

# **The Story Understanding Story**

**The truth about human intelligence**

Patrick Henry Winston

28 August 2015



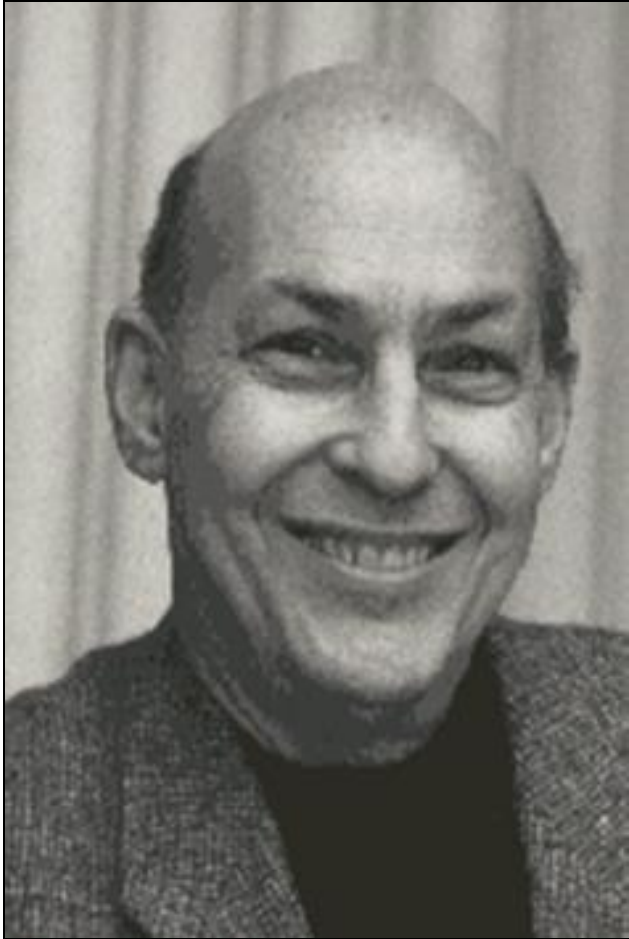
# The Strong Story Hypothesis

The mechanisms that enable us humans to tell, understand, and recombine stories separate our intelligence from that of other primates.

# Key Questions

- Why has AI made so little progress?
- How can we make progress now?
- Can a computer be really smart without a perceptual system
- Should engineers care about how natural intelligence works?
- What are the dangers of AI and what should we do about them?

# 55 Years Ago



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## STEPS TOWARD ARTIFICIAL INTELLIGENCE

*by Marvin Minsky*

### *Introduction*

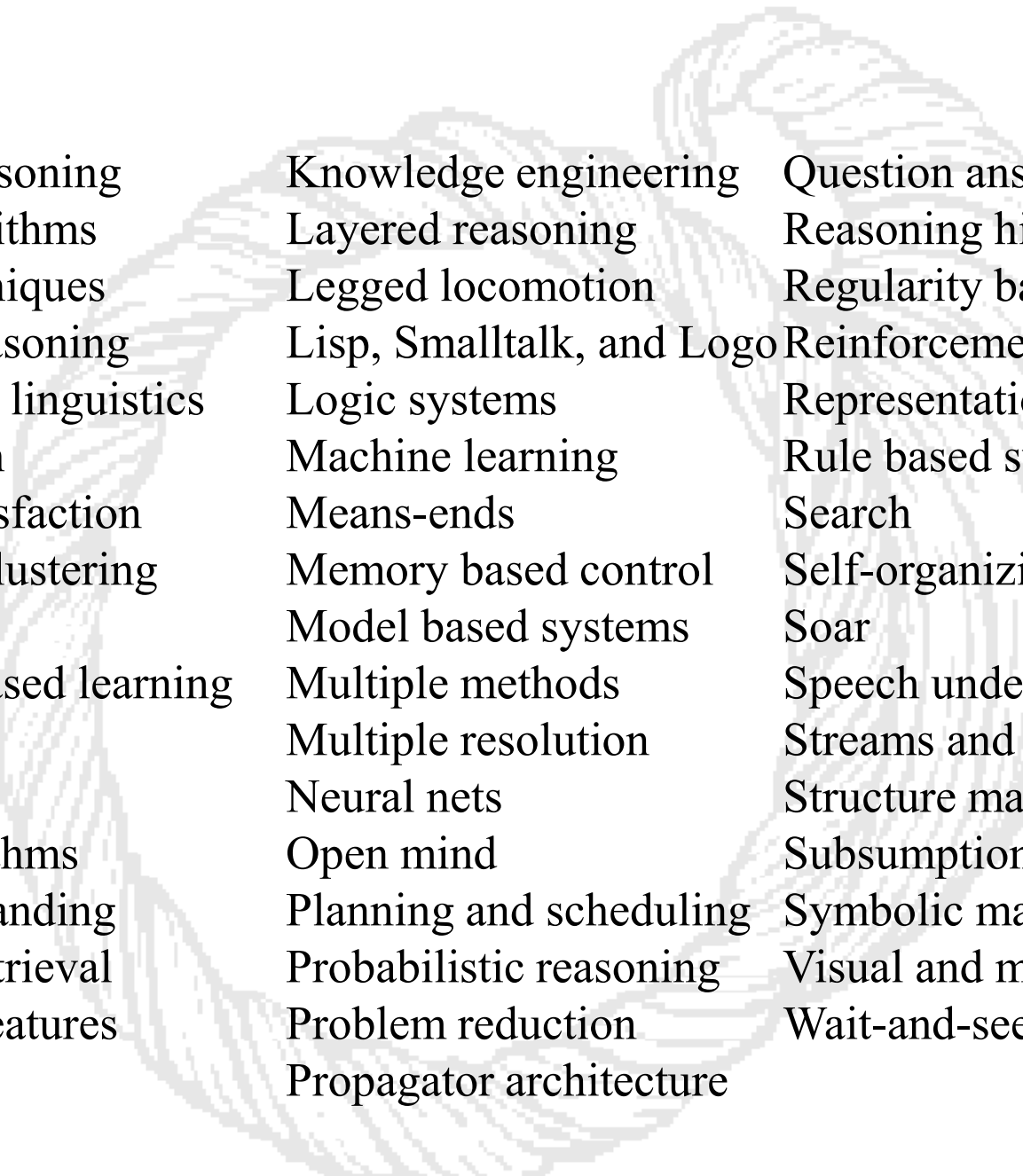
A visitor to our planet might be puzzled about the role of computers in our technology. On the one hand, he would read and hear all about wonderful “mechanical brains” baffling their creators with prodigious intellectual performance. And he (or it) would be warned that these machines must be restrained, lest they overwhelm us by might, persuasion, or even by the revelation of truths too terrible to be borne. On the other hand, our visitor would find the machines being denounced, on all sides, for their slavish obedience, unimaginative literal interpretations, and incapacity for innovation or initiative; in short, for their inhuman dullness.

Our visitor might remain puzzled if he set out to find, and judge for himself, these monsters. For he would find only a few machines (mostly “general-purpose” computers, programmed for the moment to behave according to some specification) doing things that might claim any real intellectual status. Some would be proving mathematical theorems of rather undistinguished character. A few machines might be playing certain games, occasionally defeating their designers. Some might be distinguishing between hand-printed letters. Is this enough to justify so much interest, let alone deep concern? I believe that it is; that we are on the threshold of an era that will be strongly influenced, and quite possibly dominated, by intelligent problem-solving machines. But our purpose is not to guess about what the future may bring; it is only to try to describe and explain what seem now to be our first steps toward the construction of “artificial intelligence.”

# 55 Years Ago

$$\int \frac{x^4}{(1-x^2)^{5/2}} dx = \frac{1}{3} \tan^3(\arcsin x) - \tan(\arcsin x) + \arcsin x$$

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|                            |                           |                             |
|----------------------------|---------------------------|-----------------------------|
| Analogical reasoning       | Knowledge engineering     | Question answering          |
| Anytime algorithms         | Layered reasoning         | Reasoning hierarchies       |
| Bayesian techniques        | Legged locomotion         | Regularity based learning   |
| Case-based reasoning       | Lisp, Smalltalk, and Logo | Reinforcement learning      |
| Computational linguistics  | Logic systems             | Representation              |
| Connectionism              | Machine learning          | Rule based systems          |
| Constraint satisfaction    | Means-ends                | Search                      |
| Cross-modal clustering     | Memory based control      | Self-organizing maps        |
| Cyc                        | Model based systems       | Soar                        |
| Explanation based learning | Multiple methods          | Speech understanding        |
| Frames                     | Multiple resolution       | Streams and counter streams |
| Fuzzy sets                 | Neural nets               | Structure mapping           |
| Genetic algorithms         | Open mind                 | Subsumption                 |
| Image understanding        | Planning and scheduling   | Symbolic mathematics        |
| Information retrieval      | Probabilistic reasoning   | Visual and motor routines   |
| Intermediate features      | Problem reduction         | Wait-and-see algorithms     |
| K-lines                    | Propagator architecture   |                             |



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Source: "Show and tell: A neural image caption generator." In Proceedings of the  
IEEE Conference on Computer Vision and Pattern Recognition, pp. 3156-3164. 2015.

A group of young people playing a game of frisbee

School bus



Not a school bus



Szegedy et al. 2014

Courtesy of Christian Szegedy, Wojciech Zaremba, Ilya Sutskever, Joan Bruna, Dumitru Erhan, Ian Goodfellow & Rob Fergus. License CC BY.  
Source: Szegedy, Christian, Wojciech Zaremba, Ilya Sutskever, Joan Bruna, Dumitru Erhan, Ian Goodfellow, and Rob Fergus. "Intriguing properties of neural networks." arXiv preprint arXiv:1312.6199 (2013).

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Source: Nguyen, Anh, Jason Yosinski, and Jeff Clune. "Deep neural networks are easily fooled: High confidence predictions for unrecognizable images." In Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition, pp. 427-436. 2015.

Dreyfus, 1965:  
Significant  
developments in  
AI...must await  
computers of an entirely  
different sort...



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Musk, 2014: With  
Artificial Intelligence, we  
are summoning the  
demon.

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# 65 Years Ago



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VOL. LIX. No. 236.]

[October, 1950

## MIND

A QUARTERLY REVIEW  
OF  
PSYCHOLOGY AND PHILOSOPHY

### I.—COMPUTING MACHINERY AND INTELLIGENCE

By A. M. TURING

#### 1. *The Imitation Game.*

I PROPOSE to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to reflect so far as possible the normal use of the words, but this attitude is dangerous. If the meaning of the words 'machine' and 'think' are to be found by examining how they are commonly used it is difficult to escape the conclusion that the meaning and the answer to the question, 'Can machines think?' is to be sought in a statistical survey such as a Gallup poll. But this is absurd. Instead of attempting such a definition I shall replace the question by another, which is closely related to it and is expressed in relatively unambiguous words.


The new form of the problem can be described in terms of a game which we call the 'imitation game'. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either 'X is A and Y is B' or 'X is B and Y is A'. The interrogator is allowed to put questions to A and B thus:

C: Will X please tell me the length of his or her hair?  
Now suppose X is actually A, then A must answer. It is A's

28

433

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| Topic                   | Pages |   |
|-------------------------|-------|---|
| • The test              | 3     |   |
| • How computers work    | 6     |   |
| • The counter arguments | 10    |  |
| • A program of research | 5     |   |
| • The prediction        | 1     |   |

# Suitcase Words

Intelligence

Creativity

Emotion

...



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- Serious people can think seriously about computers thinking
- There is no reason to doubt that computers will think someday



# The counter arguments

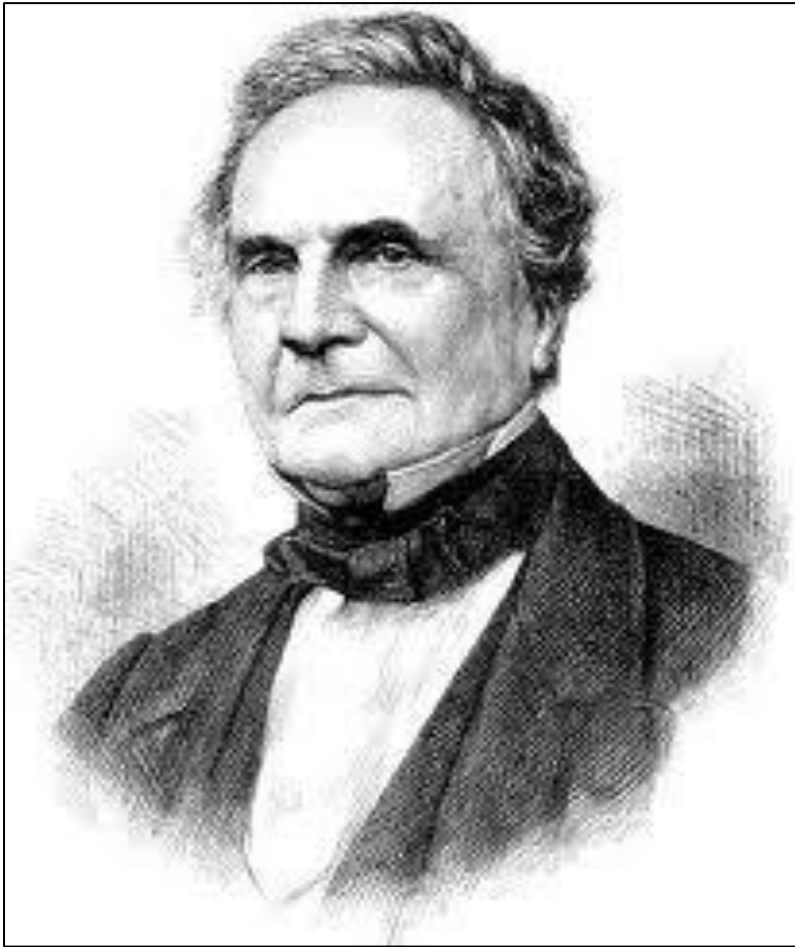
## Objections:

1. Theological
2. Head in the sands
3. Mathematical
4. Lady Lovelace's

## Arguments from:

5. Disabilities
7. Continuity in the nervous system
8. Informality of behavior
9. Extrasensory perception

# 170 Years Ago

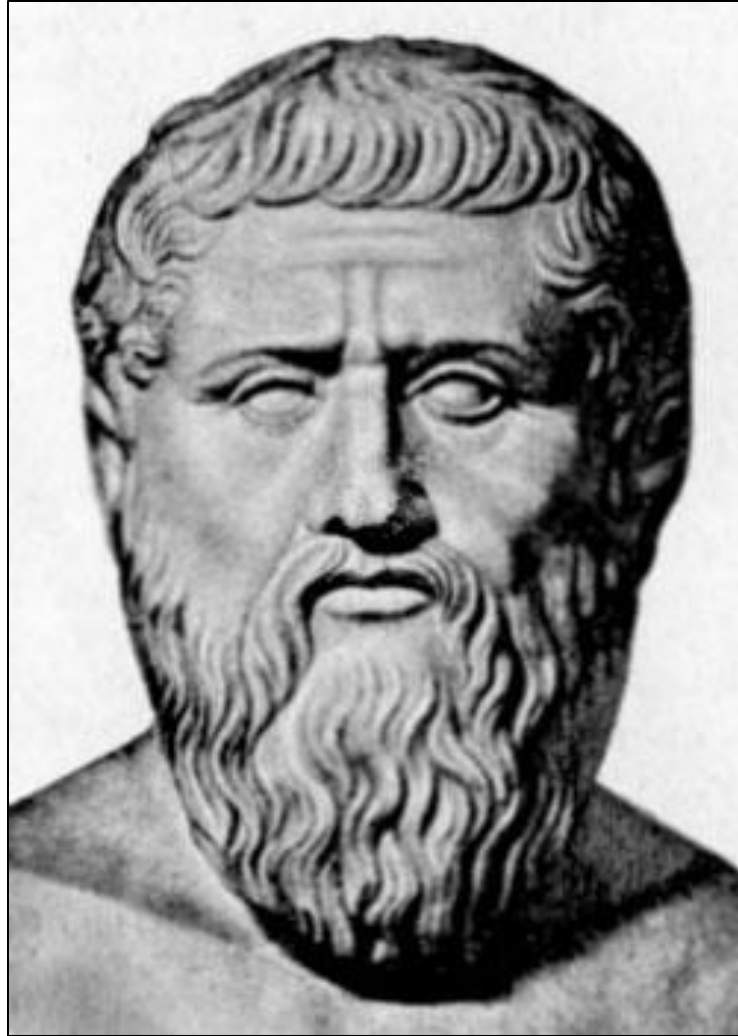


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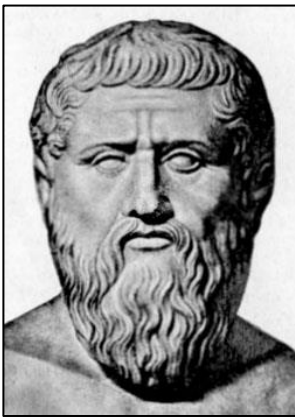


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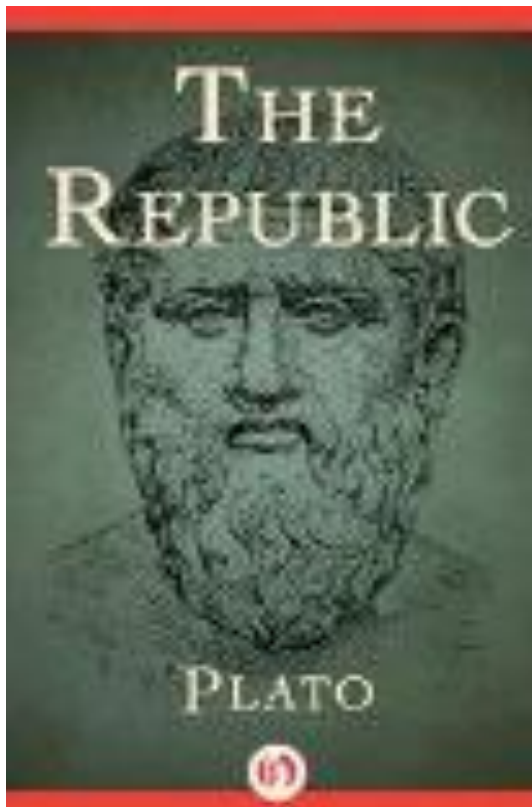
# 2400 Years Ago



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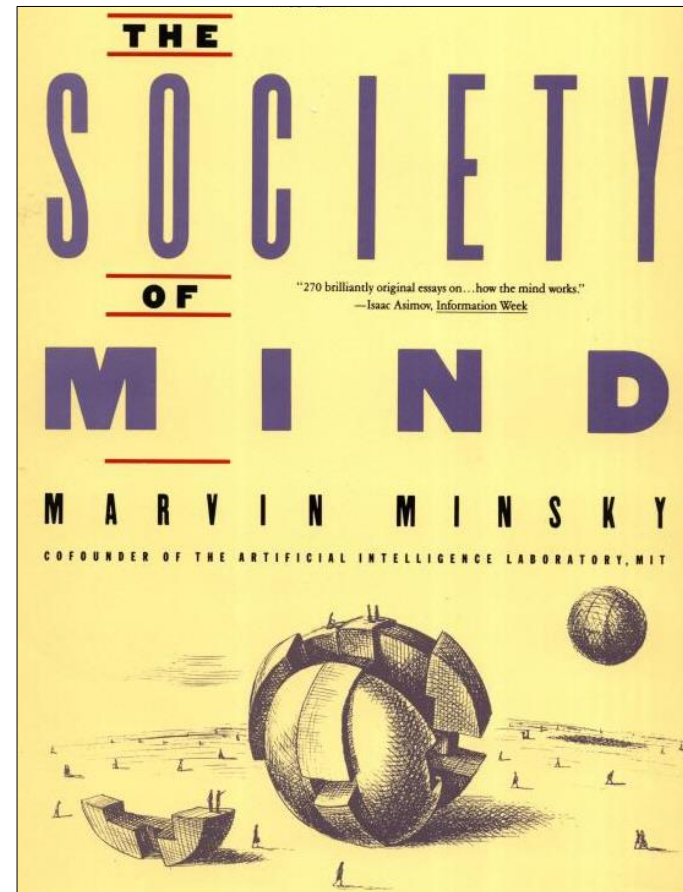


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# 50,000 Years Ago



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Source: Tattersall, Ian. "An evolutionary framework for the acquisition of symbolic cognition by Homo sapiens." *Comparative cognition & behavior reviews* 3 (2008): 99-114.



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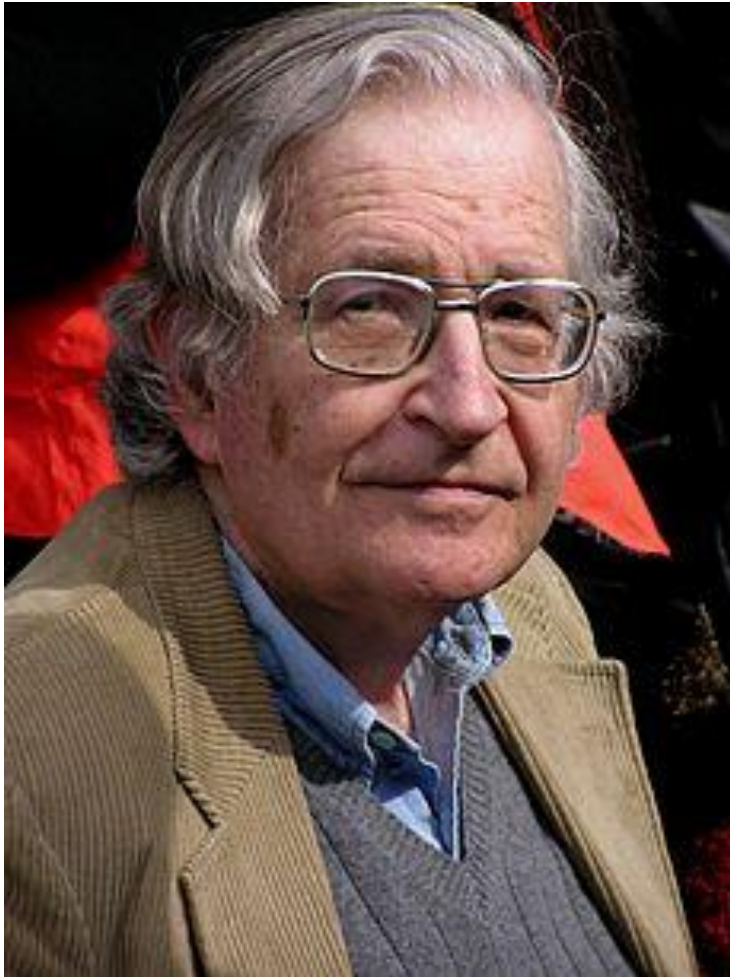


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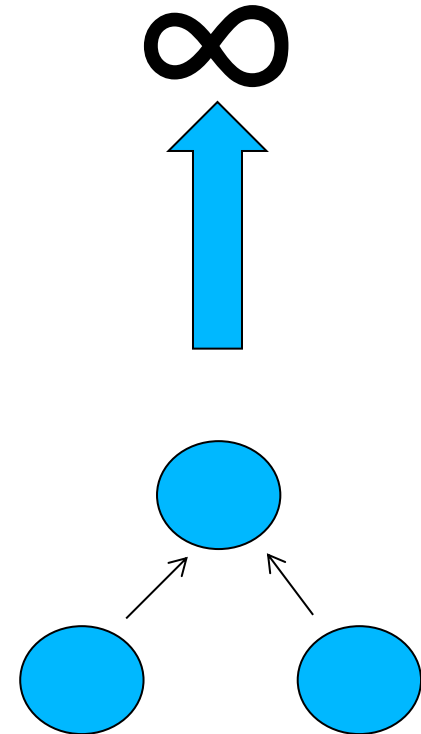


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# The Inner Language Hypothesis

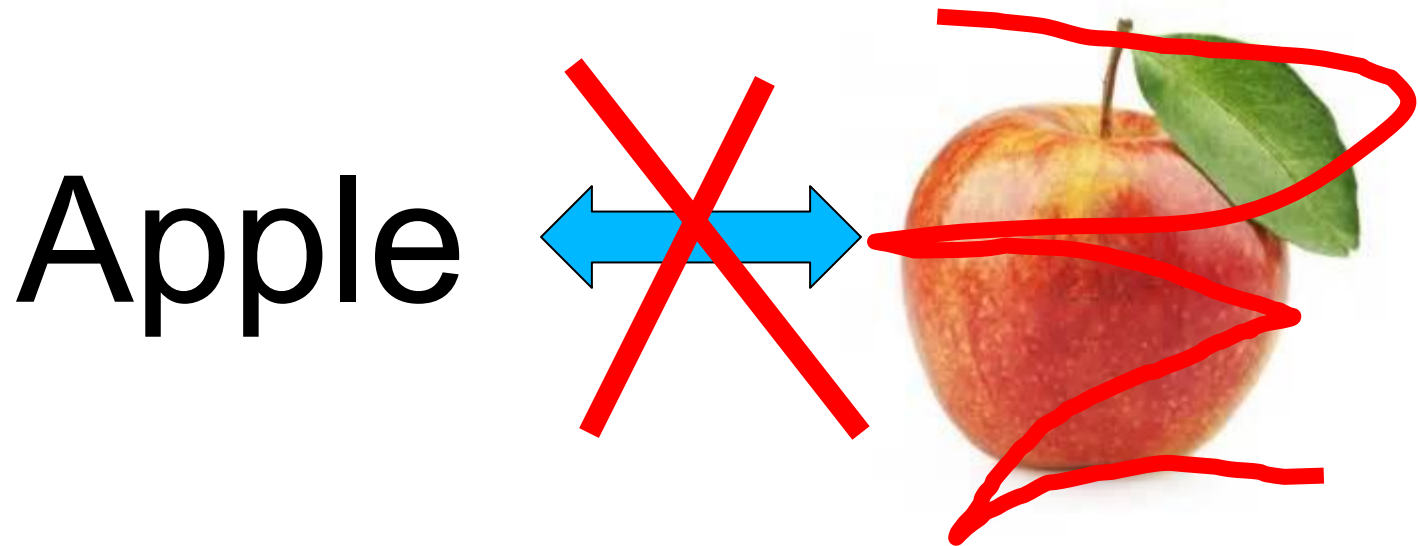


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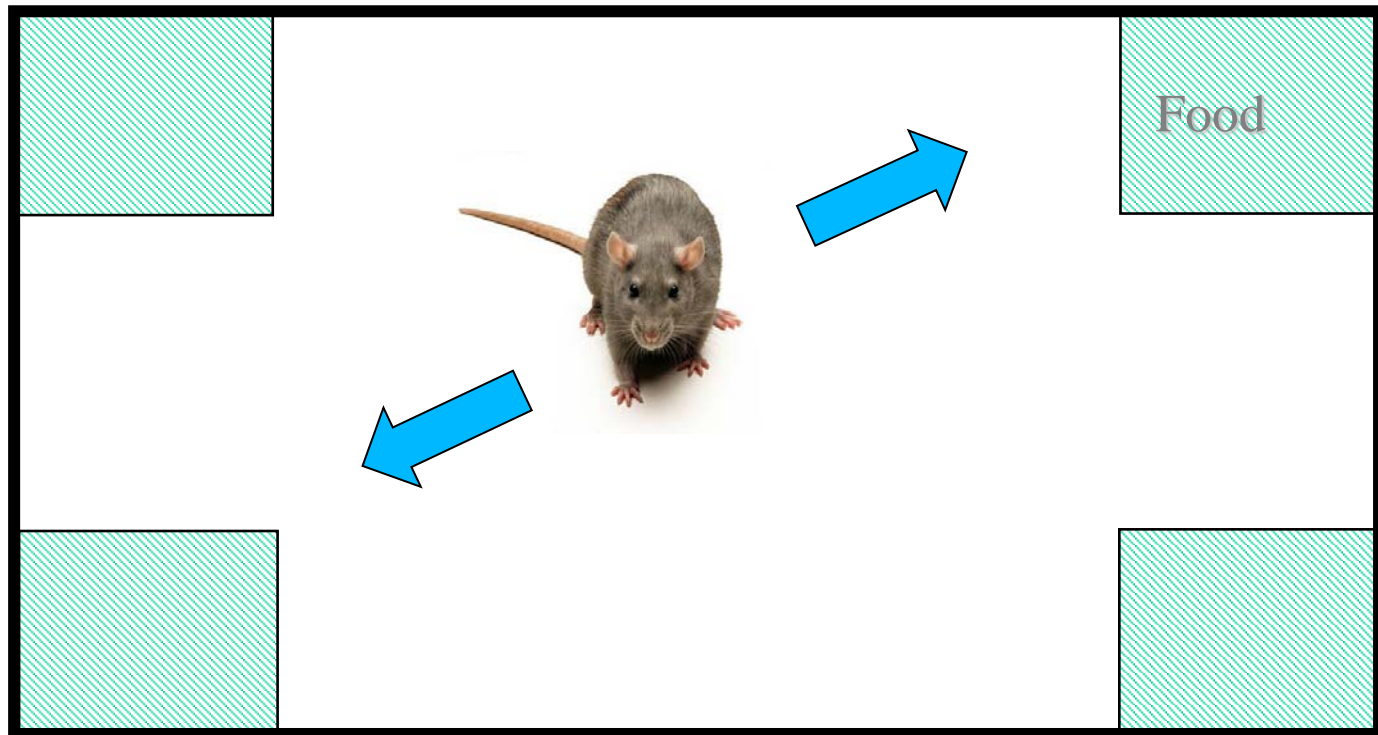


- Why do we have any language
- Why do we have more than one



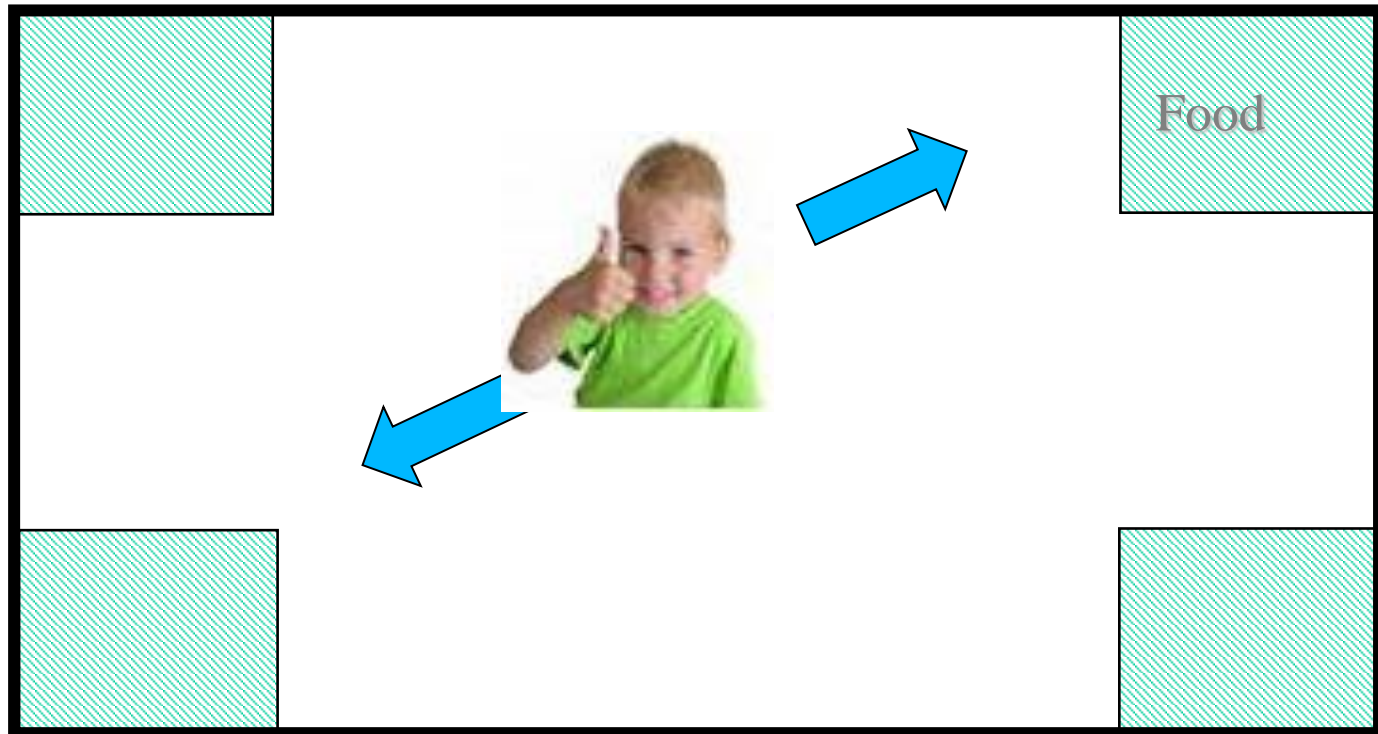
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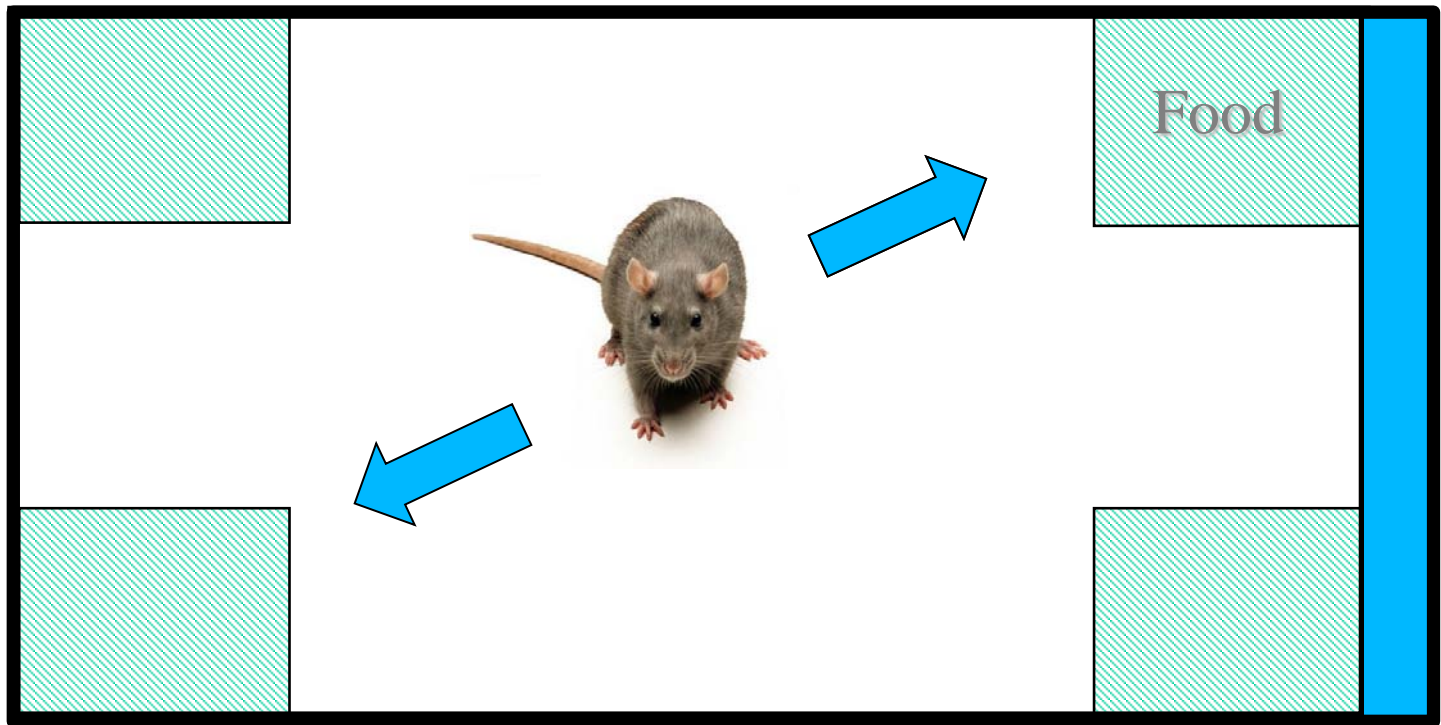


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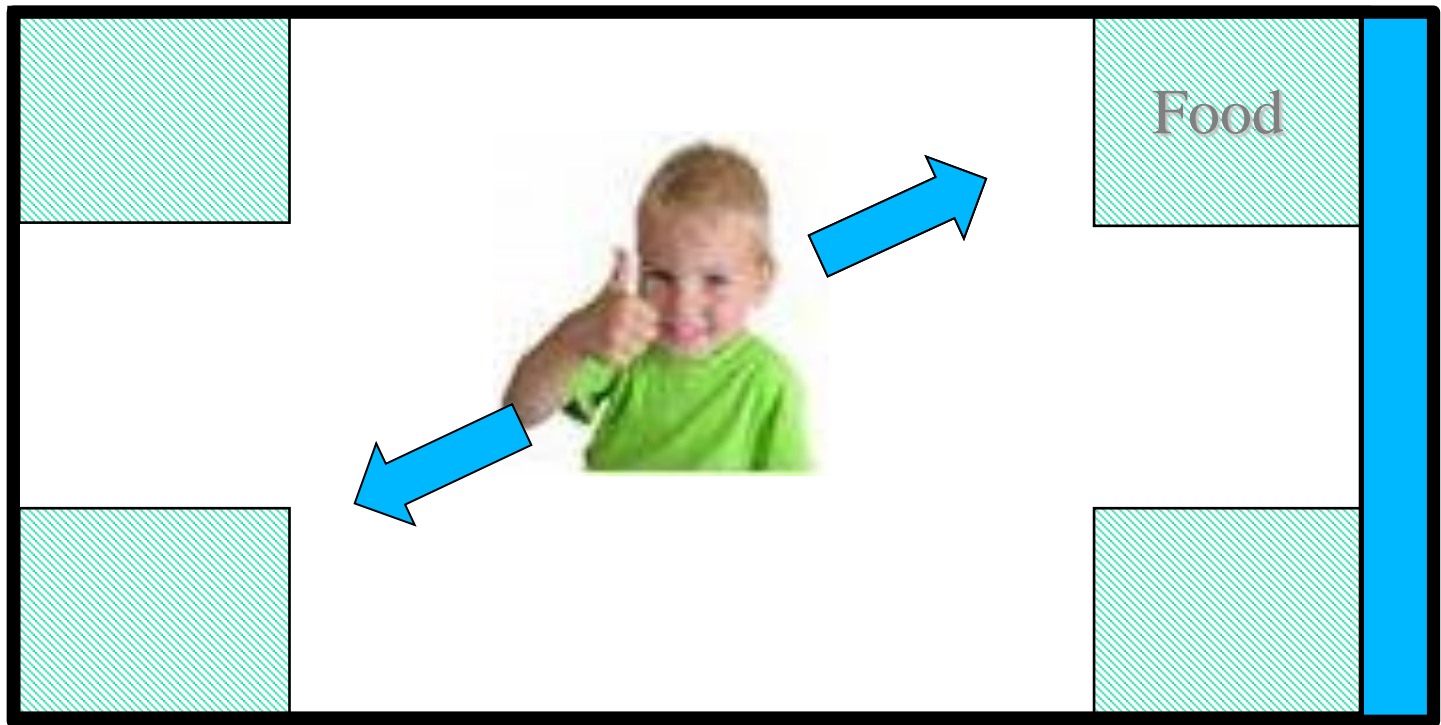
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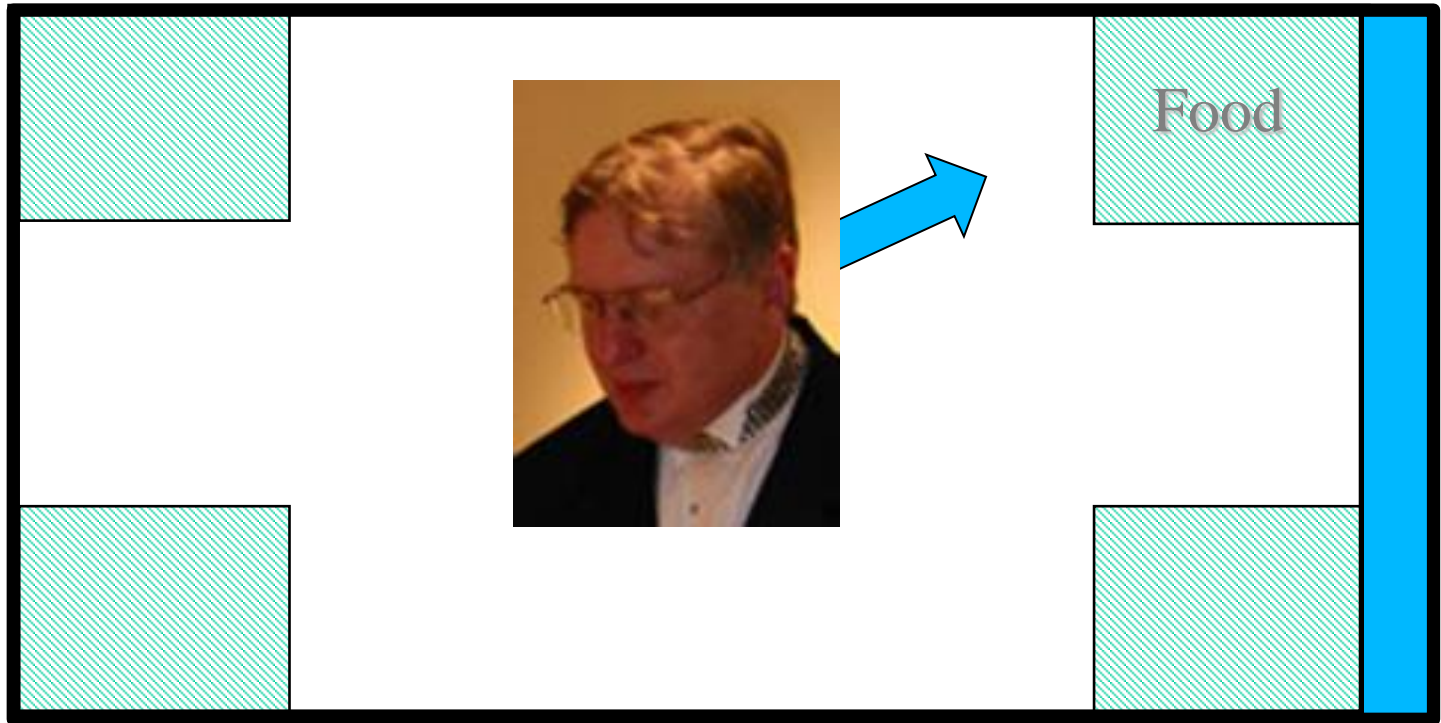
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# The Strong Story Hypothesis

The mechanisms that enable us humans to tell, understand, and recombine stories separate our intelligence from that of other primates.

Fairy and folk tales

Religious parables

Ethnic narratives

History

Literature

Experience

News

...

Law

Business

Medicine

Defense

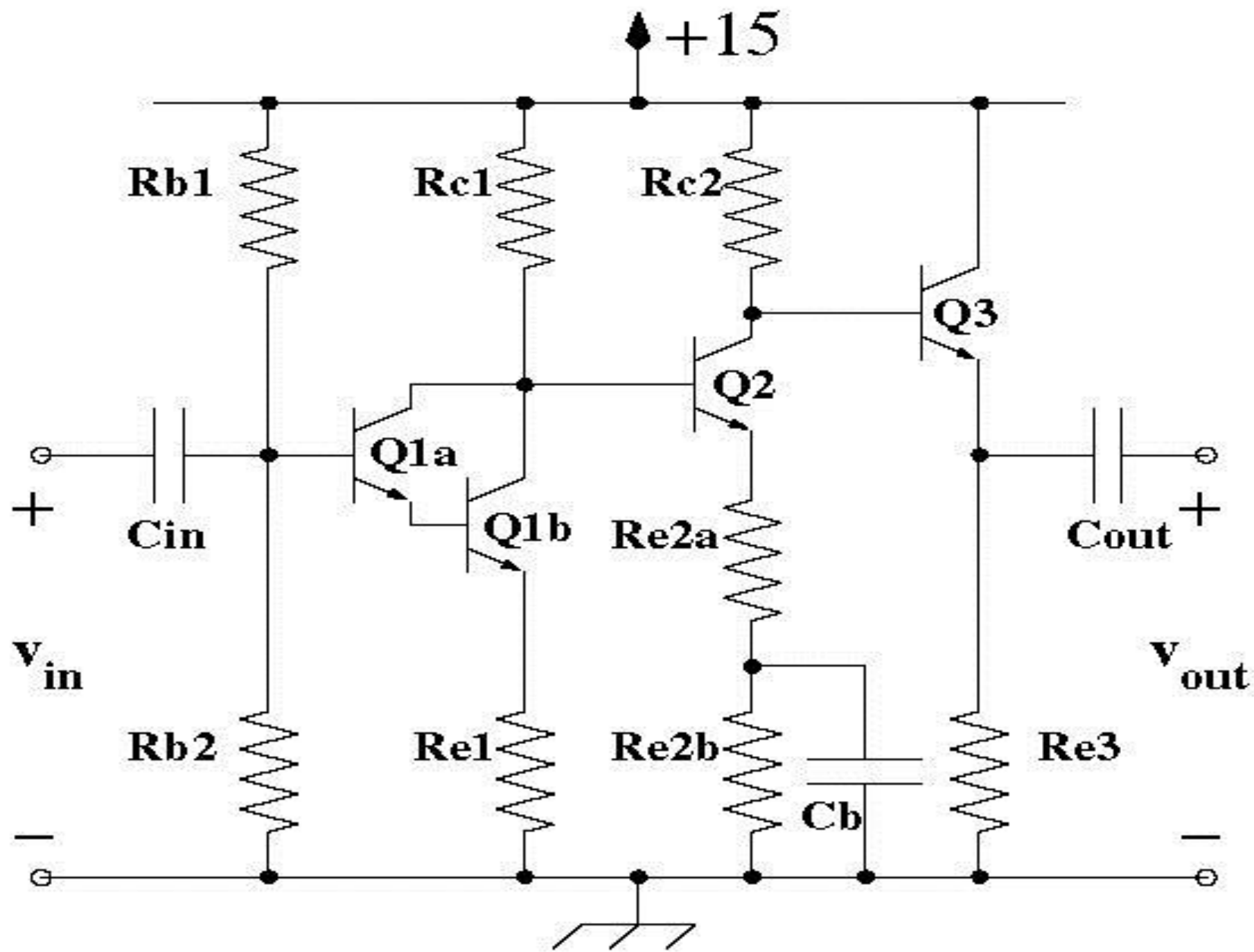
Diplomacy

Science

Engineering

...





# The Steps

Characterize behavior

Formulate computational problems

Propose computational solutions

Implement exploratory systems

Crystallize out the principles

Macbeth is a thane and Macduff is a thane. Lady Macbeth is evil and greedy. Duncan is the king, and Macbeth is Duncan's successor. Duncan is an enemy of Cawdor. Macduff is an enemy of Cawdor. Duncan is Macduff's friend. Macbeth defeated Cawdor. Duncan becomes happy because Macbeth defeated Cawdor. The witches danced and had visions. Macbeth talks with the witches. The witches predicted that Macbeth will become king. The witches astonish Macbeth. Duncan executes Cawdor. Macbeth becomes Thane of Cawdor. Duncan rewarded Macbeth because Duncan became happy. Macbeth wants to become king because Lady Macbeth persuaded Macbeth to want to become the king. Macbeth invites Duncan to dinner. Duncan complements Macbeth. Duncan goes to bed. Duncan's guards become drunk and sleep. In order to murder Duncan, Macbeth murders the guards and Macbeth stabs Duncan. Macbeth becomes king. Malcolm and Donalbain flee. Macbeth's murdering Duncan leads to Macduff's fleeing to England. In order to flee to England, Macduff rides to the coast and Macduff sails on a ship. Then, Macduff's fleeing to England leads to Macbeth's murdering Lady Macduff. Macbeth hallucinates at a dinner. Lady Macbeth says he hallucinates often. Everyone leaves because Lady Macbeth tells everyone to leave. Macbeth's murdering Duncan leads to Lady Macbeth's becoming distraught. Lady Macbeth has bad dreams. Lady Macbeth thinks she has blood on her hands. Lady Macbeth kills herself. Birnam Wood is a forest. Burnham Wood goes to Dunsinane. Macduff's army attacks Dunsinane. Macduff curses Macbeth. Macbeth refuses to surrender. Macduff kills Macbeth. The end.

...The witches predicted that Macbeth will become king. The witches astonish Macbeth. Duncan executes Cawdor. Macbeth becomes Thane of Cawdor. ... Macbeth wants to become king because Lady Macbeth persuaded Macbeth to want to become the king. Macbeth invites Duncan to dinner. ...

# Seven rule types

If xx kills yy, then yy becomes dead.

If xx angers yy, then yy **may** kill xx.

If xx kills yy, then xx **must be** insane.

If yy becomes dead, yy **cannot** become unhappy.

xx **can be** greedy because xx is foolish.

xx's having a knife **enables** xx's stabbing yy.

xx becomes king; yy becomes angry.

# Five kinds of explicit cause

Macbeth wants to murder Duncan **because**  
Macbeth wants to be king.

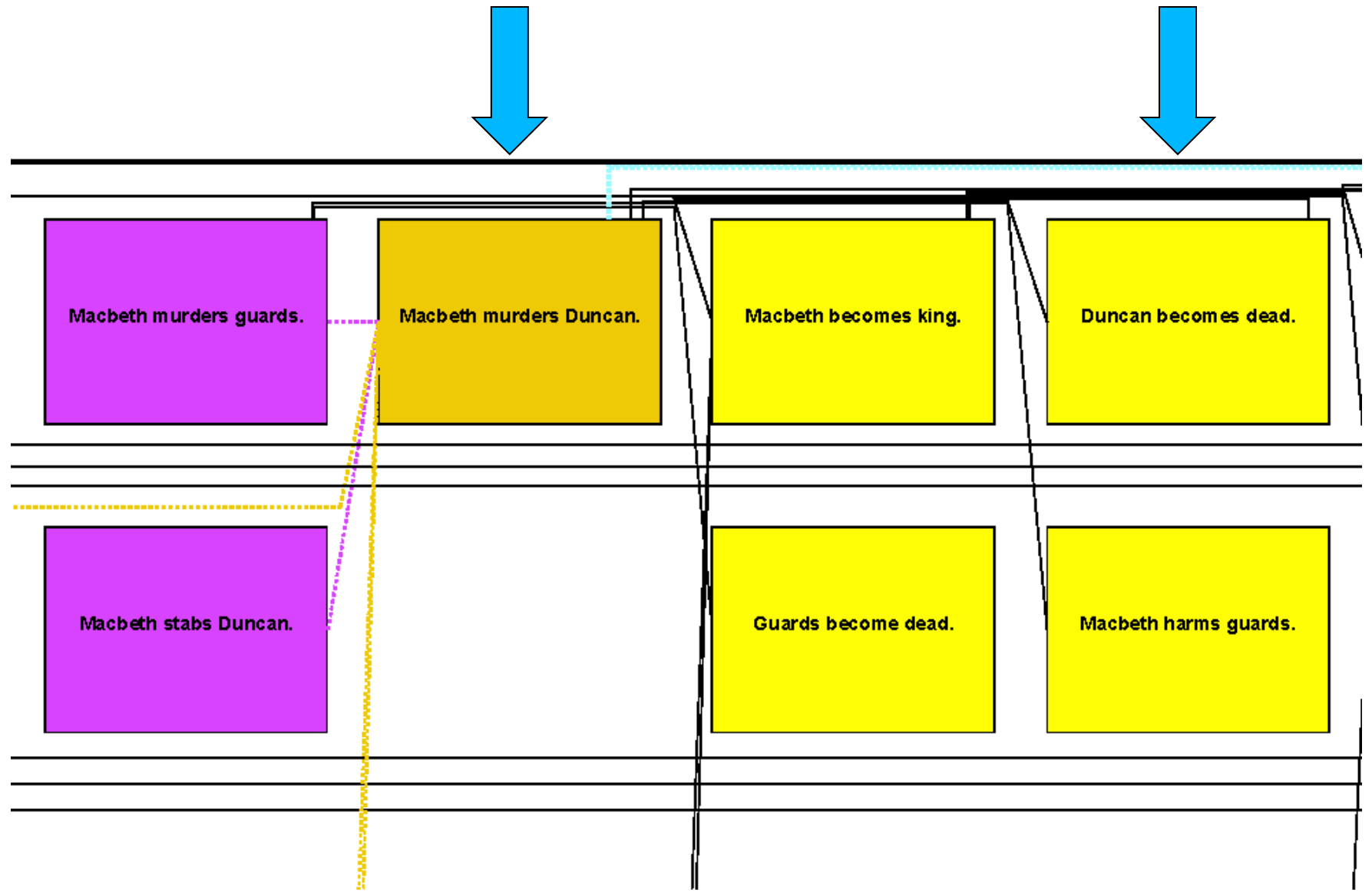
Macbeth's murdering Duncan **leads to** Macduff's  
fleeing to England

**Strangely**, Macbeth's murdering Duncan **leads to**  
Macbeth's hallucinating.

Macduff kills Macbeth; Macduff celebrates.

**In order to** murder Duncan, Macbeth kills guards  
and stabs Duncan.

# Macbeth





# Pyrrhic victory concept

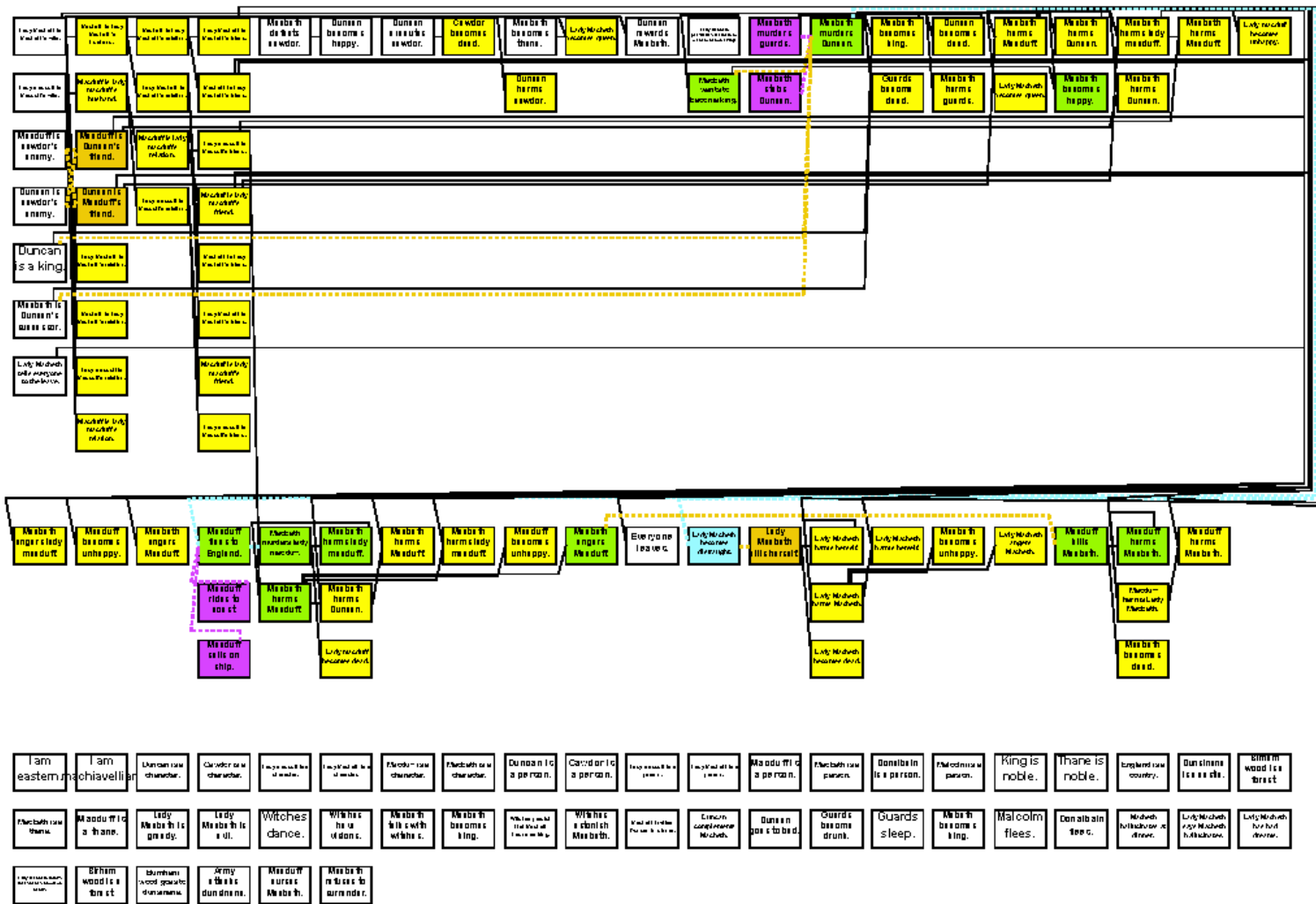
xx and yy are entities. aa is an action.

xx's wanting aa leads to xx's becoming happy.

xx's wanting aa leads to yy's harming xx.

# Macbeth/revenge

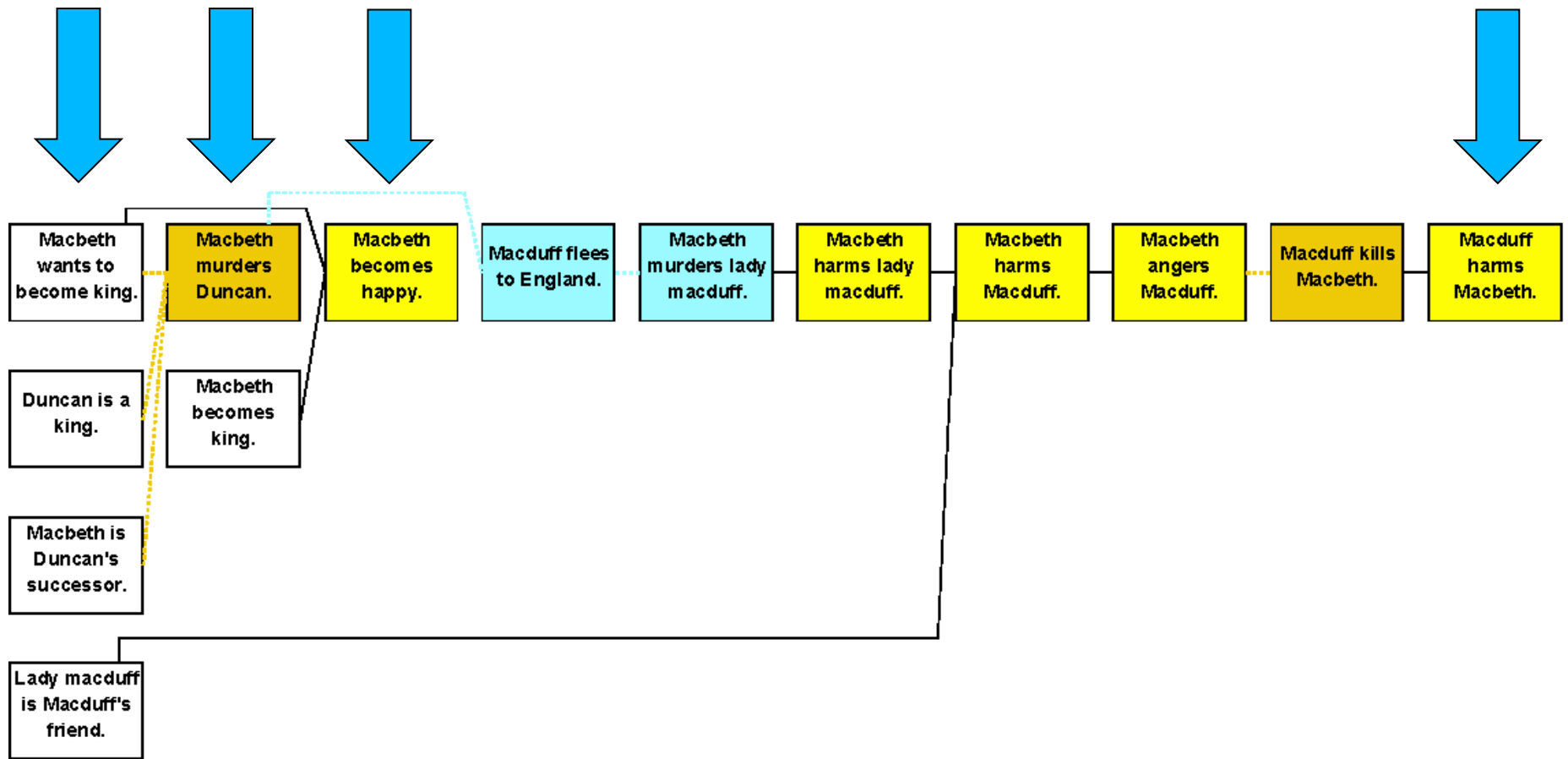
Rules: 39  
 Inferences: 70  
 Concepts: 14  
 Discoveries: 9  
 Explicit elements: 68  
 Inferred elements: 46  
 Total elements: 114  
 Story reading time: 2.8 sec  
 Total time elapsed: 5.1 sec



Analysis

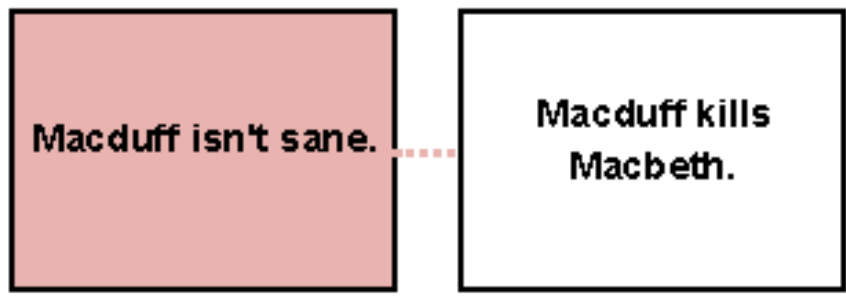
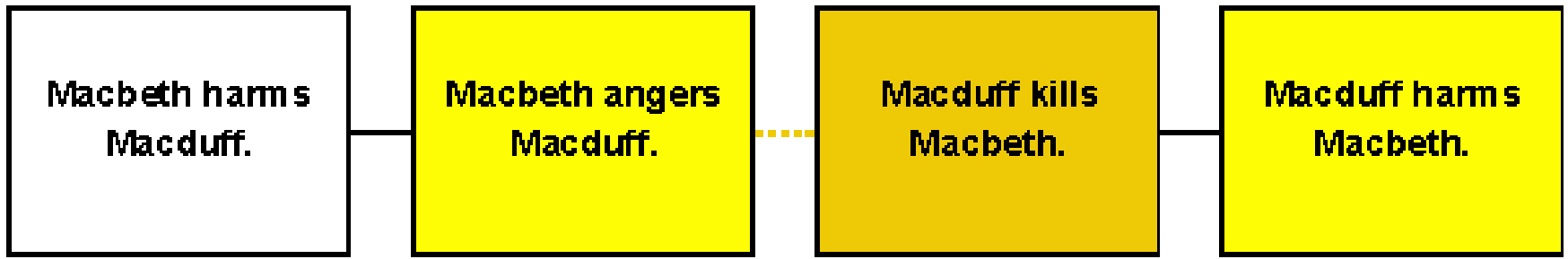
|         |         |                 |                        |                        |                        |                 |                        |         |
|---------|---------|-----------------|------------------------|------------------------|------------------------|-----------------|------------------------|---------|
| Revenge | Success | Answered prayer | Mistake because unh... | Mistake because har... | Mistake because har... | Pyrrhic victory | <b>Pyrrhic victory</b> | Suicide |
|---------|---------|-----------------|------------------------|------------------------|------------------------|-----------------|------------------------|---------|

100%



- Understanding from multiple points of view
- Concept-based comparison and retrieval
- Gap filling via precedent alignment
- Sensitivity to personality traits
- Reader-aware instructive story telling
- Concept discovery via story merging
- Summary via conceptual content
- Persuasive story telling
- Character-driven story composition
- Question driven embellishment
- Self-aware processing

# Macbeth, two cultures



# Estonia-Russia, two points of view



**Estonia is my  
friend.**

**Russia is my  
friend.**

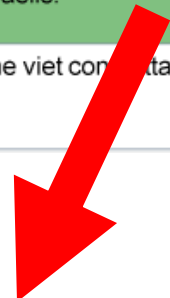


# Gap filling

- The USA knew the Viet Cong were preparing to attack the USA.
- The USA knew the USA would defeat the Viet Cong.
- The USA knew the Viet Cong knew the USA would defeat the Viet Cong.
- The USA believed the Viet Cong would not attack the USA.
- The Viet Cong attacked the USA.
- The Israelis knew the Egyptians were preparing to attack the Israelis.
- The Israelis knew the Israelis would defeat the Egyptians.
- The Israelis knew the Egyptians knew the Israelis would defeat the Egyptians.
- The Israelis believed the Egyptians would not attack the Israelis.
- ?

|   |  |  |  |                                |
|---|--|--|--|--------------------------------|
| The Israelis know the Egyptians prepare to attack them. | The Israelis know to defeat the Egyptians. | The Israelis know that the Egyptians know they defeat the Egyptians. | The Israelis believe the Egyptians not to attack them. | ---                            |
| The USA knows that the viet cong prepares to attack it. | The USA knows to defeat the viet cong.     | ---  | The USA believes the viet cong not to attack it.       | The viet cong attacks the USA. |

|  |  |  |  |                                    |
|--|--|--|--|------------------------------------|
| The Israelis know that the Egyptians prepare to attack them. | The Israelis know to defeat the Egyptians. | The Israelis know that the Egyptians know they defeat the Egyptians. | The Israelis believe the Egyptians not to attack them. | The Egyptians attack the Israelis. |
| The USA knows that the viet cong prepares to attack it.      | The USA knows to defeat the viet cong.     | The USA knows that the viet cong knows it defeats the viet cong.     | The USA believes that the viet cong doesn't attack it. | The viet cong attacks the USA.     |



The USA knows that the viet cong knows it defeats the viet cong.

The Egyptians attack the Israelis

Duncan is a person. Lady Macbeth is a person. Macduff is a person. Macbeth is a person. A thane is a noble. Macbeth is a thane. Macduff is a thane. Lady Macbeth is greedy. Macbeth defeats a rebel. Appear is a success. Macbeth has a success. Witches talk with Macbeth. Witches have visions. Duncan rewards Macbeth because Duncan becomes happy. Macbeth wants to become king because Lady Macbeth persuades Macbeth to want to become king.

**Duncan becomes dead because  
because Person x becomes dead  
whenever Person y kills person x.**

# Persuasion

**Woodcutter works for long hours. Woodcutter doesn't have enough food for whole family...**

~~...Woodcutter becomes ashamed because Woodcutter is a bad provider.~~

~~In order to lead children into forest, woodcutter lies...~~

**...Woodcutter becomes relieved because children are safe...**

**...Woodcutter wants to help children...**

**...Woodcutter tells truth to children about plan...**

**Woodcutter works for long hours. Woodcutter doesn't have enough food for whole family...**

~~...Woodcutter becomes ashamed because Woodcutter is a bad provider.~~

~~In order to lead children into forest, woodcutter lies...~~

**...Woodcutter becomes relieved because children are safe...**

**...Woodcutter wants to help children...**

**...Woodcutter tells truth to children about plan...**

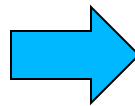
**In order to survive, witch needs to eat Humans...**

**Witch tricks children. Witch traps Hansel in cage. Witch traps Gretel in cage.**

Macbeth is a thane and Macduff is a thane. Lady Macbeth is evil and greedy. Duncan is the king, and Macbeth is Duncan's successor. Duncan is an enemy of Cawdor. Macduff is an enemy of Cawdor. Duncan is Macduff's friend. Macbeth defeated Cawdor. Duncan becomes happy because Macbeth defeated Cawdor. The witches danced and had visions. Macbeth talks with the witches. The witches predicted that Macbeth will become king. The witches astonish Macbeth. Duncan executes Cawdor. Macbeth becomes Thane of Cawdor. Duncan rewarded Macbeth because Duncan became happy. Macbeth wants to become king because Lady Macbeth persuaded Macbeth to want to become the king. Macbeth invites Duncan to dinner. Duncan complements Macbeth. Duncan goes to bed. Duncan's guards become drunk and sleep. In order to murder Duncan, Macbeth murders the guards and Macbeth stabs Duncan. Macbeth becomes king. Malcolm and Donalbain flee. Macbeth's murdering Duncan leads to Macduff's fleeing to England. In order to flee to England, Macduff rides to the coast and Macduff sails on a ship. Then, Macduff's fleeing to England leads to Macbeth's murdering Lady Macduff. Macbeth hallucinates at a dinner. Lady Macbeth says he hallucinates often. Everyone leaves because Lady Macbeth tells everyone to leave. Macbeth's murdering Duncan leads to Lady Macbeth's becoming distraught. Lady Macbeth has bad dreams. Lady Macbeth thinks she has blood on her hands. Lady Macbeth kills herself. Birnam Wood is a forest. Burnham Wood goes to Dunsinane. Macduff's army attacks Dunsinane. Macduff curses Macbeth. Macbeth refuses to surrender. Macduff kills Macbeth. The end.



Macbeth is a thane and Macduff is a thane. Lady Macbeth is evil and greedy. Duncan is the king, and Macbeth is Duncan's successor. Duncan is an enemy of Cawdor. Macduff is an enemy of Cawdor. Duncan is Macduff's friend. Macbeth defeated Cawdor. Duncan becomes happy because Macbeth defeated Cawdor. The witches danced and had visions. Macbeth talks with the witches. The witches predicted that Macbeth will become king. The witches astonish Macbeth. Duncan executes Cawdor. Macbeth becomes Thane of Cawdor. Duncan rewarded Macbeth because Duncan became happy. Macbeth wants to become king because Lady Macbeth persuaded Macbeth to want to become the king. Macbeth invites Duncan to dinner. Duncan complements Macbeth. Duncan goes to bed. Duncan's guards become drunk and sleep. In order to murder Duncan, Macbeth murders the guards and Macbeth stabs Duncan. Macbeth becomes king. Malcolm and Donalbain flee. Macbeth's murdering Duncan leads to Macduff's fleeing to England. In order to flee to England, Macduff rides to the coast and Macduff sails on a ship. Then, Macduff's fleeing to England leads to Macbeth's murdering Lady Macduff. Macbeth hallucinates at a dinner. Lady Macbeth says he hallucinates often. Everyone leaves because Lady Macbeth tells everyone to leave. Macbeth's murdering Duncan leads to Lady Macbeth's becoming distraught. Lady Macbeth has bad dreams. Lady Macbeth thinks she has blood on her hands. Lady Macbeth kills herself. Birnam Wood is a forest. Burnham Wood goes to Dunsinane. Macduff's army attacks Dunsinane. Macduff curses Macbeth. Macbeth refuses to surrender. Macduff kills Macbeth. The end.



The story is about Pyrrhic victory. Lady Macduff was Macduff's wife. Macbeth wanted to become king because Lady Macbeth persuaded Macbeth to want to become king. Macbeth murdered Duncan, probably because Duncan was a king and Macbeth was Duncan's successor. Macduff fled to England. Macbeth killed Lady Macduff. Macduff killed Macbeth, probably because Macbeth angered Macduff.



Self-conscious reflection

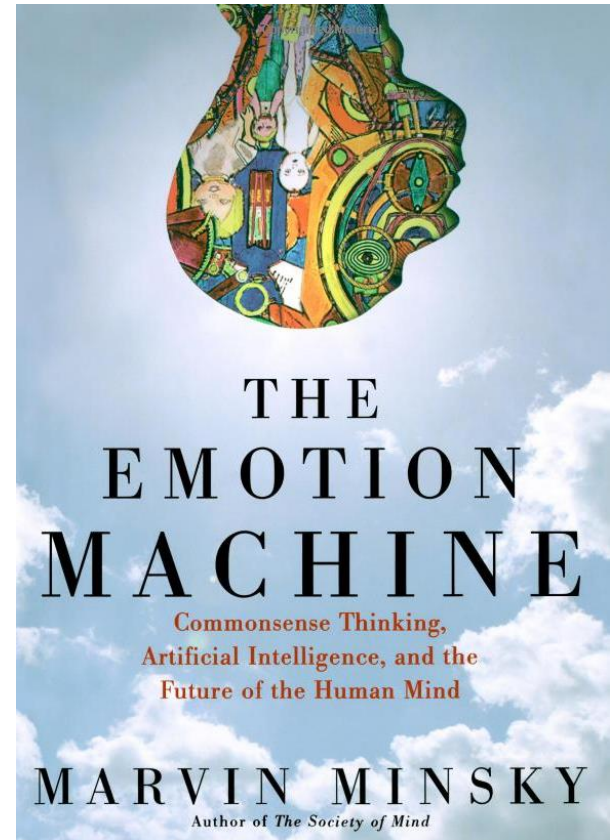
Self-reflective thinking

Reflective thinking

Deliberative thinking

Learned reactions

Instinctive reactions



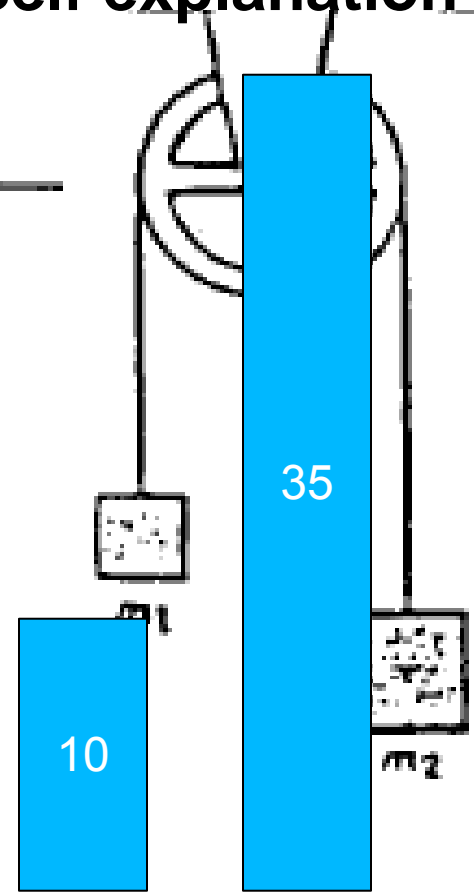
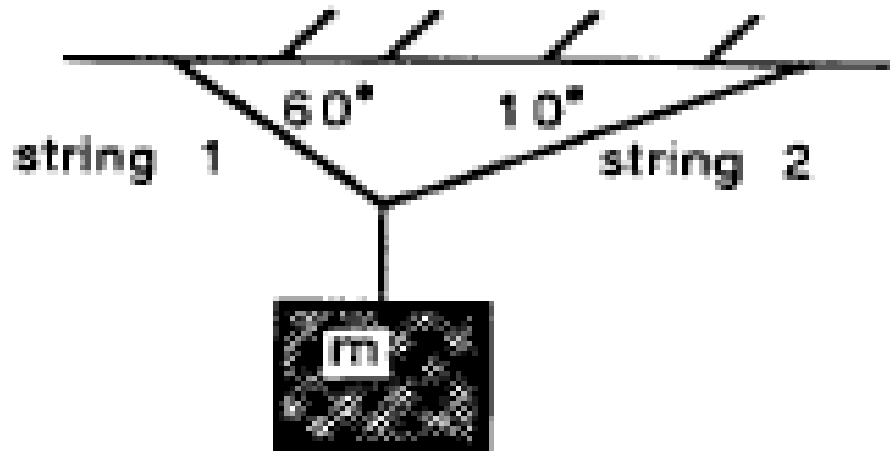
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# The social animal hypothesis

We talk to each other.

We talk to ourselves.

# Self explanation



**Worst**

**Best**

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# The Directed Perception Hypothesis

The mechanisms that enable us humans to direct and hallucinate with our perceptual faculties separate our intelligence from that of other primates.



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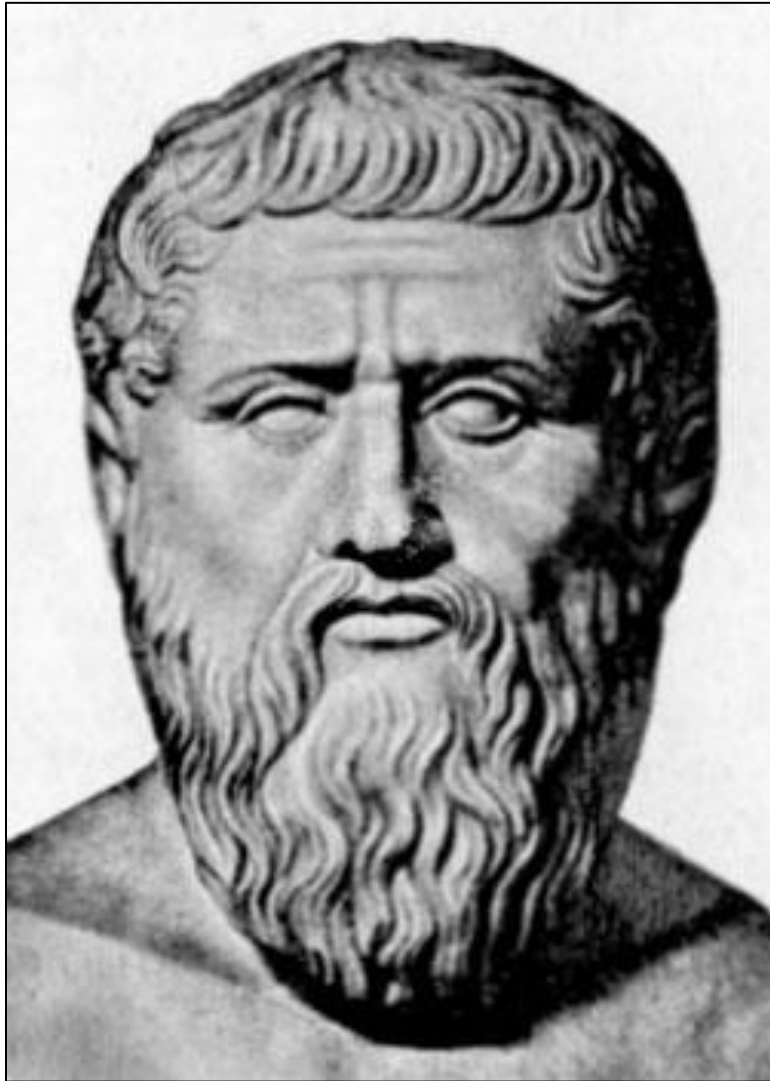
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|                 |                |                 |                |                |                 |
|-----------------|----------------|-----------------|----------------|----------------|-----------------|
| <b>Approach</b> | <b>Carry</b>   | <b>Dig</b>      | <b>Fall</b>    | <b>Give</b>    | <b>Hit</b>      |
| <b>Lift</b>     | <b>Push</b>    | <b>Run</b>      | <b>Touch</b>   | <b>Arrive</b>  | <b>Catch</b>    |
| <b>Drop</b>     | <b>Flee</b>    | <b>Go</b>       | <b>Hold</b>    | <b>Move</b>    | <b>Put down</b> |
| <b>Snatch</b>   | <b>Turn</b>    | <b>Attach</b>   | <b>Chase</b>   | <b>Enter</b>   | <b>Fly</b>      |
| <b>Hand</b>     | <b>Kick</b>    | <b>Open</b>     | <b>Raise</b>   | <b>Stop</b>    | <b>Walk</b>     |
| <b>Bounce</b>   | <b>Close</b>   | <b>Exchange</b> | <b>Follow</b>  | <b>Haul</b>    | <b>Jump</b>     |
| <b>Pass</b>     | <b>Receive</b> | <b>Take</b>     | <b>Bury</b>    | <b>Collide</b> | <b>Exit</b>     |
| <b>Get</b>      | <b>Have</b>    | <b>Leave</b>    | <b>Pick up</b> | <b>Replace</b> | <b>Throw</b>    |



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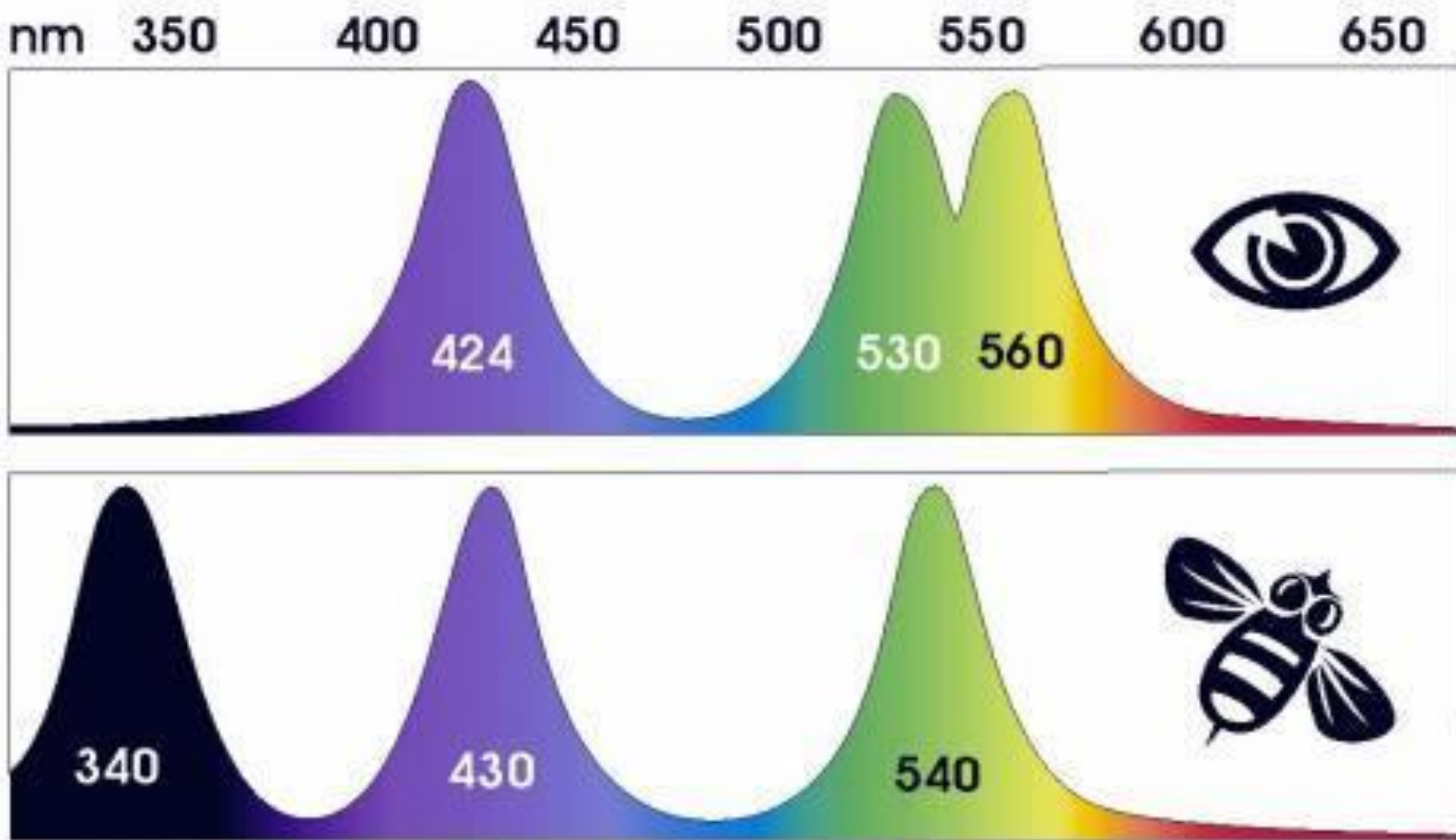
Can a machine think without a  
perceptual system?



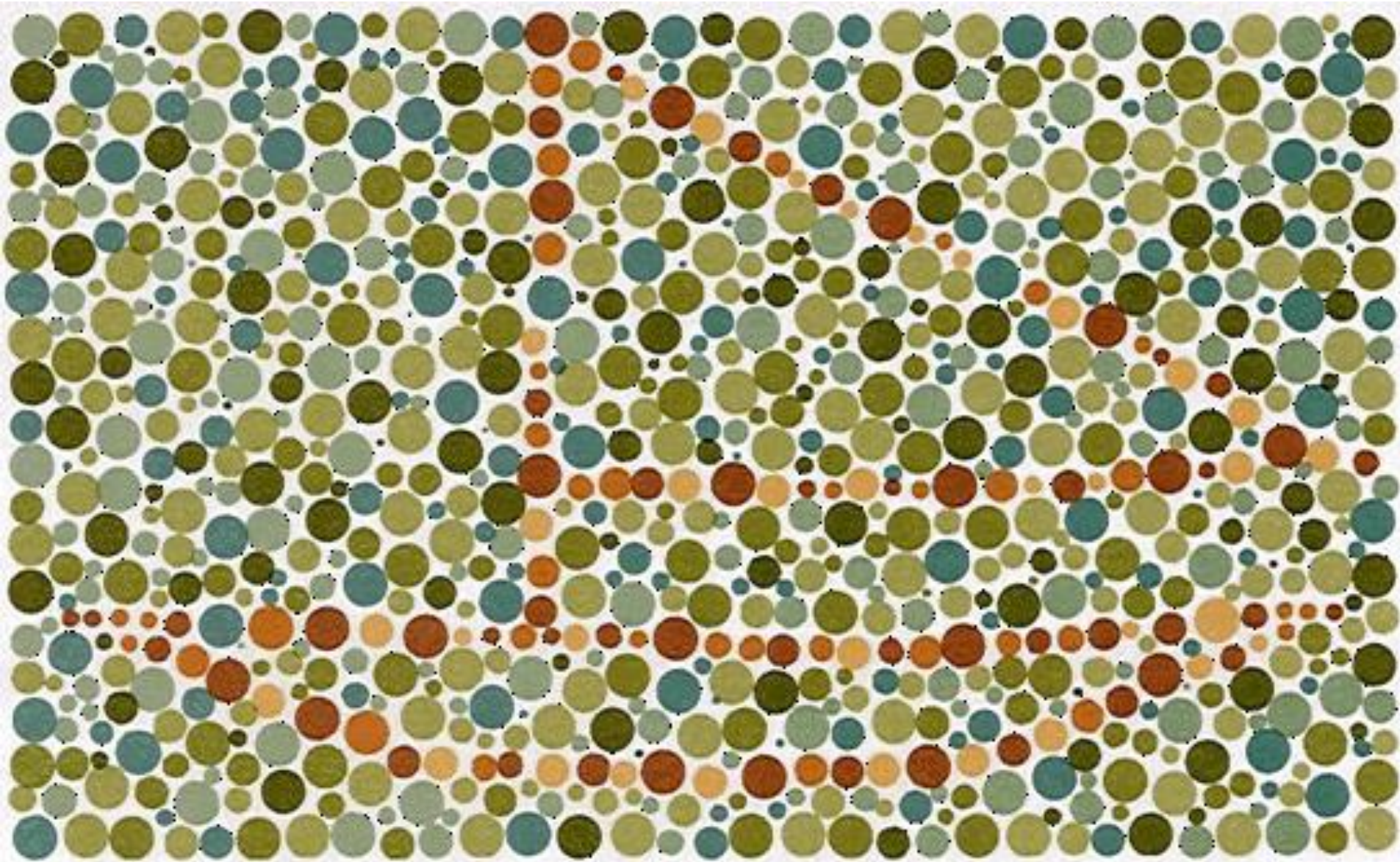
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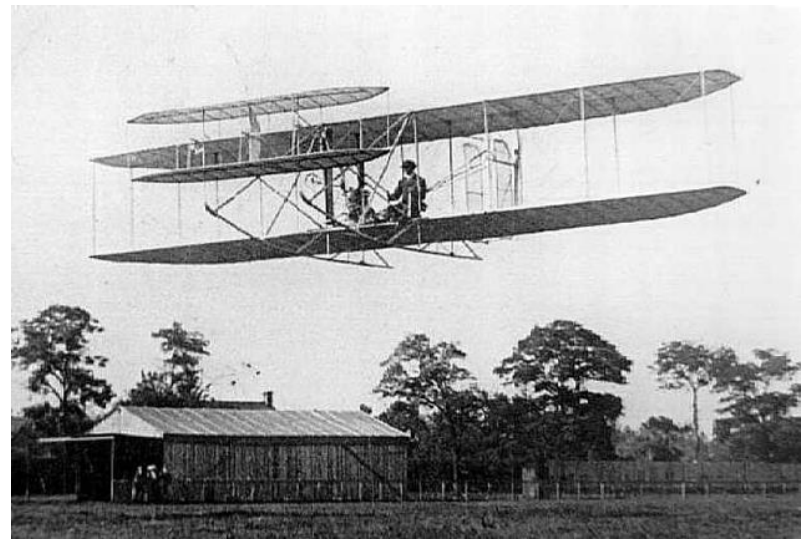
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Do we care about the science if  
all we want is the application?





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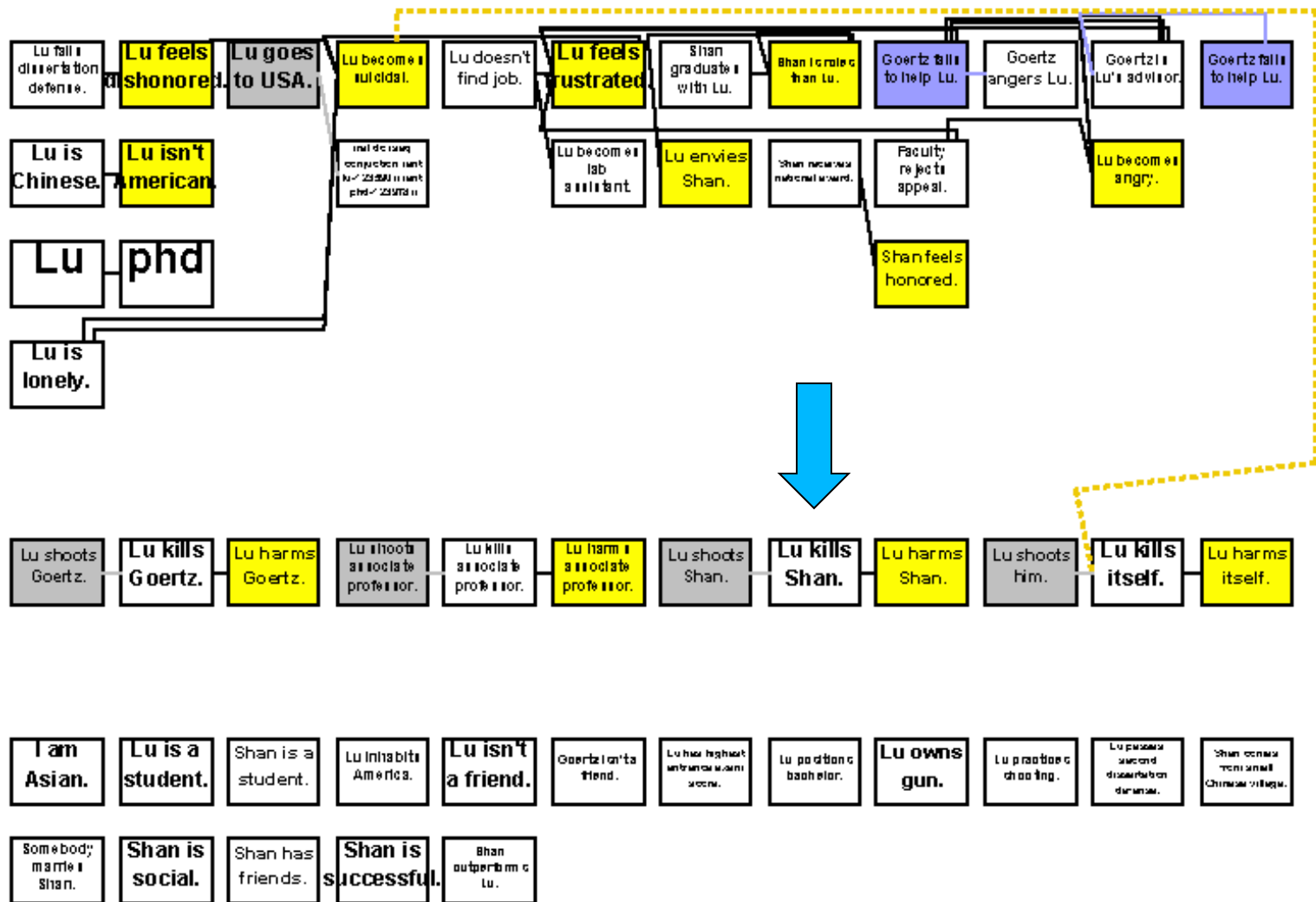


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What are the dangers?  
What can we do to lessen them?

Lu is a student. Shan is a student. Lu inhabits America. Lu fails his dissertation defense. Goertz is Lu's advisor. Goertz and Lu are not friends. Lu is Chinese. Lu went to US to do PhD. Lu had highest entrance exam score. Lu is a bachelor. Lu is lonely. Lu owns a gun. Lu practices shooting. Lu passes his second dissertation defense. Lu becomes a lab assistant because Lu does not find a job. Shan is younger than Lu. Shan graduates with Lu. Shan received national award. Faculty rejected Lu's appeal. Goertz angers Lu. Shan comes from a small Chinese village. Shan is married. Shan is social. Shan has friends. Shan is successful. Shan outperforms Lu. In order to kill Goertz, Lu shoots Goertz. In order to kill associate professor Lu shoots associate professor. In order to kill Shan, Lu shoots Shan. In order to kill Lu, Lu shoots himself.

# Lu murder story/eastern





**Dr. Jekyll, on reflection, believes America is individualistic which enables him to believe Lu kills Shan.**

**Mr. Hyde, on reflection, does not believe America is individualistic and therefore cannot believe that Lu kills Shan because America is individualistic**

## Introspection

- I ask myself whether Lu kills Shan because America is individualistic
- I ask myself whether America is individualistic
- I believe America is individualistic because I am Asian
- I add that America is individualistic to Lu murder story/eastern
- I ask myself whether I think that America's being individualistic leads to Lu's killing Shan
- I think that America's being individualistic leads to Lu's killing Shan
- The path goes from "America is individualistic" via "America is corrupt" via "Lu becomes corrupt" via "Lu becomes murderous" to "Lu kills Shan"
- I conclude that Lu kills Shan because America is individualistic because I think that America's being individualistic leads to Lu's killing Shan

## Commentary

**Did Lu kill Shan because America is individualistic?**

Be kind, resourceful, beautiful, friendly, have initiative, have a sense of humour, tell right from wrong, make mistakes, fall in love, enjoy strawberries and cream, make some one fall in love with it, learn from experience, use words properly, **be the subject of its own thought**, have as much diversity of behaviour as a man, do something really new.



Will it fly?  
Maybe best to simulate first...



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# Key questions revisited

- Why has AI made so little progress?
- How can we make progress now?
- Can a computer be really smart without a perceptual system
- Should engineers care about how natural intelligence works?
- What are the dangers of AI and what should we do about them?

# Contributions

- Suggested answers to the key questions
- Framed key hypotheses
- Championed methodological steps
- Implemented the Genesis System
- Demonstrated conceptual analysis, cultural influence, taking sides, gap filling, listener aware telling, persuasive telling, concept-based retrieval ... so far

**Human intelligence must be understood**

MIT OpenCourseWare  
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Resource: Brains, Minds and Machines Summer Course  
Tomaso Poggio and Gabriel Kreiman

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