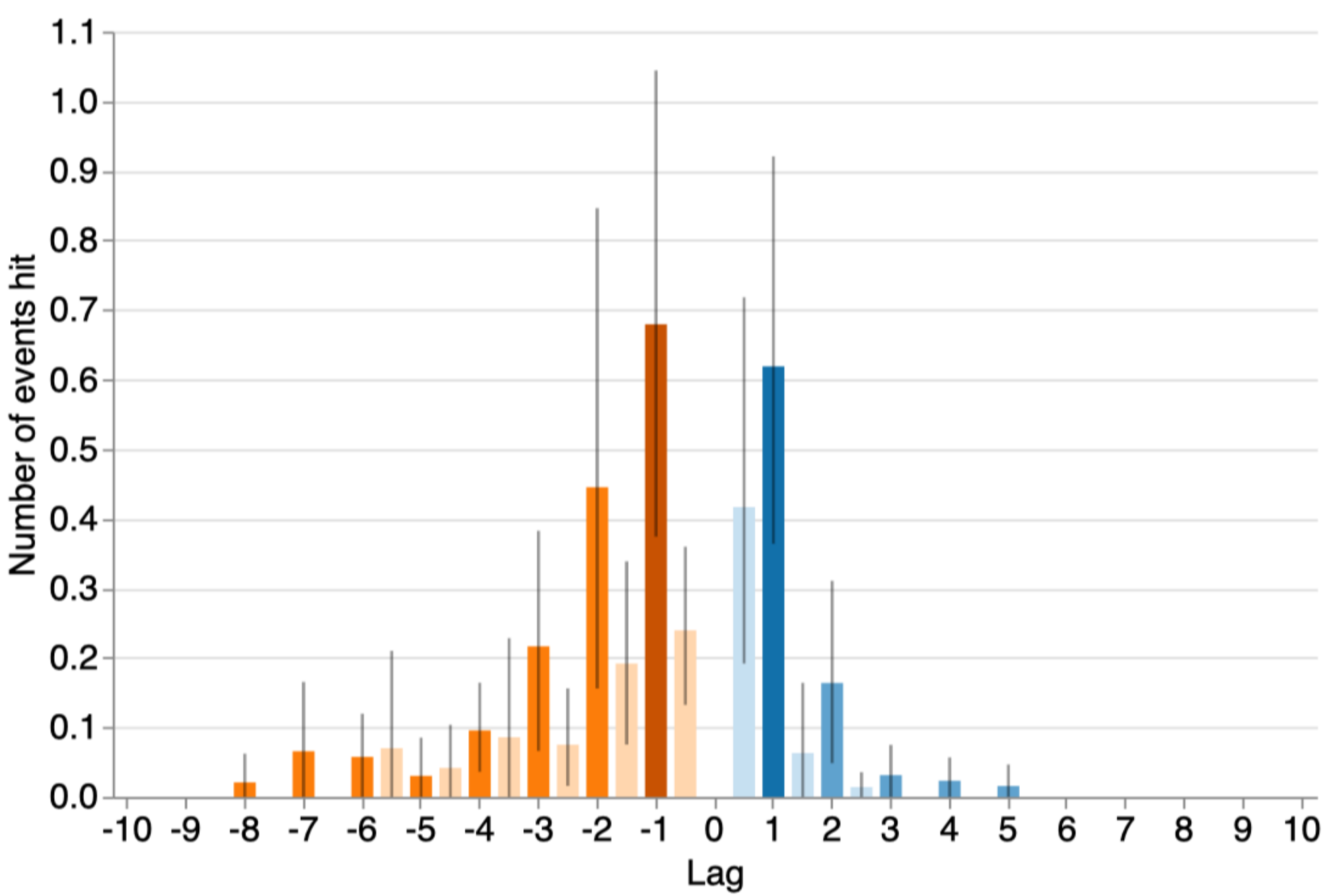


## Background

How much can we know about the past or future given observation of the present?

- Symmetry in (inferring) Markov sequences<sup>1,2</sup>
- Asymmetry in inferring naturalistic sequences<sup>3</sup> (figure below)



Participants are better able to infer unobserved past events (negative lags) than unobserved future events (positive lags)<sup>3</sup>.

- Here, we use simulations to explore the origin of this asymmetry, through the lens of the second law of thermodynamics (entropy can only increase)
- Here, entropy is defined as the number of microstates that are compatible with a given macrostate
- If we assume that the present arose from a low-entropy past state, this implies that the past is more “constrained” than the future (the past hypothesis)

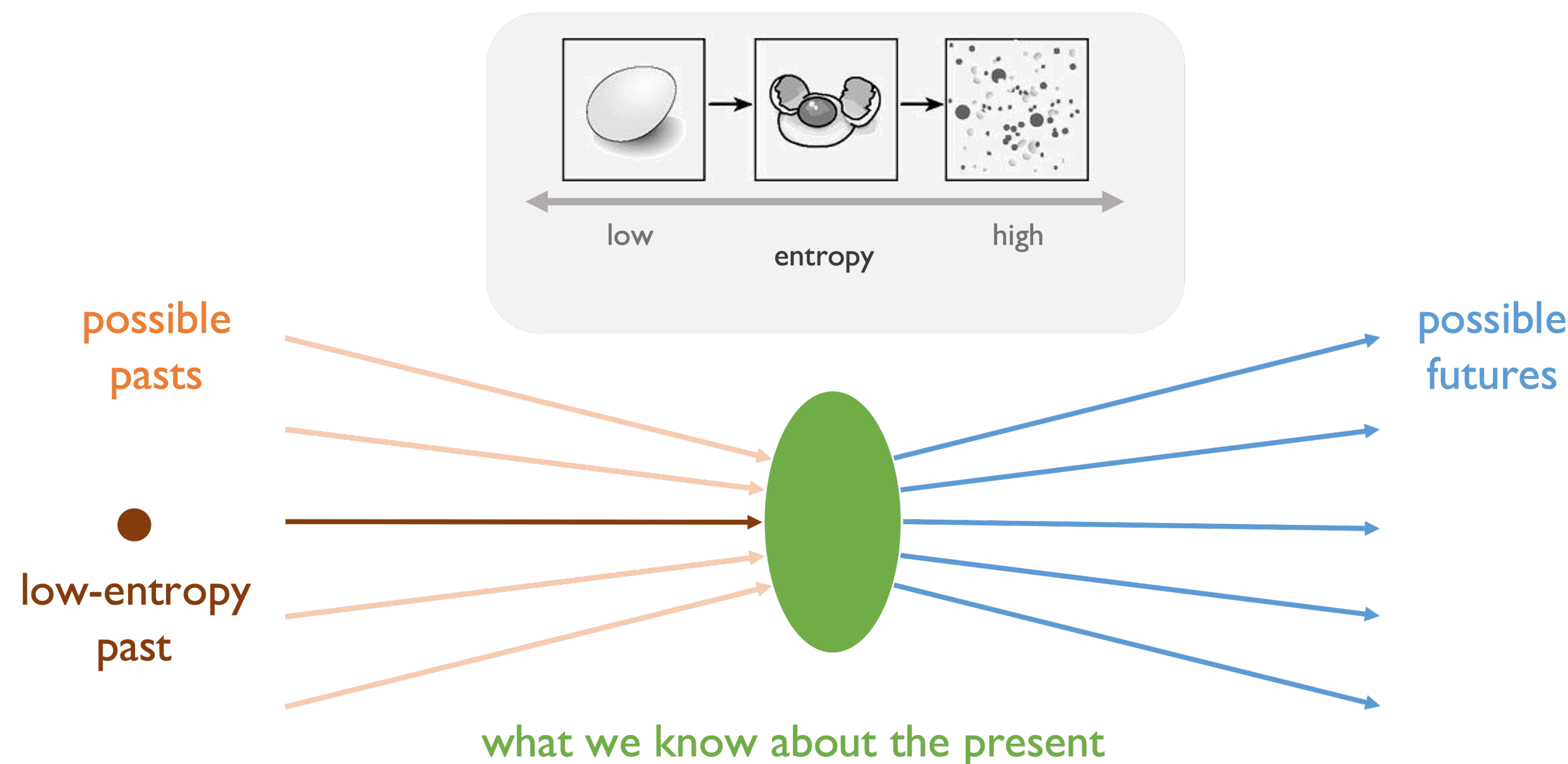
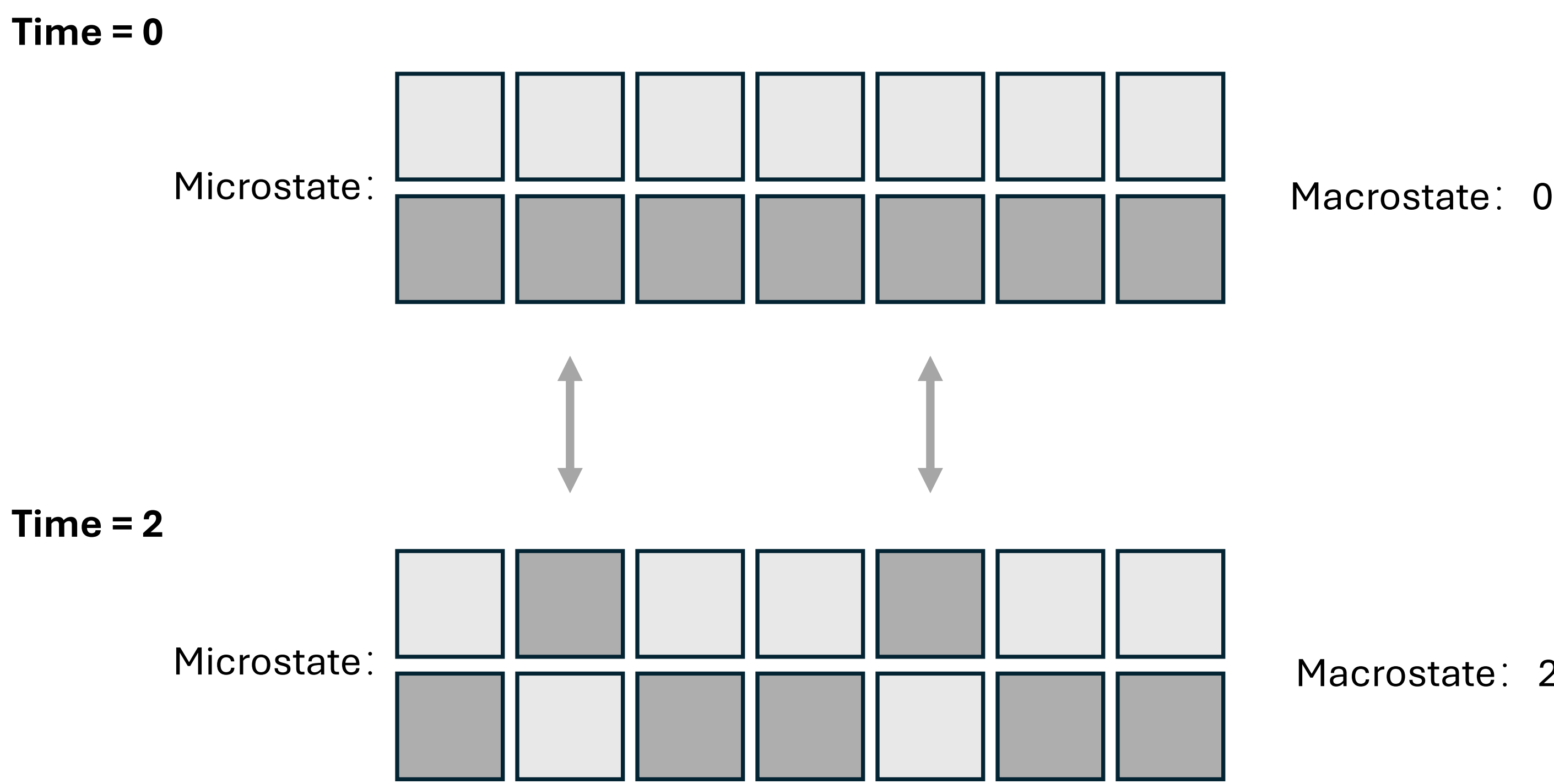


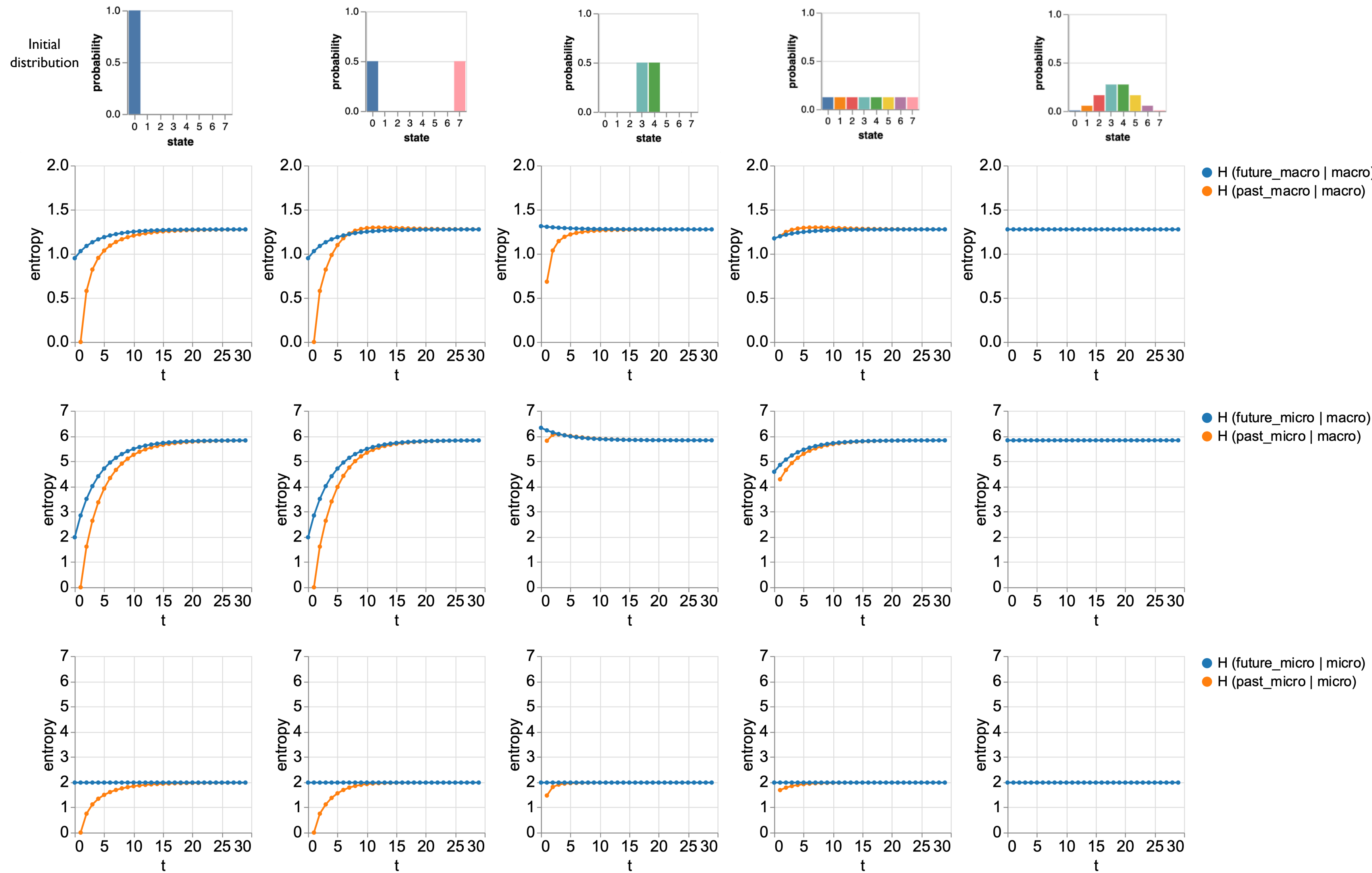
Figure adapted from <sup>4</sup>

## Approach

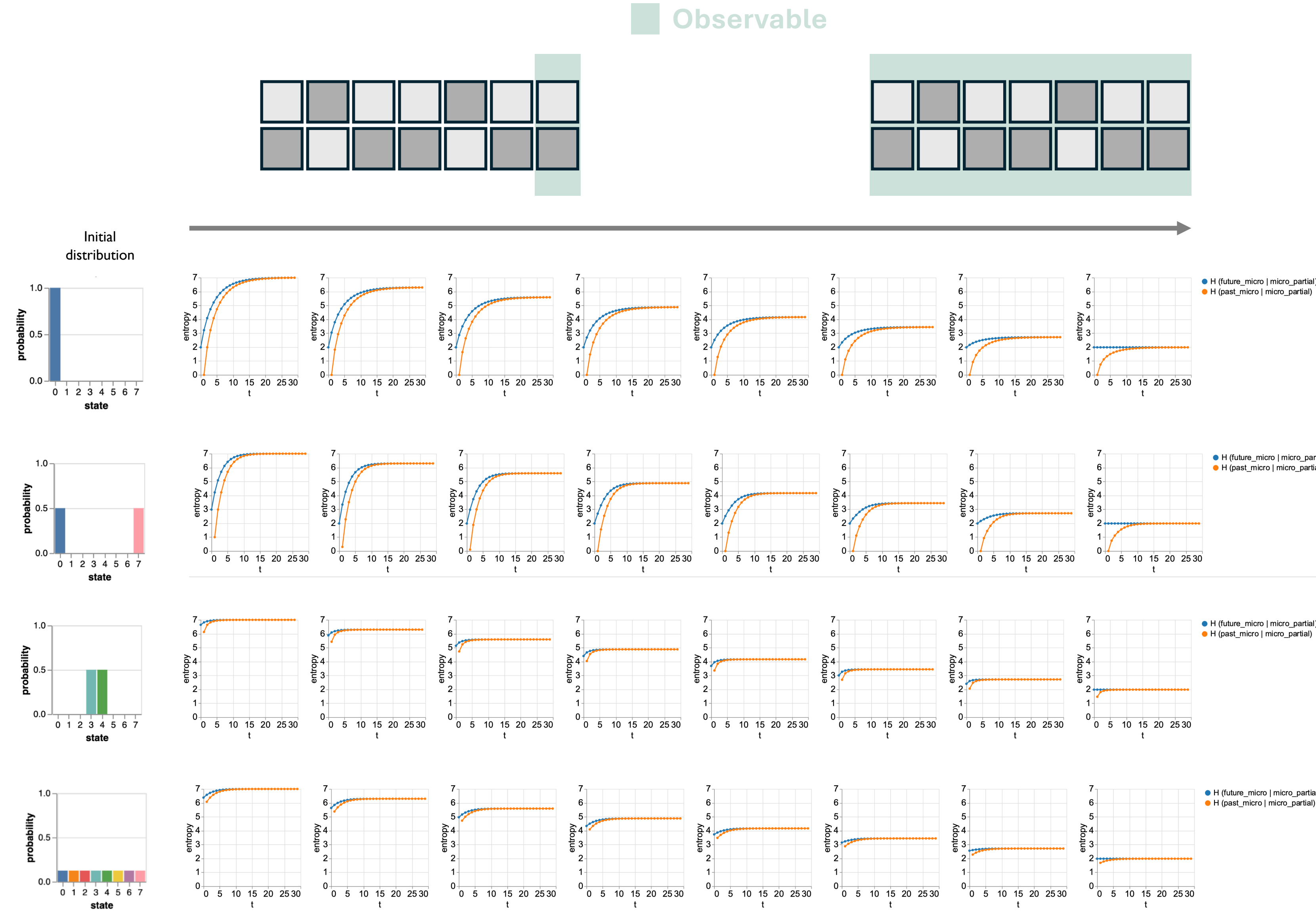


We start with seven “molecules” of each of two types, represented by light and dark squares. In each time step we “mix” the system by vertically exchanging two randomly chosen molecules. We then test the conditional entropy of past/future macro/microstate given the current macro/microstate over time, under different initial states.

## Results



We observe an asymmetry (before the system reaches equilibrium) such that there is less uncertainty about the past state than the future state.



The asymmetry preserves when assuming the current microstate was partially observable.

## Next steps

- Test if people hold the belief that there is a low-entropy initial state
- Relate to the dynamics of real-life events
- Probe the potential relation between the thermodynamic arrow of time and the psychological arrow of time. Do we remember the time direction where entropy is lower (e.g., <sup>5</sup>)?

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