PART III
INFORMATION PROCESSING MODELS OF MIND

THE PHYSICAL SYMBOL SYSTEM HYPOTHESIS

ANALOGY BETWEEN MINDS AND DIGITAL COMPUTERS

- PHYSICAL SYMBOL SYSTEM HYPOTHESIS (SIMON & NEWELL)

BASIC PRINCIPLES

Biology: Neuron doctrine

Geology: Geological activity is generated by the movement of huge plates

Artificial Intelligence: The physical symbol system hypothesis

THE PHYSICAL SYMBOL SYSTEM HYPOTHESIS

- Herbert Simon and Allen Newell

"A physical symbol system has the necessary and sufficient means for general intelligent action"

1. *(Necessity)* Anything capable of intelligent action is a physical symbol system: human mind must be a physical symbol system because humans can do intelligent action
2. *(Sufficiency)* Any (sufficiently sophisticated) PSS is capable of intelligent action

FOUR BASIC IDEAS

(1) Symbols are physical patterns

(2) Symbols can be combined to form complex symbol structures

(3) The system contains processes for manipulating complex symbol structures

(4) The processes for representing complex symbol structures can themselves by symbolically represented within the system

1. SYMBOLS ARE PHYSICAL PATTERNS

- Symbols are physical alphabet
- Each symbol has corresponding physical object, but it does not have to be of the same shape as the symbol (computer hardware and binary bit information)

2. SYMBOLS CAN BE COMBINED TO FORM COMPLEX SYMBOL STRUCTURES

- Symbols → word-like symbol structure → sentence-like symbol structure
- The process of combining symbols into complex symbol structures are governed by strict rules

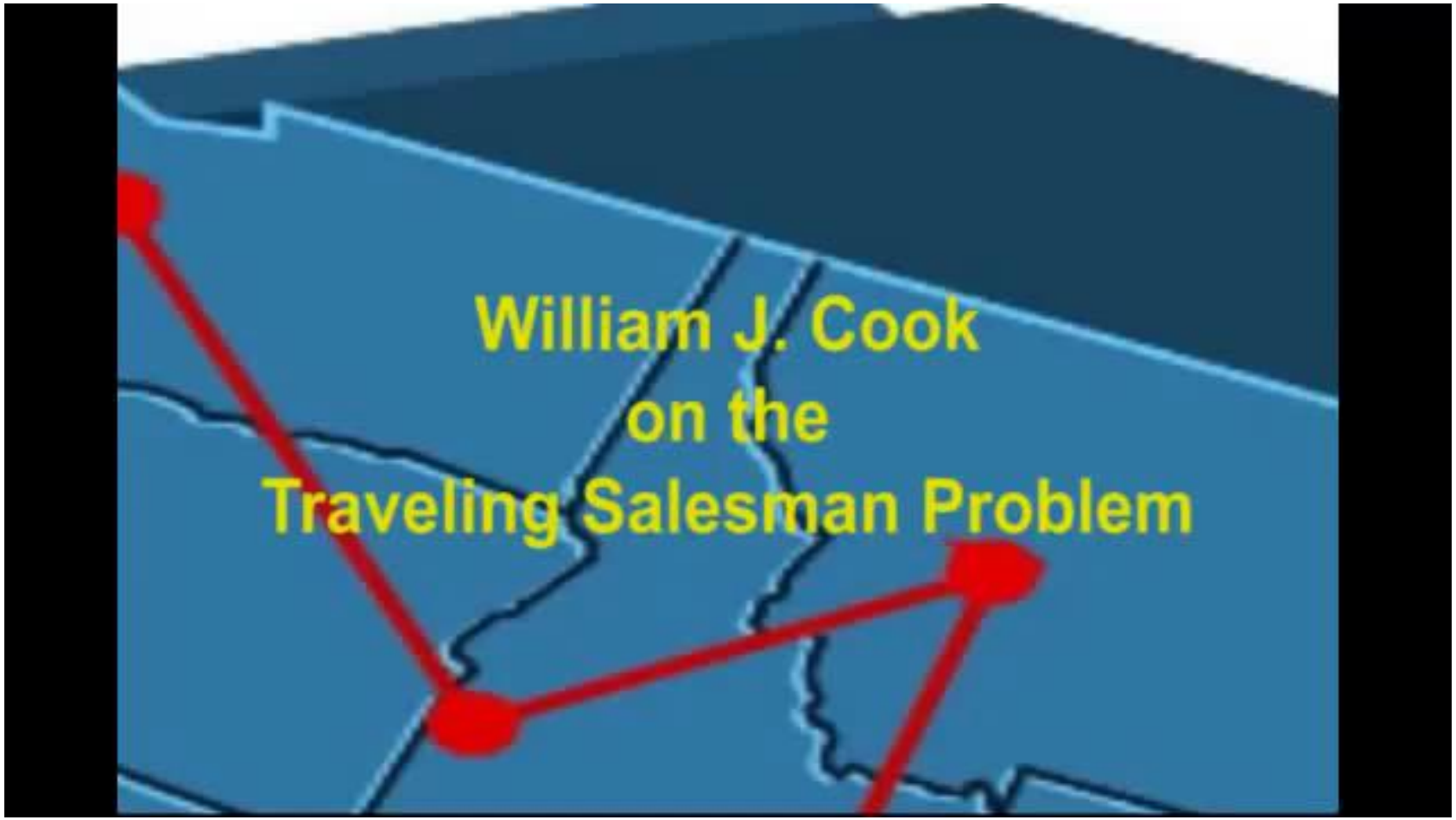
3. THE SYSTEM CONTAINS PROCESSES FOR MANIPULATING COMPLEX SYMBOL STRUCTURES

- Thinking should be understood as the rule-governed transformation of symbol structure
- The essence of intelligent thinking is the ability to solve problems!
- Problem-solving is relative to a search-space

PROBLEM-SOLVING IS RELATIVE TO A SEARCH-SPACE : CHESS EXAMPLE

- Goal: to checkmate his/her opponent
- Many possible moves
- The possible moves define the search-space

A TRAVELING SALESMAN PROBLEM



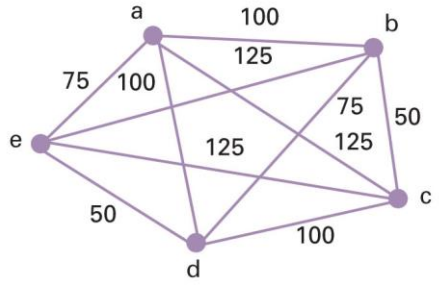
A TRAVELING SALESMAN PROBLEM

- Initial state (start state)
- A set of permissible transformation of the start state

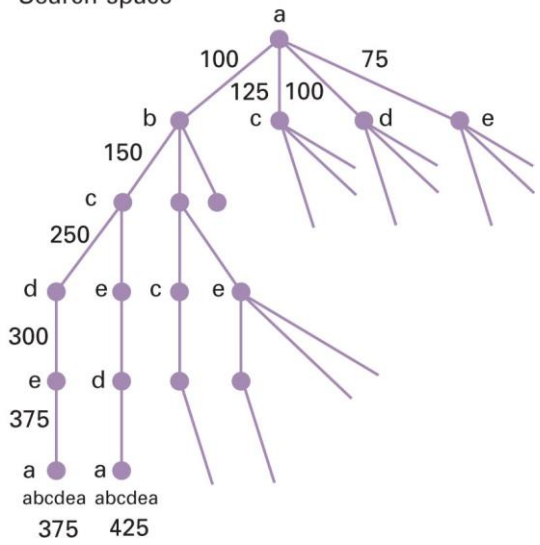
- Goal: the shortest branch of the tree that ends with Boston and that has nodes on it corresponding to each of the twenty cities that the salesman needs to visit.

A TRAVELING SALESMAN PROBLEM

An instance of the traveling salesman problem



Search-space



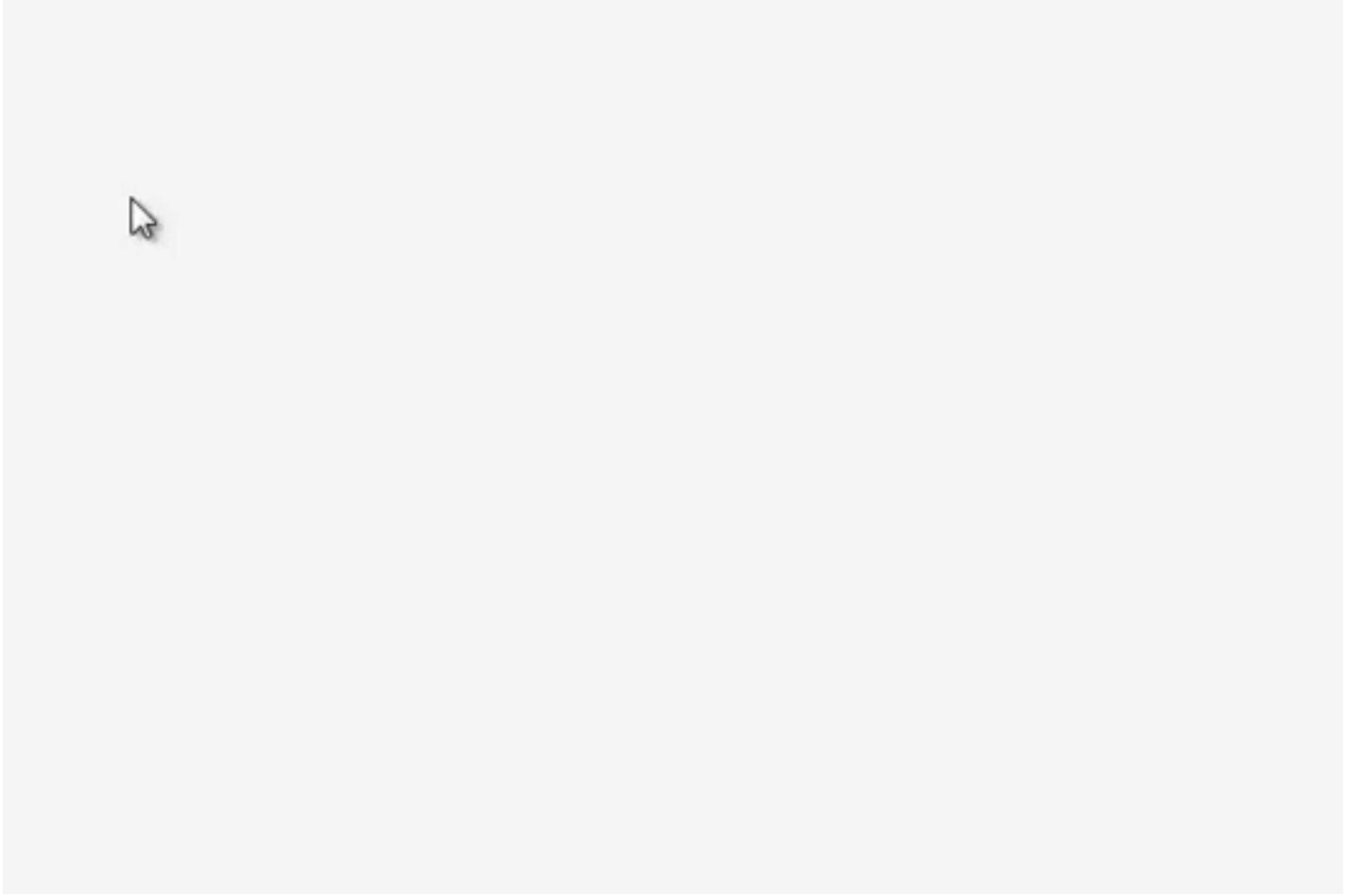
Combinatorial explosion!!

- With *n* connected cities there are (*n* – 1)! possible paths through the search space
  - Five-city: 24 different routes.
  - Twenty-city: 6x10^16 different routes.
- This can be reduced to 2^n
- But it would take a computer processing 1,000,000 possibilities per second over 30 years to solve a 50 city TP problem by brute force search

HEURISTIC SEARCH

- General Problem Solver (GPS)
- Means-end analysis
  1. Evaluate the difference between the current state and the goal state
  2. Identify a transformation that reduces the difference between current state and go al state
  3. Check that the transformation in (2) can be applied to the current state (permissi ble transformation?)
     1. If it can, then apply it and go back to step (1)
     2. If it can't, then return to (2)

MISSIONARY AND CANNIBALS



MISSIONARY AND CANNIBALS

Symbolic representation of state as *mcb*

m = number of missionaries on starting bank

c = number of cannibals on starting bank

b = number of boats on starting bank

Start state = 331

Goal state = 000

Permissible transformations?

- ***Q1. Find a solution to the Missionary and Cannibals problem. Show how your solution can be represented as a process of heuristic search***

MISSIONARY AND CANNIBALS

Impermissible states

A branch ends if it reaches a state *mcb* where

$c > m$ [more cannibals than missionaries on R bank]

$(3 - c) > (3 - m)$ [more cannibals on L bank]

mcb has already appeared earlier in the tree

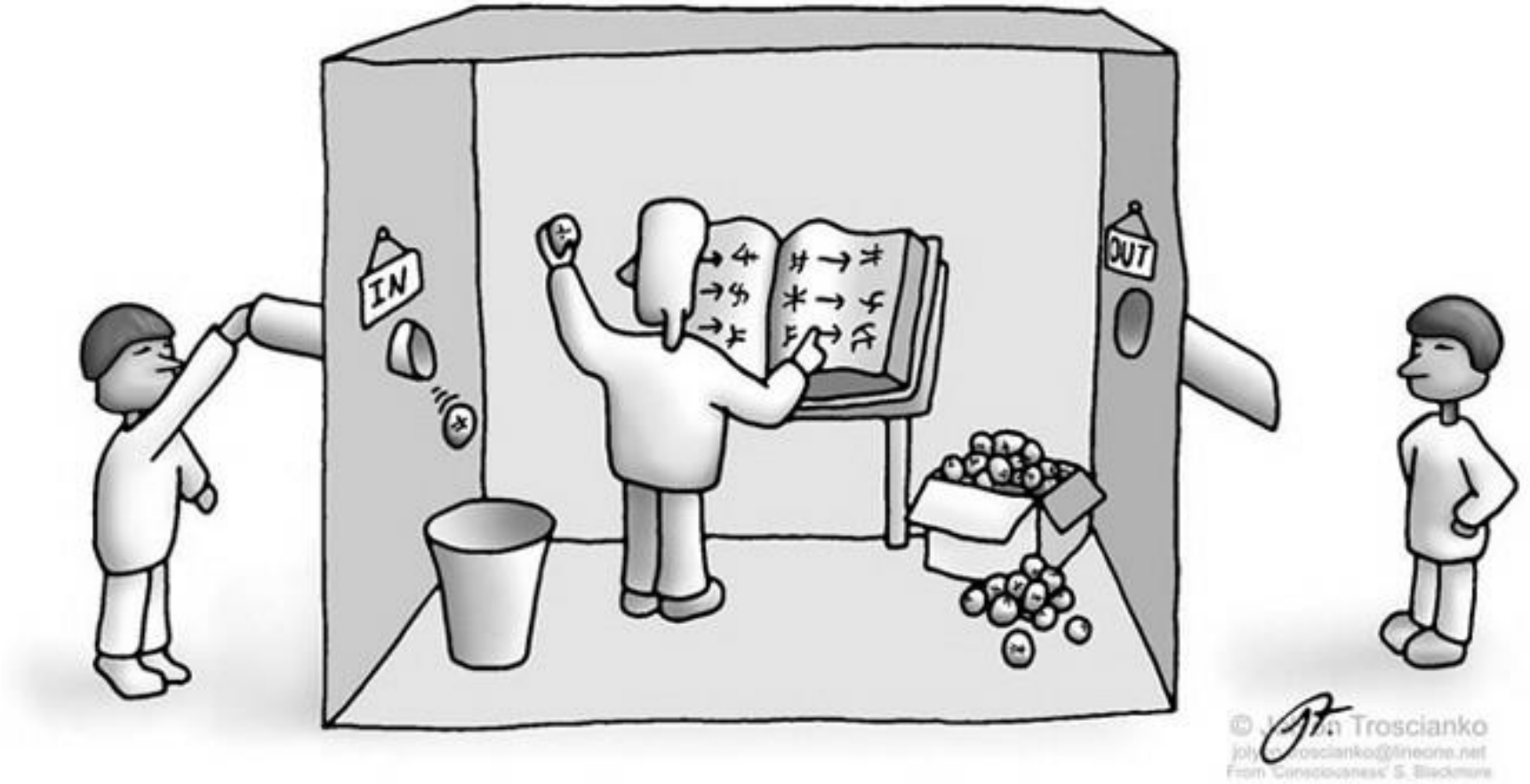
4. THE PROCESSES FOR REPRESENTING COMPLEX SYMBOL STRUCTURES CAN THEMSELVES BY SYMBOLICALLY REPRESENTED WITHIN THE SYSTEM

- A single computer nowadays can run many different programs
- This is possible because they contain symbol structures that encode information about, and instructions for, other symbol structures

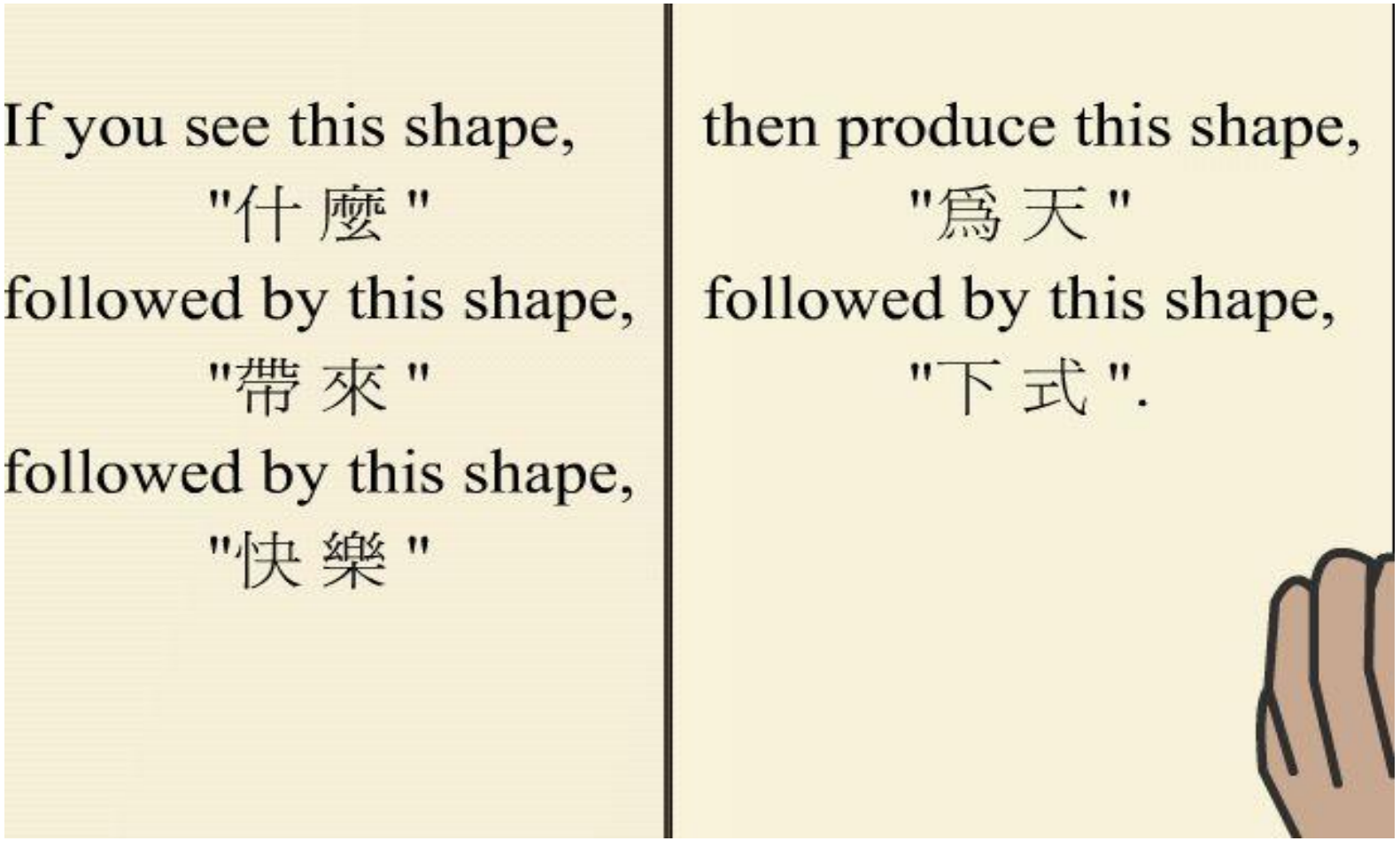
THE CHINESE ROOM ARGUMENT

SEARLE'S CHINESE ROOM

SEARLE'S CHINESE ROOM



SEARLE'S CHINESE ROOM



SEARLE'S CHINESE ROOM

Intelligence requires *Understanding*.

Does the program understands the symbols that it uses?

Does "symbols" have any meaning for the machine?

Can Physical Symbol System be Intelligent?

- ***Q2. Summarize the Chinese room argument in your own words.***