

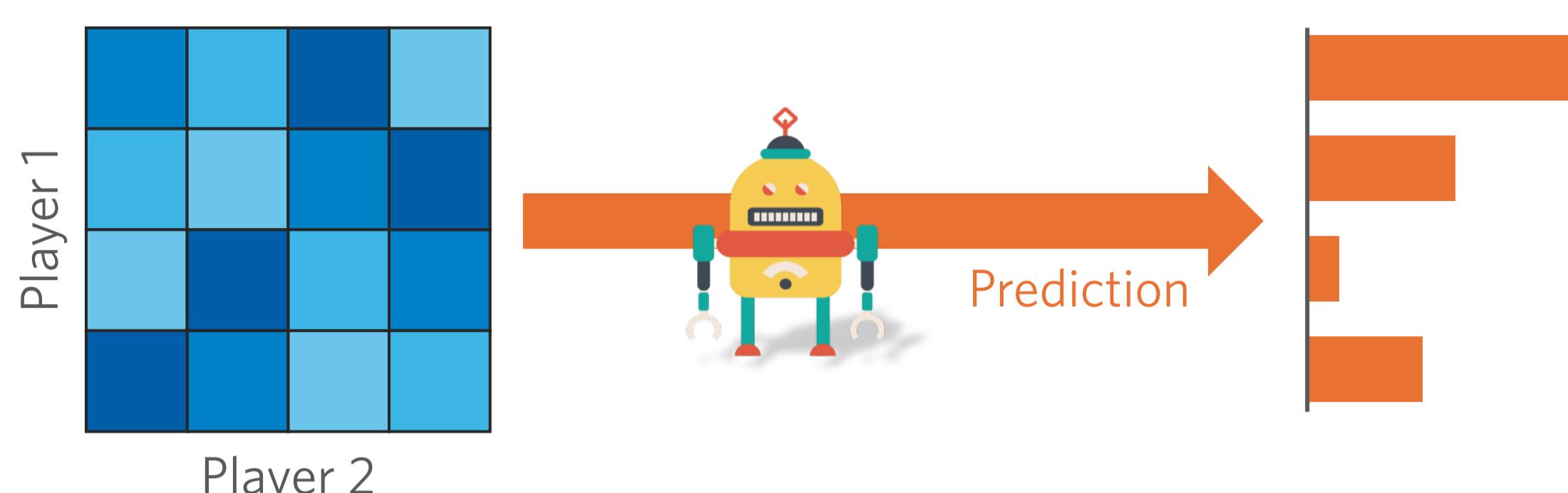
ElementaryNet: A Non-Strategic Neural Network for Predicting Human Behavior in Normal-Form Games

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Behavioral Game Theory

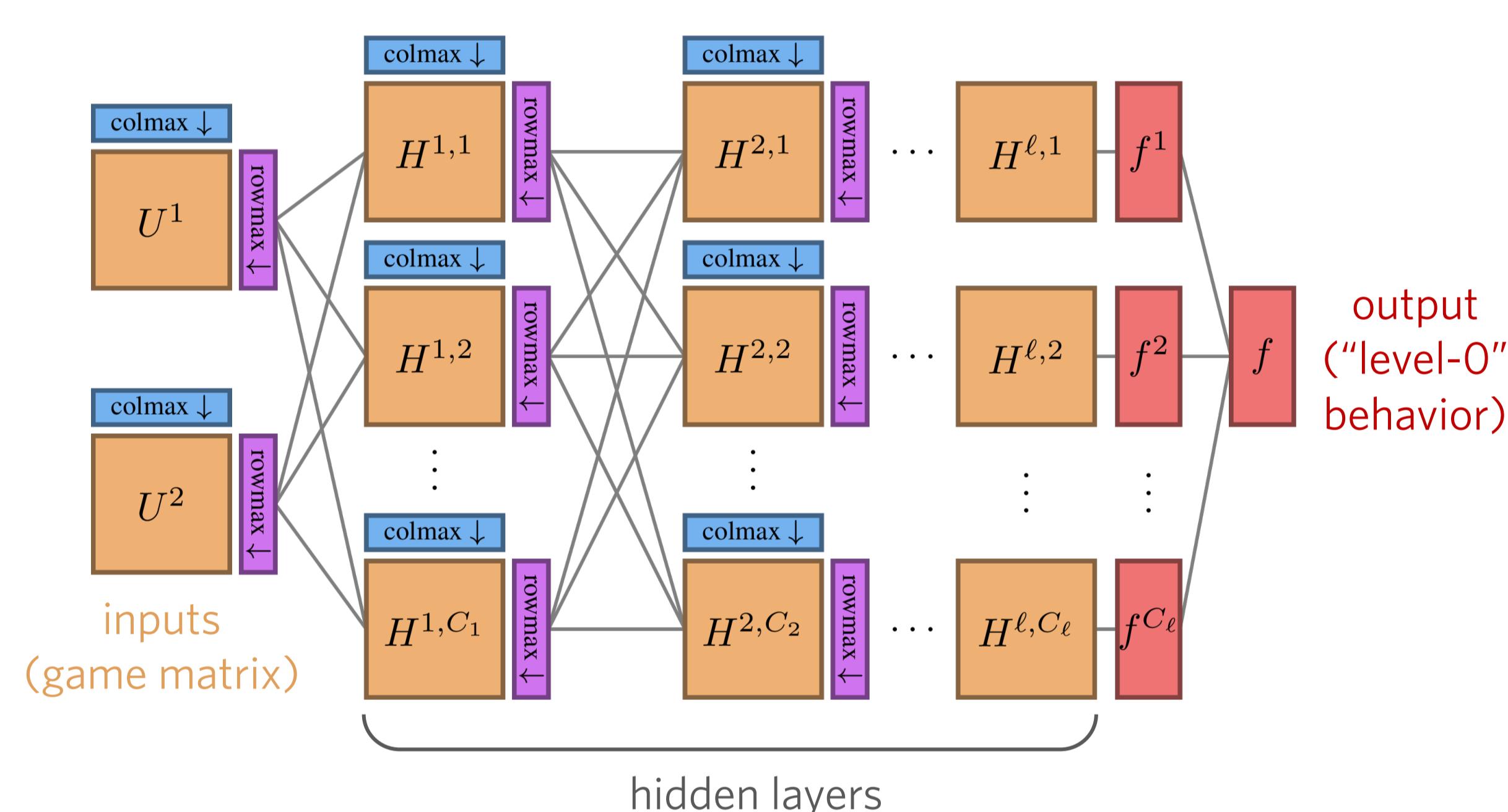
Behavioral game theorists develop models that predict the **distribution of human play** in arbitrary normal-form games



Some models aim to trade off performance with simplicity:
e.g., Poisson quantal cognitive hierarchy (QCHp)
(Camerer et al., 2004)

- "Level-0": uniform random (non-strategic)
- "Level- k ": quantal best response to lower levels (strategic)
- Good performance \Rightarrow insights about **human cognition**

Other models aim purely for performance:
e.g., GameNet uses a **neural network** to model "level-0" play
(Hartford et al., 2016)

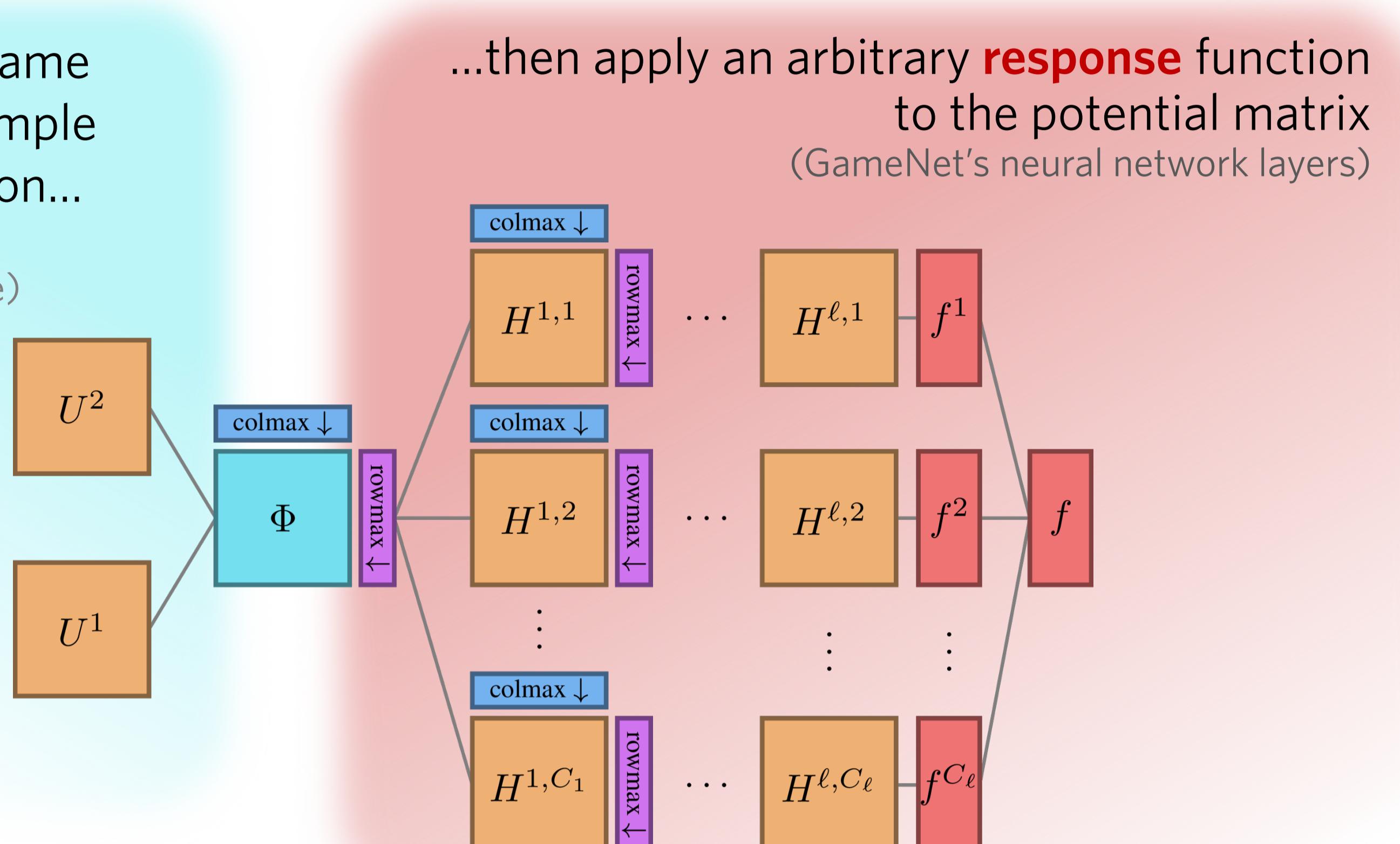


Surprising result: GameNet performs best when it has **no strategic reasoning model**!

- Is iterative reasoning a **bad model** after all?
- Or, is GameNet's neural network so flexible that it can **emulate strategic reasoning**?

We introduce a new architecture based on **elementary models**, a family of models which are provably incapable of representing strategic behavior
(Wright and Leyton-Brown, 2022)

Compress the game matrix with a simple **potential** function...
(a linear function, applied elementwise)

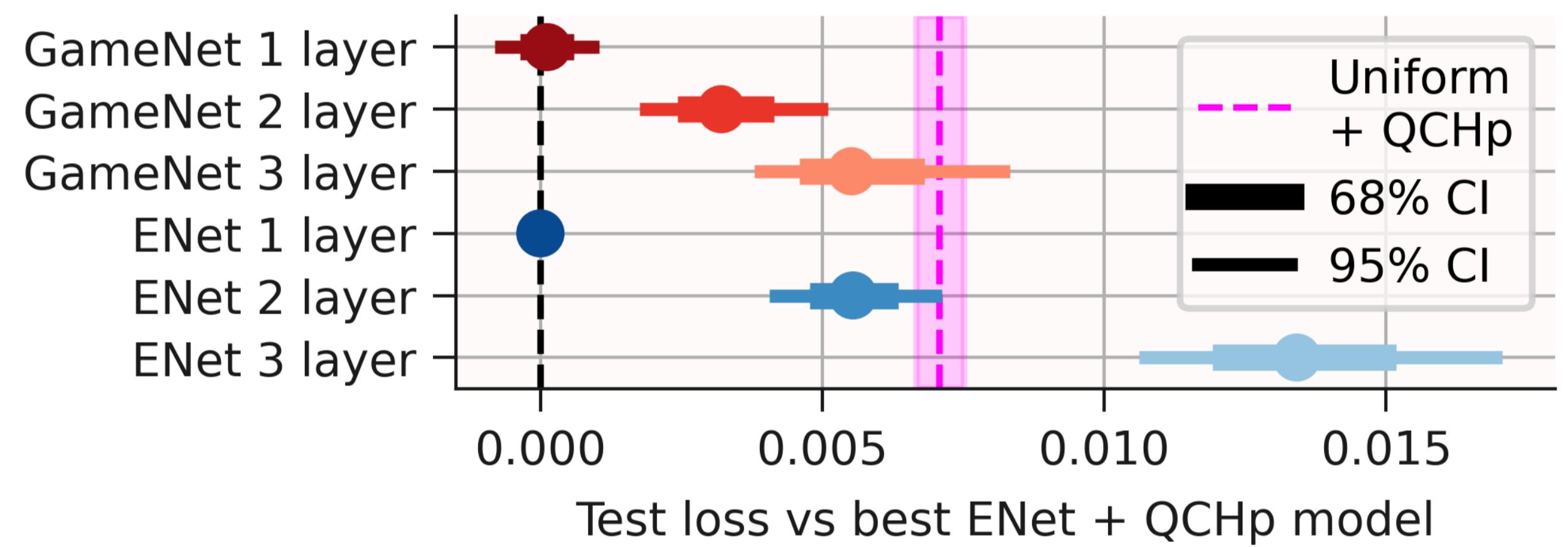


Theorem. ElementaryNet is non-strategic.

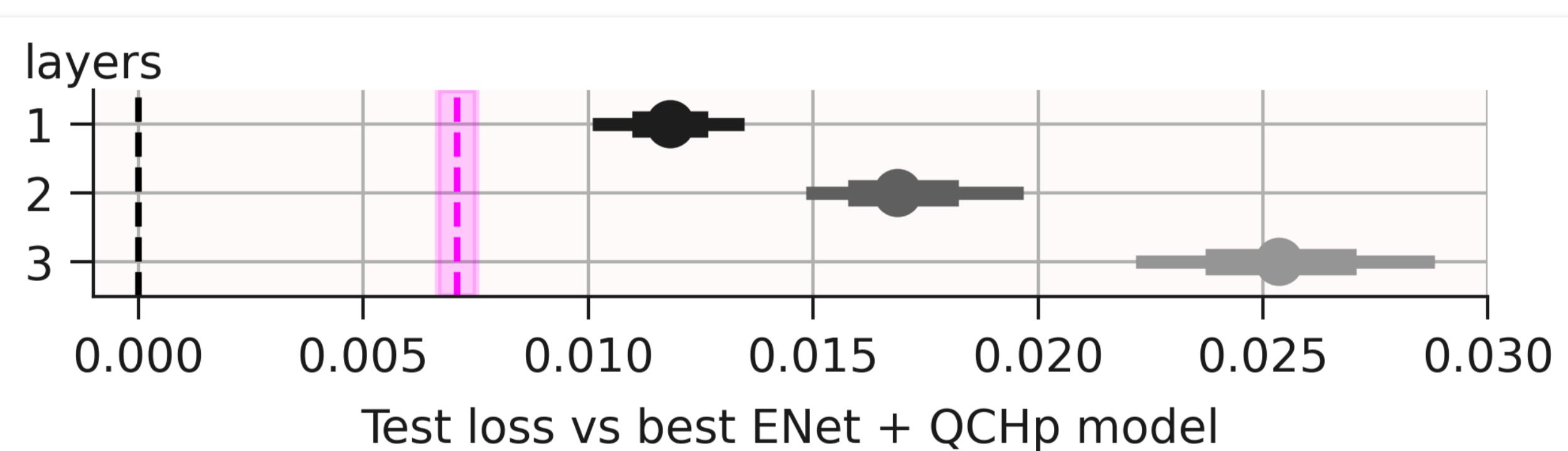
Intuitively, the potential function adds a bottleneck that makes it impossible to **both form and respond** to a belief, regardless of the flexible response function

Empirical Results

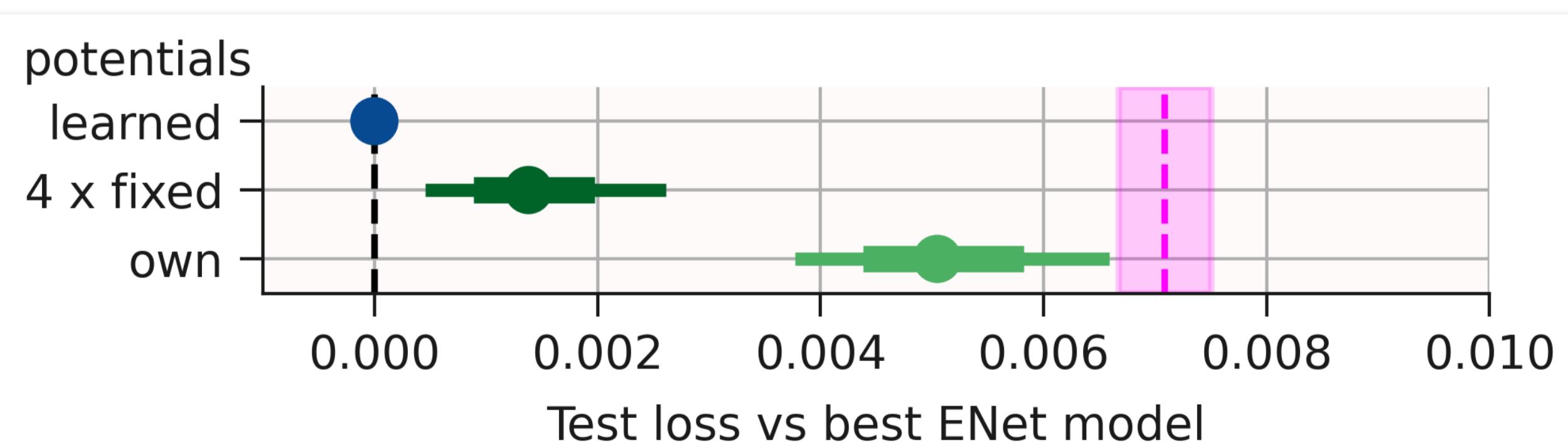
As level-0 models for QCHp, **GameNet** and **ElementaryNet** have identical performance (but both are much better than a **uniform** level-0 model)



Purely **non-strategic models** (ElementaryNet without a QCH strategic model) perform poorly

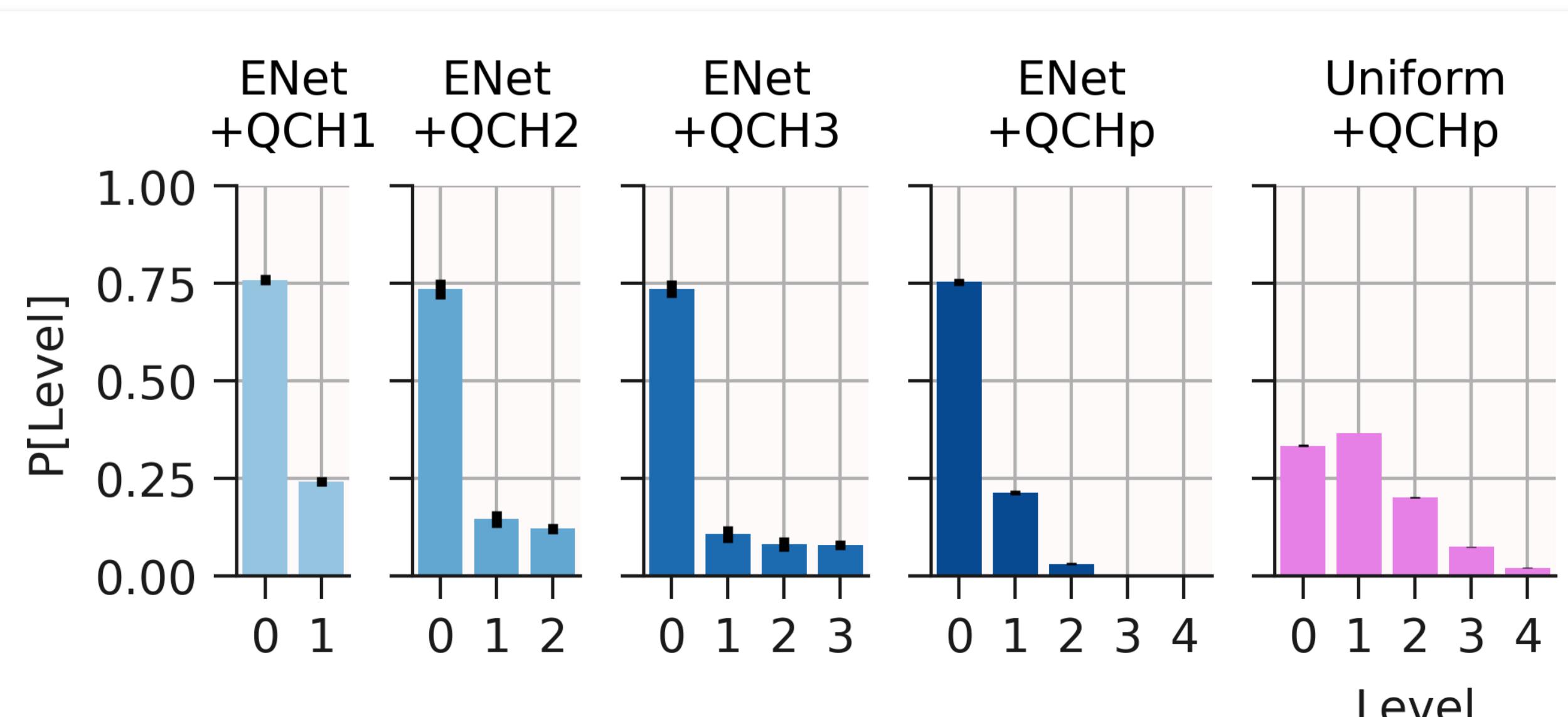


Flexible potentials are necessary for good performance:
fixed potentials from past heuristic models perform poorly



With **ElementaryNet** as the level-0 model, 75% of behavior is modelled as non-strategic!

Contrasts sharply with 35% when using the **uniform** level-0 model



The proof is constructive: we describe a specific 3-layer network that does so

Paper



Code

