

Simulated Learning of Rhythm Perception and Synchronization



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Background

- Sensorimotor synchronization, the coordination of rhythmic auditory input and motor responses, is an inherent skill in humans.
- Experiments have shown animals can learn to synchronize with metronomes through reinforcement.
- In this study, we investigate the neural processes underpinning rhythm perception and beat prediction while exploring methods to train artificial agents to entrain to rhythms.

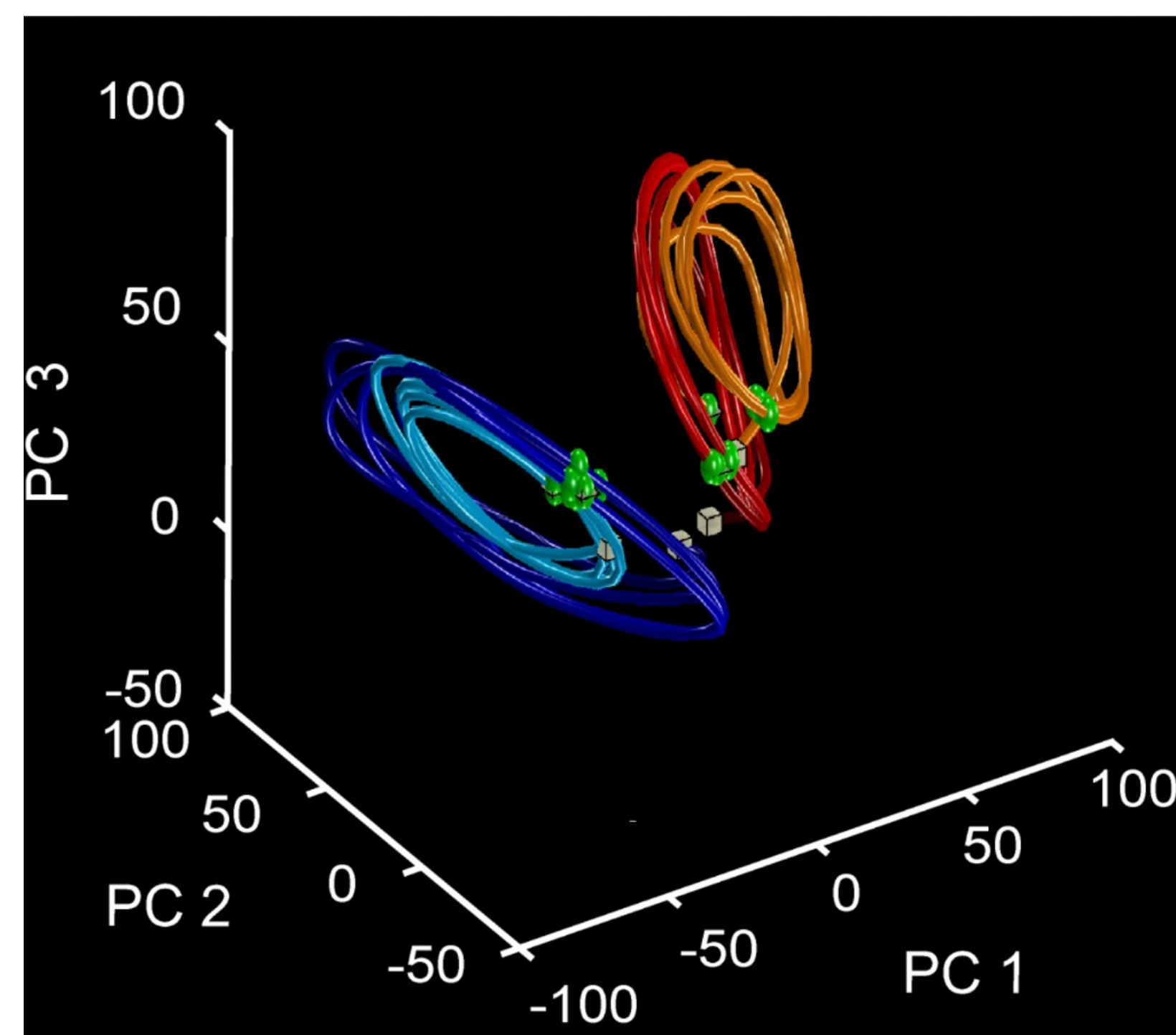


Fig1. Monkeys' Neurons' Activity in Lower Space Using PCA

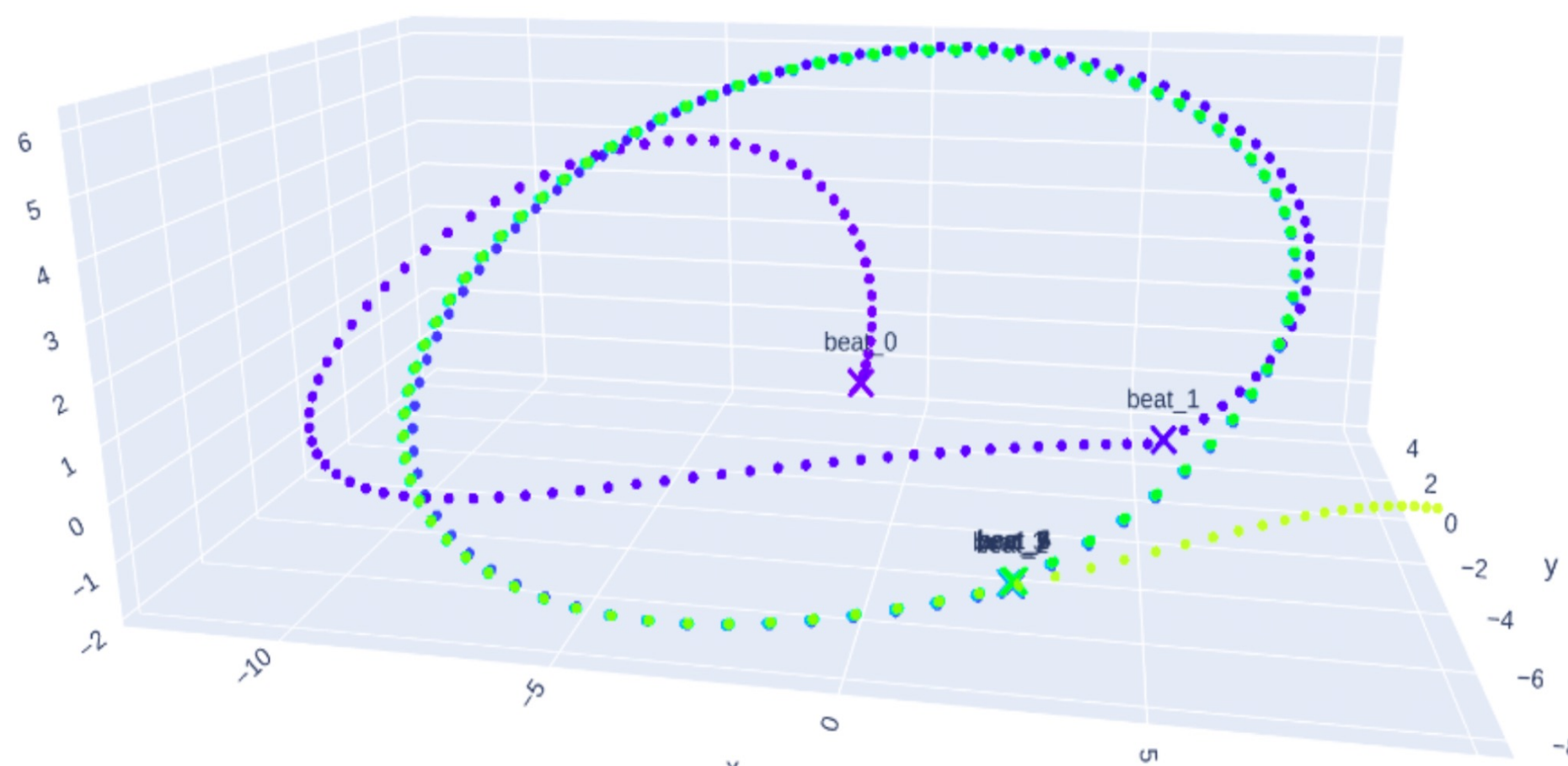


Fig2. Our Network's Unit Activity in Lower Space Using PCA

References

- DePasquale, Brian, et al. "full-FORCE: A target-based method for training recurrent networks." PloS one 13.2 (2018): e0191527.
- Gámez, Jorge, et al. "Predictive rhythmic tapping to isochronous and tempo changing metronomes in the nonhuman primate." Annals of the New York Academy of Sciences 1423.1 (2018): 396-414.

Methodology

RNNs

- Undirectioned interconnected networks, inspired by the neurons' connectivity in brains
- Processing temporal data by maintaining memory through recurrent connections

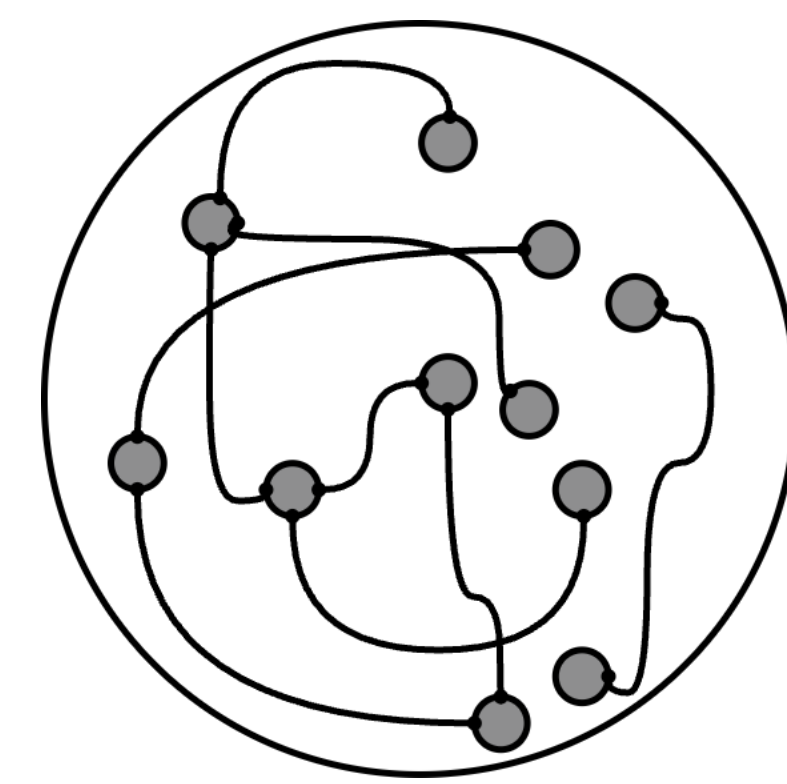


Fig3. Schema of a Recurrent Neural Network

- CTRNNs, mimicking biological processes, computes continuously
- **Input:** A series of equally spaced beats ranging from 0.4 seconds to 1.2 seconds.
- **Output:** A sine wave with the same period following each beat

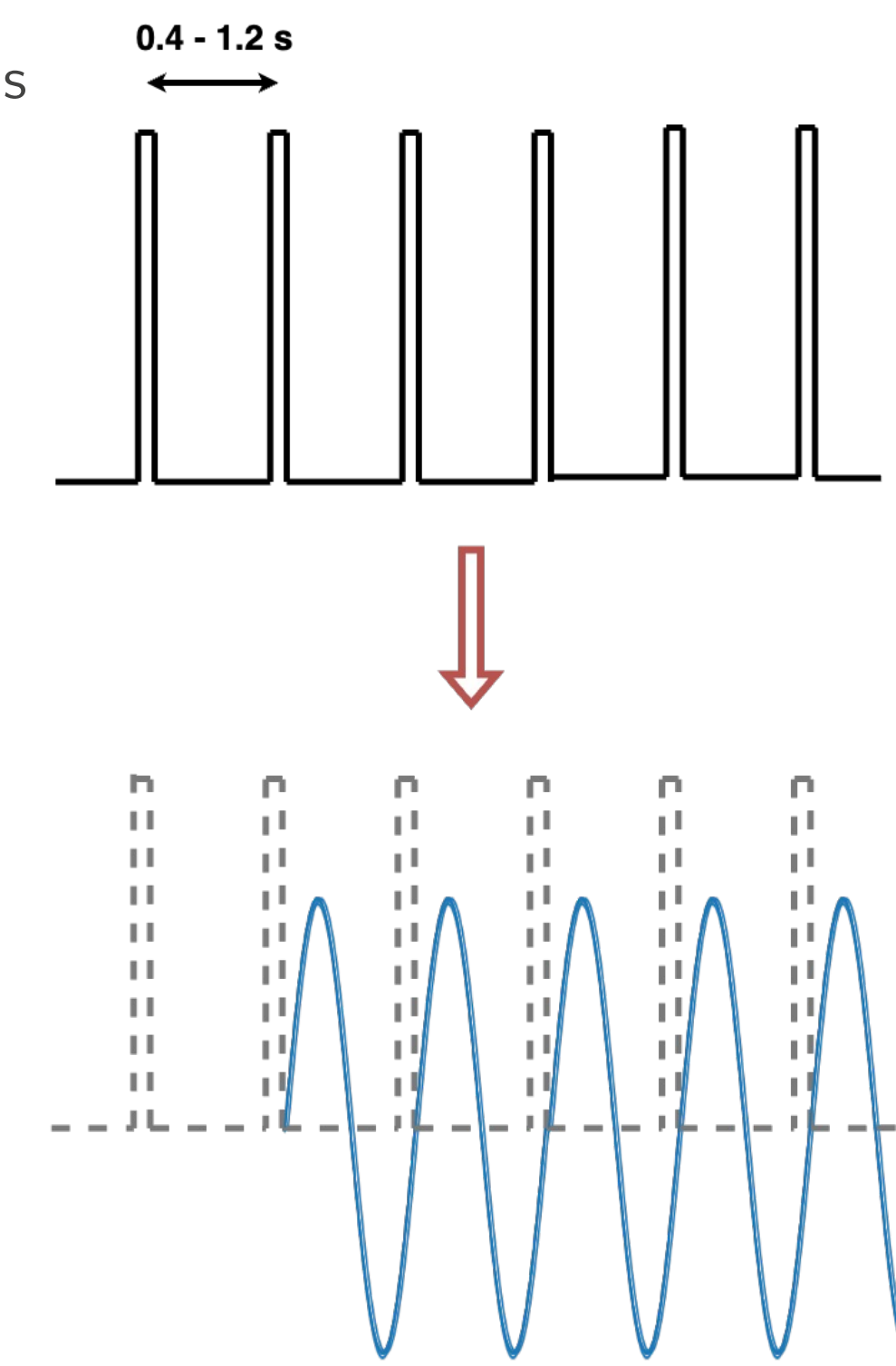


Fig4. RNN's Task Description

- Target-based method.
- Generating targets for each neuron using a second randomly connected network
- Useful for tasks with silent inputs over thousands of model integration time steps

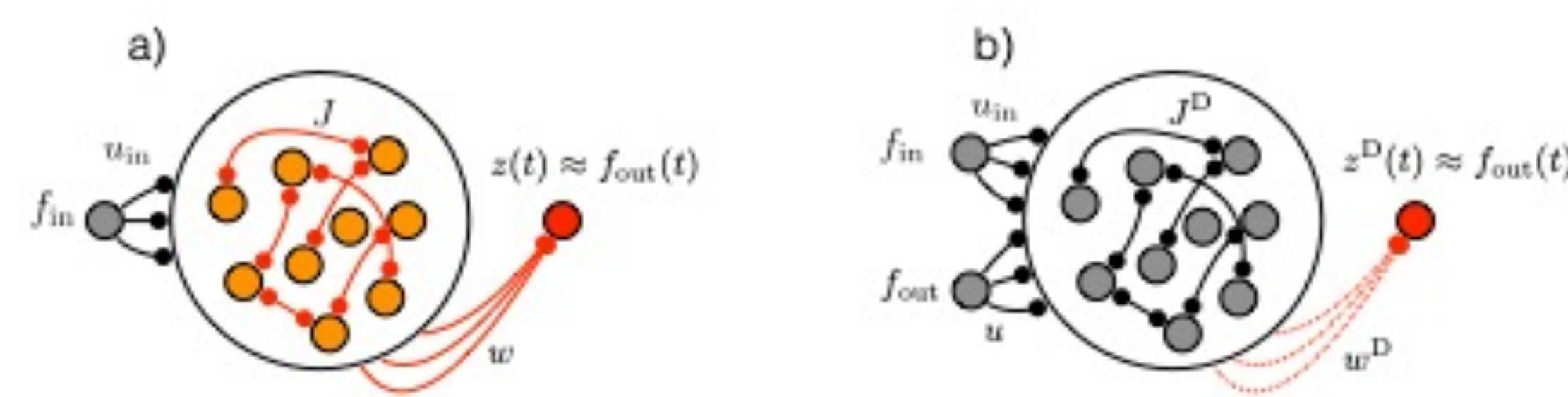


Fig5.
a) Task Performing Network
b) Target Generating Network

- **Input:** 5 input pulses
- **Output:** Generating the 6th predicted pulse with a small-time shift

Full-FORCE

- Biologically plausible training method, inspired by fundamentals of learning
- Successfully trained monkeys to tap synchronously with visual or auditory beats

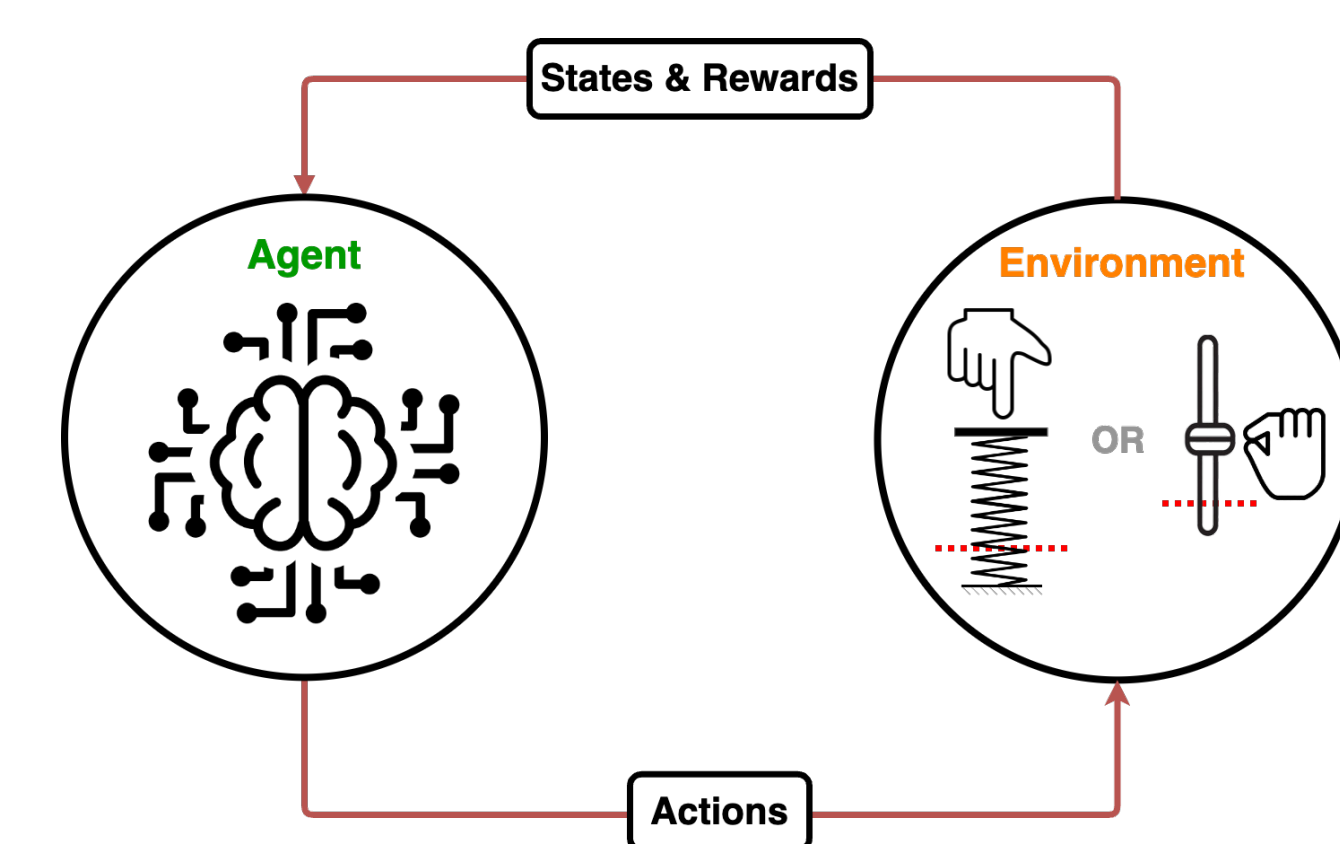


Fig6. Schema of Our RL Model:
Agent can push a spring or move a slider to tap

Reinforcement Learning

- **Input:** A fixed context cue over time
- **Output:** Agent Tap synchronously with a tempo proportional to the context cue.

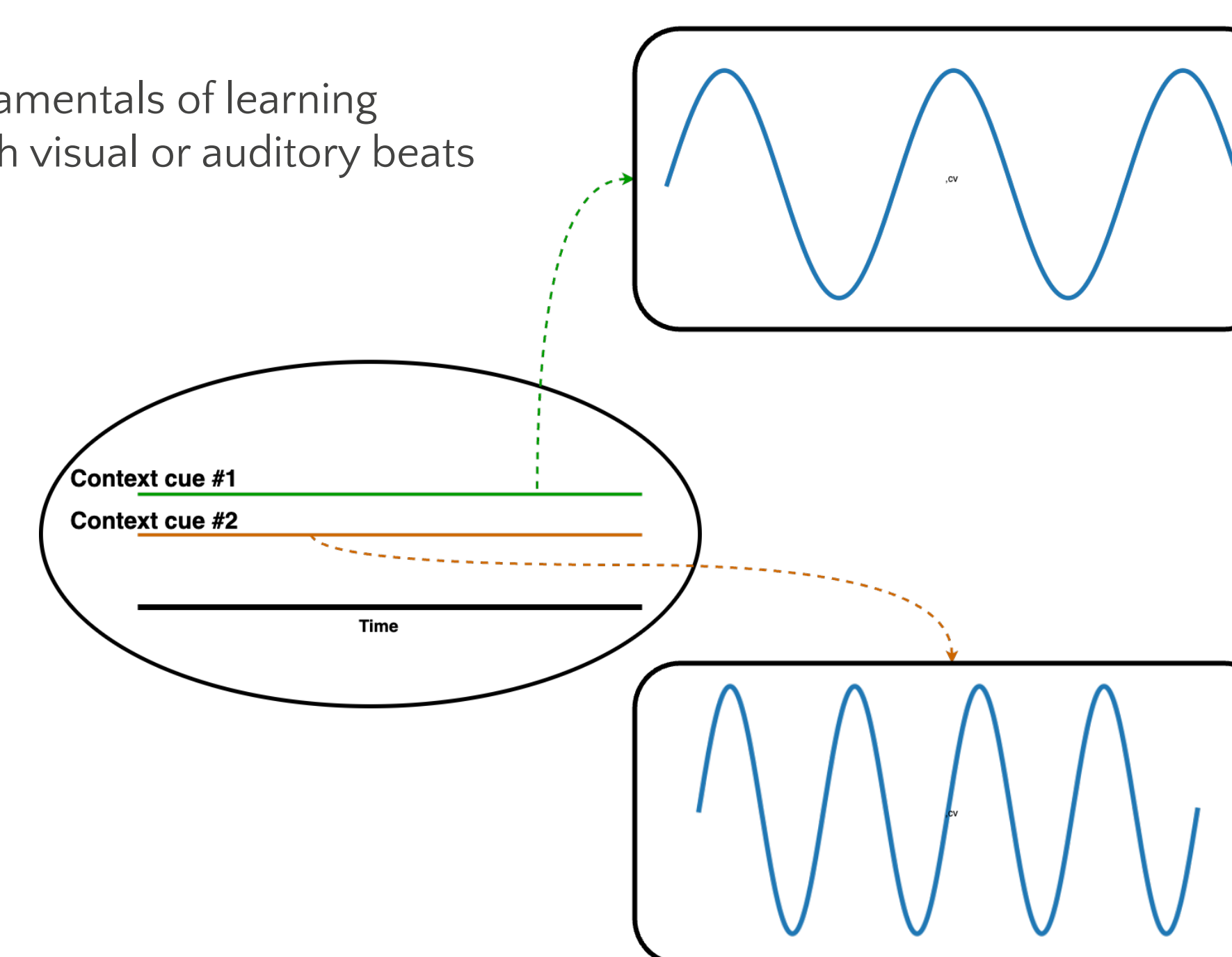


Fig7. RL's Task Description

Results

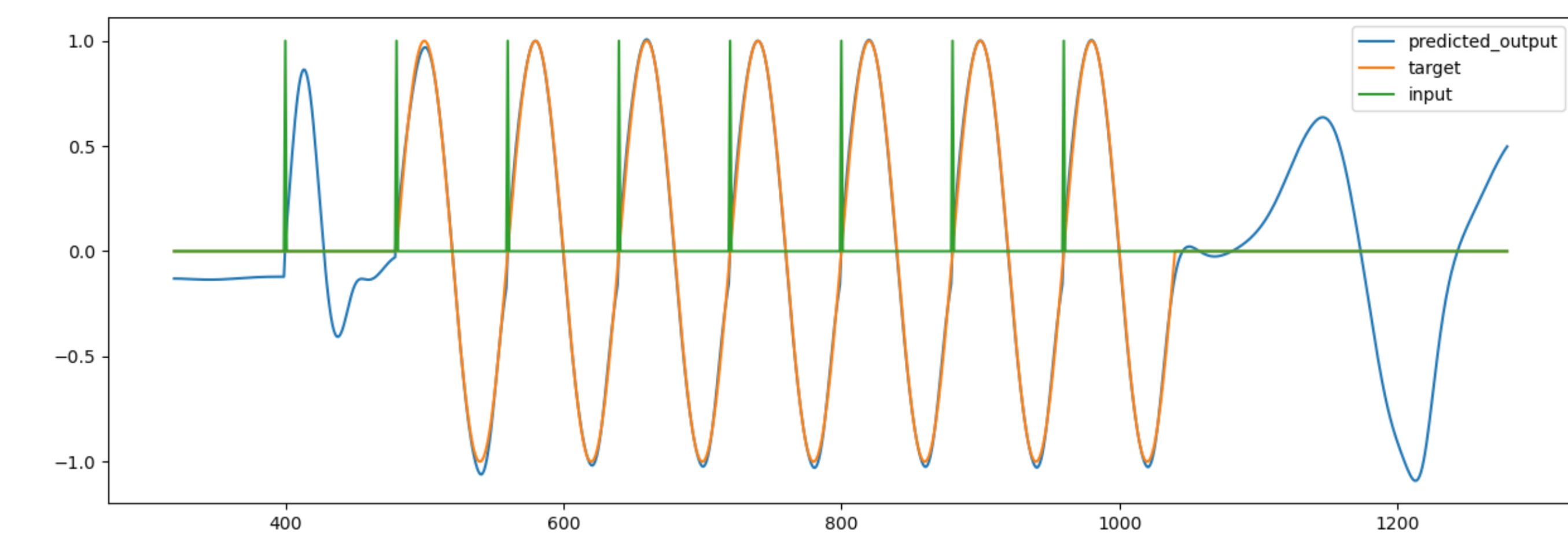


Fig8. CTRNN's Output

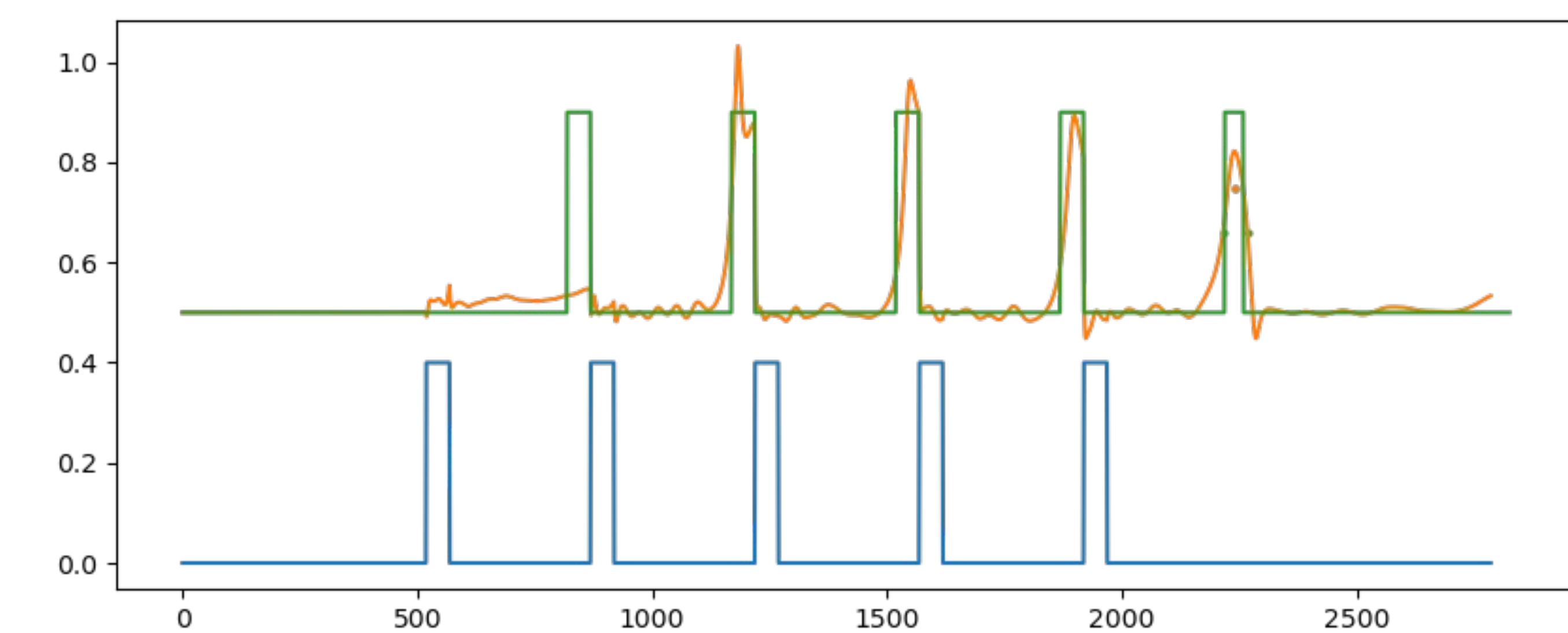


Fig9. Full-FORCE's Output

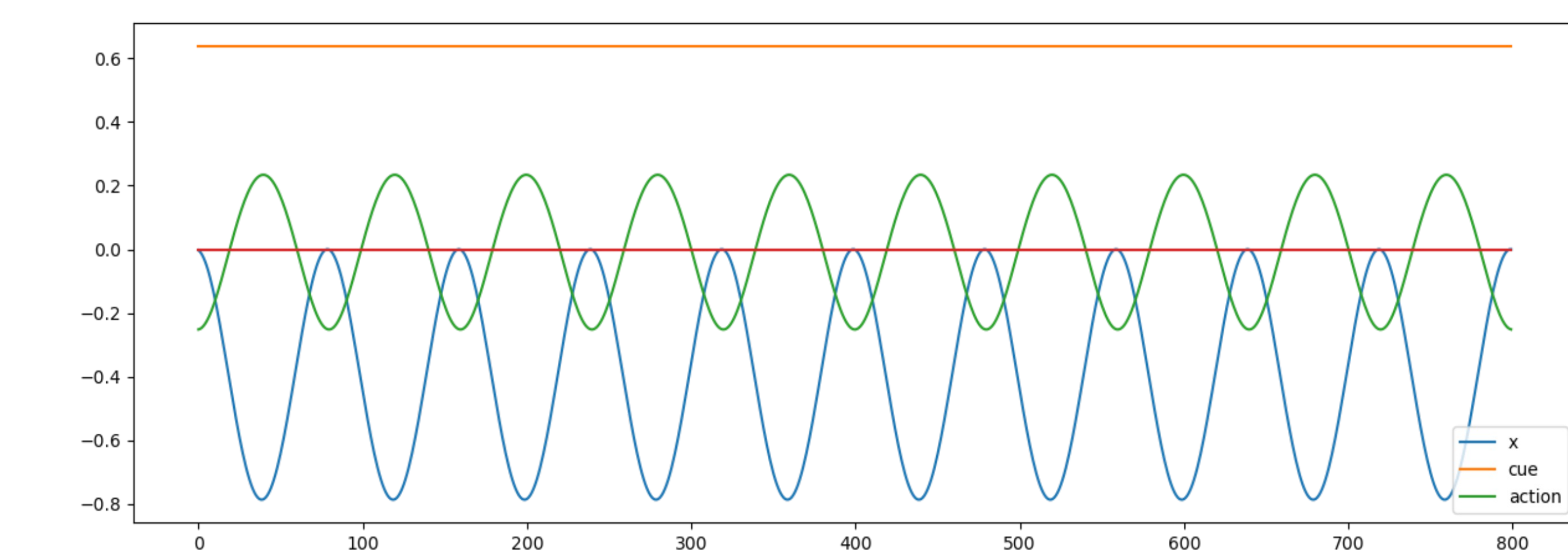


Fig10. RL's Output

Future Directions

- Teaching the RL agent to tap along rhythmic input
- Comparing and integrating computational findings with existing behavioural and experimental data
- Comparing different training regimes