Modeling Collaborative Division of Cognitive Labor

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Division of cognitive labor

- **The question**

  ”How should the pursuit of knowledge be organized, given that (...) knowledge is pursued by many human beings, each working on a more or less well-defined body of knowledge and each equipped with roughly the same imperfect cognitive capacities, albeit with varying degrees of access to one another’s activities?” [1]
- Models
  - Marginal contribution/reward models (Kitcher ⟶)
  - Epistemic networks (Zollman ⟶)
  - Epistemic landscapes (Weisberg & Muldoon ⟶)
- Functions of diversity & division of cognitive labor
  - Resource allocation
  - Error control
  - Exploration-exploitation management
- **Challenge**: Richer articulation of *cognitive collaboration* needed

Modeling collaborative problem solving

- *An individually intractable problem* addressed by a *collective of agents with heterogeneous abilities/resources*
- Elements of collective problem-solving
  1. Recursive division of a problem into sub-problems
  2. Allocation of sub-problems to different groups/individuals
  3. Combining individual solutions
- Feasibility of division of labor determined by:
  - Research strategies employed by agents
  - Difficulty of the problem (size & modularity of solution space)
  - Decomposition scheme for division of labor

Binary string model

- Scientific research as collective search in a multi-dimensional landscape [2]
- Model template: *Bit string model* [3, 4]
- Solution to a complex problem: a string of 0/1s w/ interdependencies:

- Bit: One aspect of the solution
- Examples: Finding the structure of a macromolecule, building a space shuttle / software ...
- Cognitive diversity: Each agent has a different set of heuristics for manipulating the shared bit string
- Collective task: Find string with highest epistemic utility

Moderately difficult problems

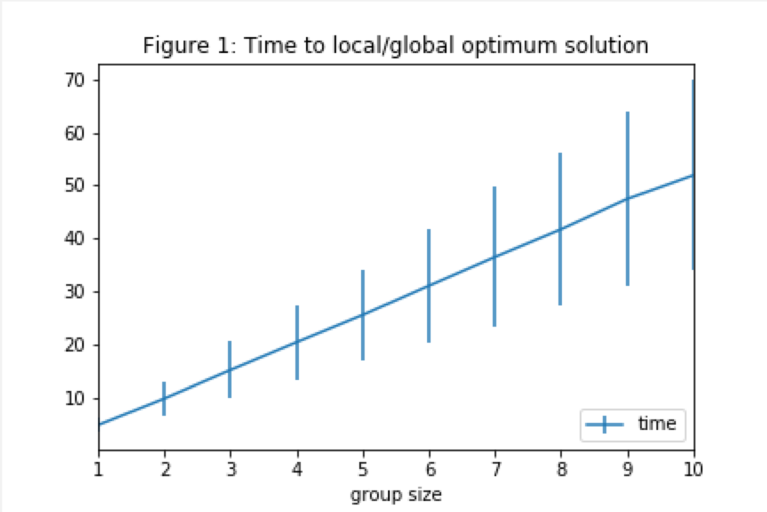
- Types of solution spaces: (i) fully modular, (ii) partly modular, (iii) hierarchical, (iv) random

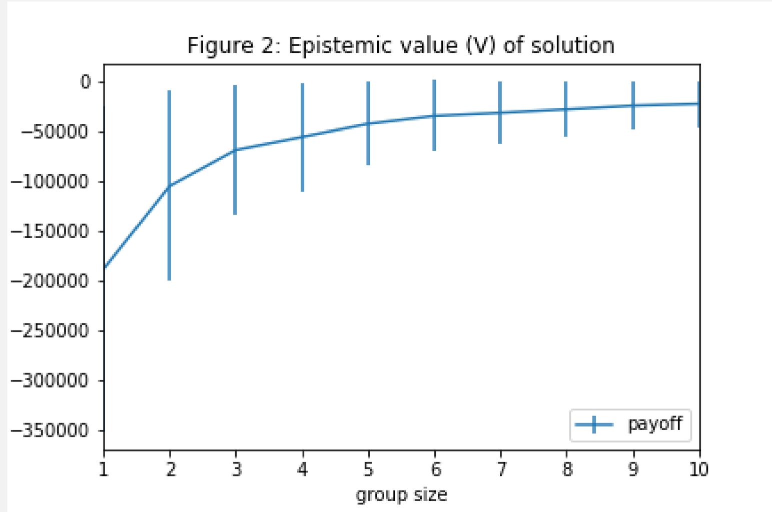
Bit#1	*Bit*#2	*Bit*#3	Value (V)
0	0	0	0
0	0	1	4
0	1	0	2
0	1	1	6
1	0	0	3
1	0	1	7
1	1	0	1
1	1	1	5

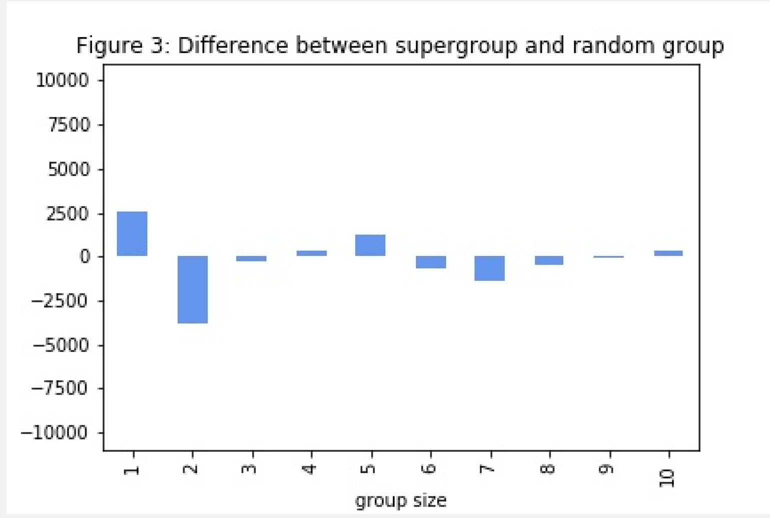
- This solution space has cover size 2: $\{Bit_1, Bit_2\}$ and $\{Bit_3\}$ can be solved separately
  - Optimal solutions to sub-problems: {10*} and {**1}
- Cover size (decomposability) provides a natural measure of problem complexity [5]

Current results

- Target claim 1: "Arbitrary returns to additional problem solvers"[3] (figs 1 & 2)
- Target claim 2: "Diversity beats ability" [6] (fig 3)







- Parameters: n=20; flipsets/agent=3; tournament size = 1000

Tentative conclusions

- Trade-offs in managing complexity: time vs. reliability; tractability vs. optimality
- Overblown interpretations of claims about possibility (of arbitrary marginal returns) (TC1)
- Binary string model does not support diversity-beats-ability theorem (TC2)

References

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