

# Sound Innovation Engine 1.0

Towards Sound Innovation Engines

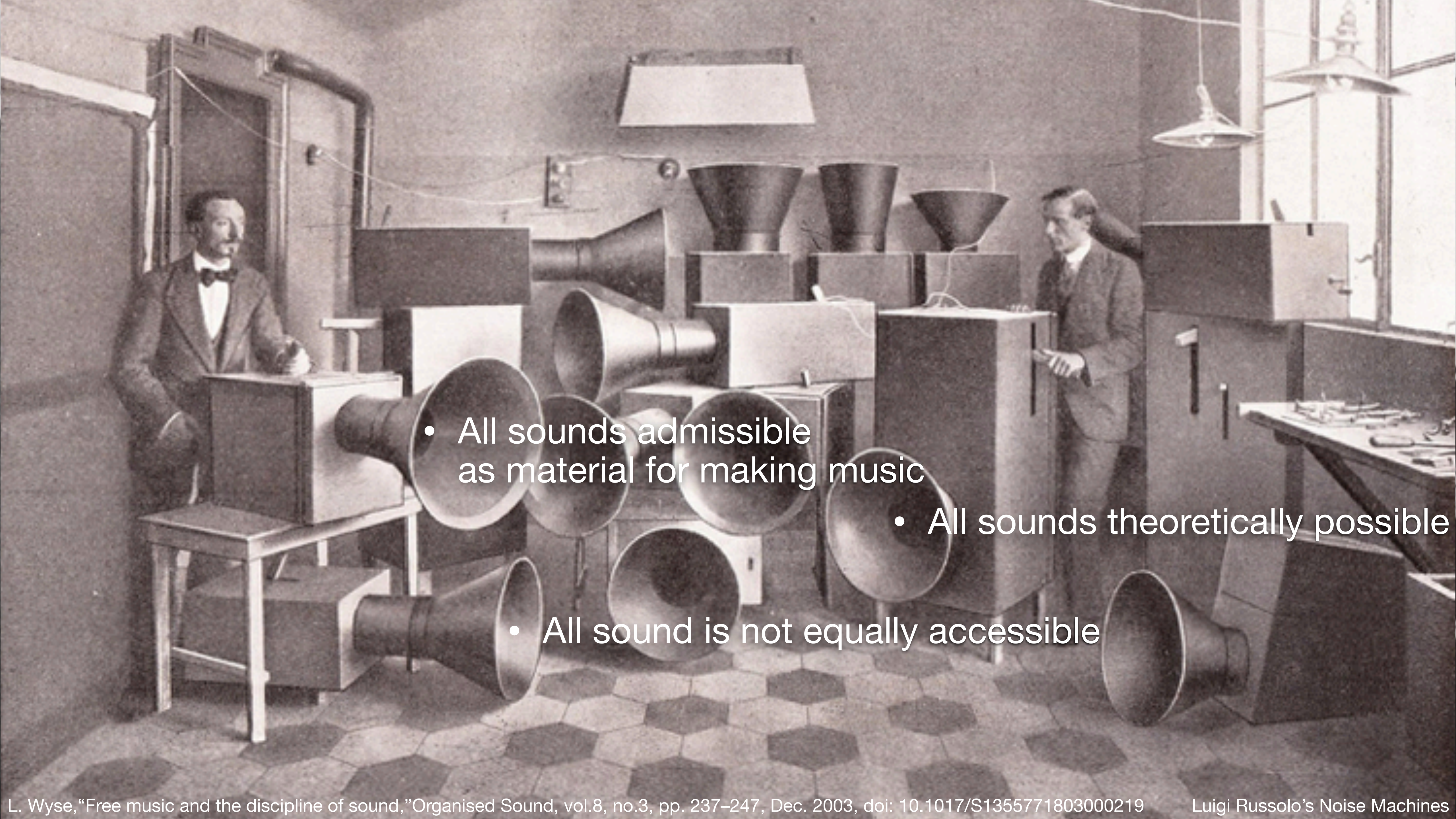
Using Pattern-Producing Networks and Audio Graphs

Björn Þór Jónsson, Çağrı Erdem, Stefano Fasciani and Kyrre Glette, January 2024



UiO • RITMO Centre for Interdisciplinary Studies in Rhythm, Time and Motion  
University of Oslo





- All sounds admissible as material for making music

- All sounds theoretically possible

- All sound is not equally accessible



**recognising sounds  
you've never heard**

**finding sounds recognised as  
pleasing but unfamiliar**



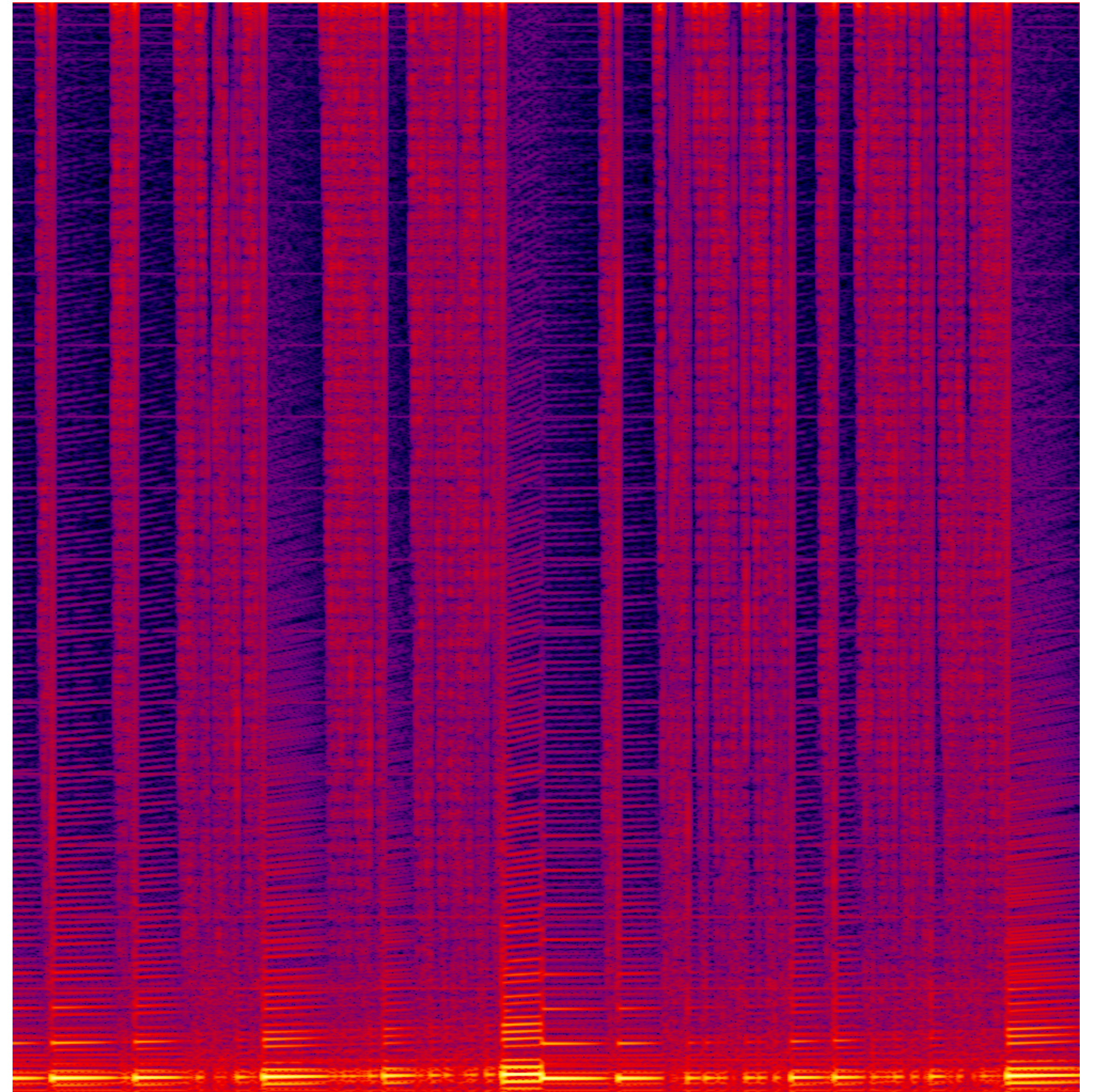
**Quality Diversity  
to discover stepping stones  
with goal switching  
on a path to greatness**



# Innovation Engines

Automate QD exploration with a model capable of:

- distinguishing novelty
- evaluating quality

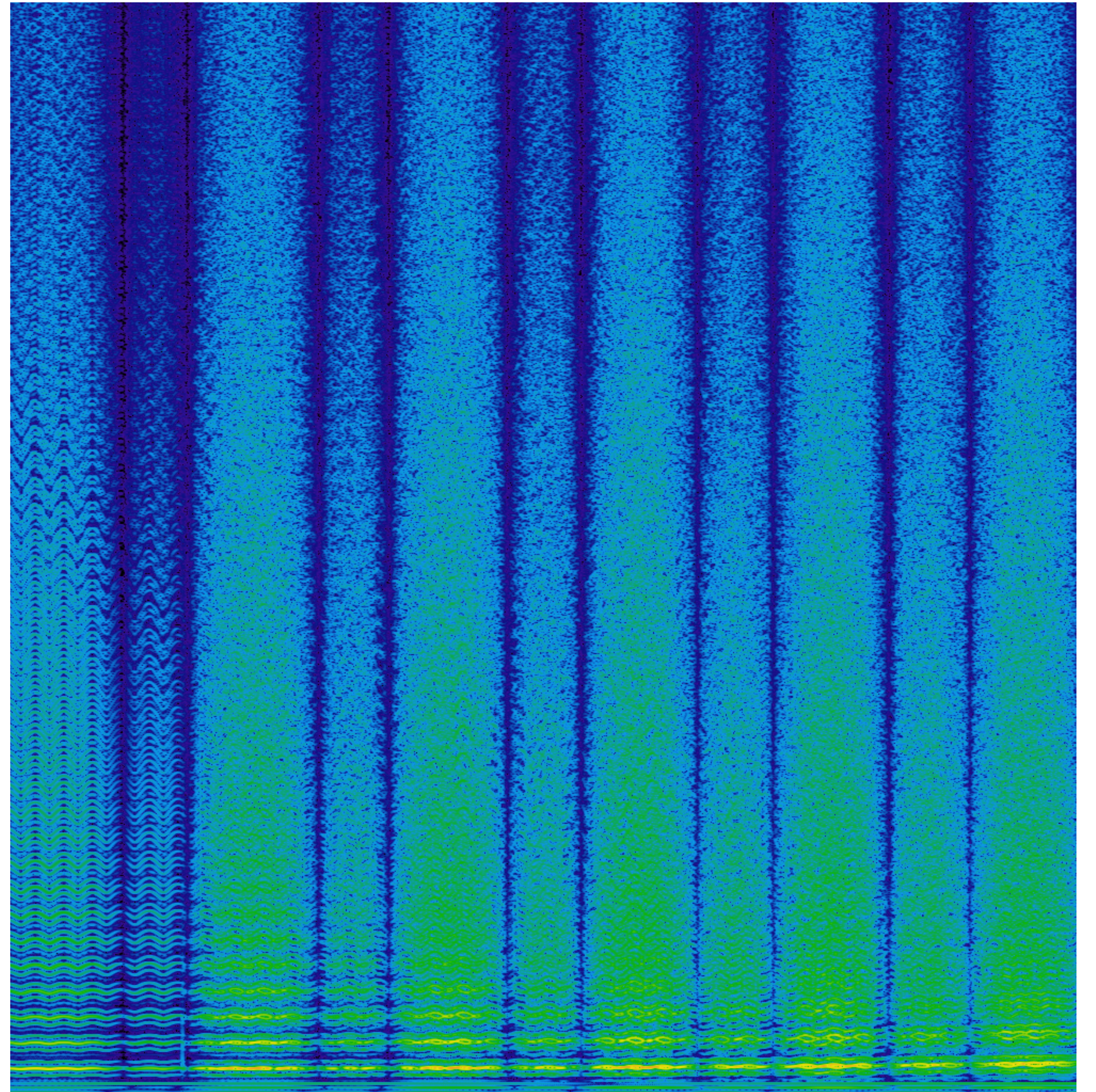




# Innovation Engines

**Ultimate goal:**

- Unsupervised classification
- Produce new types of things

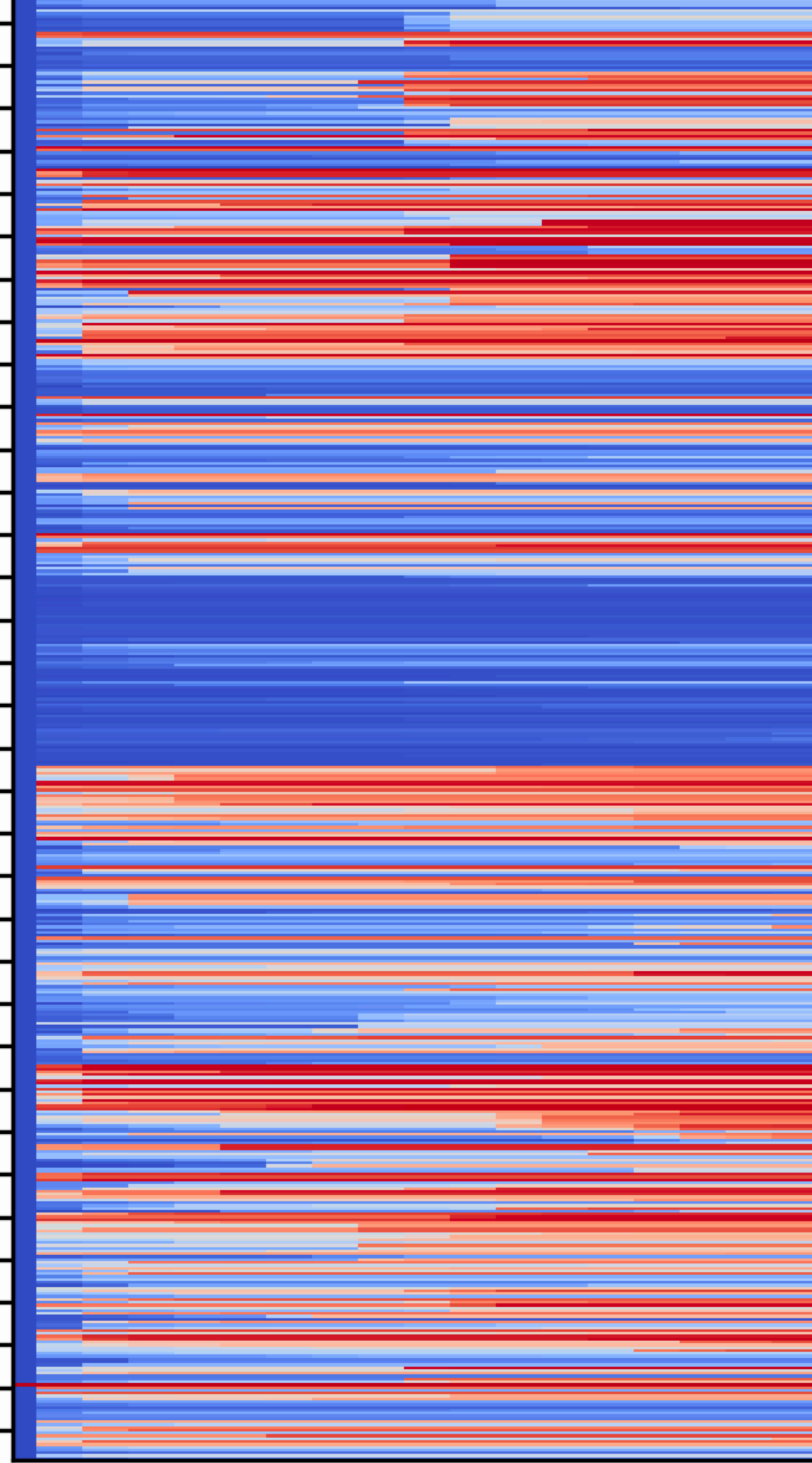




# Behavioural Descriptor

YAMNet

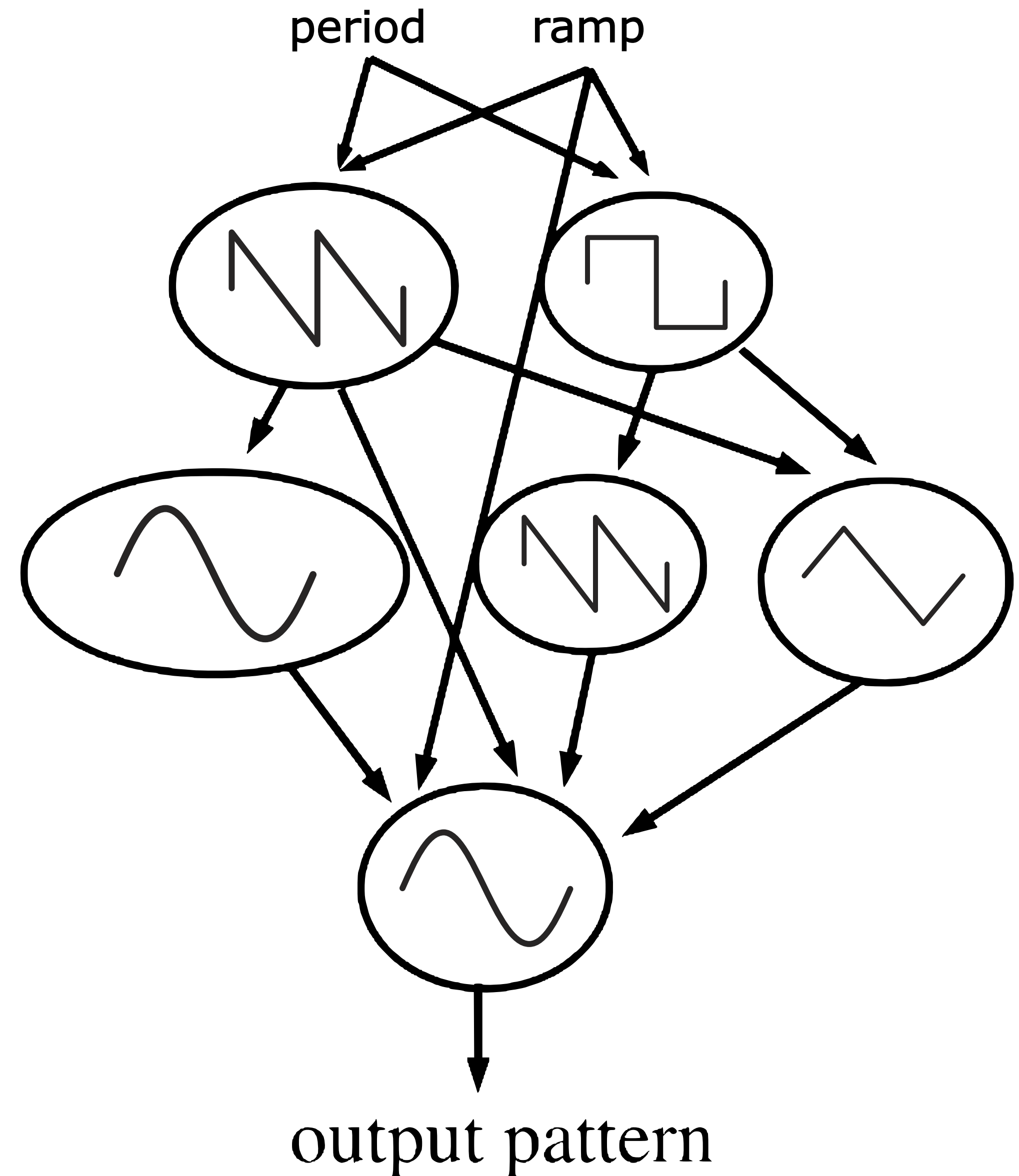
Giggle  
Synthetic singing  
Sniff  
Heart murmur  
Whimper (dog)  
Goat  
Roar  
Patter  
Guitar  
Organ  
Tabla  
Brass instrument  
Bell  
Scratching (performance technique)  
Swing music  
Electronic dance music  
Music of Asia  
Wedding music  
Rain on surface  
Motor vehicle (road)  
Bus  
Aircraft engine  
Engine starting  
Chopping (food)  
Scissors  
Siren  
Sewing machine  
Explosion  
Glass  
Boiling  
Bouncing  
Creak  
Sine wave  
Mains hum





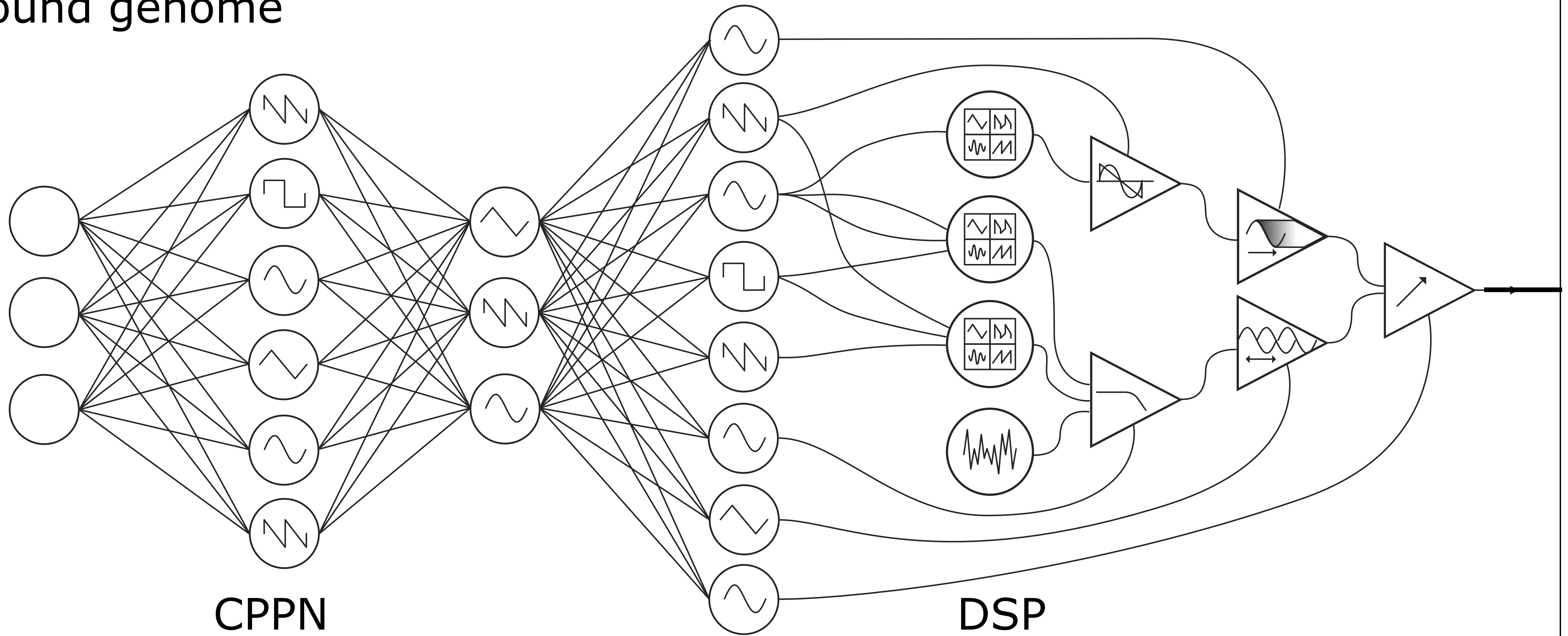
# Compositional Pattern Producing Networks CPPNs

- Abstract unfolding development in evolutionary processes
- Applied to timbral development
  - Combined with DSP graphs





sound genome



CPPN

DSP

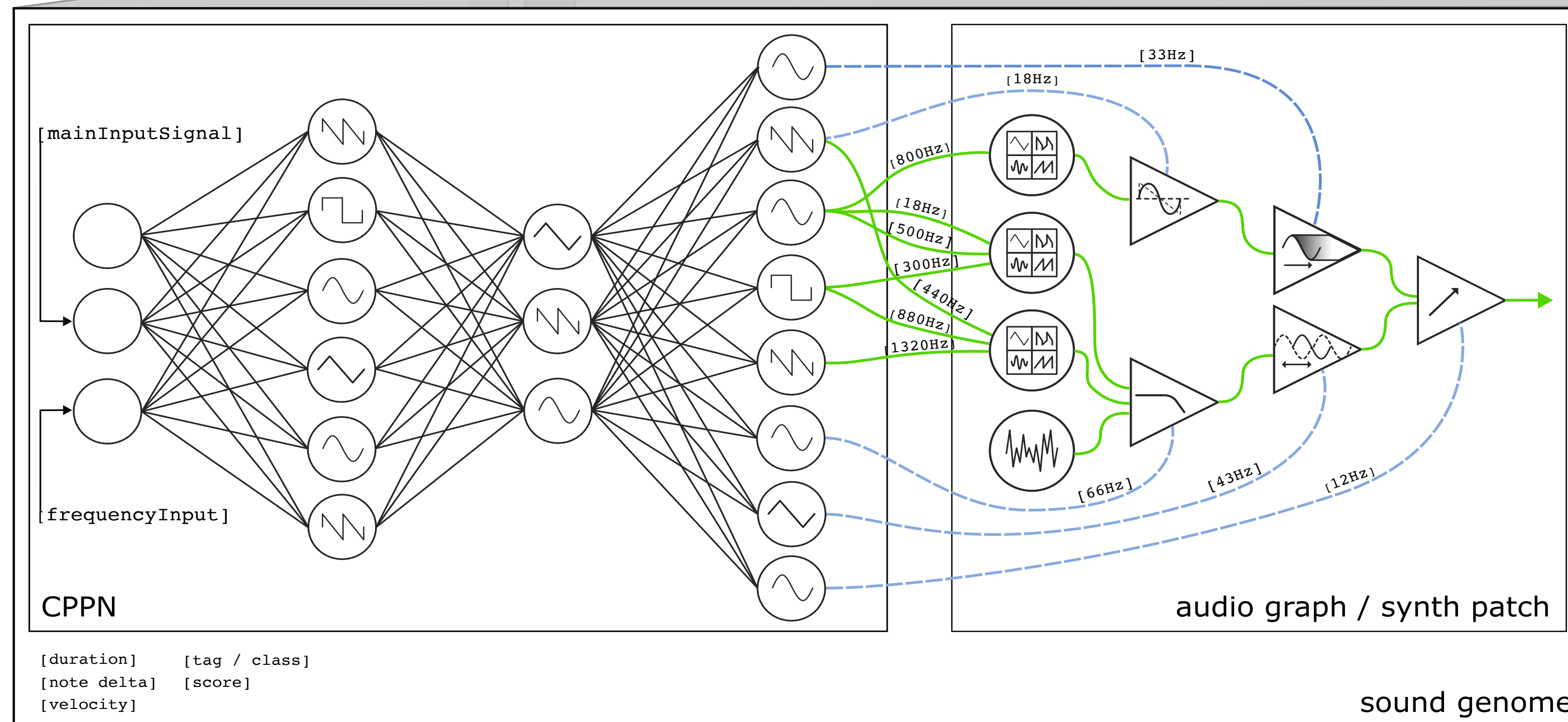
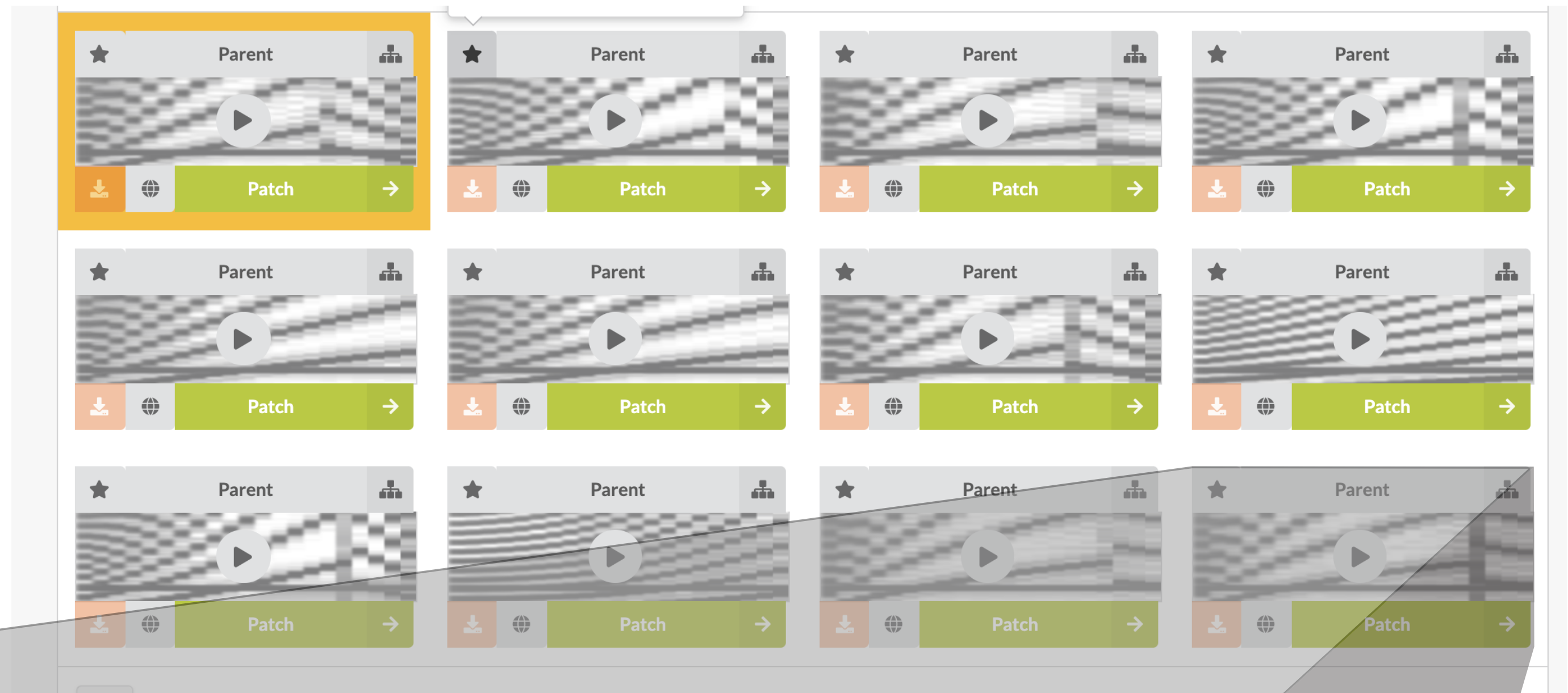
# Signal Composition

CPPN + DSP



# QD algorithm

## MAP-Elites

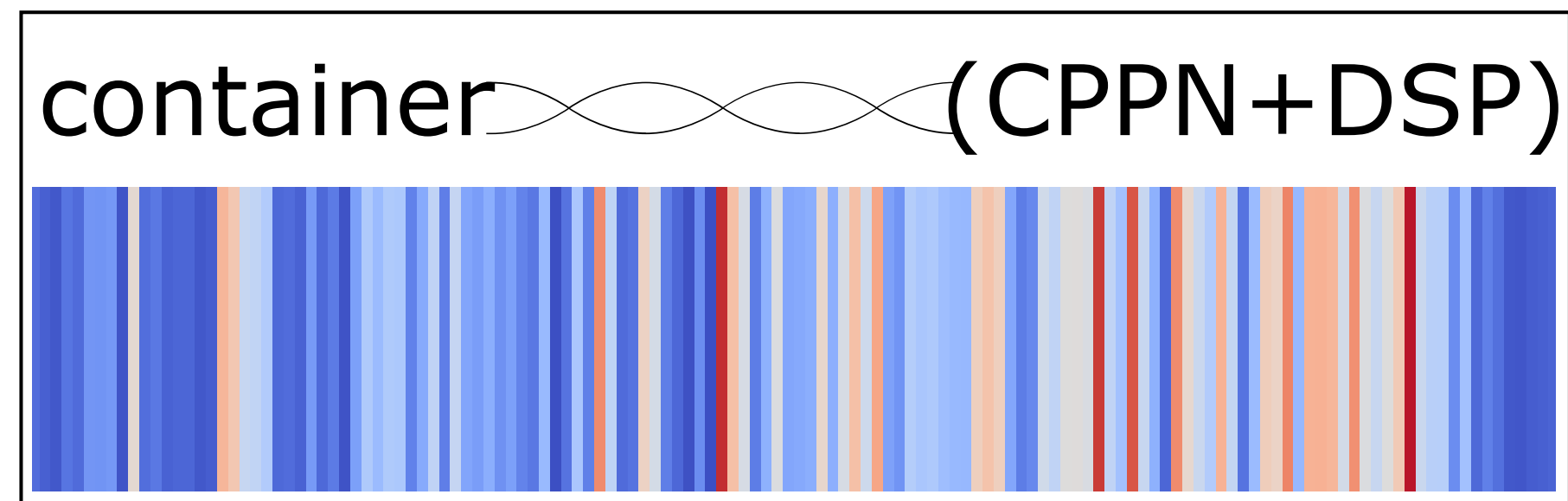


Next population size: 12



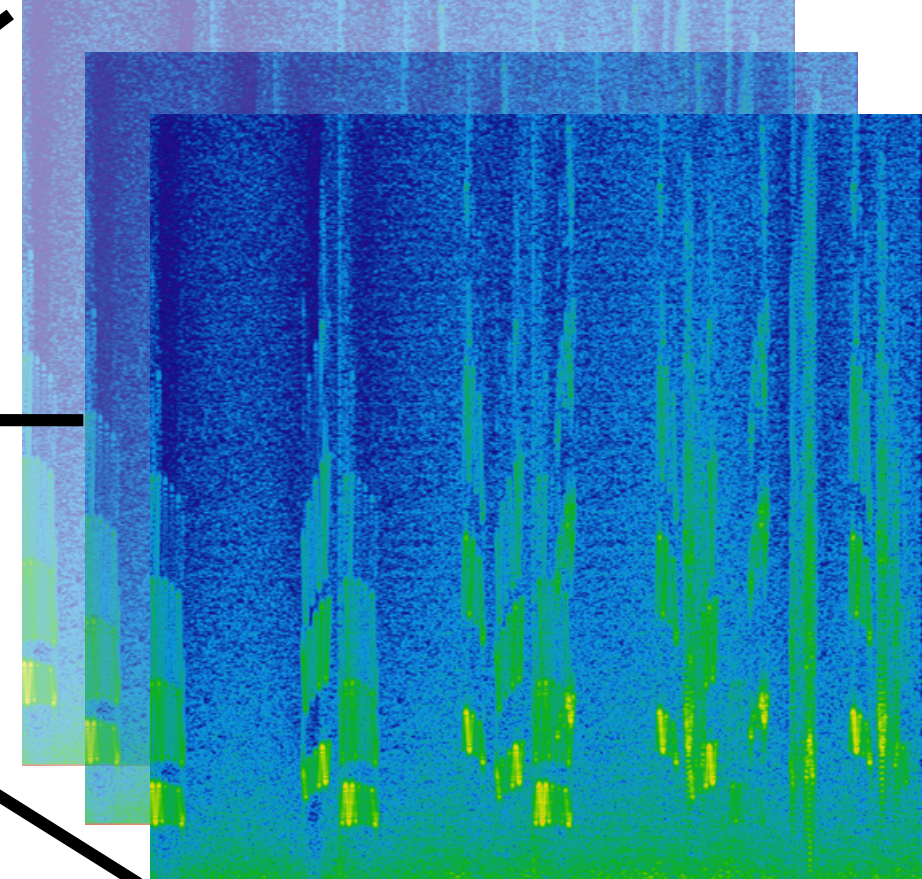
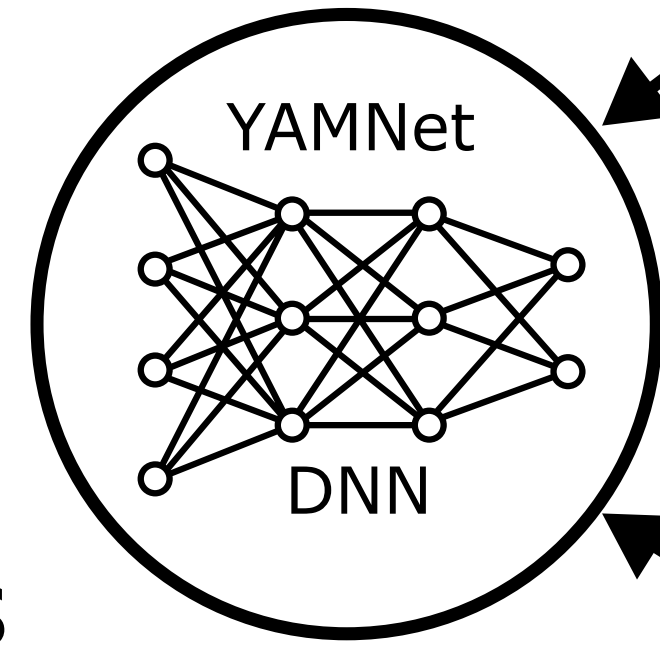


# MAP-Elites



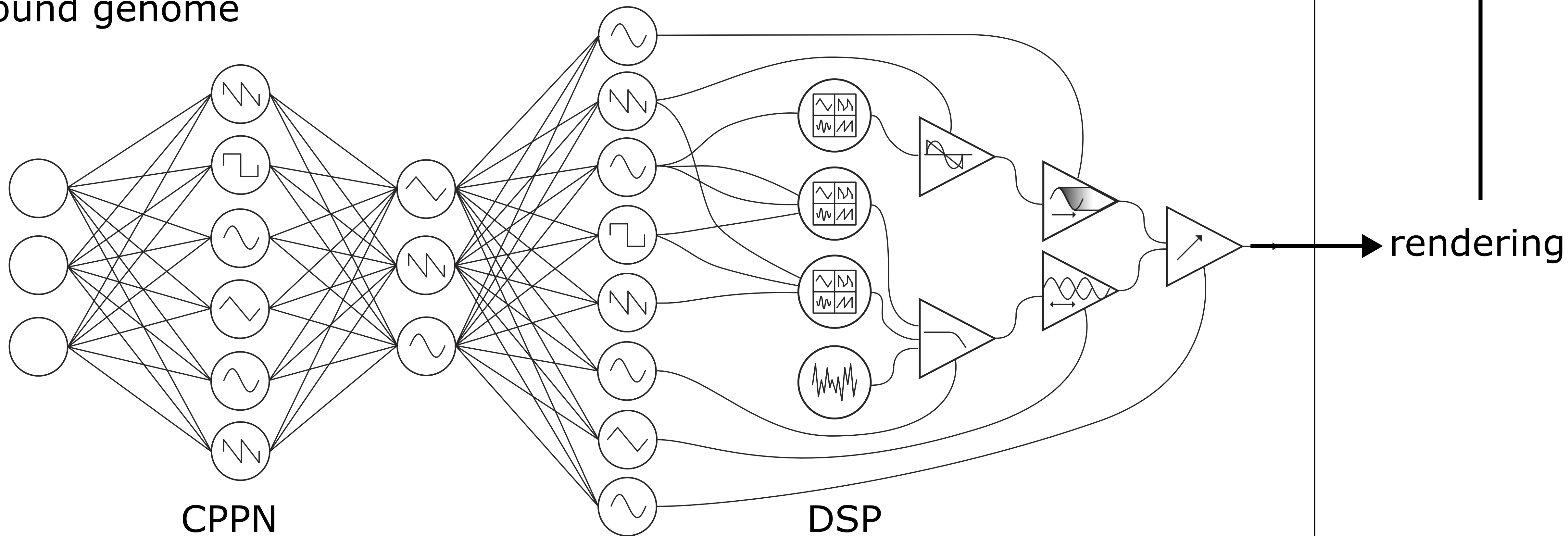
map and insert  
higher-scoring solutions

# evaluation



selection + variation

# sound genome

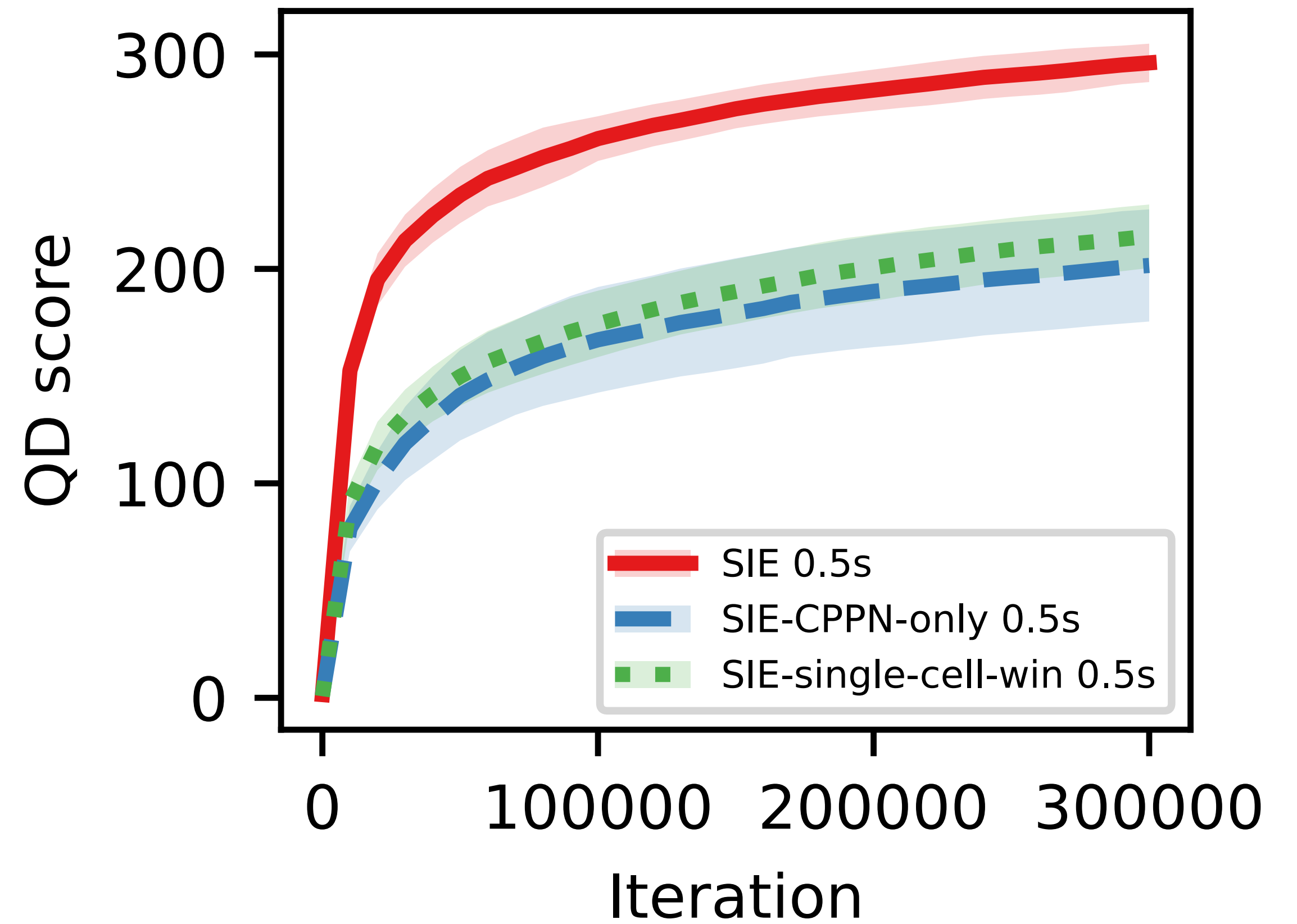




# Results

## Signal Processing Graph

- QD-score:
  - CPPN + DSP
    - vs
  - CPPN only





**57.4% ± 3.4%**

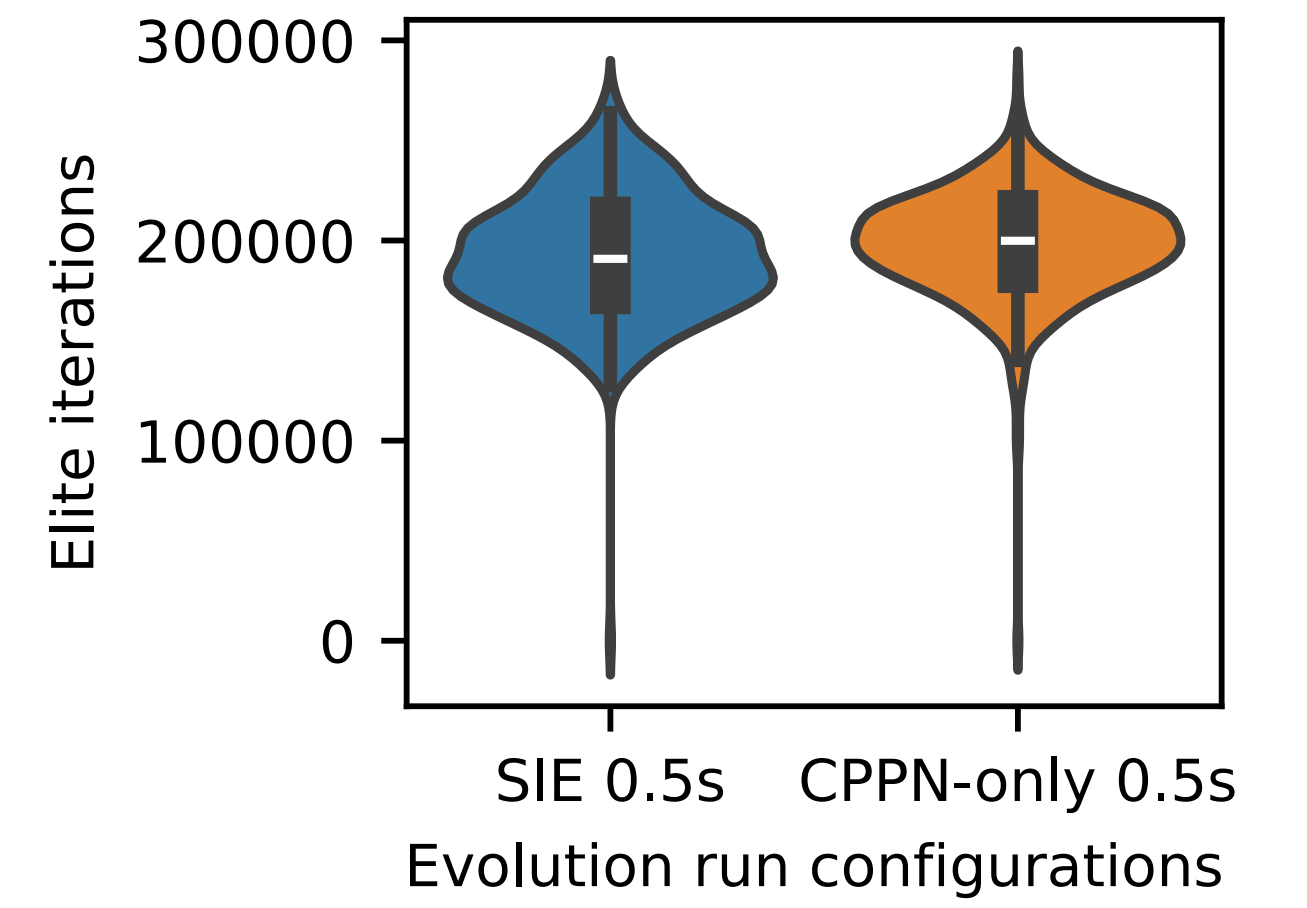
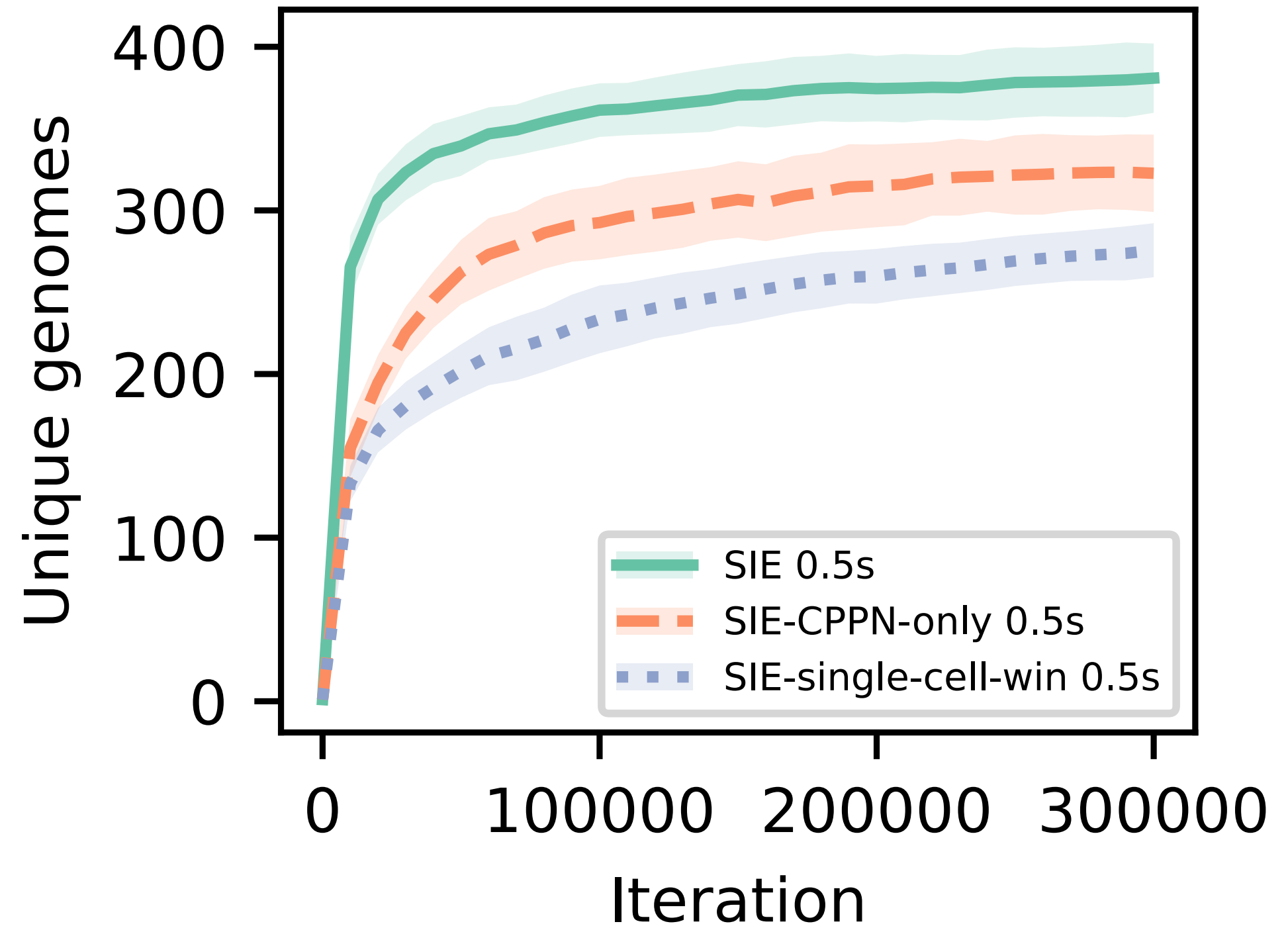
**- map coverage, when incremental - otherwise immediately full coverage**



# Results

## Elite Populations

- More diversity when evaluating sound objects from CPPN + DSP genomes

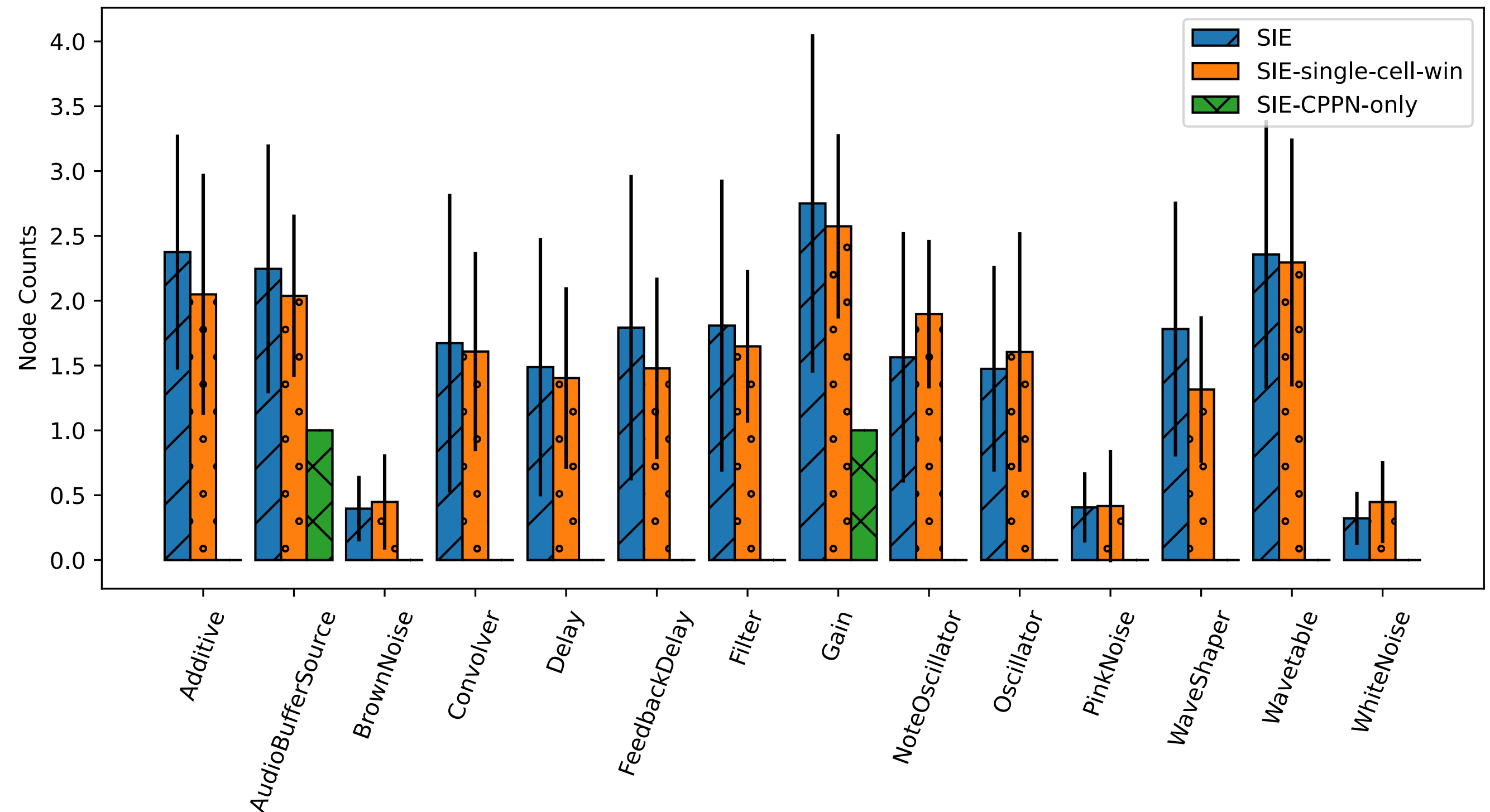
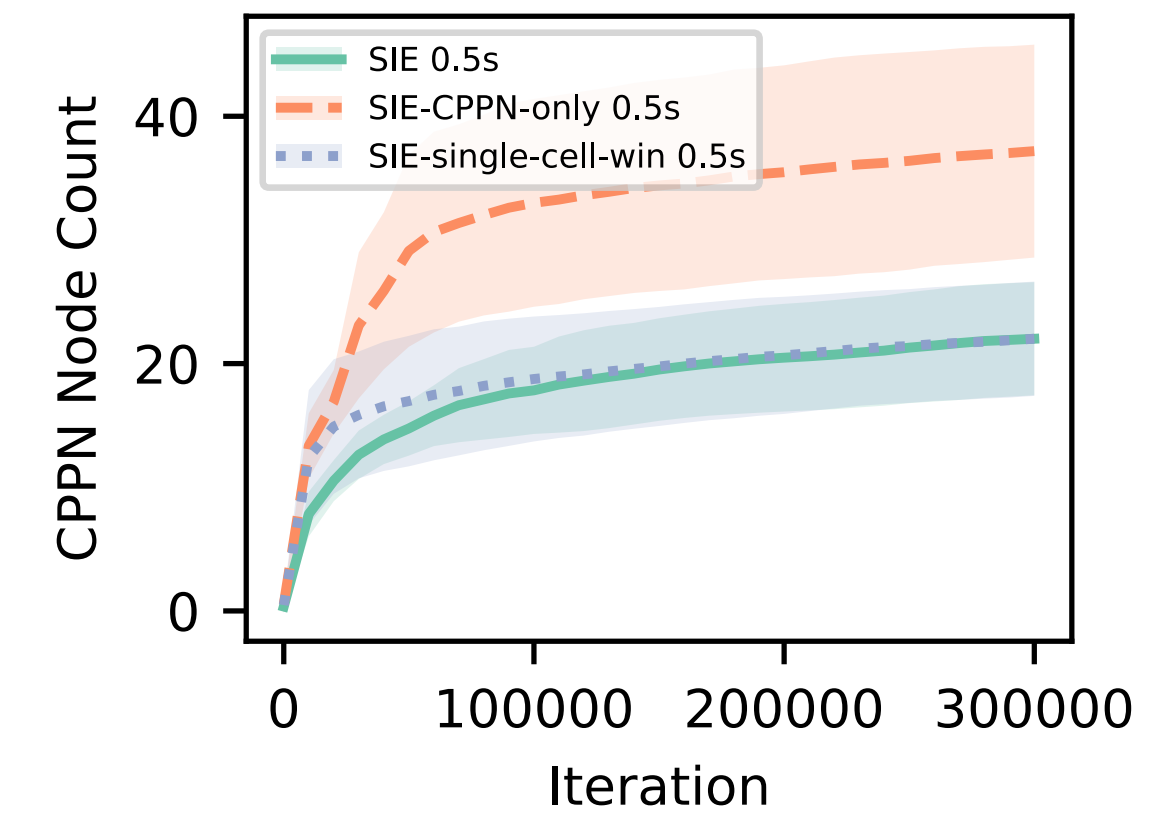
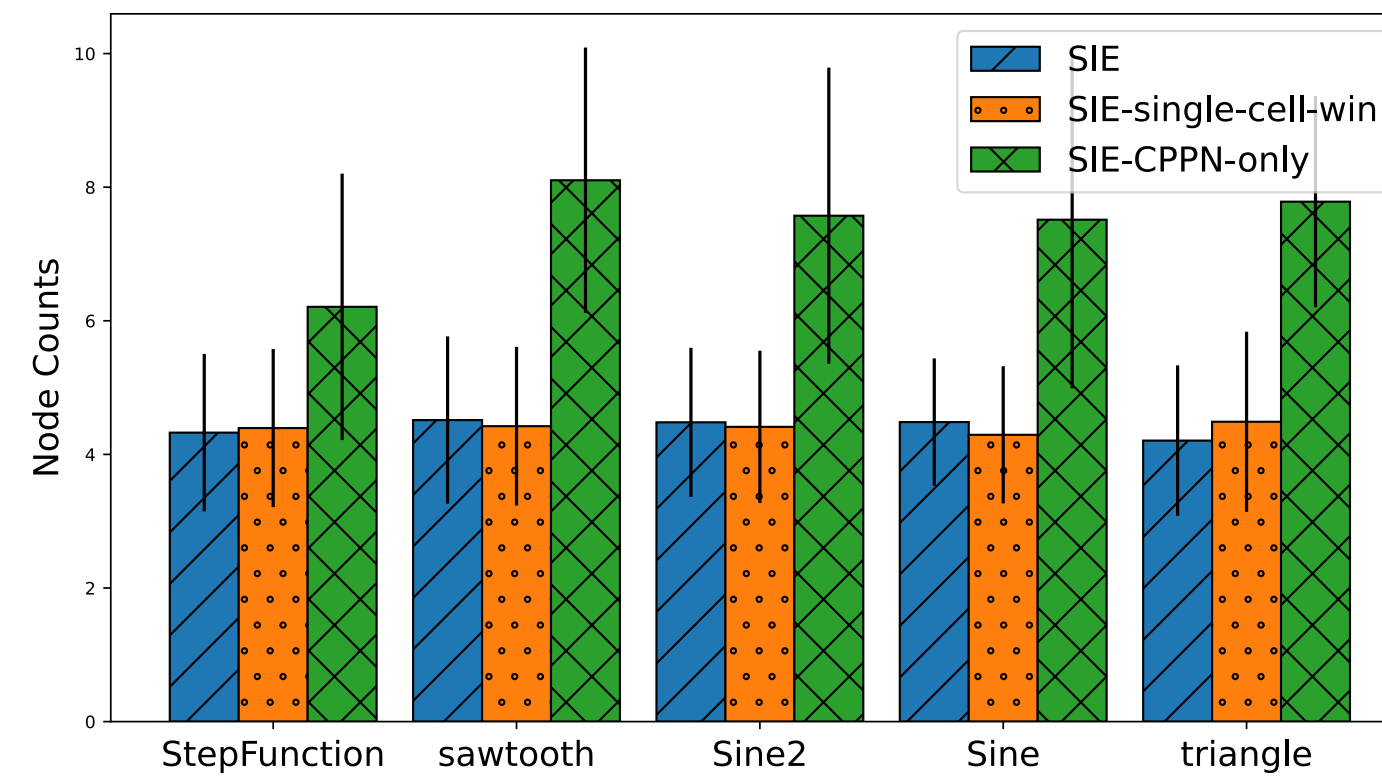




# Results

## Genome Complexity

- Uniform set of CPPN activation functions
- Custom wavetable and additive synthesis DSP nodes prominent
- CPPN only genomes with higher CPPN node count
- Compensating for the lack of DSP?

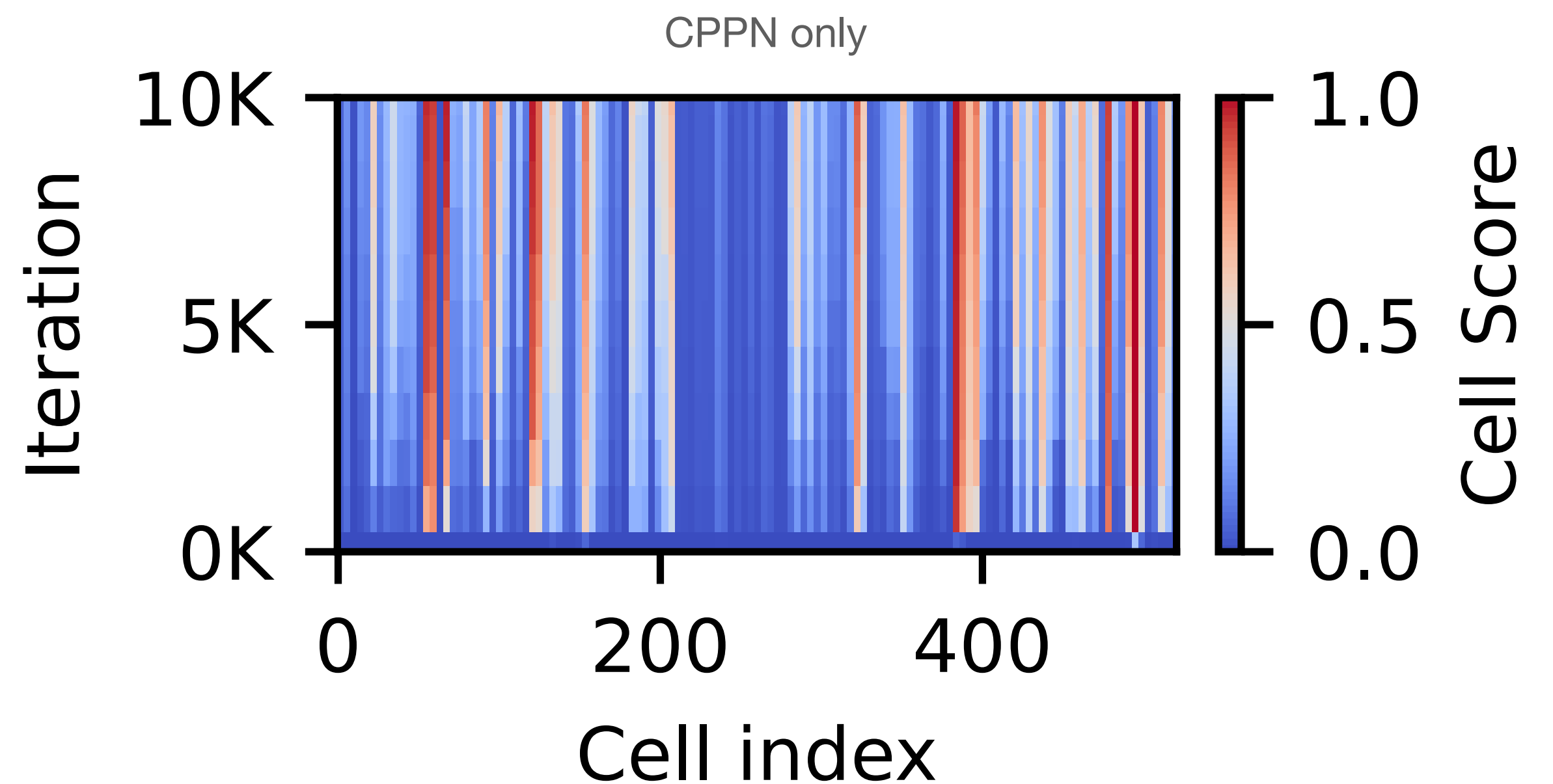
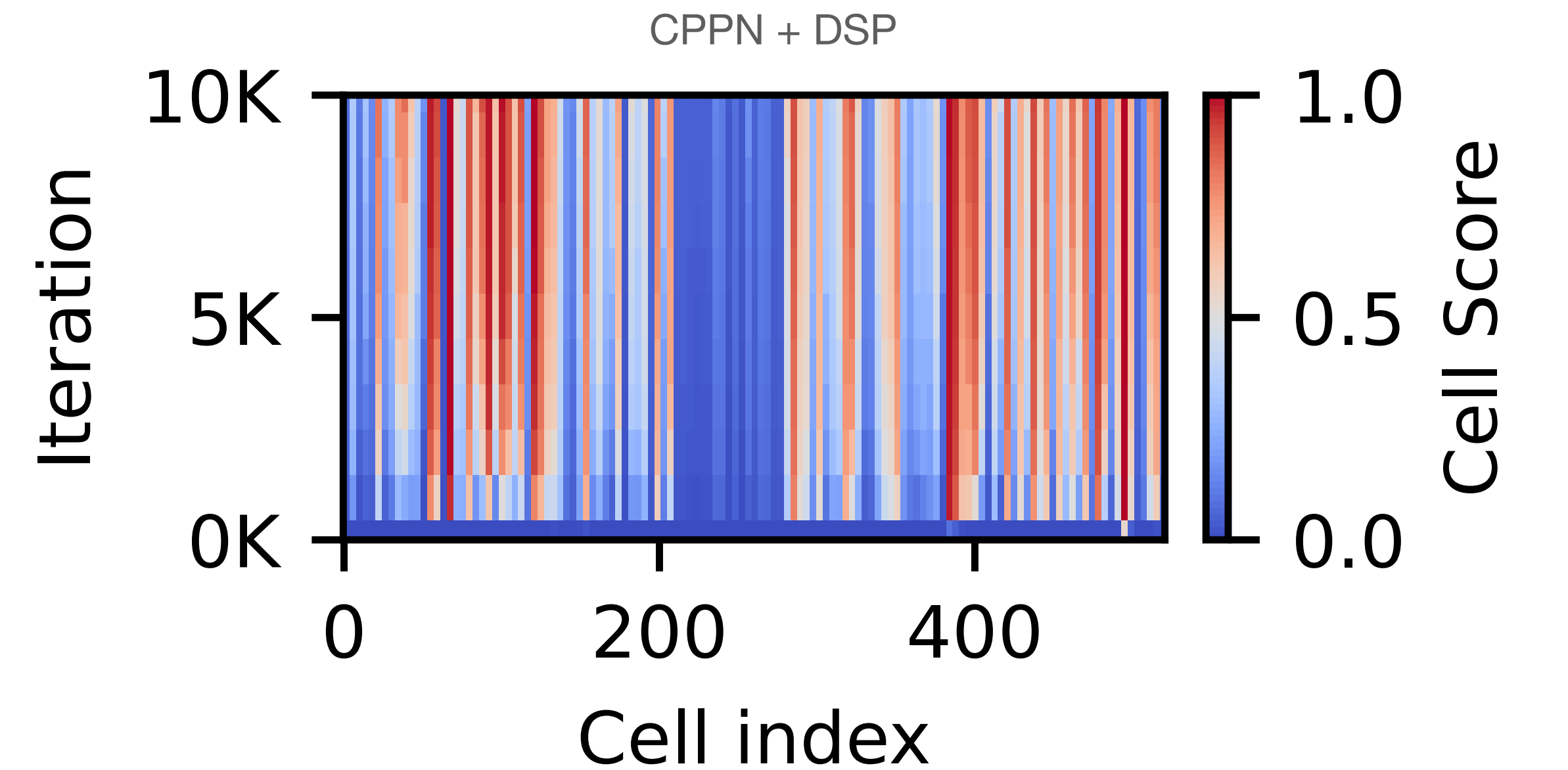




# Results

## Performance Against Pre-trained Reward Signals

- High scores across most classes
- CPPN + DSP higher overall
- Synthesiser struggles with scoring high on musical classes
  - Understandably?





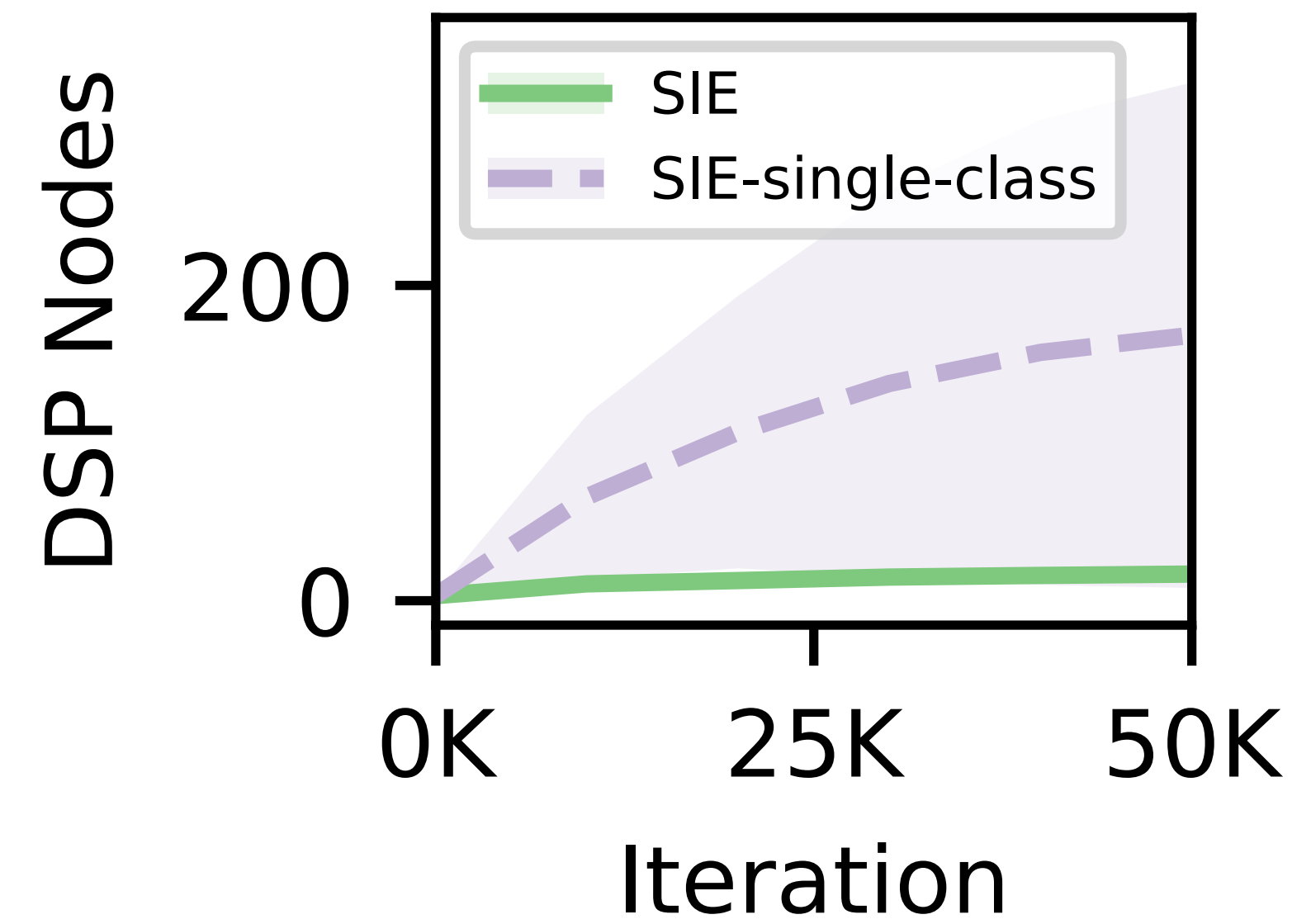
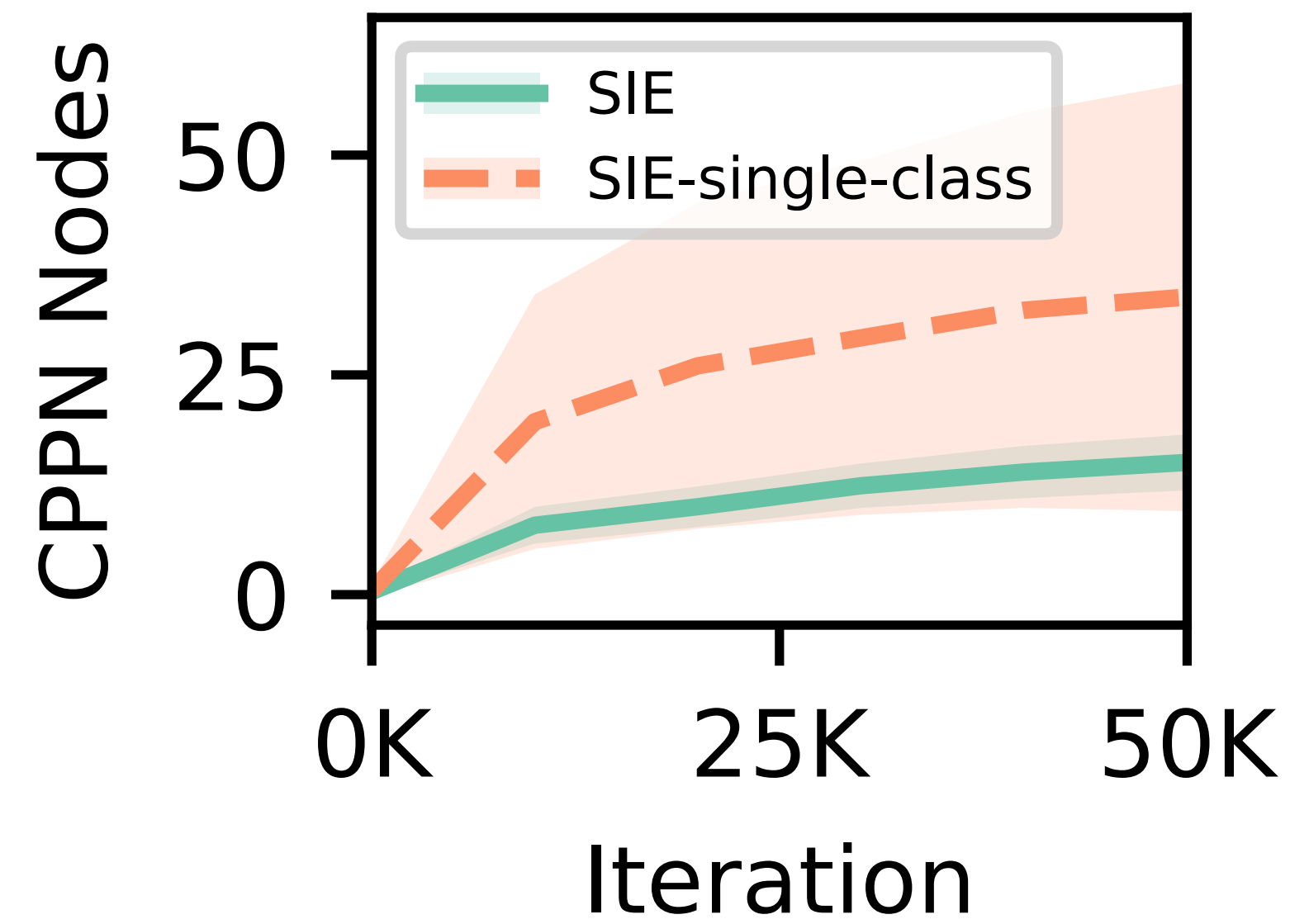
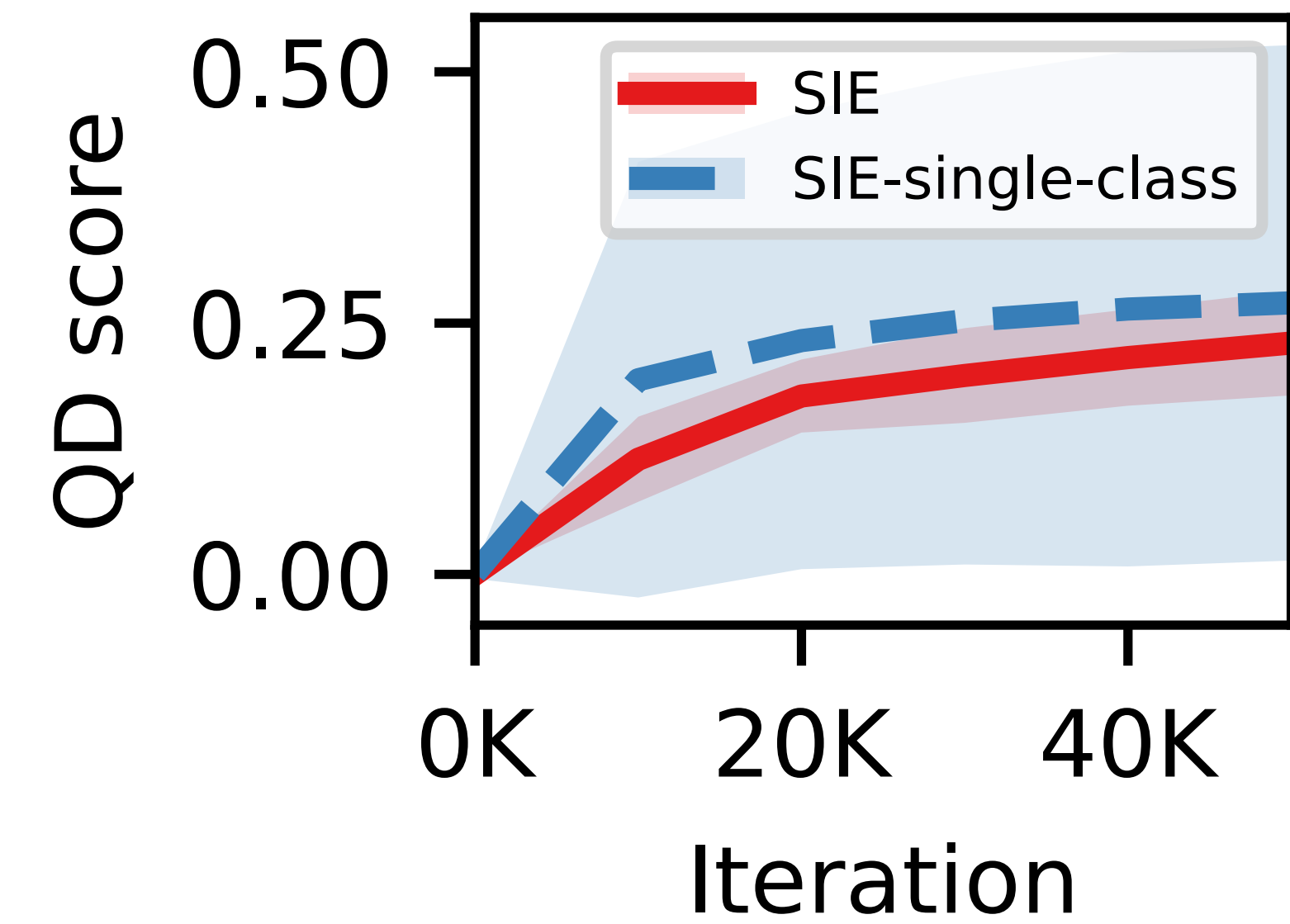
stepping  
stones

21.7 ± 3.6

goal switches

63.2% of the 34.3 ± 4.5 mean new champions per class





# Abandoning Diversity

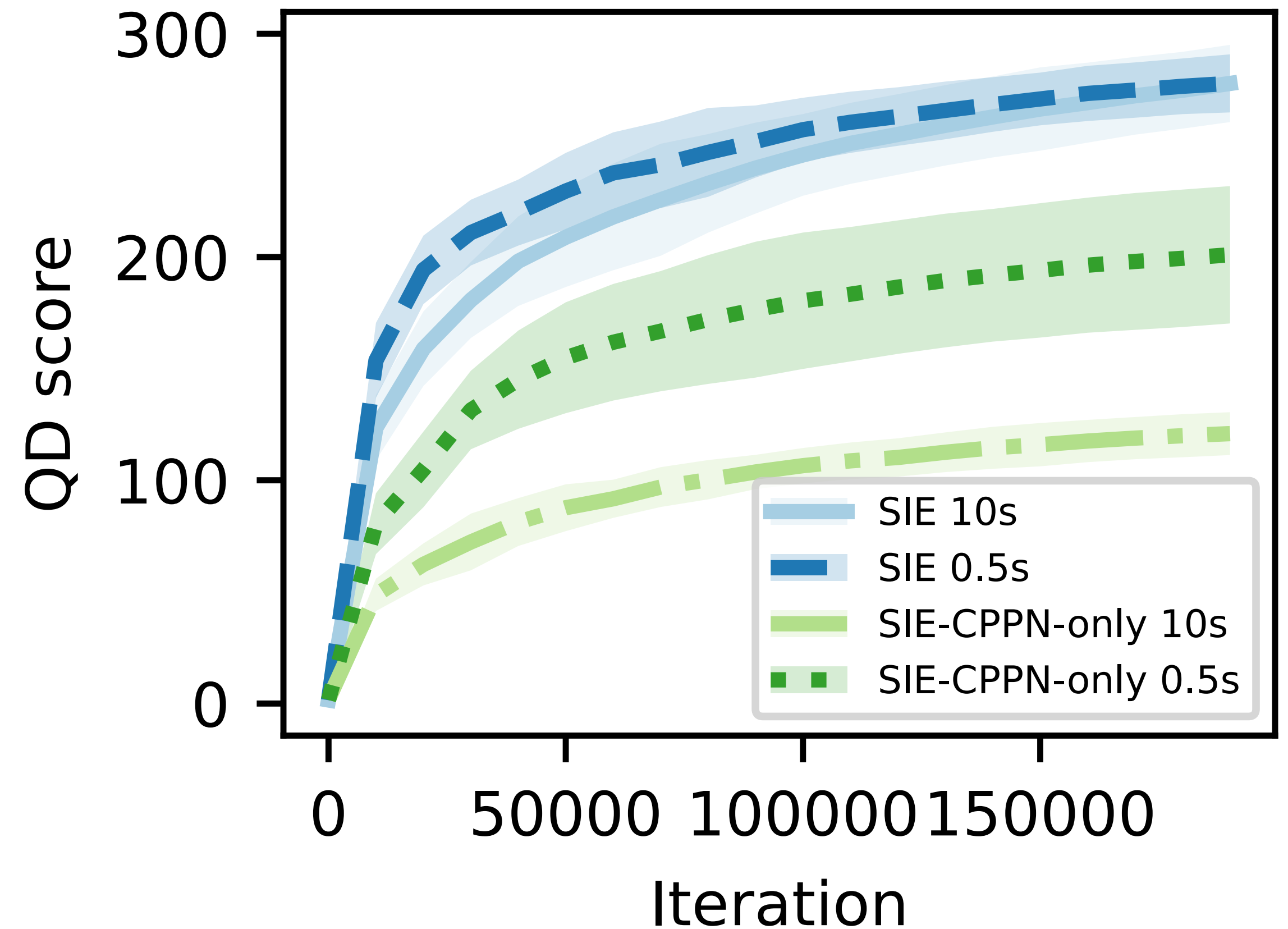
Similar performance at the cost of significantly higher complexity



# Results

## Temporal Pattern Revelation and Classifier Characteristics

- Longer time for sounds to develop doesn't benefit CPPN-only sounds
- Lack of DSP more apparent?
- CPPN + DSP duration agnostic

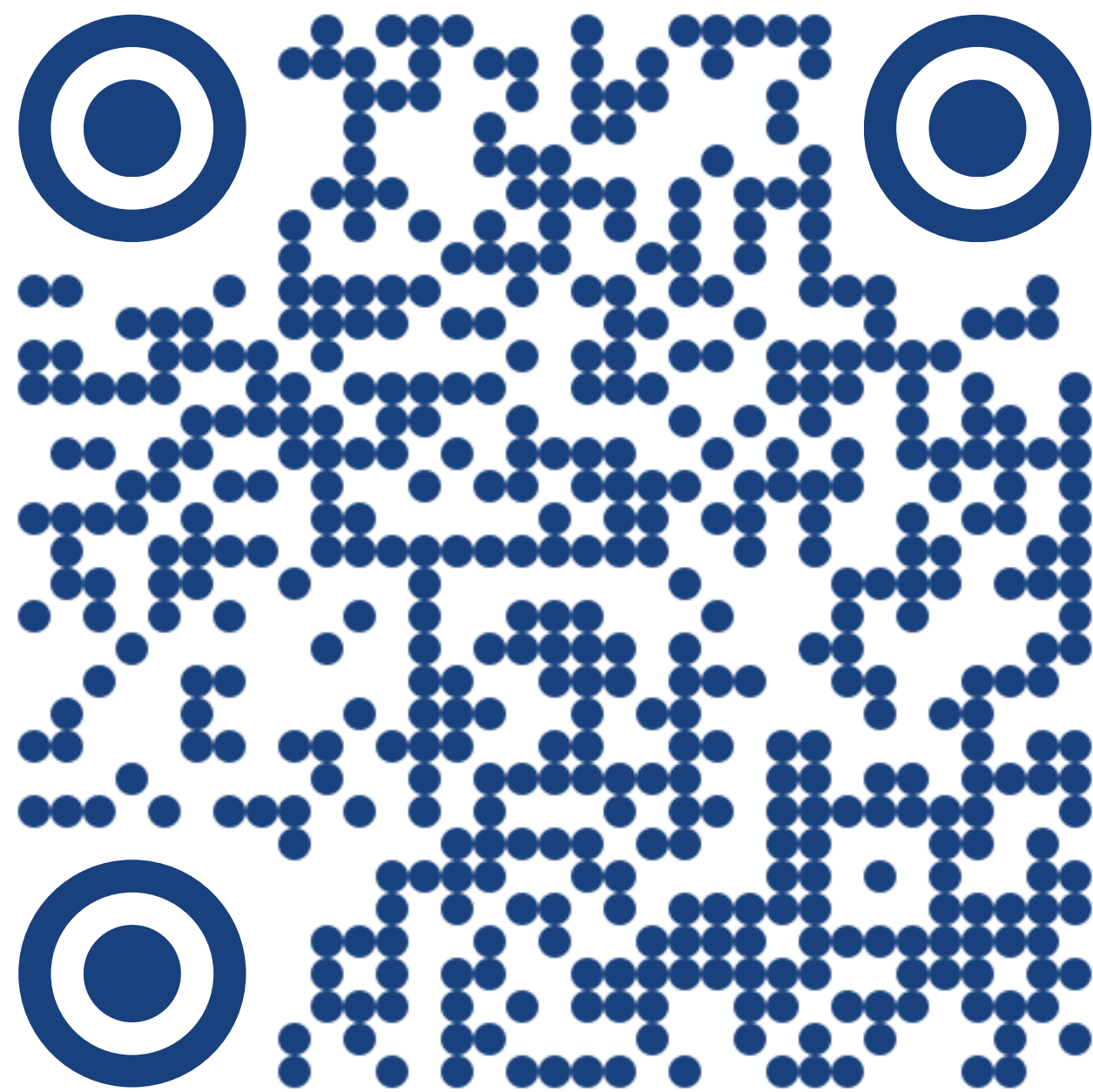




# Sound Objects and their Application

## Evoruns Explorer

- Scrub through evolutionary runs, classes and generations



synth.is/exploring-evoruns?evoRunDirPath=/QD-Fox/evoruns/c

Evolutionary runs interface showing controls for an evolution run.

Evolutionary run: evorun 156 / 329: 01HCHSSVDBK0ATN8T36MZJCZX7\_one\_comb-dur\_0.5

class: **Fart** (parent class: **Fart**) | score: 100% | Filter...

generation: 472968

automatic playback: < Auto >> **Rnd** ↻ 1⌂

manual interaction: ▶ ↺ ✕ ❤️ ⬇️  Reverse  Anti-aliasing  Apply frequency updates to control signals

favourite 0 / 0  From everyone

duration: 0.5

pitch: 0  int

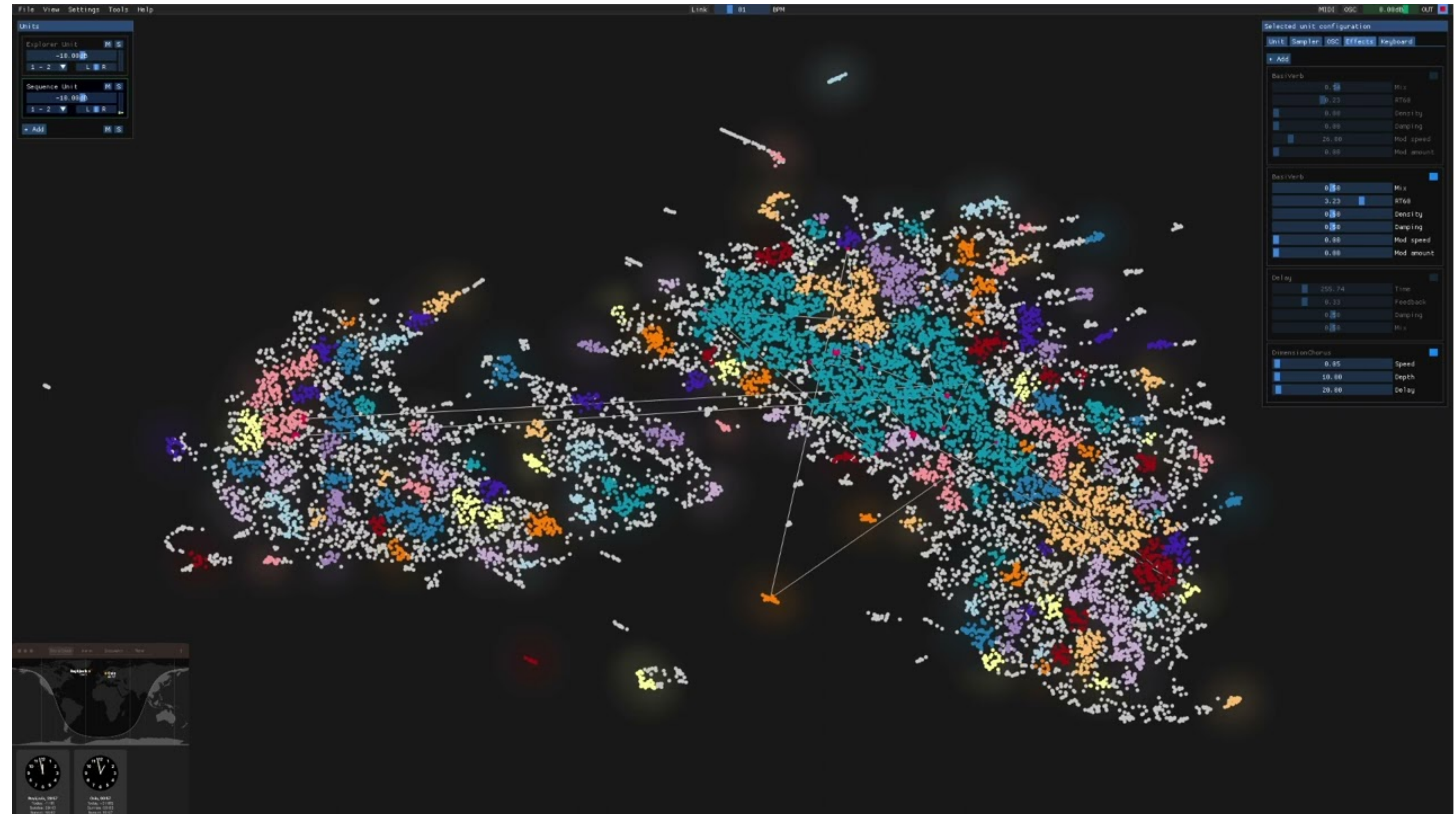
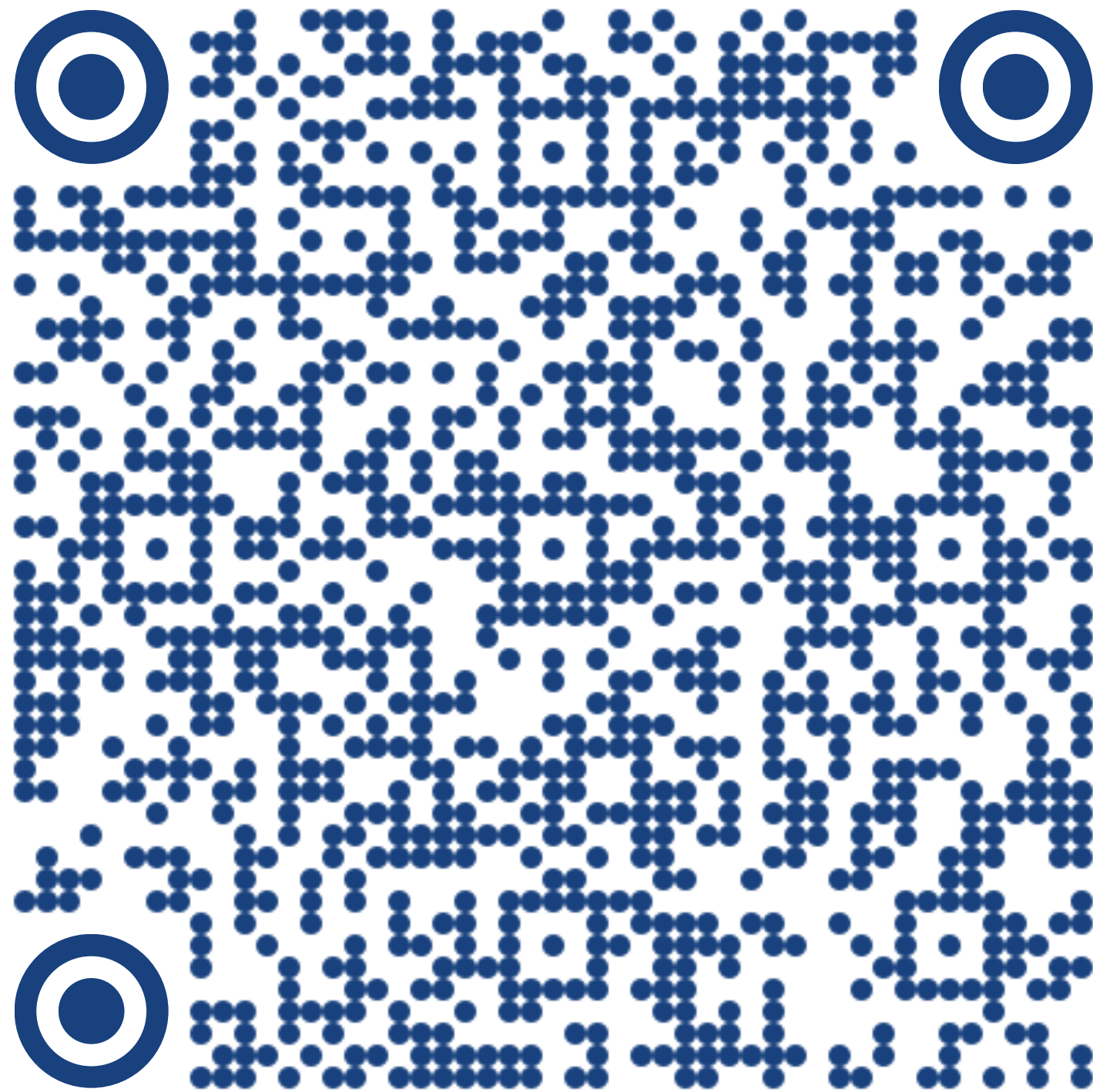
velocity: 1



# Sound Objects and their Application

## Evolutionary Sequences

- Live-stream playlist:

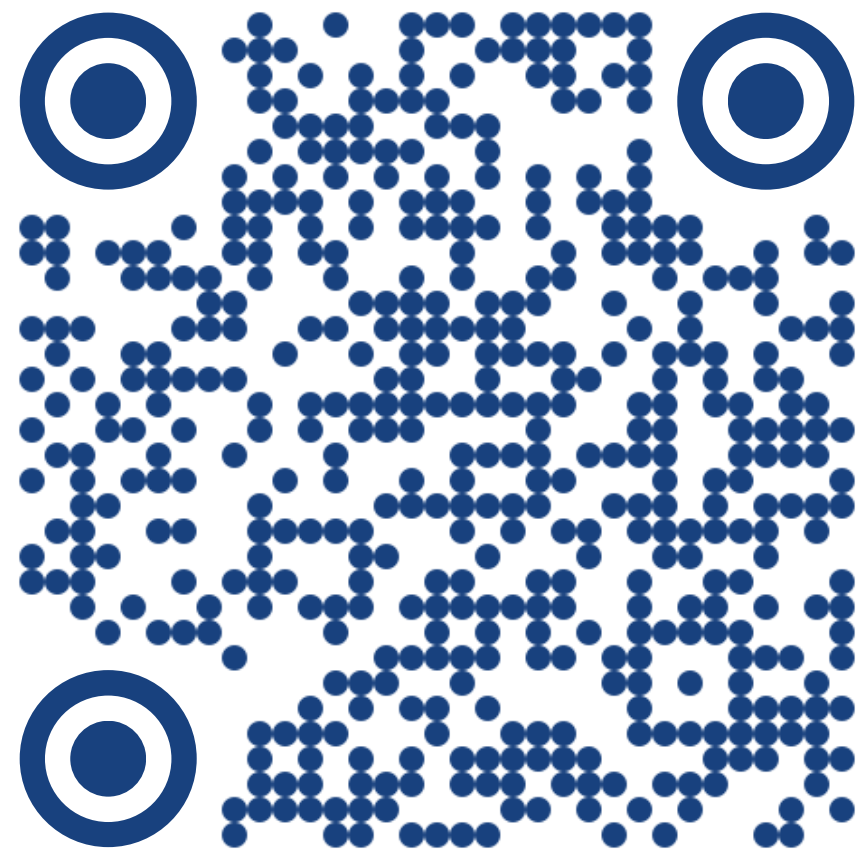




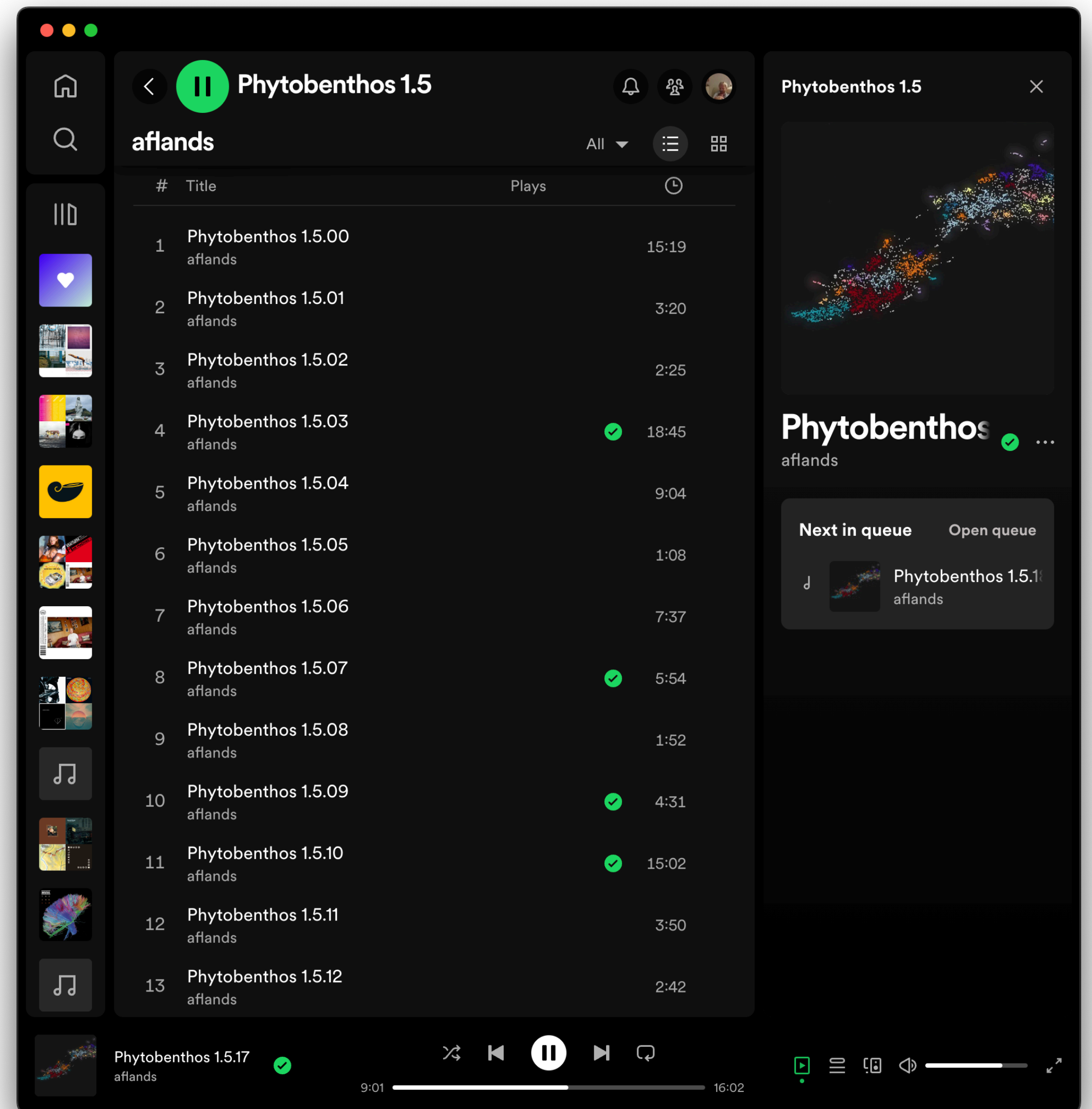
# Sound Objects and their Application

## Evolutionary Sequences

- Some of this stuff is actually on main-streaming services (WIP):



- IndieWeb publication planned

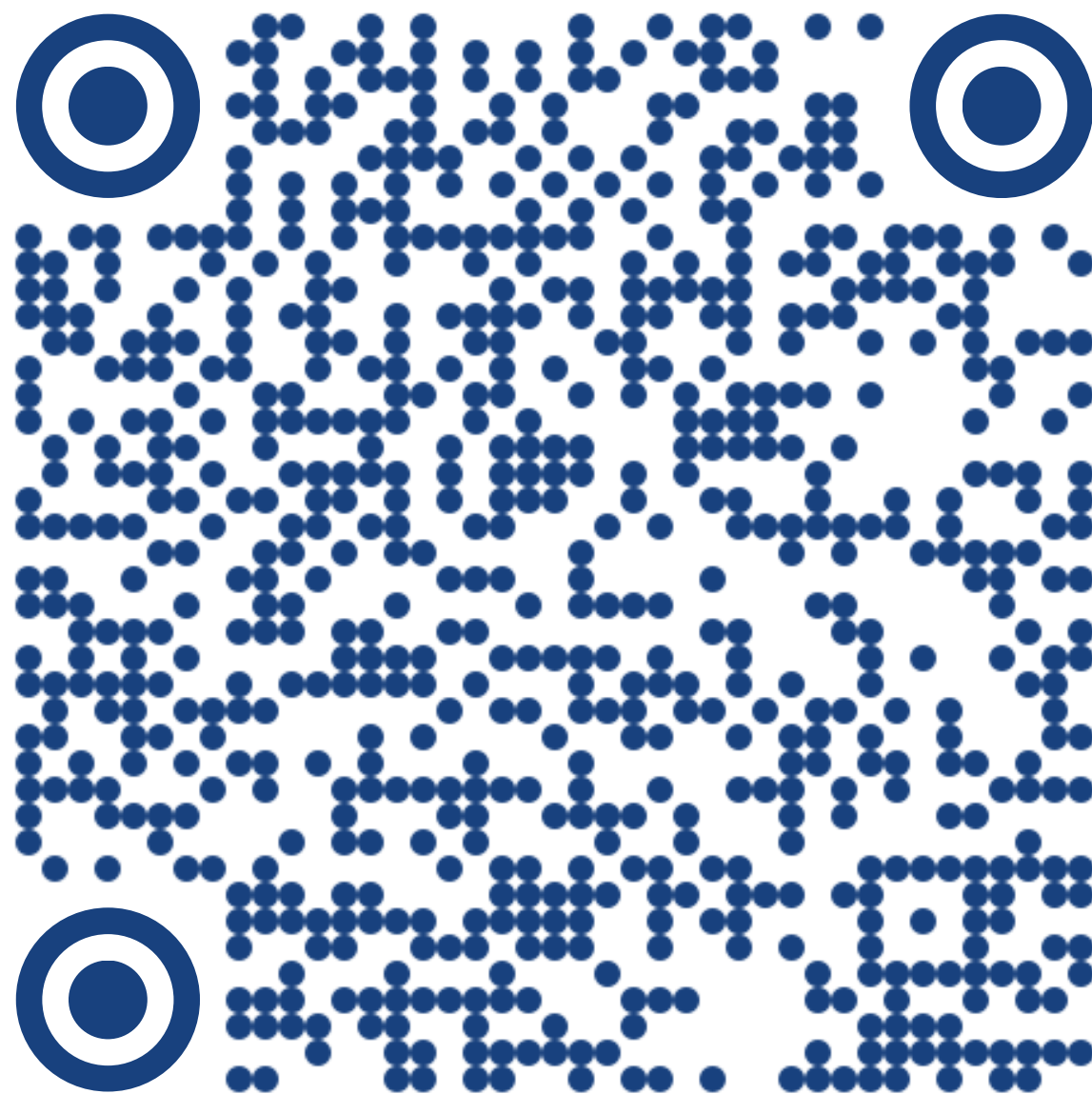


#	Title	Plays
1	Phytobenthos 1.5.00 aflands	15:19
2	Phytobenthos 1.5.01 aflands	3:20
3	Phytobenthos 1.5.02 aflands	2:25
4	Phytobenthos 1.5.03 aflands	18:45
5	Phytobenthos 1.5.04 aflands	9:04
6	Phytobenthos 1.5.05 aflands	1:08
7	Phytobenthos 1.5.06 aflands	7:37
8	Phytobenthos 1.5.07 aflands	5:54
9	Phytobenthos 1.5.08 aflands	1:52
10	Phytobenthos 1.5.09 aflands	4:31
11	Phytobenthos 1.5.10 aflands	15:02
12	Phytobenthos 1.5.11 aflands	3:50
13	Phytobenthos 1.5.12 aflands	2:42

# Sound Objects and their Application

*meat machines vs silicone machines*

- in: 🦾 *organising sound*

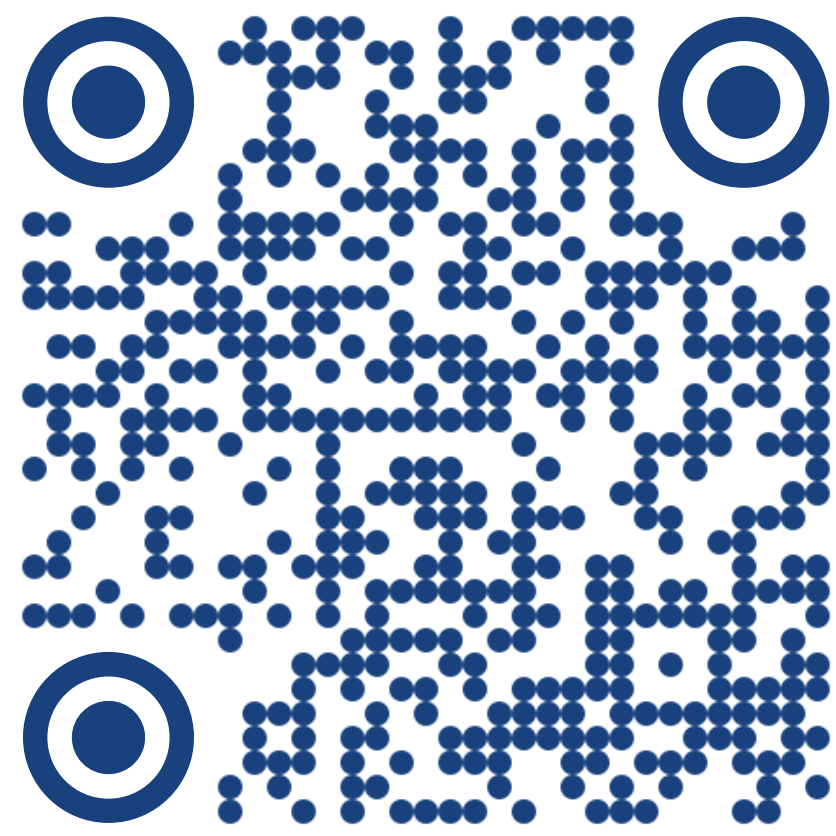


- mail results to: bthj@uio.no

A screenshot of the DataverseNO dataset viewer interface. The browser address bar shows the URL 'dataverse.no/dataset.xhtml?persistent...'. The page title is 'DataverseNO'. There are tabs for 'Files', 'Metadata', 'Terms', and 'Versions'. Below the tabs, there are buttons for 'Change View', 'Table', and 'Tree'. The 'Tree' view is selected, showing a hierarchical file structure. The root folder is 'evoruns-render', which contains a subfolder 'QD-Fox'. Under 'QD-Fox', there are several tar.xz files with their sizes: 'conf-duration\_delta\_pitch\_combinations-singleCellWin.tar.xz (151.2 MB)', 'conf-one\_comb-CPPN\_only.tar.xz (906.4 MB)', 'conf-one\_comb-noNoise.tar.xz (3.9 GB)', 'conf-one\_comb-single-class.tar.xz (1.6 MB)', 'conf-one\_comb-singleCellWin.tar.xz (1.2 GB)', 'conf-one\_comb.tar.xz (2.6 GB)', 'conf-single-class-runs.tar.xz (1.8 MB)', 'conf-single-class-runs\_112-dur-pitch-vel-comb.tar.xz (3.3 MB)', and 'conf-static\_mutation\_rate\_combinations-singleCellWin.tar.xz (540.8 MB)'. Other folders include 'QD-nemur', 'QD-ROBIN-HPC', and 'QD-ROBIN-workstations'. At the bottom, there are folders for 'plots', 'QD', and 'software', with files '00\_README.md (4.9 KB)' and '00\_README.txt (4.9 KB)'. Three pink arrows point from the 'Metadata' tab to the 'Tree' button, and from the 'Tree' button to the 'QD-Fox' folder.

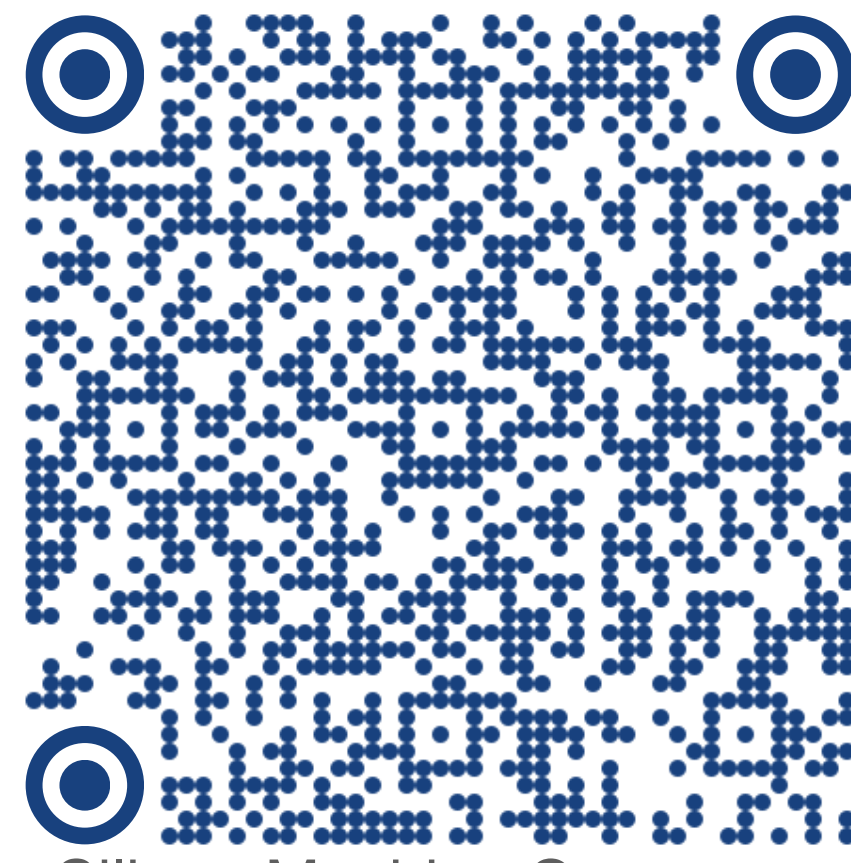


con



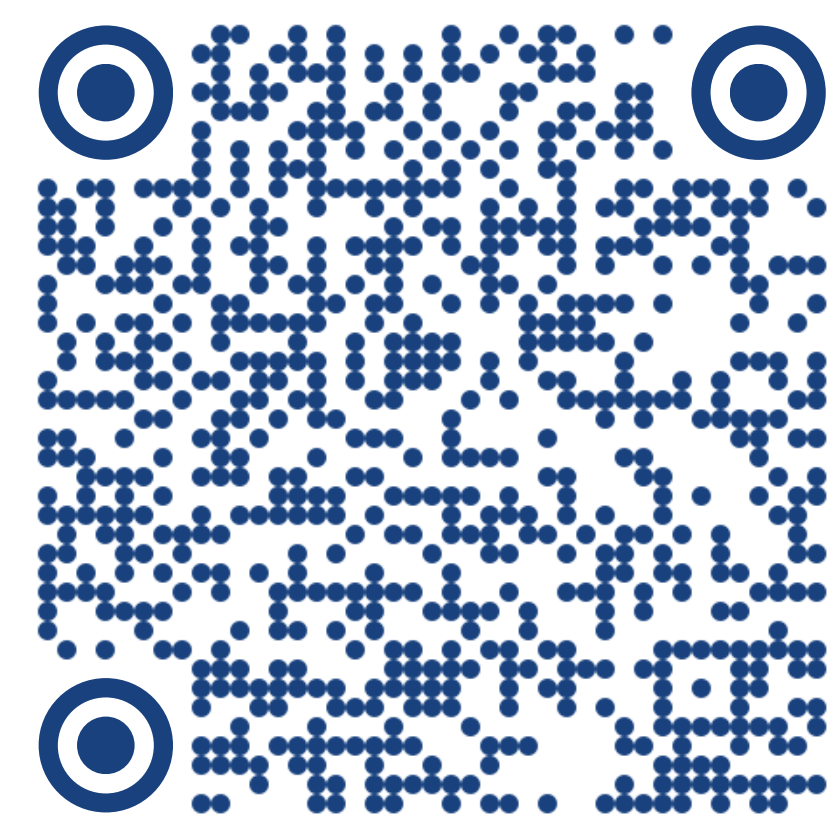
Evoruns Explorer

clu



Silicon Machine Composer

si



For Meat Machine Composers

on

- Applying diversity-promoting algorithms with classifier reward signals is a viable approach for sound discovery
- The sound synthesis approach employed achieved high confidence from a DNN classifier
- Diverse and innovative sound objects were generated, suggesting further explorations in this system
- Expanding the behaviour space beyond predefined classes using dimensionality reduction and clustering algorithms is worth exploring
- Leveraging human intuition can lead to semantically meaningful diversity in the search space
- Our system is a tool for discovering interesting sound objects, facilitating the creation of further sonic art
- Our method encourages a bottom-up process of exploration, reflecting the evolutionary path of human development
- This instrument promotes exploratory discovery and the development of human abilities through technology.