A project by:
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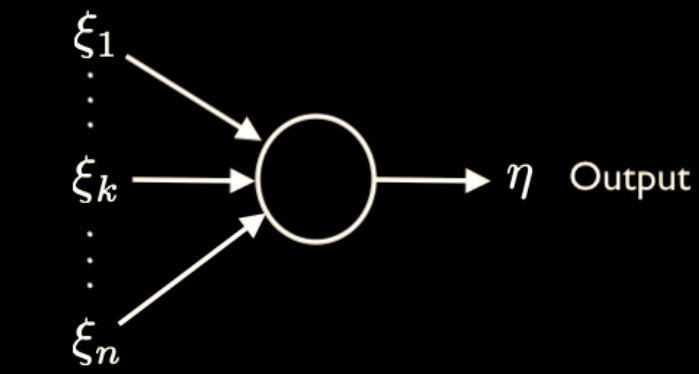
POLITECNICO DI MILANO

BLOB.

ADVANCED CODING TOOLS AND METHODOLOGIES 2021/2022

INTRODUCTION

- Idea driving the project: Sonification of a Kohonen Network (KN), also known as Self-Organizing Map (SOM).
- Web frameworks implemented: Tone.js, Canvas API, Bootstrap JS, SVG.js, Parcel API.
- Browser compatibility: optimised for Mozilla Firefox.



The unsupervised learning behavior of a KN artificial neuron has efficiency-coefficients time independent.

In KNs, forgetting rate is proportional to the weight vectors and also to a function of the output signal (feedback).

KOHONEN NETWORK (KN)

- KNs are a tool for visualize and convert high-dimensional data into simple geometric relationships on a low-dimensional display [1, 2].
- A KN enables to simulate the learning process that allows the brain to handle sensory perception (certain cortex areas have similar properties as KNs. Examples are the processing of sound and light stimuli) [3].
- Notice: KNs are not a physical analogy of an expected neuronal configuration. They simply simulate the learning processing functions of certain areas of the brain cortex.

1) The learning process proceeds along discrete time moments: $t = 1, 2, ...$

2) The learning process is fed with input data (observation vectors): $x(t)$

3) Model vectors (nodes) regression is made by the following process:

$$m_i(t+1) = m_i(t) + h_{c(x),i}(x(t) - m_i(t))$$

where index "c" (winner) is defined by the condition:

$$||x(t) - m_c(t)|| \leq ||x(t) - m_i(t)|| \ \forall i$$

and the neighborhood function (NF):

$$h_{c(x),i} = \alpha(t)\left(e^{-\frac{||r_i - r_c||^2}{2\sigma(t)^2}}\right)$$

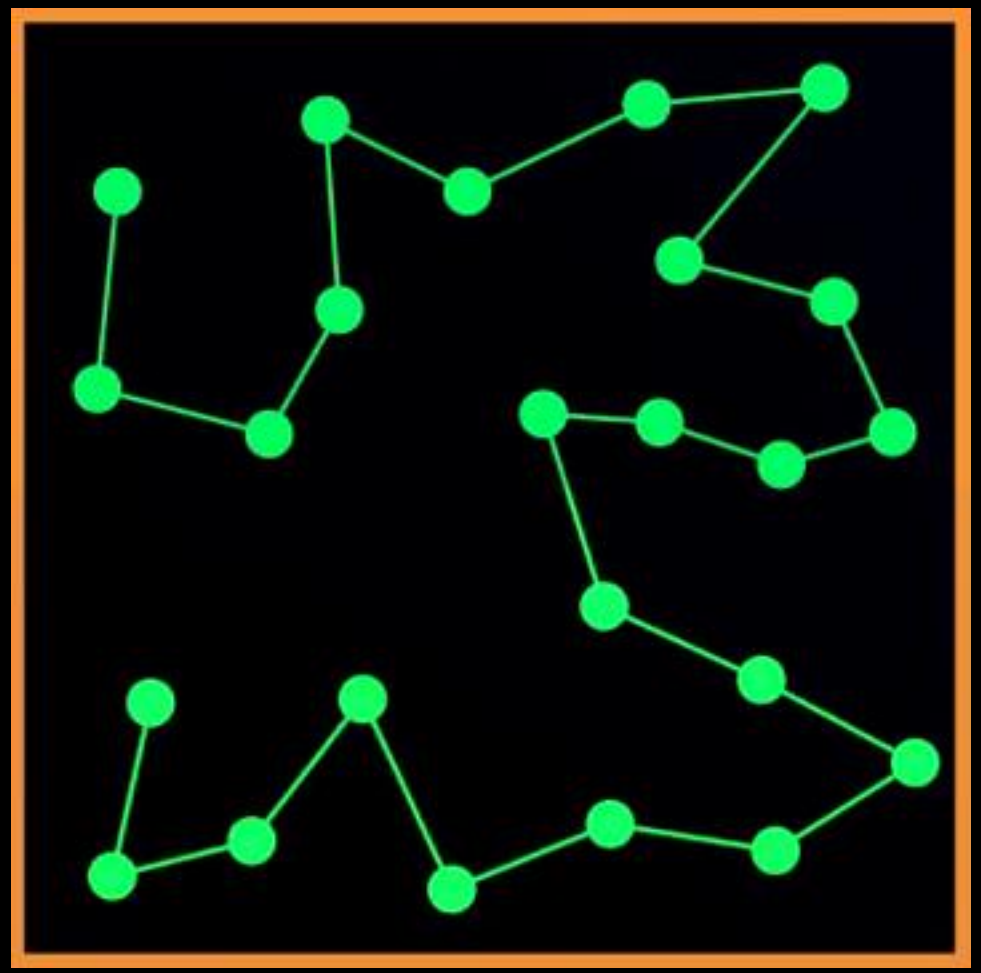
$\alpha(t)$ Learning-rate factor.

$\sigma(t)$ Width of the NF.

They both decrease monotonically with the regression steps.

KOHONEN NETWORK (KN)

- Weight vectors (nodes) during the ordering process of a uniform distributed square into a curve.



Link to the video: Self-Ordering Kohonen Network

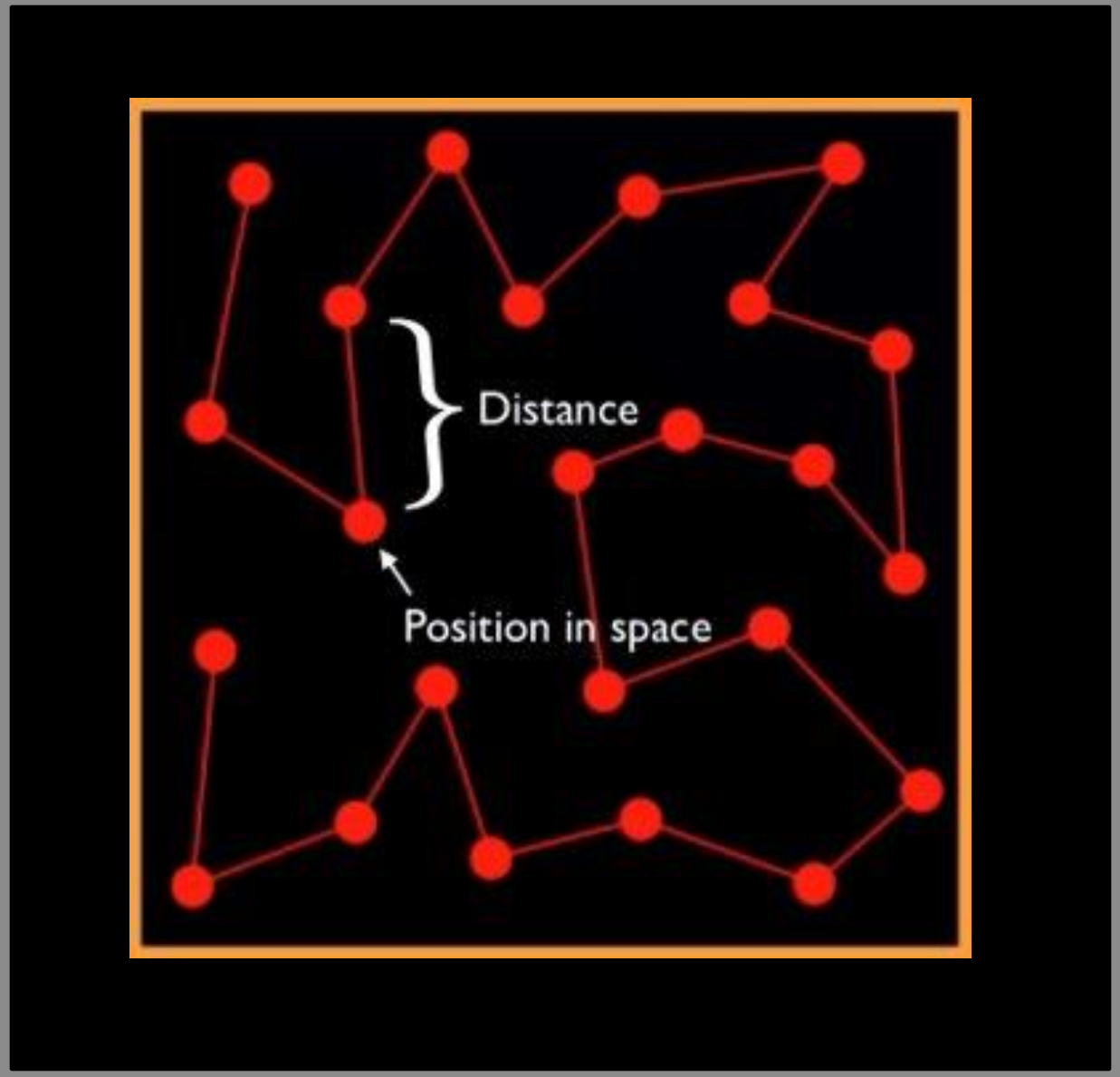
THE SONIFICATION PROCESS

- KN Sonification achieved extrapolating:

1. Nodes' relative distance (Note duration)
2. Nodes' position in space.

- By joining these features, different "pads" were developed:

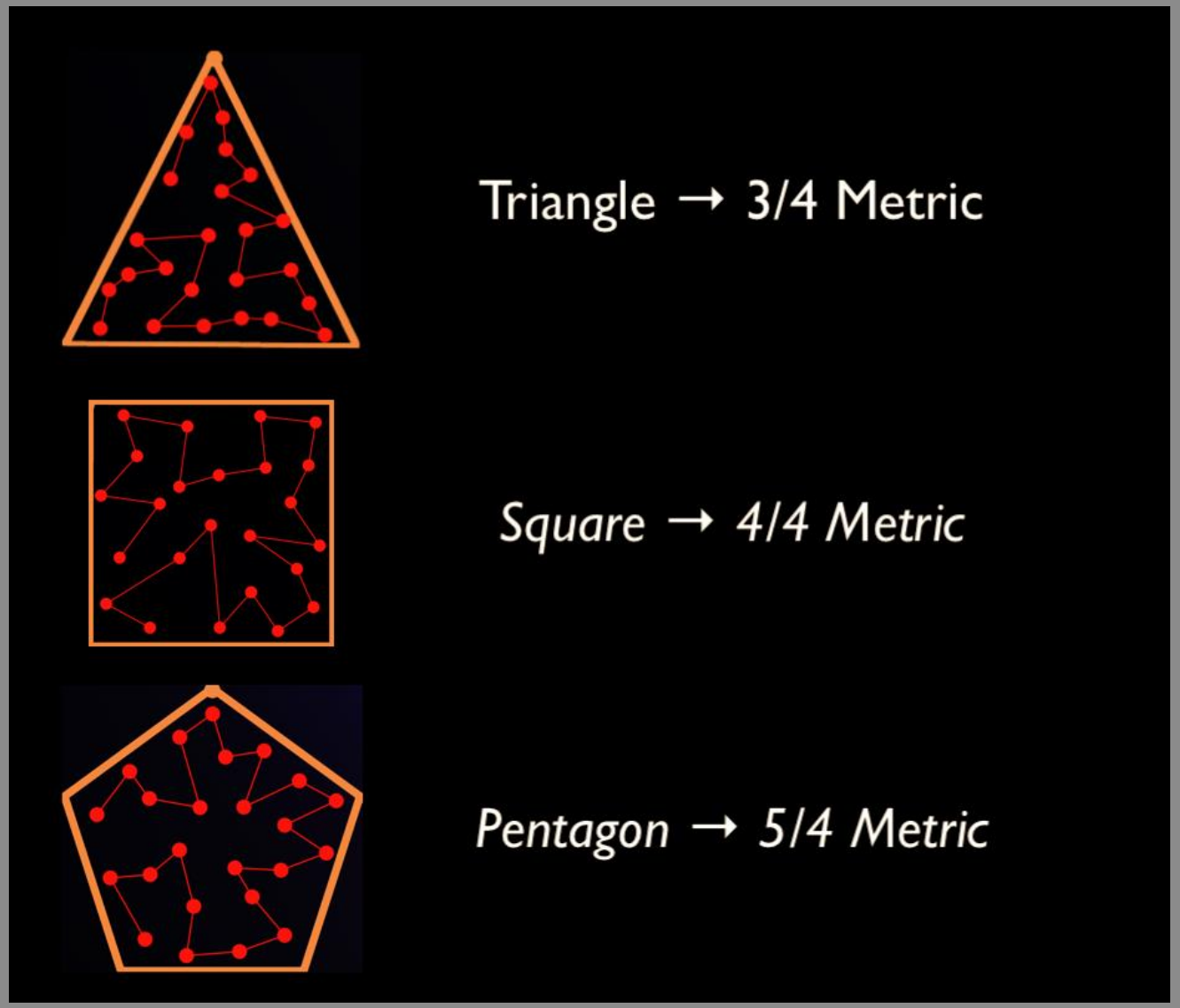
1. The Rhythmic Pad
2. The Melodic Pad
3. The Harmonic Pad



THE RHYTHMIC PAD

- The Rhythmic Pad performs solely percussive sounds:

1. Single node associated to a single sound.
2. Time position in the measure provided by relative nodes' distances.
3. Metric of the measure associated to a geometric figure (see figure).
4. Node sound is an external sample.

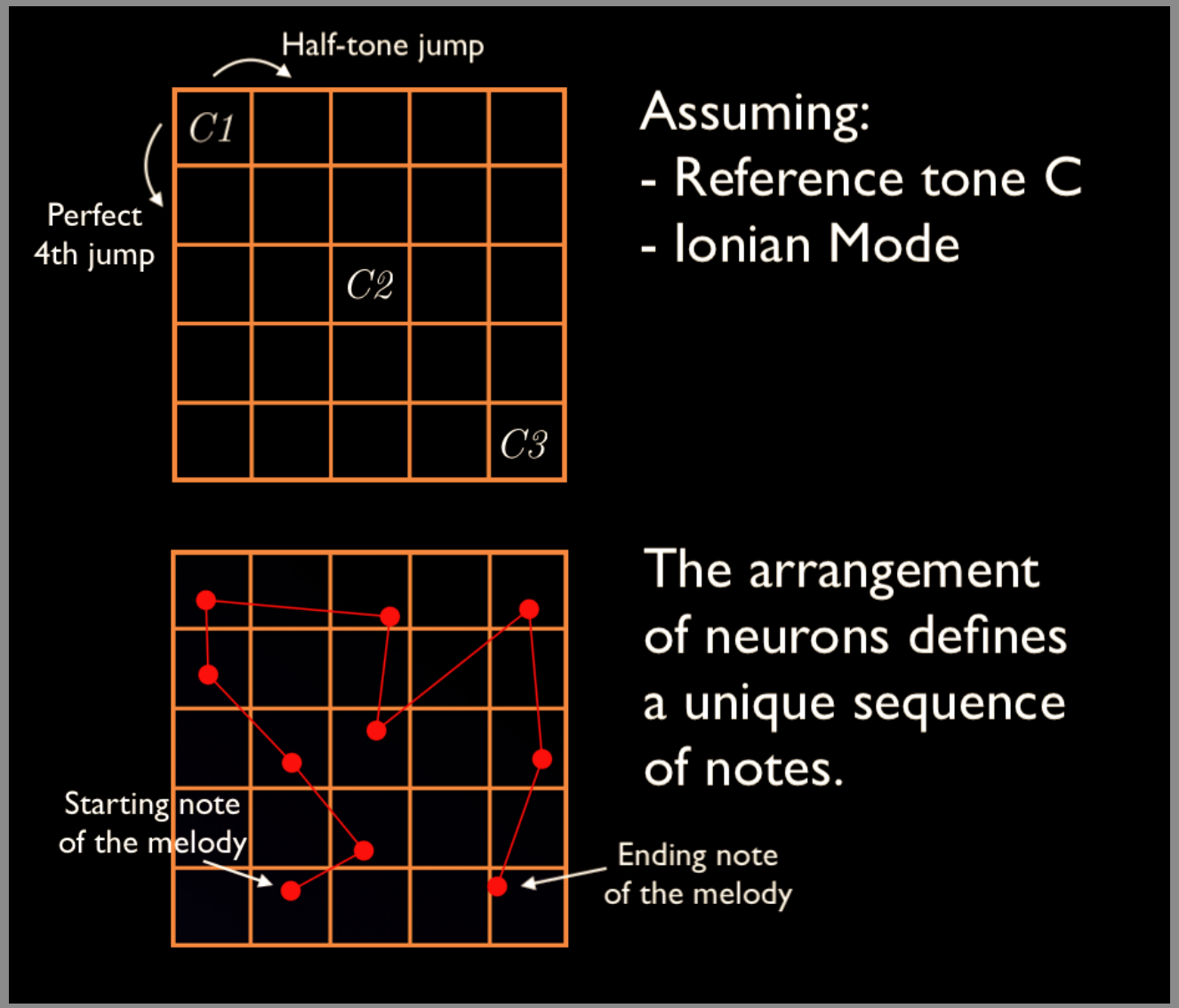


THE MELODIC PAD

- The Melodic Pad creates a melodic line:

1. Single node associated to a single note.
2. Note duration and time position in the measure provided by relative nodes's distances.
3. Scale note set by the position of the node in space (see figure).
4. Scale Tone and Scale Mode set by the user (different and uneven nodes configurations)
5. Note sound is played by a Tone.js Polysynth.

- Notice: each Scale Mode is characterized by a unique configuration in the grid.



THE MELODIC PAD: SOUND AND EFFECTS

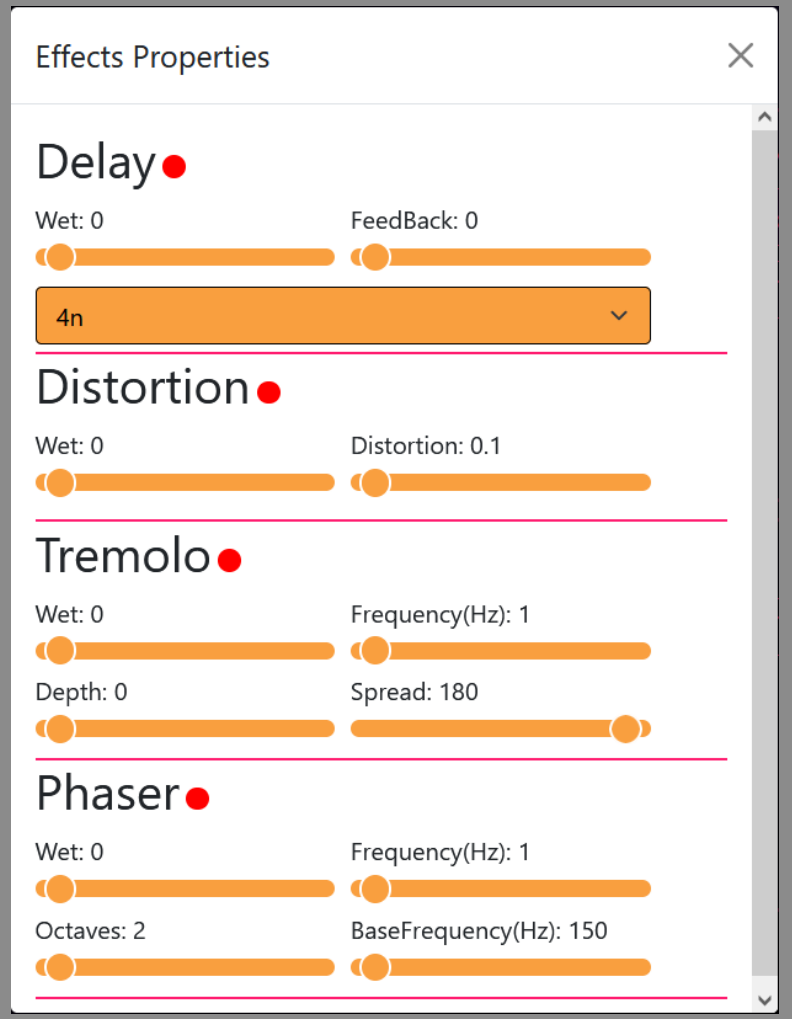
- User can change:

1. Metric (No geometric figure associated).
2. PolySynth Sound (Sine wave, Square Wave, *etc.*).
3. Envelope properties.

- User can add the following Tone.js effects to the melody:

1. Delay
2. Distortion
3. Tremolo
4. Phaser

- Bootstrap Modal plug-in was used for dialog box (popup window) to set effect parameters.

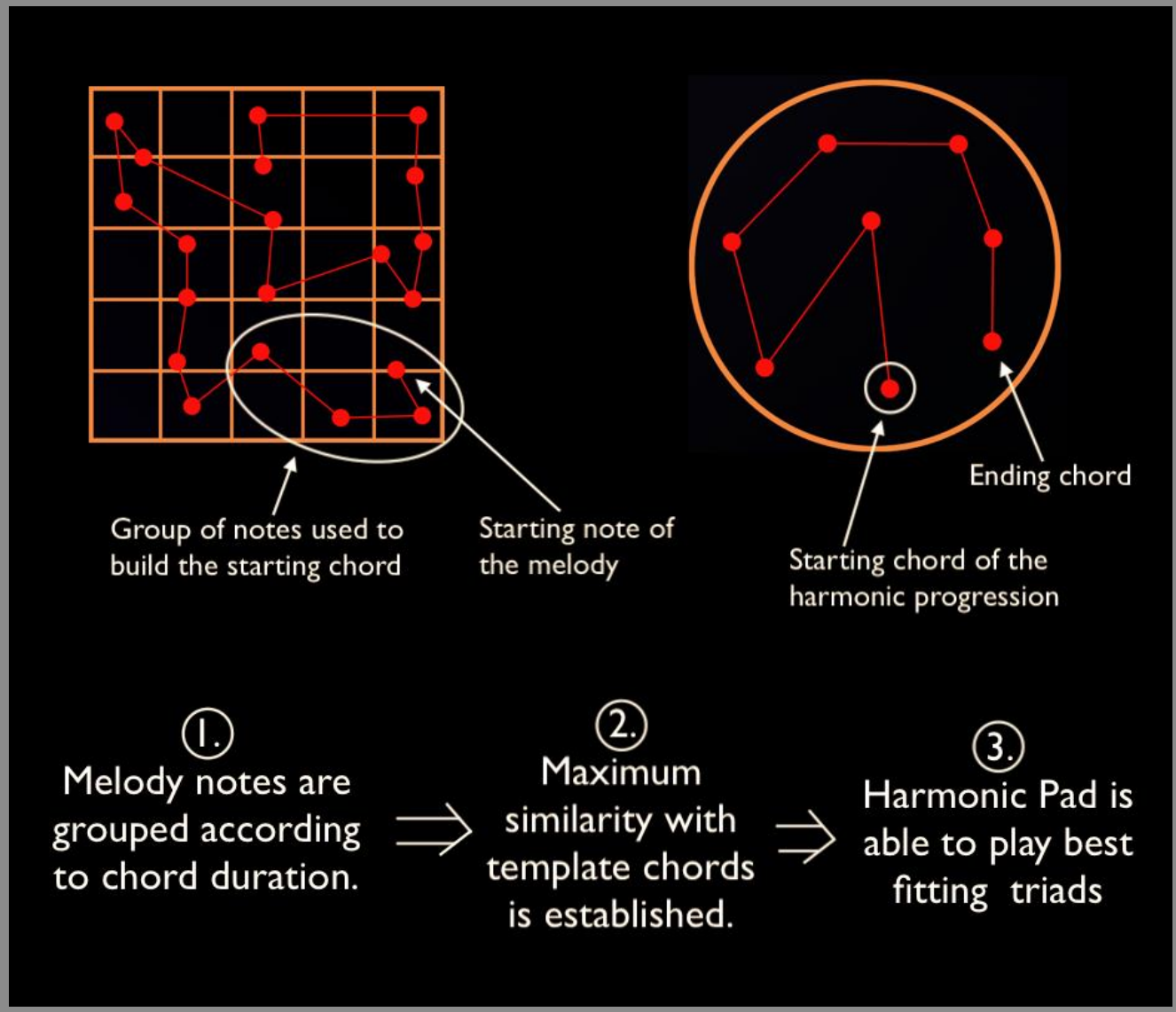


THE HARMONIC PAD

- The Harmonic Pad creates an harmonic support to the melody generated by the Malodic Pad:

1. Single node associated to a single chord.
2. Chord duration and time position in the measure provided by relative nodes's distances.
3. Scale Tone and Scale Mode are the same of the Melodic Pad (set by the user).
4. Chord sound is played by a Tone.js PolySynth.

- Notice: Melodic Pad loop duration = Harmonic Pad loop duration.

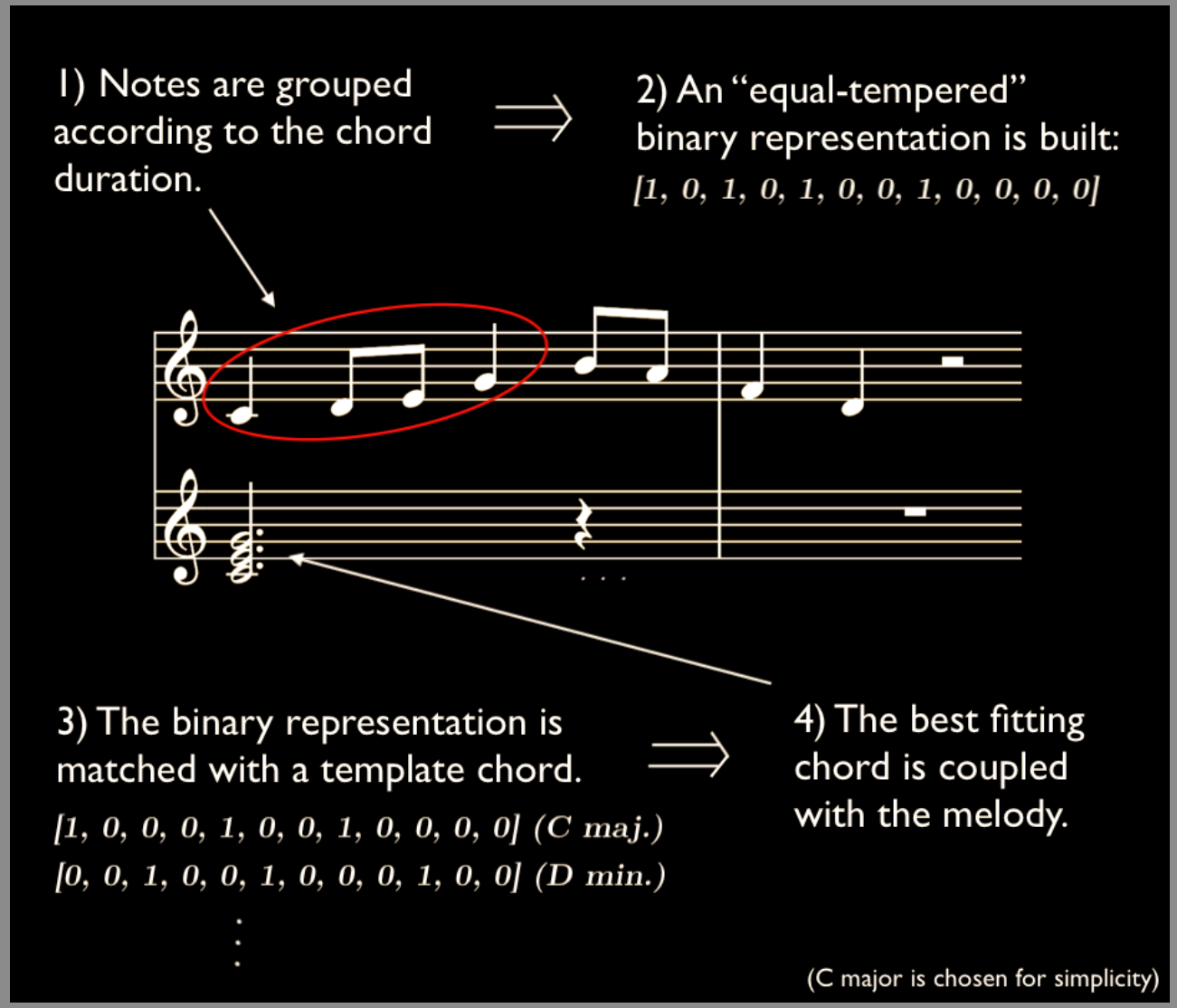


THE HARMONIC PAD: CHORD RECOGNITION

- The Harmonic Pad creates an harmonic support to the melody generated by the Malodic Pad:

1. Notes are gouped according to the chord duration.
2. An "equal tempered" binary representation is built.
3. The binary representation is matched with a template chord.
4. The best fitting chord is coupled with the melody.

- Notice: All chords are played with the form root-3rd-5th



THE "PRE-LEARNING" USER INTERFACE

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Key signature, Scale/Harmonic mode,
Harmonic and Melodic Pad sounds.

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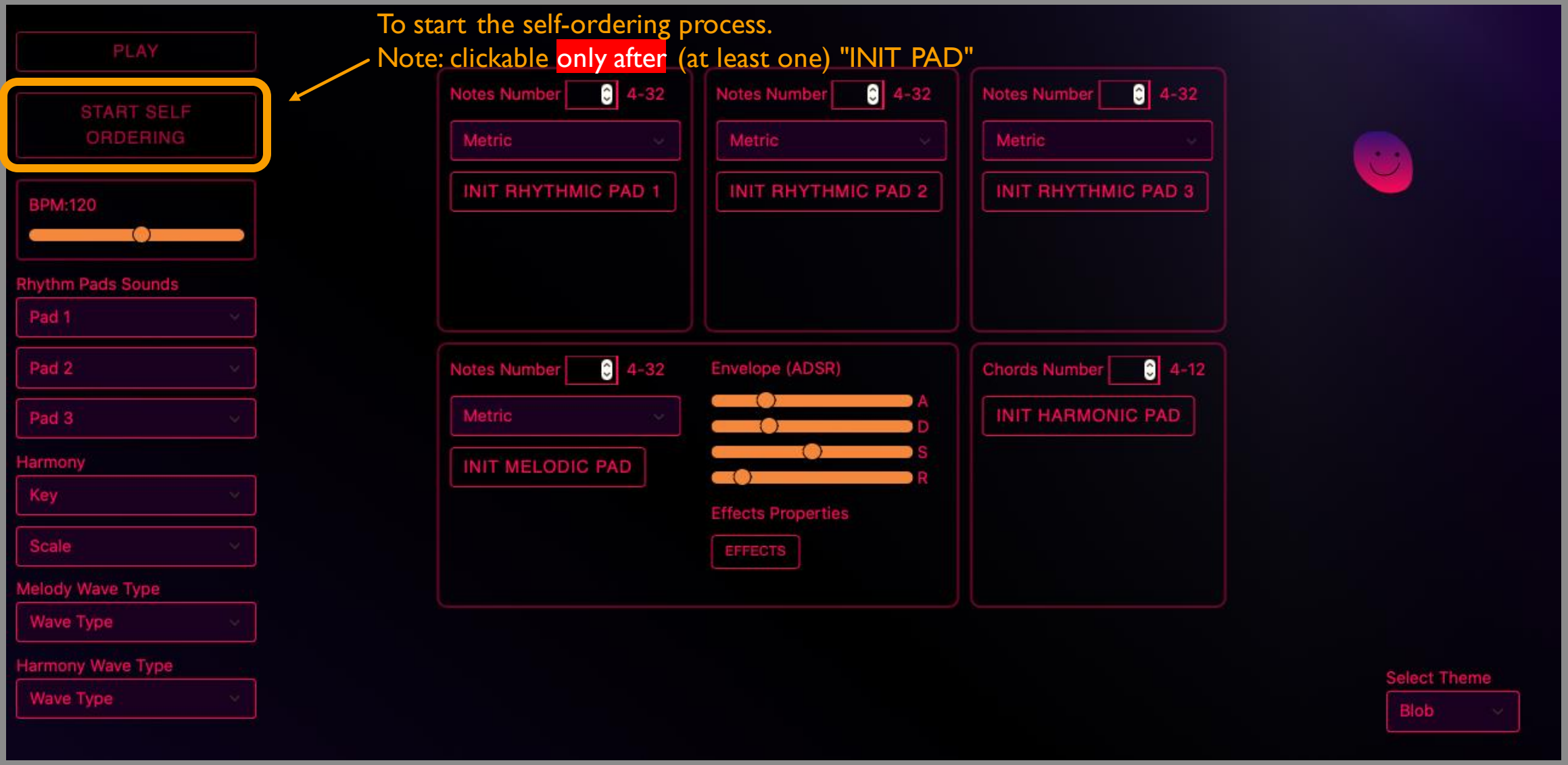

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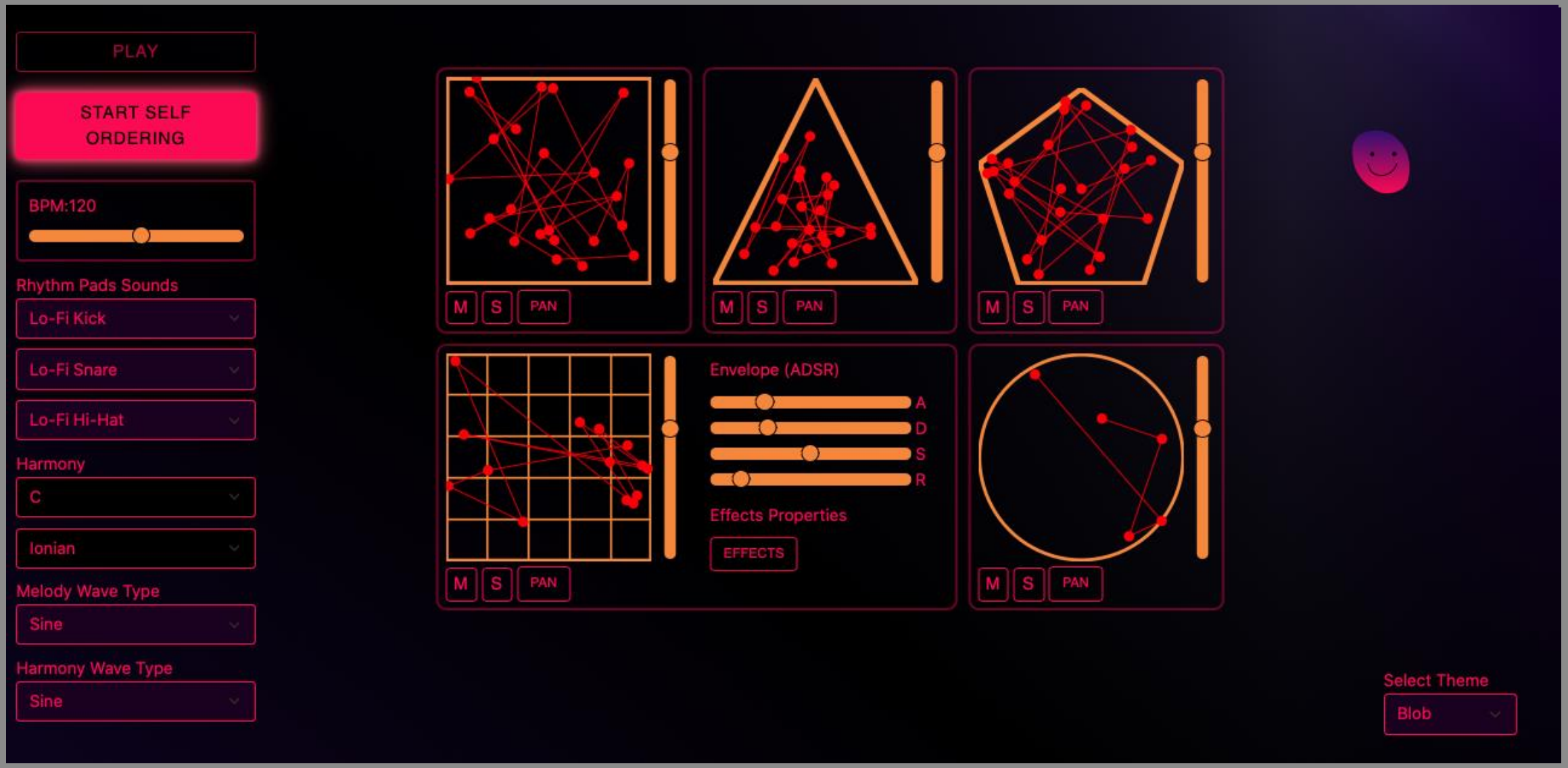
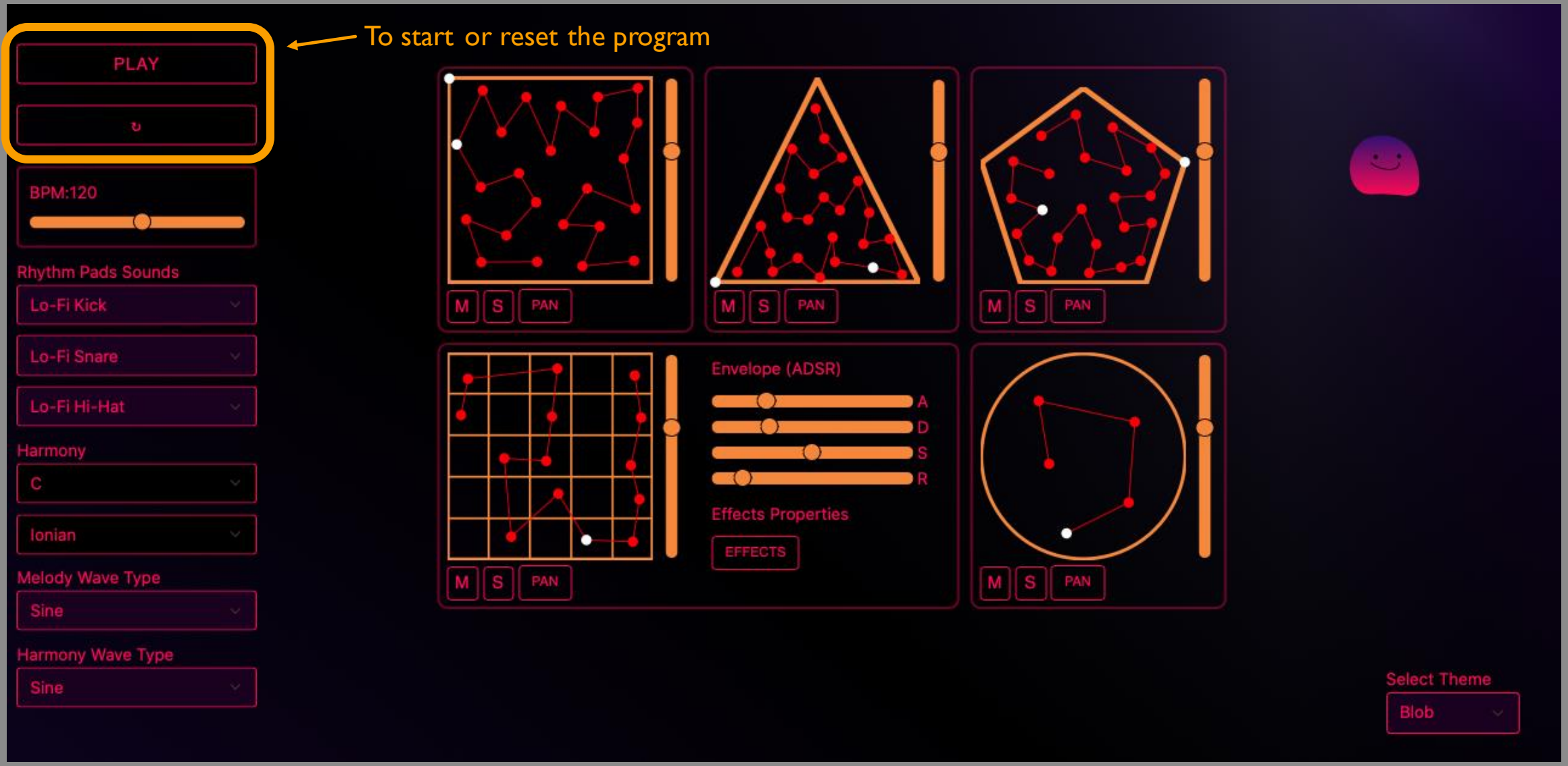


THE "POST-LEARNING" USER INTERFACE



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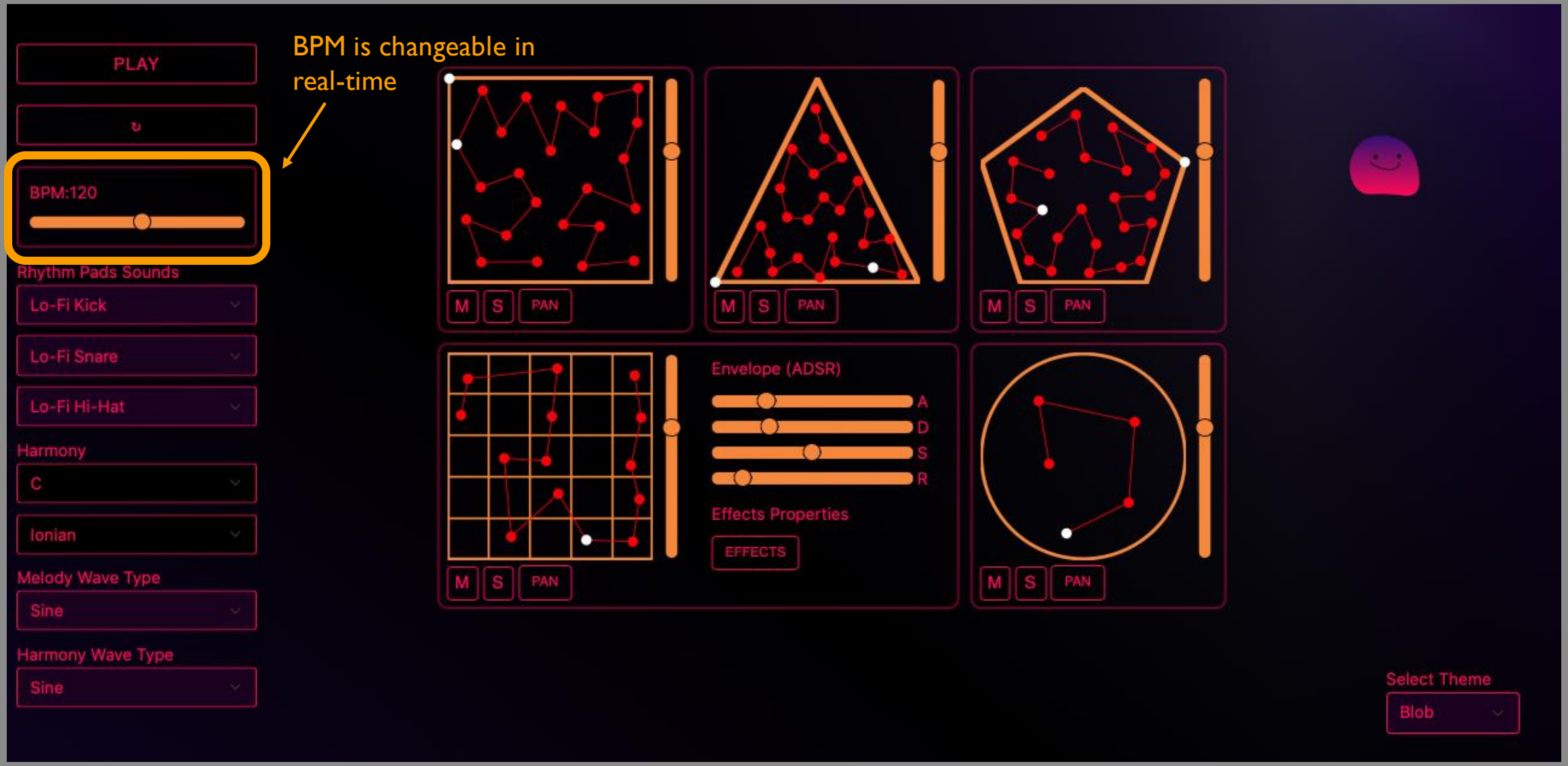

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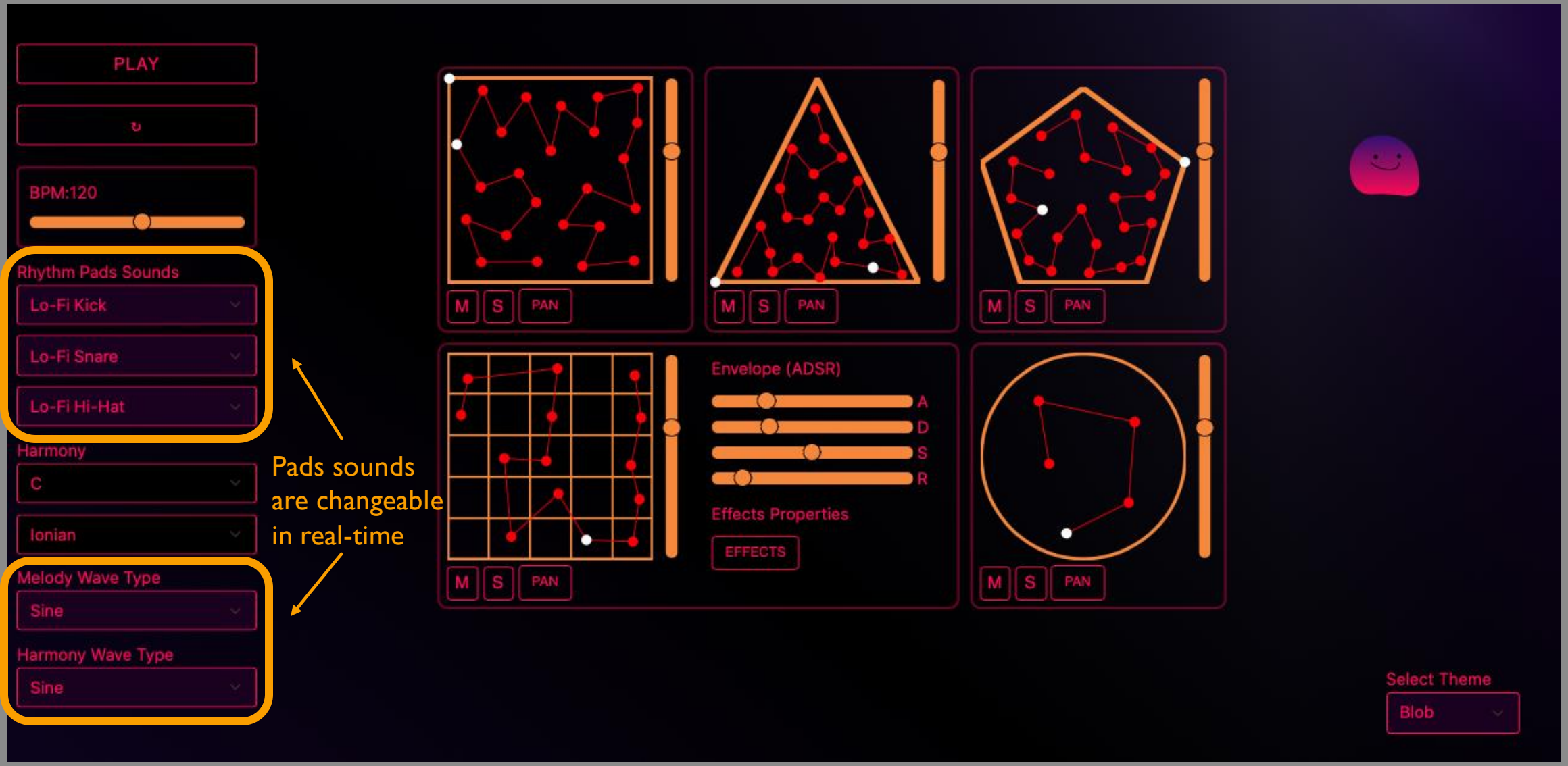

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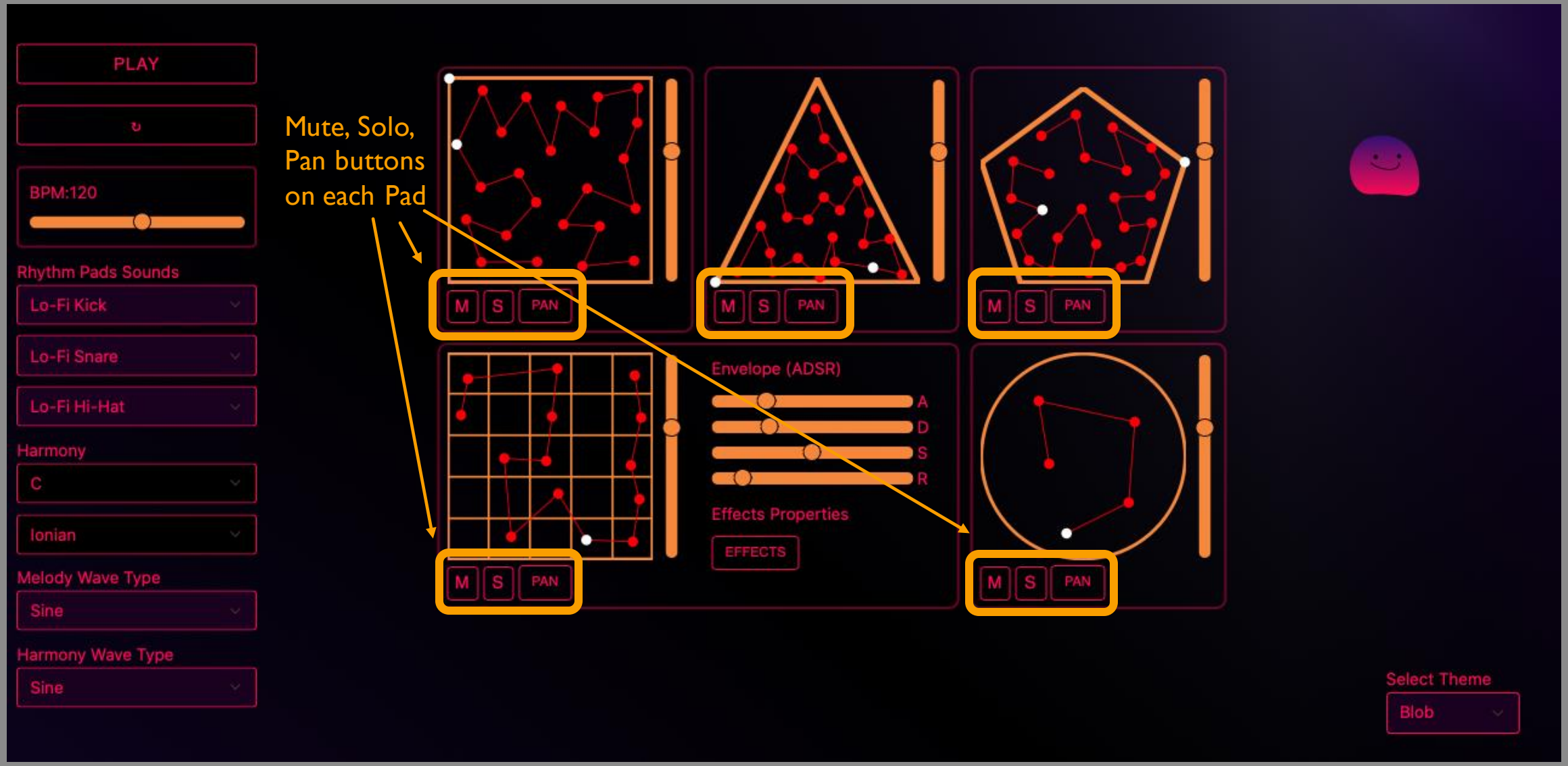

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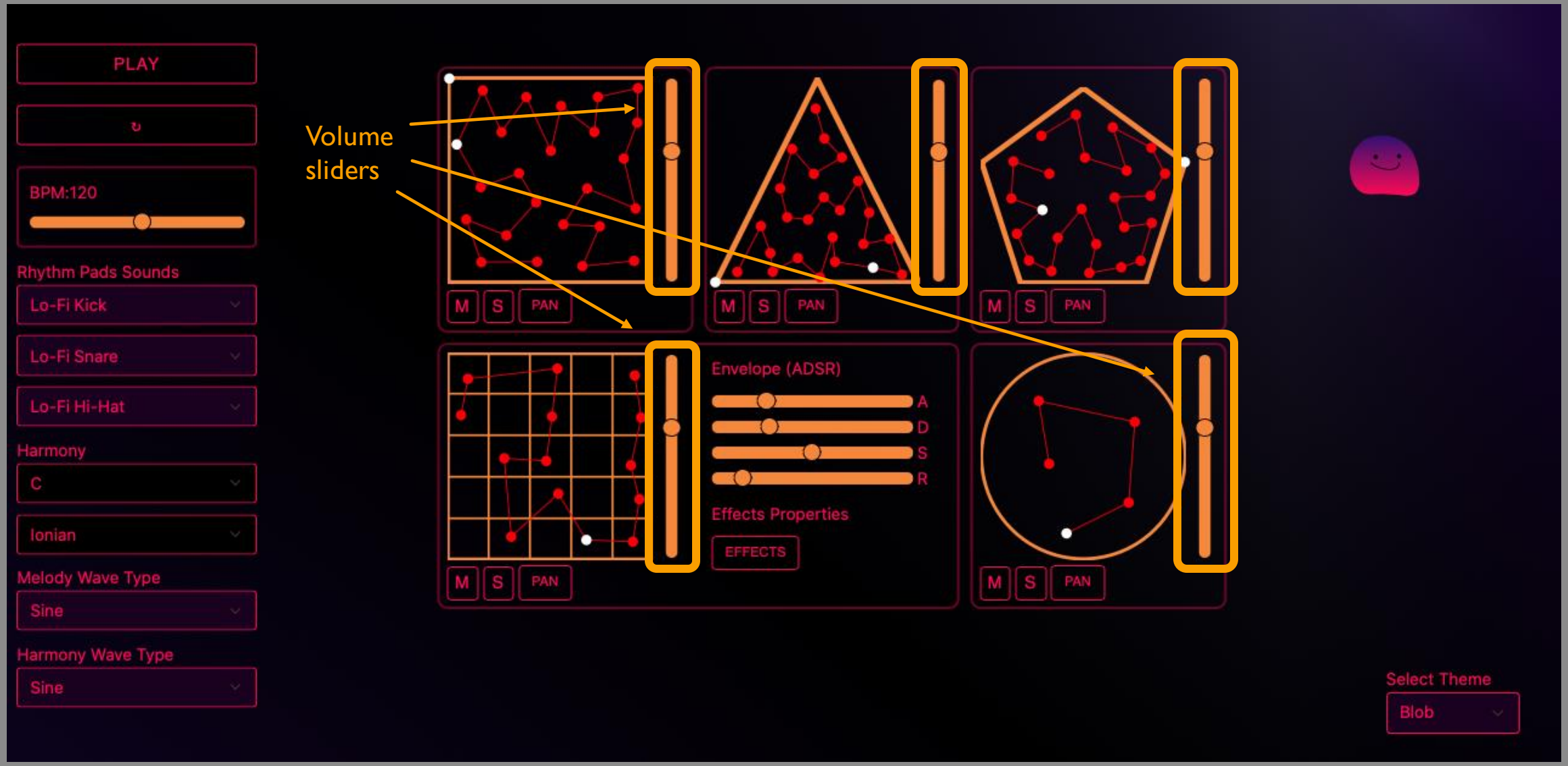

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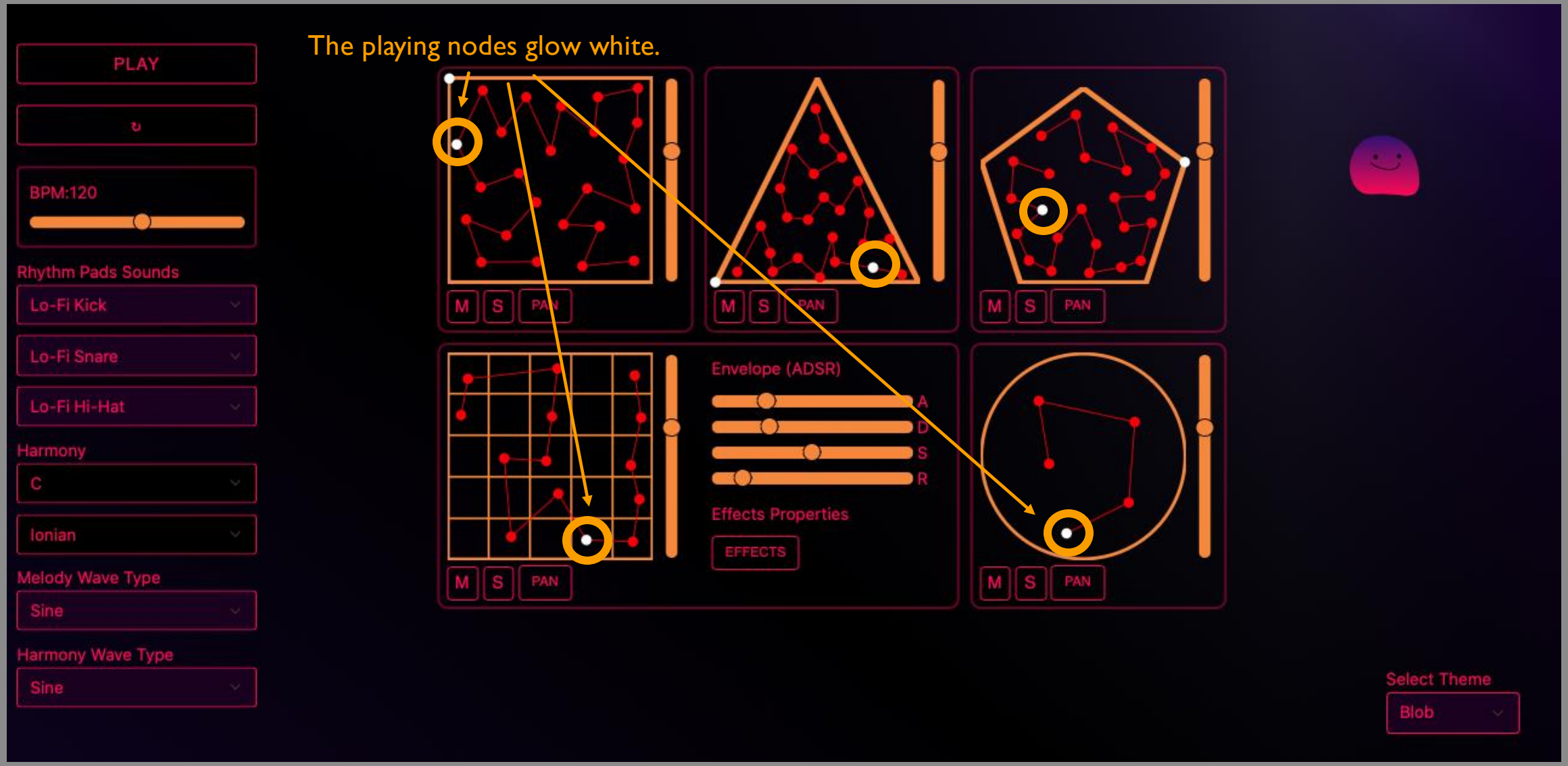

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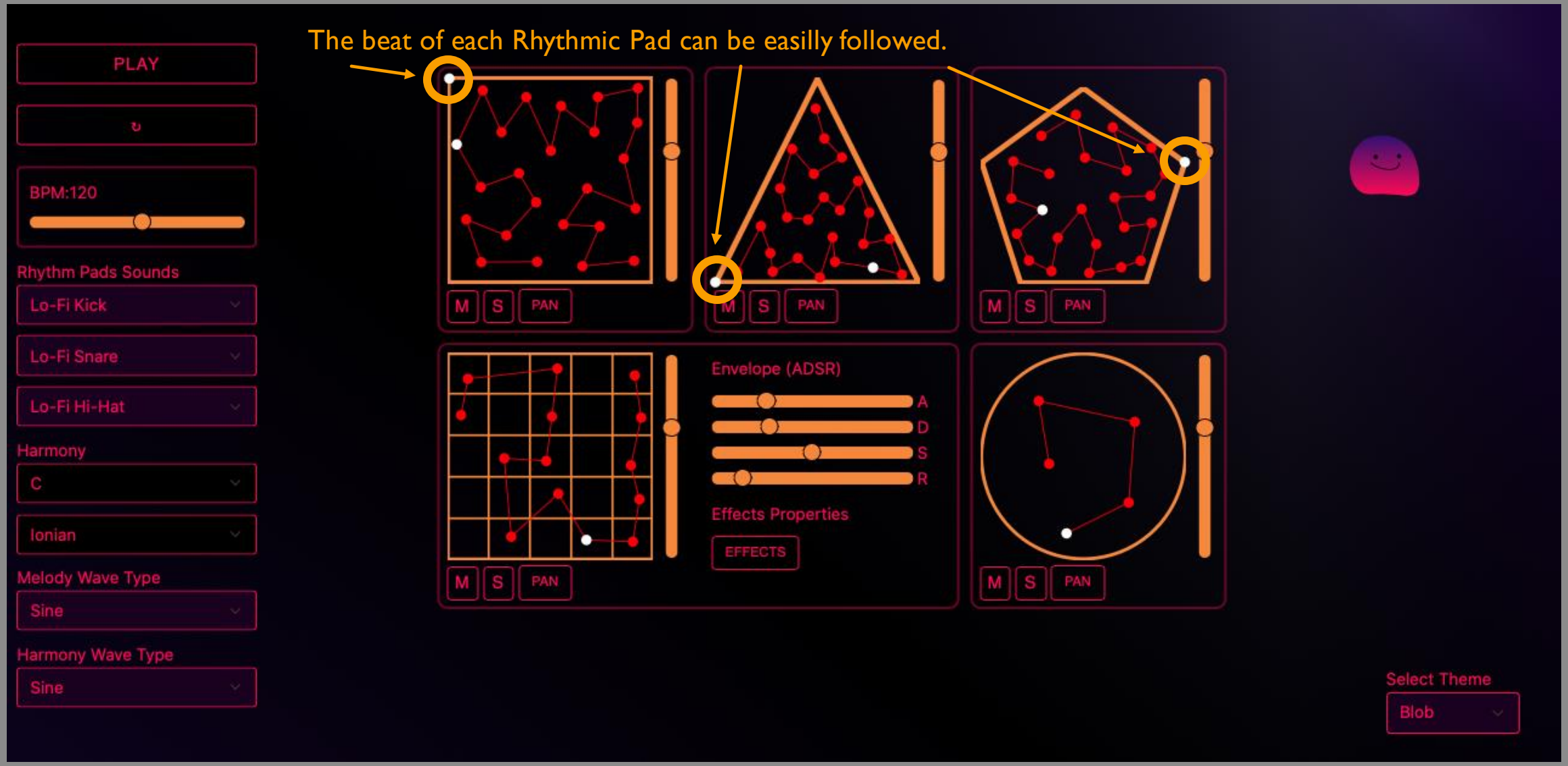
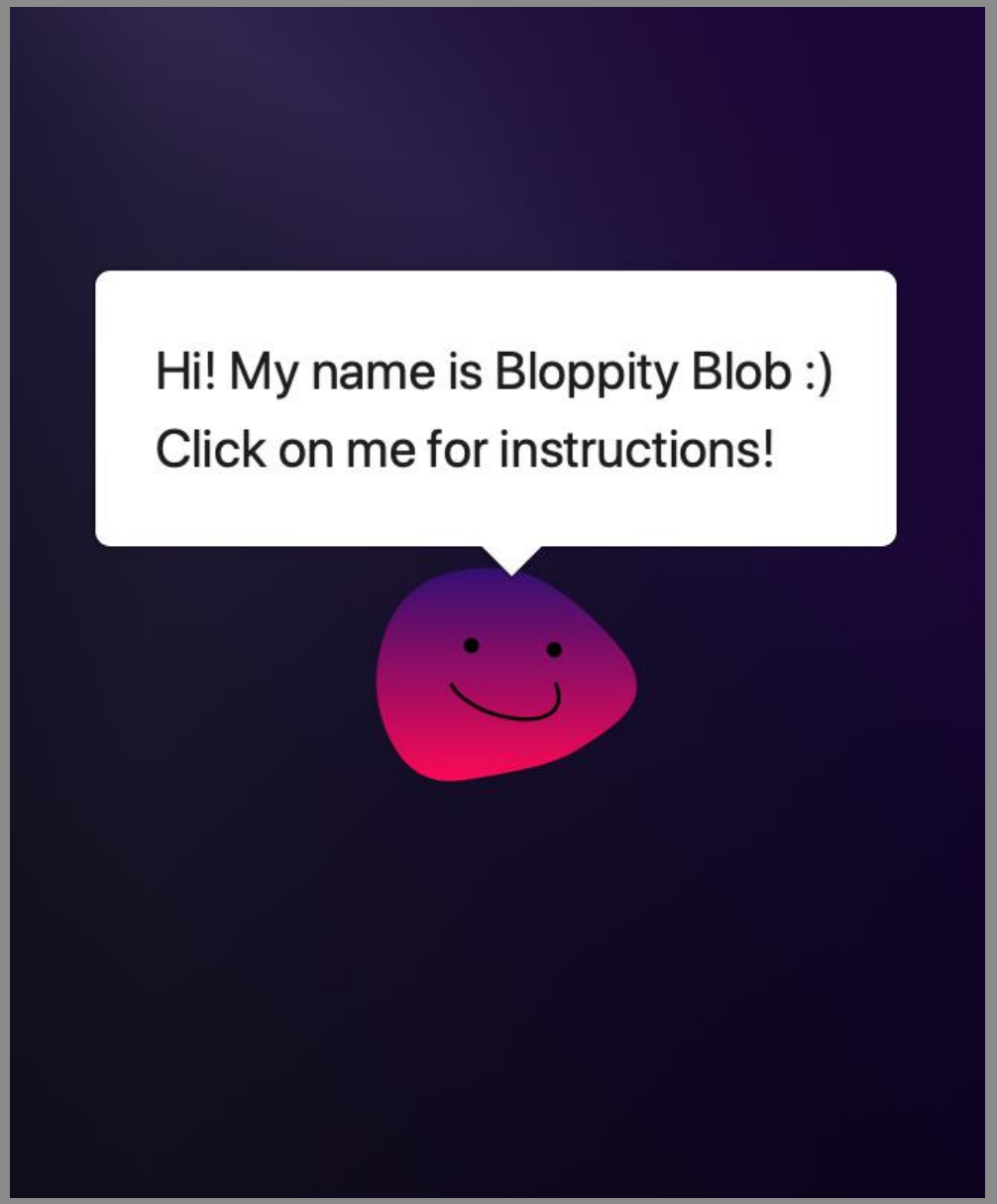


I'M HERE TO HELP YOU :)

- Bloppity Blop is clickable:

  It will help you to use correctly the program.



… Thank you for your attention.

REFERENCES

- [1] Kohonen, T. Self-organized formation of topologically correct feature maps. *Biol. Cybern.* **43**, 59–69 (1982). https://doi.org/10.1007/BF00337288
- [2] Kohonen T. (2013). Essentials of the self-organizing map. *Neural networks : the official journal of the International Neural Network Society*, *37*, 52–65. https://doi.org/10.1016/j.neunet.2012.09.018
- [3] Vrieze O.J. (1995) Kohonen network. In: Braspenning P.J., Thuijsman F., Weijters A.J.M.M. (eds) Artificial Neural Networks. Lecture Notes in Computer Science, vol 931. Springer, Berlin, Heidelberg. https://doi.org/10.1007/BFb0027024