The Limits of Meta-Learning in Artificial Intelligence

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Two kinds of intelligence

➡ We propose a novel classification scheme for intelligence:

1. **Computational problems:**

✓ Known: Problem $\underline{O}$utset and $\underline{m}$ethod (i.e. algorithm)

✓ Unknown: $\underline{T}$arget outcome (i.e. solution)

$$O \xrightarrow{\ m\ } \textcolor{red}{?}$$

2. **Learning problems:**

✓ Known: Problem $\underline{O}$utset and $\underline{T}$arget outcome (i.e. desired outcome)

✓ Unknown: $\underline{m}$ethod

$$O \xrightarrow{\ \textcolor{red}{?}\ } T$$

1. **Computational problems:**

✓ Straightforward solution: Apply the method to the problem outset to arrive to the target outcome.

$$O \xrightarrow{\mathbf{m}} ? \qquad T=\mathbf{m}(O) \qquad O \xrightarrow{\mathbf{m}} T$$
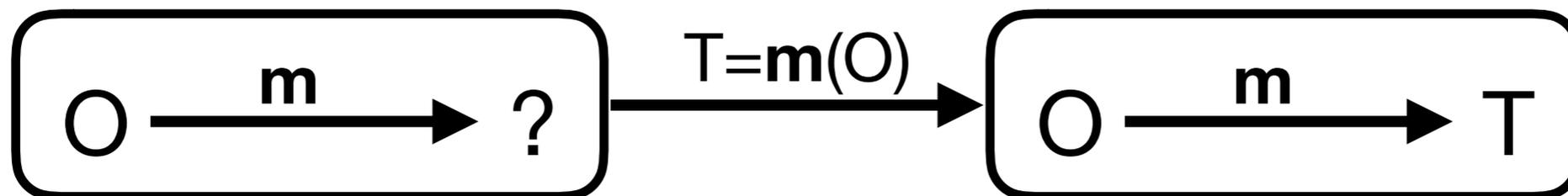
✓ We call this First Order Intelligence. Analogous to Exploitation.

2. **Learning problems:**

✓ The solution is not straightforward any more.

$$O \xrightarrow{?} T \qquad m=?(O,T) \qquad O \xrightarrow{\mathbf{m}} T$$
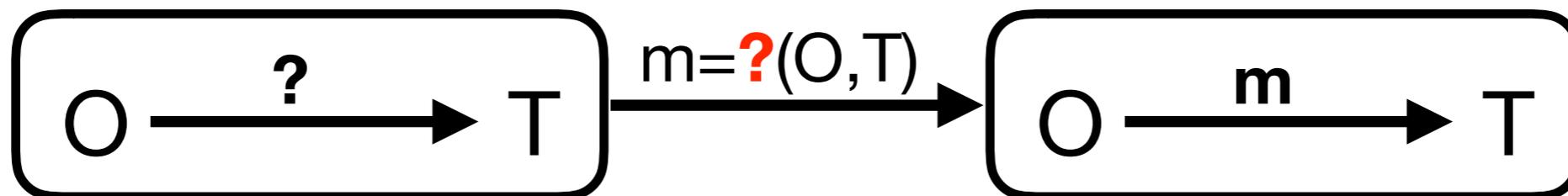
✓ To solve it, let us define **m'**:=**?** and convert it to a computational problem. Analogous to Exploration.

➡ Define the following variables:

- Problem Outset of Learning: O' =

$$O \xrightarrow{?} T$$

- Desired Target of Learning: T' =

$$O \xrightarrow{m} T$$

- Learning method: Applying m' to O' yields T':

$$O' \xrightarrow{m'} T'$$

✓ This is a computational problem! We call it Second Order Intelligence.
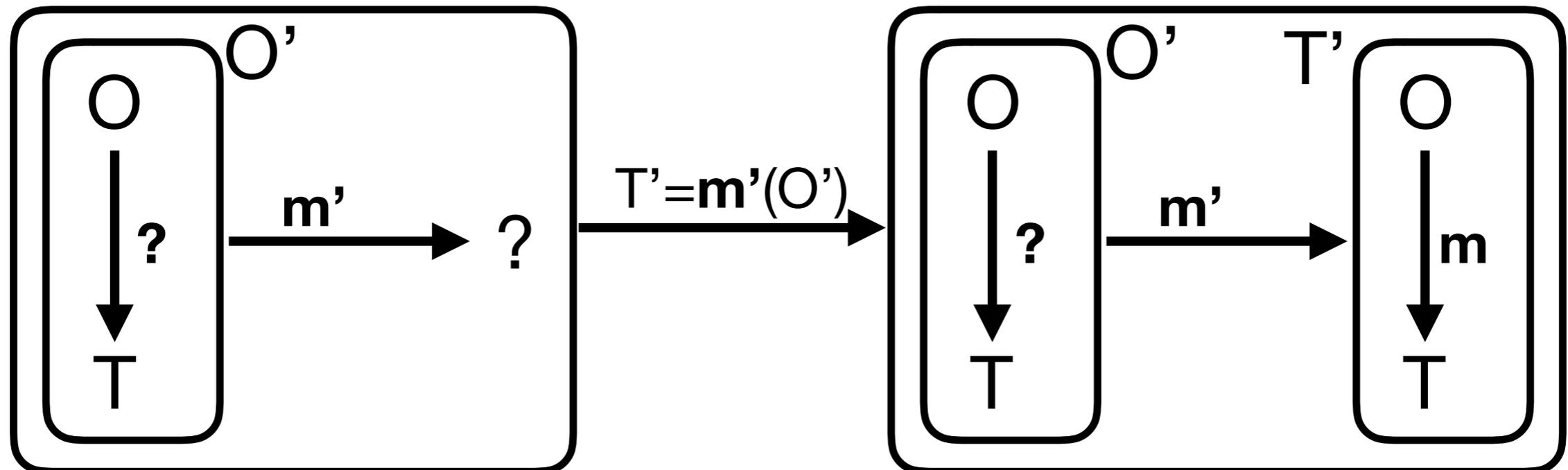
➡ It is your first time making pancakes and do not know how. Then, you have 2 problems:

➡ First, a learning problem. How to make pancakes?

$$\text{raw ingredients} \xrightarrow{?} \text{Pancakes}$$

● Our learning method **m'** is a web search for pancake recipes, which yields a recipe **m**, i.e. a method to cook raw materials.

$$\boxed{O \xrightarrow{?} T} \xrightarrow{m=m'(O,T)} \boxed{O \xrightarrow{m} T}$$
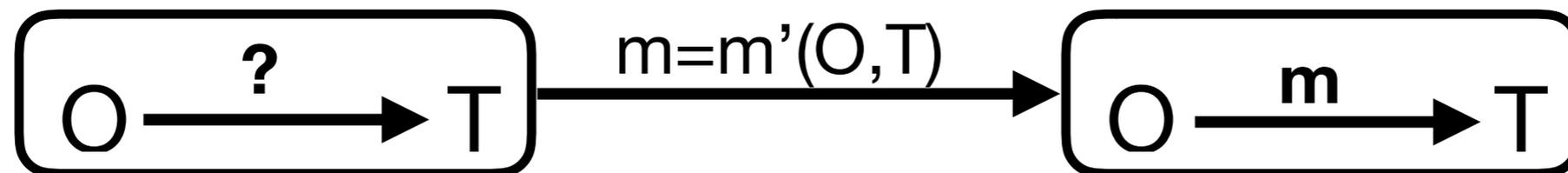
➡ Second, a computational problem.

$$\text{raw ingredients} \xrightarrow{recipe} ?$$

● You follow the recipe **m** like if you were a robot.

● Now you share the pancakes, eat and relax. (How to share pancakes?)

➡ First Order Intelligence (Doing):

- Computer algorithms

- Driving

- Most jobs
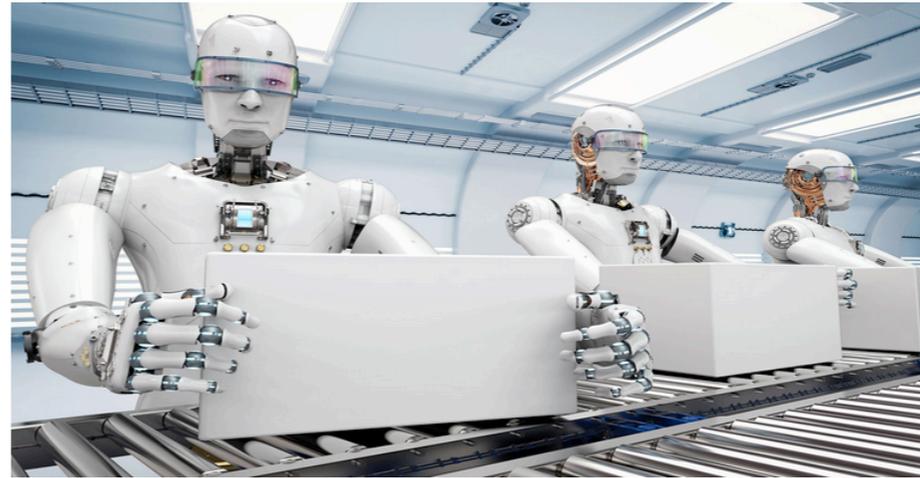
➡ Second Order Intelligence (Learning to do):

- Neural networks

- Studying

- Research jobs

➡ Third Order Intelligence (Learning to learn):

- Research apprentices

- Learning to read
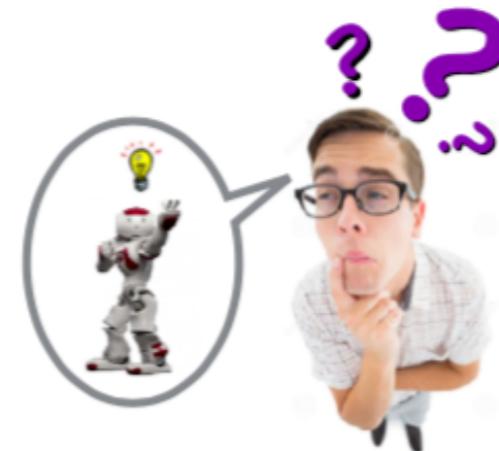
➡ 4th, 5th, 6th, etc. Order Intelligences (Learn to learn to learn to learn to…)

Recap: nth Order Intelligences

1st order	2nd order	3rd order	. . .	nth order

Model exploitation

Model exploration = Meta-model exploitation

Meta-model exploration = Meta-meta-model exploitation

Meta-meta-model exploration = . . .

. . . = Exploitation

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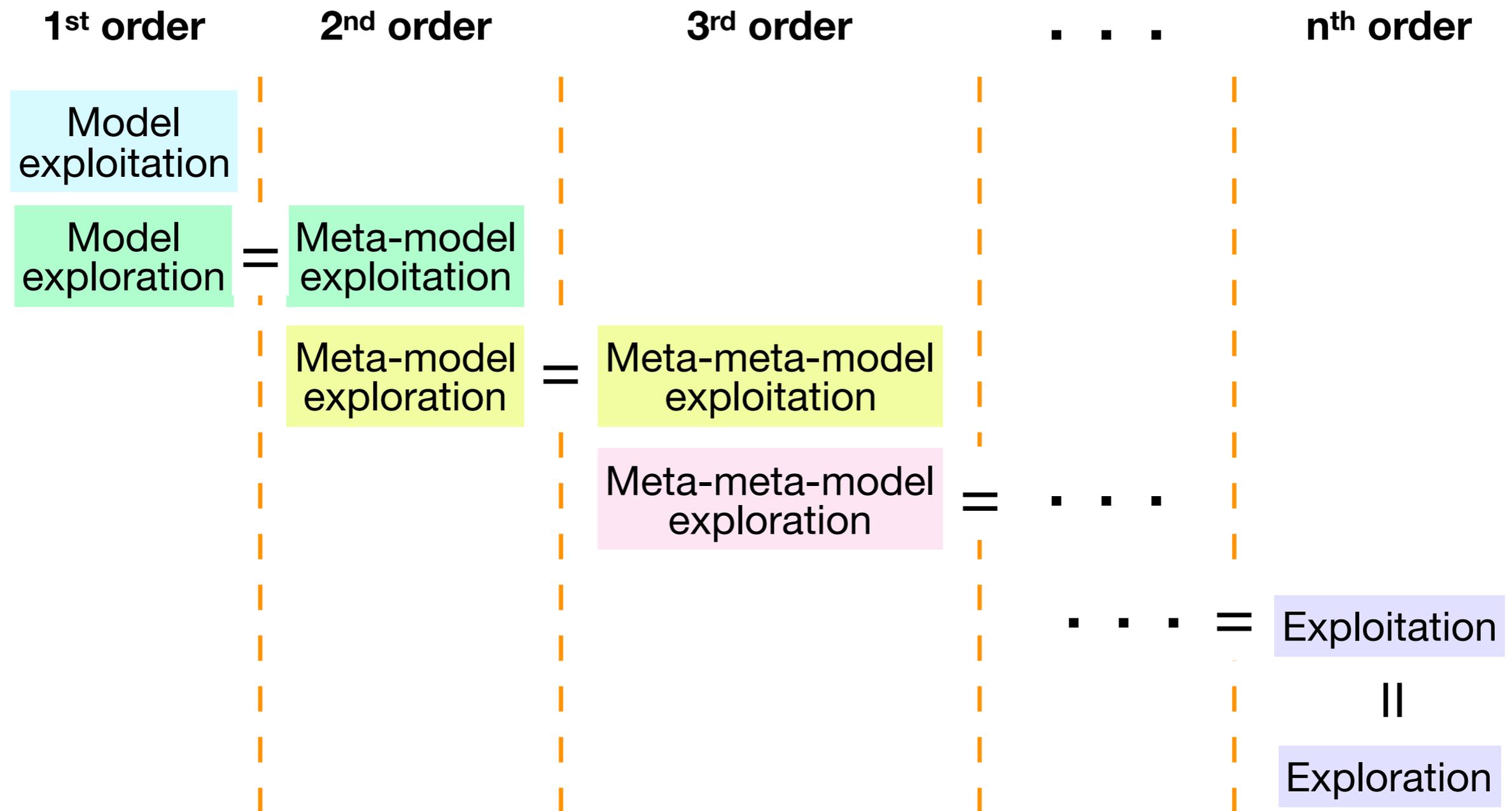
Exploration

➡ Preventing order escalation: Exploitation = Exploration

➡ Exploration modifies exploitation - it modifies itself - recursive intelligence!

➡ Deep consequences: Gödel incompleteness theorems, instability, etc.

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Thank you for your kind attention