Cognitive Agent for Rapid Explanation, Analysis, and Sourcing Online (Cogent REASON)

Gheorghe Tecuci

Learning Agents Center, Department of Computer Science
School of Computing, College of Engineering and Computing, George Mason University
tecuci@gmu.edu, http://lac.gmu.edu

Instructable Cognitive Agents

The prevailing approach to the development of knowledge-based agents is through knowledge acquisition from a subject matter expert and representing this knowledge into the agent's knowledge base, which is a form of programming. This is a *long, difficult*, and *error-prone process*.
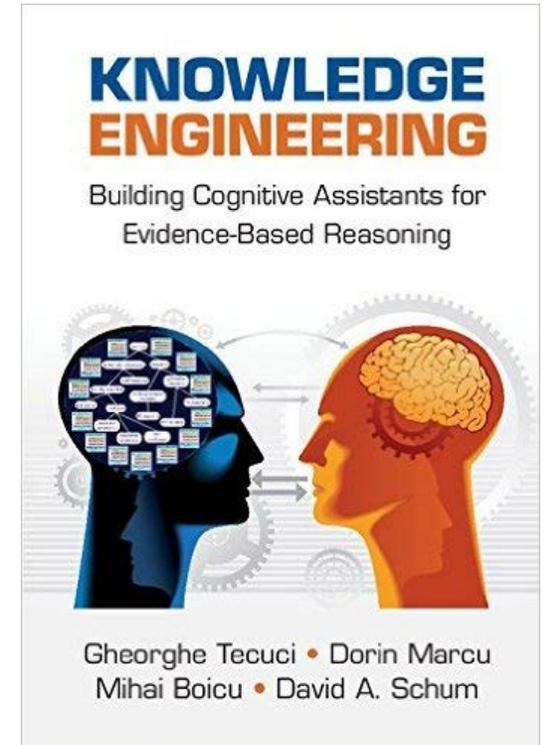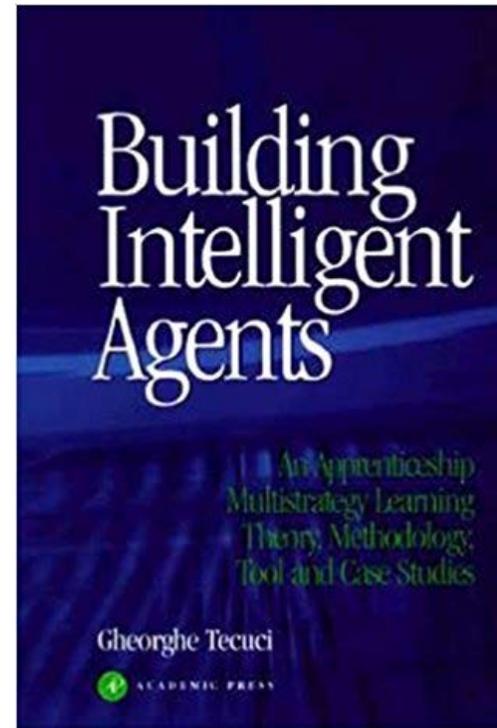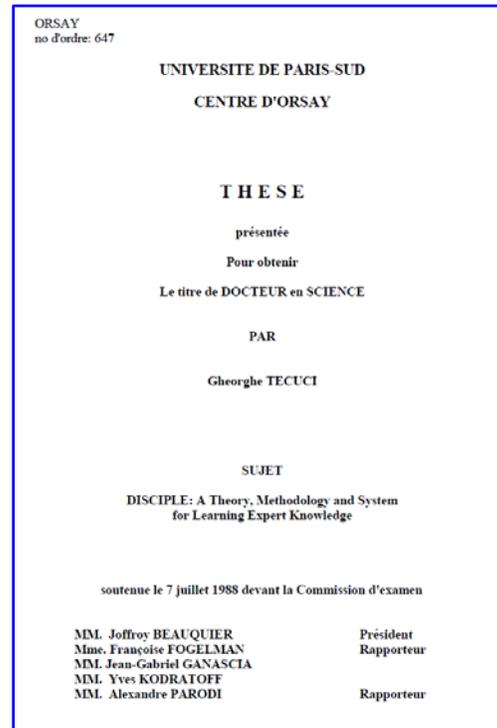
Agent Instruction researches the development of agents through teaching them as we teach students, rather than programming them.

Tecuci G., DISCIPLE: A Theory, Methodology and System for Learning Expert Knowledge,*These de Docteur en Science*, University of Paris-Sud, 1988.

Tecuci G., "BUILDING INTELLIGENT AGENTS: An Apprenticeship Multistrategy Learning Theory, Methodology, Tool and Case Studies", San Diego: Academic Press, 1998.

Tecuci, G., Marcu, D., Boicu, M., Schum, D.A., Knowledge Engineering: Building Cognitive Assistants for Evidence-based Reasoning, Cambridge University Press, 2016.

Intelligence Analysis

Tecuci, G., Schum, D.A., Marcu, D., Boicu, M. (2016). Intelligence Analysis as Discovery of Evidence, Hypotheses, and Arguments: Connecting the Dots, Cambridge University Press.

Tecuci G., Schum D.A. (2023). *Critical Thinking for Intelligence Analysis: Connecting the Dots*.

Tecuci, G., Marcu, D. (2021). A Framework for Deep Anticipatory Intelligence Analysis, *The 2021 AAAI Fall Symposium "Cognitive Systems for Anticipatory Thinking - 3rd Wave Autonomy",* Arlington, VA, Nov. 4-6.

Tecuci G., *Critical Thinking: A Gentle Introduction* (12 short lessons), 95 slides, 3 October, 2022.

Tecuci G., *Critical Thinking Practicum* (exercises with solutions), 93 slides, 7 October, 2022.

INTELLIGENCE ANALYSIS AS DISCOVERY OF EVIDENCE, HYPOTHESES, AND ARGUMENTS
CONNECTING THE DOTS
Gheorghe Tecuci • David A. Schum • Dorin Marcu • Mihai Boicu
CAMBRIDGE

Critical Thinking for Intelligence Analysis *Connecting the Dots*
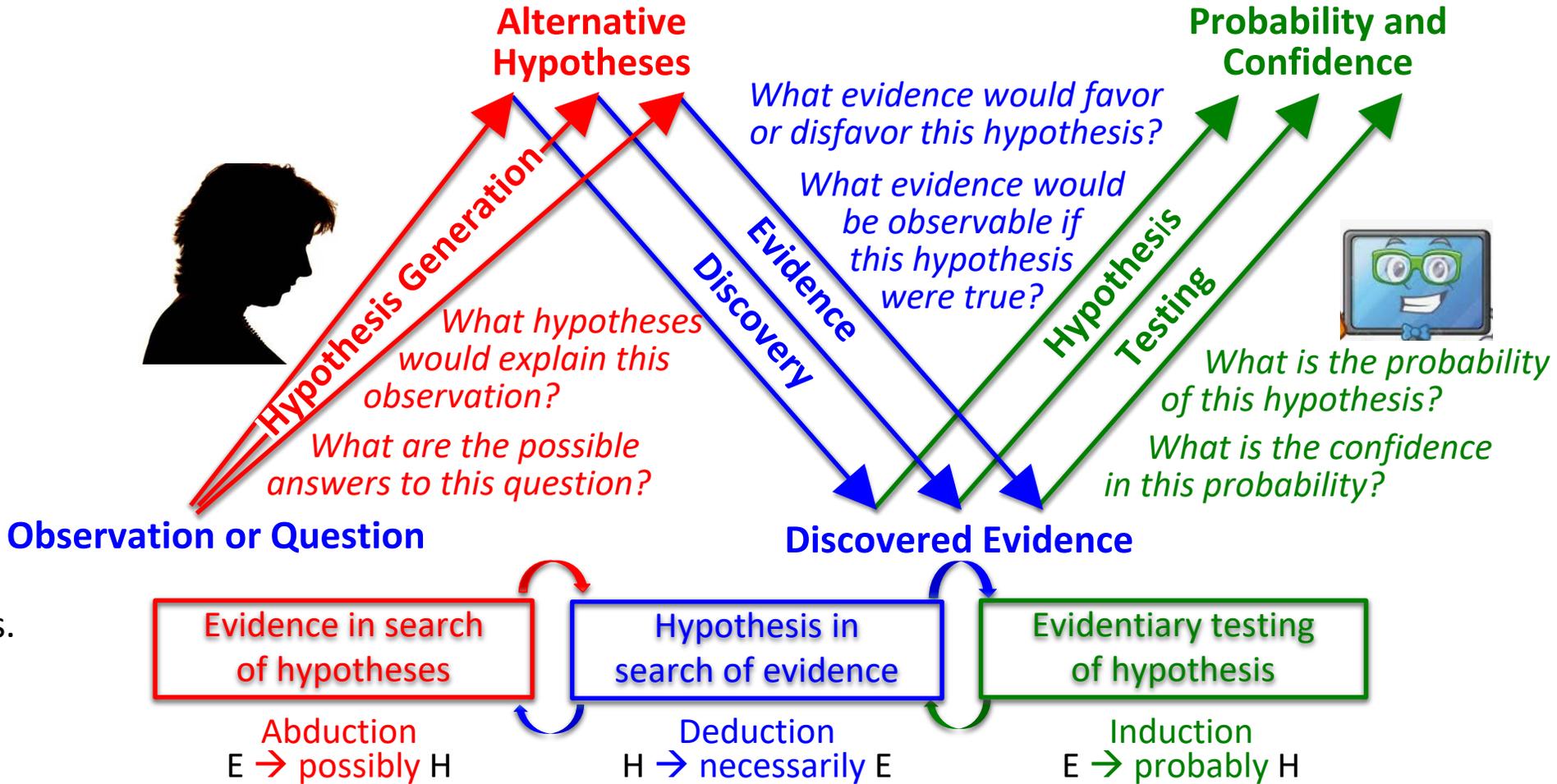Gheorghe Tecuci and David Schum

Tecuci, G., Kaiser, L., Marcu, D., Uttamsingh, C., Boicu, M. (2018). Evidence-based Reasoning in Intelligence Analysis: Structured Methodology and System, Special Issue on Evidence-based Reasoning and Applications, *Computing in Science and Engineering*, 20(6), pp.9-21, November/December.
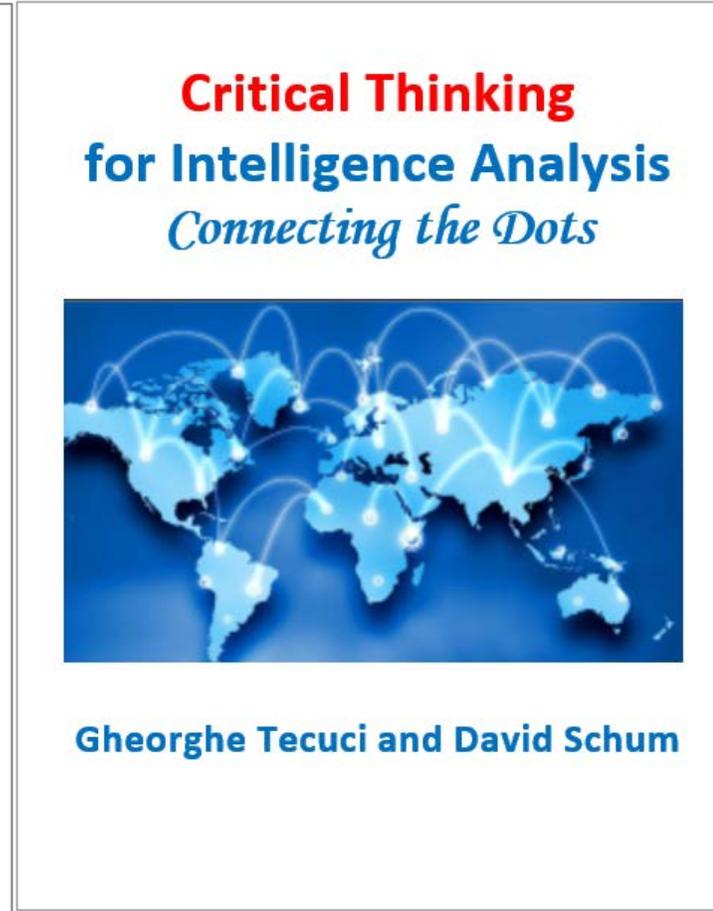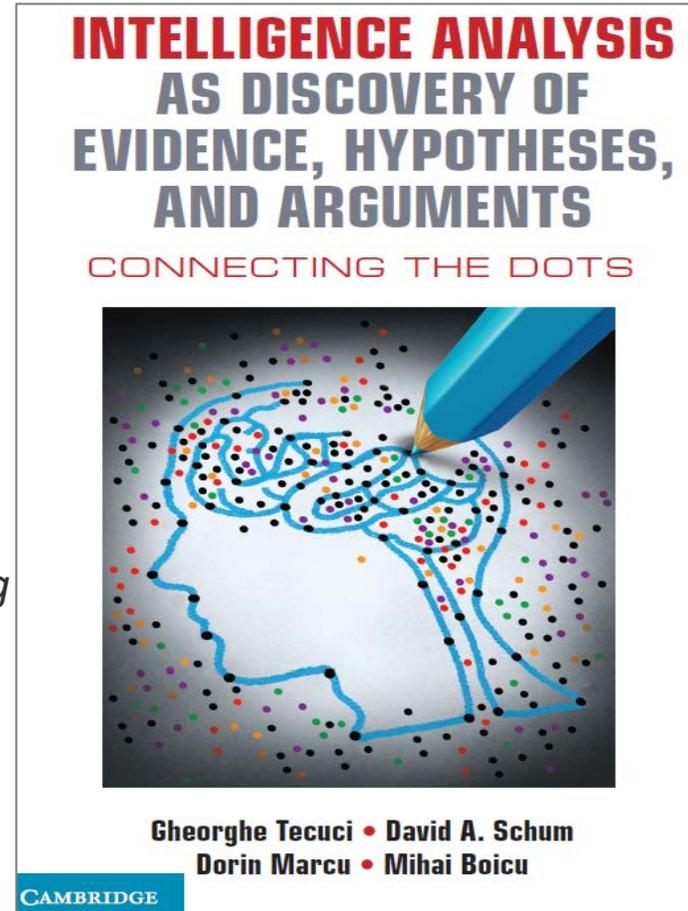
Shared Human-Agent Model of Intelligence Analysis

Enables mixed-initiative integration of the complementary reasoning capabilities of analysts (including imagination and expertise) and computer agents (including knowledge and critical reasoning).

**Alternative Hypotheses**

Probability and Confidence

Humans are slow, sloppy, forgetful, implicit, and subjective **but** have common sense, have intuition, and may find creative solutions in new situations.
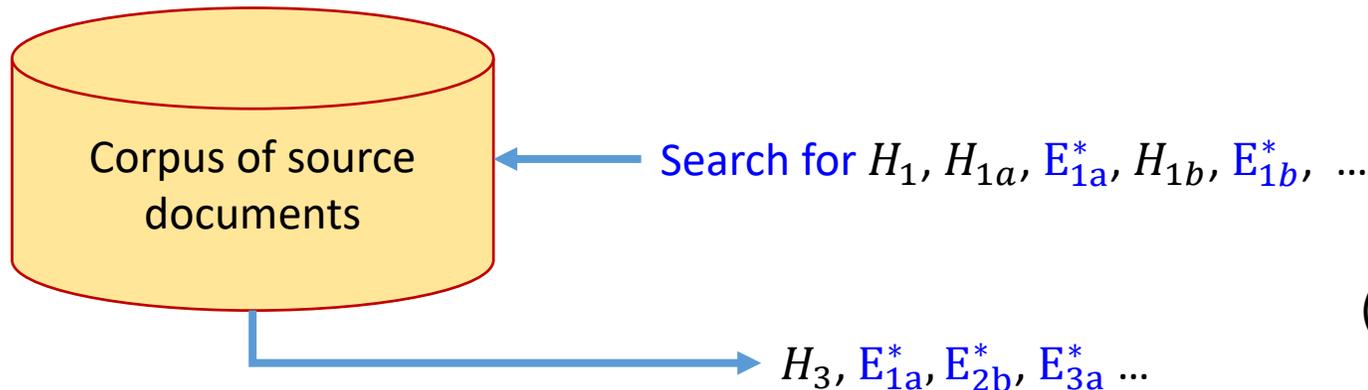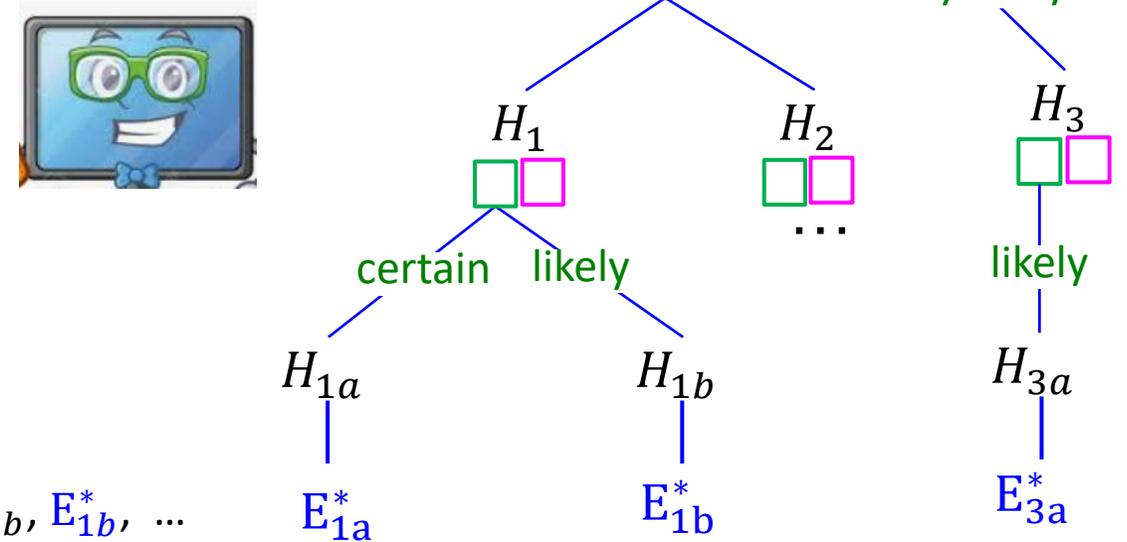
What evidence would favor or disfavor this hypothesis?

What evidence would be observable if this hypothesis were true?

Agents are fast, rigorous, precise, explicit, and objective, **but** have poor ability to deal with new situations, lack common sense and intuition

Hypothesis Generation

Evidence Discovery

Hypothesis Testing

What hypotheses would explain this observation?

What are the possible answers to this question?

What is the probability of this hypothesis?

What is the confidence in this probability?

Observation or Question

Discovered Evidence

Evidence in search of hypotheses	Hypothesis in search of evidence	Evidentiary testing of hypothesis
Abduction	Deduction	Induction
E → possibly H	H → necessarily E	E → probably H

Tecuci, G., Marcu, D., Kaiser, L., Boicu, M. (2021). Shared Model of Sense-making for Human-Machine Collaboration, *The 2021 AAAI Fall Symposium "AI in Government and Public Sector,"* Arlington, VA, November 4-6.

Task Area 1 (TA1) – Identify Additional Evidence: Automatically find relevant supporting and contrary evidence in addition to the evidence used in a draft report.

Automatically extracting the argumentation from the analytic report
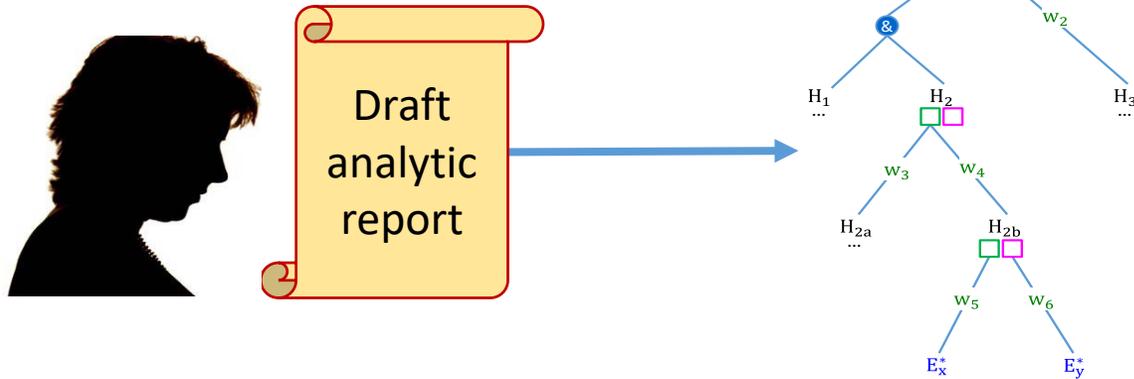
Hypothesis-driven discovery of evidence

Search for H_1, H_{1a}, E_{1a}^*, H_{1b}, E_{1b}^*, ...

H_3, E_{1a}^*, E_{2b}^*, E_{3a}^* ...

What evidence would be observable if H were true? (look for *necessary conditions* for H to be true or false).

What evidence would favor or disfavor H? (look for *sufficient conditions* and *indicators*, for H to be true or false).

Task Area 2 (TA2) – Identify Reasoning Strengths and Weaknesses: Automatically find strengths and weaknesses in the reasoning of a draft report.

Develop methods to automatically detecting and proposing mitigations for a wide variety of biases in an argumentation, such as:

- The *confirmation bias* (the tendency to seek only that information that is consistent with the preferred hypothesis), signaled when a hypothesis has only favoring arguments and evidence.

- The *satisficing bias* (choosing the first hypothesis that appears good enough rather than carefully identifying all possible hypotheses and determining which one is the most consistent with the evidence), signaled when the user has analyzed only one of the possible hypotheses, ignoring its alternatives. It is also signaled when several hypotheses are analyzed, but one of them has a significantly larger argumentation.

- The *absence of evidence bias* (failure to consider the degree of completeness of the available evidence), signaled when there are too many assumptions.

Tecuci G., Schum D.A. (2023). Analytic Bias, in *Critical Thinking for Intelligence Analysis: Connecting the Dots,* pp. 215-224.

Task Area 3 (TA3) – Produce Recommendations to Increase Quality of Argumentation: Based in part on the output of TA1 and TA2, automatically produce comments that enable analysts to substantially improve the argumentation in their reports.
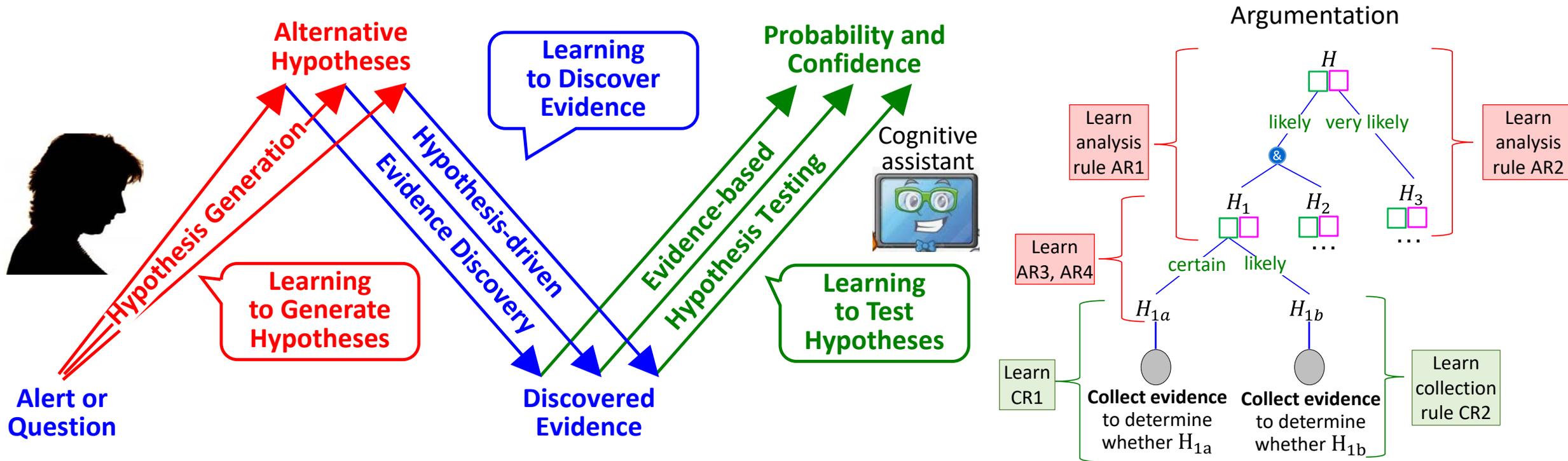
Tecuci, G., Marcu, D., Boicu, M, Kaiser, L. (2020). Instructing a Cognitive Agent to Perform Sensemaking in Intelligence, Surveillance and Reconnaissance, 19 pages, *Eighth Annual Conference on Advances in Cognitive Systems (ACS 2020)*, online, Palo Alto Research Center, Palo Alto, CA, August 10-12.

Tecuci, G., Meckl, S., Marcu, D., Boicu, M. (2019). Instructable Cognitive Agents for Autonomous Evidence-Based Reasoning, *Advances in Cognitive Systems, 8*. Also in *Proceedings of the Seventh Annual Conference on Advances in Cognitive Systems*, Technical Report Number COLAB[2]-TR-4, pp.183-204, Massachusetts Institute of Technology, Cambridge, MA, August 2-5.