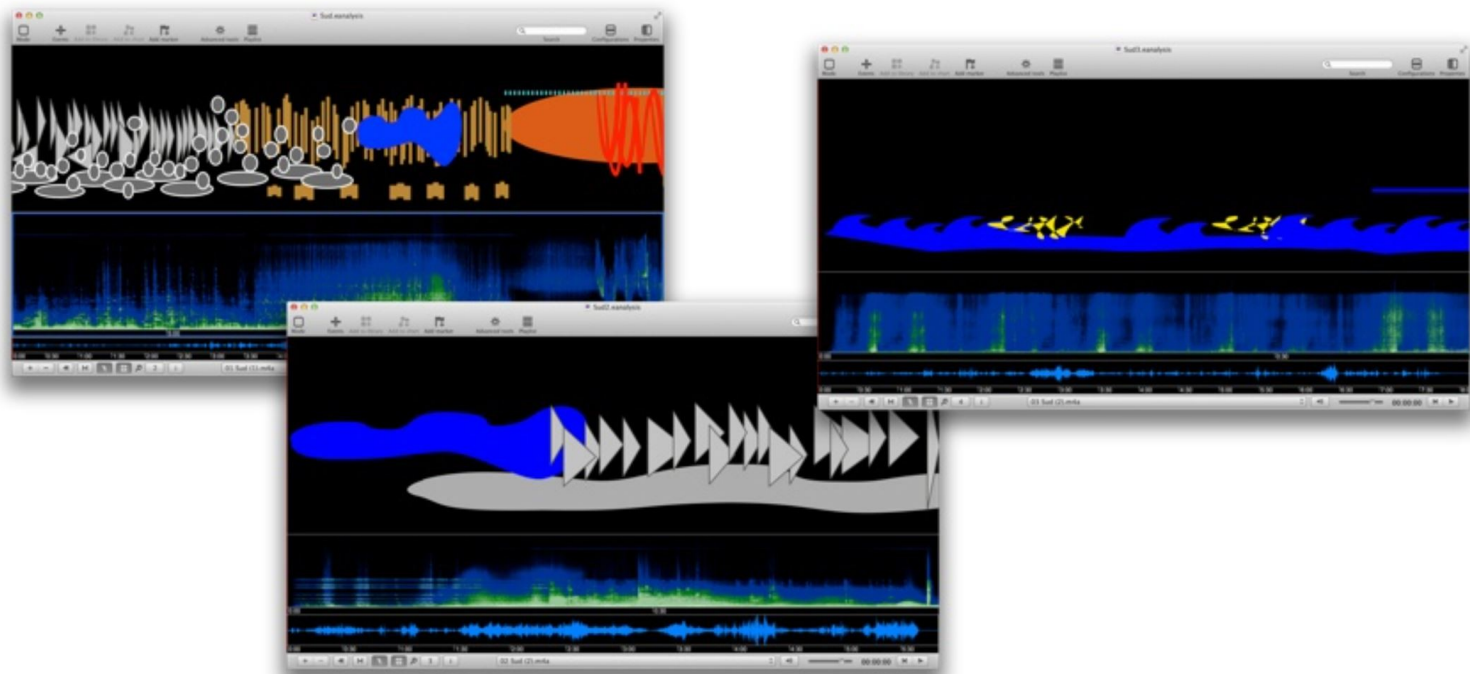
The acousmograph



Sonata n° 16 for piano, rondo, Wolfgang Amadeus Mozart.

Koechlin, O. et Vinet, H. « The Acousmographie, a Macintosh software for the graphical representation of sounds » in Proceedings of the International Computer Music Conference, pp. 586-588. Montreal: Faculty of Music, McGill University 1991.

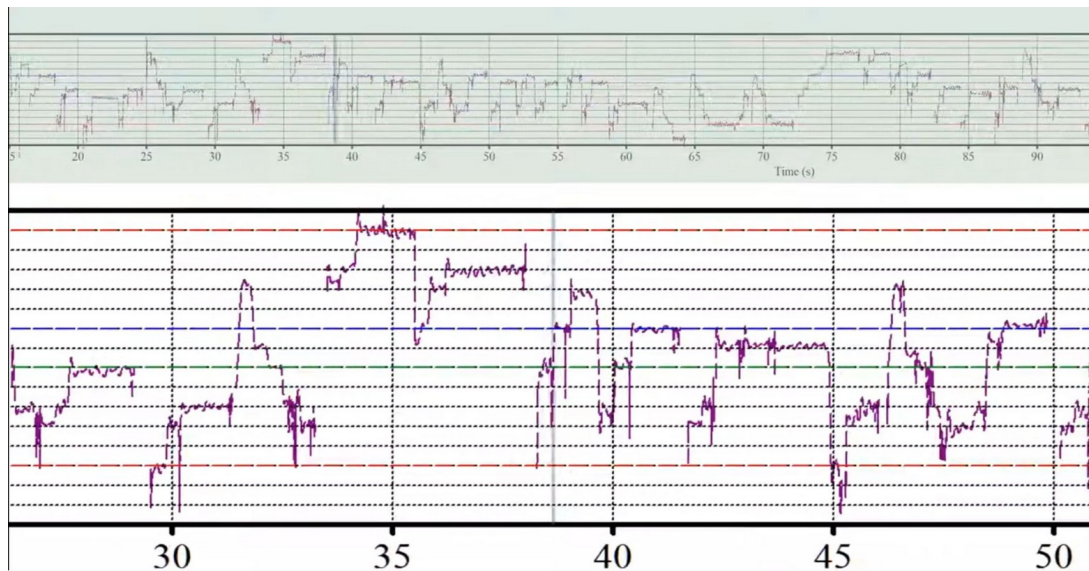
E-Analysis



Sud de Jean-Claude Risset, représentation par Pierre Couprie

http://logiciels.pierrecouprie.fr/?page_id=402

PRAAT

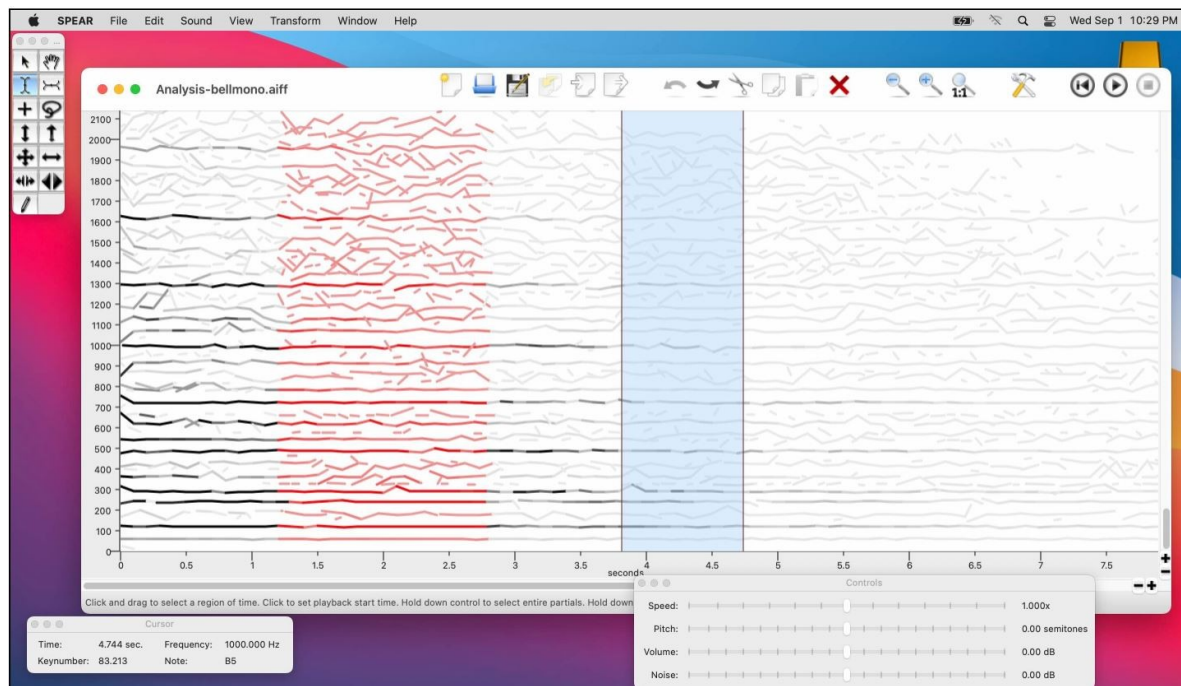


Hurrian song 6 (h6), analysis from CERMAA
<https://analyses.foreofico.org/other/hurrian-song-6-h6>

www.praat.org.

Boersma, P. van Heuven, V. *Speak and unSpeak with Praat*. Glot International. 5 (9/10): 341-347, 2001

SPEAR



<https://www.klingbeil.com/spear/>

Klingbeil, Michael *Software for spectral Analysis, Editing and Synthesis*. International computer music conference (ICMC) 2005.

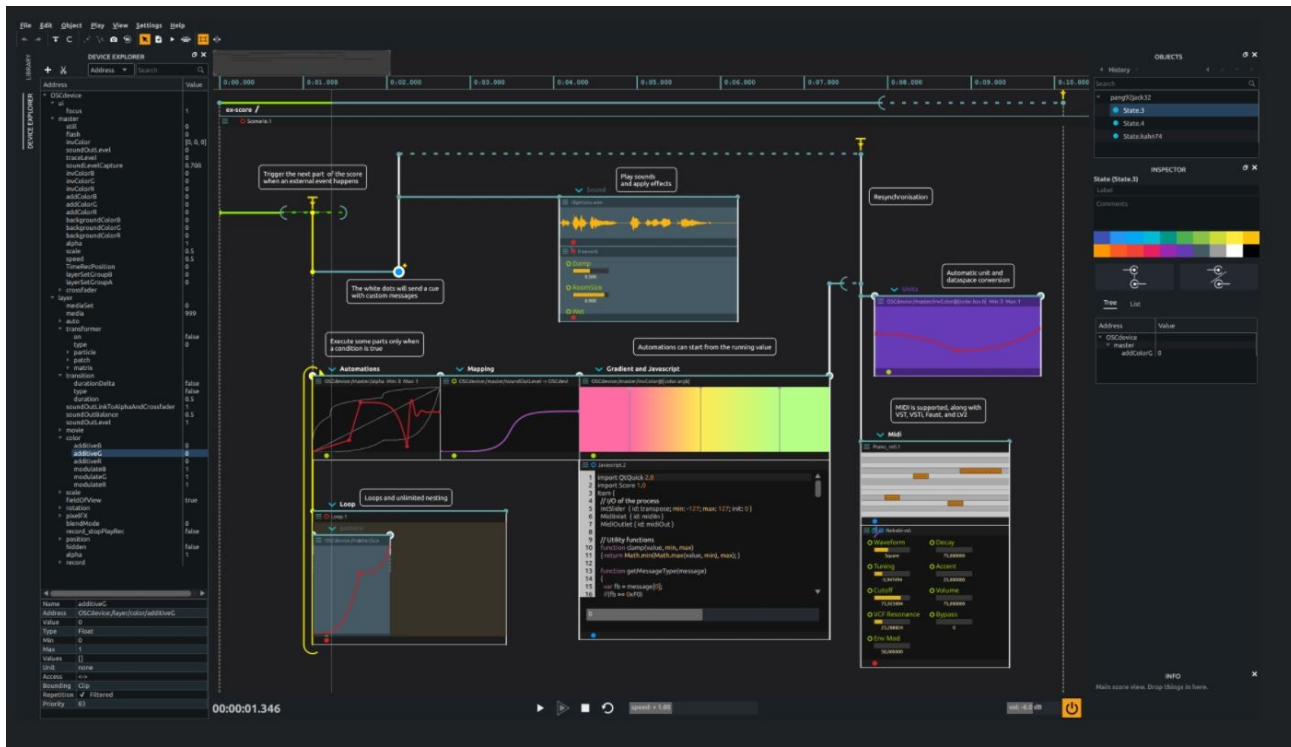
Antescofo



<https://antescofo-doc.ircam.fr/>

Cont, A. *ANTESCOFO : Anticipatory Synchronization and Control of Interactive Parameters in Computer Music*, International Computer Music Conference (ICMC), p.33-40, Belfast, Ireland, 2008. hal00694803

OSSIA-Score



<https://ossia.io/>

J.-M. Celerier, P. Baltazar, C. Bossut, N. Vuaille, J.-M. Couturier, and al., *Ossia: Towards a unified interface for scoring time and interaction*, in Proc. Int. Conf. On Technologies for Music Notation and Representation - TENOR 2015, Paris, France, 2015.

Analysis and cognition

- Musical semiology

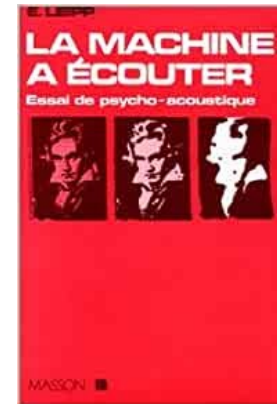
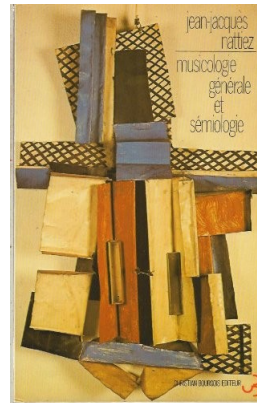
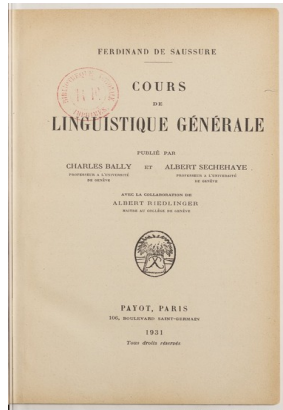
Nattiez, J.-J. Musicologie générale et sémiologie. Christian Bourgois, 1987.

- Notions of paradigm and syntagm

De Saussure, F. Cours de linguistique générale. Payot, Paris, 1906.

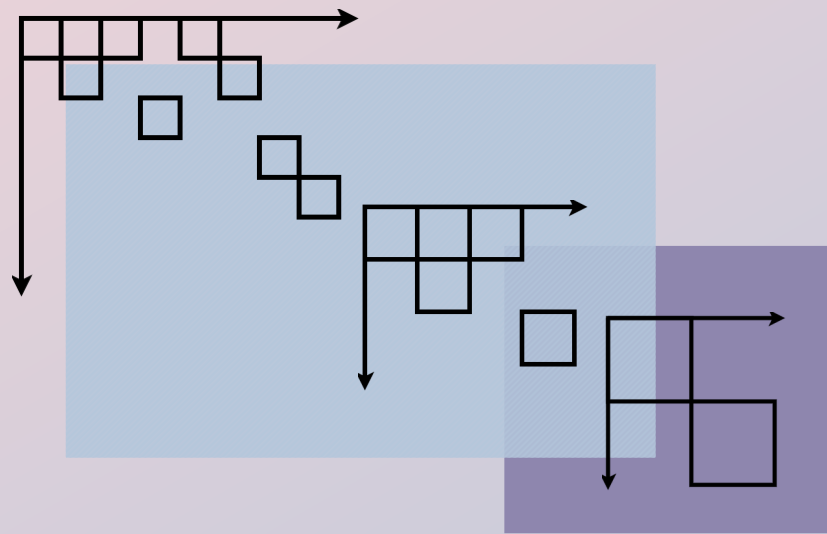
- « *Machine à Ecouter* » (Listening Machine)

Leipp, E. La Machine à Ecouter, Essai de psychoacoustique. Masson, Paris, 1977



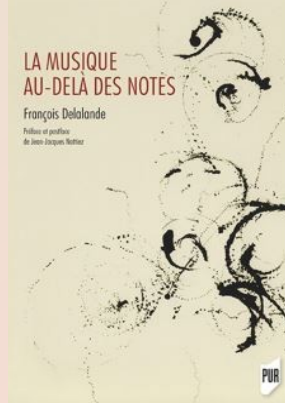
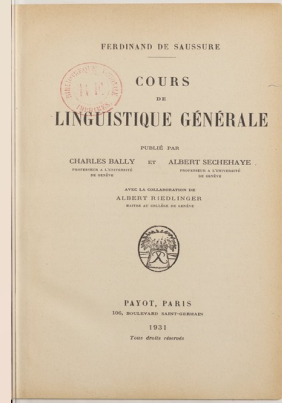
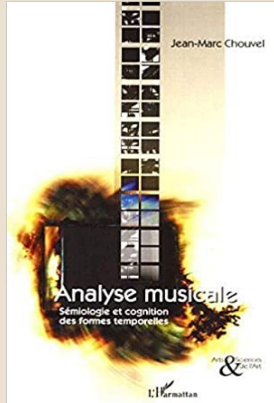
The cognitive algorithm

Objectives and state of the art



Objectives and state of the art

- Modelise the music structure and the paradigmatic analysis, automate this modelisation
 - Proposition of a model that is submitted to the listening constraints
 - Parametrisation of the system



- Chauvel, J.-M. *Analyse Musicale, sémiologie et cognition des formes temporelles*, L'Harmattan, Paris, 2006.
- De Saussure, F. *Cours de linguistique générale*. Payot, Paris, 1906.
- Delalande, F. *La musique au-delà des notes*. Presse Universitaires de Rennes, 2019.

Objectives and state of the art

- Monitor the algorithm to understand :
 - The algorithm's computational load
 - The attention's phenomenons



Ottolaske.com

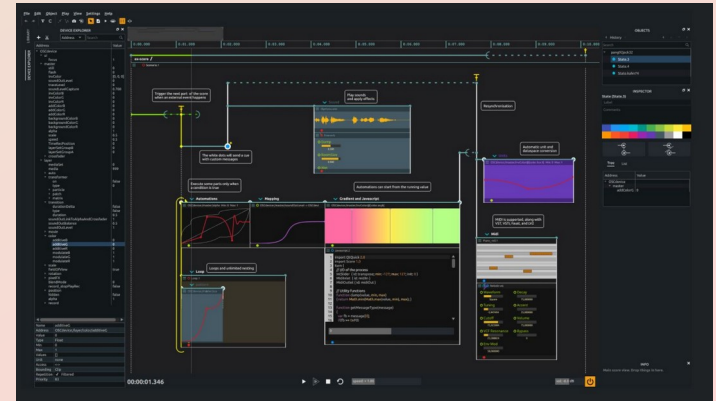
- Laske, O.E. *Music, Memory and Thought, explorations in Cognitive Musicology*. University Microfilms, International, Ann Arbor (MI), 1977.

Objectives and state of the art

- Represent this modelisation
 - Difficulty as we produce a hierarchy of diagrams
- Propose an accessible pluggin for musicologists
 - Integration in ossia-score.

- J.-M. Celerier, P. Baltazar, C. Bossut, N. Vuaille, J.-M. Couturier, and al., *Ossia: Towards a unified interface for scoring time and interaction*, in Proc. Int. Conf. On Technologies for Music Notation and Representation - TENOR 2015, Paris, France, 2015.

ossia.io



Axioms

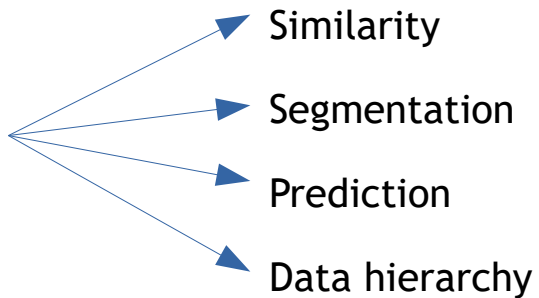
Which definition of music ?

We define music as a succession of objects, each object being an instance of materials.

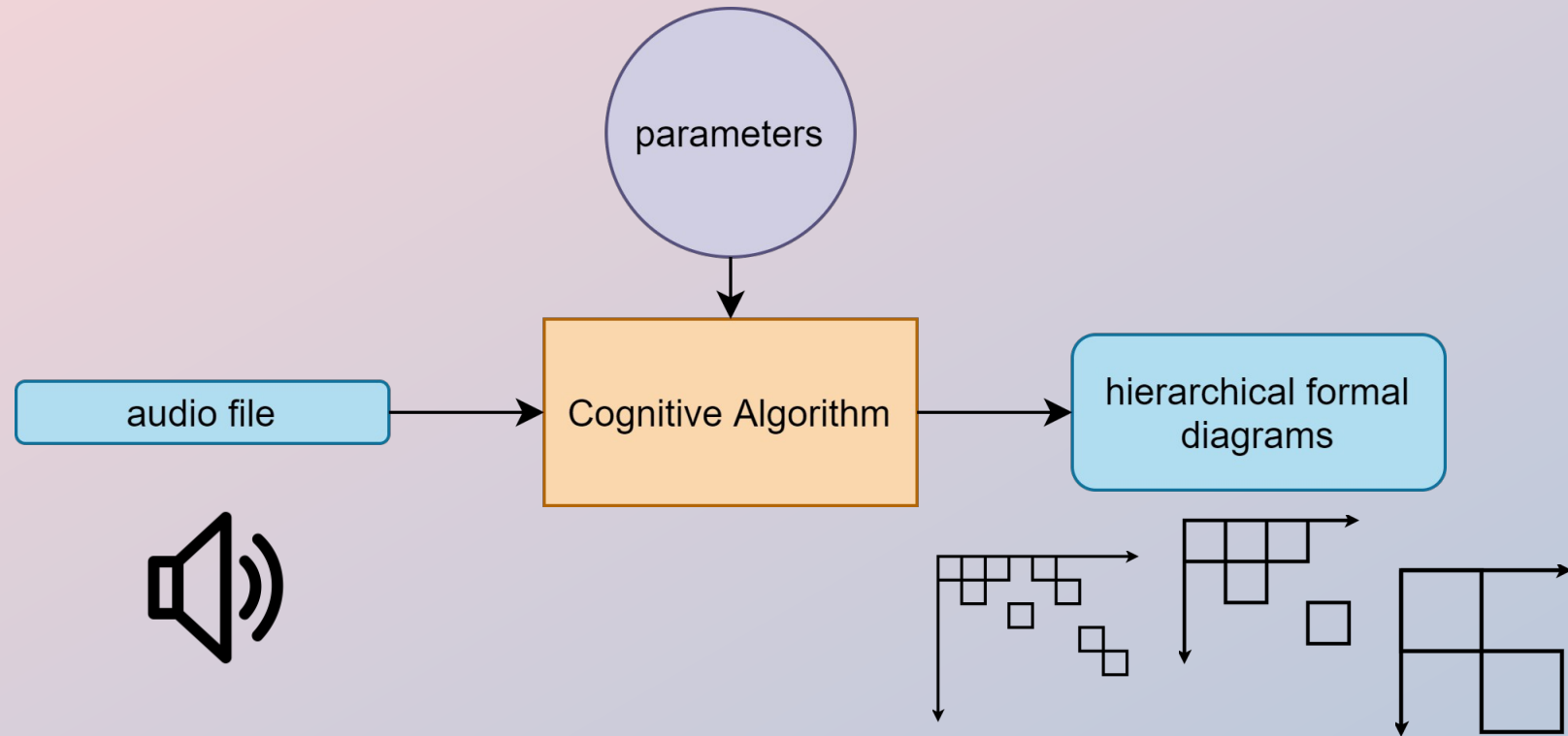
For now, transitions between objects are considered as objects.



Music listening
operations

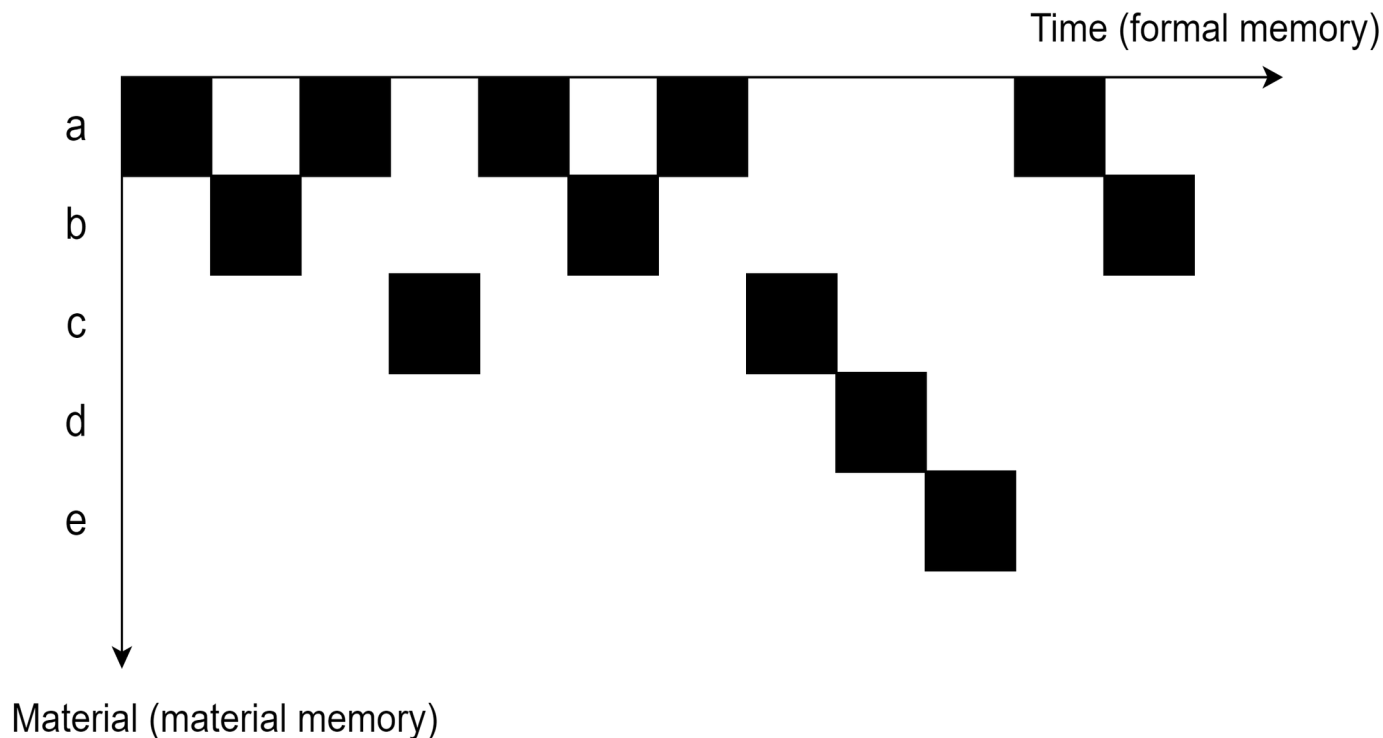


The Cognitive algorithm - Presentation



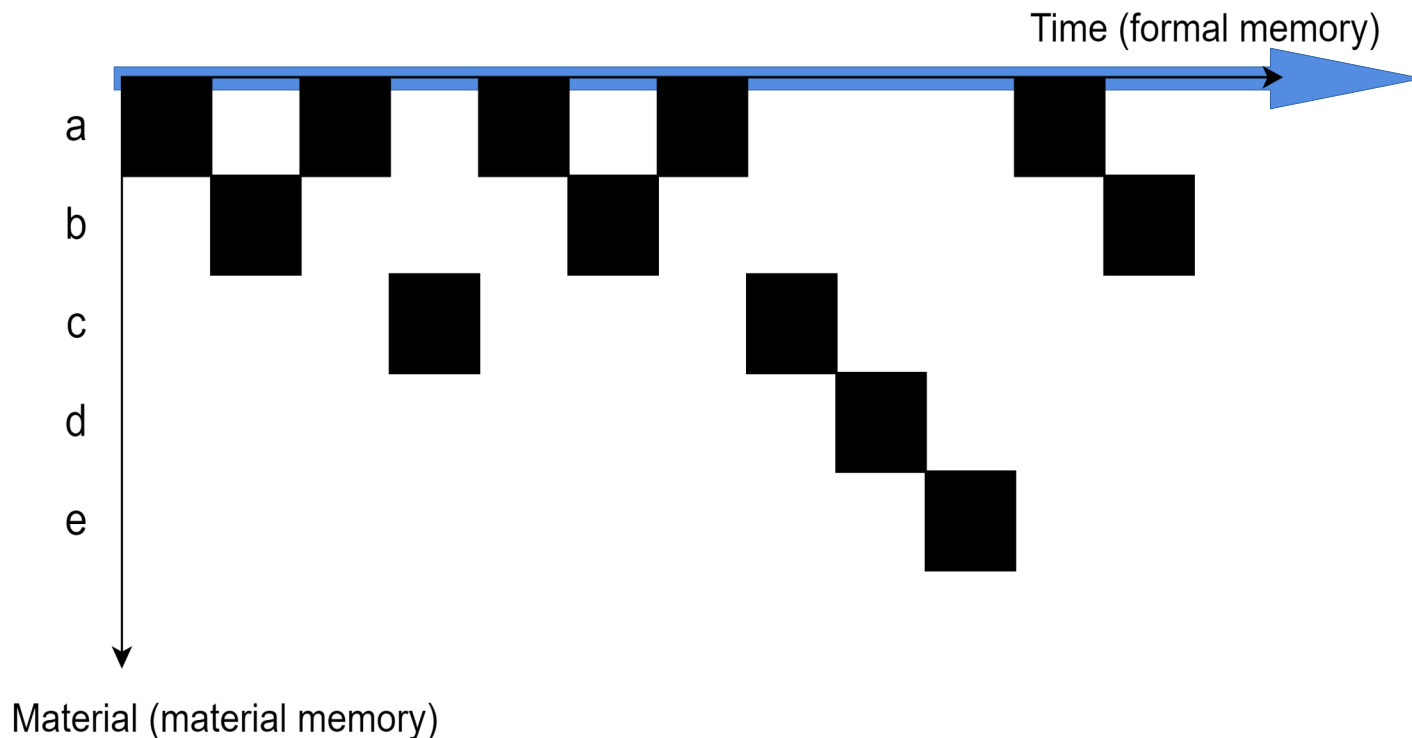
Formal Diagram - Presentation

Formal diagram of a piece of music associated with
the sequence of encoded materials « abacabacdeab »



Formal Diagram - Presentation

Formal diagram of a piece of music associated with
the sequence of encoded materials « abacabacdeab »



Formal Diagram - Presentation

Formal diagram of a piece of music associated with
the sequence of encoded materials « abacabacdeab »

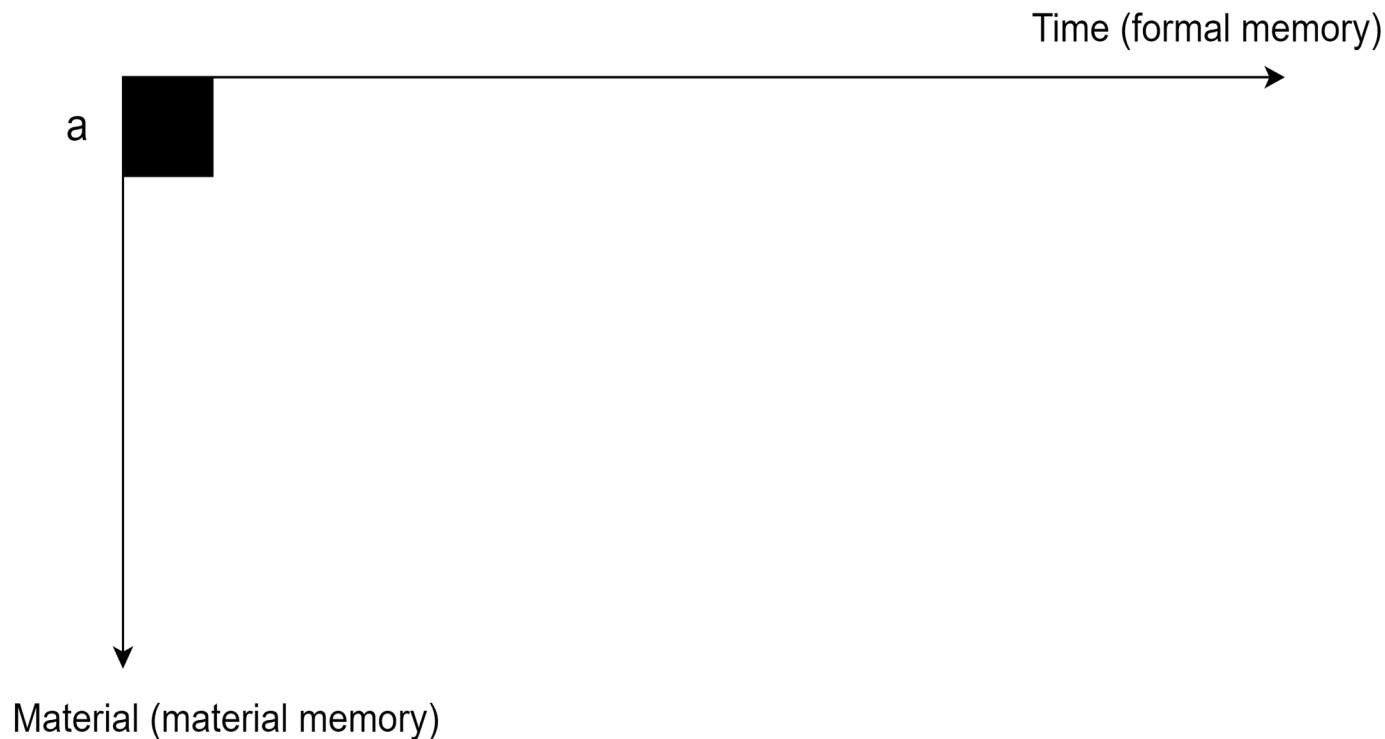
Time (formal memory)



Material (material memory)

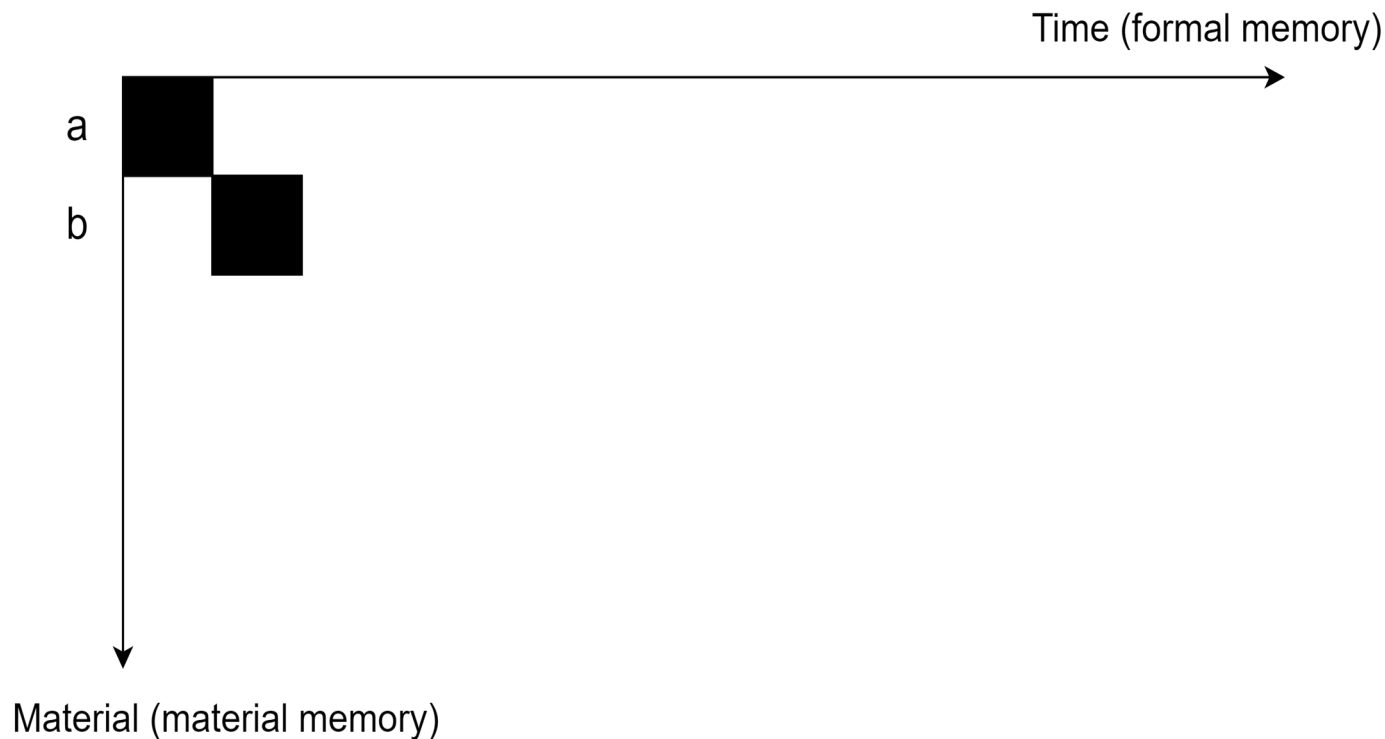
Formal Diagram - Presentation

Formal diagram of a piece of music associated with
the sequence of encoded materials « abacabacdeab »



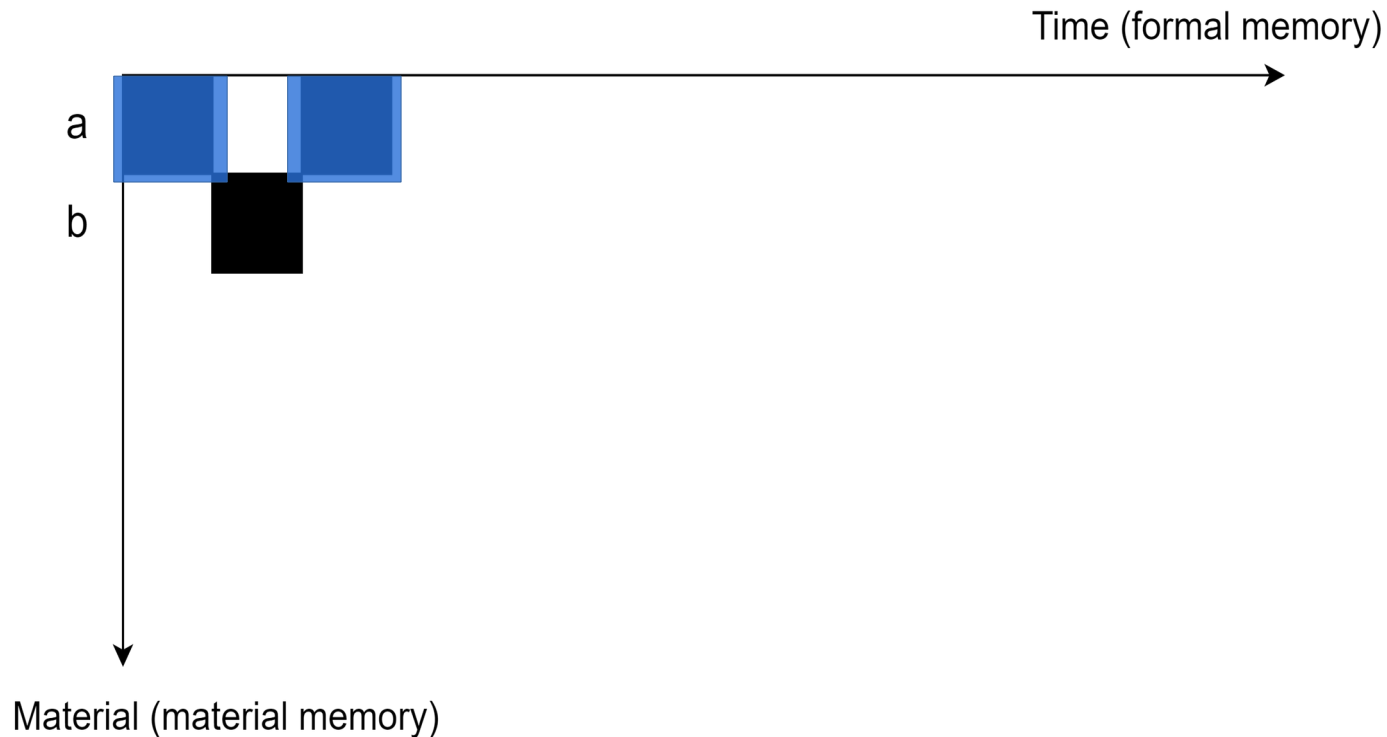
Formal Diagram - Presentation

Formal diagram of a piece of music associated with
the sequence of encoded materials « abacabacdeab »



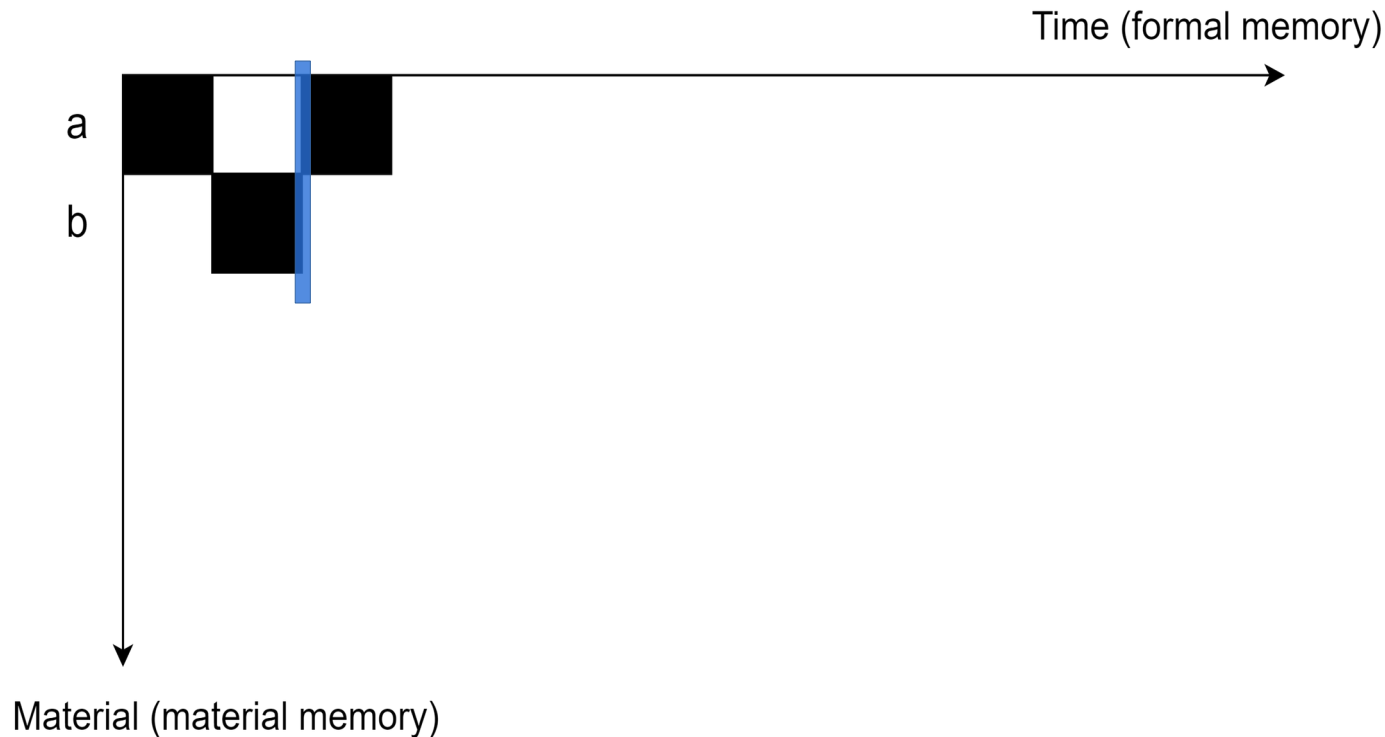
Formal Diagram - Presentation

Formal diagram of a piece of music associated with
the sequence of encoded materials « abacabacdeab »



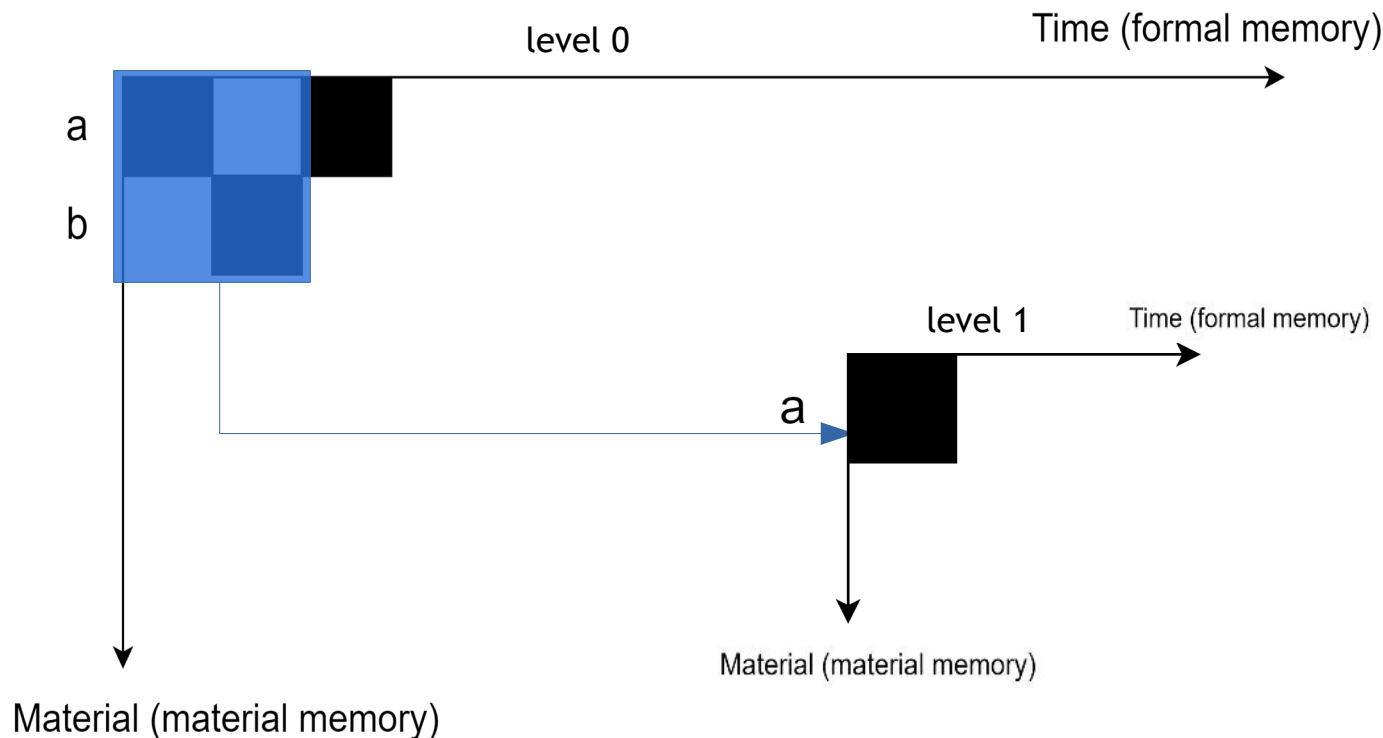
Formal Diagram - Presentation

Formal diagram of a piece of music associated with the sequence of encoded materials « abacabacdeab »



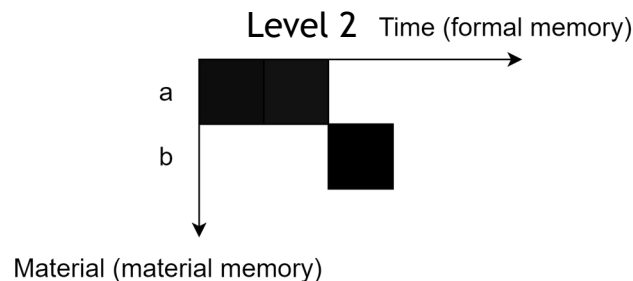
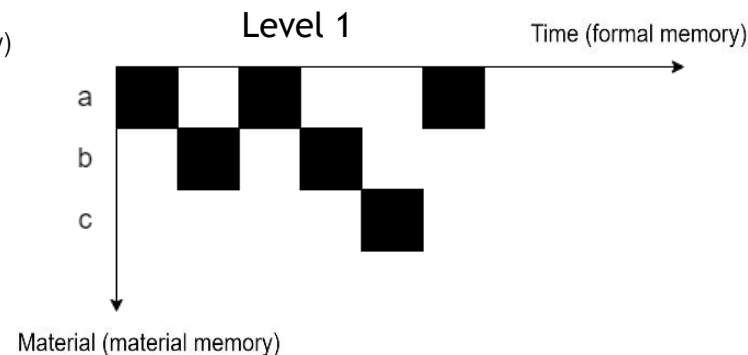
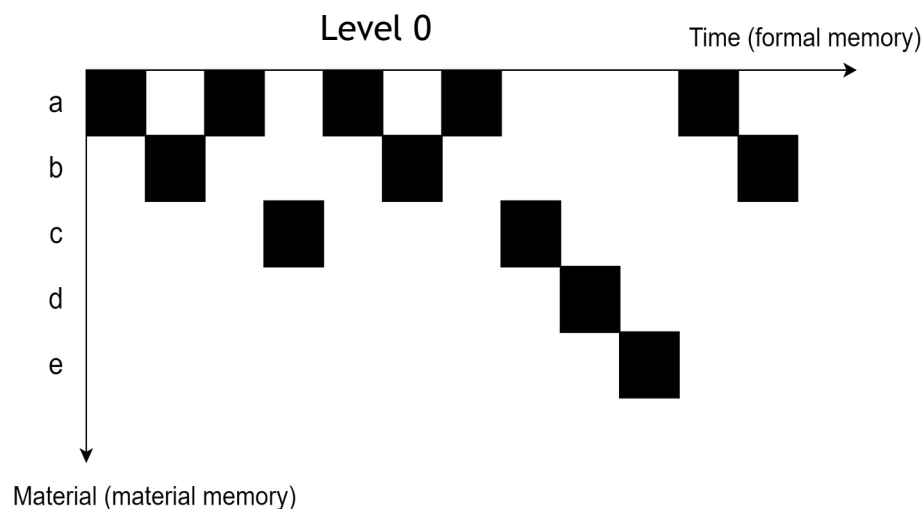
Formal Diagram - Presentation

Formal diagram of a piece of music associated with the sequence of encoded materials « abacabacdeab »

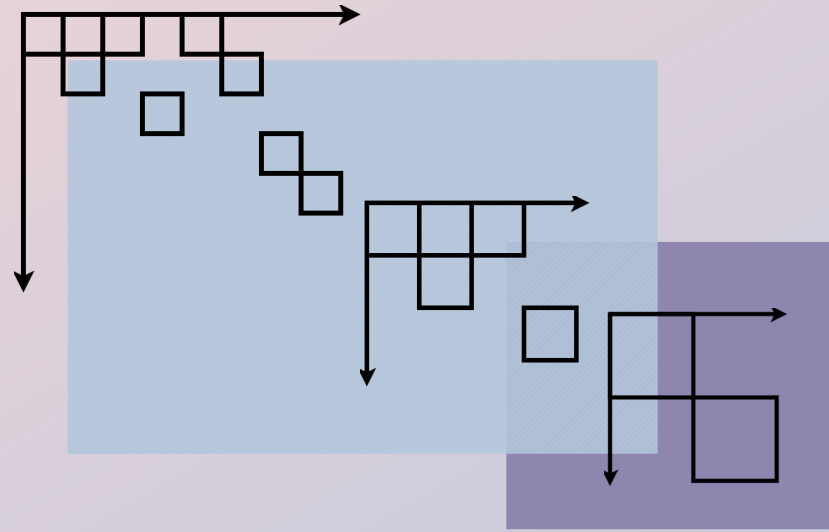


Formal Diagram - Presentation

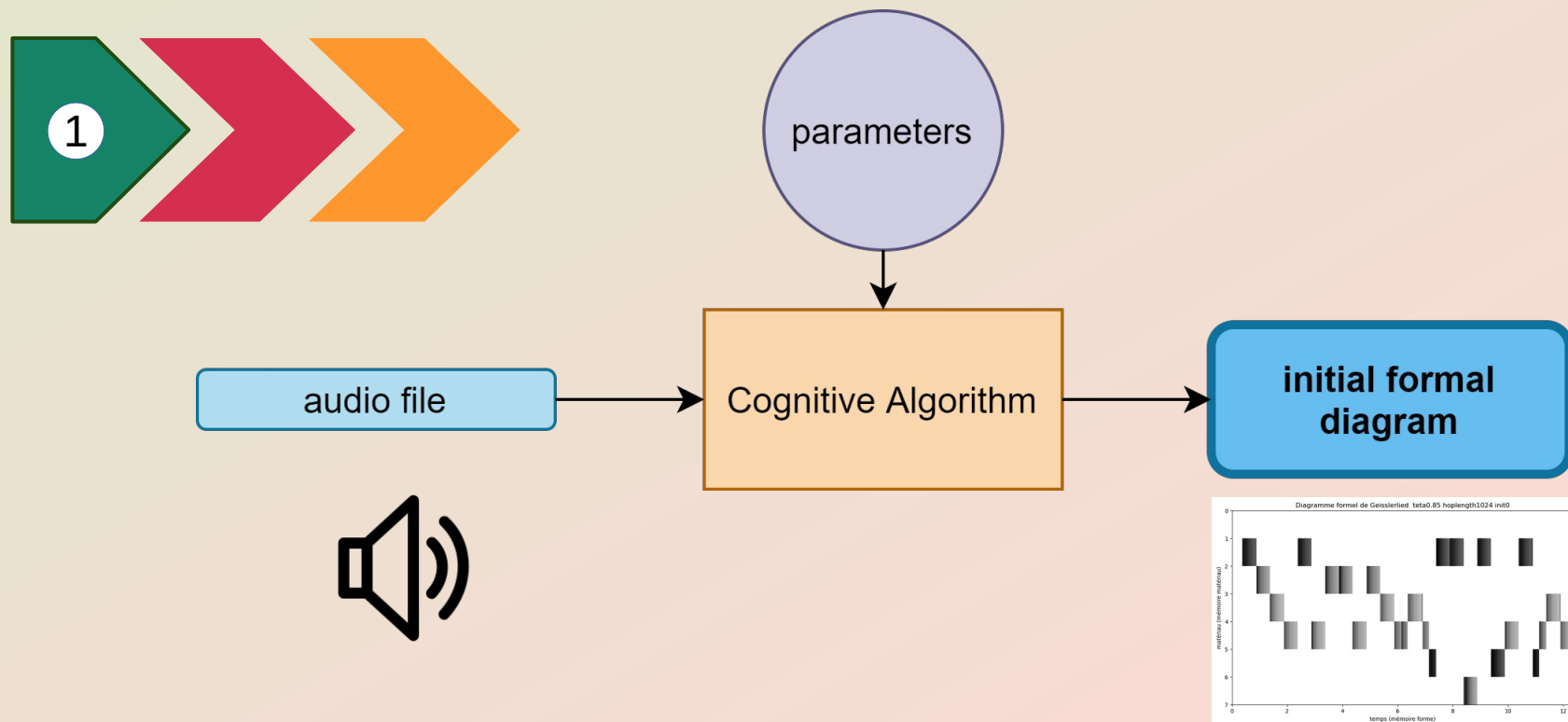
Formal diagrams of a piece of music associated with the sequence of encoded materials « abacabacdeab » at level 0



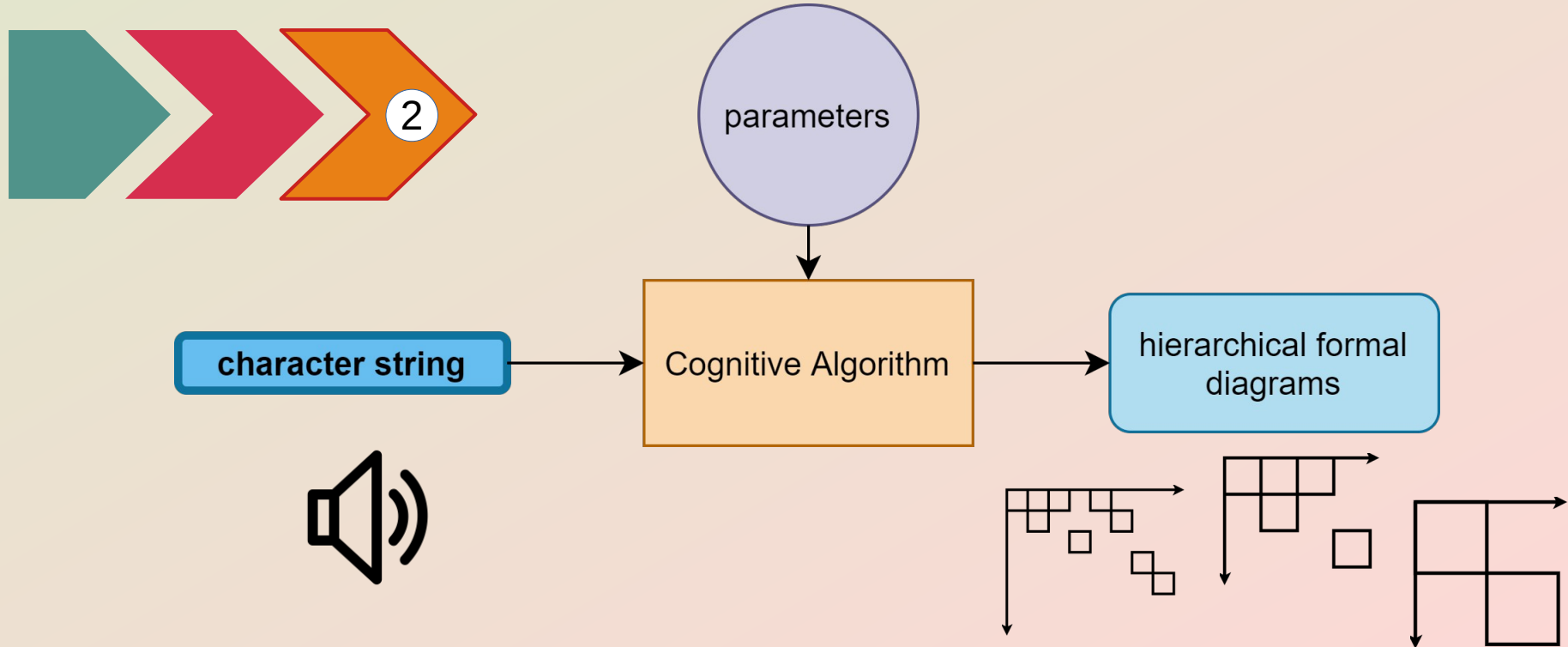
Algorithm implementation



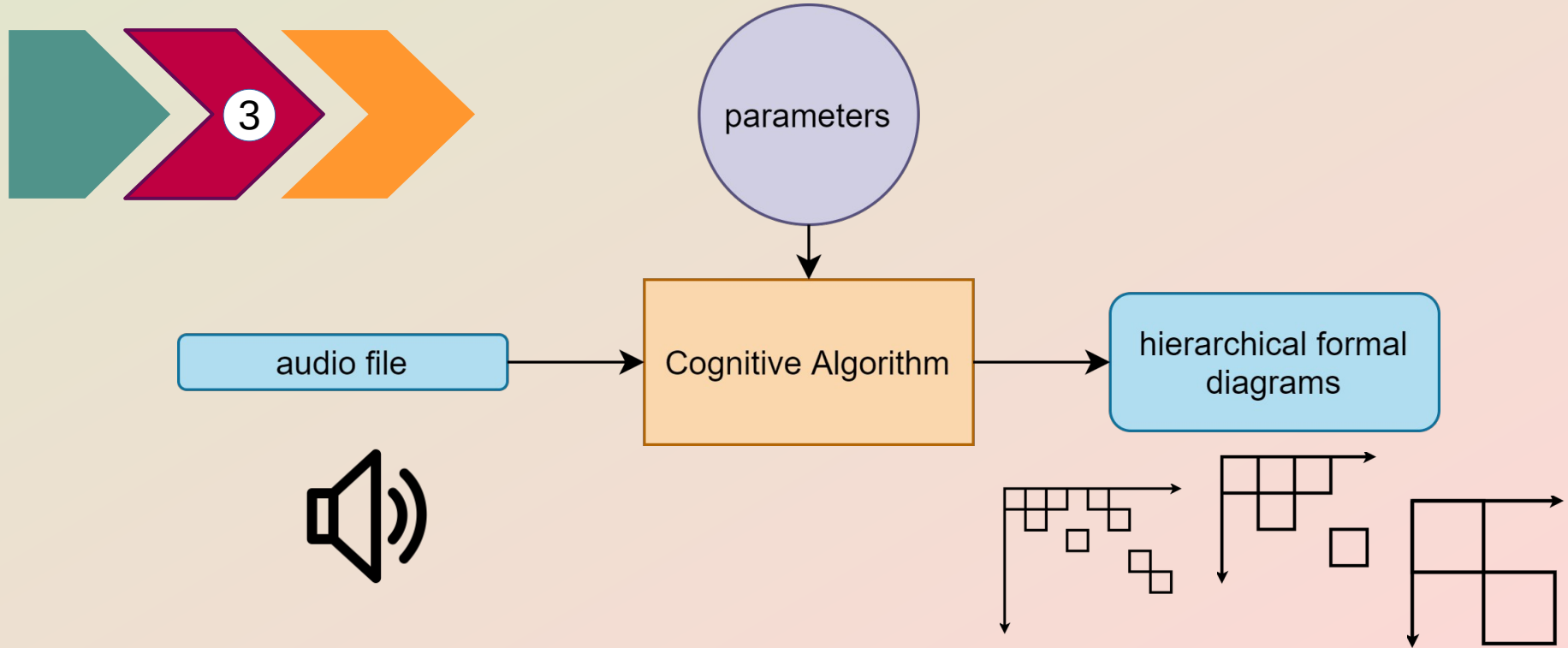
From audio to an initial formal diagram



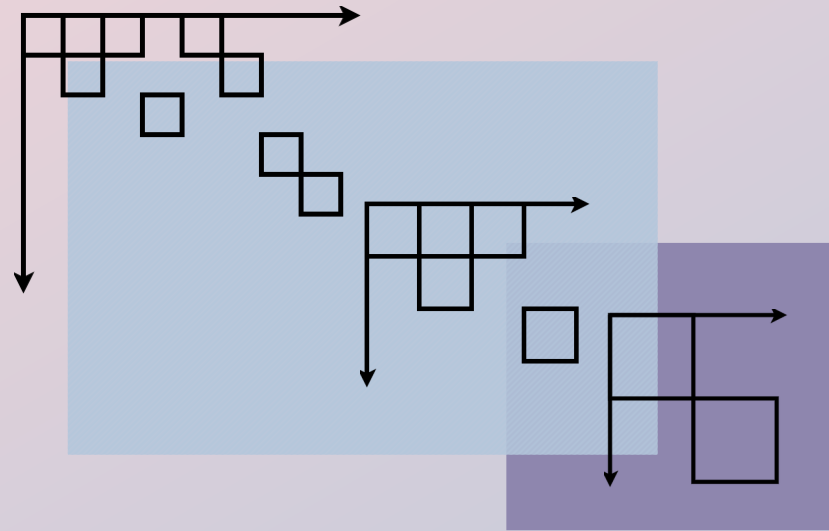
From symbols to hierarchical formal diagrams



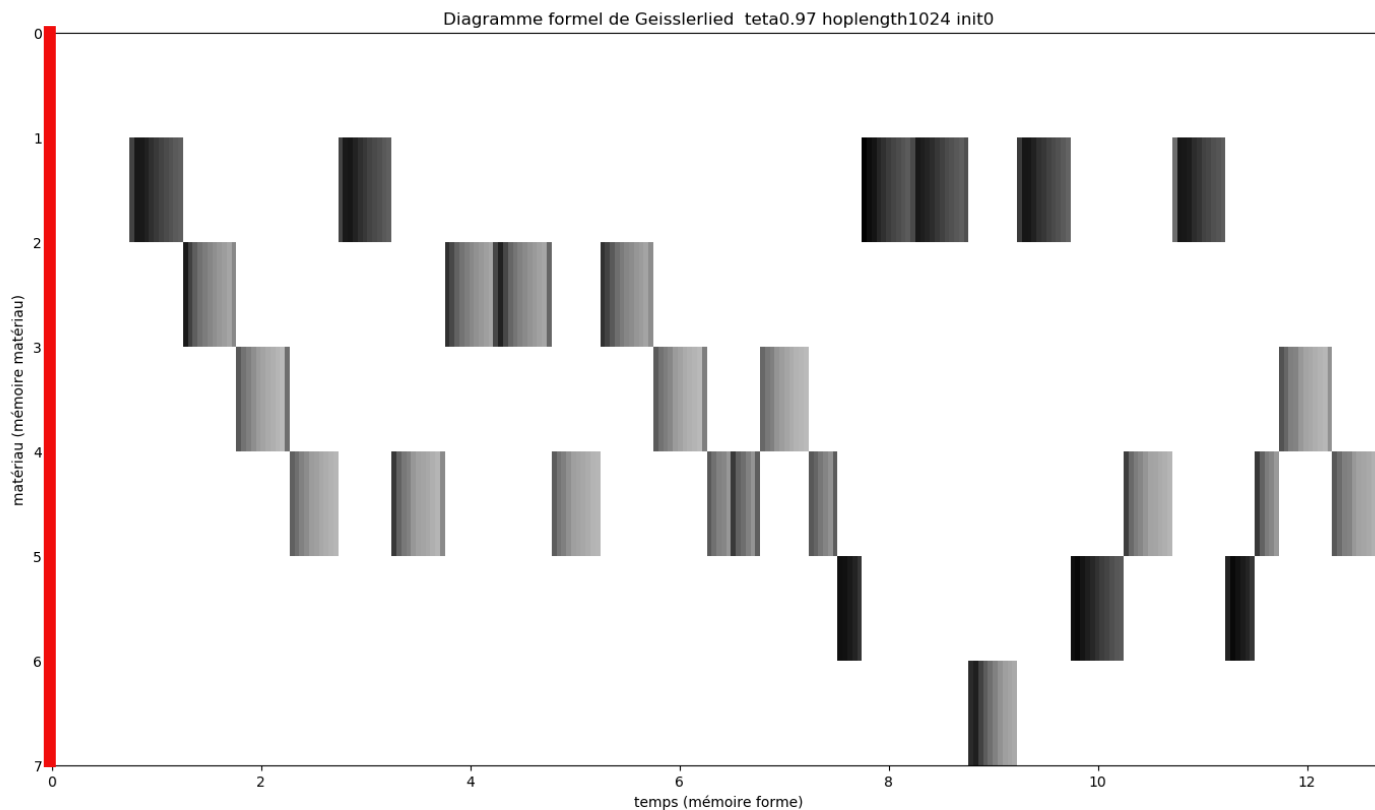
From audio to hierarchical formal diagrams



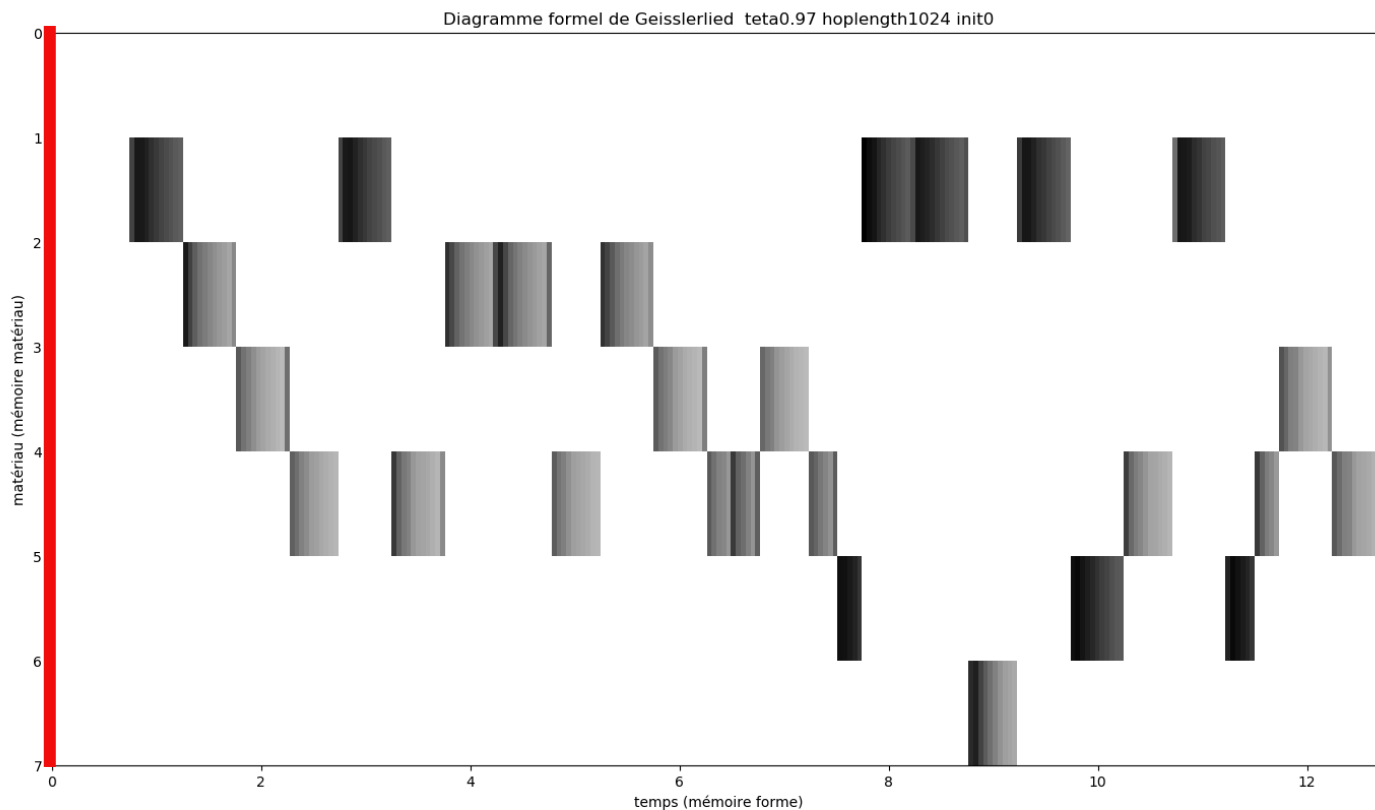
Current results



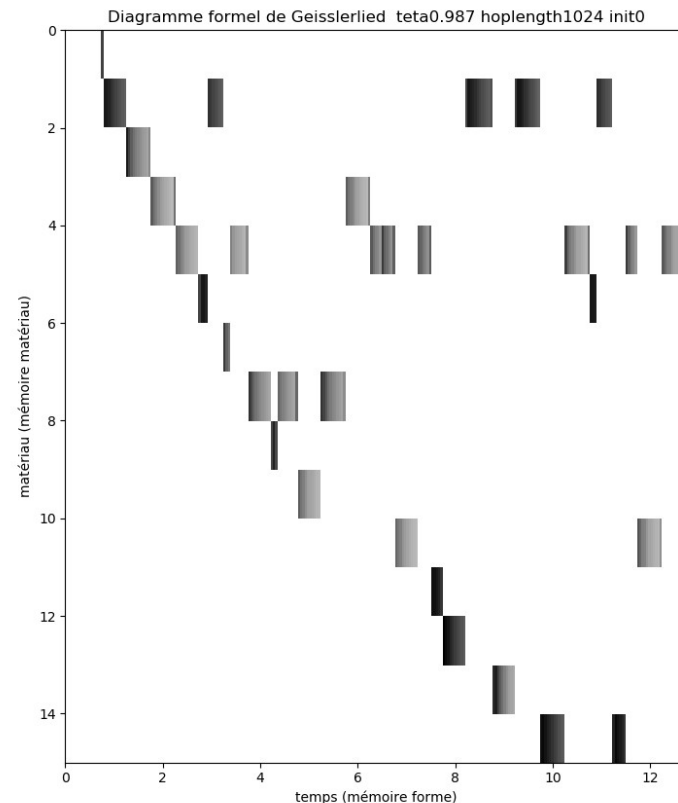
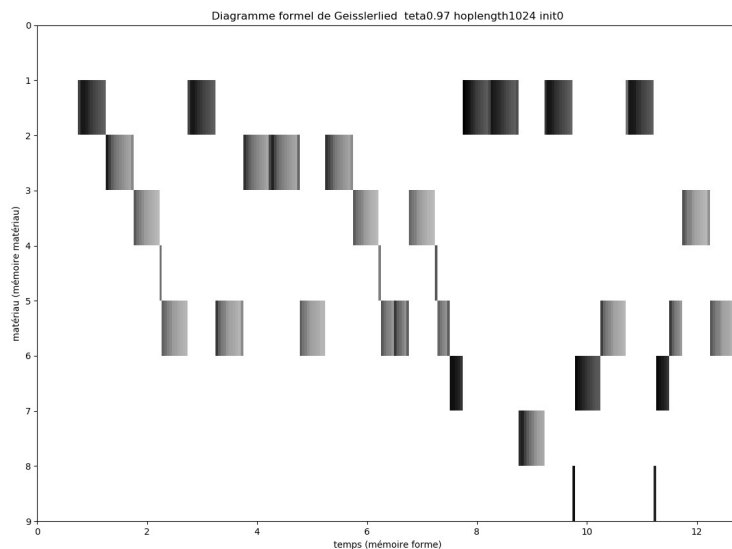
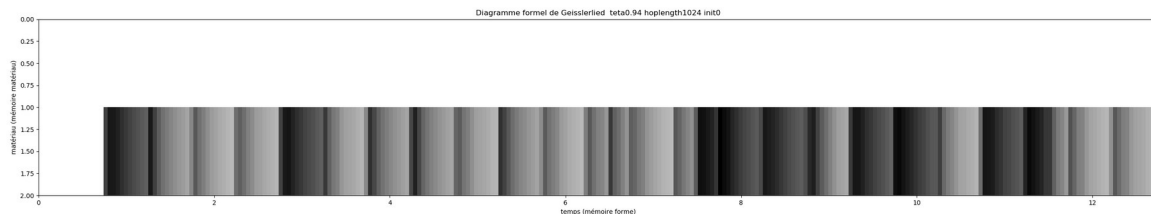
From audio to an initial formal diagram



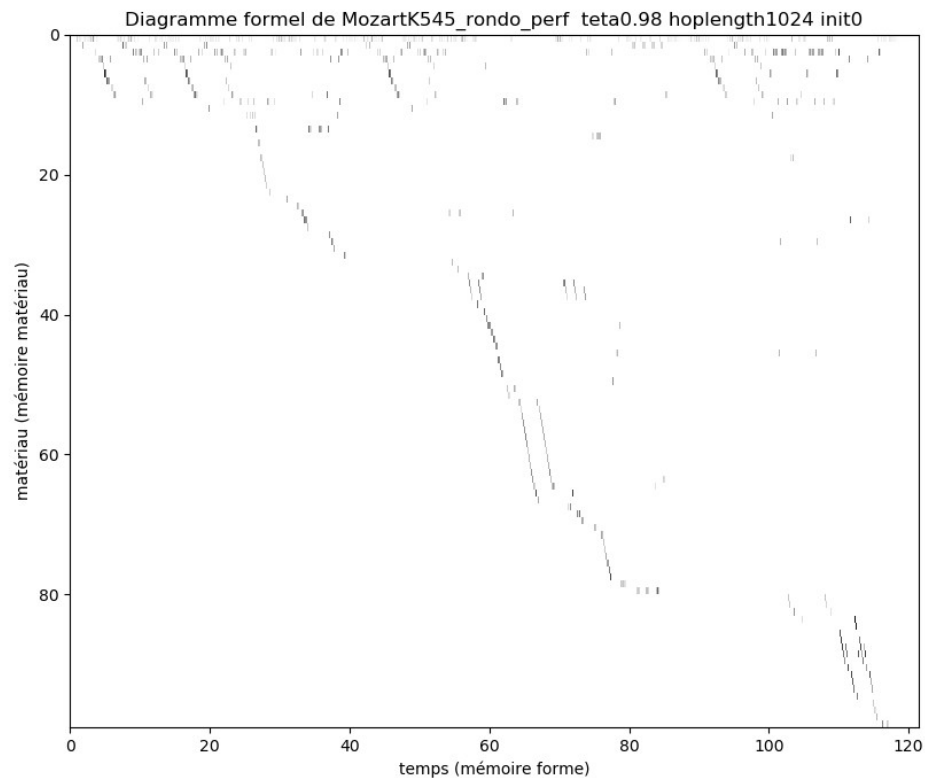
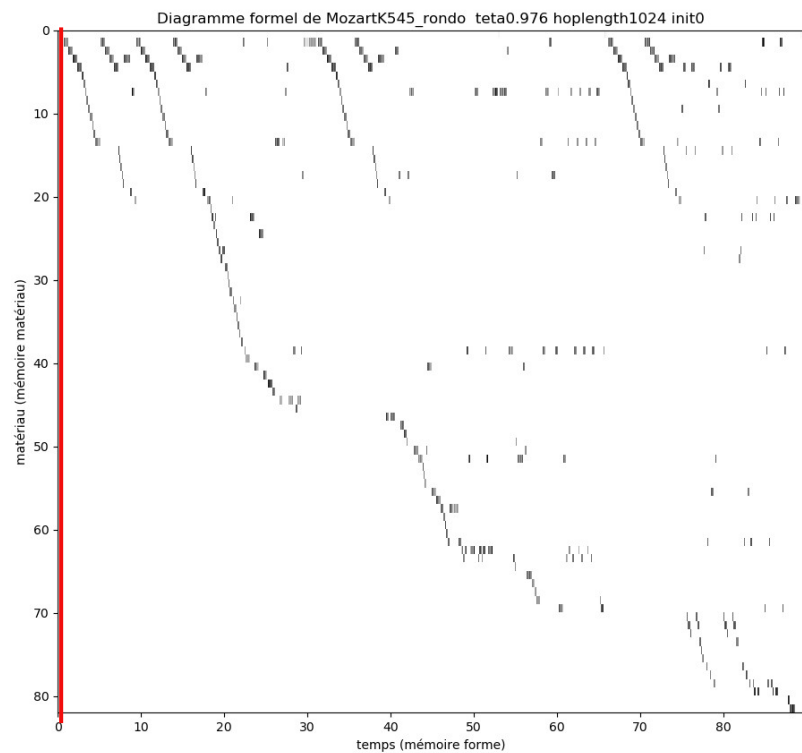
From audio to an initial formal diagram



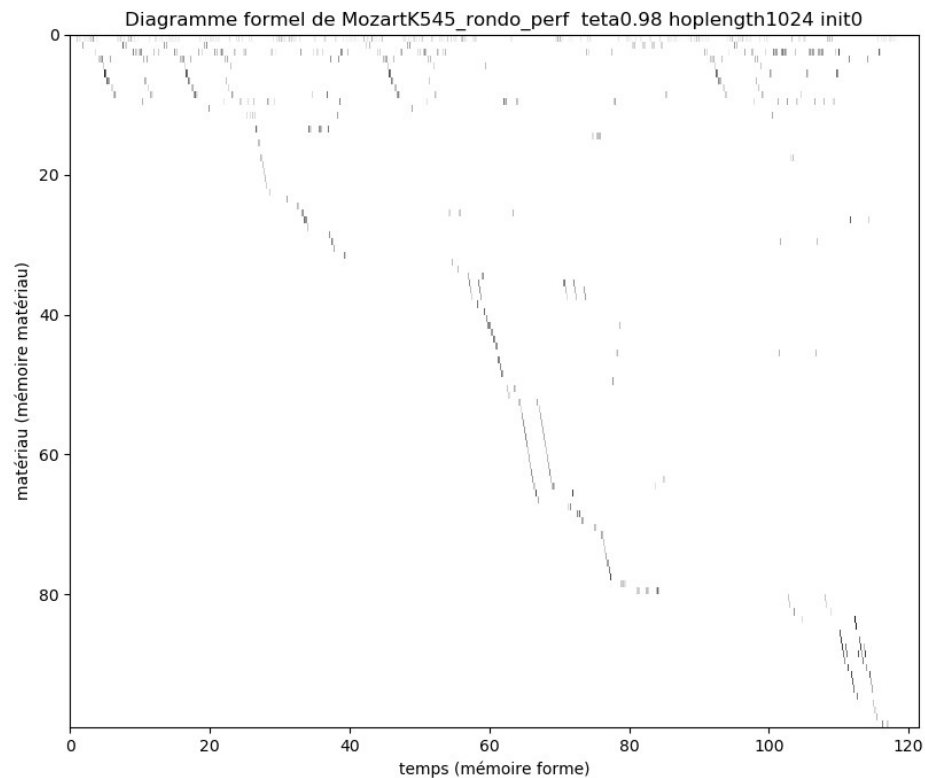
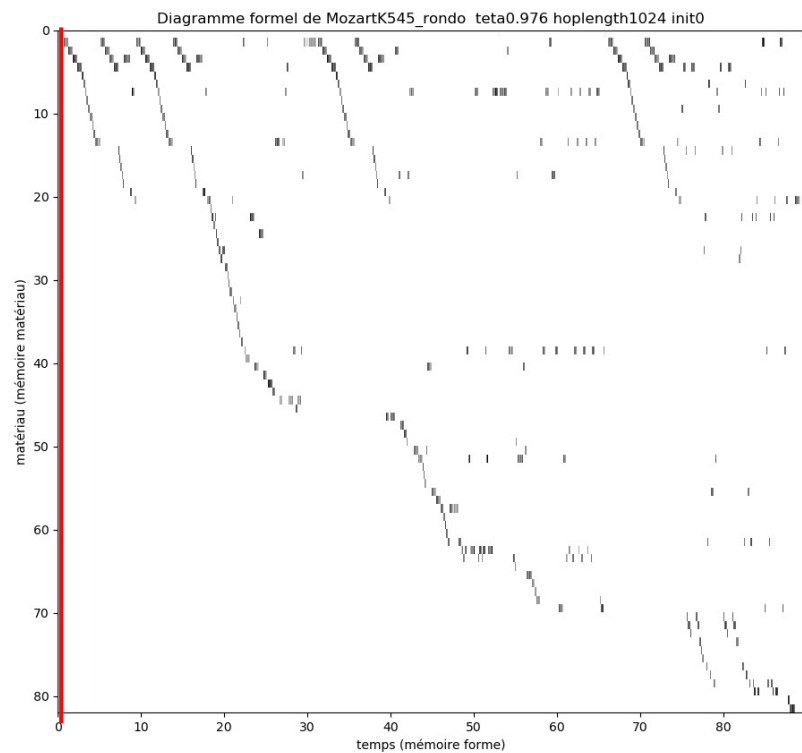
From audio to an initial formal diagram



From audio to an initial formal diagram



From audio to an initial formal diagram



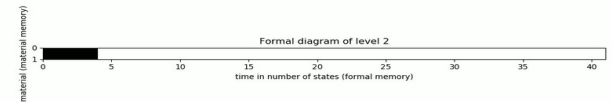
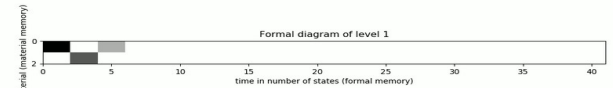
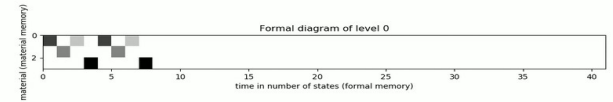
From symbols to hierarchical formal diagrams

5 (180) **RONDO.**
Allegretto.

W. A. M. 545.

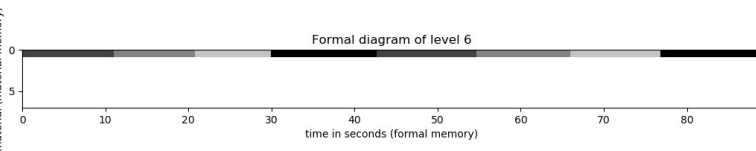
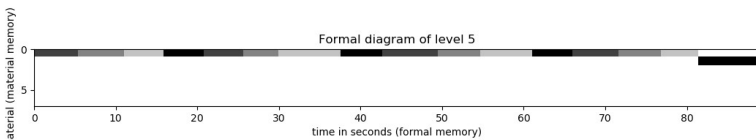
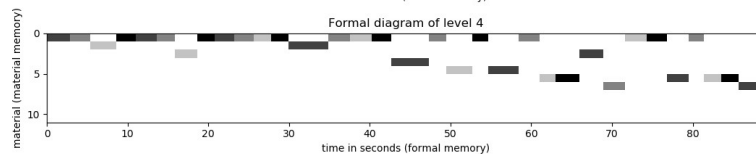
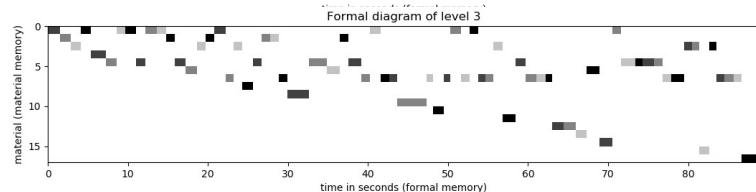
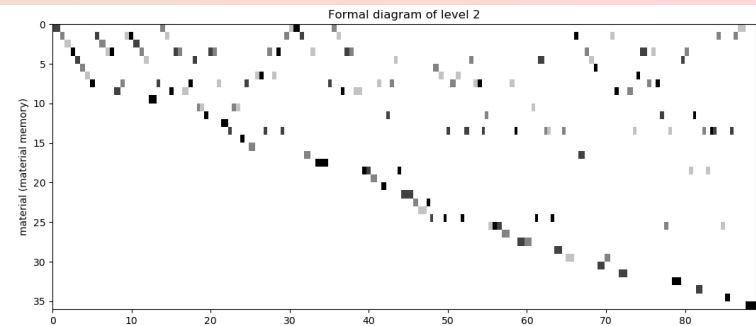
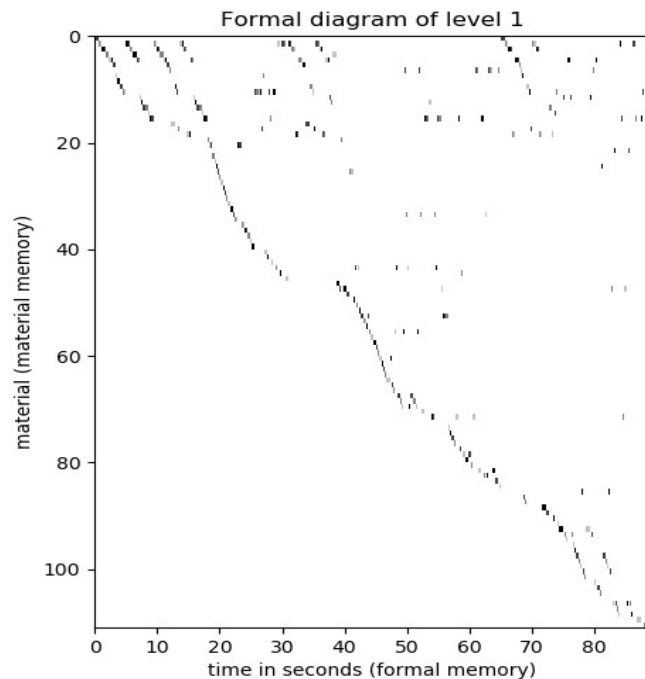
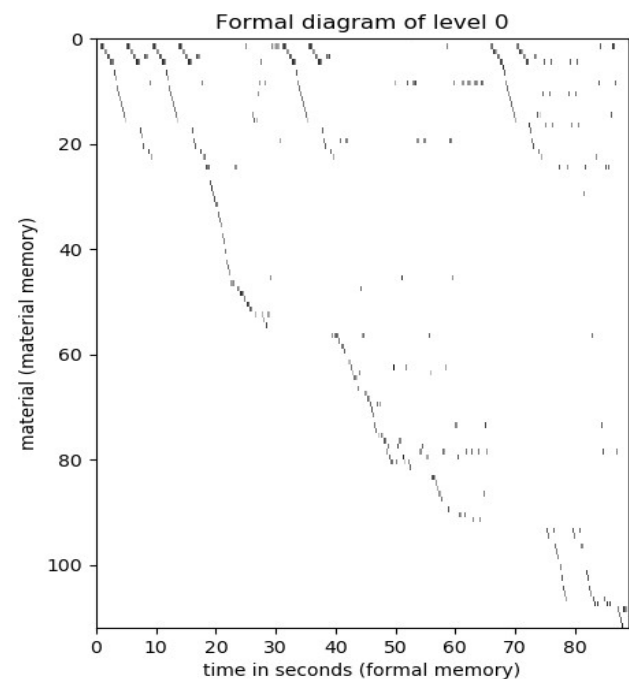
181 9

W. A. M. 545.



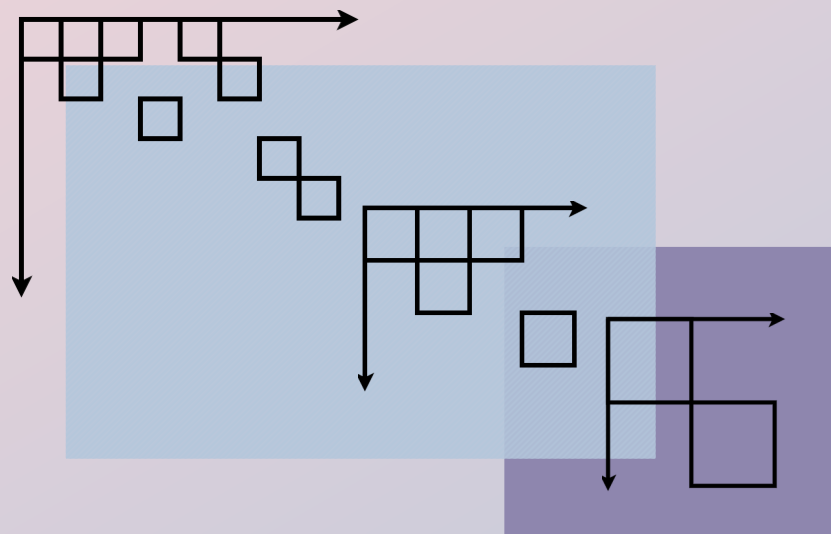
→ abacabacdeabfgabachijklmhinopqabacsrsttu

From audio to hierarchical formal diagrams



W.A. Mozart, Rondo K545, rules 1,2,3,4 and 5

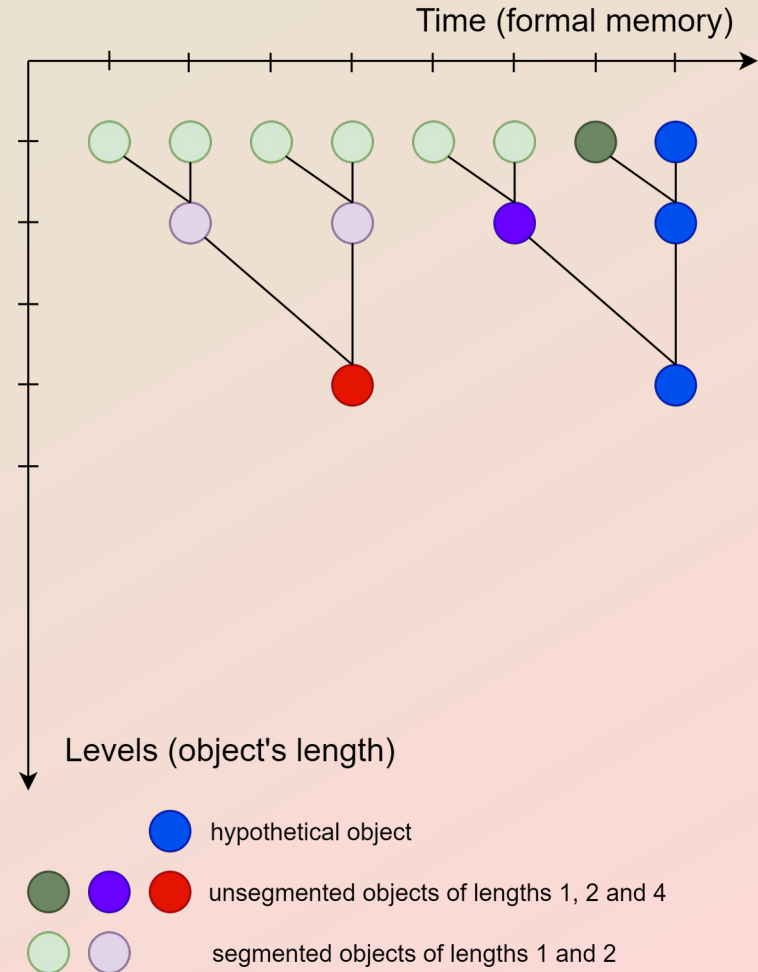
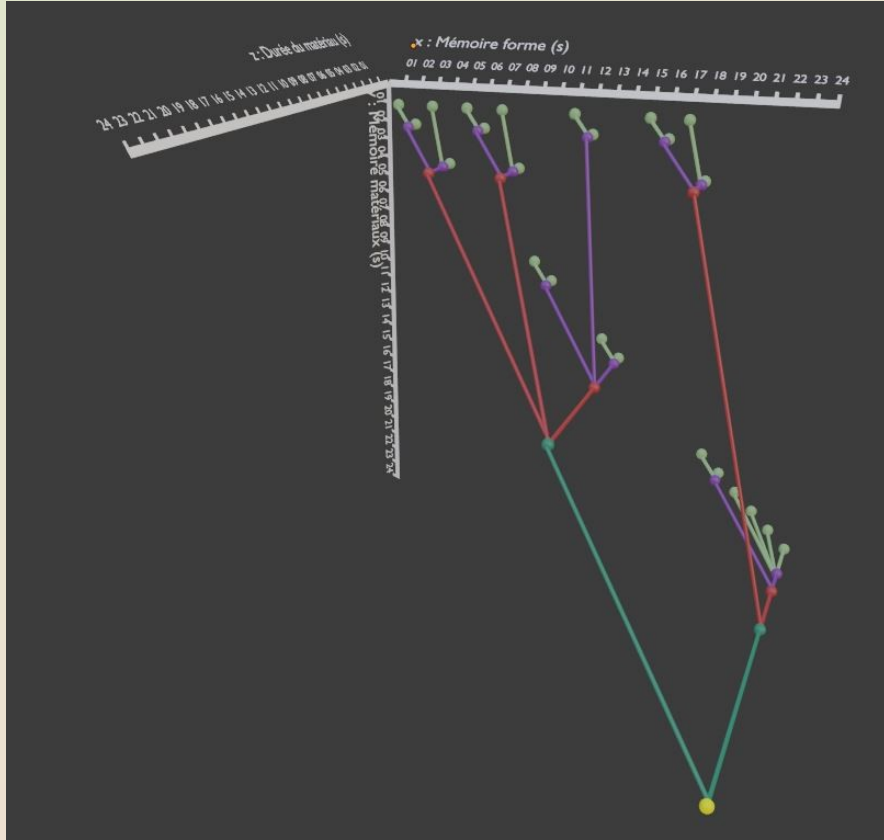
3D representation



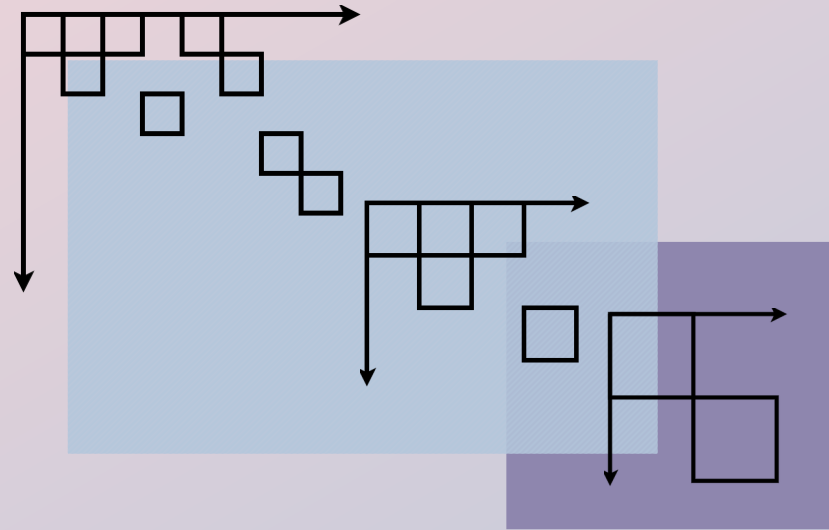
3D representation

- More readable representation :
 - Understandable for a musicologist
 - Make sense in every point of view
 - Emphasize the relation between objects of different levels
 - Internship with Erwan Michel, M2 student in cognitive ergonomics, Toulouse Jean-Jaurès University

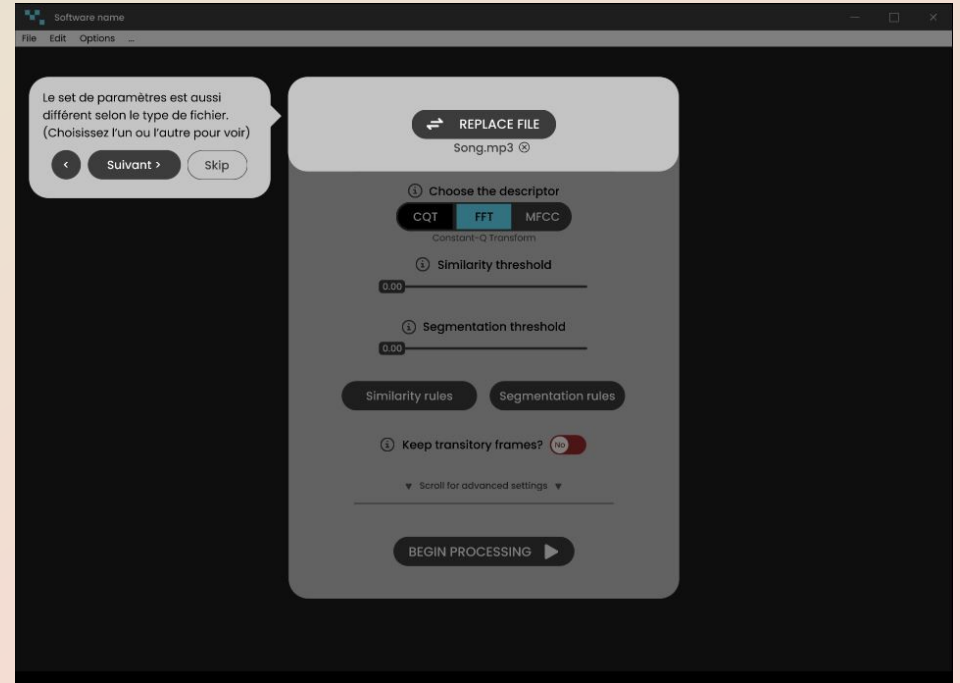
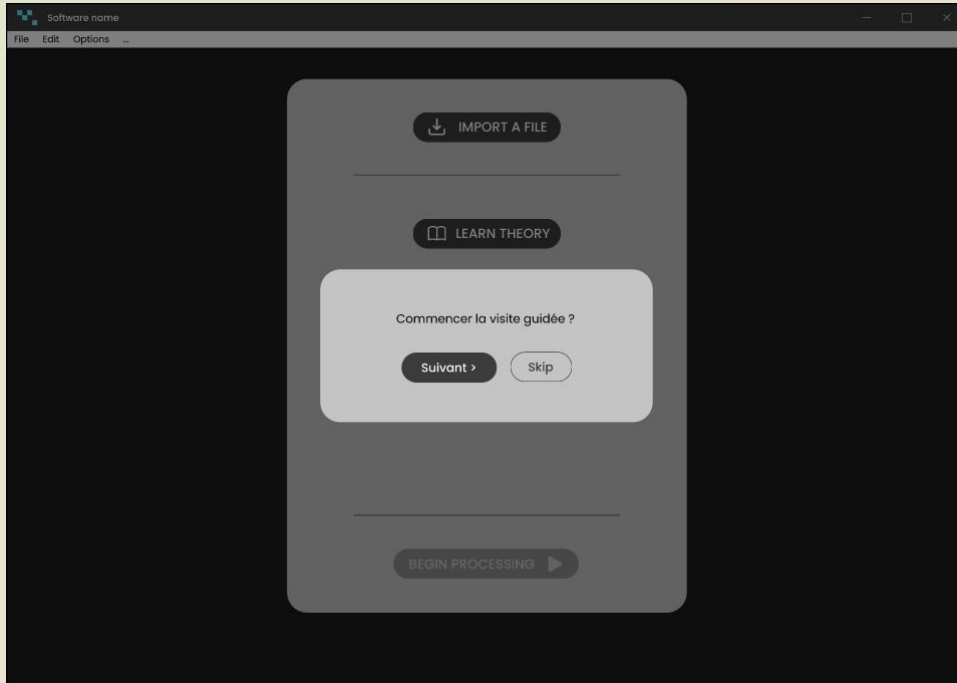
3D representation

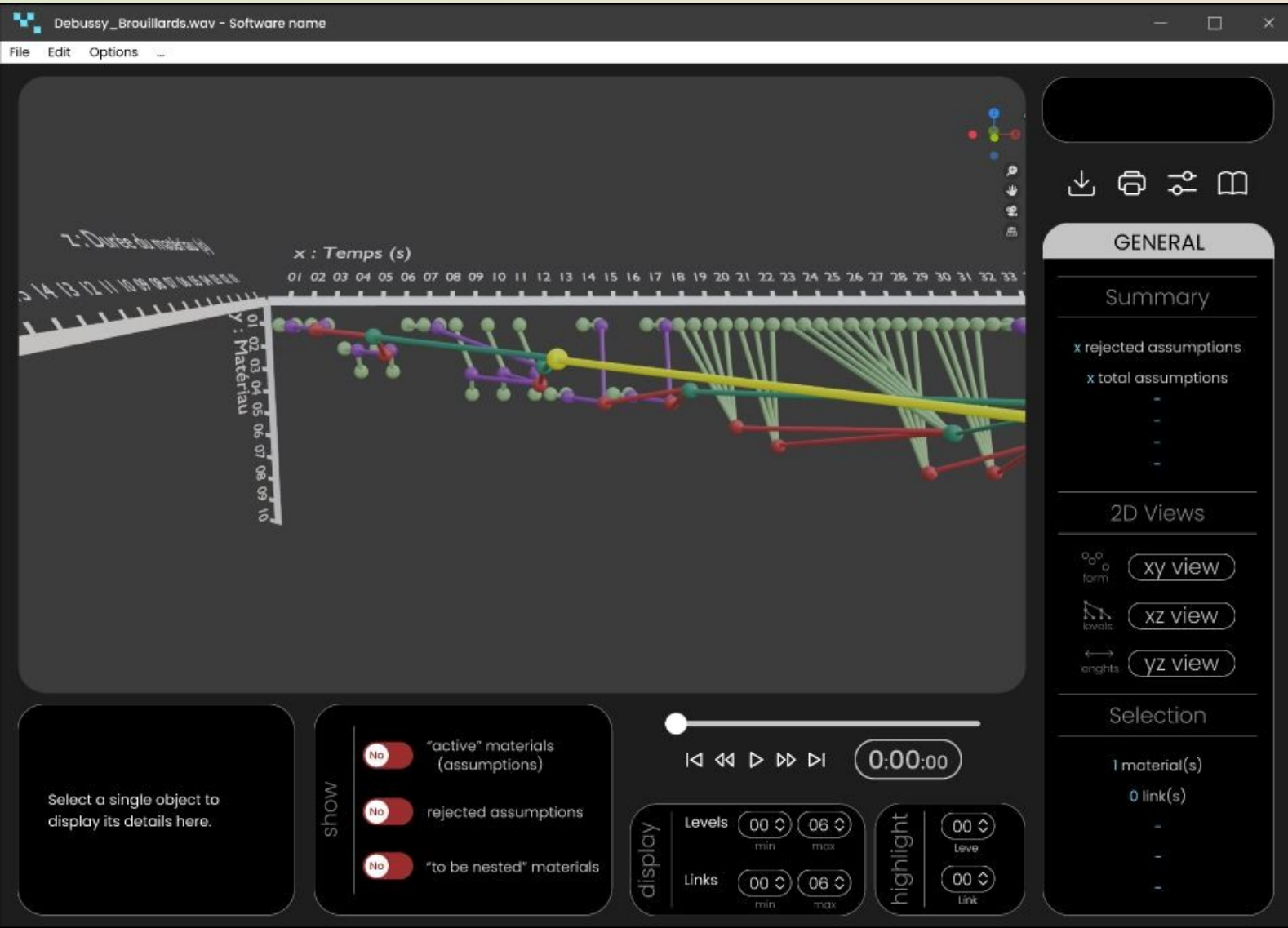


Interface



Interface





Interface

- Before the development of an ergonomic interface as a plug-in, we present a web interface for the first tests :



Démo !

Pour me contacter :

josephine.calandra@u-bordeaux.fr

site personnel :

<https://www.labri.fr/perso/jcalandra001/>