

# UNCONVENTIONAL APPROACHES TO AI

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# INSIGHTS FROM THE PAST

- UNCONVENTIONAL APPROACHES IN AI: COMPLEX SYSTEMS PERSPECTIVES, COGNITIVE PSYCHOLOGY, SOCIAL SCIENCES, COMPUTATIONAL MODELS OF CREATIVITY AND OTHER UNCONVENTIONAL MODELS
- THIS IS AI OR CLASSICAL AI BEFORE BIG DATA. THE TIME IS NOW RIPE TO REVISIT THESE WONDERFUL IDEAS AND THINK ABOUT HOW TO INCORPORATE THEM IN MODERN AI/DEEP LEARNING. INSIGHTS FROM THE PAST CAN INFORM FUTURE APPROACHES TO AI, ESPECIALLY IN THE AGE OF BIG DATA.
- LOOKING AT THE HERITAGE OF COMPUTING AND ITS INTERDISCIPLINARY PAST CAN INSPIRE NEW APPROACHES FOR THE FUTURE. WE NEED TO LEARN LESSONS FROM THE HISTORY OF AI, WHAT APPROACHES WORKED AND DID NOT WORK IN THE PAST AND HOW AI WENT THROUGH MULTIPLE WINTERS.
- THESE APPROACHES CAN BE USED TO DEVELOP TECHNIQUES THAT CAN INSPIRE EXPLAINABLE AI.

# INSIGHTS FROM THE PAST

- UNCONVENTIONAL APPROACHES IN AI: COMPLEX SYSTEMS PERSPECTIVES, COGNITIVE PSYCHOLOGY, SOCIAL SCIENCES, COMPUTATIONAL MODELS OF CREATIVITY AND OTHER UNCONVENTIONAL MODELS
- NEUROSCIENCE (PERCEPTRONS)
- COGNITIVE PSYCHOLOGY

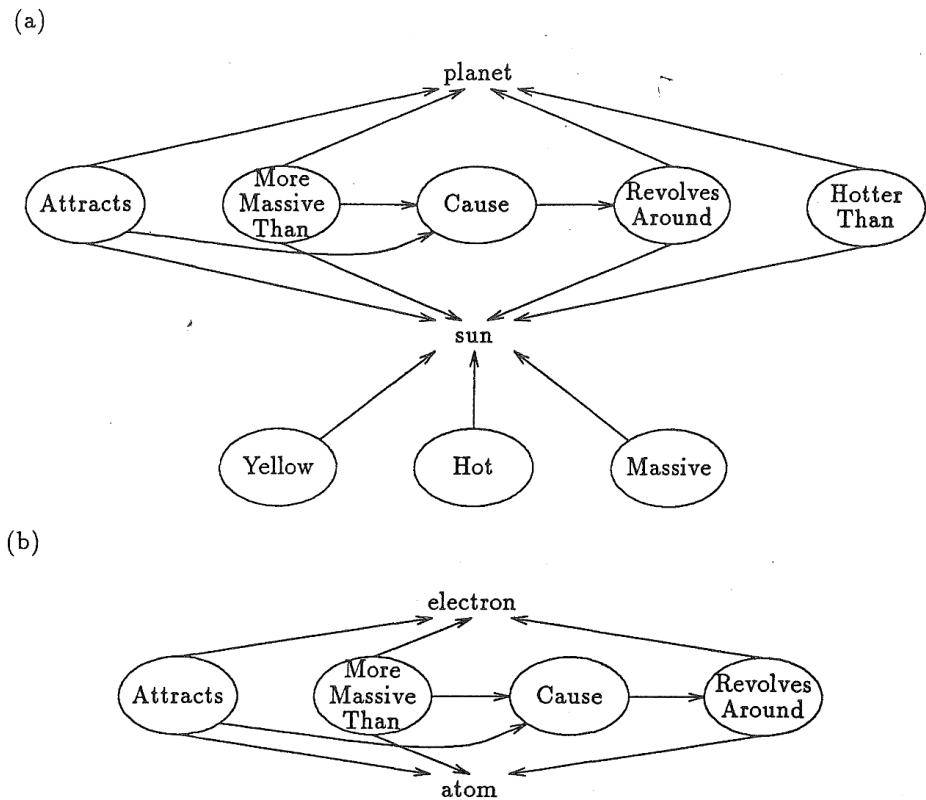
# APPROACHES

- NARRATIVES AND STORIES
  - HOW WE MAKE SENSE OF OUR COMPLEX ENVIRONMENT
- COMPUTATIONAL MODELS OF CREATIVITY AND INSIGHT
- CASE BASED REASONING
  - DOCTORS, LAWYERS
- ANALOGIES
- DREAMS
  - AID GENERALIZATION AND PREVENT OVERFITTING
- COMMONSENSE REASONING

# COMPUTATIONAL MODELS OF CREATIVITY AND INSIGHT

- WE ARE TOLD OF EUREKA MOMENTS (ARCHIMEDES, NEWTON, ...)
- IN REALITY WE ALWAYS BUILD ON THE WORK OF OTHERS
- THERE IS A PREPARATION STAGE
- INCUBATION STAGE
- RETRIEVAL/INDEXING (KEKULE DREAMING OF A SNAKE AND THEN LINKING IT TO BENZENE RINGS)

# ANALOGIES



**Figure 2.** Creating a representation for the atom from the statement, "The atom is like the solar system." Higher order relations are carried over and simple attributes are ignored.



### 1. In Search of the Bull

In the pasture of the world,  
I endlessly push aside the tall  
grasses in search of the Ox.  
  
Following unnamed rivers,  
lost upon the interpenetrating  
paths of distant mountains,  
My strength failing and my vitality  
exhausted, I cannot find the Ox.



### 2. Discovery of the Footprints

Along the riverbank under the  
trees,  
I discover footprints.  
  
Even under the fragrant grass,  
I see his prints.  
  
Deep in remote mountains they  
are found.  
  
These traces can no more be  
hidden  
than one's nose, looking  
heavenward. [\[web 8\]](#)



### 3. Perceiving the Bull

I hear the song of the nightingale.  
The sun is warm, the wind is mild,  
willows are green along the shore  
  
-  
  
Here no Ox can hide!  
What artist can draw that massive  
head,  
those majestic horns? [\[web 8\]](#)

# STORIES AND ANALOGIES

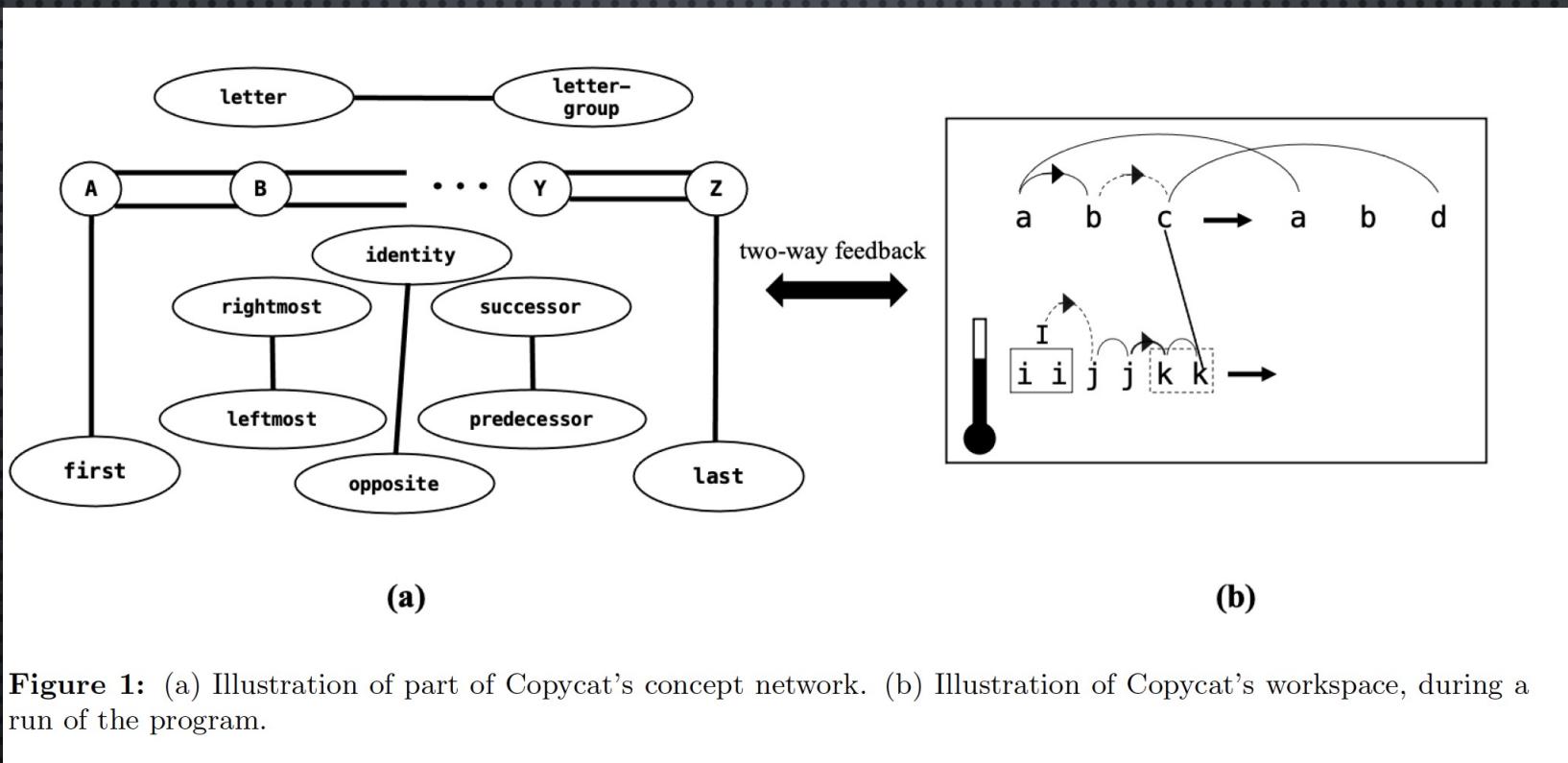
# APPROACHES

- EXPLAINABILITY (INSIGHTS FROM SOCIAL SCIENCES)
  - MILLER, 2019
- HOW DO YOU GENERATE EXPLAINABLE MODELS BY WORKING WITH DOMAIN EXPERTS
  - RUDIN, 2019
  - IMPORTANT FOR HIGH STAKES DECISIONS IN DOMAINS LIKE HEALTHCARE, RECIDIVISM PREDICTION
- CASE BASED REASONING
  - HOW HUMANS REASON
- WE CAN TAKE INSPIRATION FROM OTHER DISCIPLINES AND DEVELOP NEW XAI APPROACHES

# APPROACHES

- ABSTRACTION AND REASONING
- ABC -> ABD
- XYZ -> ?

# APPROACHES



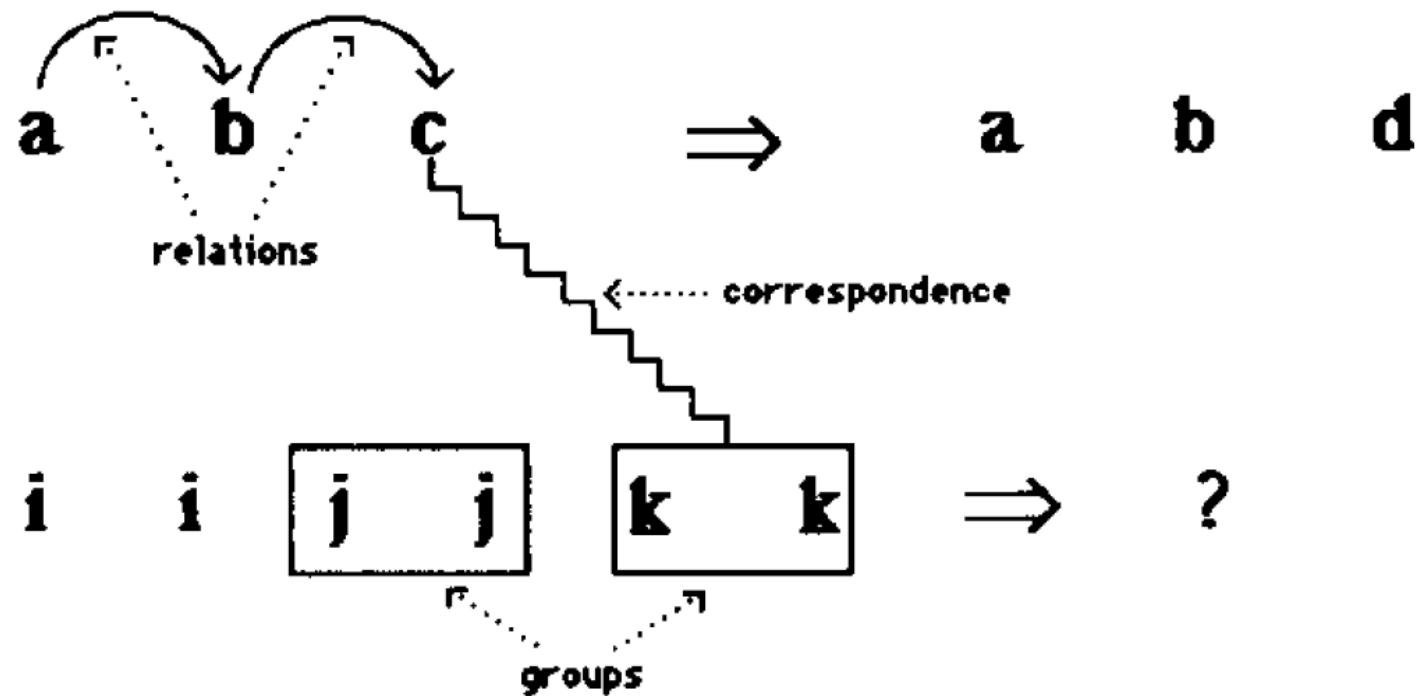
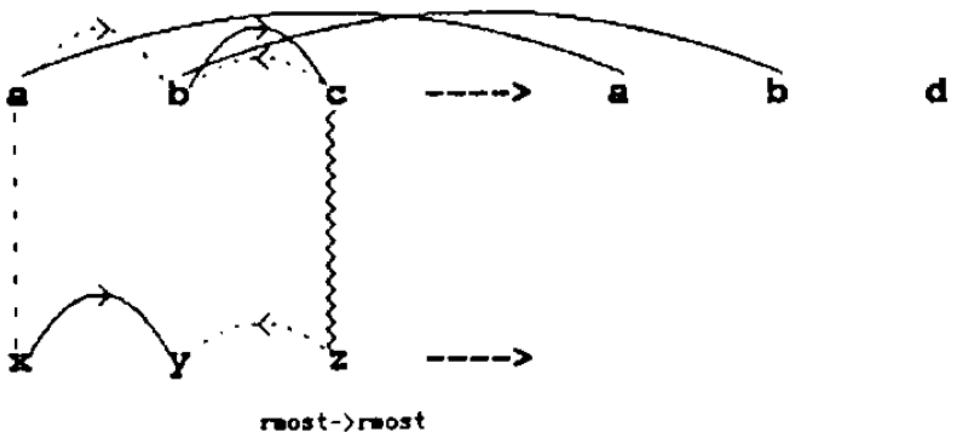


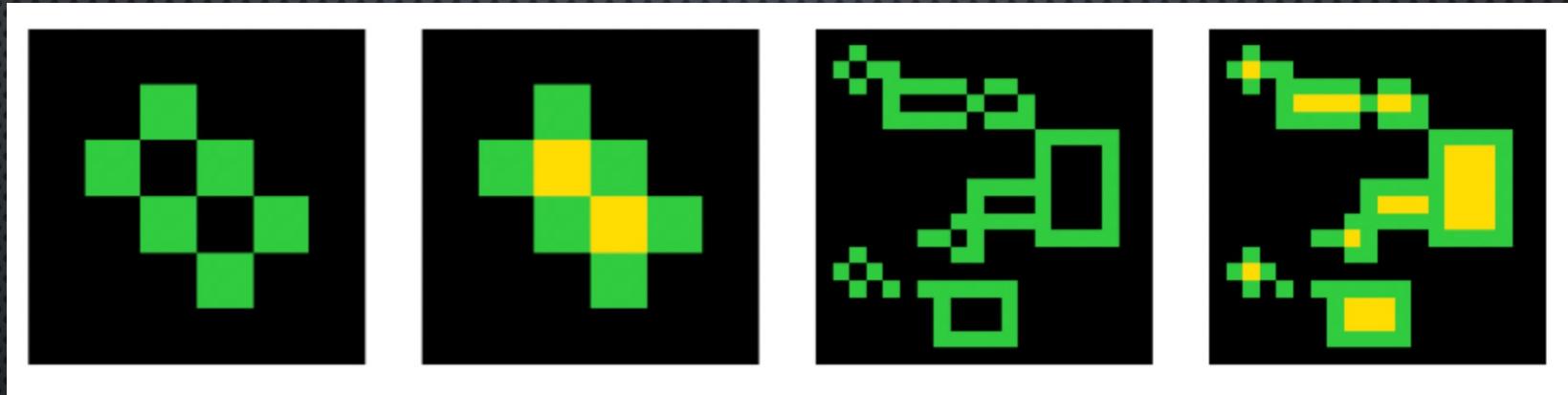
Fig. 2. Perceptual structures, including relations, groups, and a correspondence.

Fig. 2 shows examples of perceptual structures that could be built in the process of solving the problem “ $\textit{abc} \Rightarrow \textit{abd}$ ,  $\textit{iijjkk} \Rightarrow ?$ ”. The types of structures built by the program include *descriptions* of objects (e.g. the *C* in *abc* is the string’s *rightmost* letter), *relations* between objects (e.g. the *B* in *abc* is the *successor* of its left neighbor, the *A*), *groups* of objects (e.g., *jj* is a group of adjacent identical letters; the entire string *abc* could be seen as a group of adjacent letters that increase alphabetically), and *correspondences* between objects (e.g. the *C* in *abc* corresponds to the group *kk* in *iijjkk*). (See section 5 for examples of these structures in a run of the program.)



3. Some relations between letters within each string have been built and others continue to be considered. Copycat, unlike people, has no left-to-right or alphabetic-forwards biases, and in general is equally likely to perceive relations in either direction, although here, *successor* tends to be activated early when the **C**-to-**D** change is noticed, causing the system to tend to perceive the letters as having left-to-right successor relations rather than right-to-left predecessor relations. A correspondence between the **C** and the **Z** (jagged vertical line) has been built. Both letters are *rightmost* in their respective strings: this underlying concept mapping is displayed beneath the correspondence. In response to the growing amount of structure, the temperature has dropped to 76.

# NEW DATA



ABSTRACTION AND REASONING CORPUS

# STRUCTURE MAPPING ENGINE: ANALOGIES

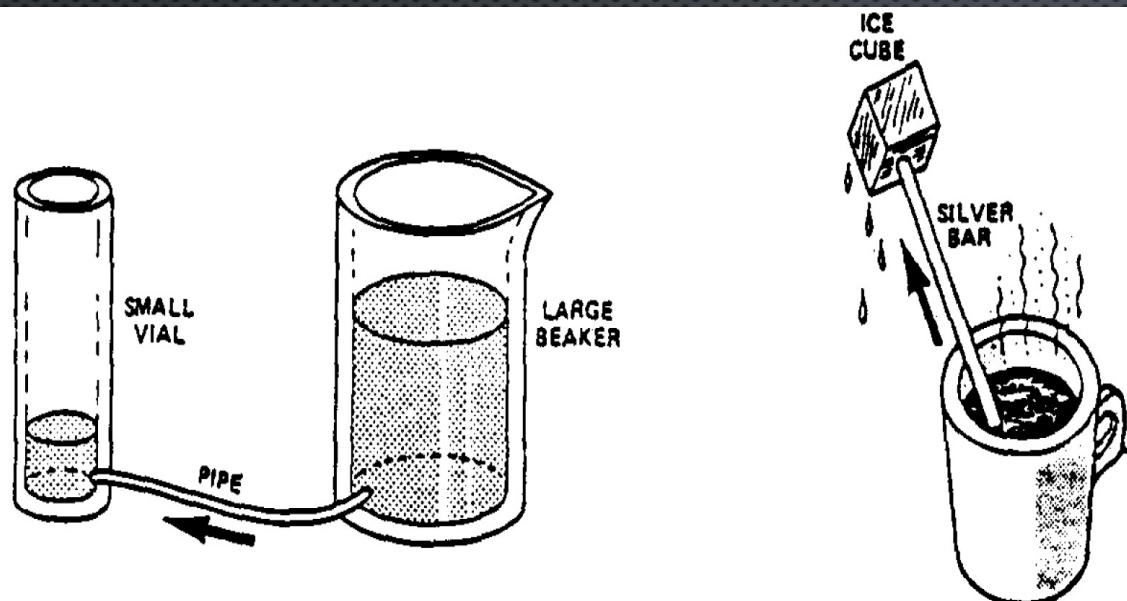


Fig. 1. Two physical situations involving flow (adapted from [3]).

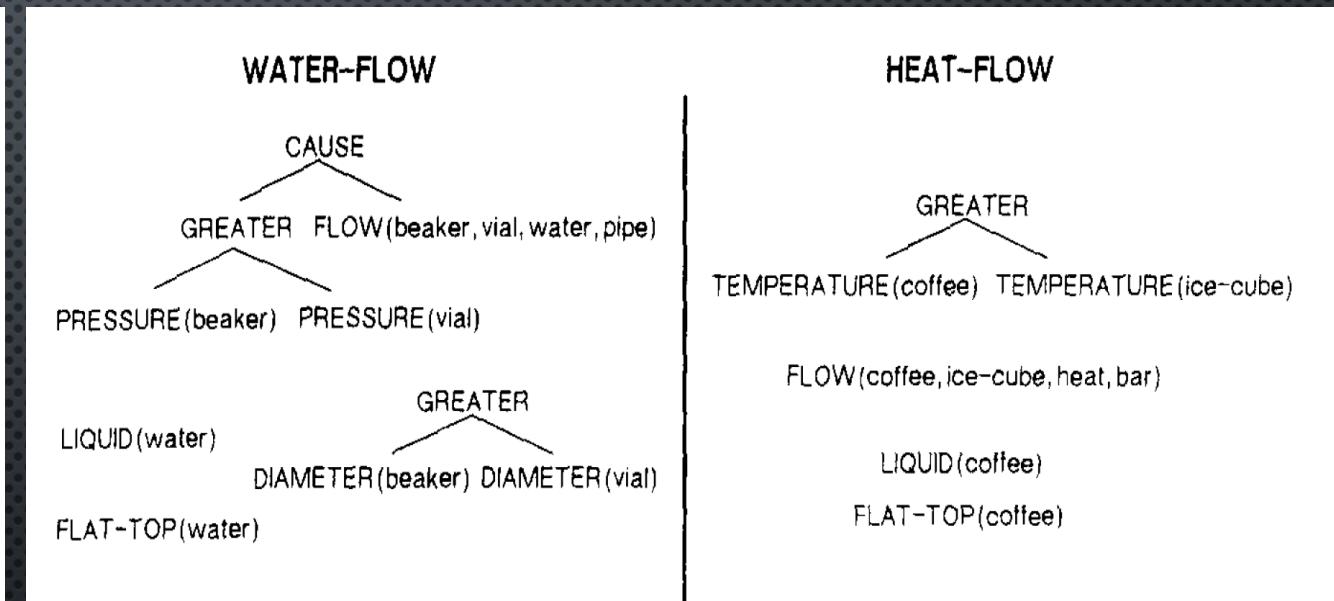


Fig. 2. Simplified water flow and heat flow descriptions.

# QUALITATIVE PROCESS MODELS

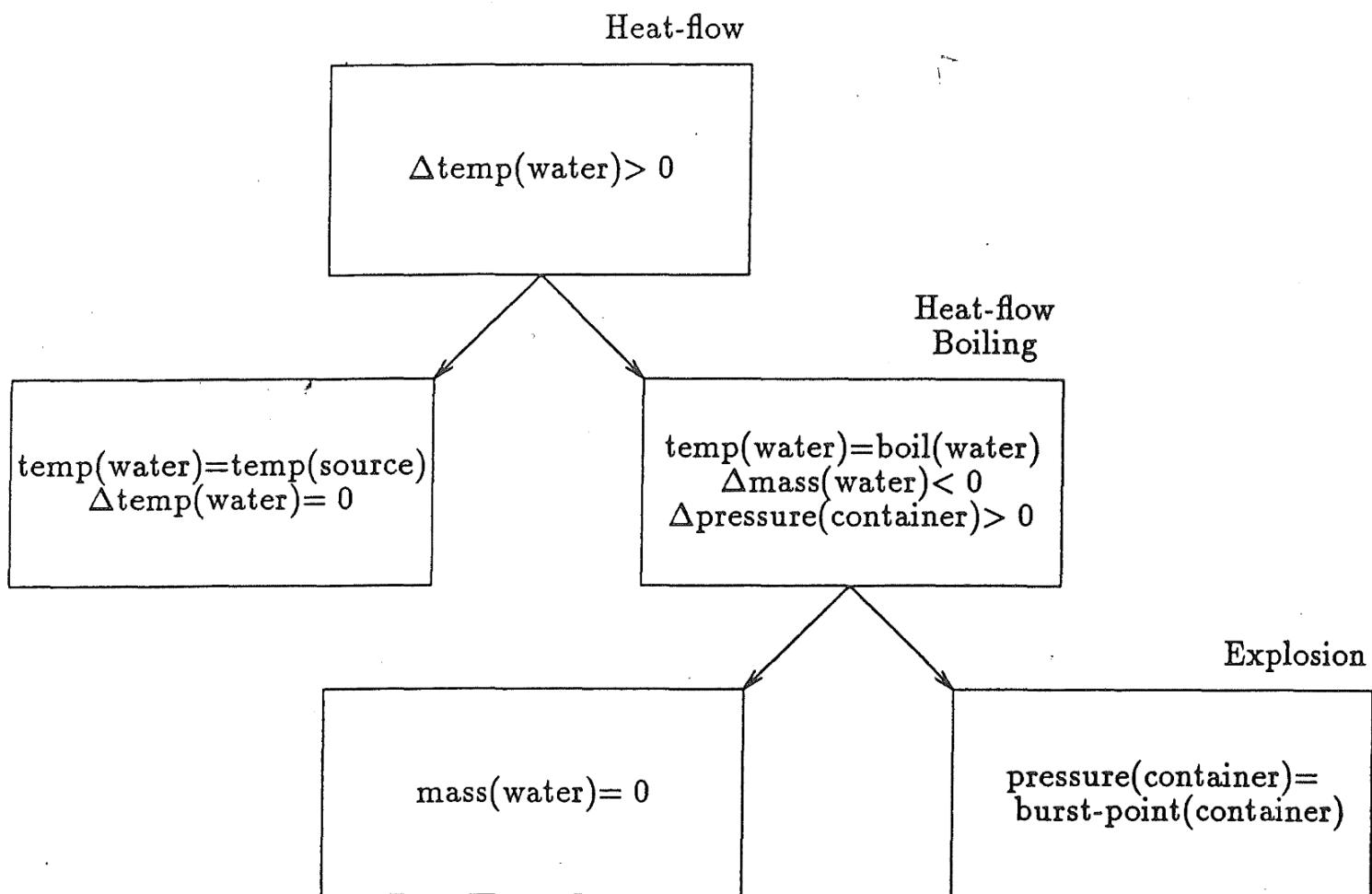


Figure 3. An envisionment for boiling water.

# COLLECTIVE INTELLIGENCE

- OTHER IDEAS
  - OTHER PATHS TO INTELLIGENCE (IN OTHER SPECIES)
  - COLLECTIVE INTELLIGENCE

# COLLECTIVE INTELLIGENCE

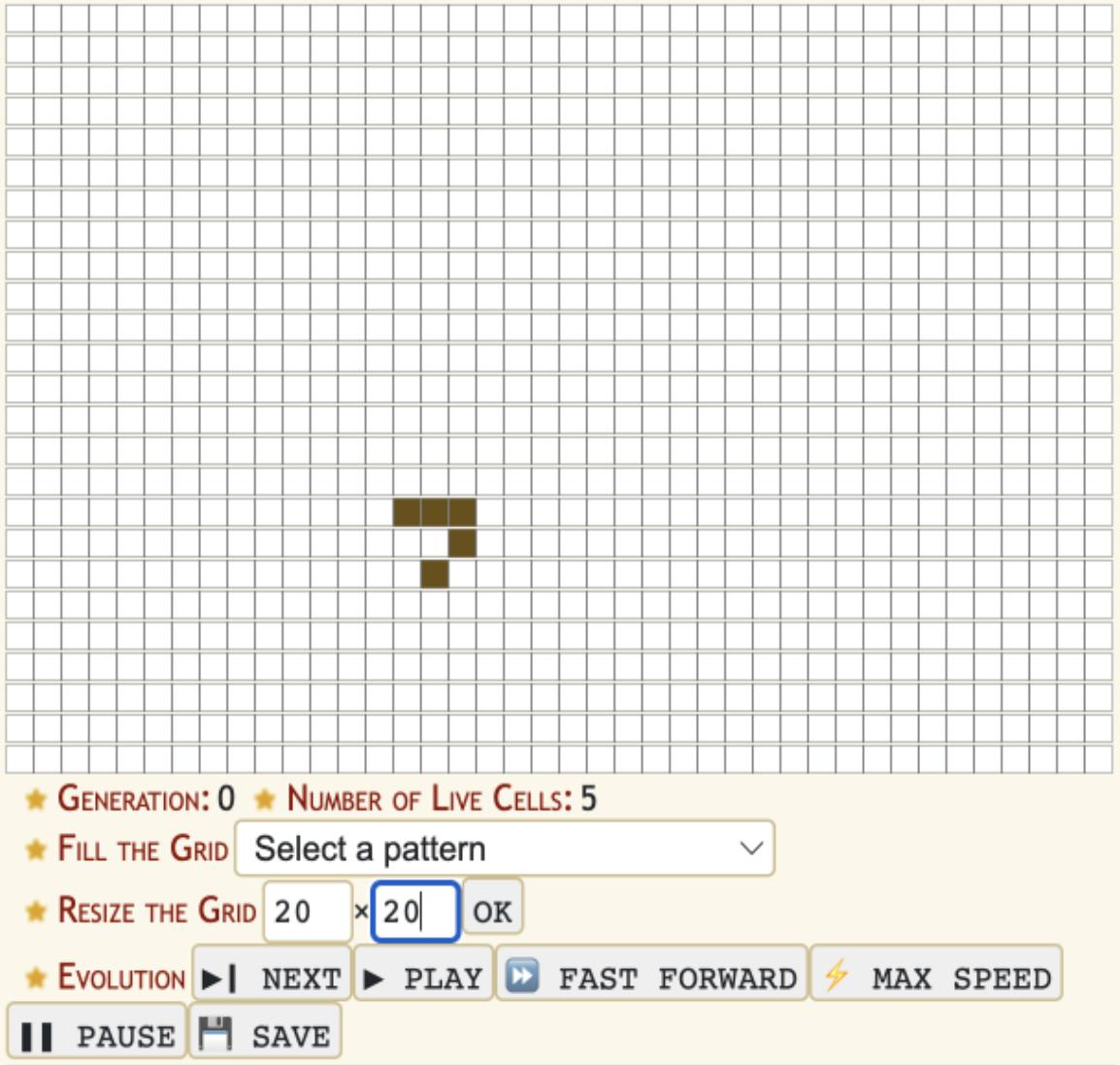
- TASK ALLOCATION AND DIVISION OF LABOUR
- COMPLEX NEST ARCHITECTURE
- STIGMERGY



MORPHOGENESIS OF TERMITE MOUNDS,  
PNAS, 2019

## THE GAME OF LIFE SIMULATOR

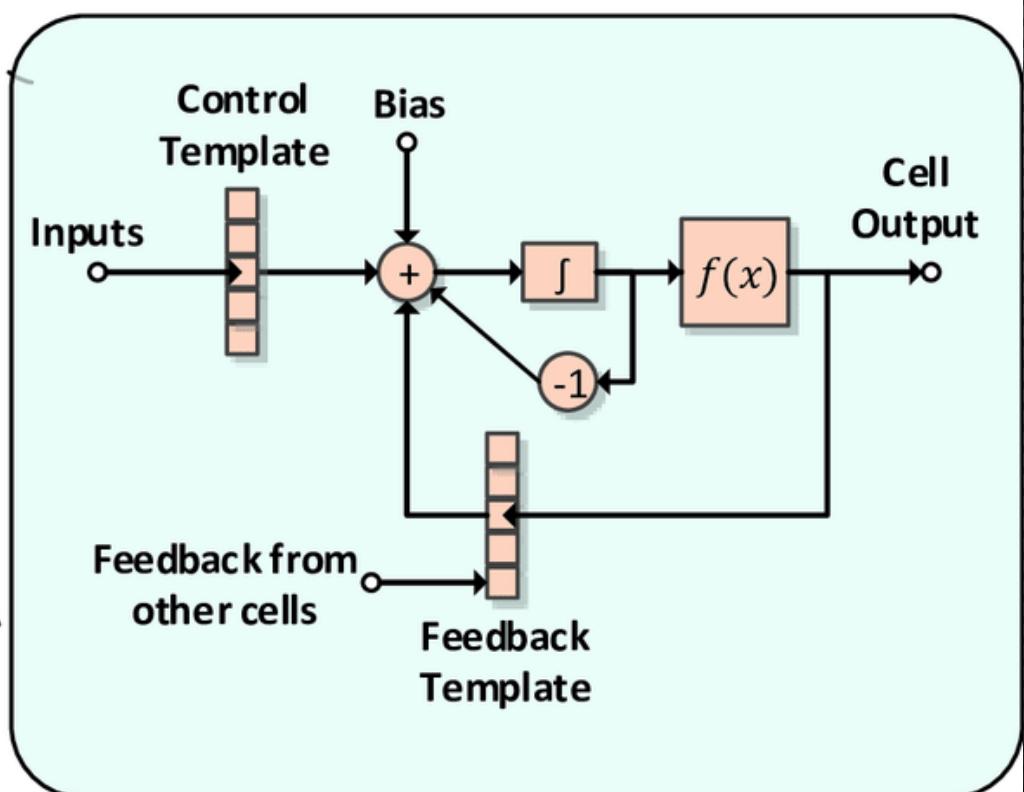
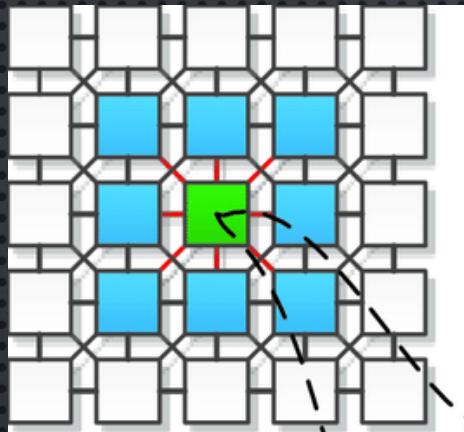
★ GRID FOR THE GAME OF LIFE



# COLLECTIVE INTELLIGENCE

- CELLULAR AUTOMATA
- IF A LIVING CELL IS TOO ISOLATED (0 OR 1 NEIGHBOR) THEN IT DIES THE NEXT EVOLUTION (DEATH BY UNDER-POPULATION).
- IF IT IS REASONABLY SURROUNDED (2 OR 3 NEIGHBORS) THEN IT REMAINS ALIVE, BUT WHAT IF IT IS SURROUNDED BY TOO MANY CELLS (4 OR MORE NEIGHBORS) IT DIES TO THE NEXT GENERATION (DEATH BY OVER-POPULATION).
- A CELL CAN ALSO BECOME A LIVE CELL IF A DEAD CELL IS SURROUNDED BY THREE LIVING CELLS, THEN IT BECOMES ALIVE (BIRTH BY REPRODUCTION).

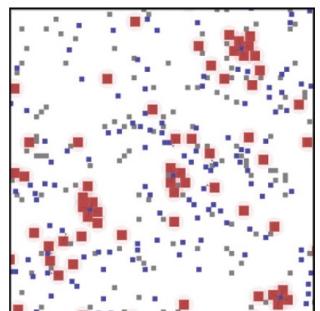
# COLLECTIVE INTELLIGENCE



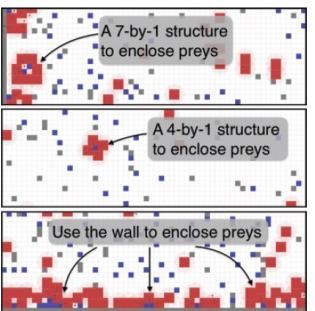
- CELLULAR NEURAL NETWORKS
- INSPIRATIONS FOR NOVEL DEEP LEARNING ALGORITHMS
- *COLLECTIVE INTELLIGENCE FOR DEEP LEARNING: A SURVEY OF RECENT DEVELOPMENTS*

SOFT RADIAL BASIS CELLULAR NEURAL NETWORK (SRB-CNN) BASED ROBUST LOW-COST TRUCK DETECTION USING A SINGLE PRESENCE DETECTION SENSOR, 2016

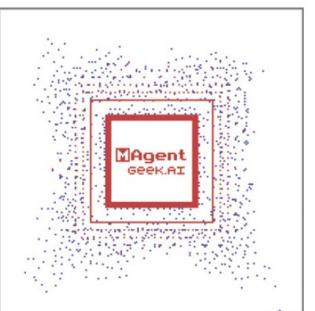
# COLLECTIVE INTELLIGENCE



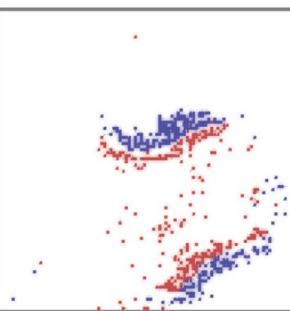
(a) Pursuit (1)



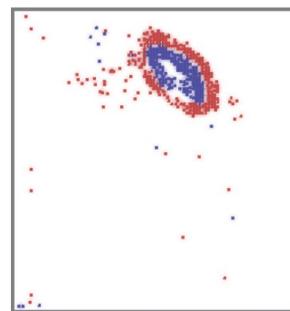
(b) Pursuit (2)



(c) Gathering

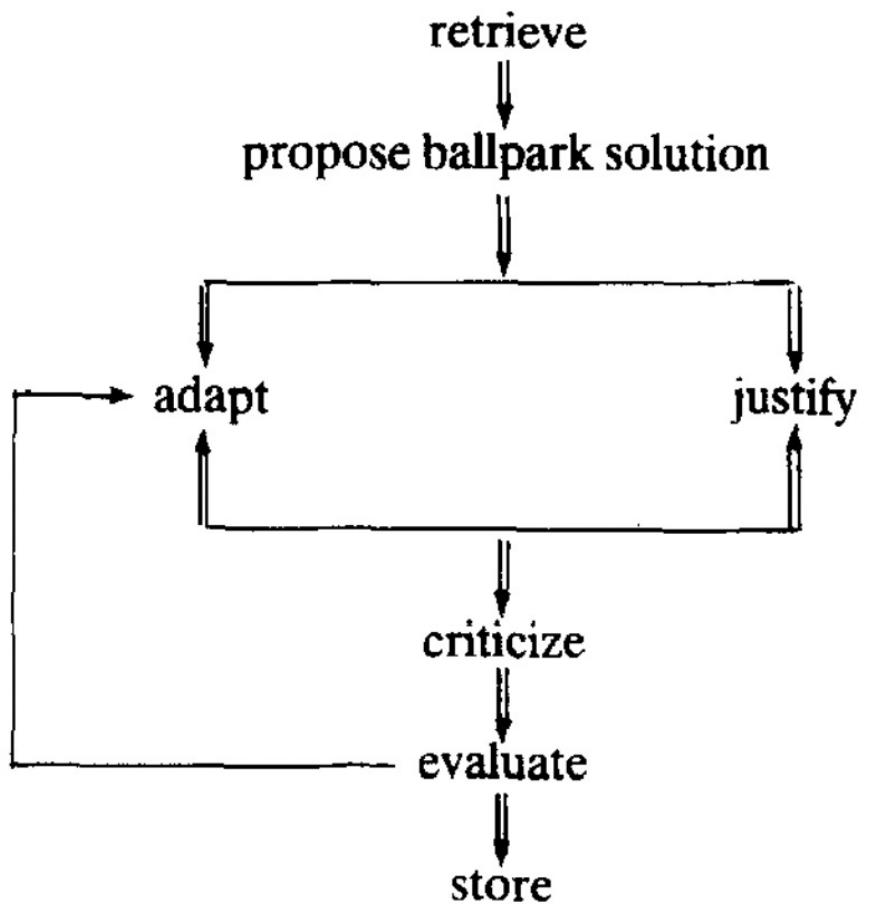


(d) Battle (1)



(e) Battle (2)

- GRID WORLD
- MILLIONS OF AGENTS
- EVOLUTION OF CO-OPERATION, COMPETITION, ALTRUISM AND OTHER STRATEGIES



*Fig. 1.* The case-based reasoning cycle.

# CASE BASED REASONING

- HOW HUMANS REASON
- DOCTORS, LAWYERS, ...

AN INTRODUCTION TO CASE BASED REASONING, JANET KOLODNER, 1992

# APPROACHES

- NARRATIVES AND STORIES (PATRICK WINSTON)
  - HOW WE MAKE SENSE OF OUR COMPLEX ENVIRONMENT
- DREAMS
  - AID GENERALIZATION AND PREVENT OVERFITTING
- COMMONSENSE REASONING (DAVIS, MARCUS)

# STORY UNDERSTANDING

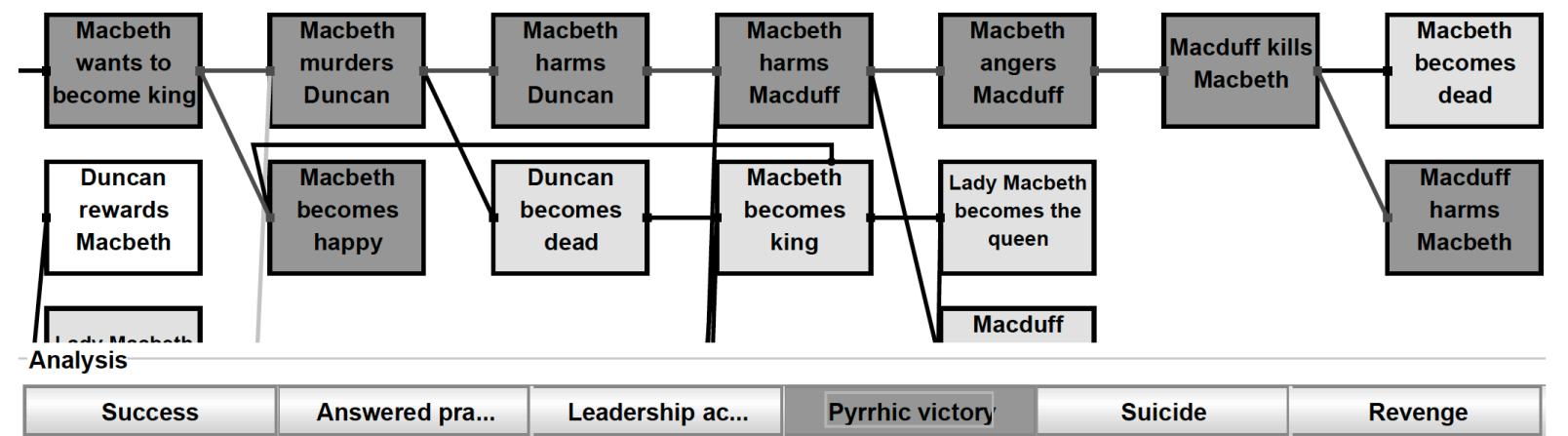


Figure 2: Genesis's story understanding system uses the elaboration graph, together with reflection patterns, to augment the explicit knowledge provided in the story and simple inferences generated using commonsense rules. Here, Genesis discovers a Pyrrhic victory, shown in dark gray.

# RESOURCES

- [HTTPS://GITHUB.COM/NEELSOUMYA/SPECIAL\\_TOPICS\\_UNCONVENTIONAL\\_AI](https://github.com/NEELSOUMYA/SPECIAL_TOPICS_UNCONVENTIONAL_AI)

# ADMINISTRIVIA

- PRESENTATIONS

- PRESENT AND LEAD A DISCUSSION ON ONE OF THESE PAPERS (OR ANY OTHER RELATED PAPER: COME SPEAK WITH ME).
- THE IDEA IS THAT YOU RAISE SOME INTERESTING QUESTIONS.
- THIS COURSE IS MEANT TO TEACH YOU RESEARCH SKILLS (LIKE THINKING CRITICALLY ABOUT A PAPER, LITERATURE REVIEW SKILLS, WRITING).

# ADMINISTRIVIA

- WRITEUP/REPORT
  - ON THE PAPER YOU PRESENT, AND THE TOPIC IN GENERAL (UNCONVENTIONAL AI).
  - DO A LITERATURE REVIEW OF OTHER PAPERS IN THE FIELD.
  - REFLECT/WRITE ON HOW THESE TECHNIQUES CAN BE INCORPORATED IN MODERN AI/DEEP LEARNING.
  - THE INTENTION IS FOR YOU TO
    - LEARN HOW TO READ PAPERS
    - COMPARE AND CONTRAST THEM TO OTHER PAPERS
    - THEN THINK WHAT THIS MEANS FOR MODERN AI/DEEP LEARNING.
  - SHOW ME DRAFTS

# ADMINISTRIVIA

- WRITEUP/REPORT
  - SHORT REPORT (LESS THAN 4000 WORDS). THE IDEA IS WRITE A COHERENT NARRATIVE.
  - SUGGEST HOW THESE IDEAS CAN BE INCORPORATED IN MODERN AI/DEEP LEARNING SYSTEMS
  - WHY DO YOU THINK THESE IDEAS WERE NOT SUCCESSFUL IN THE 1950s/1960s?
  - WHAT KIND OF DATA WOULD WE NEED TO ENSURE THESE TECHNIQUES WOULD WORK TODAY?
  - WHAT LESSONS CAN WE LEARN FROM THE HISTORY OF AI, WHAT APPROACHES WORKED AND DID NOT WORK IN THE PAST?
  - WHAT COULD BE THE DISADVANTAGES OF THESE APPROACHES?
  - RATIONAL RECONSTRUCTION (ANALYTICAL LITERATURE REVIEW/SURVEY) OF A RESEARCH AREA
- OTHER THOUGHTS ON THE WRITEUP
  - A DETAILED RESEARCH PROPOSAL WITH SOME GROUND WORK ALREADY ACCOMPLISHED

# ADMINISTRIVIA

- HOW TO READ PAPERS

- [HTTPS://WWW.CS197.SEAS.HARVARD.EDU/](https://www.cs197.seas.harvard.edu/)
- [HTTPS://DOCS.GOOGLE.COM/DOCUMENT/D/1bPhwNdCCKkm1\\_ADD0rx1YV6r2JG98qYMTxUTT5GDAdQ/E  
DIT#HEADING=H.YXLVJ6BO3Y2](https://docs.google.com/document/d/1bPhwNdCCKkm1_ADD0rx1YV6r2JG98qYMTxUTT5GDAdQ/edit#heading=h.yxlvj6bo3y2)
- READ WIDELY AND THEN FOCUS ON A FEW PAPERS
- TAKE MULTIPLE PASSES THROUGH PAPERS

# ADMINISTRIVIA

- HOW TO WRITE
  - WRITE REGULARLY
  - SCHEDULE TIME FOR WRITING
  - [HTTPS://SITES.GOOGLE.COM/SITE/NEELSOUMYA/RESEARCH-RESOURCES/SCIENTIFIC-WRITING](https://sites.google.com/site/neelsoumya/research-resources/scientific-writing)
  - [HTTPS://WWW.YOUTUBE.COM/WATCH?V=DEVJXINR5WK](https://www.youtube.com/watch?v=DEVjXINr5Wk)
  - BOOK ON WRITING (CONTACT ME TO BORROW A COPY)
    - *HOW TO WRITE A LOT: A GUIDE TO PRODUCTIVE ACADEMIC WRITING* (PAUL SILVIA)

# ADMINISTRIVIA

- PICK PAPERS AND ASSIGNED READING
  - DATES AND NAMES
  - WE ALL READ PAPERS BEFORE THE CLASS
  - CLASS PARTICIPATION
    - PREPARE A QUESTION BEFOREHAND



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I hear the song of the nightingale.  
The sun is warm, the wind is mild,  
willows are green along the shore

-

Here no Ox can hide!  
What artist can draw that massive  
head,  
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