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A Vocal Learning Model: Development And Analysis

Silvia Pagliarini, Arthur Leblois, Xavier Hinaut

► **To cite this version:**

Silvia Pagliarini, Arthur Leblois, Xavier Hinaut. A Vocal Learning Model: Development And Analysis. IMOL 2019 - Fourth International Workshop on Intrinsically Motivated Open-ended Learning, Jul 2019, Frankfurt, Germany. hal-02413140

HAL Id: hal-02413140

<https://inria.hal.science/hal-02413140v1>

Submitted on 16 Dec 2019

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A Vocal Learning Model: Development And Analysis

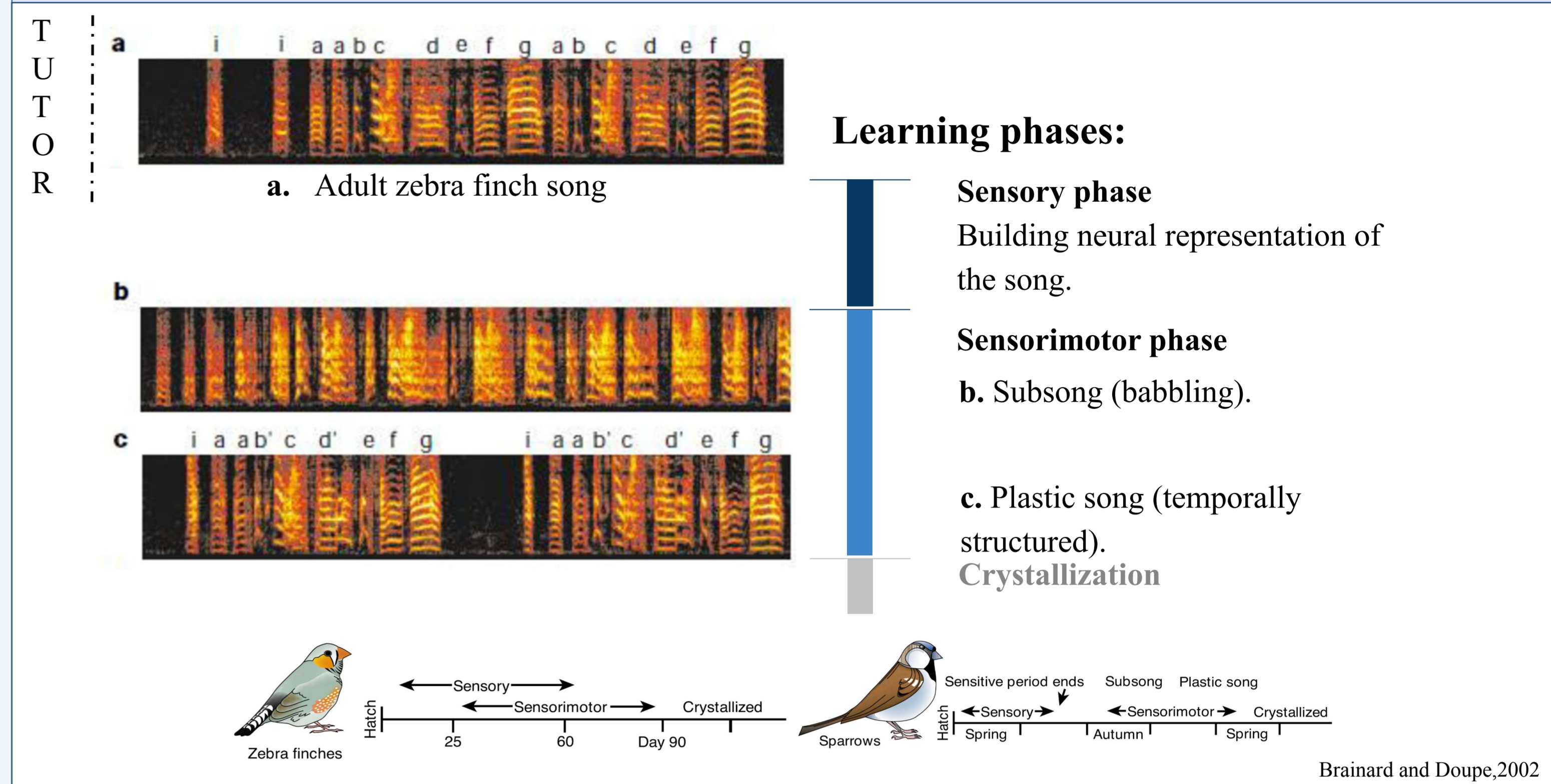
Silvia Pagliarini^{1,2,3}, Arthur Leblois³, Xavier Hinaut^{1,2,3}

- 1) Mnemosyne, Inria Bordeaux Sud-Ouest, UMR 5800, CNR, Bordeaux INP, Talence, France
- 2) LaBRI, UMR 5800, CNRS, University of Bordeaux, Talence, France
- 3) IMN, UMR 5293, CNRS, University of Bordeaux, Bordeaux, France



AIM: build a vocal learning model underlying song learning in birds, and understand how to make it biologically plausible.

VOCAL LEARNING IN BIRDS



INTRODUCTION

KEYWORDS

Sensorimotor learning: control problem which maps a sensory input into a motor output.

Imitation: the ability to replicate another's behaviour, i.e. to generate an appropriate motor command to reproduce a sensory stimulus.

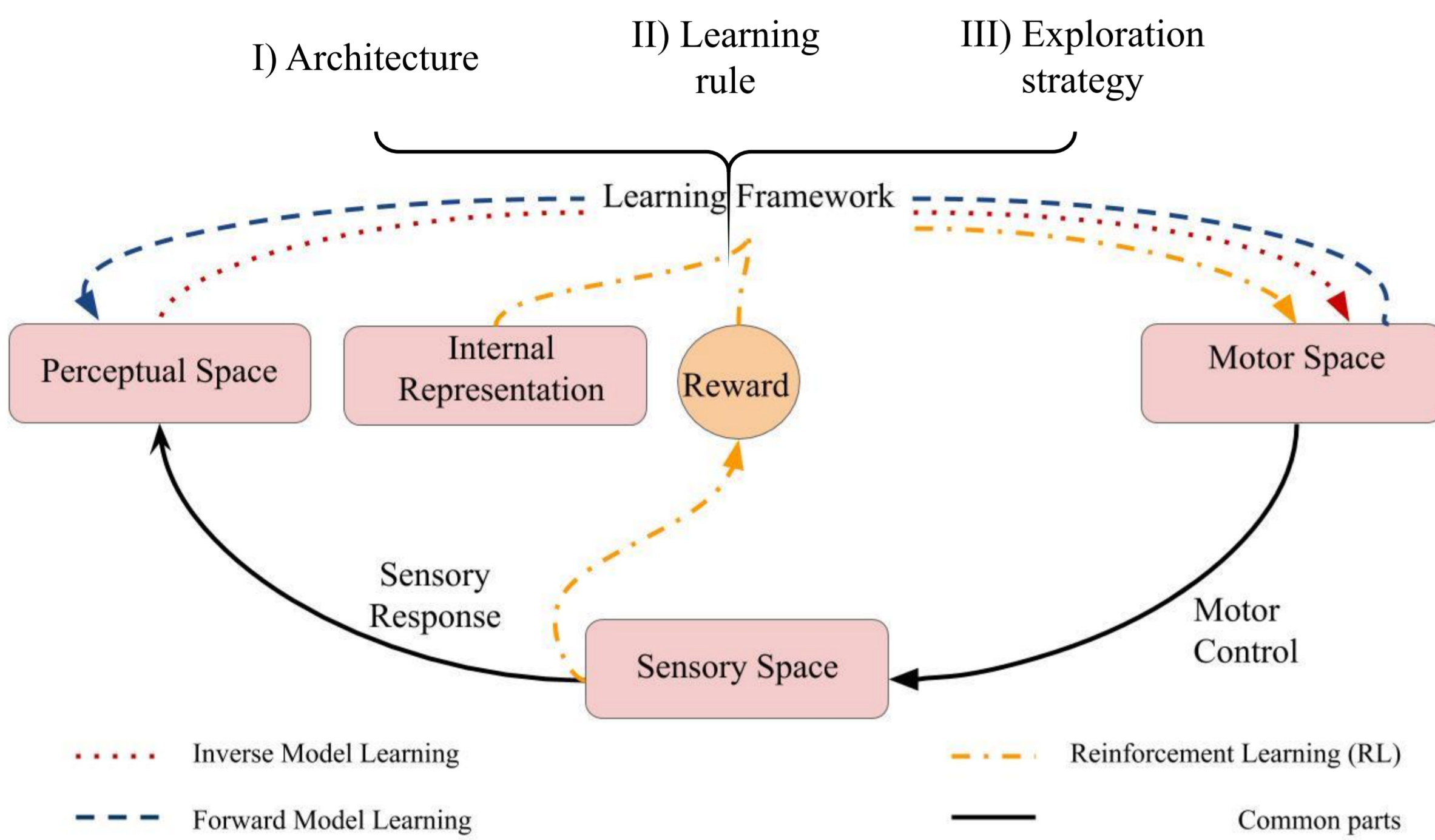
Inverse model learning: use the desired and actual motor configuration to estimate the motor commands needed to reach the desired configuration (to produce the appropriate sensory stimulus).

Reinforcement learning: learn an action policy to maximize the expected reward (which encode the goal of the learning).



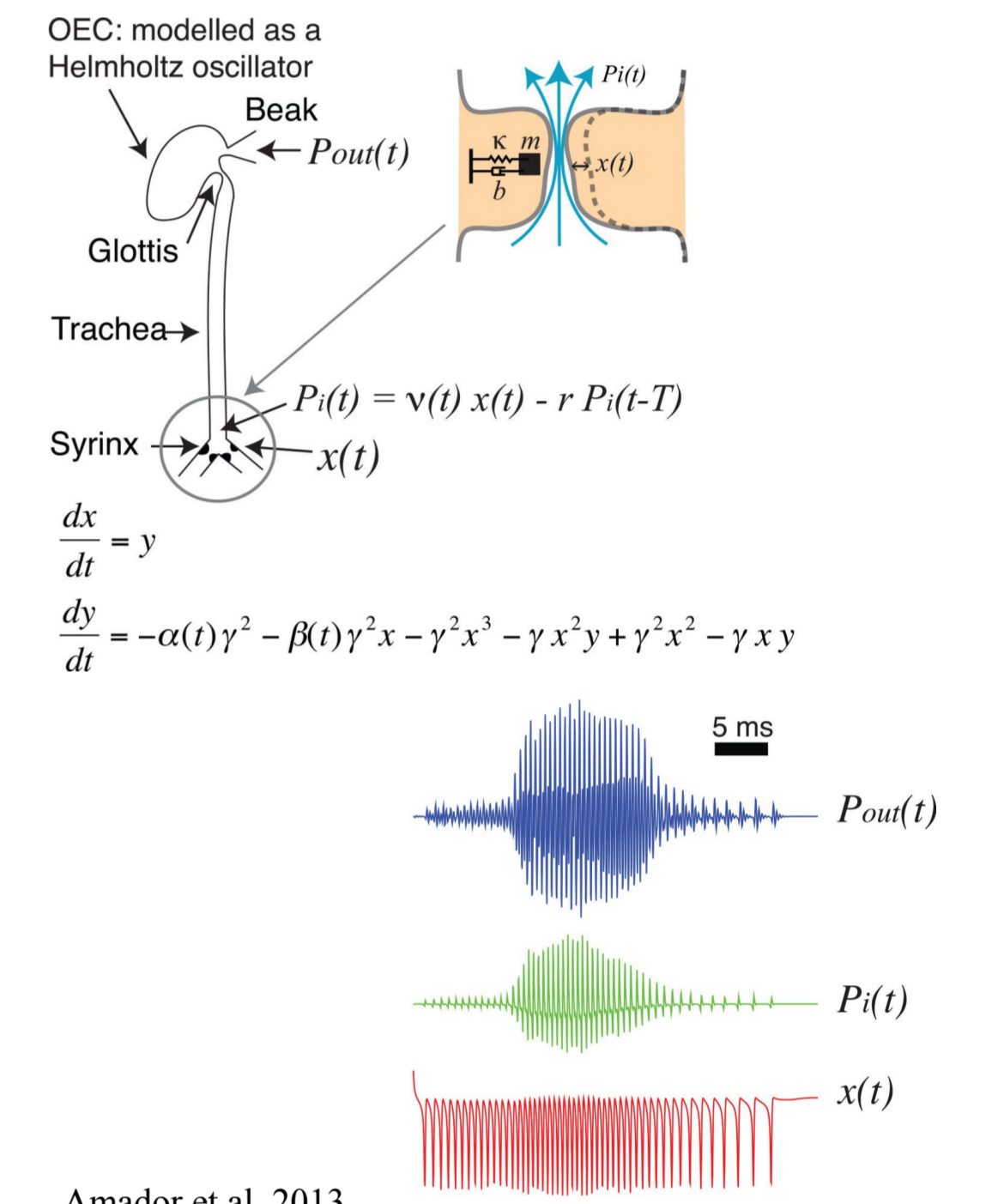
Da Cunha et al., 2010

SENSORIMOTOR MODEL COMPONENTS [1]



Motor control model

- Respiratory system and vocal organs.
- Anatomical properties and small size of birds make the investigation of vocal fold mechanisms difficult.
- The vocal output is driven by a complex gesture-dependent control scheme, and the brain does not control each motor control parameter independently [2].



Perceptual space

- How the brain encodes sensory stimulus.
- Highly nonlinear dynamics.
- Low dimensional representation of the sensory space.

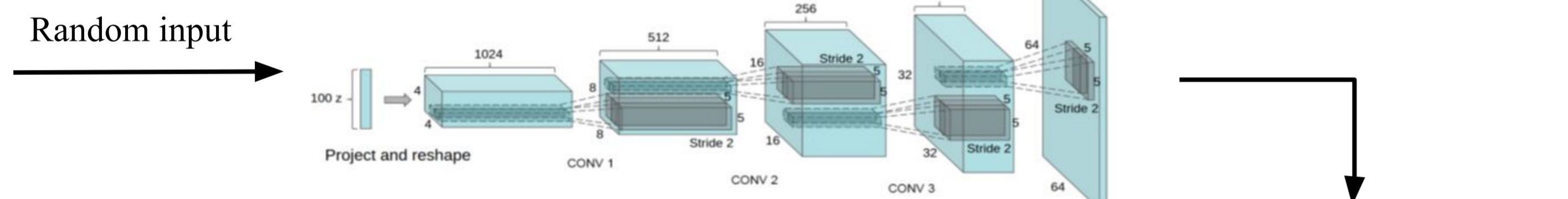
MOTOR CONTROL MODEL

AIM: learn the semantic modes in high-dimensional audio signals, and build a latent space useful for exploration. In addition, have sound production in the model.

WaveGAN [3]

- Two player minimax game: generator VS discriminator [4].
- Inspired by DCGAN architecture [5].

GENERATOR

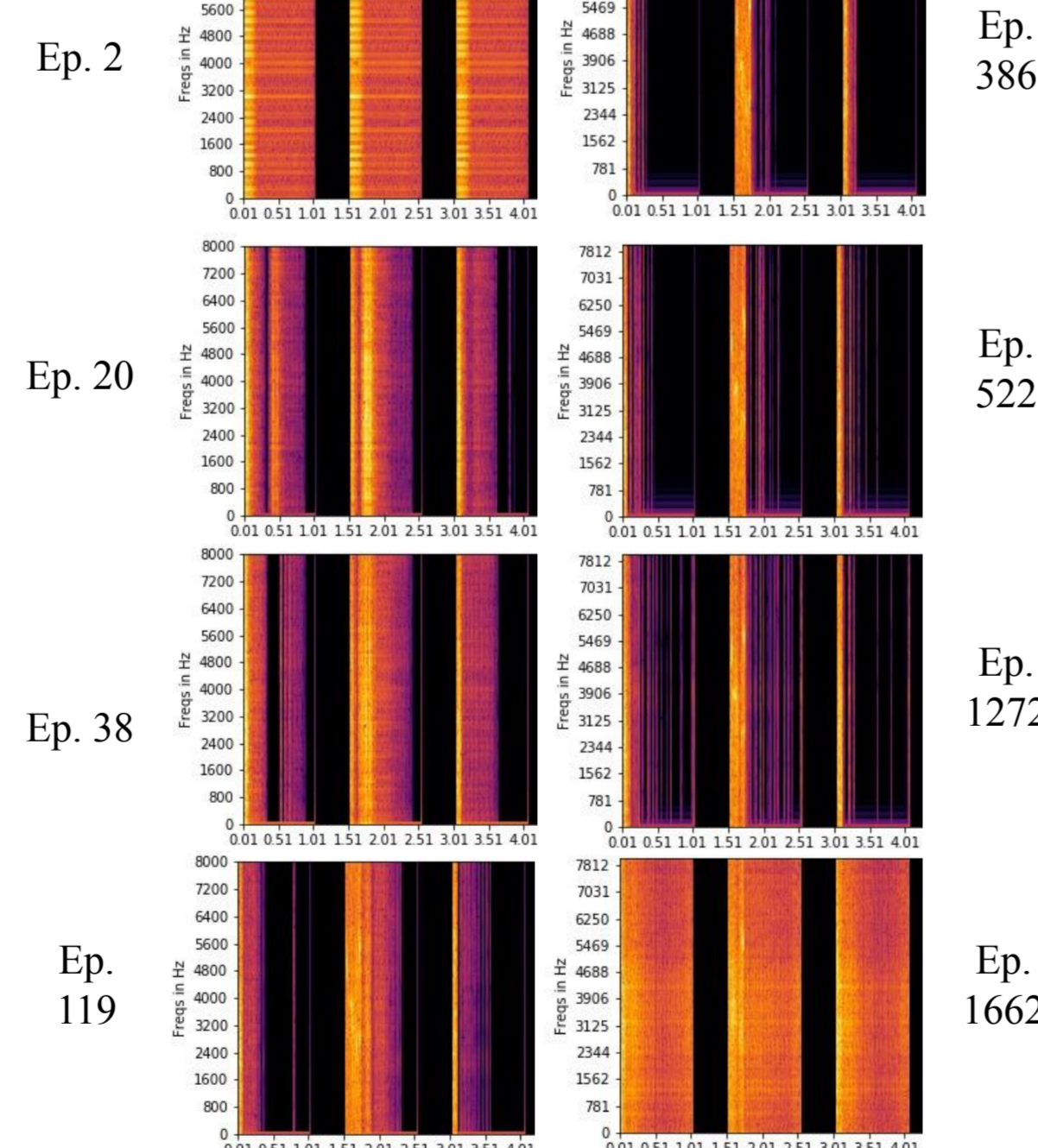
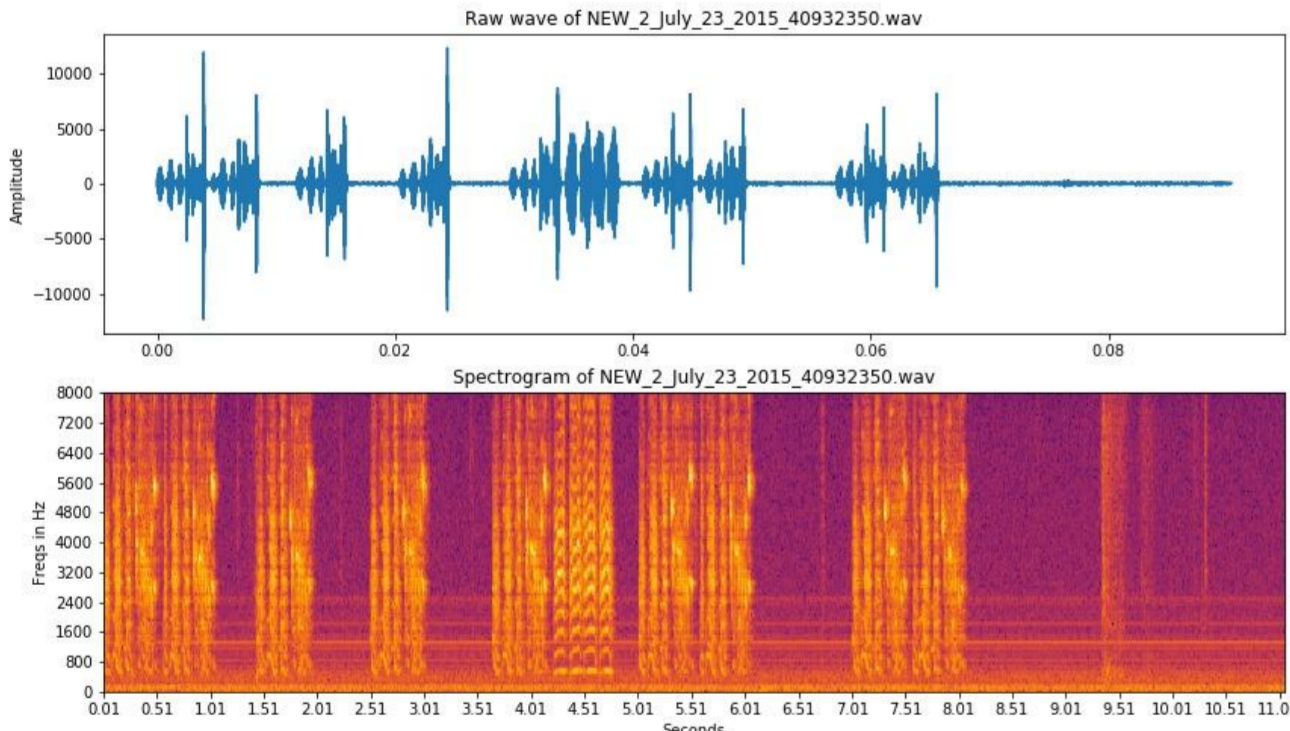


GENERATED SOUND DURING TRAINING

- Batch size = 64
- Epochs = 1662

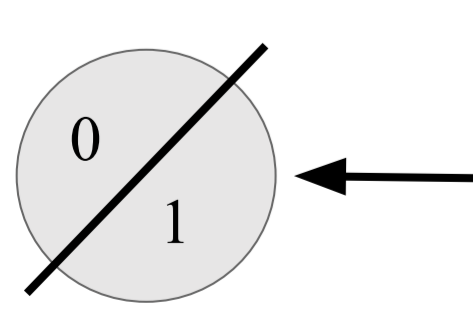
DATASET

- Recordings from an adult zebra finch with sampling rate 44100.
- Downsampled single syllables. N = 4946 syllables.



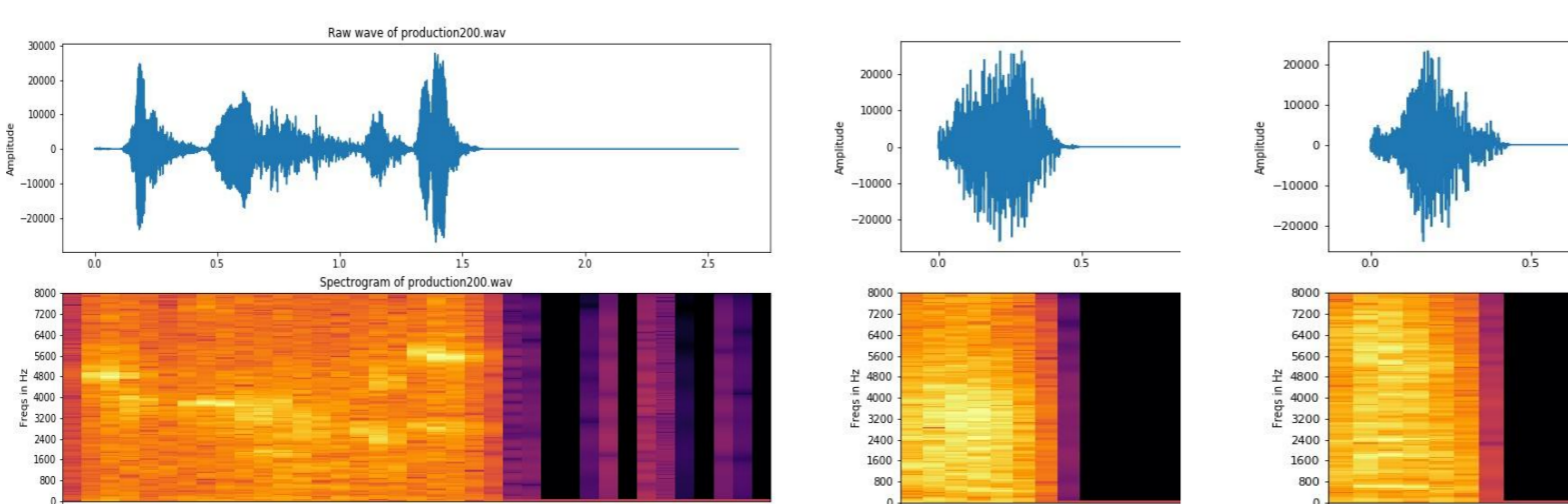
DISCRIMINATOR

- Discriminator trained 5x generator update.



GENERATED SOUND AFTER TRAINING

- Batch size = 64
- Epochs = 517



Inception Score (IS) = 1.95 ± 0.02

PERCEPTUAL SPACE

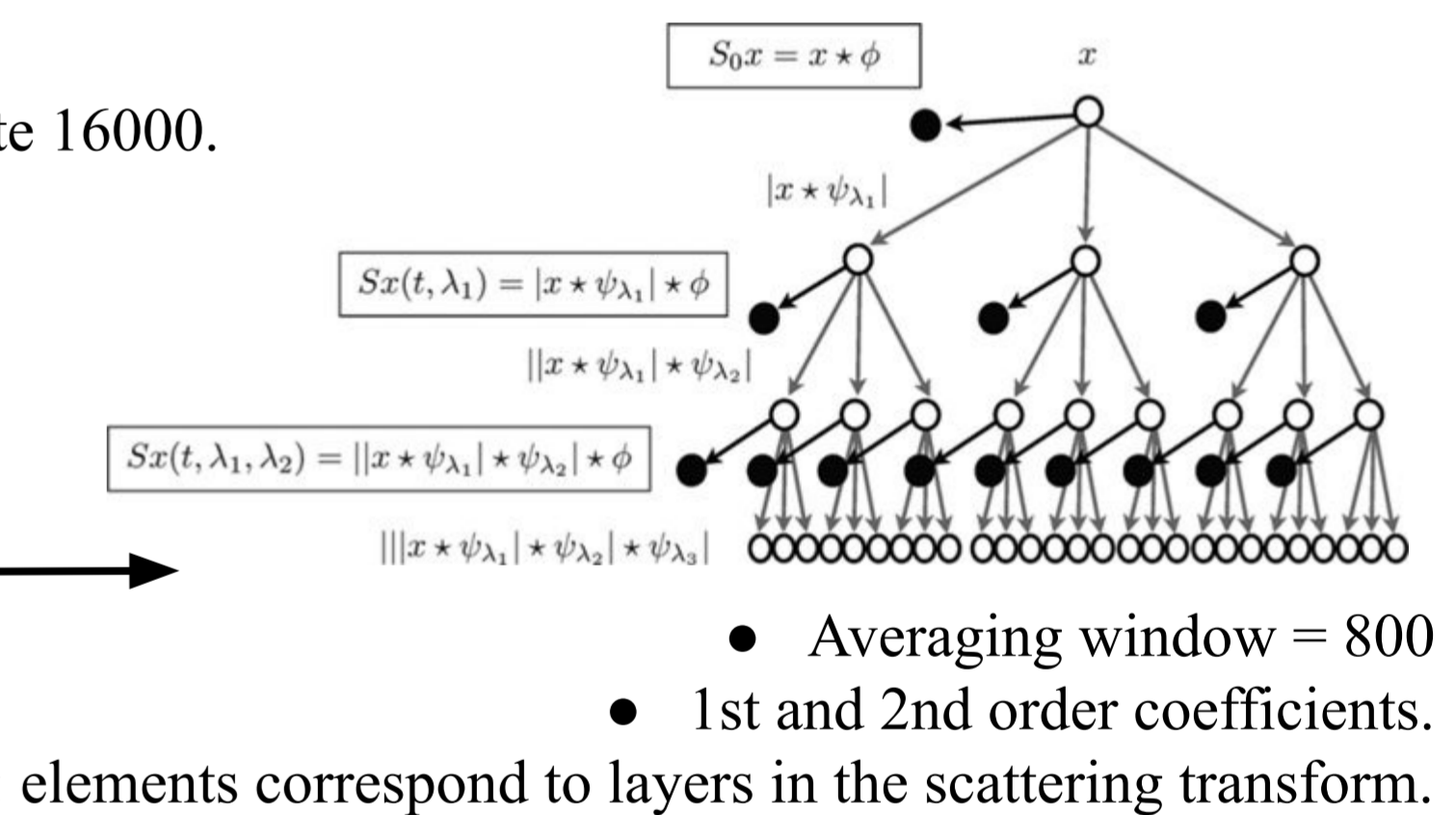
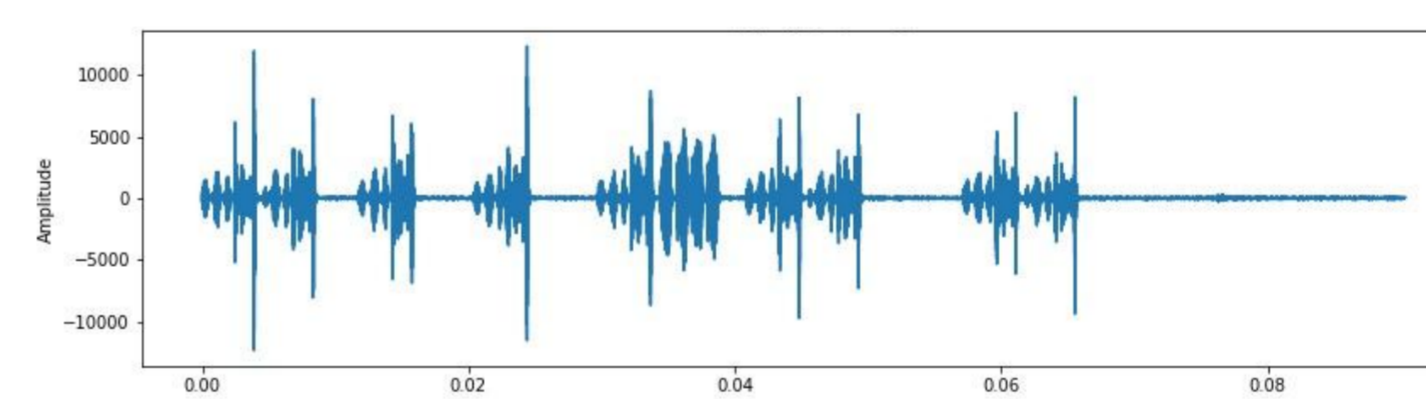
AIM: have a lower dimensional representation of the physical acoustic space, which is the sensory space (sound).

Deep scattering transform [6]

- From MFCC coefficients introducing wavelets.
- Scattering coefficients can be seen as a convolutional neural networks.

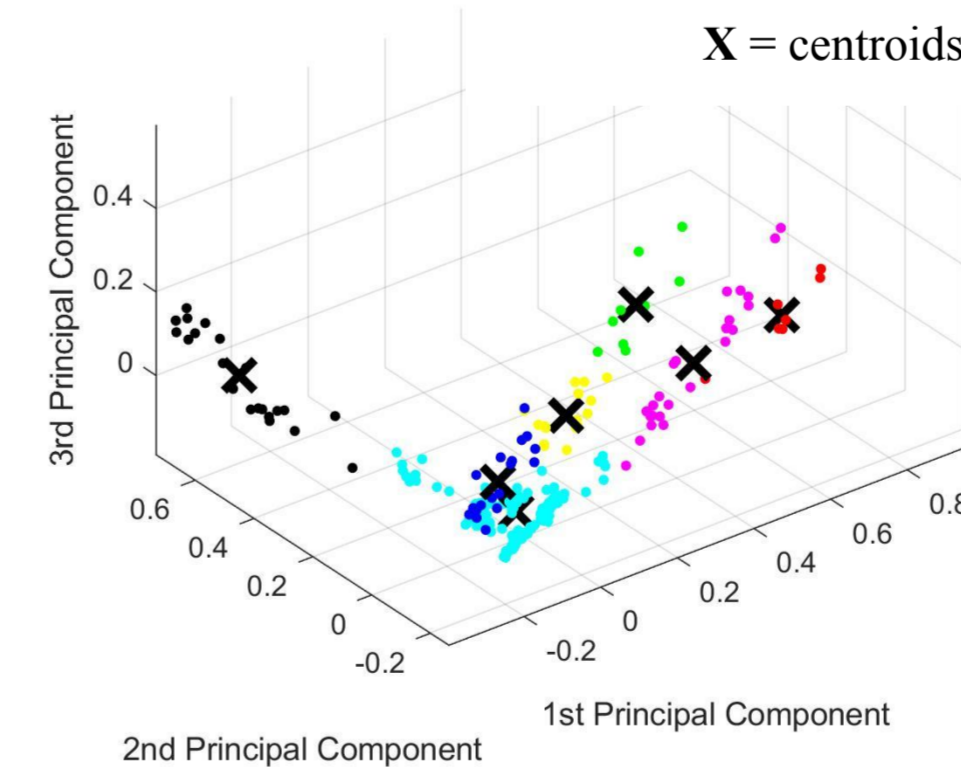
DATASET

- Recordings from an adult zebra finch with sampling rate 16000.

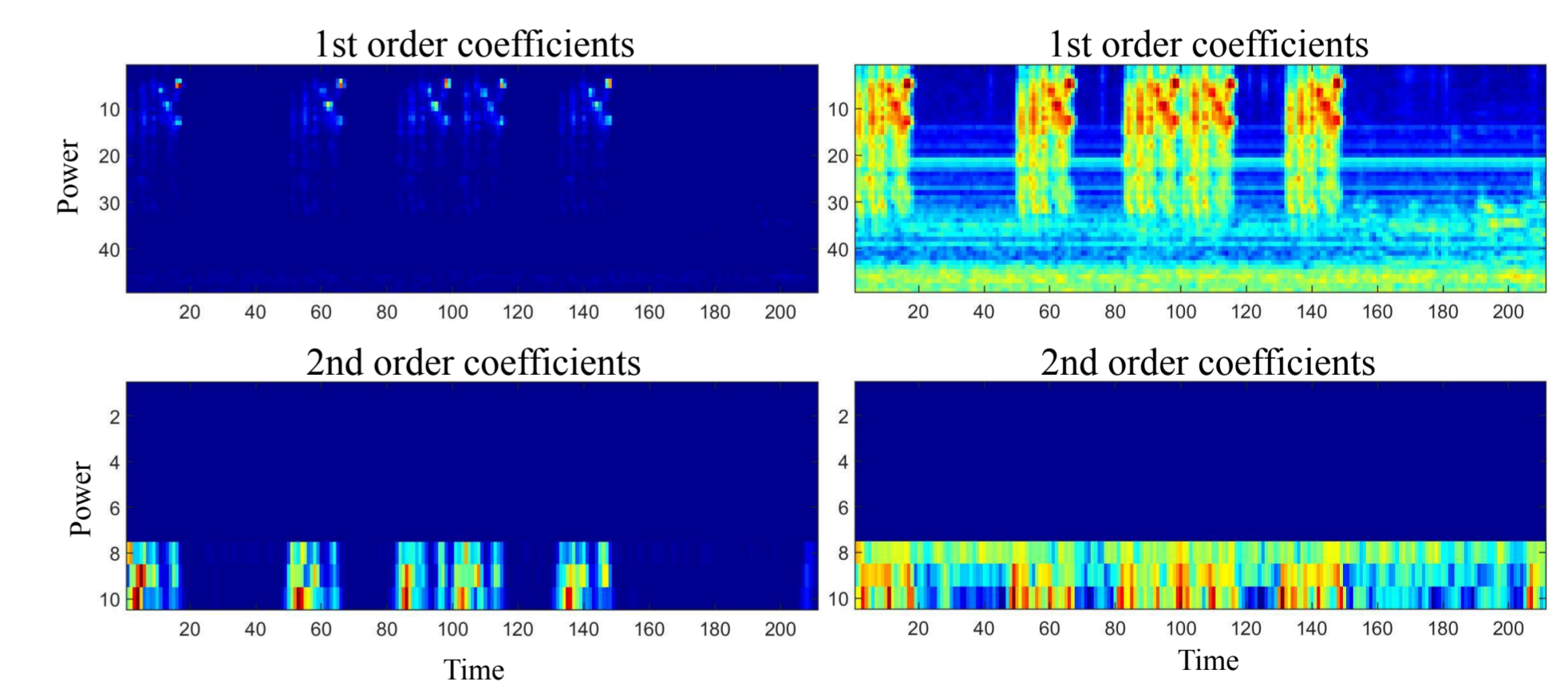


PCA analysis

- N = 52 syllables.
- PCA analysis.
- k-means algorithm.



Second-order, translation-invariant scattering transform of one-dimensional signals



PERSPECTIVES

Motor control model

- Explore the possibility to use a dynamical system model.
- More exhaustive evaluation of the generative model.

Exploration strategy

- Intrinsic motivation to drive motor exploration.
- Investigate the geometrical properties of latent space generated with the GAN.

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