Using Cross-Domain Data to Predict Syllogistic Reasoning Behavior

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Motivation

- The human ability to reason is an **integral part of our intelligence**
- Reasoning research is often done on single (isolated) reasoning domains
  – Syllogisms[1], Conditionals[2], Spatial-relational reasoning[3],…
- This leaves three core questions open:
  1. **Is there a general reasoning ability**[4]?
  2. **Is the separation of the domains justified?**
  3. **What other factors contribute to reasoning?**

→ We present an **extensive cross-domain dataset** and an analysis using **predictive modeling** to tackle those questions

Study

- Web-experiment with **95 participants** over three sessions
- Tasks to assess cognitive traits (i.e., CORSI[5], CRT[6],…)
- Study covered three **central reasoning domains**

Syllogistic Reasoning

All cooks are golfers.
Some golfers are monks.

What, if anything, follows?

- Two quantifier statements connected via a middle term
- Task: Conclude what holds for the other terms (cooks, monks)

→ Participants solved all **64 traditional syllogisms** []
→ Multiple-Choice responses or „No valid conclusion“ (NVC)

Conditional Reasoning

If Joe cuts his finger, it bleeds.
His finger bleeds.

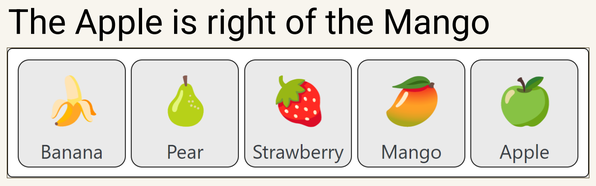
What, if anything, follows?

- Consist of a conditional rule and a statement
- Content was adapted from commonly used tasks

→ Participants solved MP, MT, AC and DA
→ **Normal** and **counterfactual**[7] versions
→ Abstract **Wason-Selection-Task**[8] were also tested

Spatial Reasoning

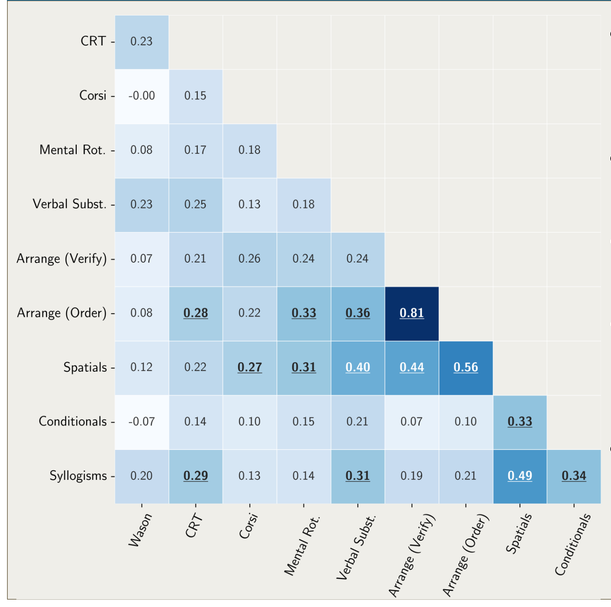
The Banana is left of the Strawberry
The Pear is left of the Strawberry
The Strawberry is left of the Mango
The Apple is right of the Mango



- Premises describing the arrangement of 5 fruits
- Indeterminate & determinate tasks (balanced)
- Task: Verify or correct a given arrangement, or determine specific relations

→ **16 tasks** asking for **relations** (with/without memorizing premises)
→ **20 verficication** and re-arrangement tasks

Relations Between Domains



- Build Spearman's rank **correlations** between participants‘ performance in different domains and tests
- All **traditional reasoning domains correlate** with each other

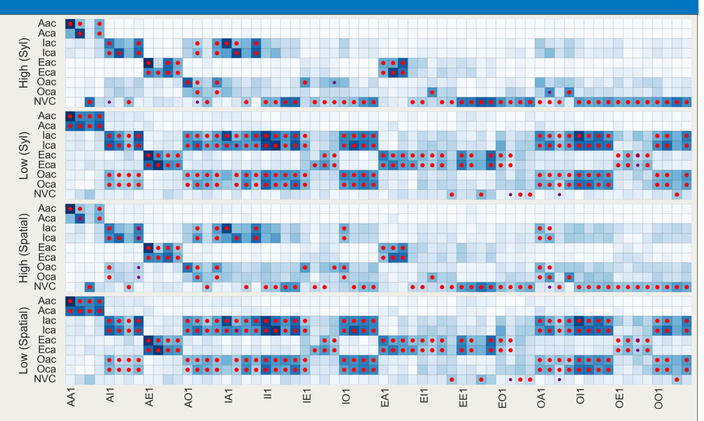
→ There seems to be some **general ability** to solve reasoning tasks
→ This ability **does not translate** to general cognitive abilities

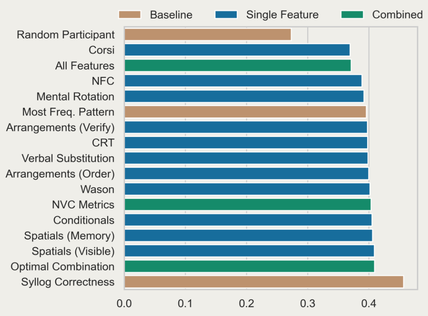
- However, domains have their **unique traits**: e.g., Only Spatial reasoning correlates with Mental Rotations

Towards Predictive Modeling

- **Goal: Predict behavior based on other domains**
- We split participants into two groups based on performance
- Patterns are similar for syllogisms and other domains

→ Can we make accurate predictions using information from **multiple domains**?





- We predict individual patterns using a recommender system[9] based on the performance in the other domains
- Optimal feature combination used performance in conditionals, spatials and verbal substitution

→ Prediction did not improve much beyond the most-frequent pattern

Results

- We obtained an **extensive dataset**, covering multiple reasoning domains
  - Dataset is publicly available
- Reasoning capabilities **are transferrable** to a degree:
  - Participants **performance** correlates across domains
  - Little transferrability about **specific reasoning behavior**

1. Findings support a **general reasoning ability**, but it does not account for the full behavior
2. Each reasoning domain has its **own intricacies** worth investigating
3. Factors measured by the other cognitive tasks were only minor influences and offered **little additional information**

References

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