



ALMA MATER STUDIORUM  
UNIVERSITÀ DI BOLOGNA



Berkeley  
UNIVERSITY OF CALIFORNIA

CARMINE-EMANUELE CELLA

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# ARTISTIC RESEARCH AND (COMPUTATIONAL) CREATIVITY

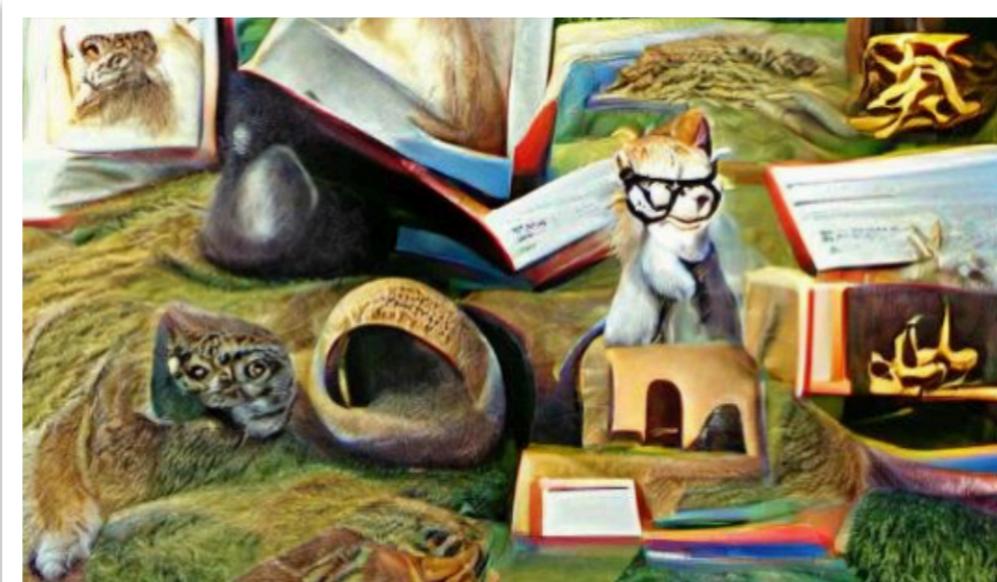
AN INTRODUCTION

# ON ARTISTIC RESEARCH

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# WHAT IS ARTISTIC RESEARCH? (1/2)



*"KeefyKat" by Keith Roberson*

**“I create art which explores technologies, like virtual art and artificial intelligence, and demonstrate their potential as artistic mediums and for new kinds of expression,”**

*Keith Roberson (FSU)*

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## WHAT IS ARTISTIC RESEARCH? (2/2)

- The term *artistic research* is an umbrella term that covers an eclectic array of methodological and epistemological approaches
- The key elements that unify this diverse body of work are: it is **research**; and one or more **art** forms or processes are involved in the doing of the research
- How art is involved varies enormously

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## WHAT IS ARTISTIC RESEARCH? (2/2)

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Research in the arts serves as a **dynamic, multidimensional creative landscape** for exploration, artistic expression, and innovation

# BACH, FUGUE C MINOR, WTC VOL. 2 (EXCERPT)



# BACH, FUGUE C MINOR, WTC VOL. 2 (EXCERPT)



BACH'S EXAMPLE

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## RELATIONAL COMPLEXITY



## RELATIONAL COMPLEXITY

SUBJECT (theme)



## BACH'S EXAMPLE

# RELATIONAL COMPLEXITY

## SUBJECT (theme)



## RELATIONAL COMPLEXITY

SUBJECT (theme)

A musical score from Bach's Example, featuring two staves of music. The top staff is in common time (indicated by 'C') and the bottom staff is in common time (indicated by 'C'). The music consists of eighth and sixteenth notes. Three specific melodic segments are highlighted with red boxes:

- SUBJECT (theme):** A box highlights the first measure of the top staff, which consists of three eighth notes followed by a sixteenth note.
- DILATED SUBJECT:** A box highlights the second measure of the top staff, which consists of a sixteenth note followed by a series of eighth and sixteenth notes.
- INVERTED SUBJECT:** A box highlights the third measure of the bottom staff, which consists of a sixteenth note followed by a series of eighth and sixteenth notes.

DILATED SUBJECT

INVERTED SUBJECT

## RELATIONAL COMPLEXITY

SUBJECT (theme)



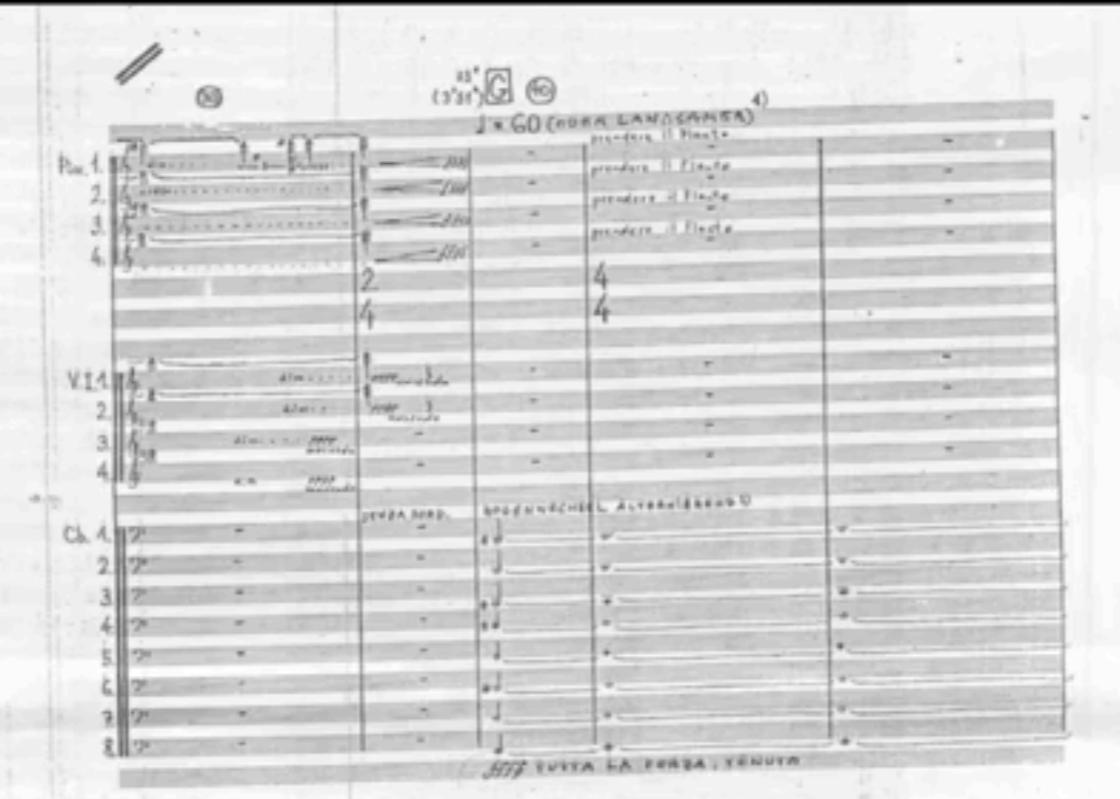
**Multi-scale hierarchical relationships**

# LIGETI, ATMOSPHÈRES (EXCERPT)



1) or slower  
2) alternating change of bow

# LIGETI, ATMOSPHÈRES (EXCERPT)



1) or slower  
2) alternating change of bow

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## A NEW TYPE OF COMPLEXITY

Melodies → Streams

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Melodies → Streams

Rhythm → Density

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Melodies → Streams

Rhythm → Density

Chords → Textures

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# A NEW TYPE OF COMPLEXITY

Melodies → Streams

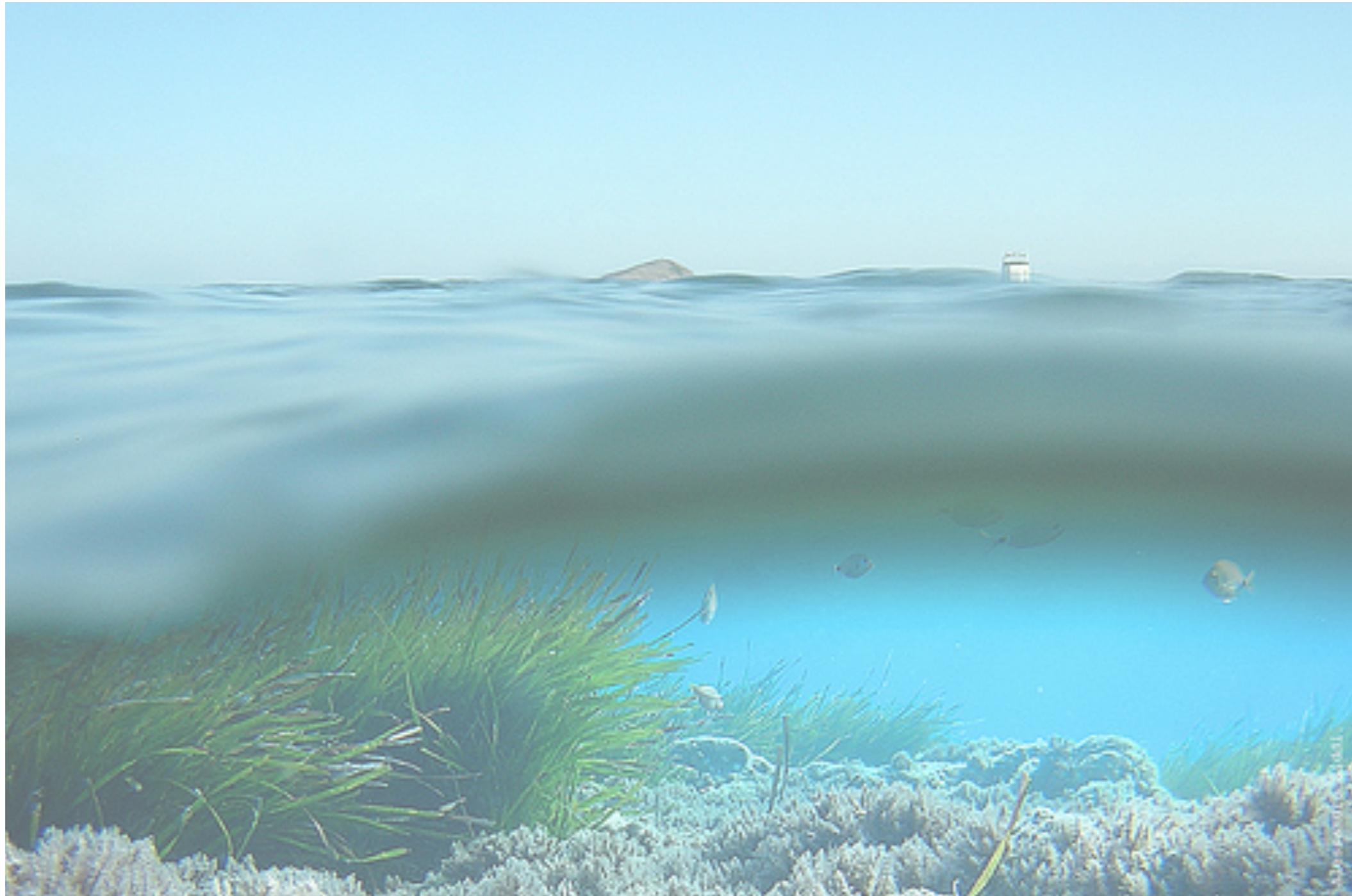
Rhythm → Density

Chords → Textures

Symbols → Sounds

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# IS MUSIC LIKE THE SEA?

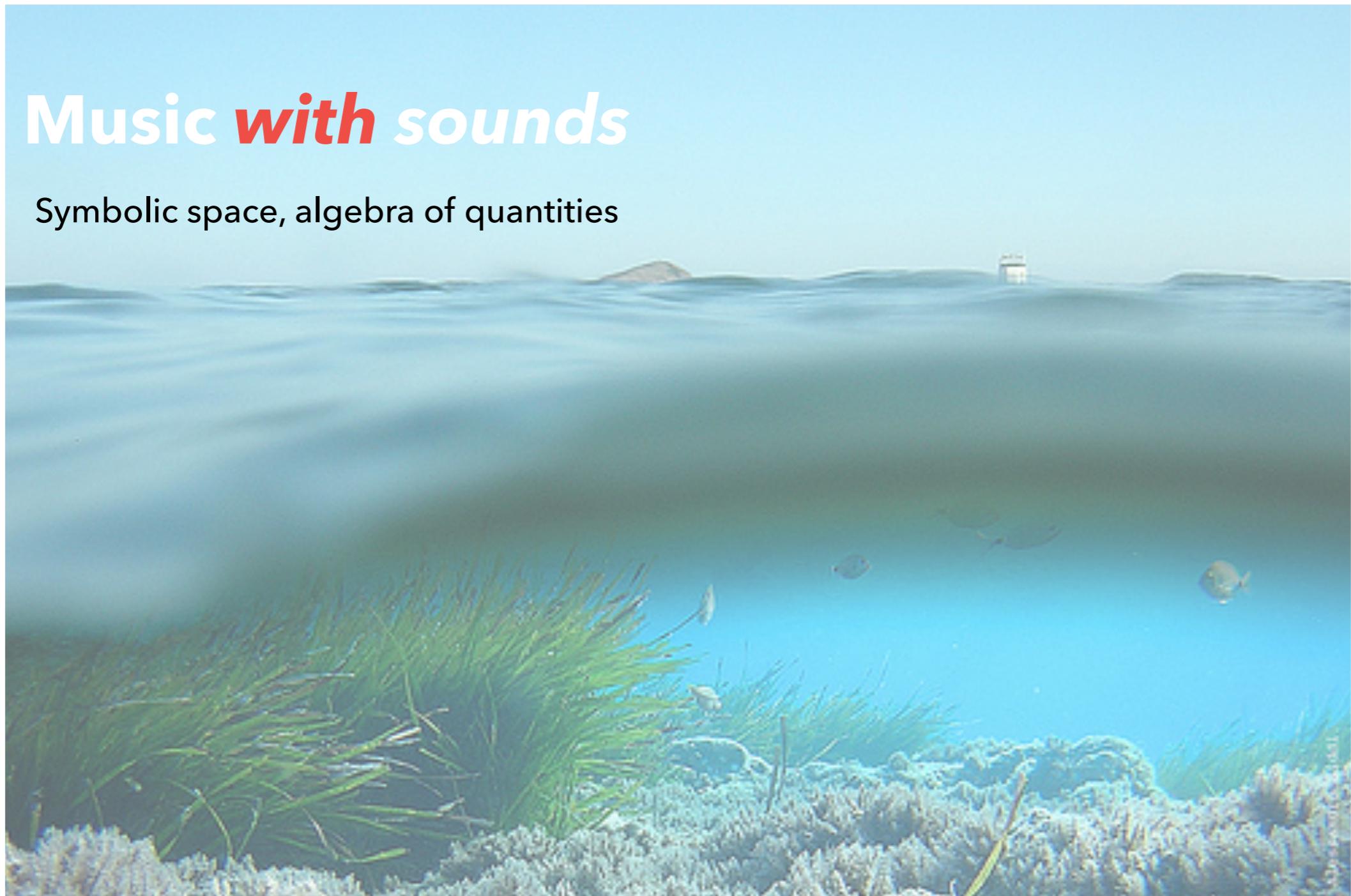


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# IS MUSIC LIKE THE SEA?

Music **with** sounds

Symbolic space, algebra of quantities



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# IS MUSIC LIKE THE SEA?



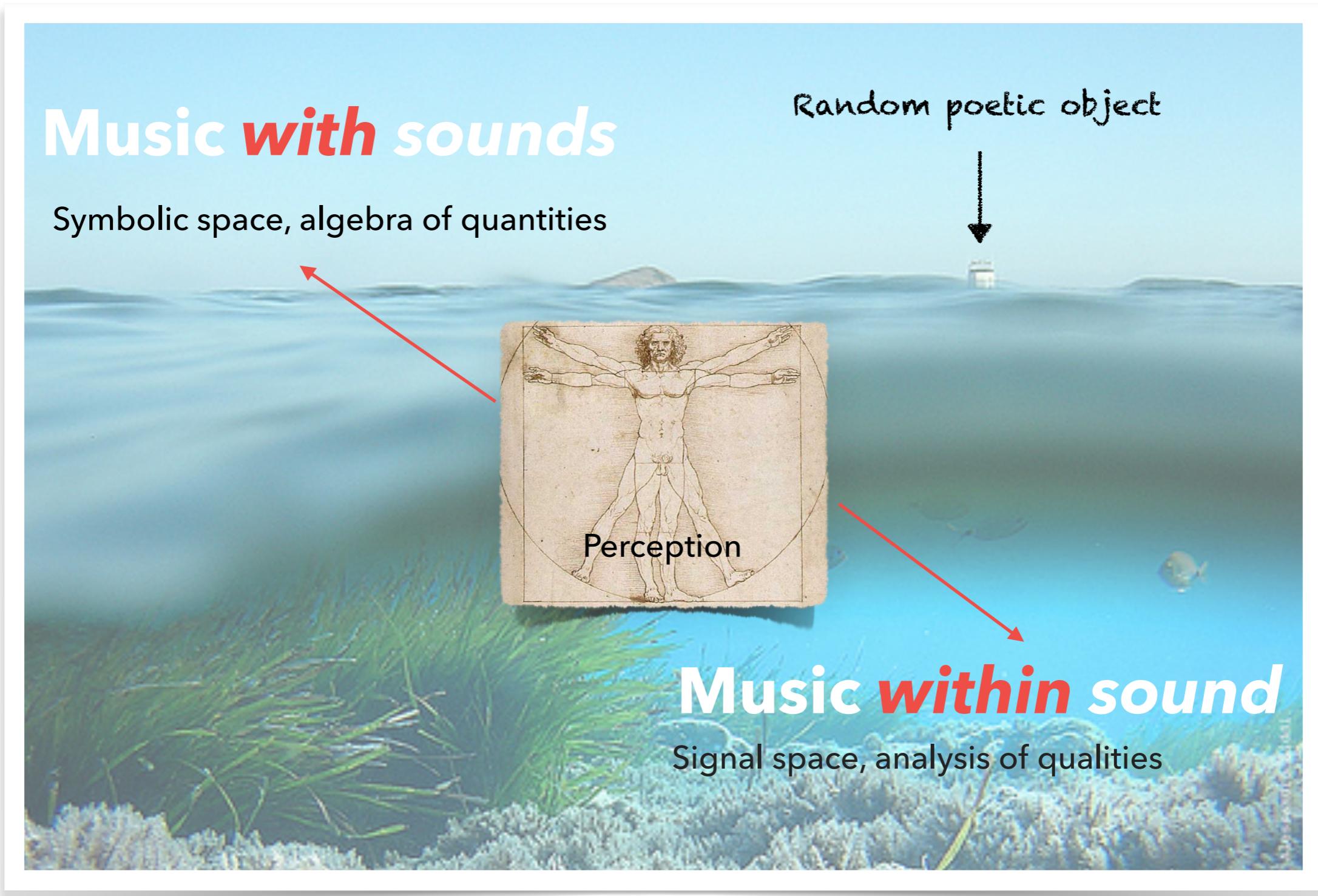
**Music *with* sounds**

Symbolic space, algebra of quantities

**Music *within* sound**

Signal space, analysis of qualities

# IS MUSIC LIKE THE SEA?



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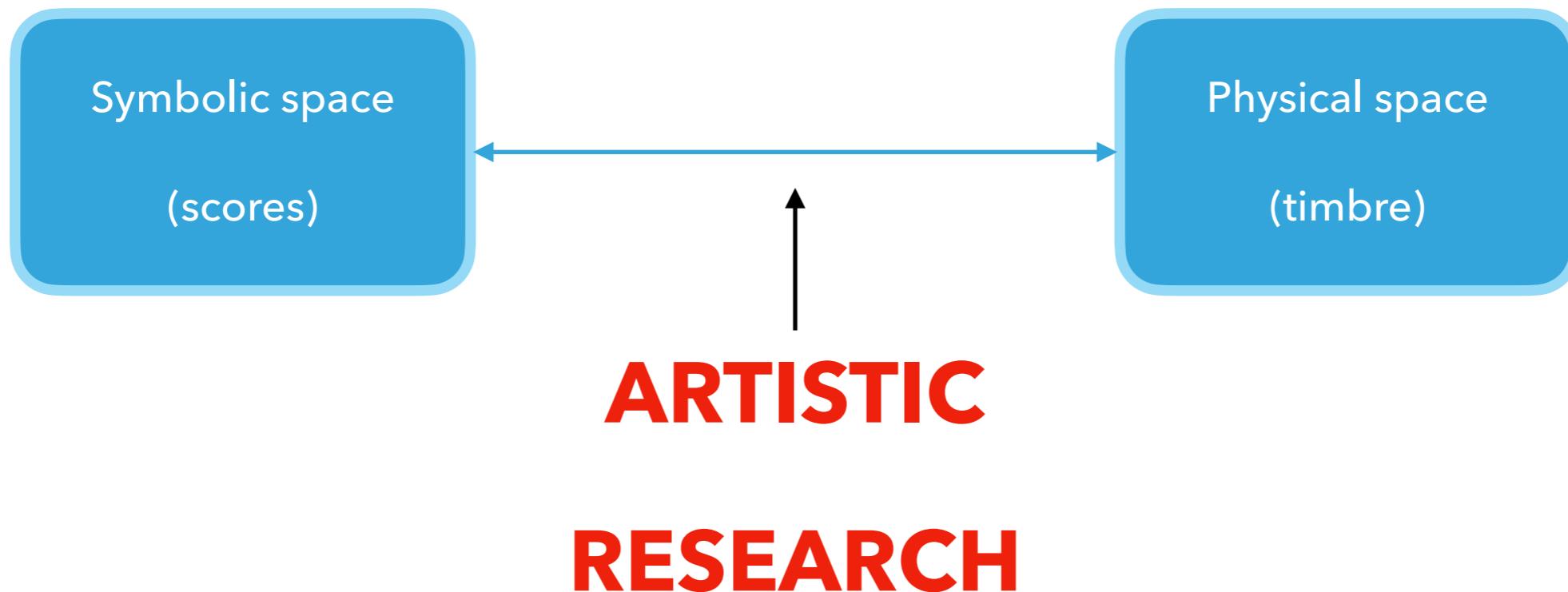
# MY DEFINITION OF ARTISTIC RESEARCH

Which connections can we make between  
the symbolic space and the signal space?



# MY DEFINITION OF ARTISTIC RESEARCH

Which connections can we make between  
the symbolic space and the signal space?



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# CAN COMPOSERS THINK IN SOUNDS?



- What is the mental model of an artist during the creative process?
- Can we use mathematical or computational models to support/foster/discover this mental model?

# ON (COMPUTATIONAL) CREATIVITY

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# WHAT IS CREATIVITY?

- giving a precise definition of this concept is not a trivial task
- general idea is that it relates to the ability that some human individuals possess to create something that did not exist before
- “creations” start from concepts that already existed, or at least that could already have existed, but that nobody had already explicitly linked in a fixed product. This kind of “novel linkage”

Dali, The persistence of memory

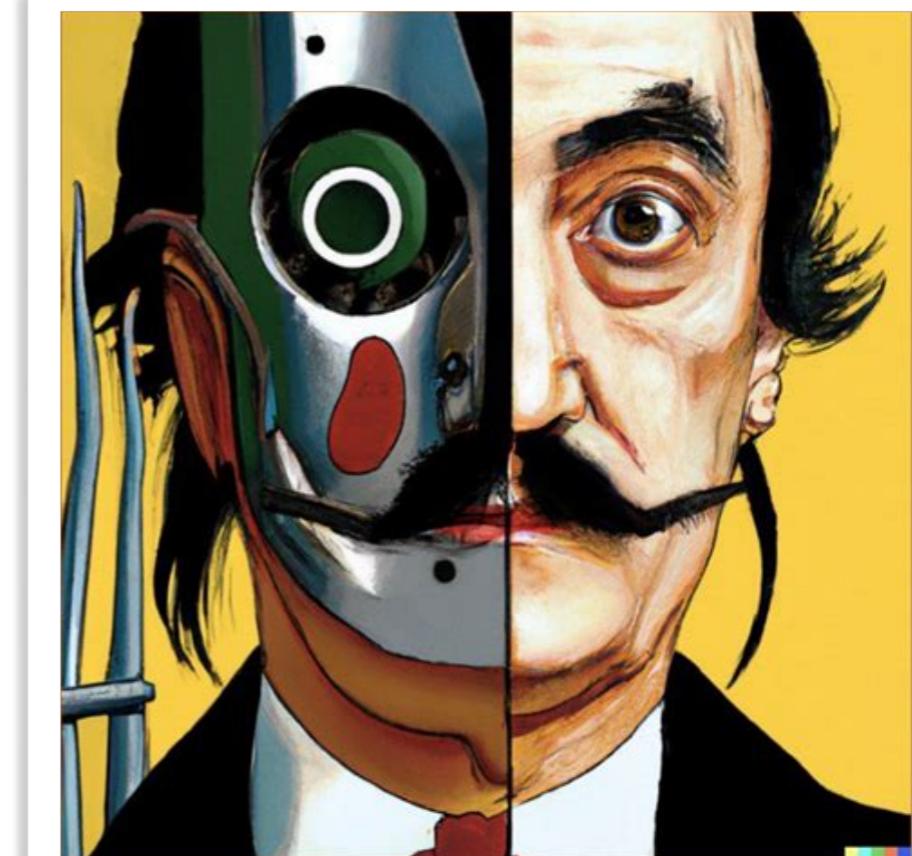
clocks had been painted before,  
and everybody has experienced  
that things can melt, but  
nobody had yet linked these two  
concepts in a painting



# TOWARDS COMPUTATIONAL CREATIVITY



The Dancing Salesman  
Problem (2011). Artwork created by the software  
called The Painting Fool.



Images created by

Dall-E 2

<https://openai.com/dall-e-2/>

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TEXT DESCRIPTION

An astronaut Teddy bears A bowl of  
soup

that is a portal to another  
dimension that looks like a  
monster as a planet in the universe

as digital art in the style of  
Basquiat drawn on a cave wall



DALL-E 2



<https://openai.com/dall-e-2/>

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TEXT DESCRIPTION

An astronaut **Teddy bears** A bowl of  
soup

mixing sparkling chemicals as mad  
scientists **shopping for**  
**groceries** working on new AI research

in the style of ukiyo-e as a one-line  
drawing **in ancient Egypt**



DALL·E 2



# DEEP DREAM



Prior  
attempts  
at AI-  
generated  
synthetic  
images

# ACCOUNTABILITY

Who is the artist?



Pierre Fautrel of OBVIOUS with  
“Portrait of Edmond de Belamy.”  
<https://obvious-art.com>

# GAN (GENERATIVE ADVERSARIAL NETWORKS)



Ian Goodfellow

“Bel ami” means “good friend” in French, hence the name “Portrait of Edmond de Belamy” is a tribute to Ian Goodfellow, known as the “GANfather”

---

# ROBBIE BARRAT



Open source GAN  
software on Github



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# CAN COMPUTERS BE CREATIVE??

*“Computers can’t create anything. For creation requires, minimally, originating something. But computers originate nothing; they merely do that which we order them, via programs, to do.”*

Lovelace (1842).

---

# CAN COMPUTERS BE CREATIVE??

*“Computers can’t create anything. For creation requires, minimally, originating something. But computers originate nothing; they merely do that which we order them, via programs, to do.”*

Lovelace (1842).

Alan Turing, responded to Lady Lovelace’s objection pointing out that she had no real experience in programming, while we now know that a computer can often surprise us by doing the exact opposite of what we intended, until a program is thoroughly checked for bugs (Turing, 1950)

CREATIVITY = ERROR?

# EVALUATING COMPUTATIONAL CREATIVITY



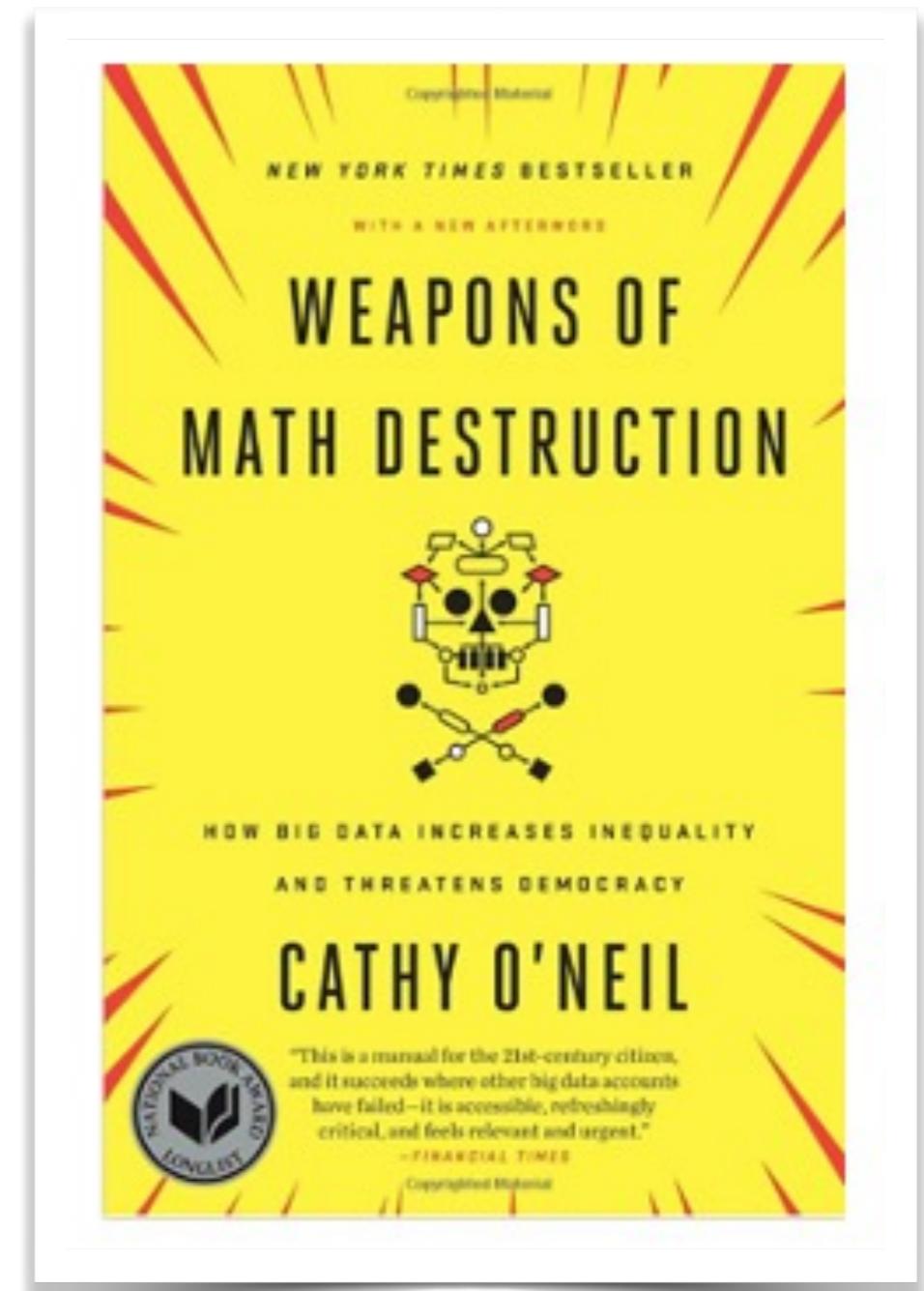
HOW DO WE ASSESS CREATIVITY?

- **Turing Test-Like Approaches:** if a human cannot distinguish computer creativity from human creativity, the computer has achieved a satisfying level of creativity.
- **Self-Assessment Frameworks:** frame the chosen Process in some kind of creativity scale, for example distinguishing if the used process is combinational, explorational or transformative
- **Quantitative Metrics:** a set of criteria for the evaluation of creativity based on the Product perspective, judged according to *Value* and *Typicality* (Richie, 2001)

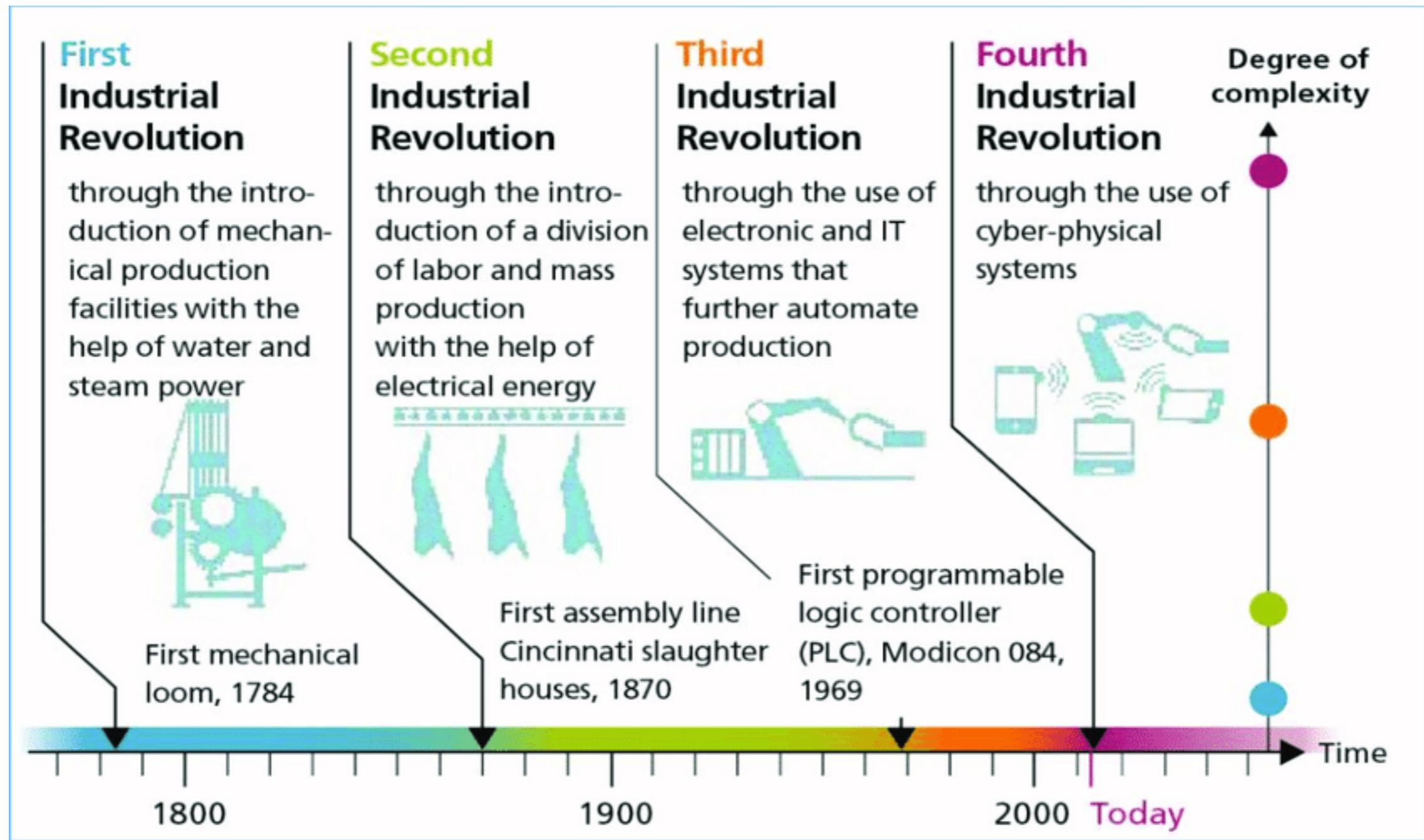
# LARGER IMPACTS OF AI



AI generated identities



# THE FOUR REVOLUTIONS



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# NEW SKILLS

## 1. Simple physical labor



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# NEW SKILLS

1. **Simple** physical labor



2. **Complex** physical labor



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# NEW SKILLS

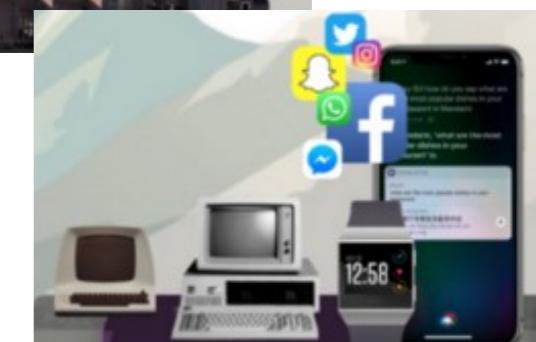
1. **Simple** physical labor



2. **Complex** physical labor



3. **Simple** intellectual tasks  
(planning, scheduling ,etc.)



# NEW SKILLS

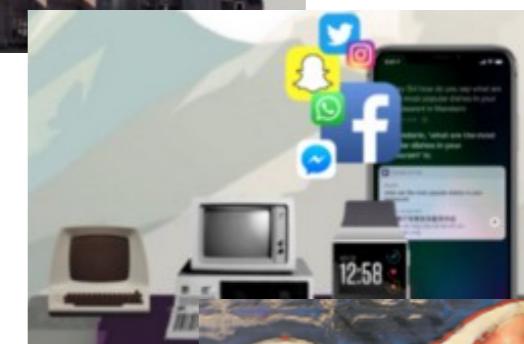
1. **Simple** physical labor



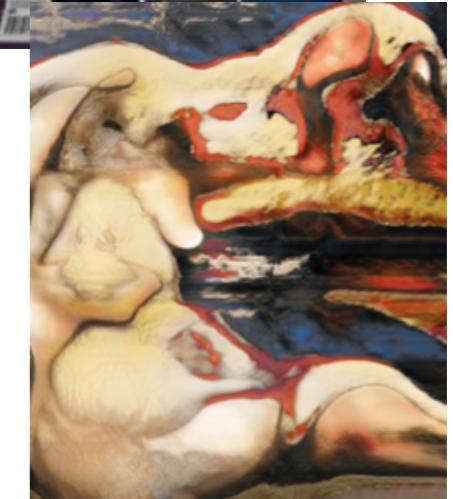
2. **Complex** physical labor

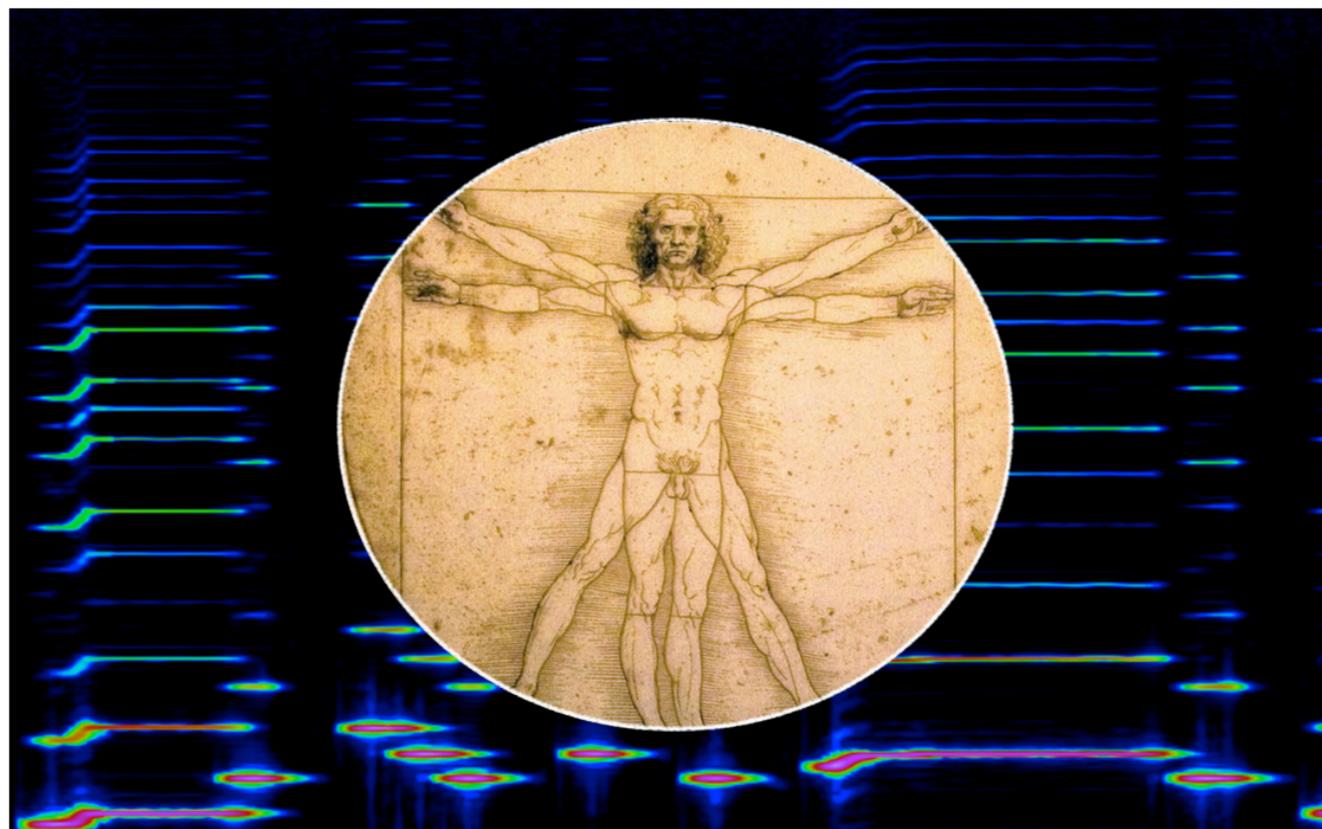


3. **Simple** intellectual tasks  
(planning, scheduling ,etc.)



4. **Complex** intellectual tasks  
(game playing, artistic  
creation, etc.)



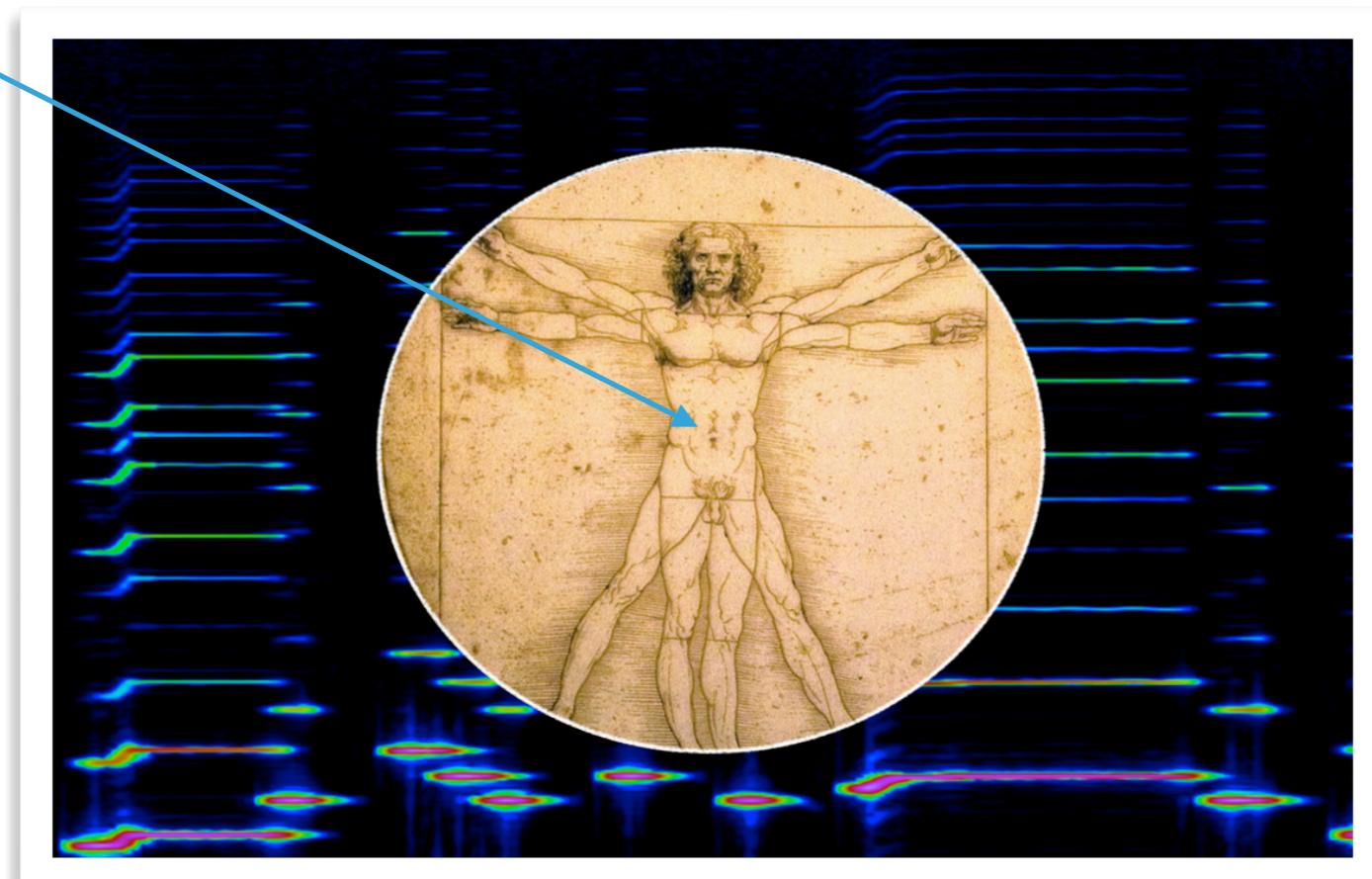


What's next?

(what makes us...human?)

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# Emotions?

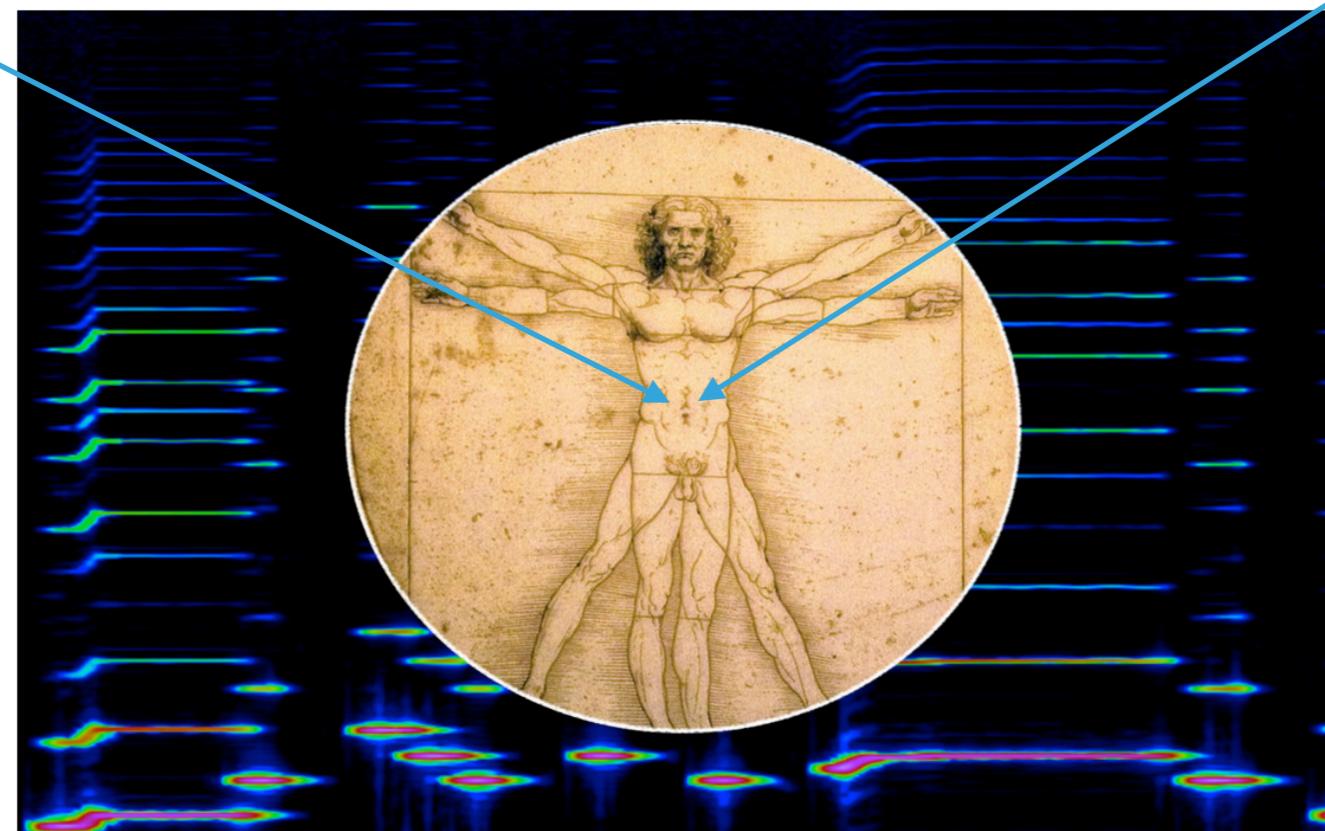


## What's next?

(what makes us...human?)

Emotions?

Genetics?

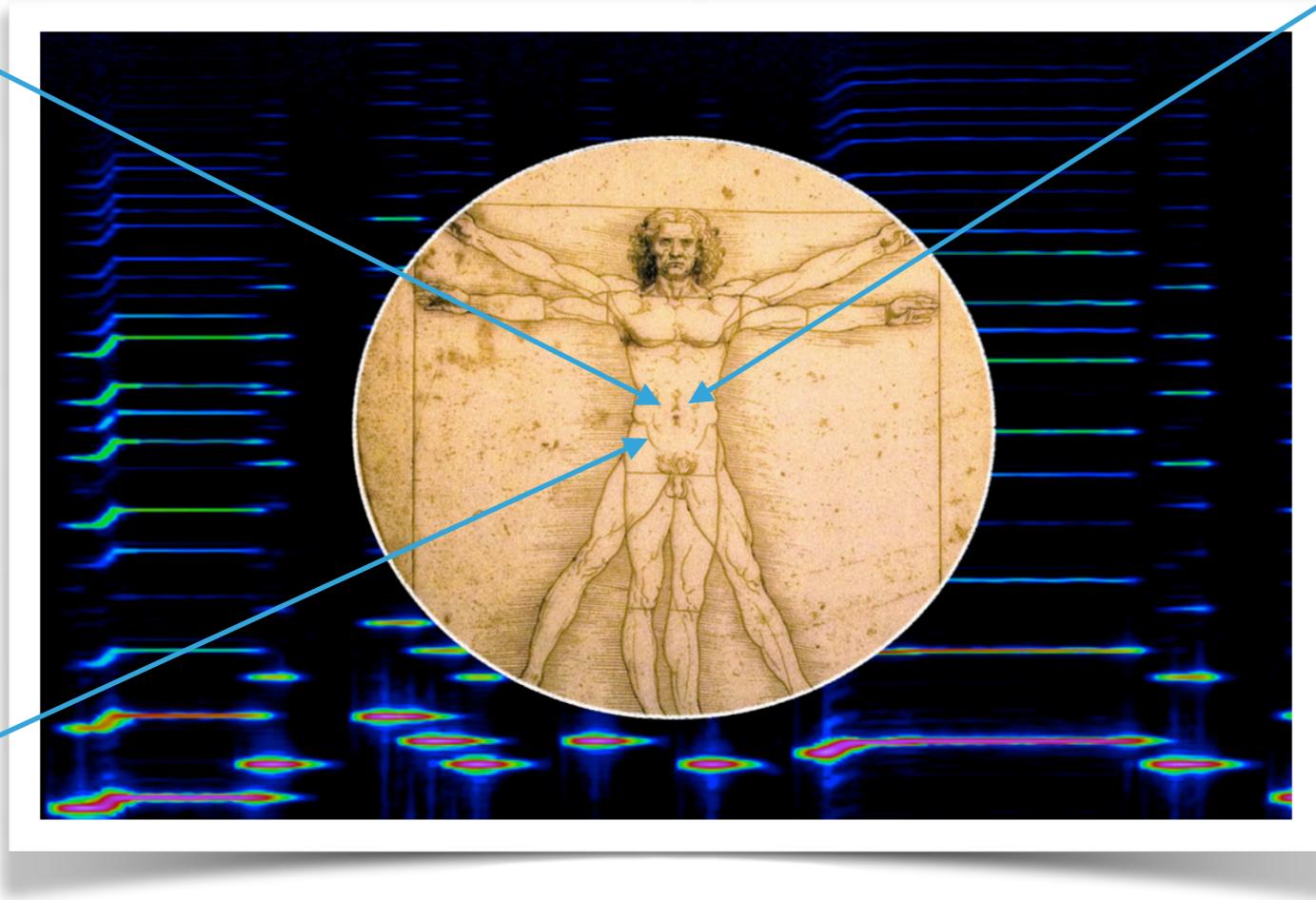


What's next?

(what makes us...human?)

Emotions?

Genetics?



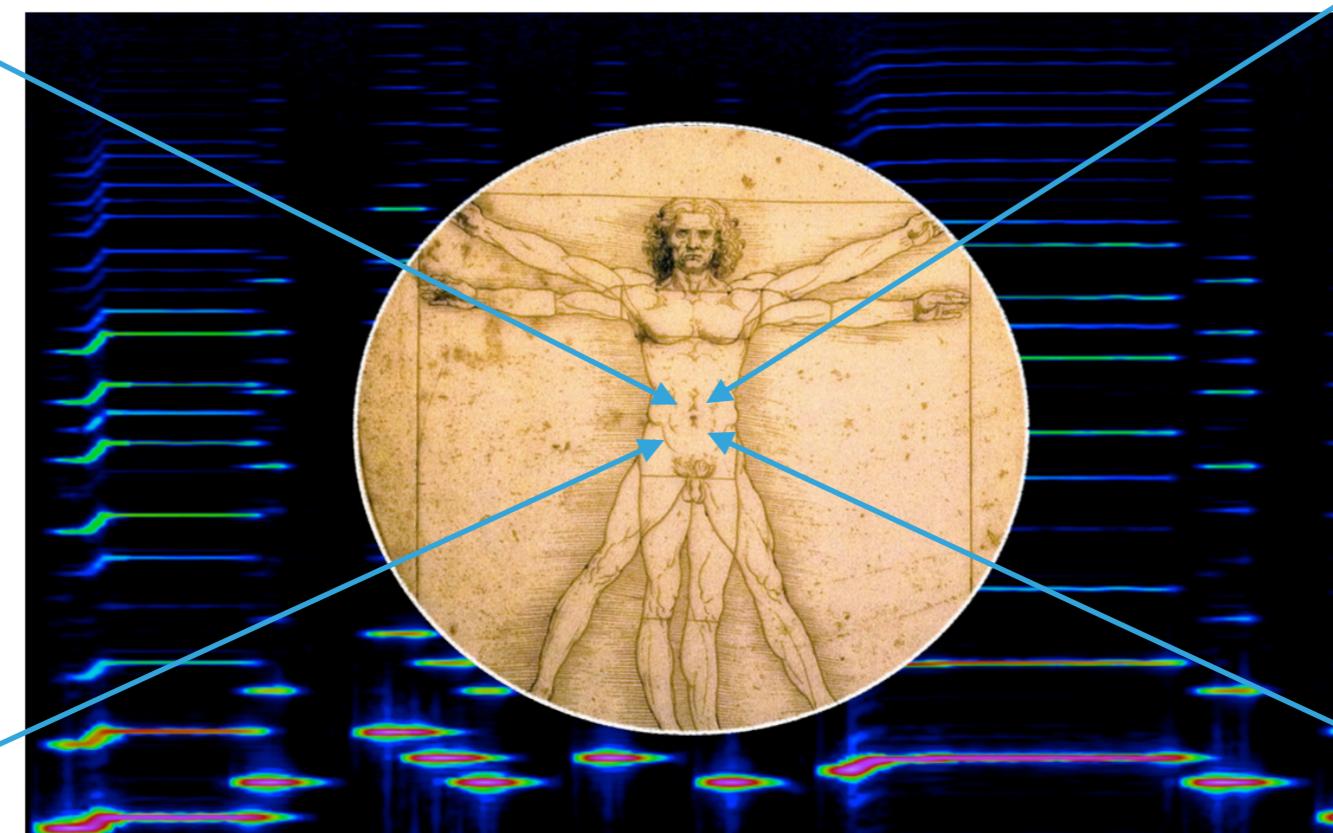
Culture?

What's next?

(what makes us...human?)

Emotions?

Genetics?



Culture?

Relationships?

What's next?

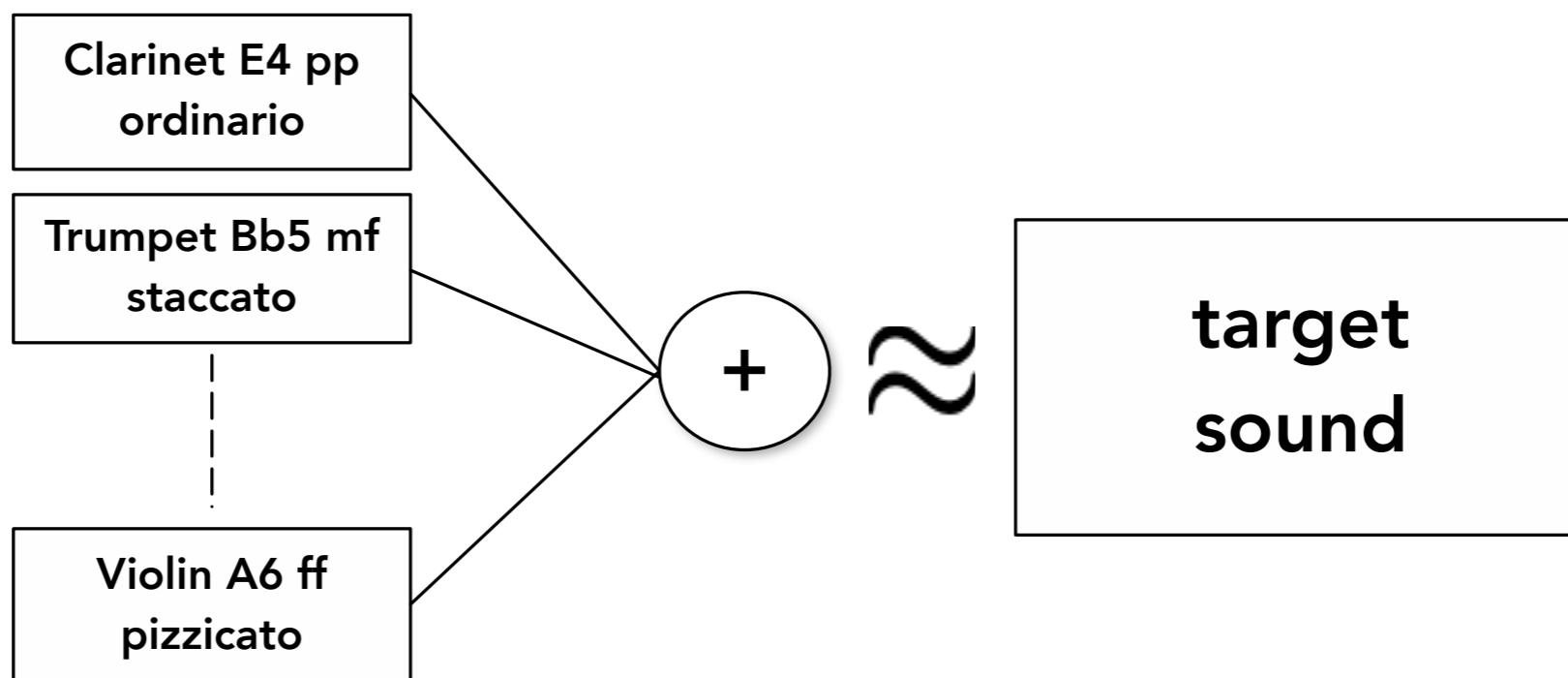
(what makes us...human?)

# AN EXAMPLE: ASSISTED ORCHESTRATION

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## A PRELIMINARY DEFINITION

The process of searching for the best combinations of orchestral sounds to match a target sound under specified metric and constraints.



# ORCHESTRATION: PROJECTION

Muovendo  $\text{♩} = 78$

103

A musical score page showing seven staves of music for an orchestra. The instruments are Picc., Fl., Ob., Eng. horn, Cl., B. Cl., and Bass. The tempo is Muovendo  $\text{♩} = 78$  and the dynamic is  $103$ . The score includes various musical markings such as trills, slurs, and dynamics like ff, sfff, and simile. Measure numbers 6, 6, 6, 3, 3, 3, and 3 are indicated above the staves.

Picc.

Fl.

Ob.

Eng. horn

Cl.

B. Cl.

Bass

# ORCHESTRATION: PROJECTION

Muovendo  $\text{♩} = 78$

103

The musical score shows six staves of music for an orchestra. The instruments are Picc. (Piccolo), Fl. (Flute), Ob. (Oboe), Eng. horn, Cl. (Clarinet), and B. Cl. (Bass Clarinet). The score includes dynamic markings such as *ff*, *fff*, *tr.*, *simile*, and *dim.*. Measure numbers 7 and 8 are indicated at the top. The tempo is marked as  $\text{♩} = 78$ .

PROJECTION

Signal space  
(timbre)

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# ORCHESTRATION: INDUCTION?

Signal space  
(timbre)

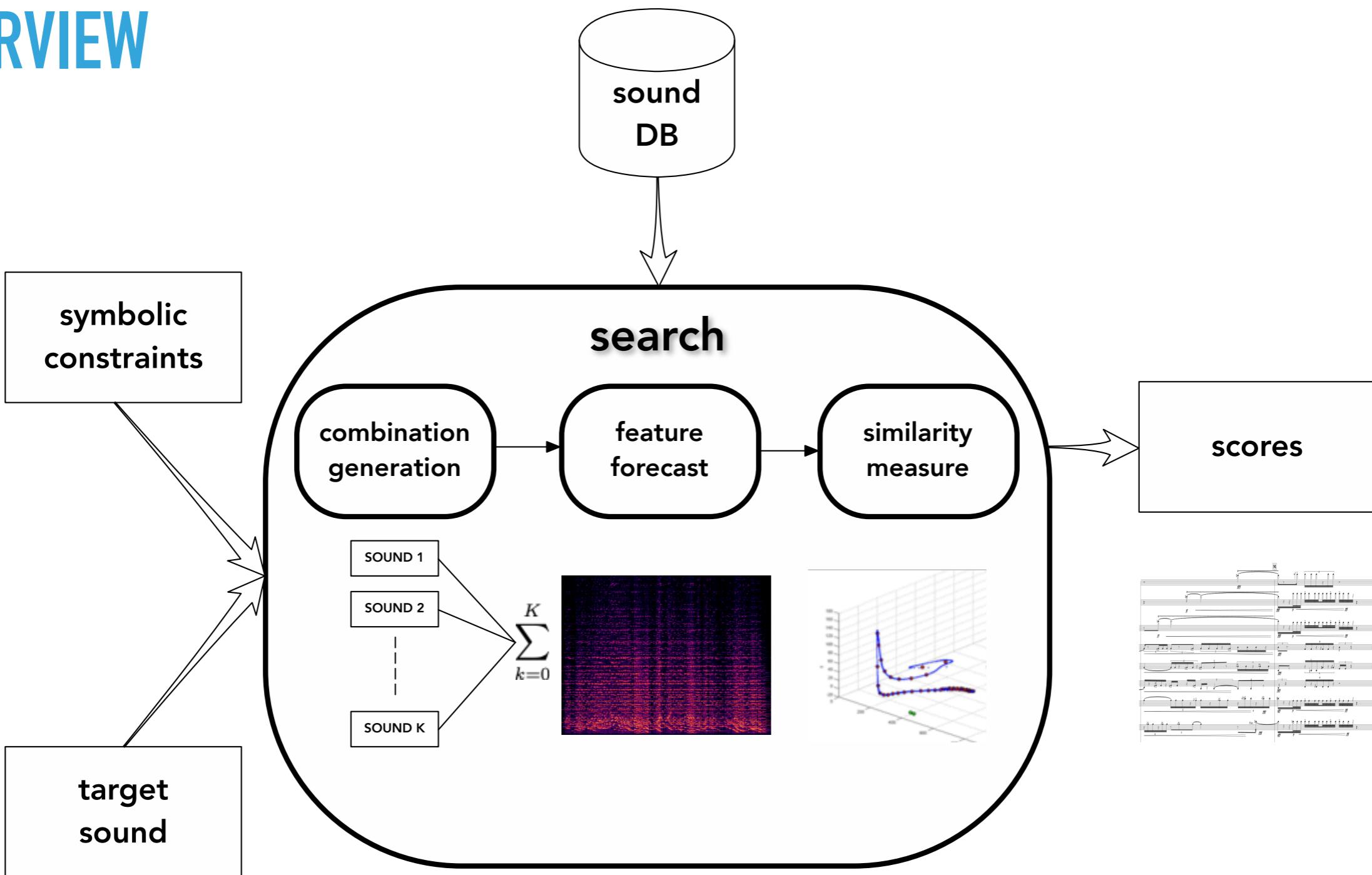
# ORCHESTRATION: INDUCTION?

A musical score for orchestra, showing ten staves of music. The instruments listed from top to bottom are Flute (Fl), Oboe (Ob), Clarinet (Cl), Bassoon (Bn), Horn (Hn), Trombone (Tp), Tuba (Tbn), Violin (Vn), Viola (Va), and Cello/Bass (Cb). Each staff includes a clef, key signature, and dynamic markings. For example, the Flute starts at forte (ff) and ends at piano (pp). The Trombone starts at piano (pp) and ends at mezzo-forte (mf). The Violin starts at forte (ff) and ends at piano (pp). The Viola starts at piano (pp) and ends at forte (ff). The Cello/Bass starts at forte (ff) and ends at piano (pp).

?

Signal space  
(timbre)

# OVERVIEW



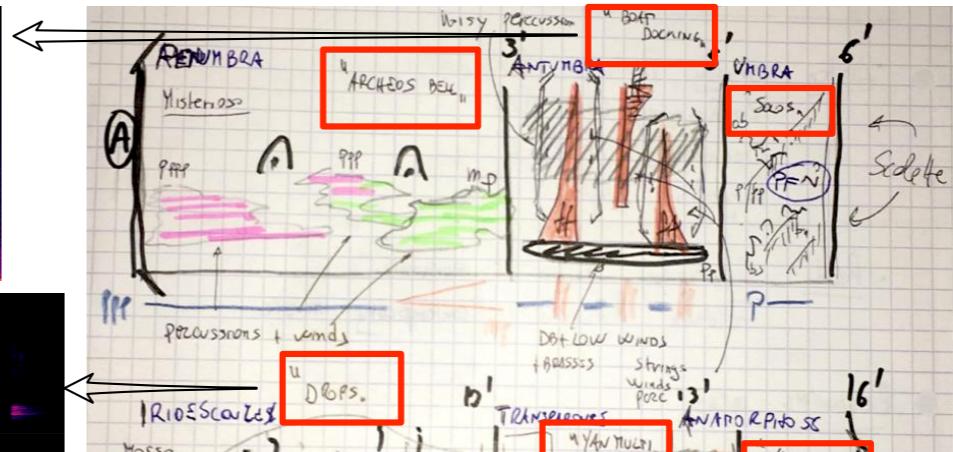
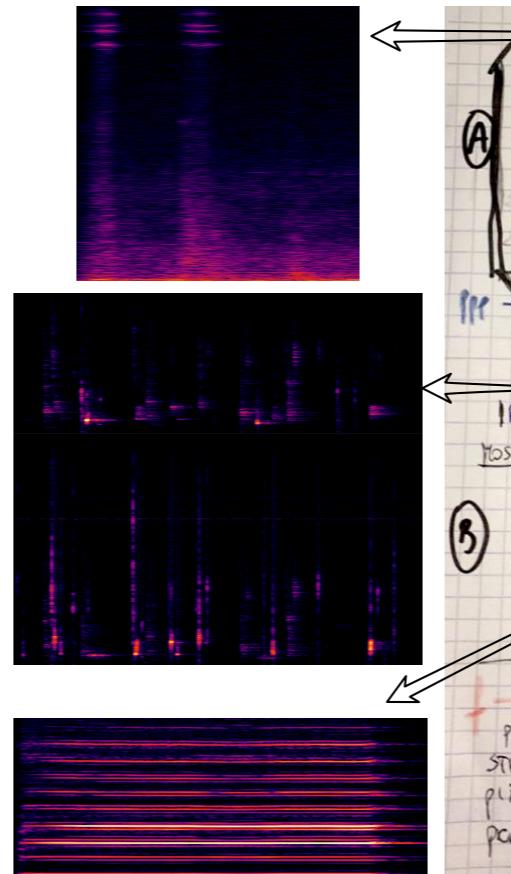
# C. E. CELLA, STADES D'OMBRE, STADES DE LUMIÈRE (2018)

## Target sound

# Orchidea solution

## Real orchestration

(longer excerpt)



FULL SCORE

# Stades d'ombre, stades de lumière

*For Eli*

Carmine-Emanuele Cella (2018)

**C** **Grave** ♩ = 48

**C** **Grave** ♩ = 48

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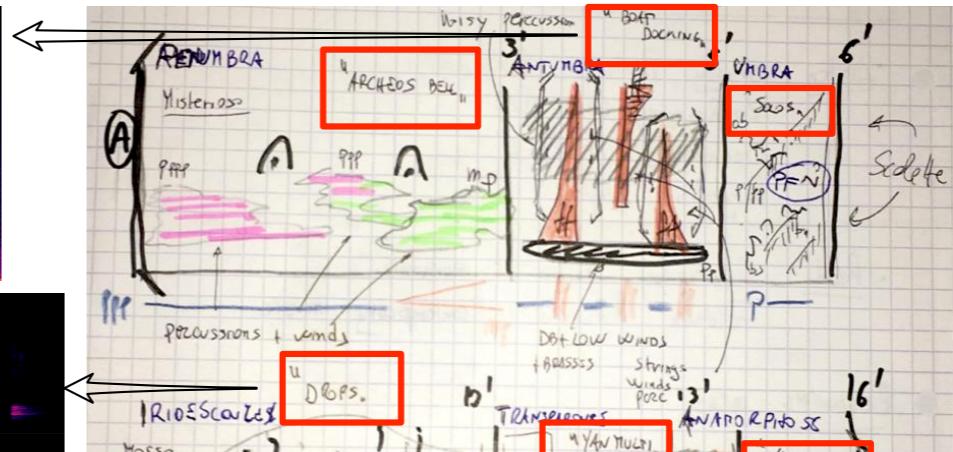
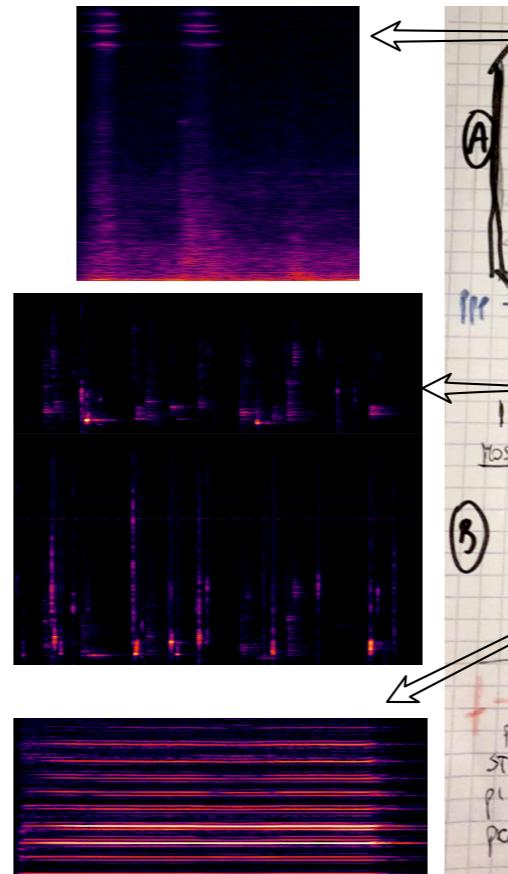
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**C** **Grave**, = 48

Flute: harmonic tremolo, **pp**, **p**  
Oboe: **mf** *senza crescere*, **mp**  
Clarinet in B $\flat$ : **PPP**, **mp**  
Bassoon: **p** *senza crescere, **PPP**  
Horn in F: opening and closing with hand, **ppp** *senza crescere*, **p**  
Trumpet in B $\flat$ : harmon mute, **ppp**, straight mute, **p**  
Trombone: **PPP**, **p**  
Percussion: **PPP** *TAM TAM*, irregular movements with superball, **mp**, *l.v.*  
Piano: irregular movements with hands on the strings in the lower region, **ppp**, **p**, *l.v.*, **pizz.**  
Violin I: increasing vibrato speed, **p** *espress.*, **sp**  
Violin II: **ppp**, **pizz.**, **mp**  
Viola: **ppp**, **p**, **pp**, **ppp**, **pizz.**, **mp**  
Cello: lead mute, increasing vibrato speed, **ppp**, **sp** *espress.*  
Double Bass: **ppp** *senza crescere*, **pizz.**, **mp***

**C** **Grave**, = 48

Violin I: **p** *espress.*, **sp**  
Violin II: **ppp**, **pizz.**, **mp**  
Viola: **ppp**, **pizz.**, **mp**  
Cello: lead mute, increasing vibrato speed, **ppp**, **sp** *espress.*  
Double Bass: **ppp**, **pizz.**, **mp**

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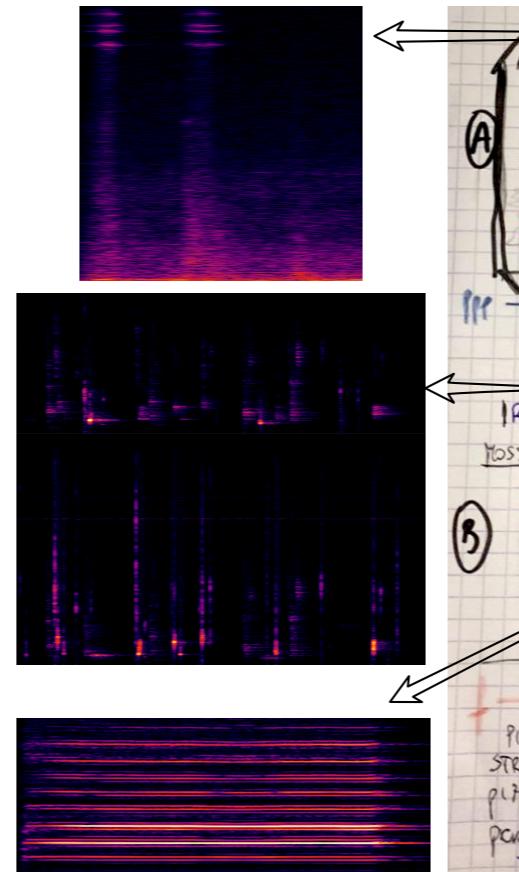
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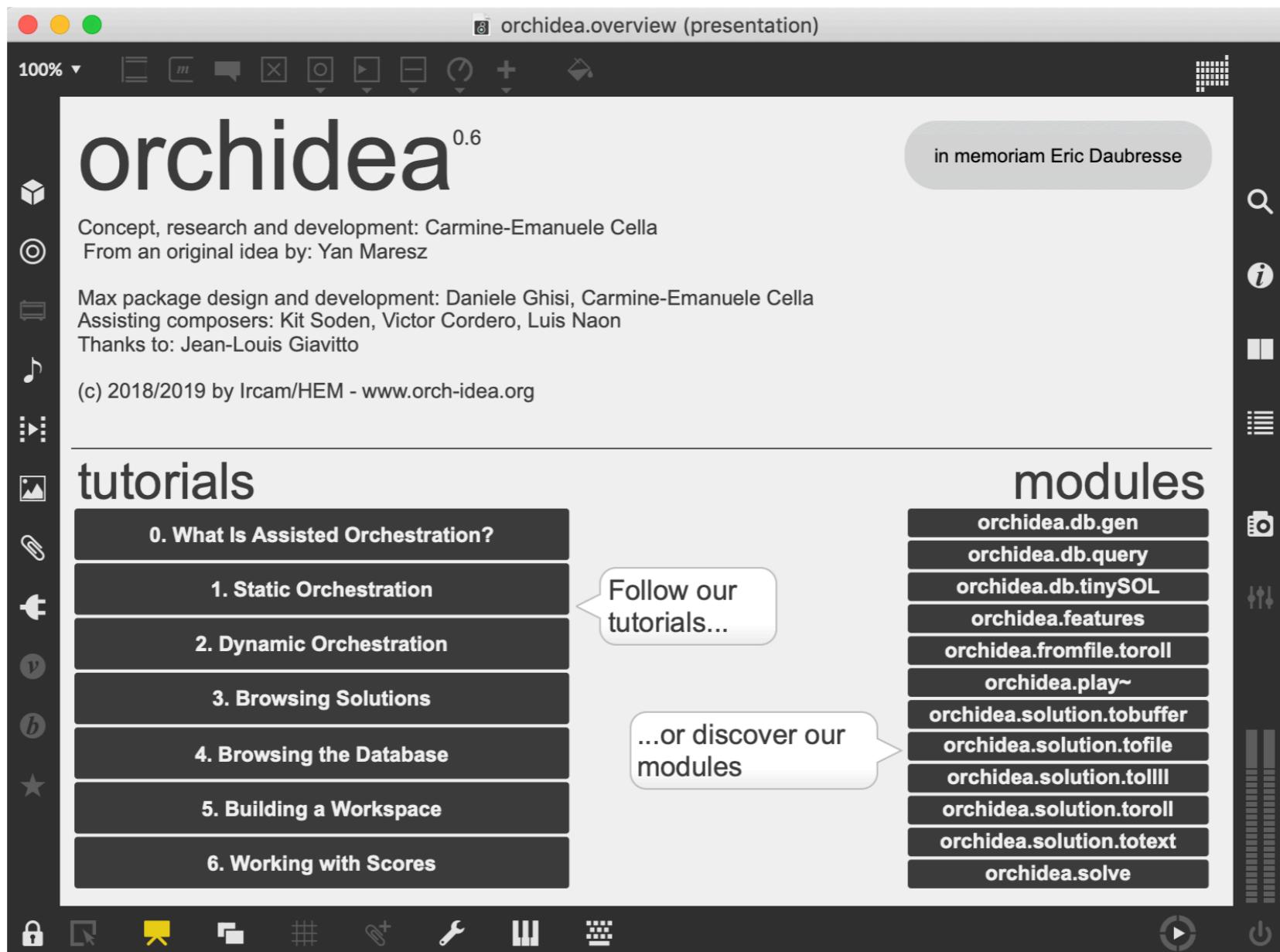
# Stades d'ombre, stades de lumière

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Carmine-Emanuele Cella (2018)

# ORCHIDEA MAX PACKAGE

Carmine-Emanuele Cella, Daniele Ghisi



[www.orch-idea.org](http://www.orch-idea.org)

# ORCHIDEA STANDALONE

Alessandro Petrolati, Daniele Ghisi, Carmine-Emanuele Cella

The screenshot displays the Orchidea Standalone software interface. On the left, a vertical toolbar includes icons for Target Audio Source, Properties, Optimization, Analysis, Segmentation, Filters, and Orchestra. The main window shows a musical score titled "Orchidea" with a timeline from 0'00" to 0'50". The score consists of multiple staves for various instruments: A Sax, Acc, BTb, BTb+S, Bn, Cb, Cb+S, CLBb, Fl, and Gtr. Each staff contains musical notation with performance instructions such as "play+sing", "fortepiano", "key click", "pizz", "ord", "slap", and "stopped". The background of the score area is green. On the right side of the interface, there is a detailed view of the "Properties" panel, which contains settings for "Target" (set to "Colour"), "Solve From Script" (set to "Open"), "Use" (set to "Orchestration"), and optimization parameters like "Quality" (set to "Medium"), "Initialization" (set to "Random"), "Diversity" (set to 0.01), "Sparsity" (set to 0.001), "Partials Filtering" (set to 0.10), and segmentation thresholds.

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# THANK YOU!!!



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# THANK YOU!!!



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