Outcome Frequencies in Repeated Collapse-Selection Dynamics

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Abstract

In a previous note, a minimal collapse-selection model was shown to produce definite measurement outcomes in a two-state system via convergence to fixed-point sectors. However, that construction did not address the emergence of outcome statistics across repeated measurements. In this note, we extend the model by considering an ensemble of initial configurations. Each trial evolves deterministically under the same collapse operator, but variation in initial conditions produces a distribution of outcomes. We show that outcome frequencies arise as a measure over the basins of attraction of the collapse dynamics, providing a minimal account of statistical behavior without introducing intrinsic randomness.

1 Introduction

In the previous note, collapse-selection dynamics were shown to produce definite outcomes in a two-state system through convergence to fixed-point sectors. While this captures the emergence of individual measurement outcomes, it does not address the statistical behavior observed in repeated measurements.

In standard quantum mechanics, repeated measurements yield outcome frequencies governed by probabilities. The aim of this note is to construct the simplest possible extension of the collapse-selection model that reproduces such statistical behavior.

We show that outcome frequencies arise naturally when collapse dynamics are applied across an ensemble of initial configurations, without introducing intrinsic stochasticity into the collapse operator itself.

2 Setup: Ensemble of Initial Configurations

We consider an ensemble of initial states:

$$\mathcal{E} = \{(w_0^{(k)}, w_1^{(k)})\}_{k=1}^{N} \tag{1}$$

Each configuration satisfies:

$$w_0^{(k)}, w_1^{(k)} \geq 0, \quad w_0^{(k)} + w_1^{(k)} = 1 \tag{2}$$

We interpret this ensemble as representing variation in the initial relational configuration across repeated trials.

3 Collapse Dynamics

We use the same collapse operator as in the previous note:

$$w_i' = \frac{w_i^{\gamma}}{w_0^{\gamma} + w_1^{\gamma}}, \quad \gamma > 1 \tag{3}$$

For each trial k, the configuration evolves as:

$$(w_0^{(k)}, w_1^{(k)}) \xrightarrow{\Phi} (1, 0) \quad \text{or} \quad (0, 1) \tag{4}$$

depending on which component is initially dominant.

4 Repeated Measurement Procedure

We define a repeated measurement process by applying the collapse operator independently to each element of the ensemble.

Let:

$$N_0 = \text{number of trials yielding } (1, 0) \tag{5}$$

$$N_1 = \text{number of trials yielding } (0, 1) \tag{6}$$

We define outcome frequencies:

$$f_0 = \frac{N_0}{N}, \quad f_1 = \frac{N_1}{N} \tag{7}$$

5 Emergence of Outcome Frequencies

5.1 Deterministic Dynamics per Trial

Each individual trial evolves deterministically under the collapse operator and converges to a fixed-point sector.

5.2 Statistical Behavior Across Ensemble

Across the ensemble, different initial configurations lead to different outcomes. The observed frequencies arise from the distribution of initial states.

5.3 Key Result

Outcome frequencies are determined by the measure of initial configurations within the basins of attraction of each fixed point:

$$f_0 \approx \int_{\mathcal{B}_0} \rho(w_0, w_1)\, d\Sigma \tag{8}$$

where $\mathcal{B}_0$ denotes the basin of attraction of the fixed point $(1, 0)$, and ρ is the distribution over initial configurations.

Here, ρ represents a distribution over initial relational configurations and is not assumed to arise from intrinsic stochasticity, but from variation in initial conditions across trials.

6 Relation to Standard Quantum Mechanics

In standard quantum mechanics, outcome probabilities are given by:

$$P(0) = |\alpha|^2, \quad P(1) = |\beta|^2 \tag{9}$$

In the present construction,f_0, f_1 are determined by the measure of initial configurations within the respective basins of attraction.

Thus, probability is interpreted as arising from the structure of initial relational configurations rather than intrinsic randomness.

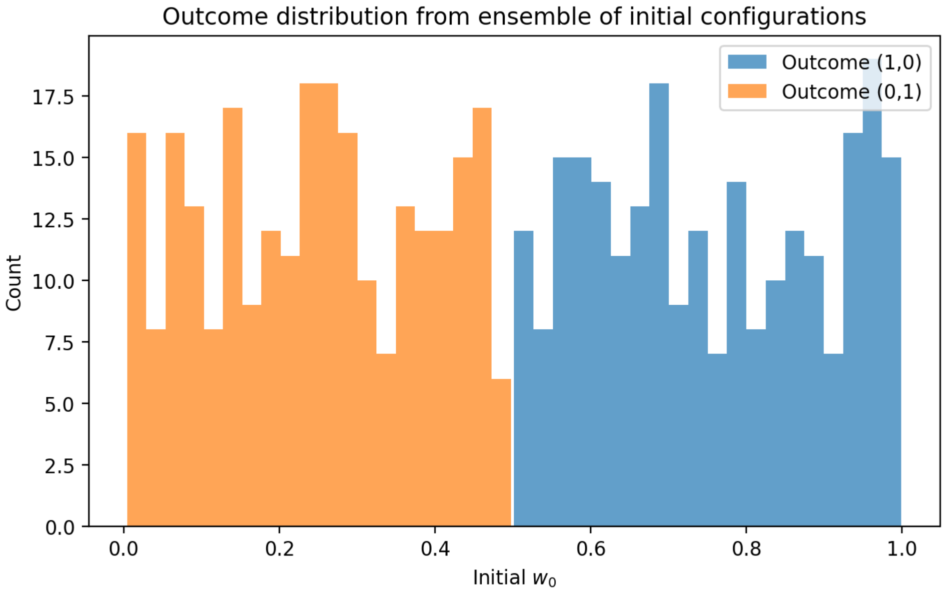

Figure 1: Outcome distribution from an ensemble of initial configurations. Each initial state (w_0, w_1) evolves deterministically under the collapse operator defined in Eq. (3). The histogram illustrates the partition of initial configurations into basins of attraction corresponding to the fixed-point sectors.. Outcome frequencies arise from the measure of initial configurations within each basin. The figure was generated by direct iteration of the collapse map over a uniformly sampled ensemble.

7 Interpretation

7.1 Determinism and Apparent Randomness

In this model:

- Collapse dynamics are deterministic.
- Apparent randomness arises from variation in initial configurations.

7.2 Measurement Reinterpreted

Measurement outcomes correspond to fixed-point sectors of collapse dynamics, while probabilities reflect the distribution of initial relational configurations across basins of attraction.

8 Limitations and Next Steps

This construction is minimal and does not yet provide:

- a derivation of the Born rule,
- a principled origin for the distribution ρ,
- a connection to environmental or dynamical sources of variation.

Future work will address:

- derivation of probability distributions from underlying dynamics,
- extension to multi-state systems,
- connections to decoherence and environment-induced selection.

9 Conclusion

We have shown that outcome frequencies can arise from deterministic collapse-selection dynamics when applied across an ensemble of initial configurations. This provides a minimal account of statistical behavior in measurement without introducing intrinsic stochasticity, and establishes a foundation for further exploration of probability within collapse-based frameworks.