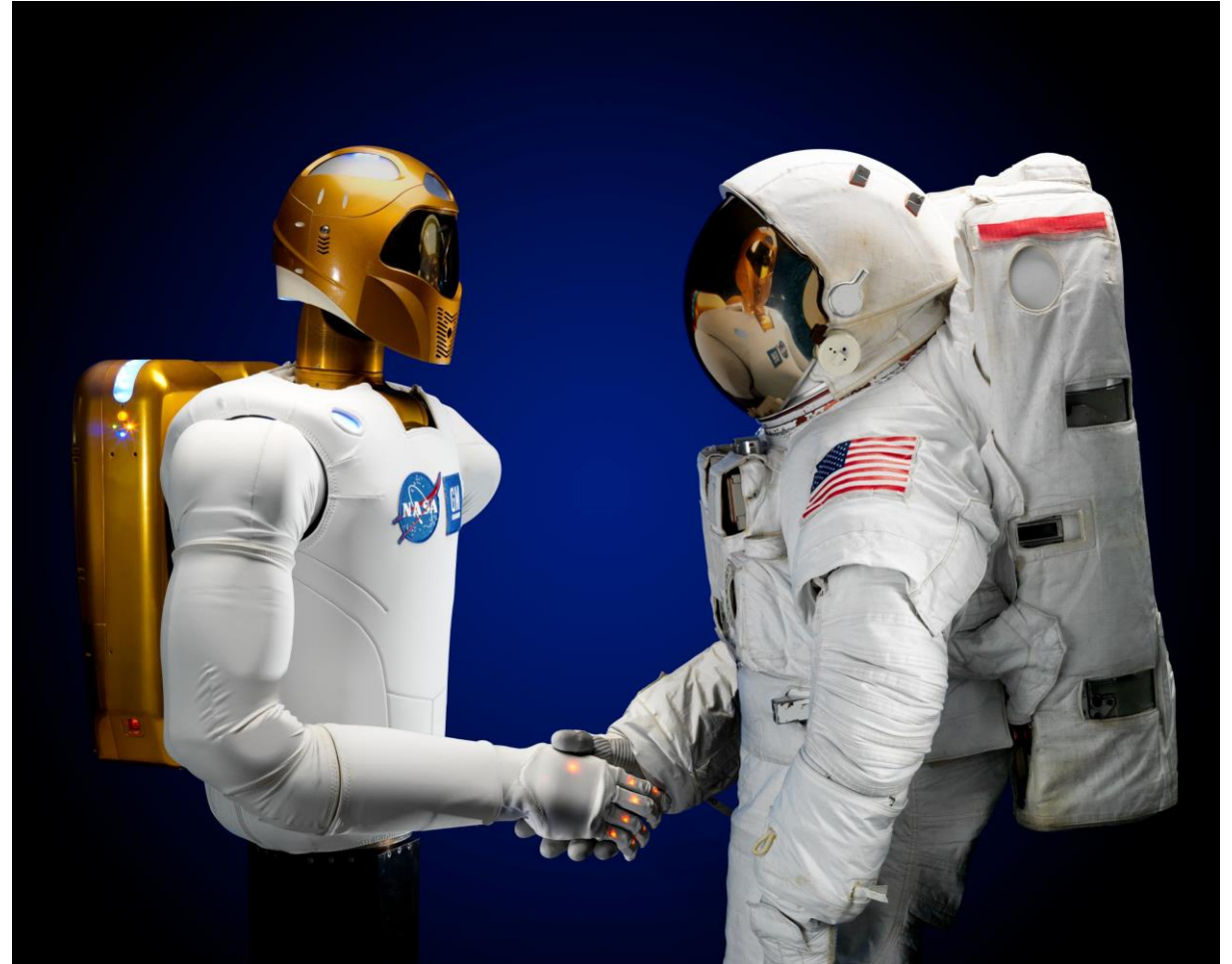# On the Impossibility of Learning to Cooperate with Adaptive Partner Strategies in Repeated Games

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Ad-Hoc Cooperation

- Learn to cooperate with an *unknown* partner

- Apply reinforcement learning if their strategy is stationary

- What should we do when our partner is *adaptive*?
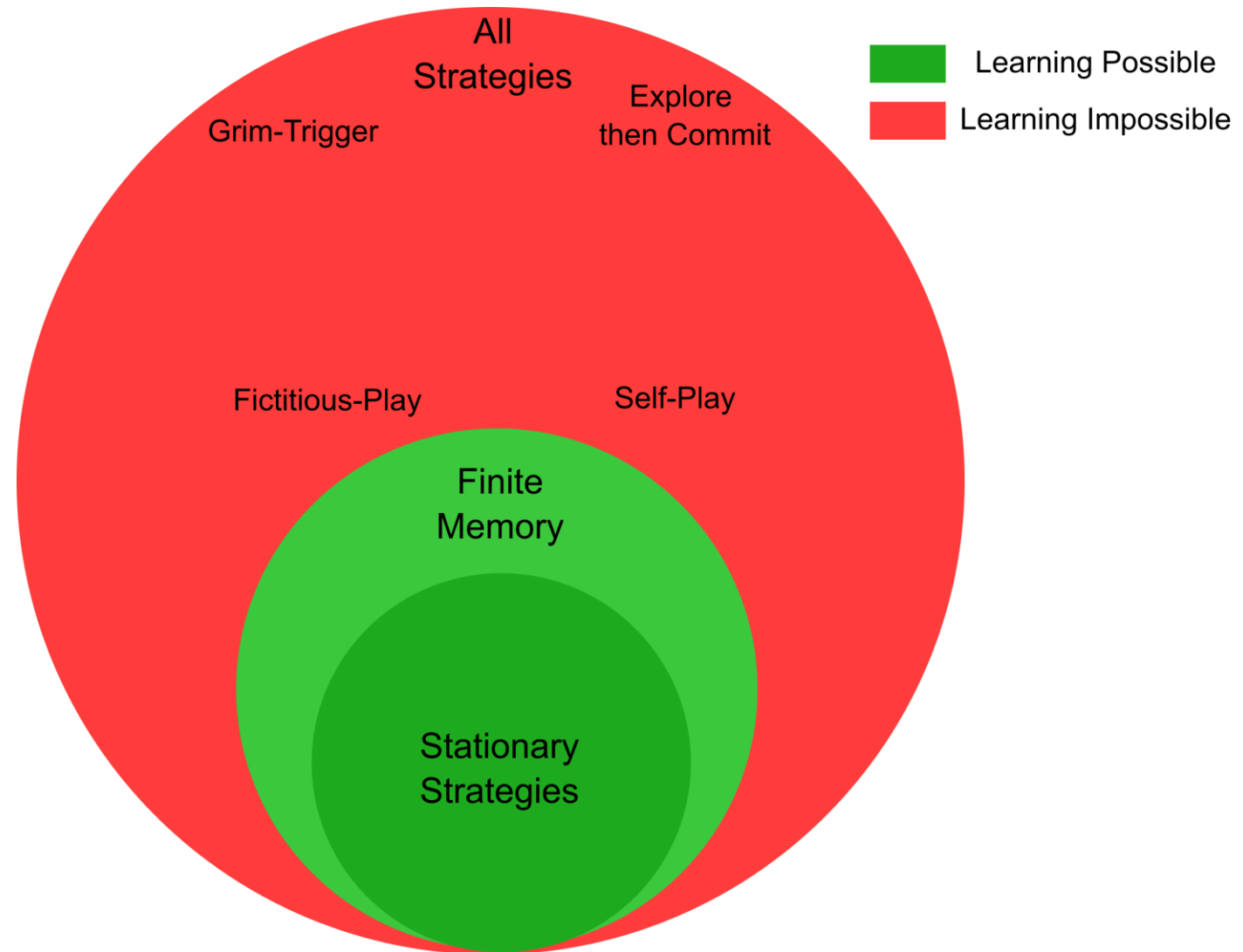

Credit: NASA

"Grim Trigger" Strategies

$$G = \begin{bmatrix} 2 & 0 & 1 \\ 0 & 2 & 1 \end{bmatrix}$$

- In repeated game G, a *"grim trigger"* strategy for the **column player** permanently switches to its *"safety"* action after a miscoordination

- As we cannot predict our partner's initial action, there is no way we can always avoid such a miscoordinations – *failure is always possible*
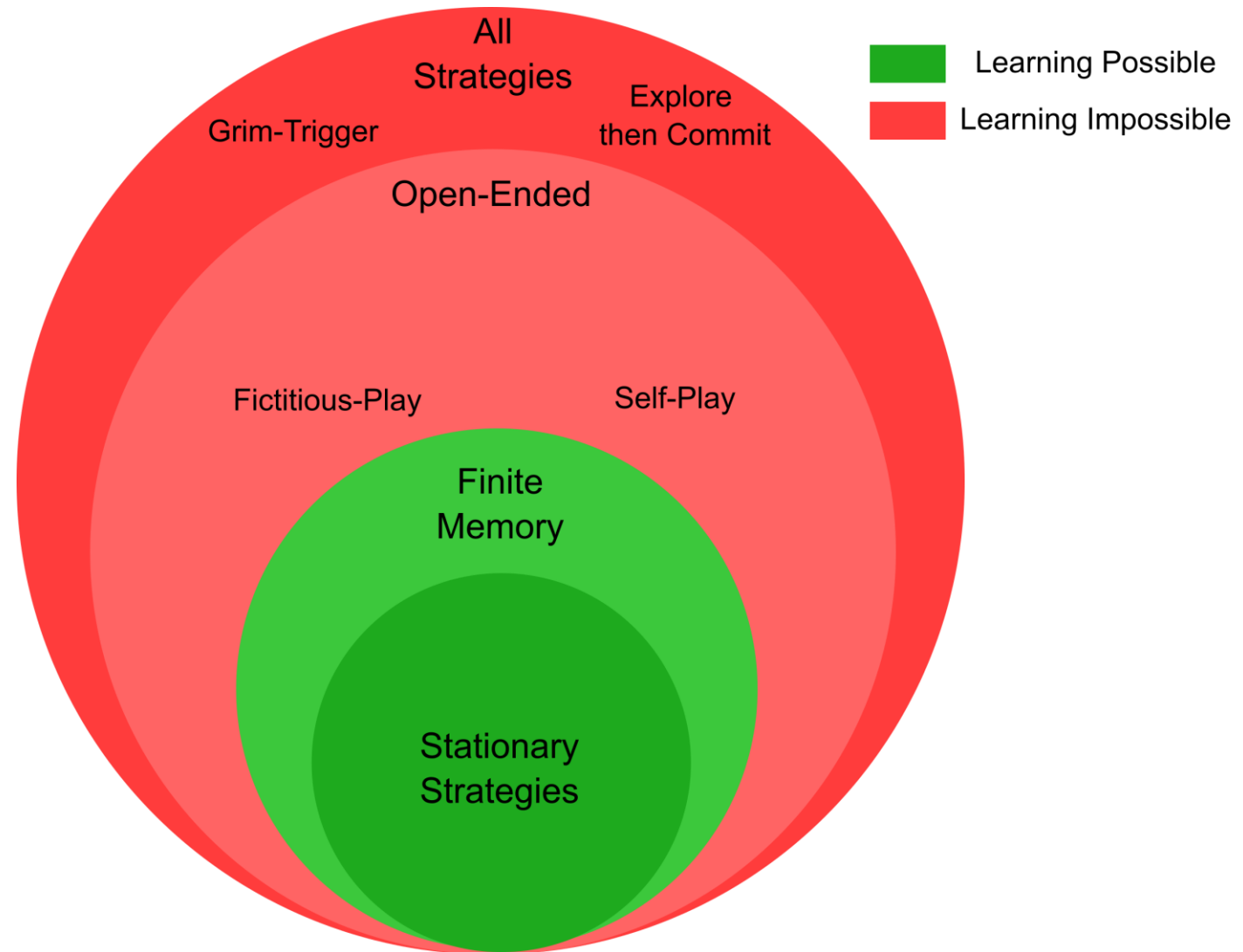
Theoretical Guarantees

- Cannot reliably cooperate with *grim-trigger* partners

- Finite memory allows cooperation - *too restrictive*

All
Strategies

Grim-Trigger

Explore
then Commit

Fictitious-Play

Self-Play

Finite
Memory

Stationary
Strategies

Learning Possible

Learning Impossible

Open-Ended Partners

- "Open-ended" partners always forgive mistakes

- Reliable cooperation is *still* impossible

Open-Ended Partners

$$G = \begin{bmatrix} 2 & 0 & 1 \\ 0 & 2 & 1 \end{bmatrix}$$

- The **column player** predicts that the **row player** will play their first action for the next n rounds, and then switch to their second action

- The **column player** plays their "safety" action for $n + 1$ rounds, then switches to their first action **iff** the **row player** has not switched

Conclusions

- Open-endedness is insufficient to guarantee cooperation

- What types of assumptions should we make?