Conditions for Born-Like Scaling in Collapse-Selection Dynamics

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Abstract

Previous notes have shown that collapse-selection dynamics can produce definite outcomes in a two-state system and that outcome frequencies arise from an ensemble of initial configurations. However, these constructions do not specify why observed frequencies should follow the Born rule. In this note, we introduce symmetry and consistency constraints on the ensemble of initial configurations and show that these conditions select a weighting consistent with Born-like scaling. This provides a minimal pathway by which standard quantum probabilities may emerge from collapse-selection dynamics without introducing intrinsic stochasticity.

1 Introduction

In previous notes, collapse-selection dynamics were shown to produce definite outcomes through convergence to fixed-point sectors, and outcome frequencies were shown to arise from repeated application of collapse across an ensemble of initial configurations.

While this provides a minimal account of measurement and statistical behavior, it does not explain why observed frequencies should follow the Born rule:

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

The aim of this note is to identify conditions under which Born-like scaling emerges within the collapse-selection framework.

2 Ensemble Representation

We consider a distribution over initial configurations:

$$\rho(w_0, w_1) \tag{2}$$

defined on the state space:

$$\Sigma = \{(w_0, w_1)\}, \quad w_0, w_1 \geq 0, \quad w_0 + w_1 = 1 \tag{3}$$

As in the previous note, collapse dynamics partition this space into basins of attraction:

$$\mathcal{B}_0 = \{(w_0, w_1) \mid \Phi \to (1, 0)\} \tag{4}$$

$$\mathcal{B}_1 = \{(w_0, w_1) \mid \Phi \to (0, 1)\} \tag{5}$$

Outcome frequencies are then given by:

$$f_0 = \int_{\mathcal{B}_0} \rho(w_0, w_1)\, d\Sigma, \quad f_1 = \int_{\mathcal{B}_1} \rho(w_0, w_1)\, d\Sigma \tag{6}$$

The form of ρ is not assumed a priori, but is subject to the structural constraints introduced below.

3 Symmetry and Consistency Constraints

These constraints are motivated by the requirement that outcome weighting be invariant under relabeling, consistent under aggregation, and independent of arbitrary parameterization.

We now introduce constraints on the ensemble distribution ρ.

3.1 Label Symmetry

The distribution should be invariant under relabeling of outcomes:

$$\rho(w_0, w_1) = \rho(w_1, w_0) \tag{7}$$

This ensures no intrinsic bias between outcomes.

3.2 Coarse-Graining Consistency

If two configurations are grouped into a single effective outcome, the resulting weighting should be consistent with the original distribution. This imposes constraints on how probability weights combine under aggregation.

3.3 Scale Invariance

The weighting of outcomes should depend only on relative proportions, not on arbitrary parameterization. This implies that the relevant measure depends on ratios of weights.

4 Consequence: Born-Like Scaling

Under these constraints, the outcome frequencies are constrained to take a form proportional to the initial weights::

$$f_0 \propto w_0, \quad f_1 \propto w_1 \tag{8}$$

Normalizing under the constraint $f_0 + f_1 = 1$, we obtain:

$$f_0 = w_0, \quad f_1 = w_1 \tag{9}$$

We identify the initial configuration weights with squared amplitudes in the standard quantum representation:

$$w_0 = |\alpha|^2, \quad w_1 = |\beta|^2 \tag{10}$$

we obtain:

$$f_0 = |\alpha|^2, \quad f_1 = |\beta|^2 \tag{11}$$

This matches the Born rule.

This does not constitute a derivation of the Born rule, but rather identifies a class of constraints under which Born-like scaling is selected.

5 Interpretation

In this construction:

- Collapse dynamics remain deterministic.
- Outcome frequencies arise from the measure of initial configurations.
- Born-like scaling reflects structural constraints on admissible ensemble distributions under collapse-selection dynamics.

Thus, probability is not introduced as a primitive stochastic element, but emerges from the combination of collapse dynamics and symmetry constraints.

6 Limitations and Open Questions

This construction does not yet constitute a full derivation of the Born rule. In particular:

- The origin of the distribution ρ is not specified.
- The symmetry and consistency constraints are introduced rather than derived.
- Extension to continuous systems and higher-dimensional state spaces remains to be addressed.

Future work will investigate whether these constraints arise naturally from deeper properties of collapse-selection dynamics.

7 Conclusion

We have shown that Born-like probability scaling emerges under symmetry and consistency constraints on the ensemble of initial configurations within a collapse-selection framework. This provides a minimal pathway toward understanding quantum probabilities as arising from structural properties of the state space rather than intrinsic randomness.