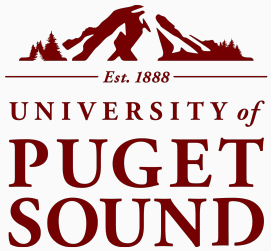

Plasticity and Evolvability

CSCI 440 Check In 2

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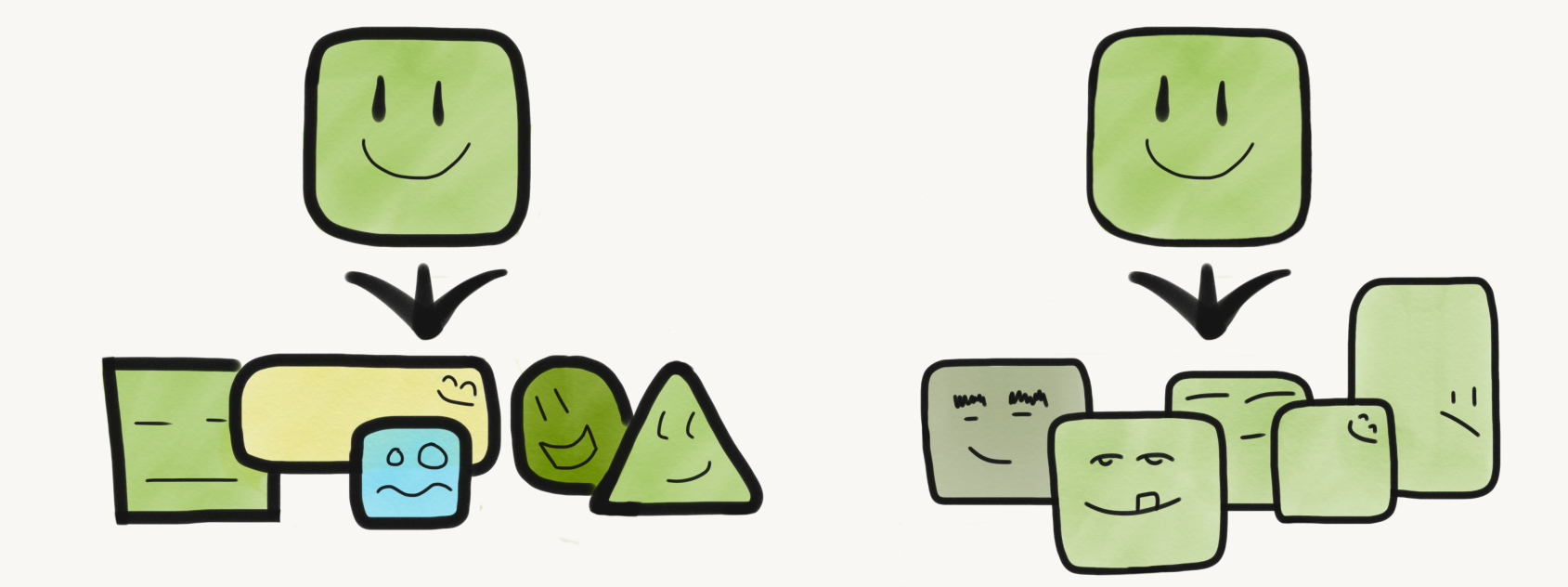
Evolvability Review

Defining Evolvability

consensus: the amount of useful variation generated by the evolutionary process

- evolvability as the ability to generate heritable variation
- evolvability as bias towards useful variation

Evolvability as Heritable Variation



(a) high individual evolvability (b) low individual evolvability

Figure 1: An illustration of individual evolvability, considering evolvability as heritable variation [Wilder and Stanley, 2015].

Evolvability as Bias towards Useful Variation

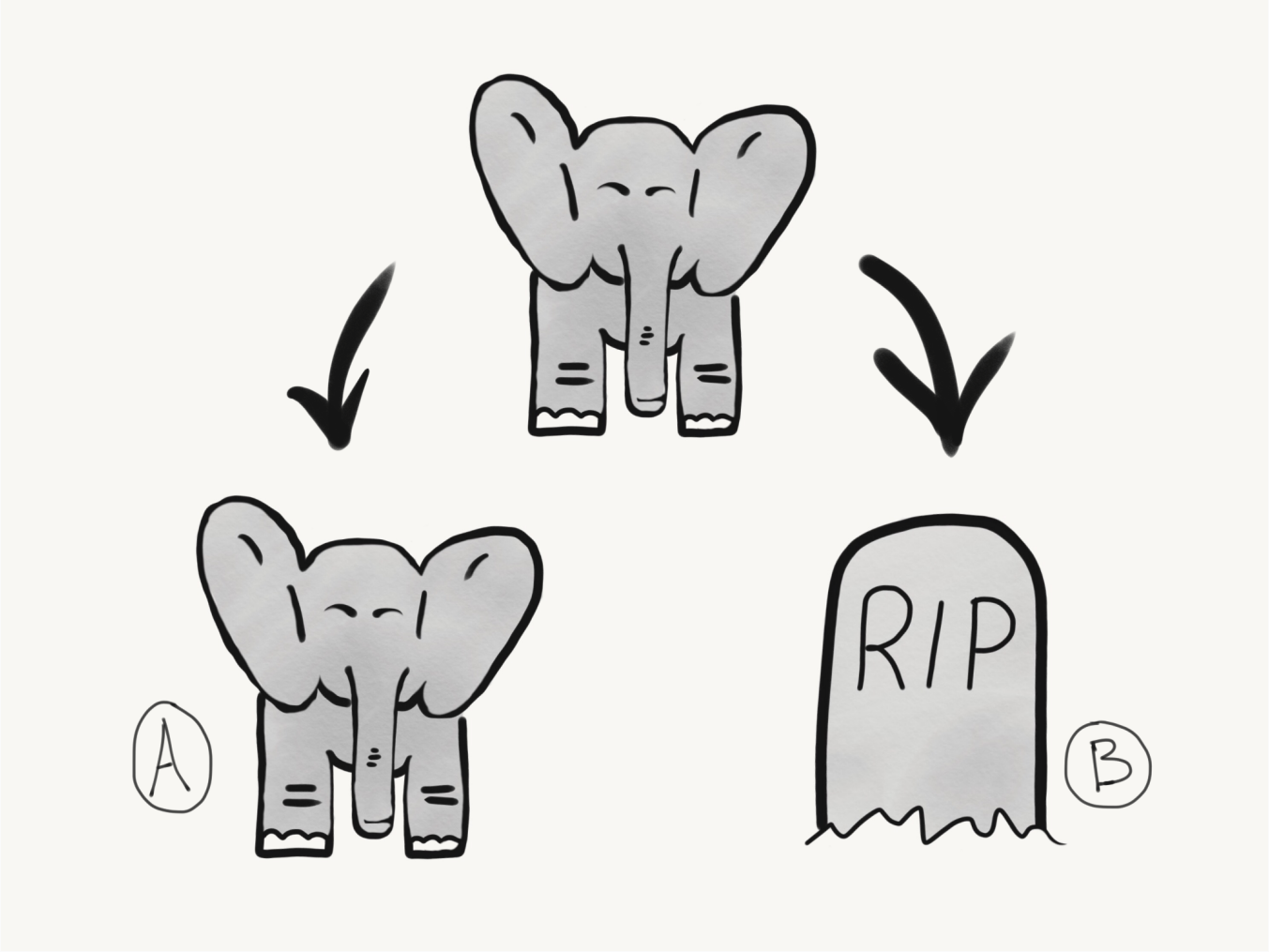


Figure 2: Illustration of robustness; high evolvability left and low evolvability right [Downing, 2015].

Reading an Evolvability Signature

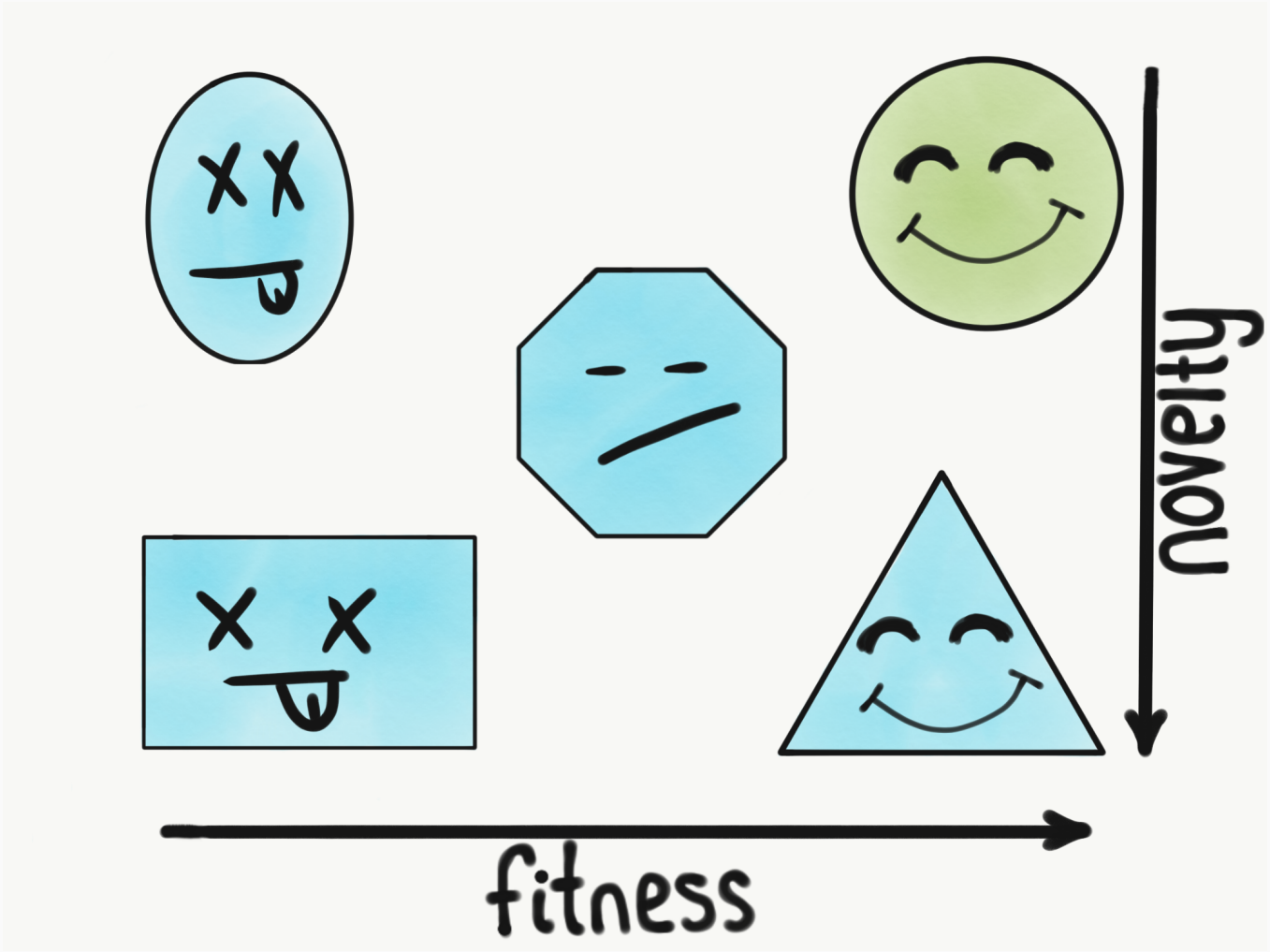


Figure 3: Cartoon illustration describing the layout of an evolvability signature diagram [Tarapore and Mouret, 2015].

Expanded Model

Motivation

- previous model: phenotypic distance tied directly to fitness score
- add more sophisticated fitness evaluation to separate phenotypic distance and fitness score
- adjust genetic regulatory network setup to scale better
- add hidden states to allow greater network intricacy

Conway's Game of Life

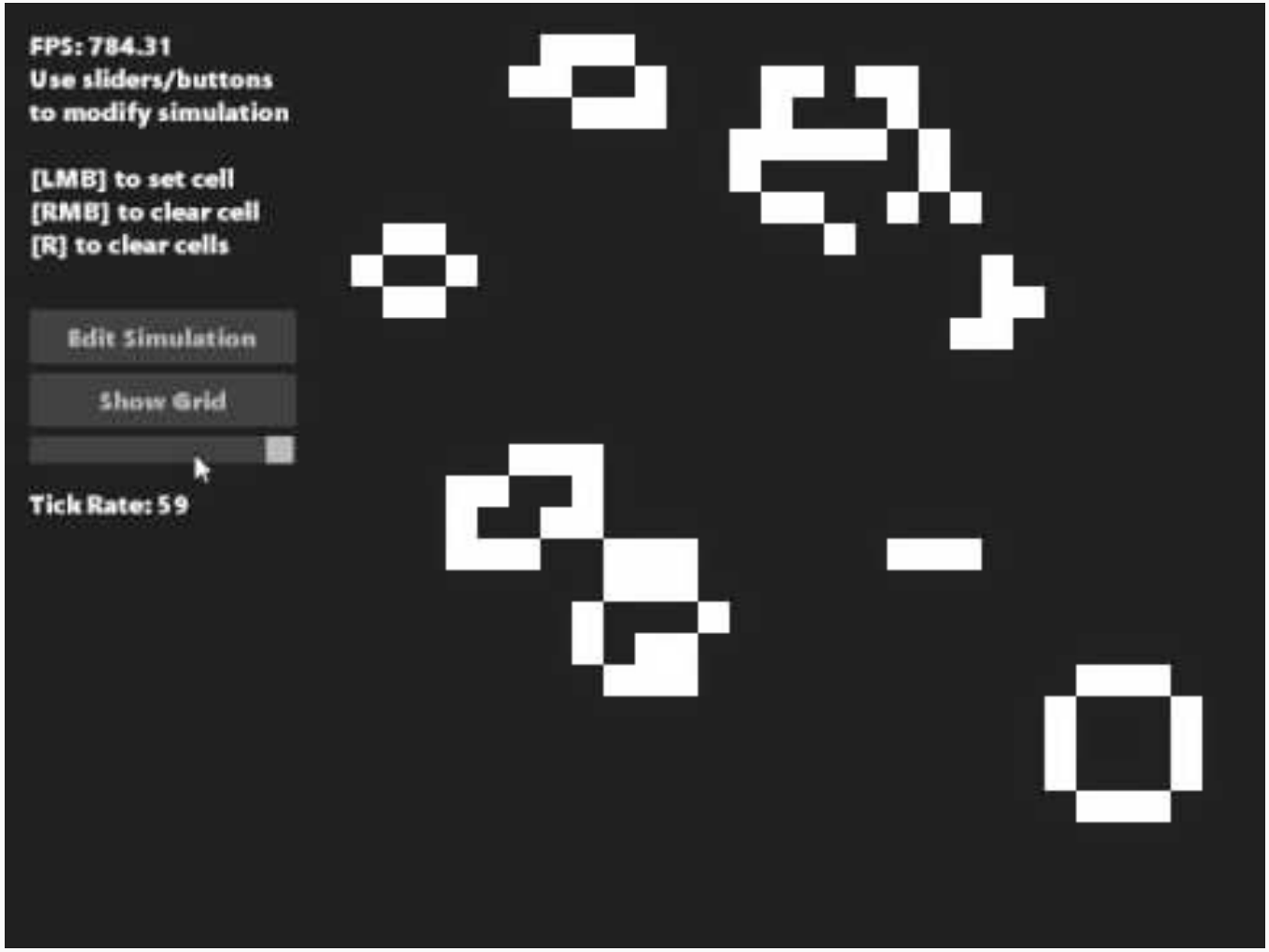


Figure 4: Video illustrations of Conway's Game of Life cellular automata in action.

Adjusted Genetic Regulatory Network Model

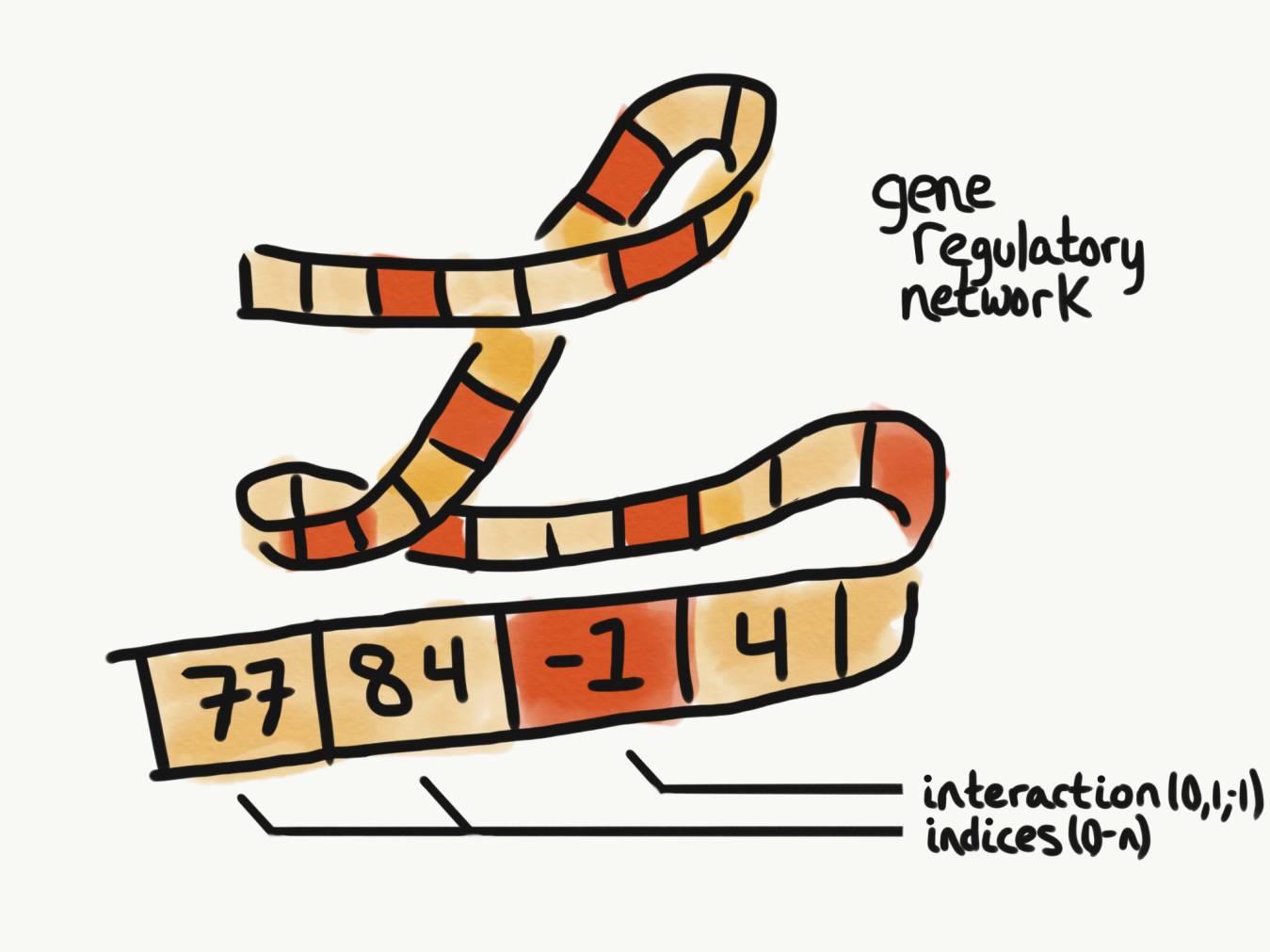


Figure 5: A cartoon depiction of the expanded genetic regulatory network model employed, originally inspired by [Wilder and Stanley, 2015].

Complete Model

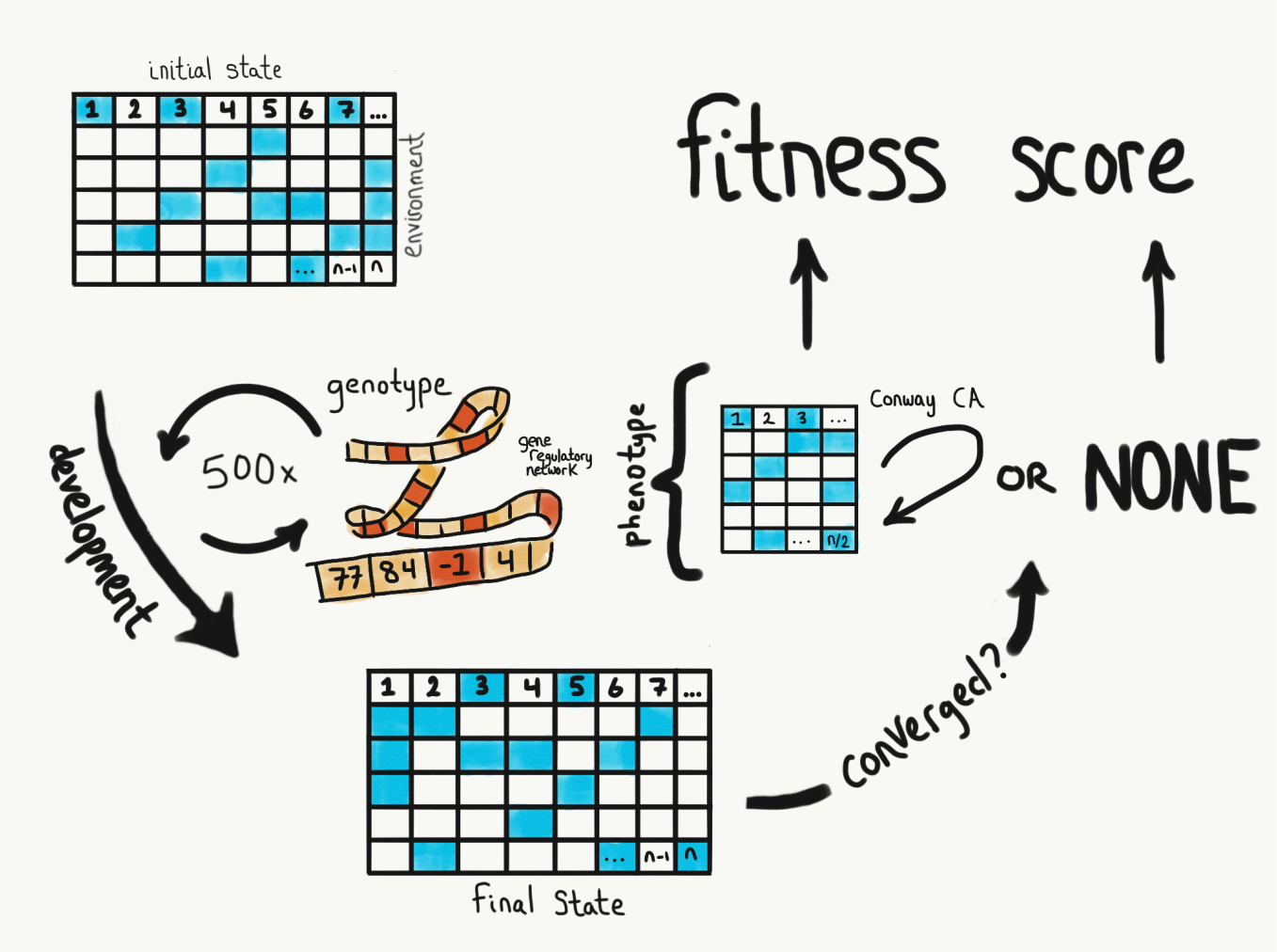


Figure 6: A cartoon overview of the development and assessment processes of the expanded model, based loosely on [Wilder and Stanley, 2015].

Direct Plasticity: Initial State Perturbation

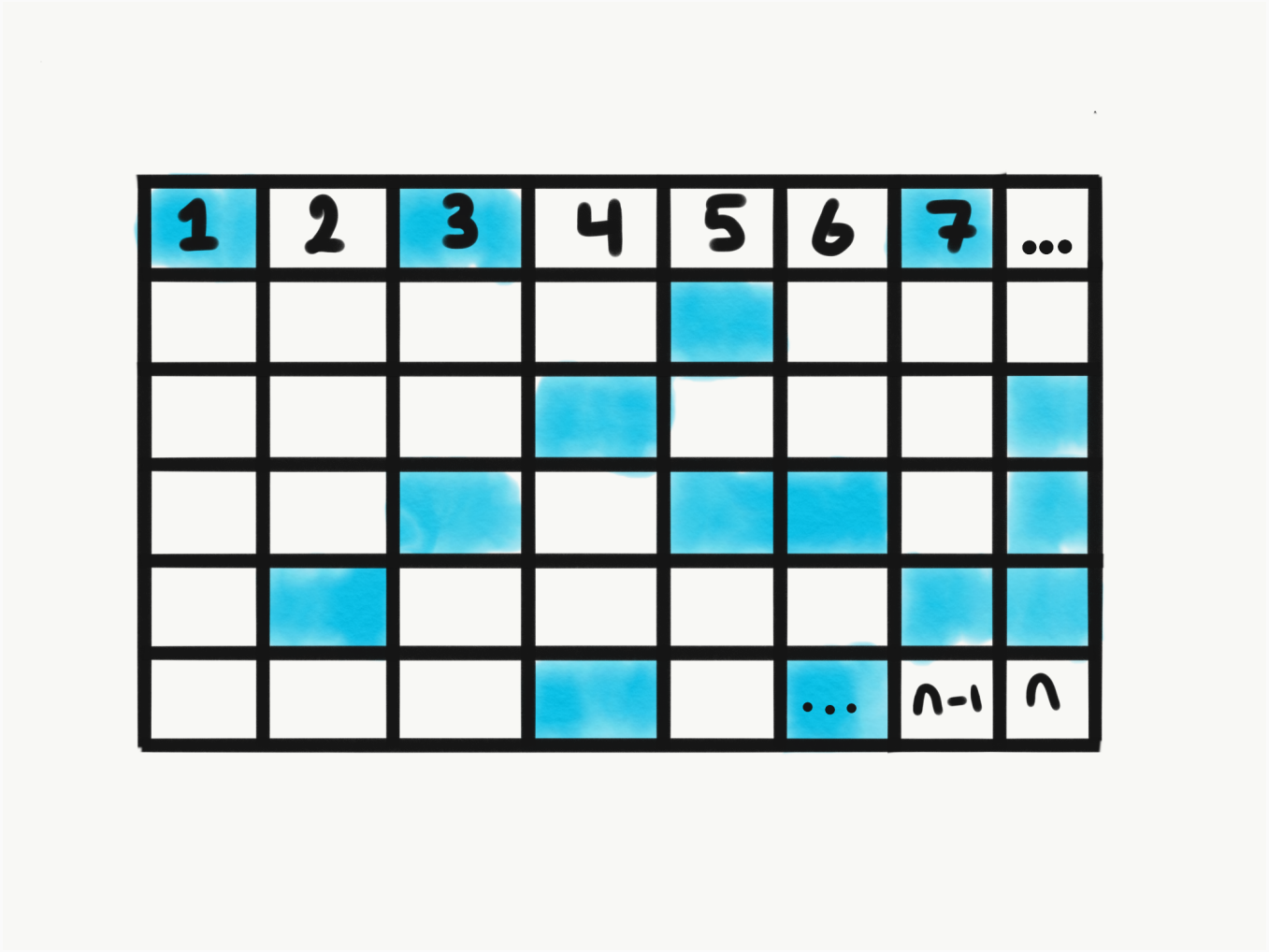


Figure 7: A graphical example of an initial state, which represents environmental conditions encountered by the genetic regulatory network.

Direct Plasticity: Initial State Perturbation

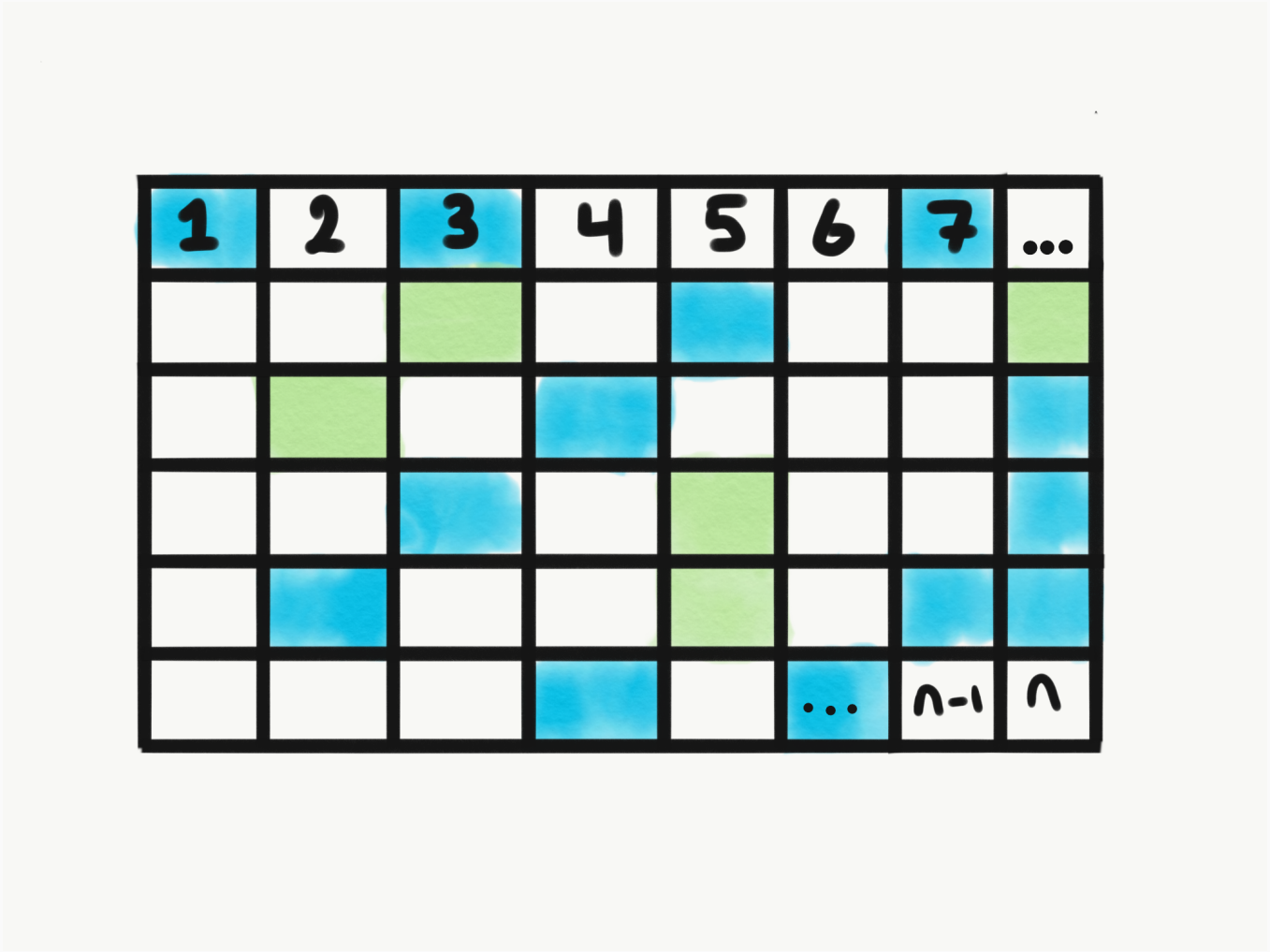


Figure 8: A graphical example of an initial state after random perturbation.

Direct Plasticity: Initial State Perturbation

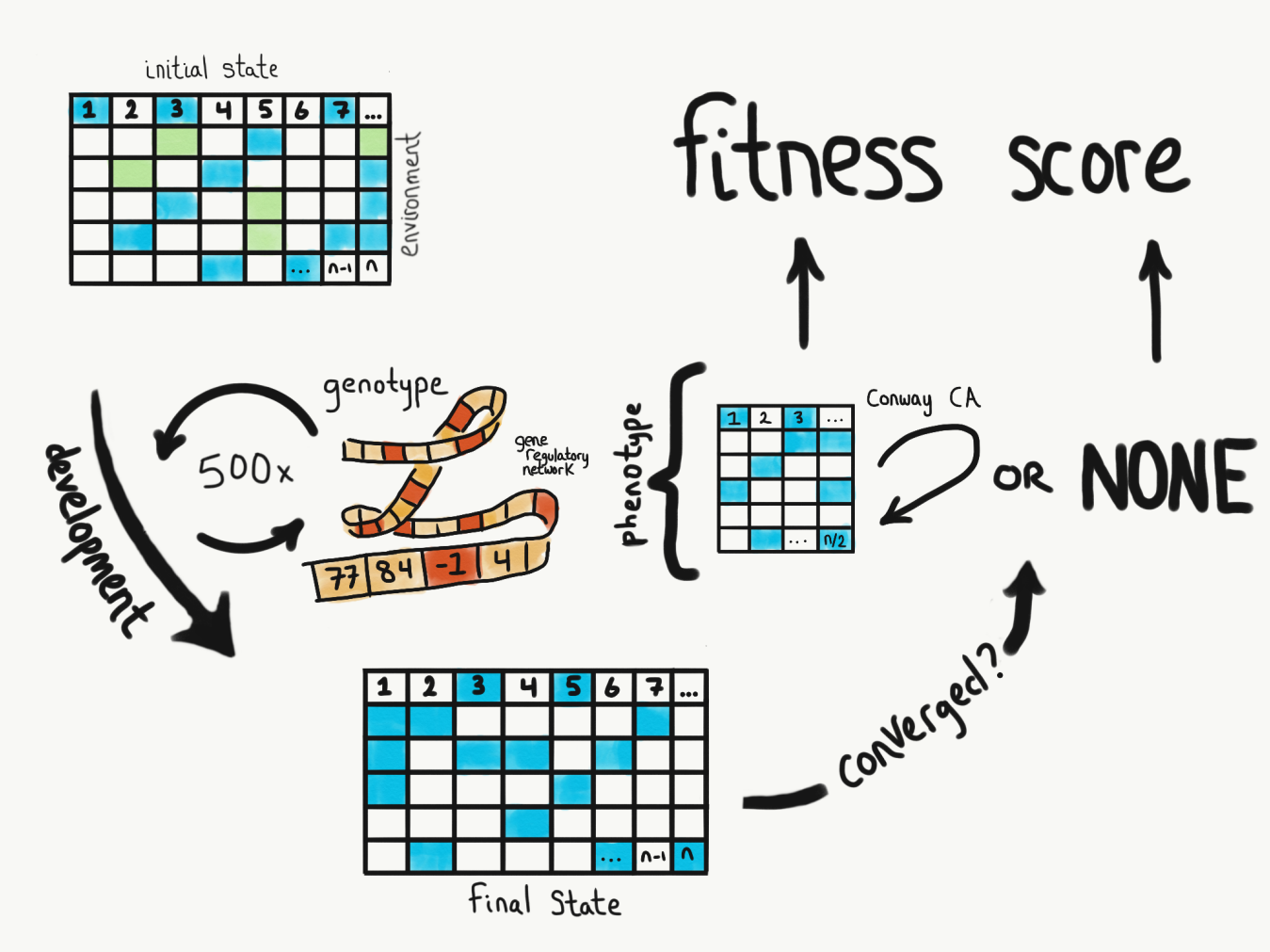


Figure 9: A cartoon overview of the development and assessment processes of the expanded model depicting perturbed initial conditions.

Preliminary Results

Evolvability Signature $P = 0$

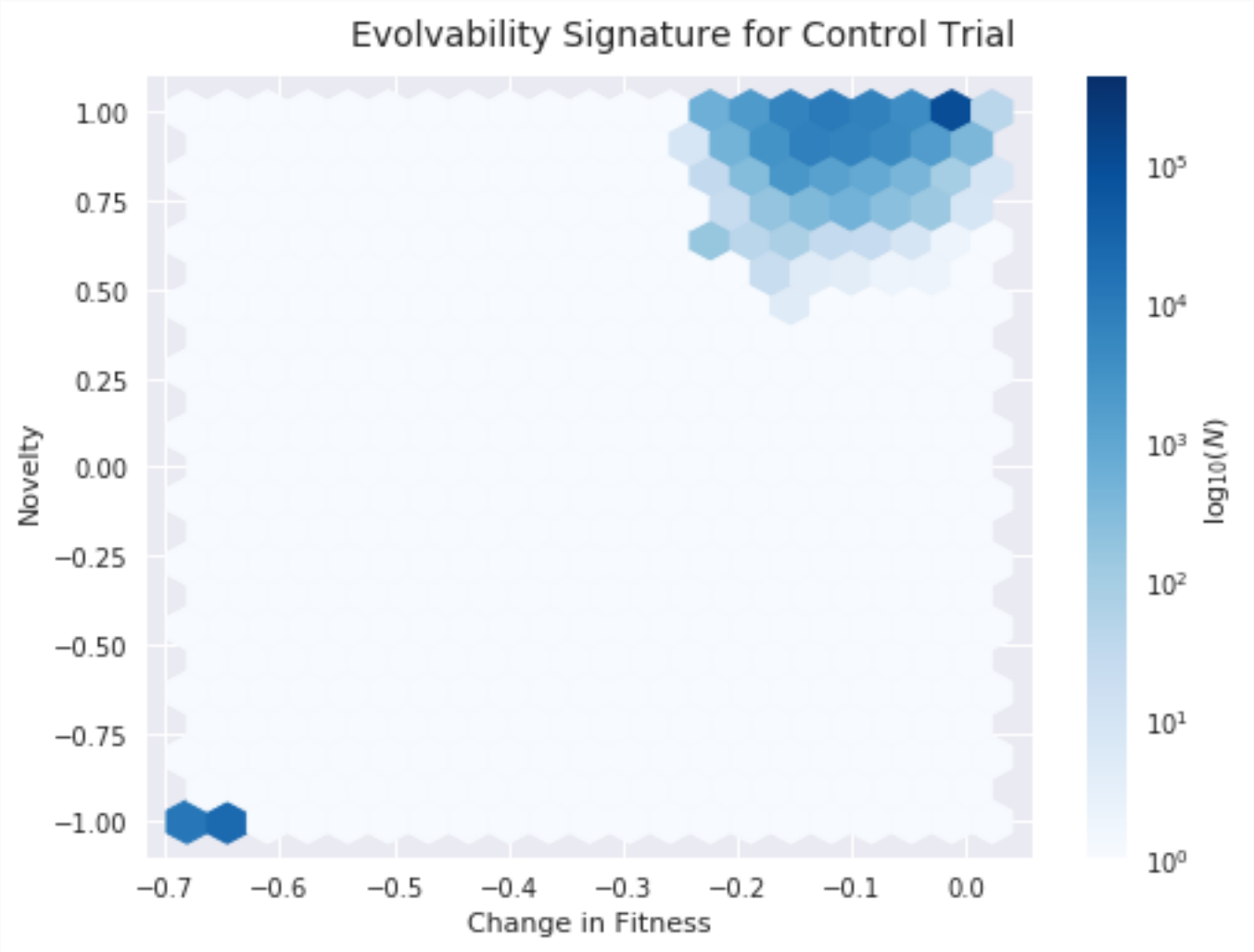


Figure 10: Evolvability signature of champion evolved with no initial plasticity. Figure after [Tarapore and Mouret, 2015].

Evolvability Signature $P = 0.1$

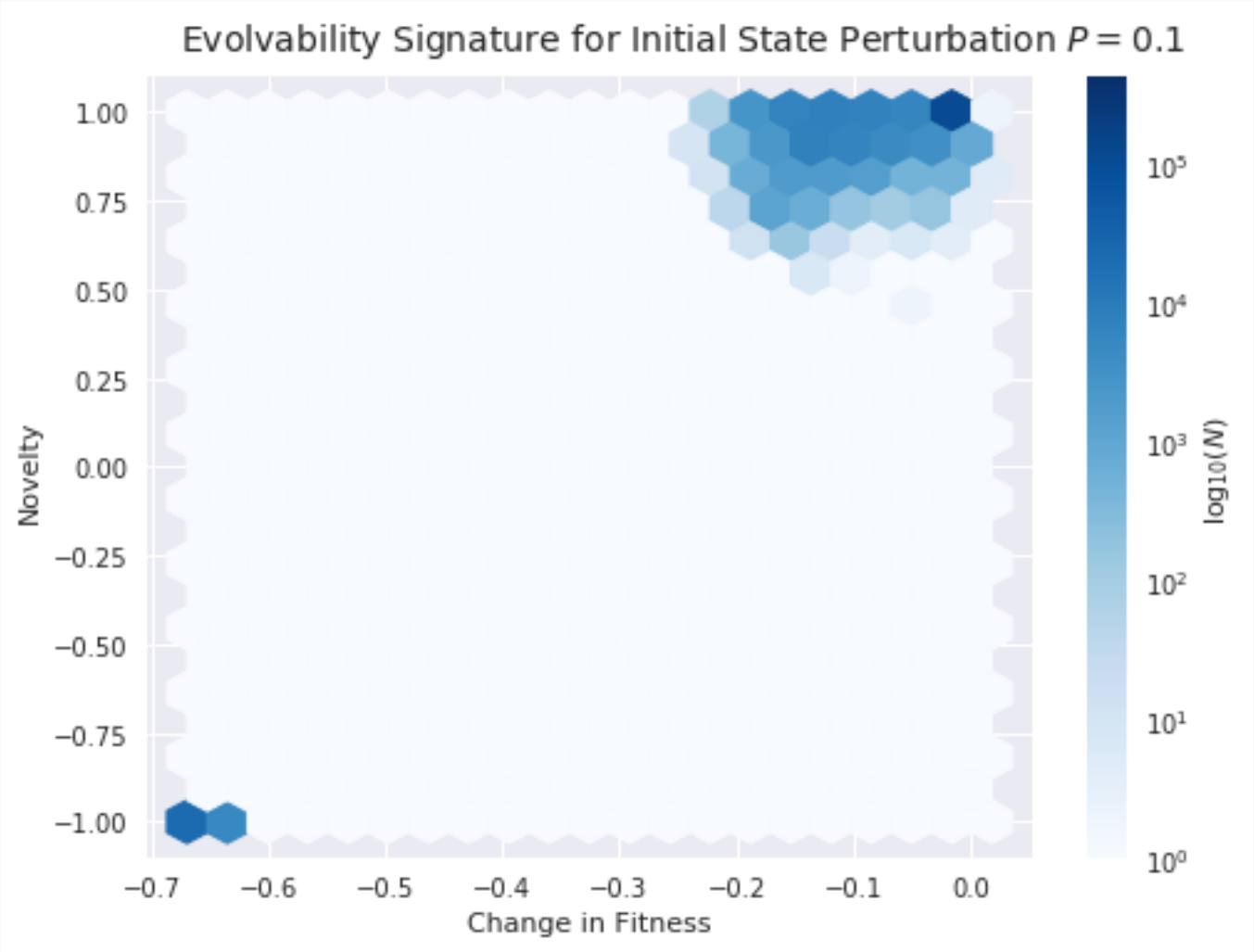


Figure 11: Evolvability signature of champion evolved with medium initial plasticity, $P = 0.1$. Figure after [Tarapore and Mouret, 2015].

Evolvability Signature $P = 0.2$

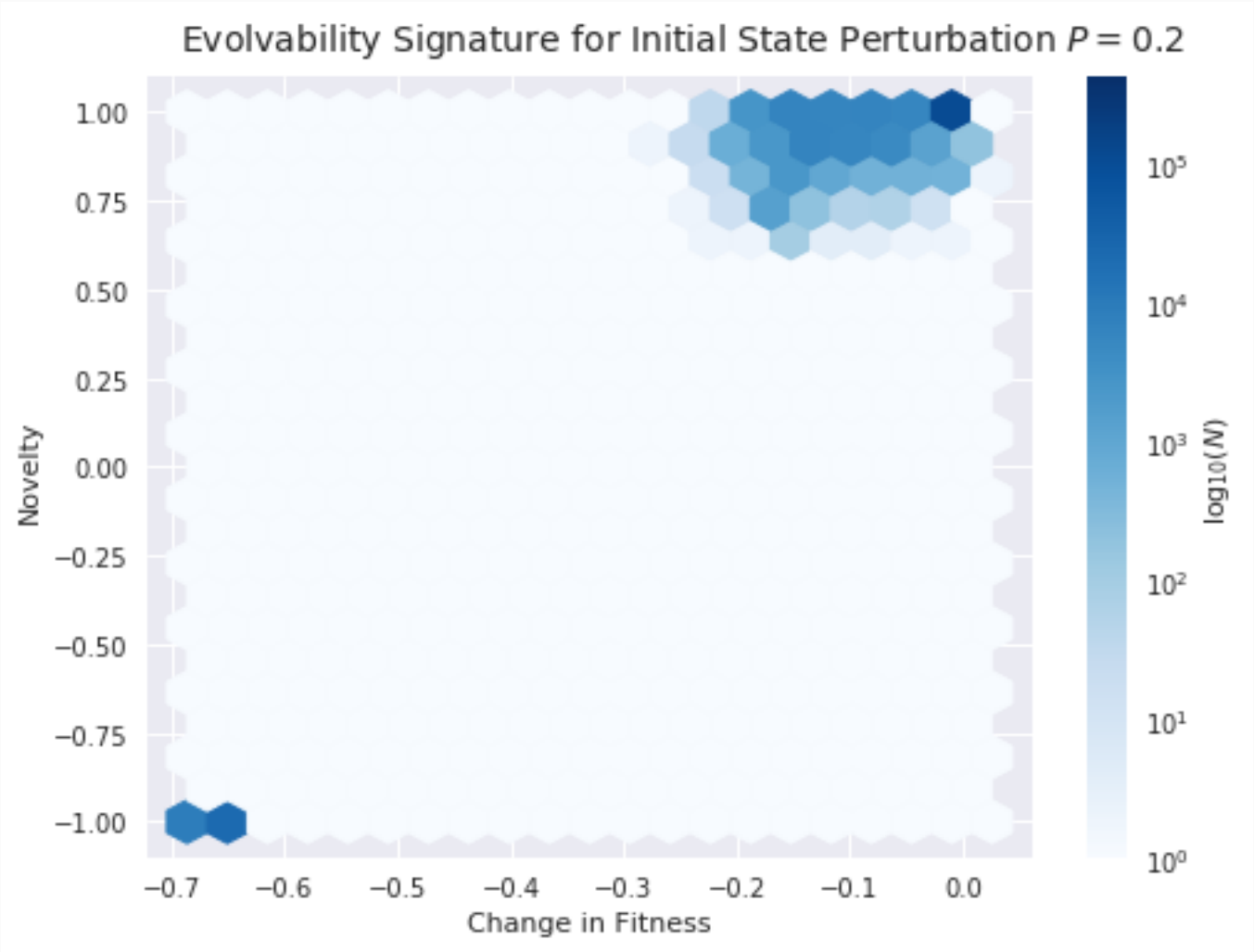


Figure 12: Evolvability signature of champion evolved with greater initial plasticity, $P = 0.2$. Figure after [Tarapore and Mouret, 2015].

Frequency of Silent Mutation

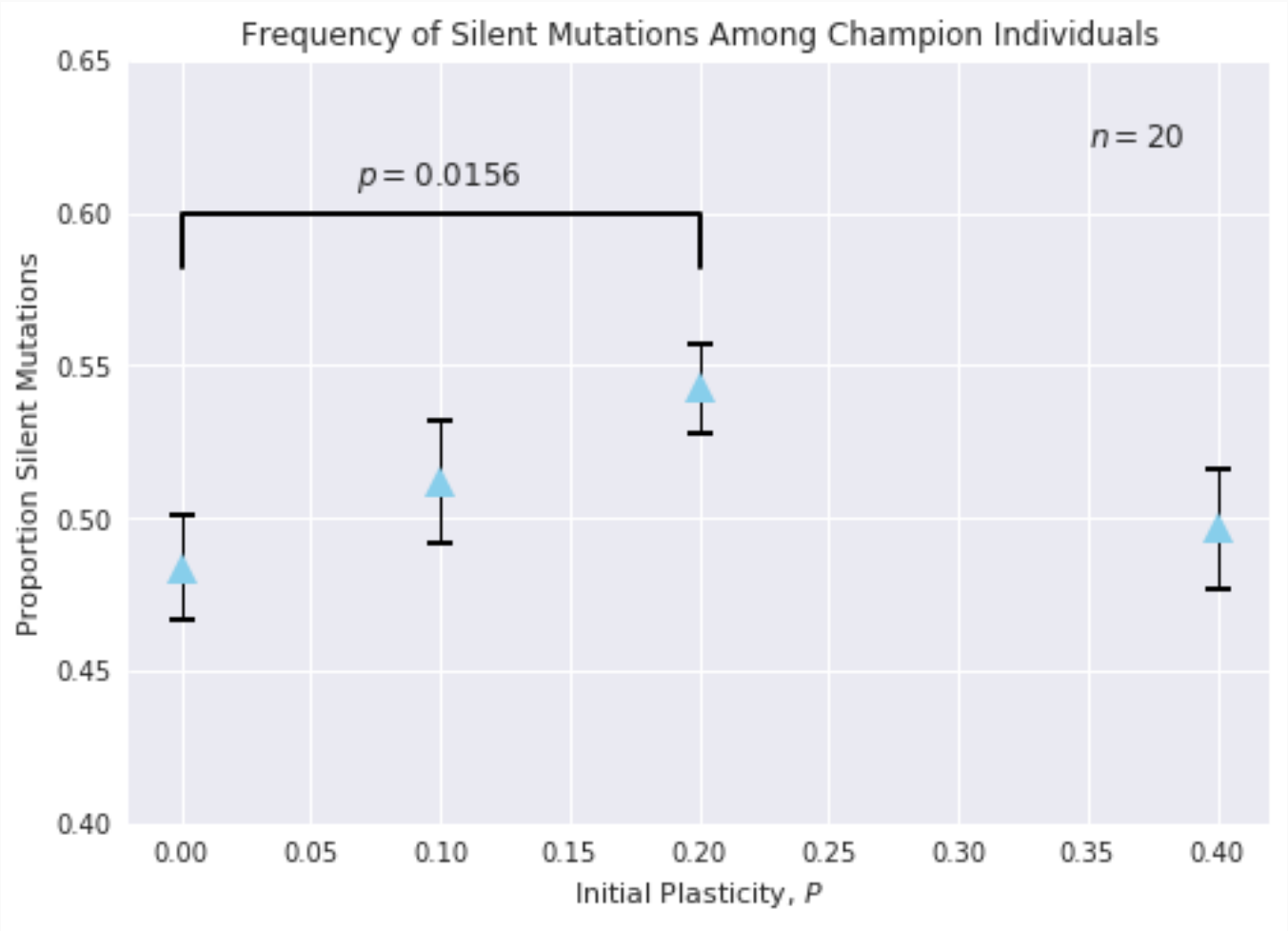


Figure 13: Frequency of silent mutation of champion individuals across initial plasticity conditions.

Preliminary Results: Summary

- as in [Reisinger et al., 2005], repeated evaluations ($n = 10$) were required to observe impact of direct plasticity
- direct plasticity increases robustness to mutation
- direct plasticity does not seem to promote canalization

Project Schedule

Experimental Questions

- how do genetic regulatory networks evolved with direct plasticity differ structurally from control networks? [Reisinger and Miikkulainen, 2007]
- impact of other modes of direct plasticity on evolvability (rule noise, fixed states, intermediate state perturbation)?
- impact of indirect plasticity on evolvability?
- combined impact of direct and indirect plasticity on evolvability?

Progress To Date

⋮

- **Week 5** – code and test second model (part III) ✓
- **Week 6** – run second model ✓
- **Week 7** – analyze data from second model ✓
- **Week 8** – further experimental tweaks and data collection ✓
- **Week 9** – spring break, complete data collection ✗

⋮

From Here Onwards (old plan)

⋮

- **Week 10**
  - *Wednesday March 22nd*: Honors thesis presentation
- **Week 11** prepare for departmental presentation, Complete data analysis
- **Week 12** thesis writing ☕☕☕
  - *Monday April 3rd*: Math/CS Department seminar
- **Week 13** more, and more frantic, thesis writing ☕☕☕☕☕
- **Week 14** prepare for Math/CS Day presentation, adapt thesis material for Capstone report
- **Week 15** prepare for Math/CS Day presentation, adapt thesis material for Capstone report
  - *Saturday April 29th*: Math/CS Day presentation

⋮

From Here Onwards (new plan)

⋮

- **Week 10** perform experiments with indirect plasticity
- **Week 11** perform experiments with indirect plasticity
- **Week 12** perform combined experiments with indirect and direct plasticity
- **Week 13** network structure analysis
  - *Monday April 10th*: Math/CS Department presentation
- **Week 14** prepare for Math/CS Day presentation, capstone writeup
- **Week 15** prepare for Math/CS Day presentation, capstone writeup
  - *Saturday April 29th*: Math/CS Day presentation

⋮

Questions?

References I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Intelligence emerging : adaptivity and search in evolving neural systems.
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