Autism-Inspired AI for Visuospatial and Social Reasoning

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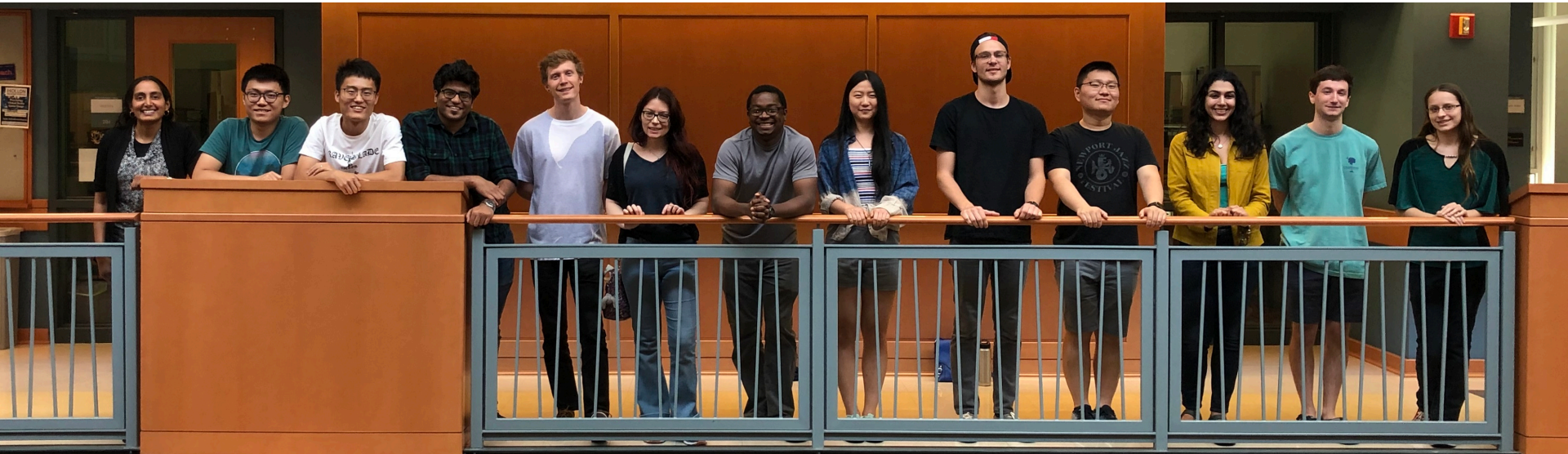
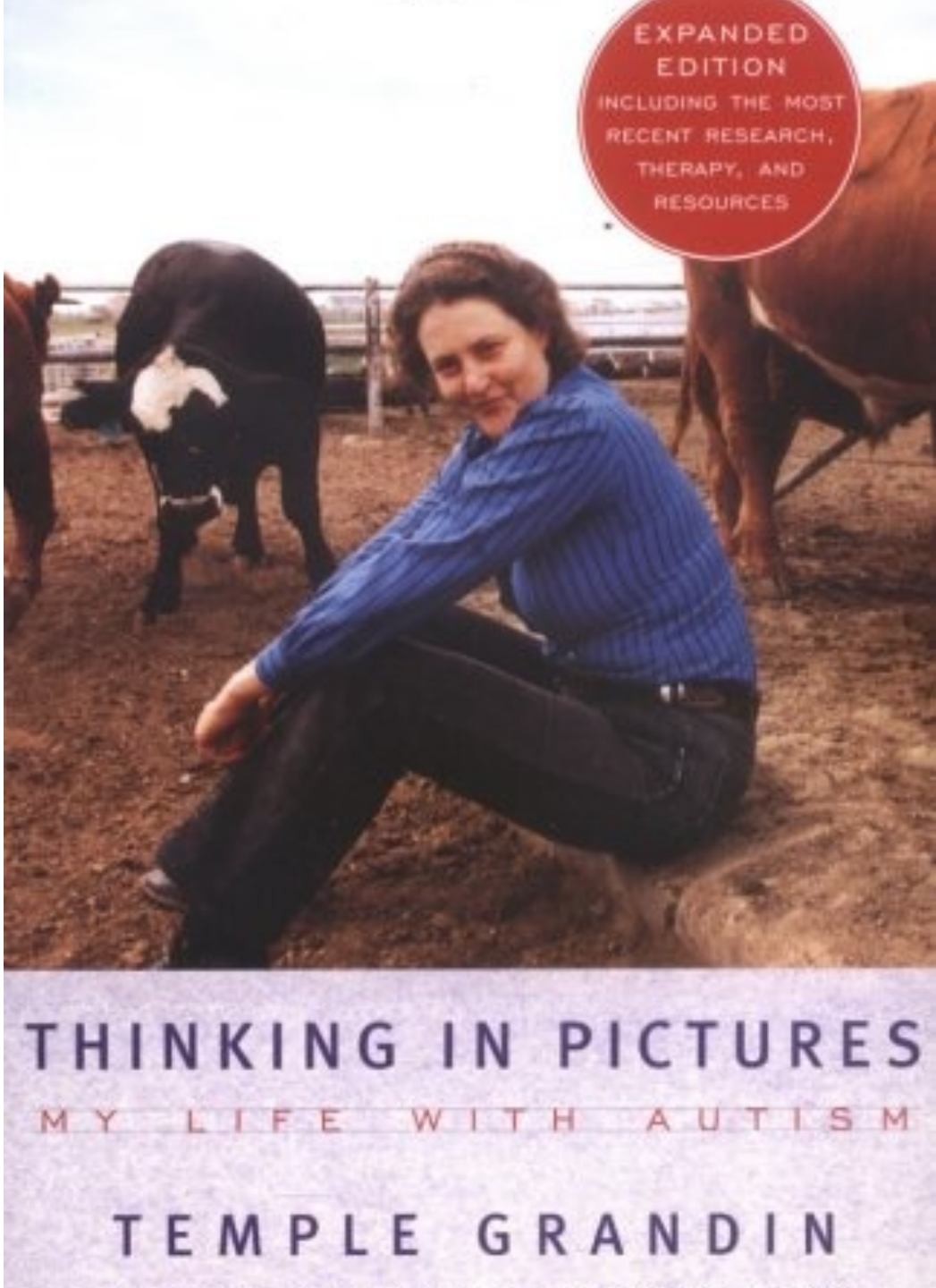
Vanderbilt Frist Center for Autism & Innovation

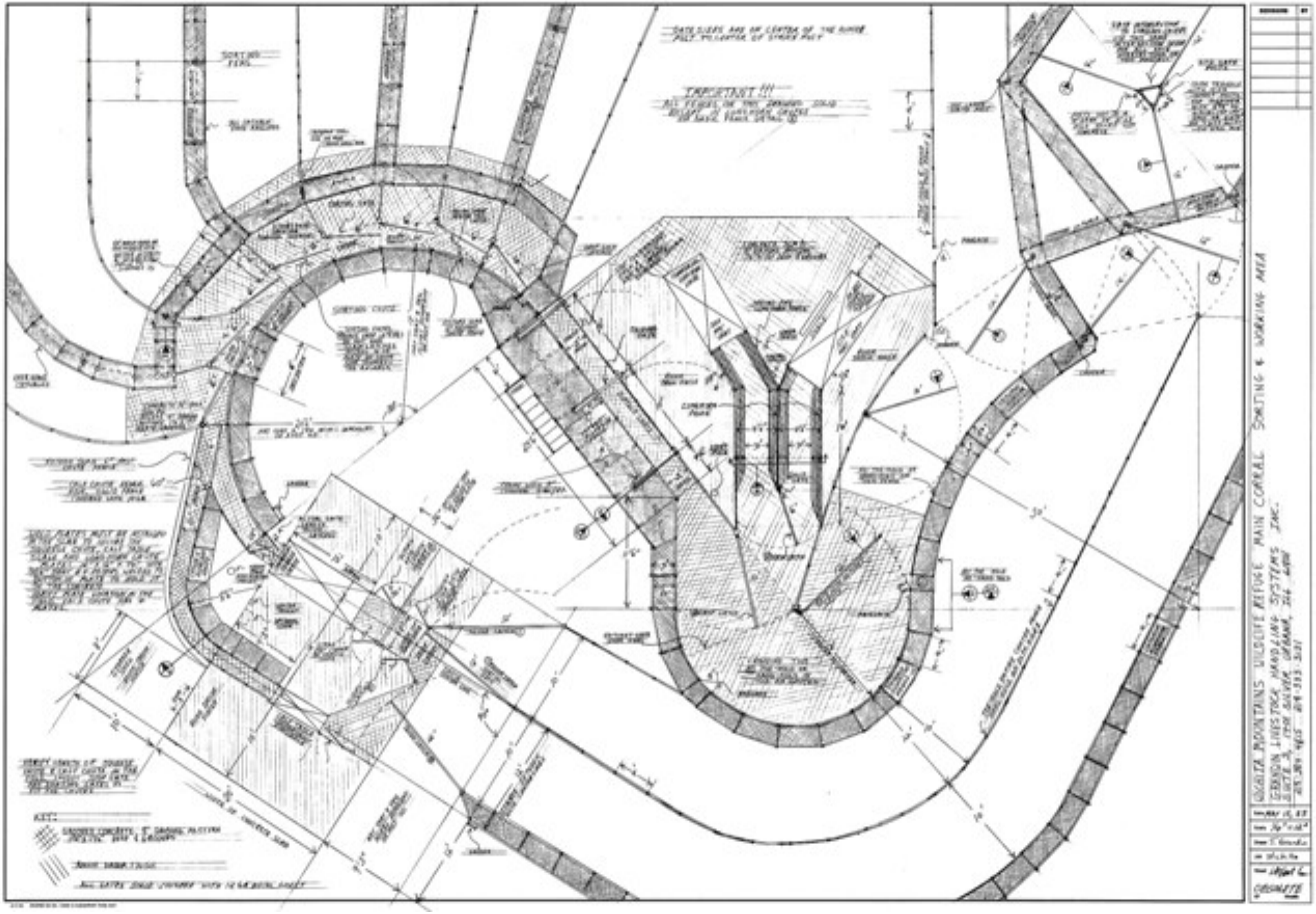
Artificial Intelligence & Visual Analogical Systems (AIVAS) Lab



My research:

AI inspired by Temple Grandin and others on the autism spectrum





http://www.grandin.com

Q1. What can AI and cognitive science learn by looking at the visuospatial abilities of autistic individuals?

Q2. How can AI approaches to social reasoning help autistic individuals improve their everyday social lives?

Outline

- Visuospatial reasoning
  - An interactive example
  - A recipe
  - Many ways to solve many problems
  - Learning to solve problems

- Teaching Social Reasoning
  - Three components of theory of mind
  - Teaching social reasoning the way we teach scientific reasoning

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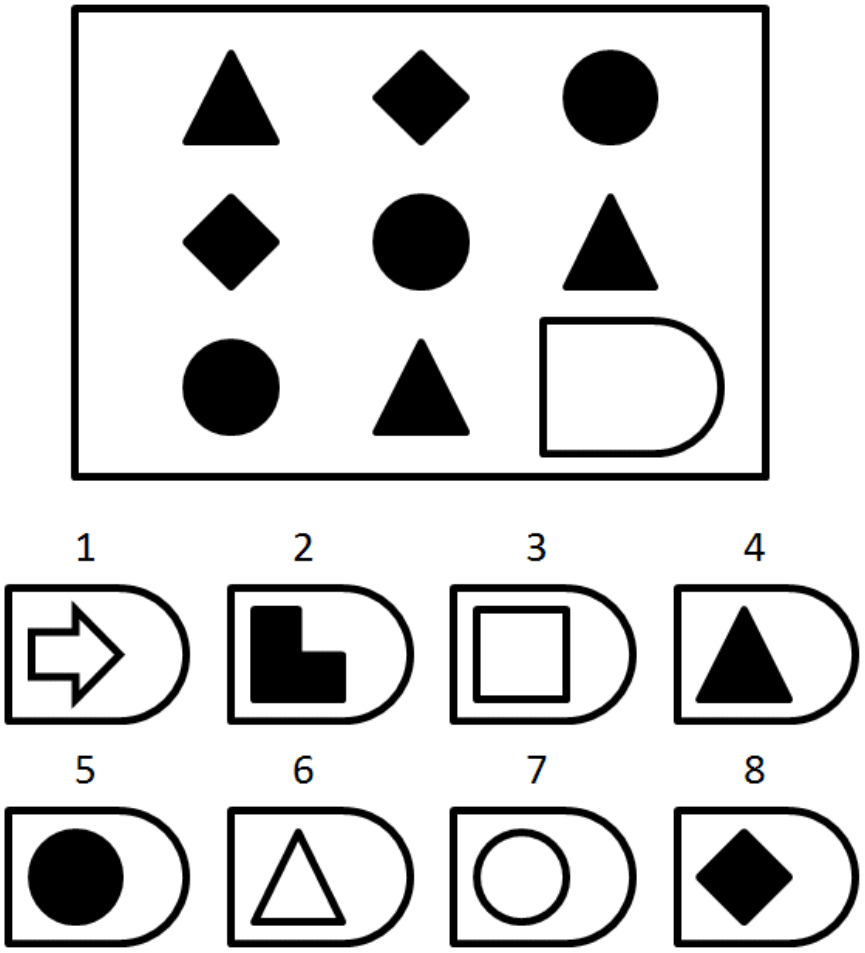
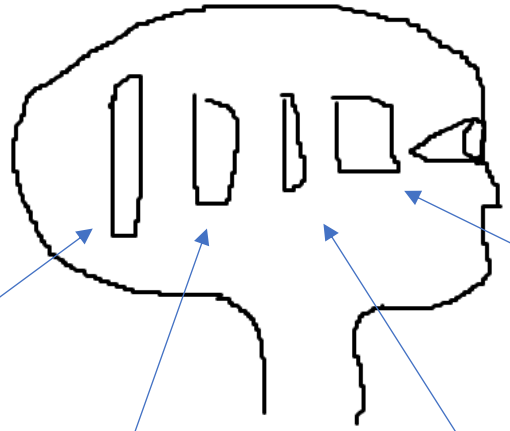


- How did you know what to do?
- How did you plan your strategy?
- How many other ways could you do what you did?

A recipe for visuospatial reasoning



low-level visual perception

primitive visuospatial reasoning skills

actual problem-solving strategy

online strategy learning and adaptation (metacognitive)

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A visual imagery-based architecture for visuospatial reasoning

James Ainooson
Ryan Yang
Tianyu Hua

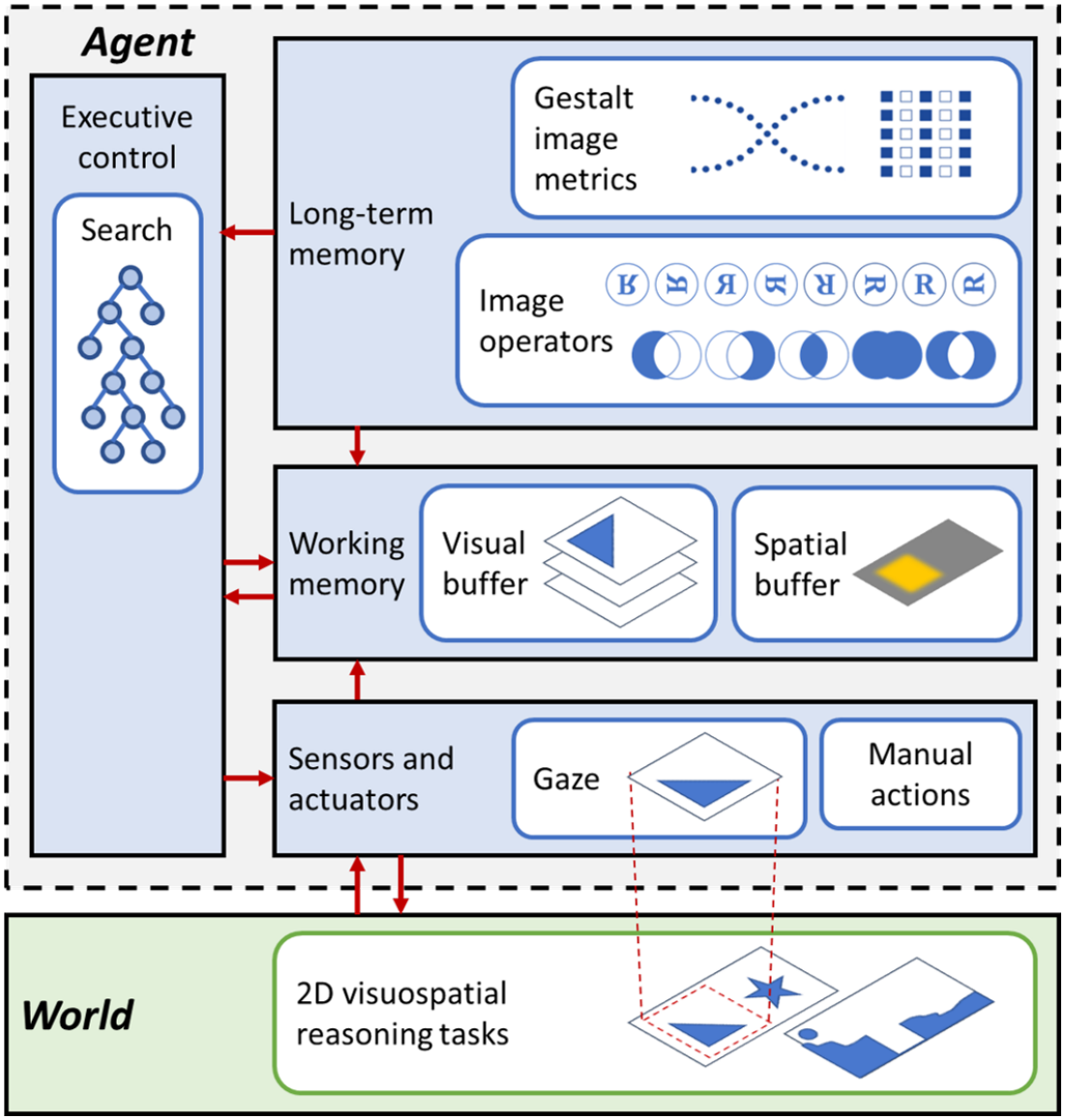


Table 3. General Strategy of our computational models.

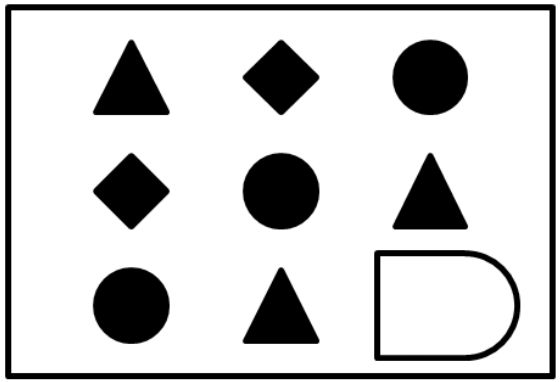
Given a RPM problem or sub-problem $\boldsymbol{p}$:

1. Pick an analogy $\boldsymbol{a}$, a transformation $\boldsymbol{t}$ and an option O:
   I. Calculate a score for how good the matrix part of $\boldsymbol{p}$ $\boldsymbol{t}$, abbreviated as PAT score.
   II. Generate a predicted image using $\boldsymbol{p}$, $\boldsymbol{a}$, $\boldsymbol{t}$ and O.
   III. Calculate a score of how good O is w.r.t the predic O score.
   IV. Calculate a score using the PAT score and the O sc PATO score.
2. Repeat 1 until we get sufficiently many PATO scores, and the highest PATO score as the answer.

Table 4. Confident Strategy.

Given a RPM problem or sub-problem $\boldsymbol{p}$:

1. For each analogy and each transformation:
   I. Calculate the PAT score
2. Let A and T be the analogy and the transformation of the maximum PAT score.
3. For each option O:
   I.Generate a predicted image using $\boldsymbol{p}$, A, T and O.
   II. Calculate the $PATO$ score of the predicted image.
4. Return the option with the highest $PATO$ score as the answer.



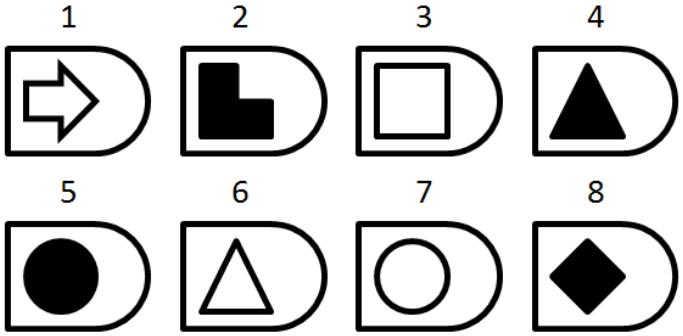


Table 5. Neutral Strategy.

Given a RPM problem or sub-problem $\boldsymbol{p}$:

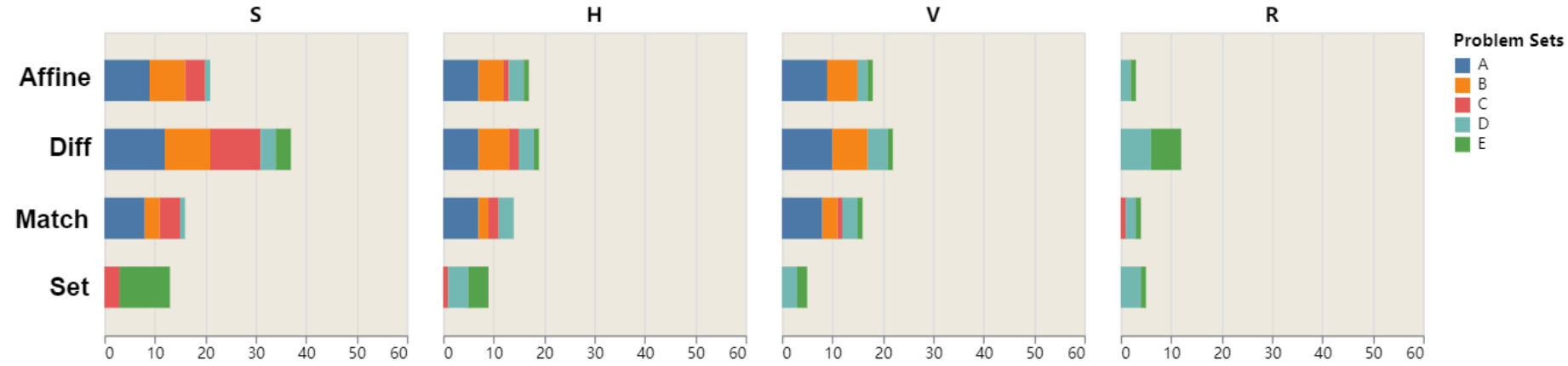
1. For each analogy and each transformation:
   I. Calculate the PAT score
2. For each analogy A and each option O:
   I. Let T_A be the transformation of maximum PAT score of A.
   II. Generate a predicted image using $\boldsymbol{p}$, A, T and O.
   III. Calculate the $PATO$ score of the predicted image.
3. Return the option with the highest $PATO$ score as the answer.

Table 6. Prudent Strategy.

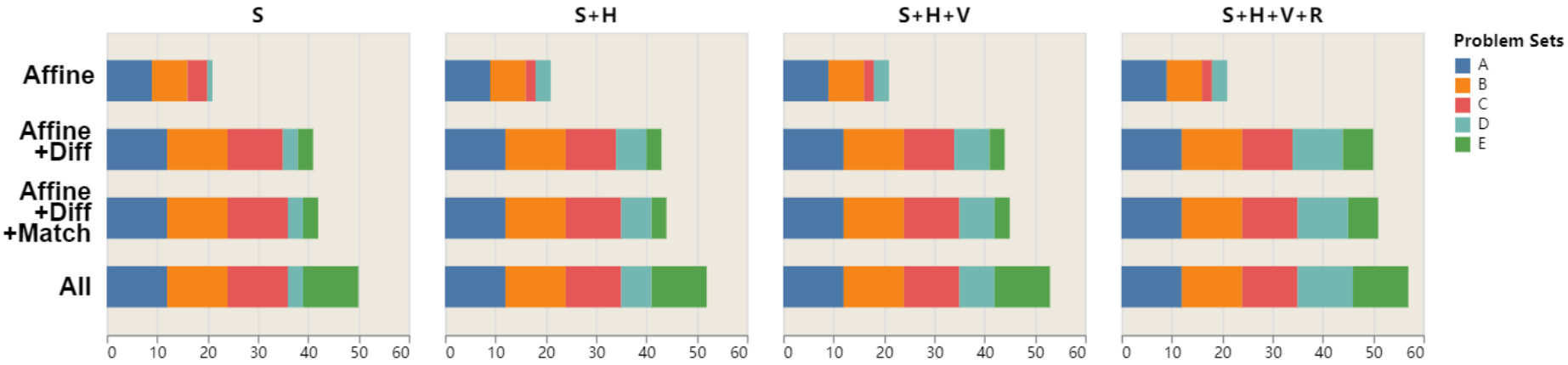
Given a RPM problem or sub-problem $\boldsymbol{p}$:

1. For each analogy A, each transformation T and each option O:
   I. Calculate the PAT score
   II. Generate a predicted image using $\boldsymbol{p}$, A, T and O.
   III. Calculate the $PATO$ score of the predicted image.
2. Return the option with the highest PATO score as the answer.

Latest results on the Raven's Standard Progressive Matrices test

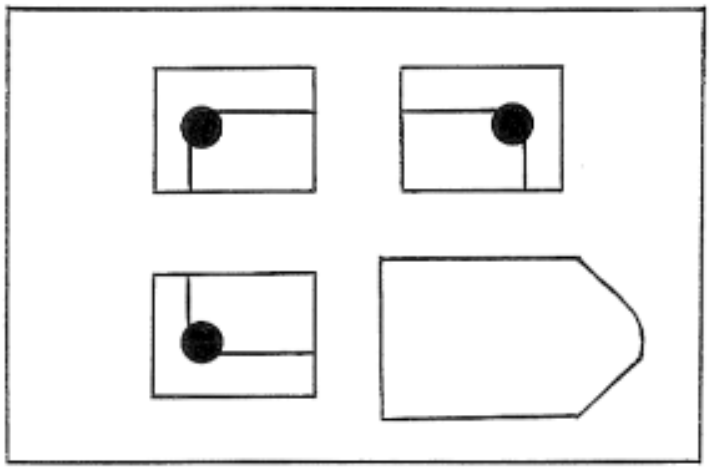


(a)



(b)

Another type of strategy entirely...



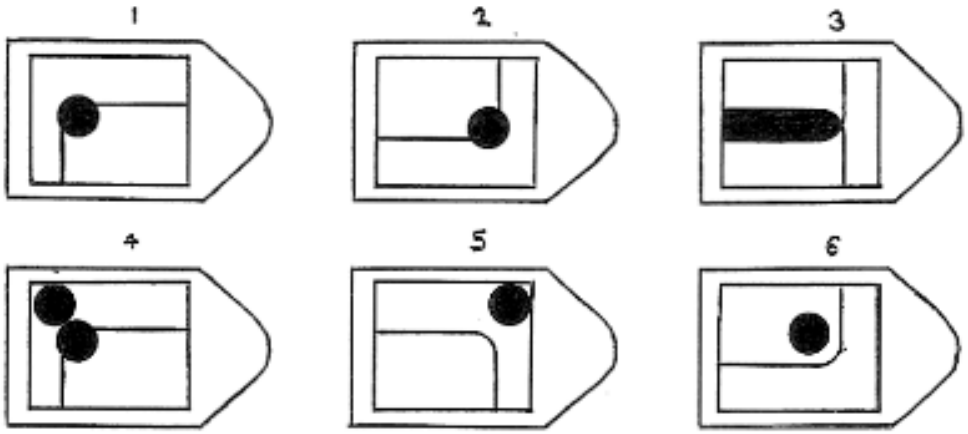
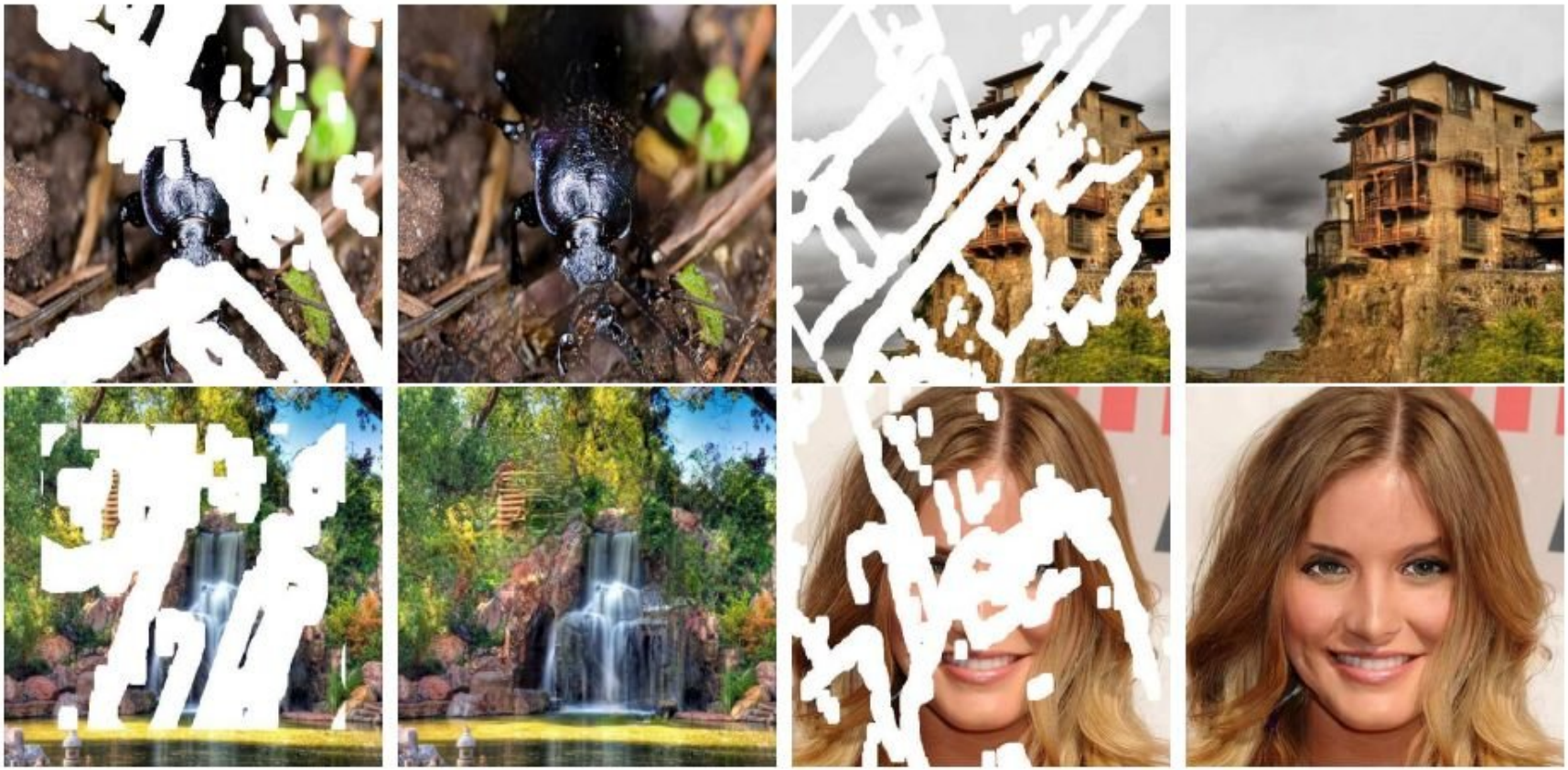
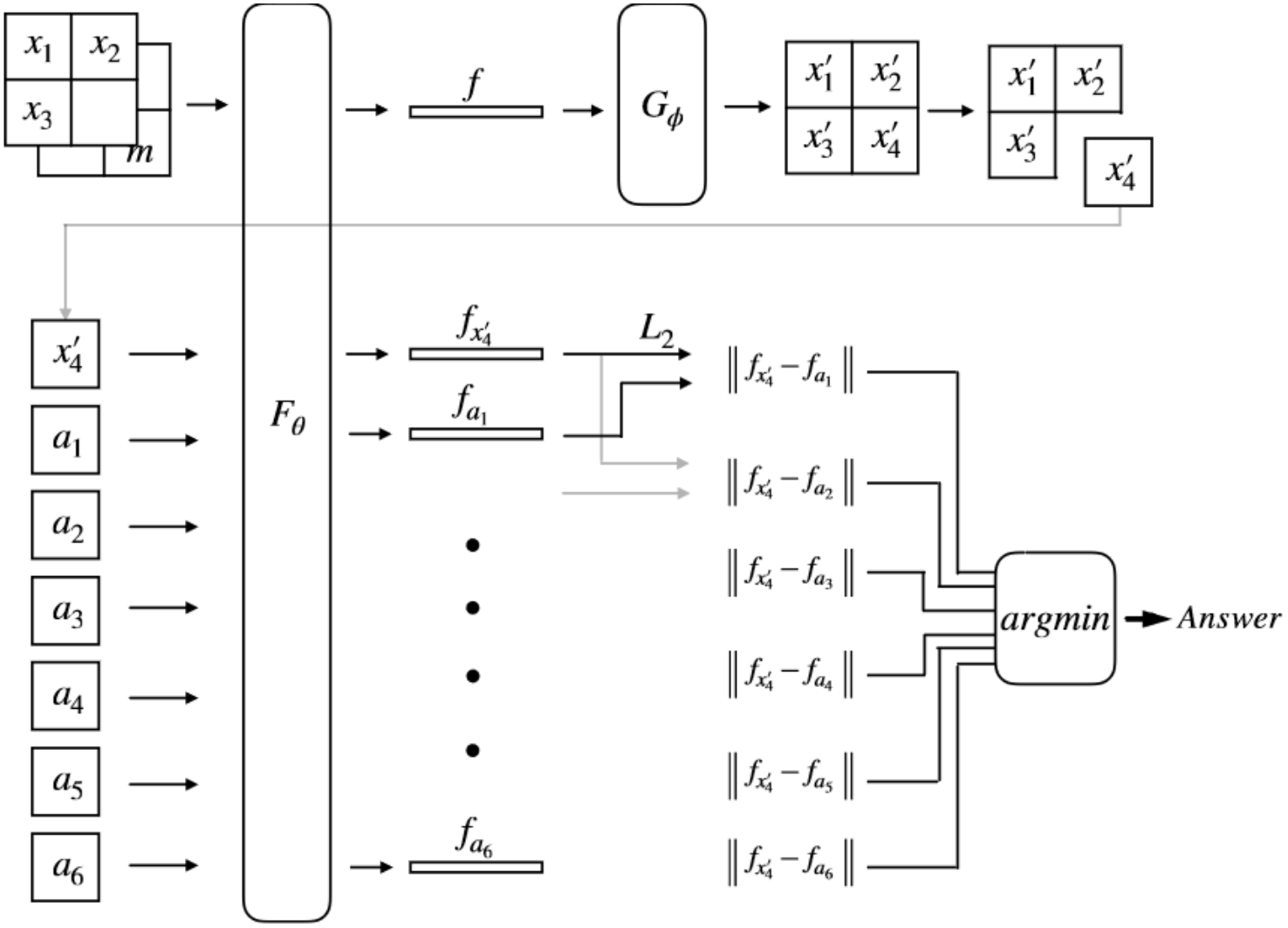


Image Inpainting (Gestalt?)

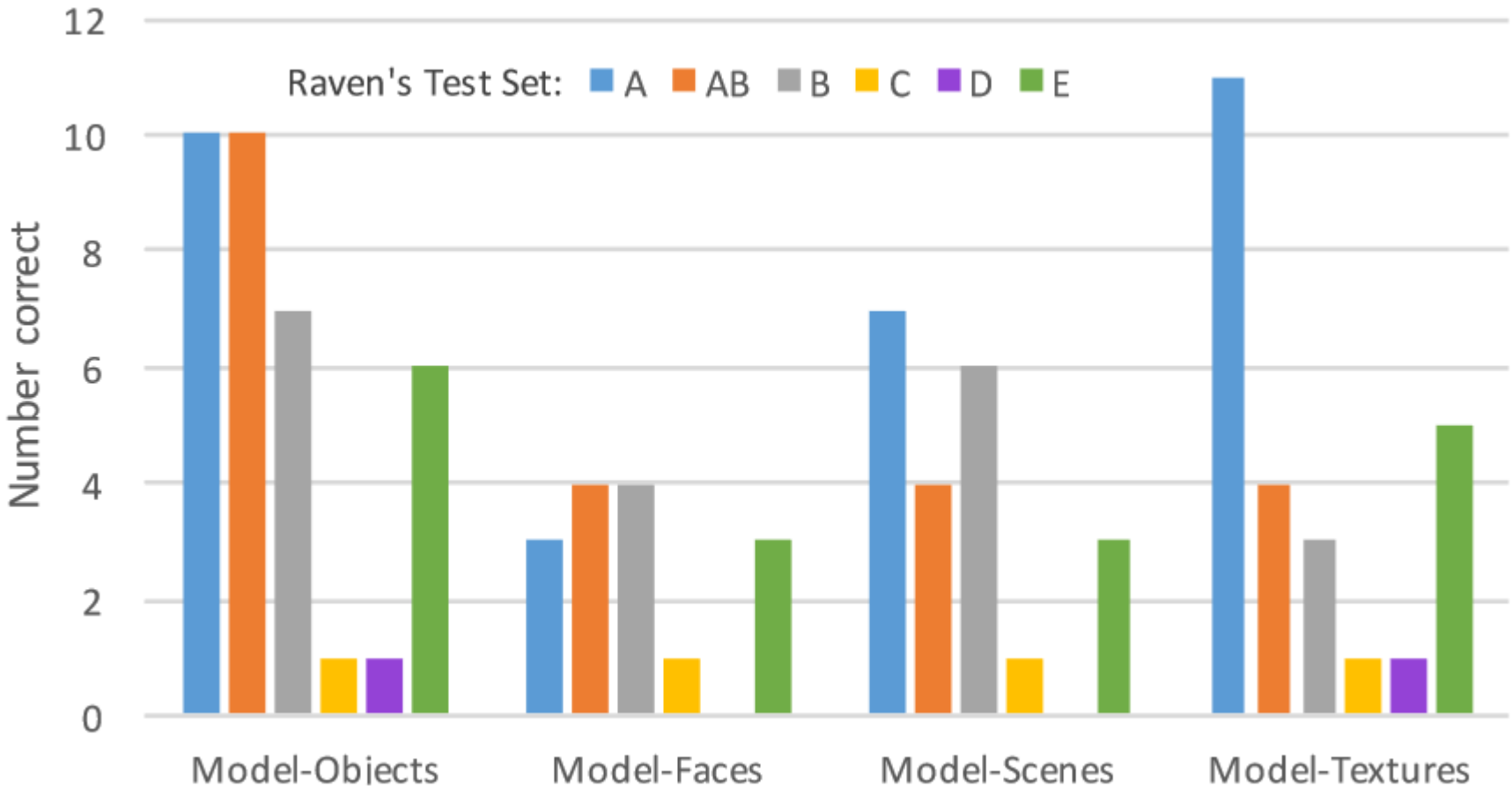


Liu, G., Reda, F. A., Shih, K. J., Wang, T. C., Tao, A., & Catanzaro, B. (2018). Image inpainting for irregular holes using partial convolutions. In *Proceedings of the European Conference on Computer Vision (ECCV)* (pp. 85-100).

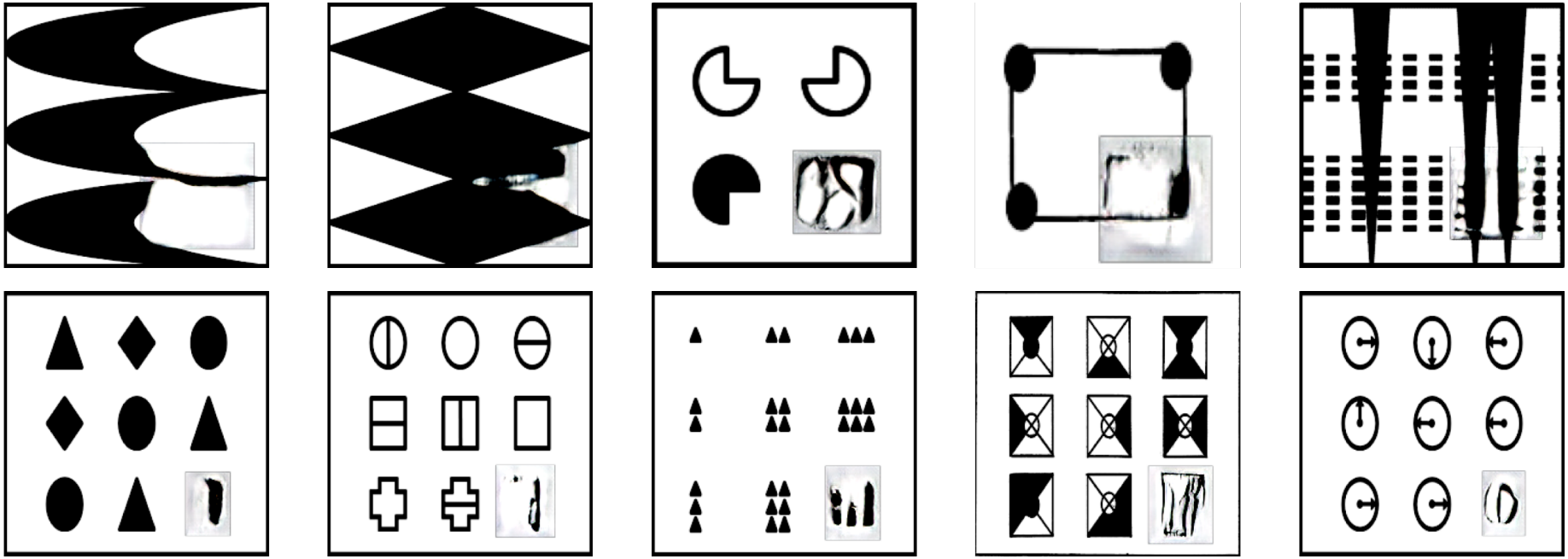
Using an inpainting network to solve Raven's problems



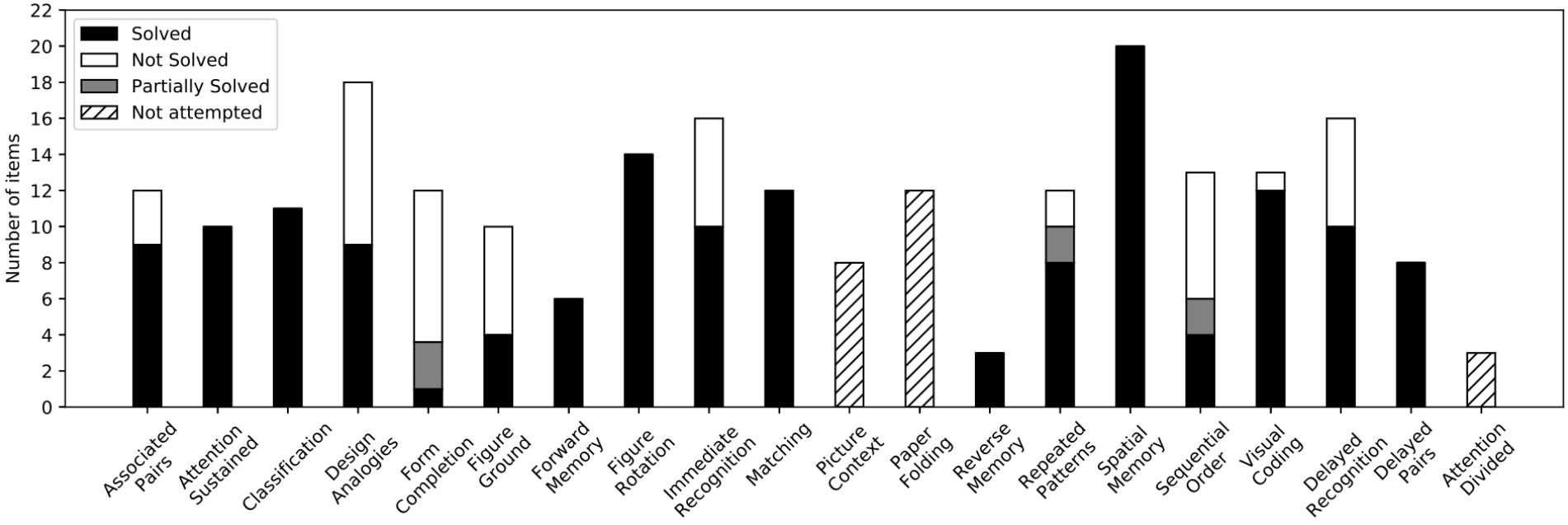
Results on the Colored and Standard Progressive Matrices tests



Inpainting examples



Latest results on the Leiter-R test battery (20 subtests)



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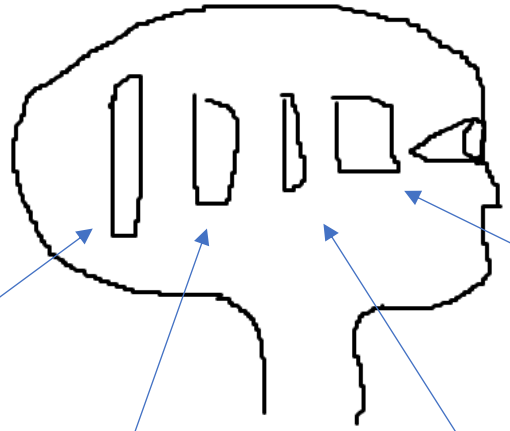
A recipe for visuospatial reasoning



low-level visual perception

primitive visuospatial reasoning skills

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online strategy learning and adaptation (metacognitive)

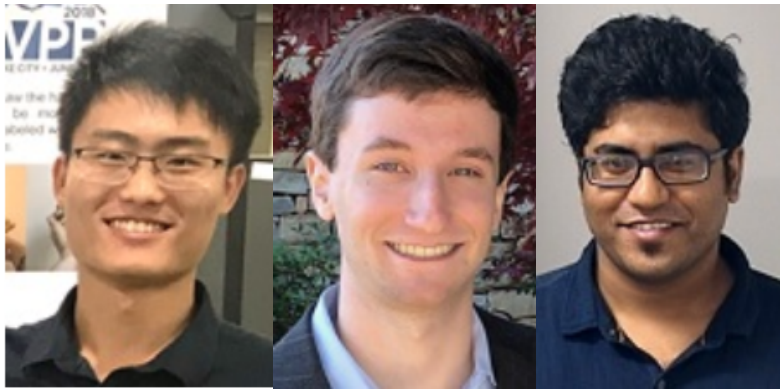
Learning primitive visuospatial reasoning skills from perceptual experience

With collaborator Linda Smith at Indiana University

Infant-view object play as the source of training inputs

http://www.indiana.edu/~cogdev/

Toybox Dataset



Tengyu Ma
Joel Michelson
Deepayan Sanyal

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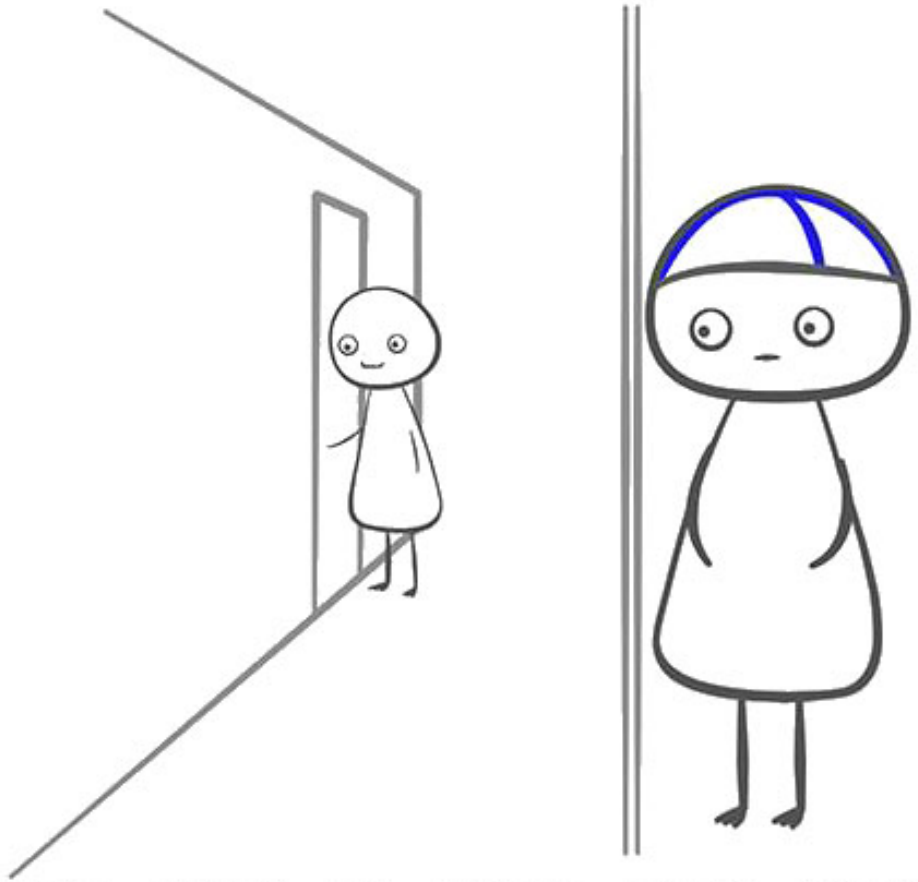
FINNISH NIGHTMARES

FINNISHNIGHTMARES.BLOGSPOT.FI
FACEBOOK.COM/FINNISHNIGHTMARES
TWITTER.COM/FINN_MATTI

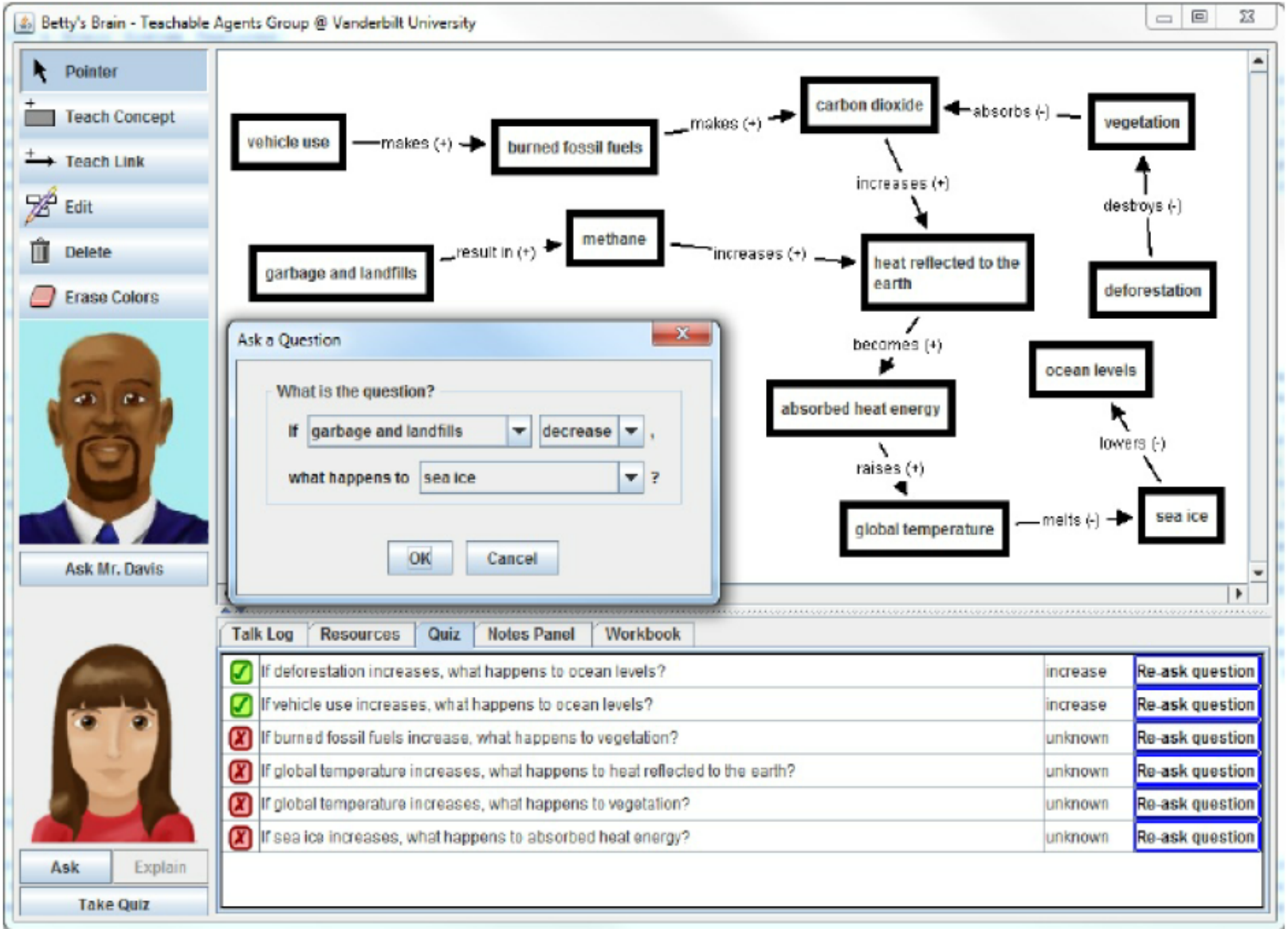


WHEN YOU WANT TO LEAVE YOUR APARTMENT
BUT YOUR NEIGHBOR IS IN THE HALLWAY

Three components of theory of mind

- Social perception
- Social knowledge
- Social reasoning

How we teach scientific reasoning

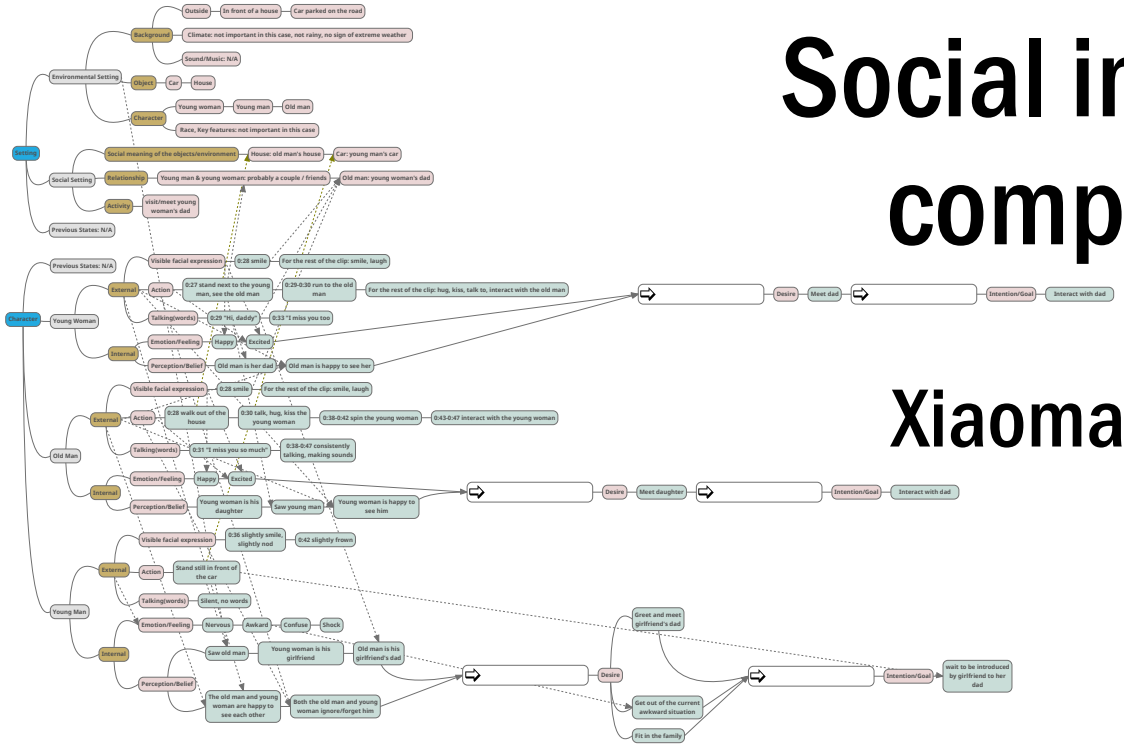


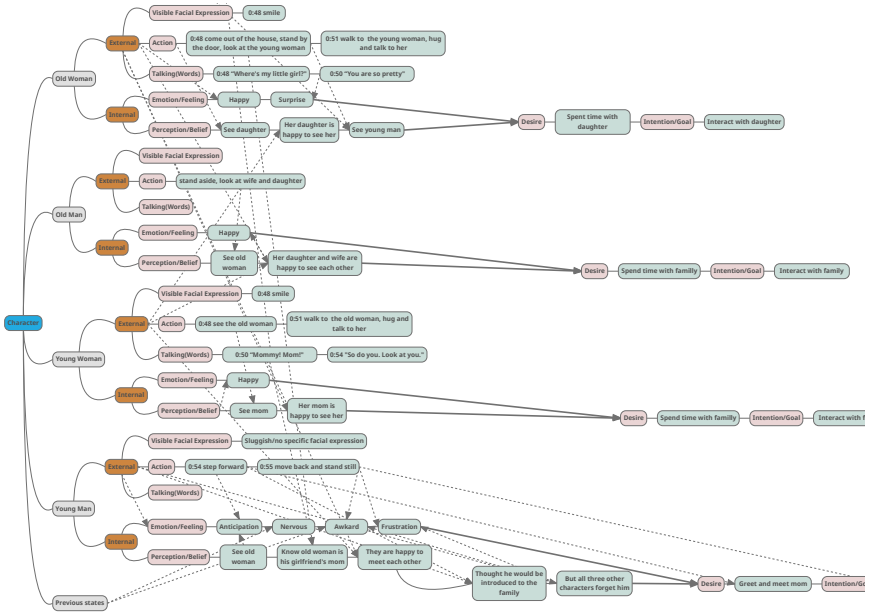
Social interaction as a complex system?

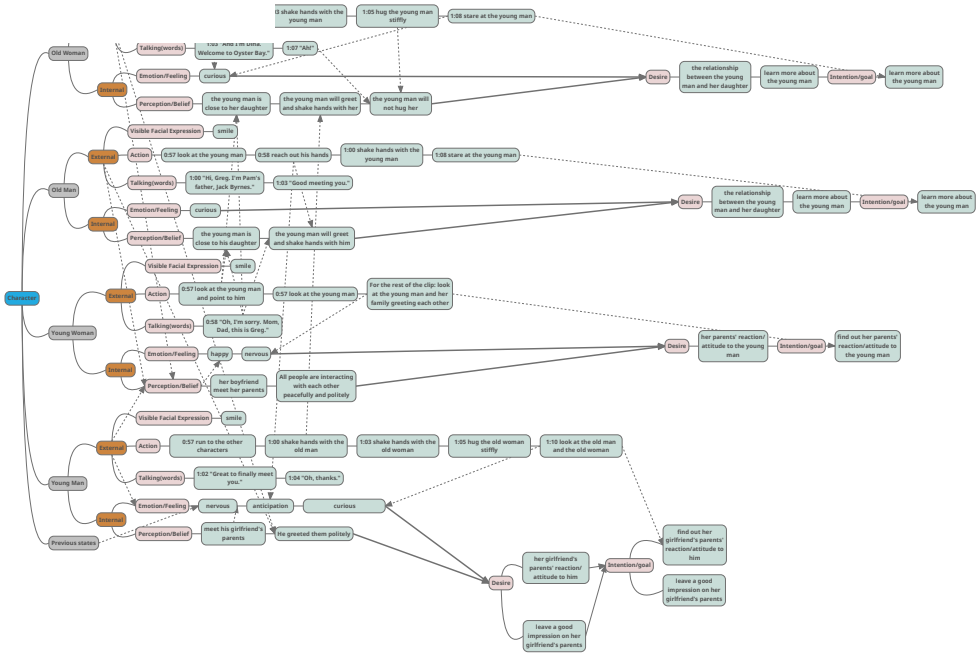
Xiaoman (Mandy) Zi

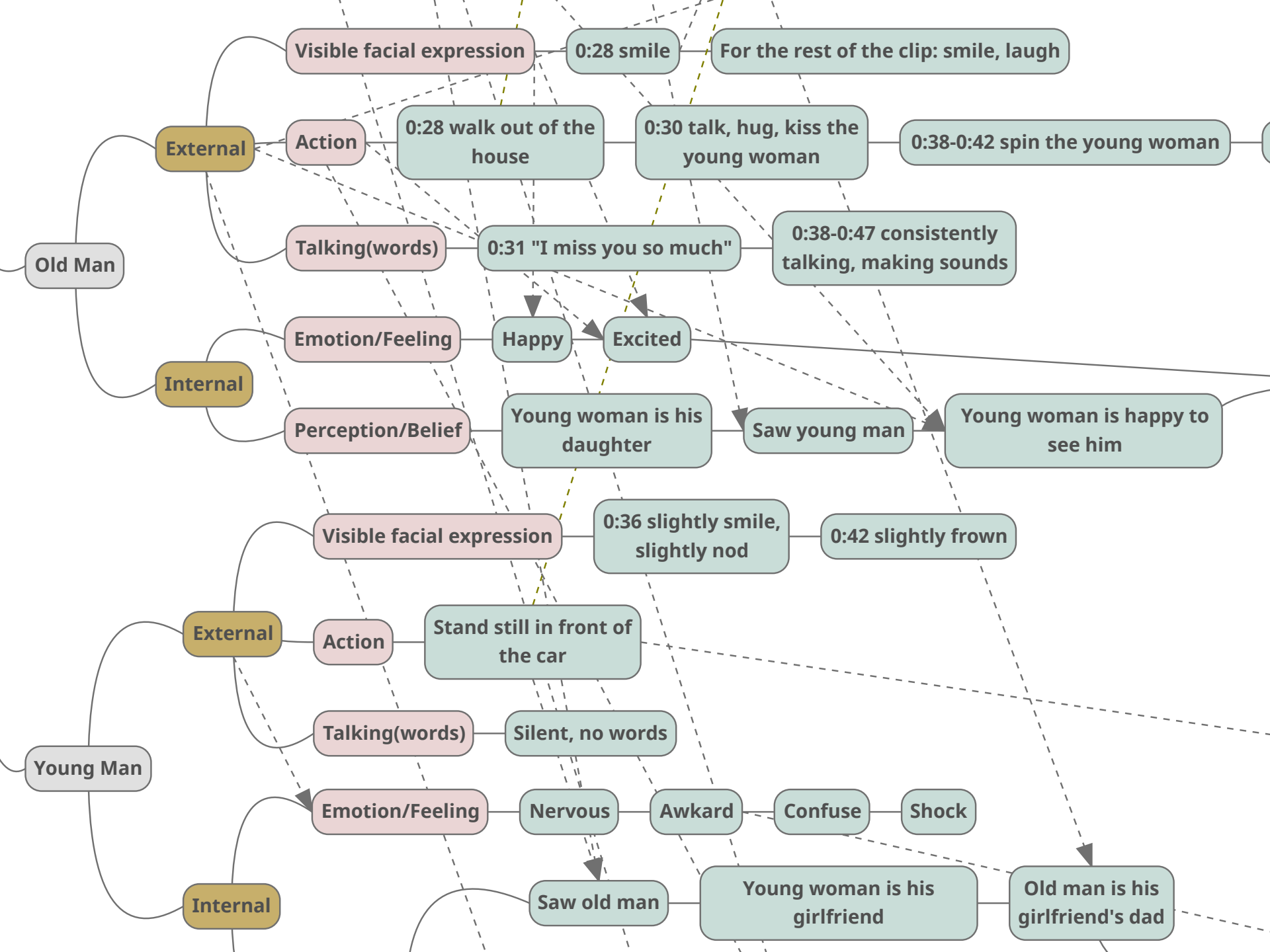
Social interaction as a complex system?

Xiaoman (Mandy) Zi







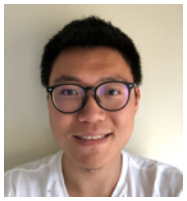

Visible facial expression
0:28 smile
For the rest of the clip: smile, laugh
External
Action
0:28 walk out of the house
0:30 talk, hug, kiss the young woman
0:38-0:42 spin the young woman
Talking(words)
0:31 "I miss you so much"
0:38-0:47 consistently talking, making sounds
Old Man
Emotion/Feeling
Happy
Excited
Internal
Perception/Belief
Young woman is his daughter
Saw young man
Young woman is happy to see him
Visible facial expression
0:36 slightly smile, slightly nod
0:42 slightly frown
External
Action
Stand still in front of the car
Talking(words)
Silent, no words
Young Man
Emotion/Feeling
Nervous
Awkard
Confuse
Shock
Internal
Saw old man
Young woman is his girlfriend
Old man is his girlfriend's dad

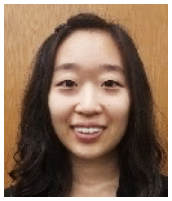
Film Detective

Helping kids learn to decode social scenarios through a film-based game

Department of Electrical Engineering and Computer Science





Artificial Intelligence and Visual Analogical Systems

Maithilee Kunda, PI (Assistant Professor of CS)
Roxanne Rashedi (postdoctoral fellow, PhD in Education)
Shiyao Li (MS in Data Science, 2021)
Phil Chen (MS in CS, 2019)
Mandy Zi (BS in CS, 2020)
Christine Kim (BS in CS and Cognitive Studies, 2020)



Open-Ended Learning Environments

Gautam Biswas, Co-PI (Professor of CS)
Marian Rushdy (research engineer)
Shitanshu Mishra (postdoctoral fellow, PhD in CS)

Vanderbilt Kennedy Center





Treatment and Research Institute for Autism Spectrum Disorders (TRIAD)

Zachary Warren, Co-PI (Professor of Pediatrics, Psychiatry & Behavioral Sci., and Special Ed.; TRIAD Executive Director)
Pablo Juarez, Co-PI (Senior Associate of Pediatrics, Psychiatry & Behavioral Sci., and Special Ed.; TRIAD Director)
Amy Kinsman (TRIAD Educational Consultant)
Amy Swanson (TRIAD Project Manager)
Nicole Bardett (TRIAD Project Coordinator)

Department of English



Creative Writing Programs

Morgan Elrod-Erickson (BA in English and Chemistry, 2022)
Bryan Hollis (BA in Cinema & Media Arts, and English, 2021)
Chris Ketchum (MFA, Creative Writing)

Data Science Institute

Ben Lane (research scientist)

Qualitative Research Core



David Schlundt (Associate Professor of Psychology)
Kemberlee Bonnet (Research Coordinator)
Rebecca Schulte (BS in Psychology, 2020)

Film Detective Team & Collaborators

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“The world needs all kinds of minds.”

- Temple Grandin