

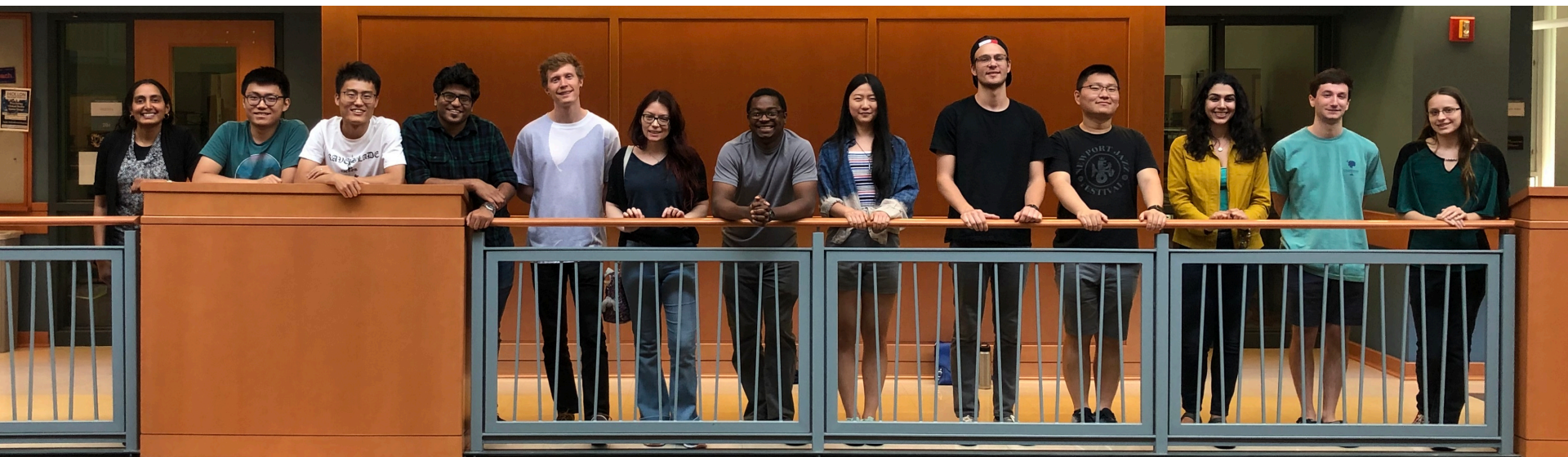
Autism-Inspired AI for Visuospatial and Social Reasoning

Maithilee Kunda

Assistant Professor, EECS, Vanderbilt University

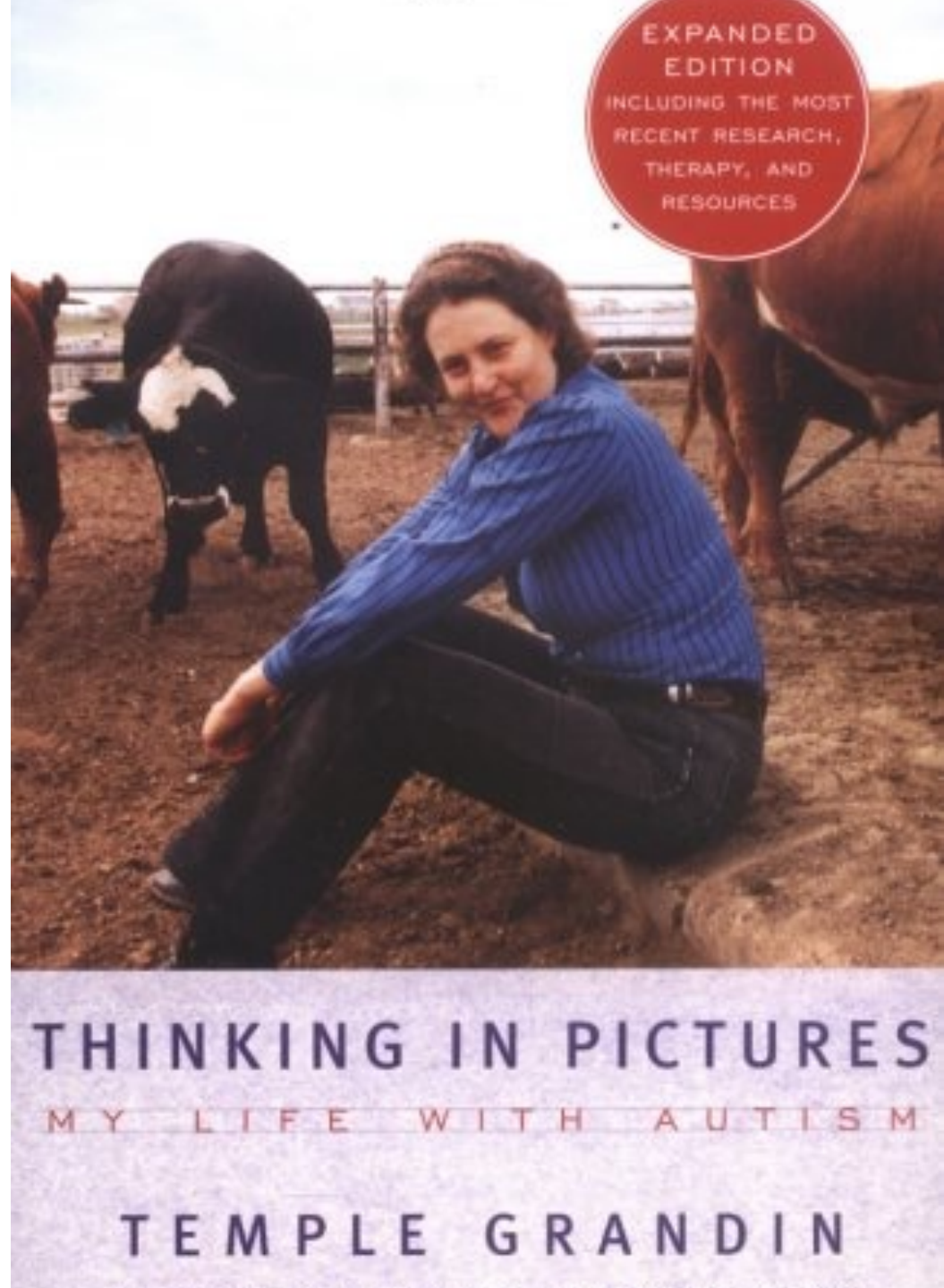
Vanderbilt Frist Center for Autism & Innovation

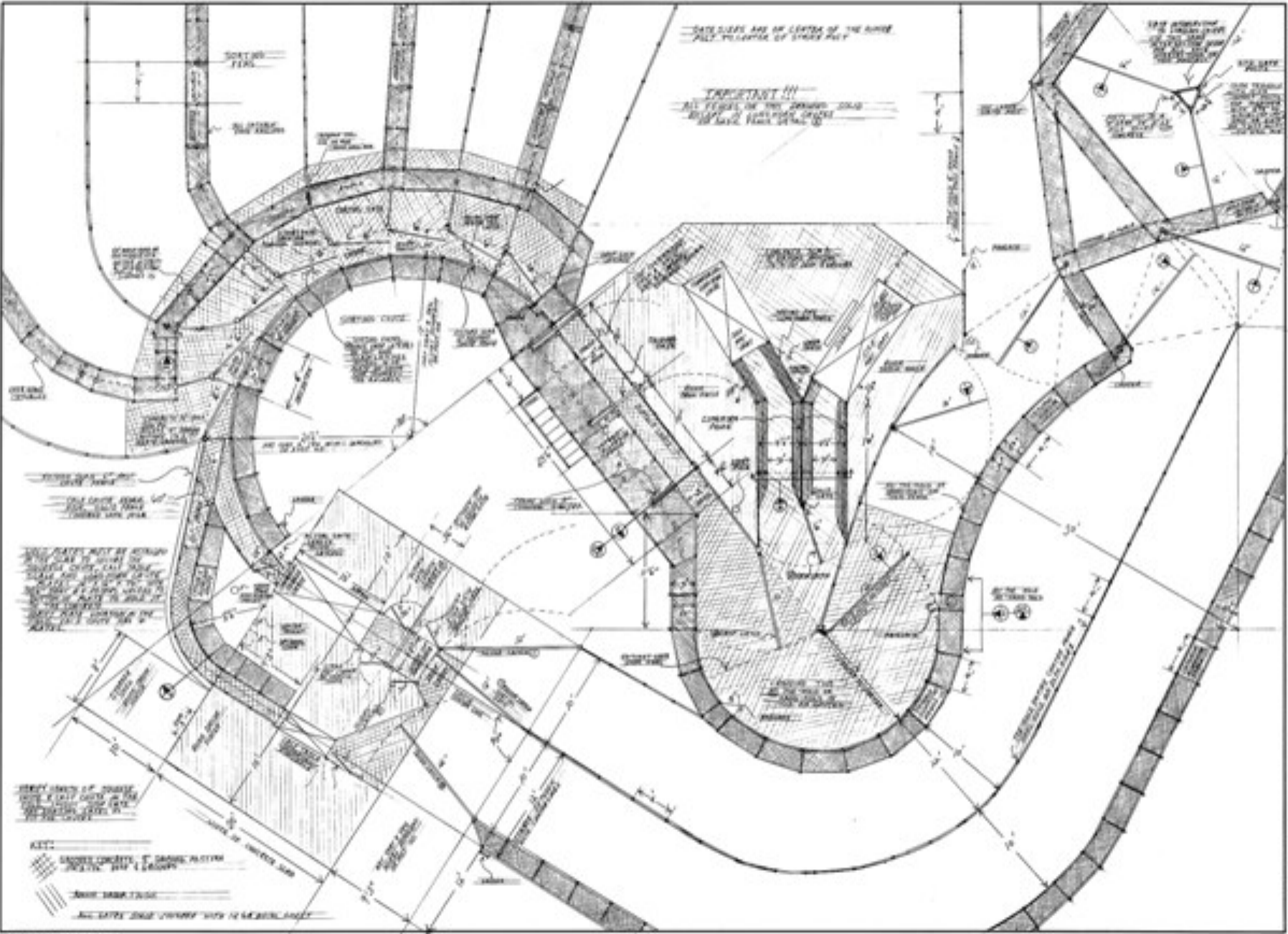
Artificial Intelligence & Visual Analogical Systems (AIVAS) Lab



My research:

**AI inspired by
Temple Grandin
and others on the
autism spectrum**





DATE LINES ARE ON CENTER OF THE RIVER
 FULL Y-SCALE OF SHOWN PLAN

IMPORTANT!!!
 ALL DETAILS OF THE DESIGN SHALL
 BE MADE FROM THIS PLAN

THIS PLAN IS NOT TO BE
 USED FOR ANY OTHER
 PURPOSES WITHOUT THE
 WRITTEN CONSENT OF
 GRANDIN

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 USED FOR ANY OTHER
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 GRANDIN

KEY:
 UNPAVED CONCRETE, 1" DRINKING WATER
 2025 PSI 2" & 4" LAYERS
 PAVED CONCRETE
 ALL DATA SHALL CORRESPOND WITH 12 & 18 PANEL SHEETS

GRANDIN INDUSTRIES
 WASTEWATER TREATMENT MAIN CORRAL SORTING & WORKING AREA
 GRANDIN INDUSTRIES WASTEWATER TREATMENT SYSTEMS, INC.
 10000 W. 10TH AVENUE, DENVER, CO 80202
 TEL: 303-733-3030 FAX: 303-733-3031



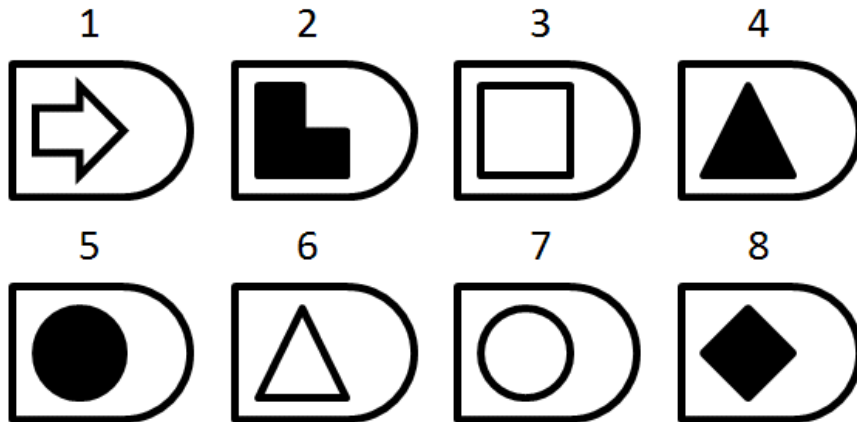
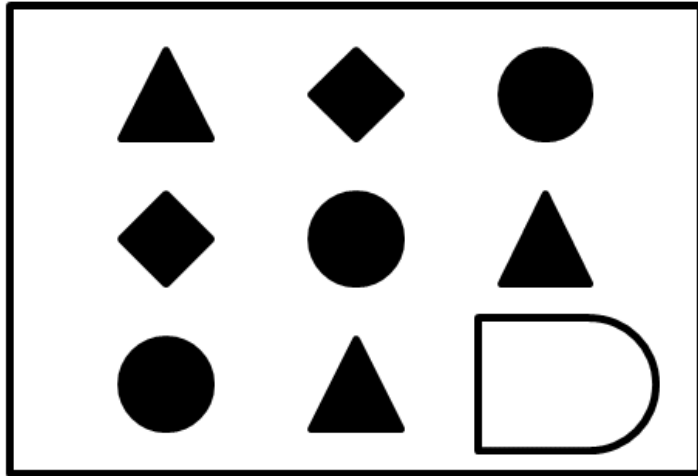
- Q1. What can AI and cognitive science learn by looking at the visuospatial abilities of autistic individuals?**
- Q2. How can AI approaches to social reasoning help autistic individuals improve their everyday social lives?**

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**

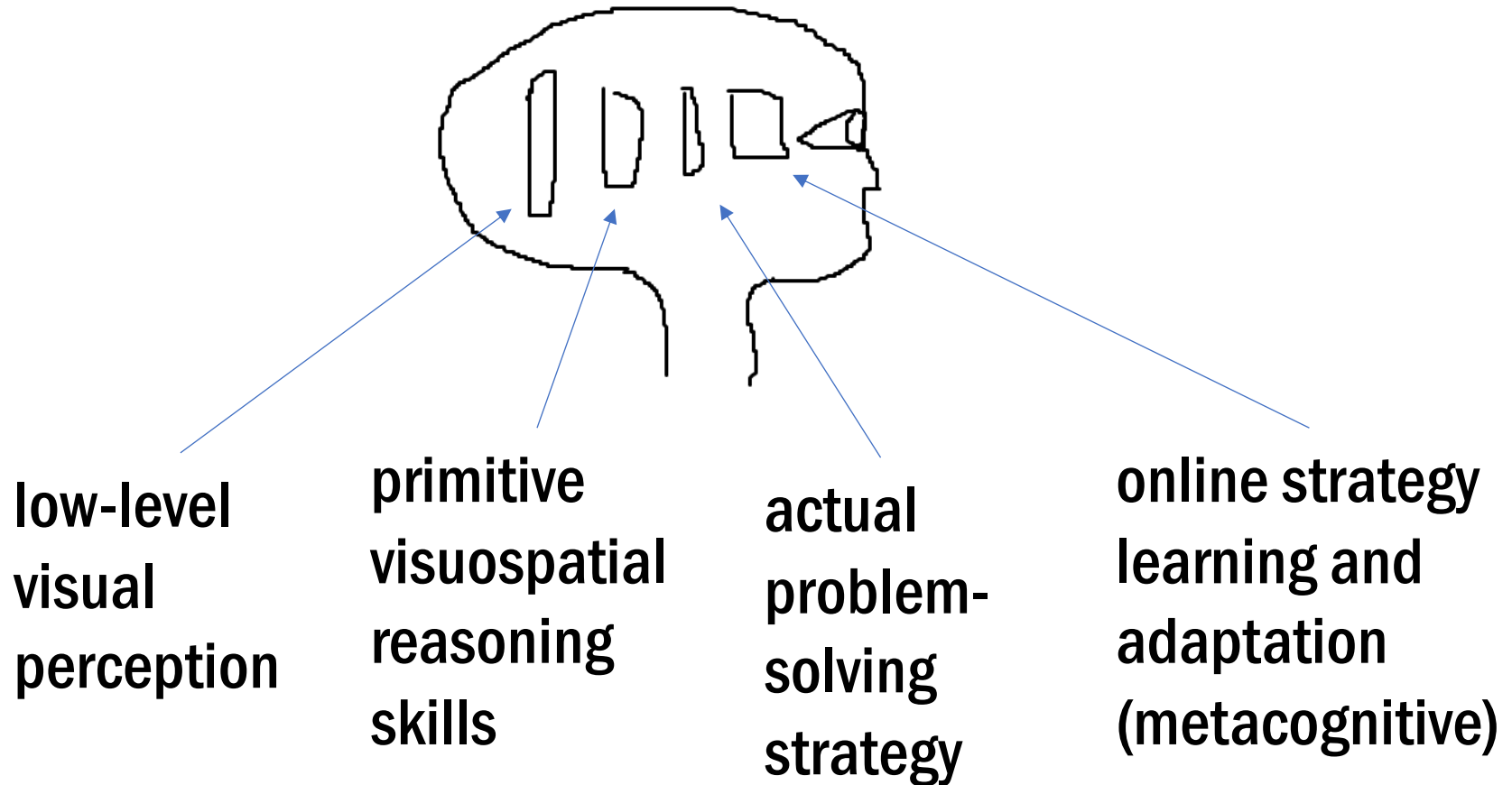
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- How did you know what to do?
- How did you plan your strategy?
- How many other ways could you do what you did?

A recipe for visuospatial reasoning



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A visual imagery-based architecture for visuospatial reasoning



James Ainooson
Ryan Yang
Tianyu Hua

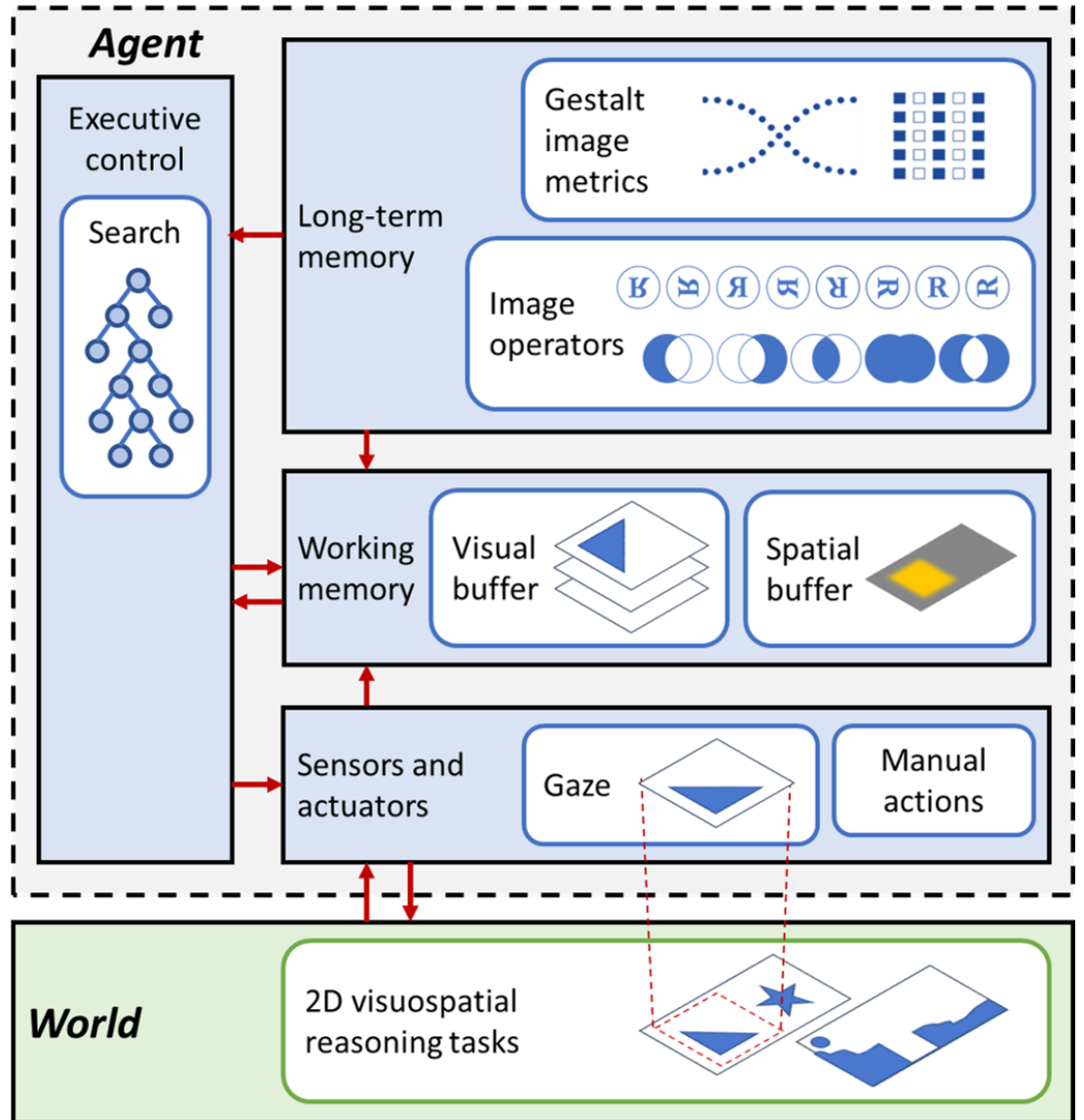


Table 3. General Strategy of our computational models.

Given a RPM problem or sub-problem p :

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

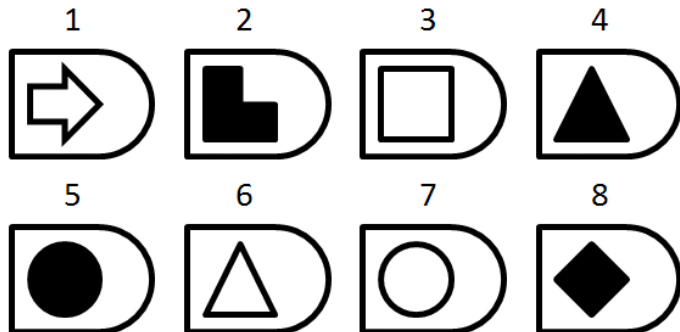
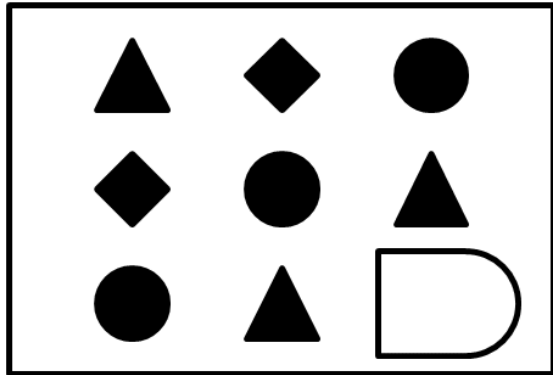


Table 4. Confident Strategy.

Given a RPM problem or sub-problem 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 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 p :

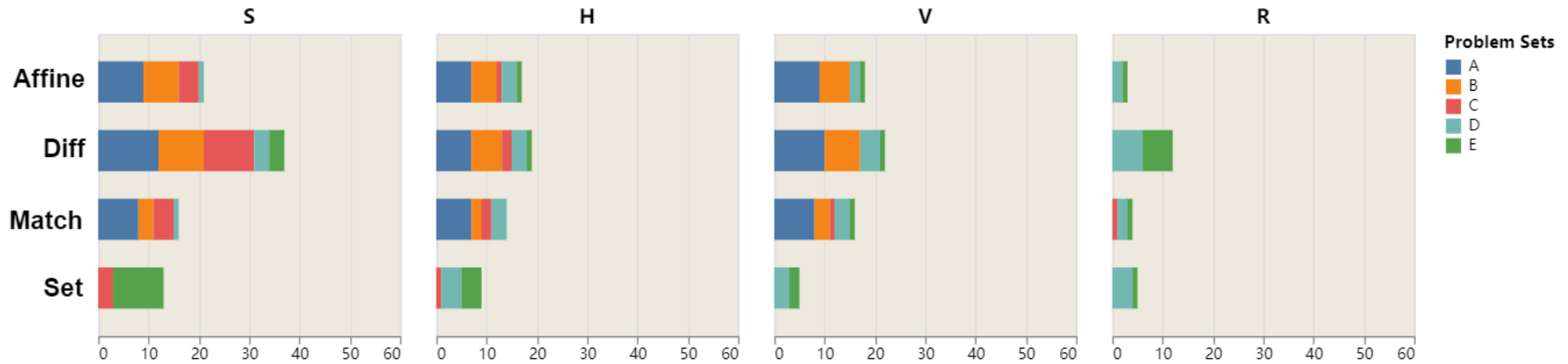
1. For each analogy and each transformation:
 - I. Calculate the PAT score
2. For each analogy A and each option O :
 - I. Let T_A be the transformation of maximum PAT score of A .
 - II. Generate a predicted image using p , A , T and O .
 - III. Calculate the $PATO$ score of the predicted image.
3.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

Table 6. Prudent Strategy.

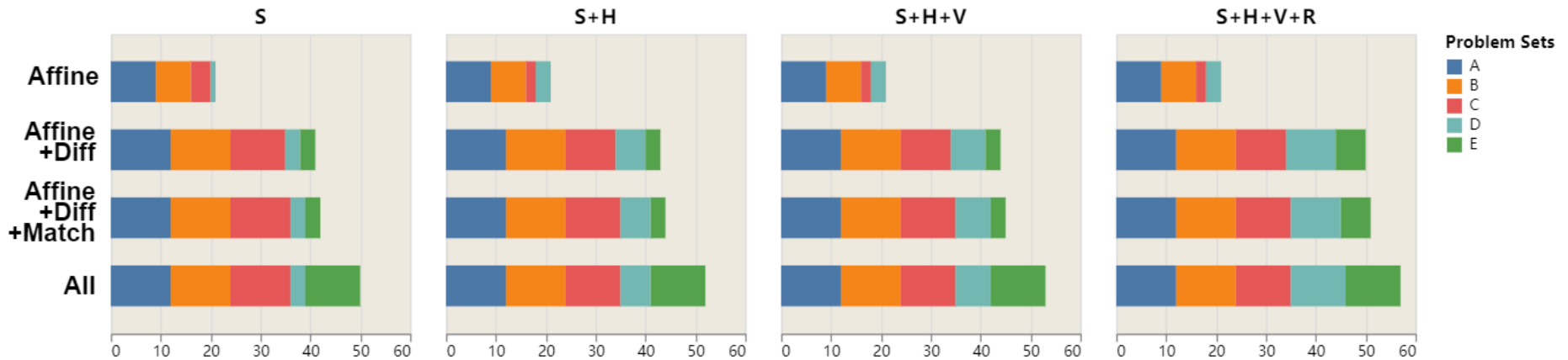
Given a RPM problem or sub-problem p :

1. For each analogy A , each transformation T and each option O :
 - I. Calculate the PAT score
 - II. Generate a predicted image using 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...

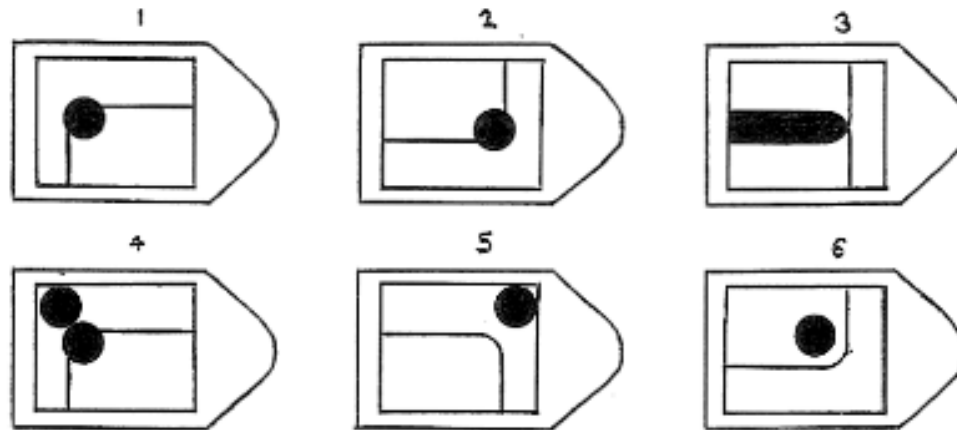
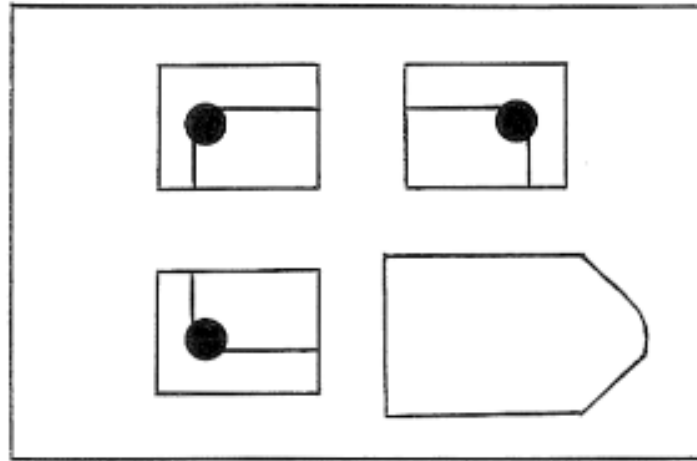
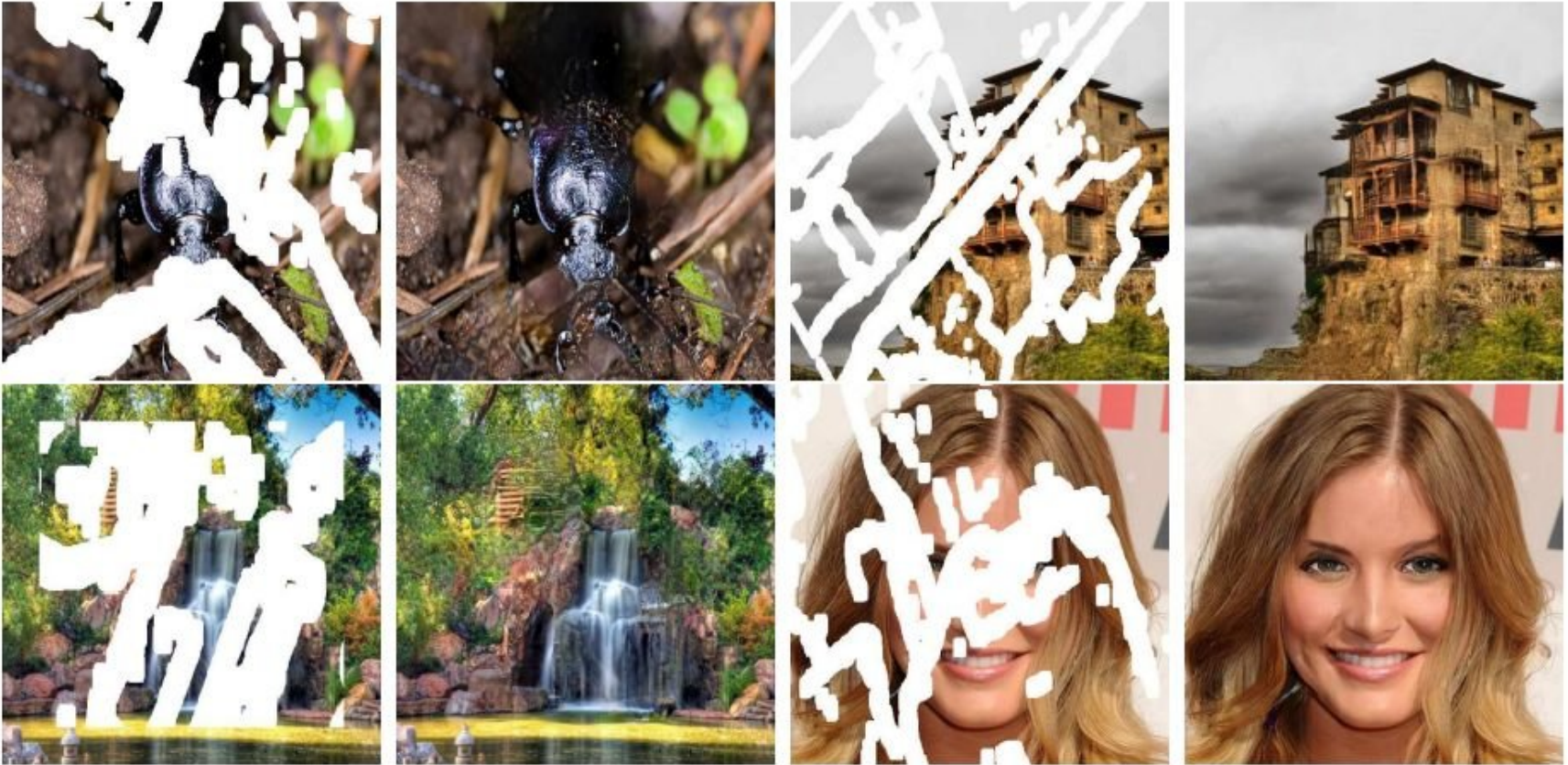
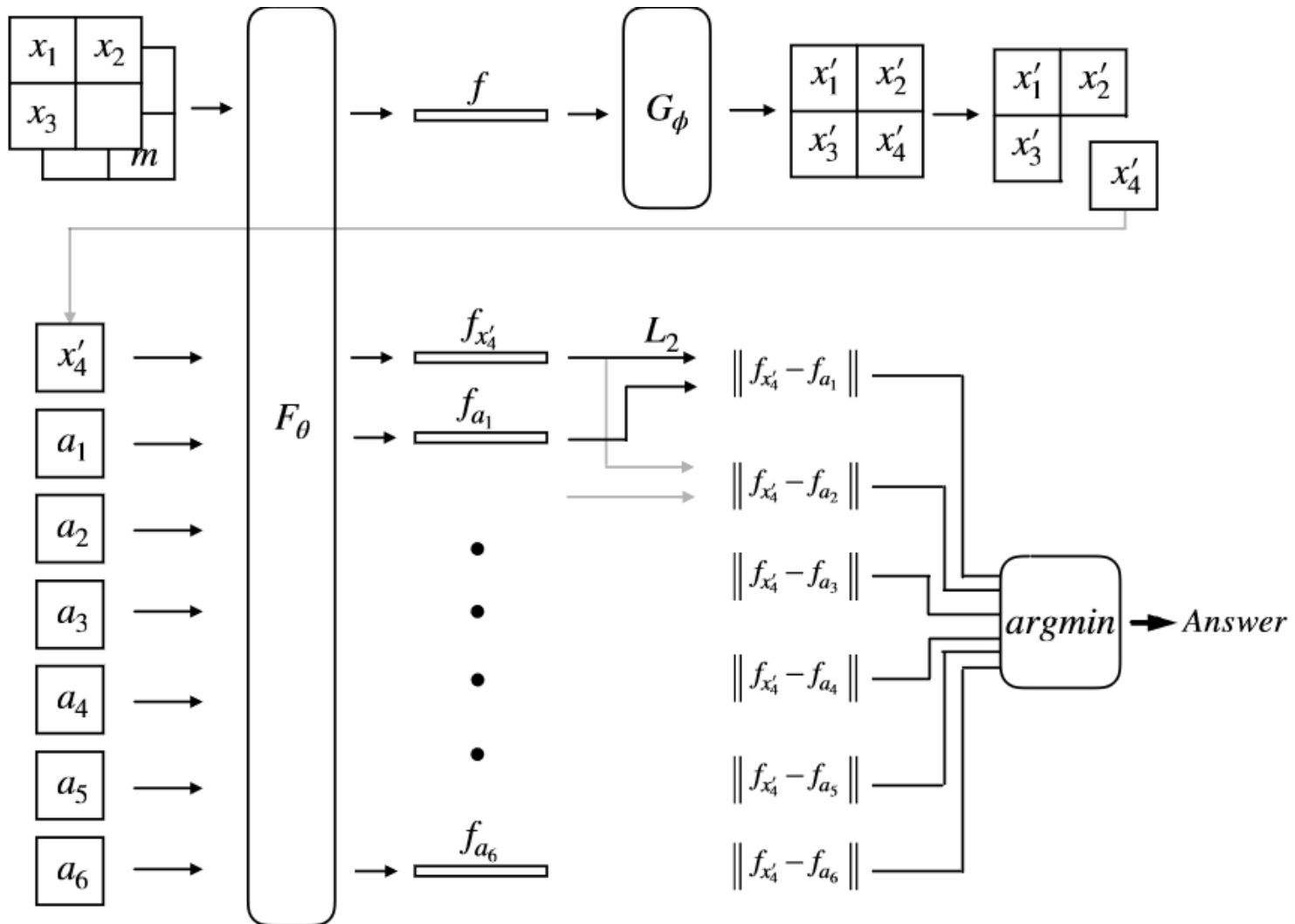


Image Inpainting (Gestalt?)

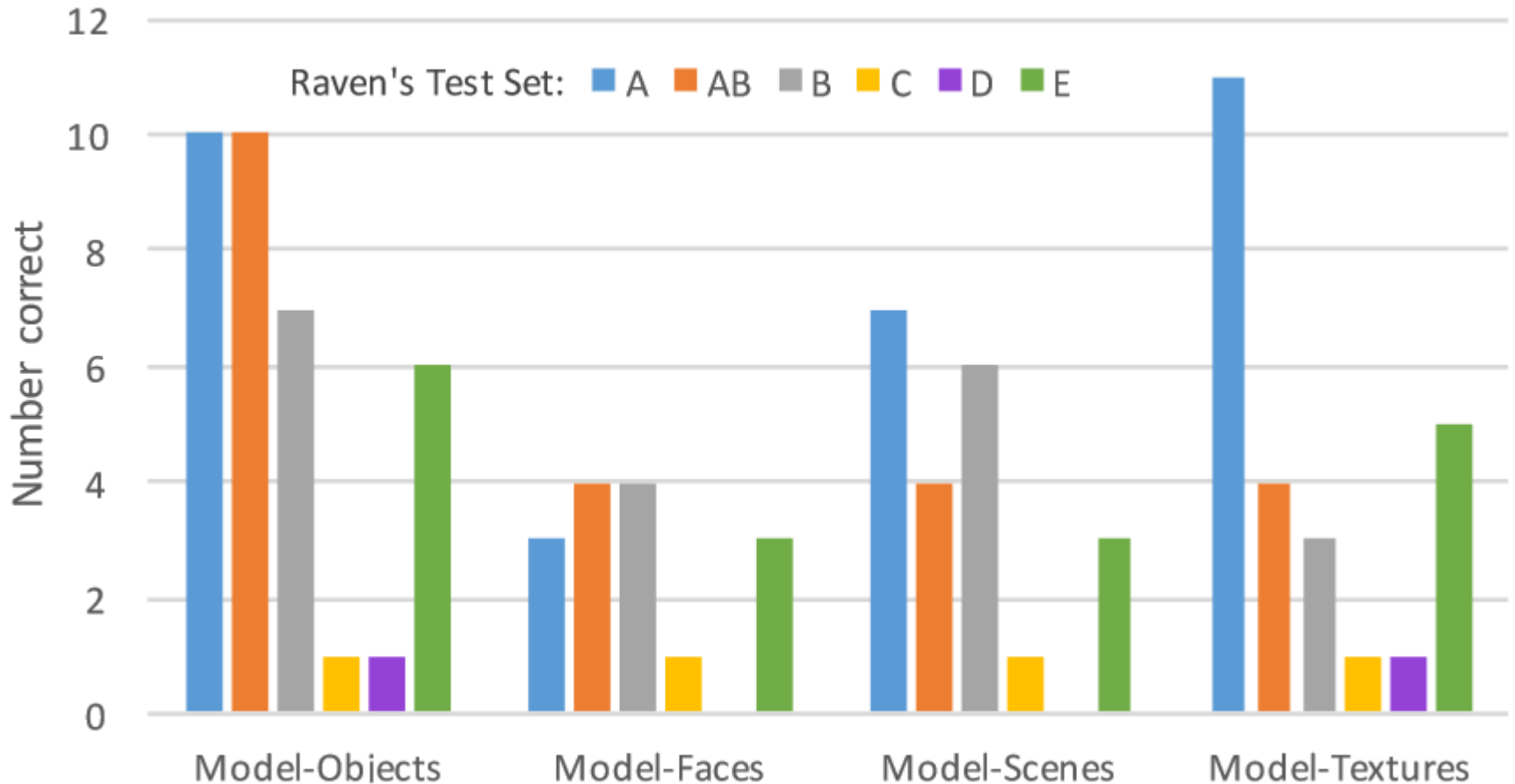


Liu, G., Reda, F. A., Shih, K. J., Wang, T. C., Tao, A., & Catanzaro, B. (2018). Image inpainting for irregular holes using partial convolutions. In *Proceedings of the European Conference on Computer Vision (ECCV)* (pp. 85-100).

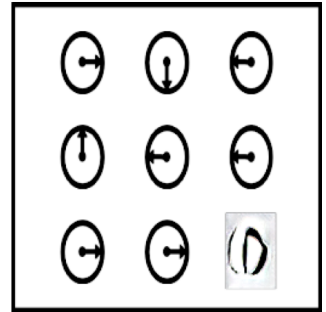
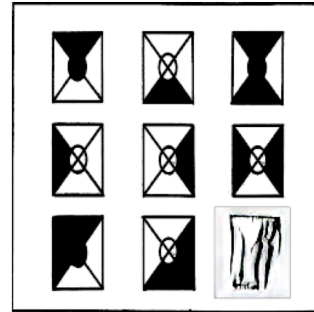
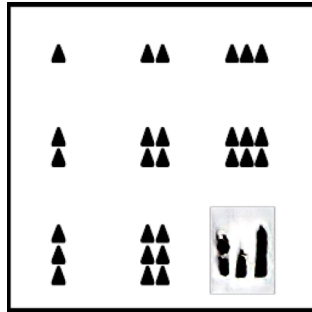
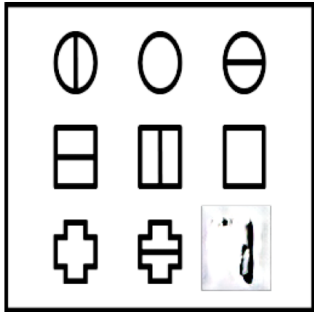
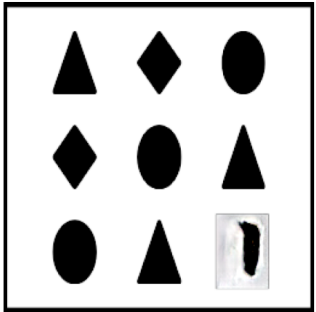
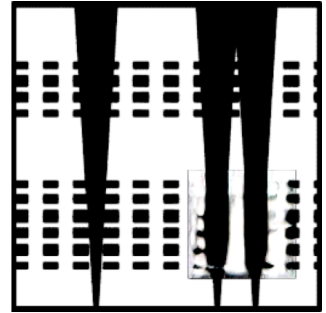
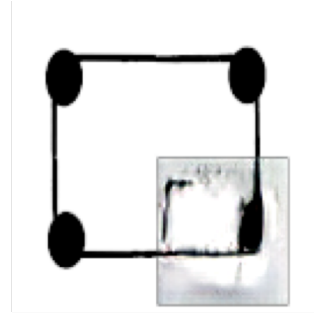
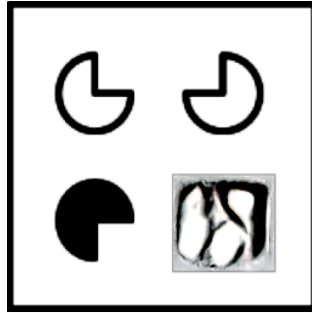
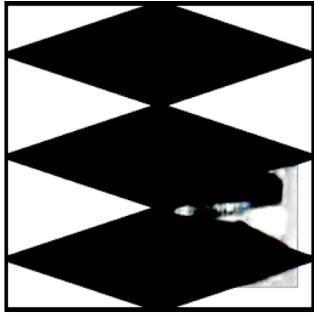
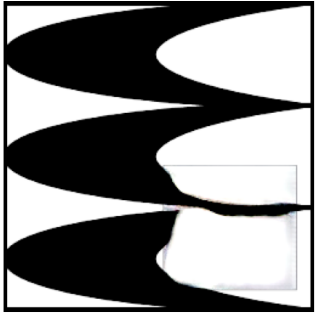
Using an inpainting network to solve Raven's problems



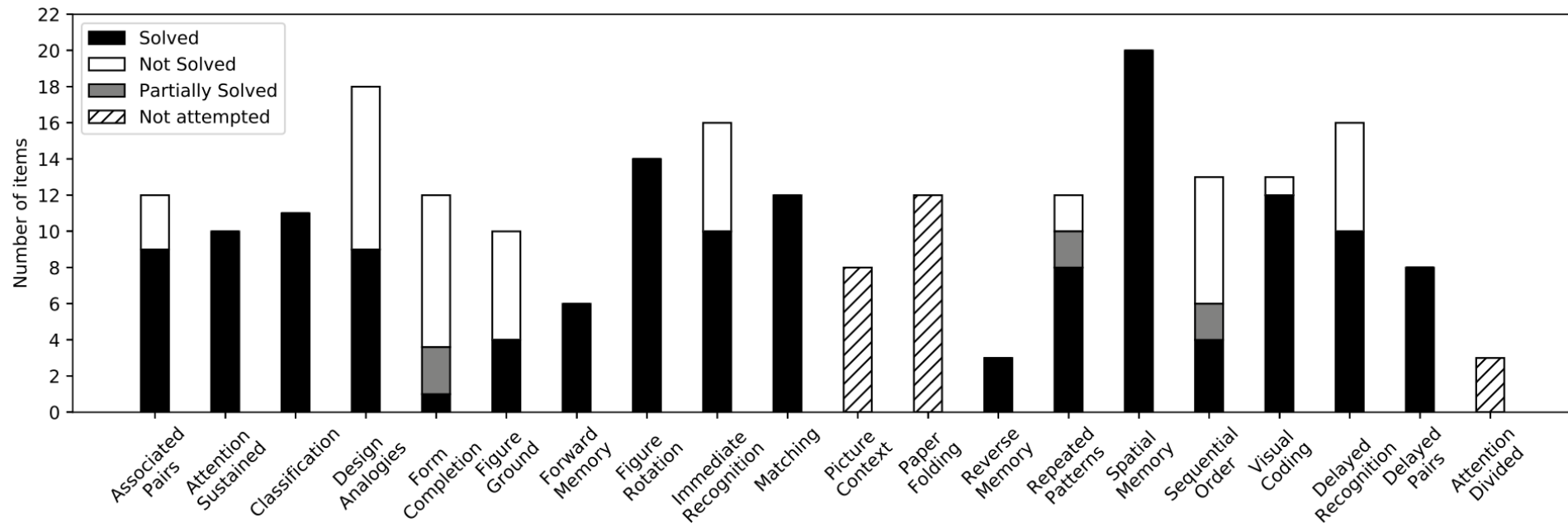
Results on the Colored and Standard Progressive Matrices tests



Inpainting examples



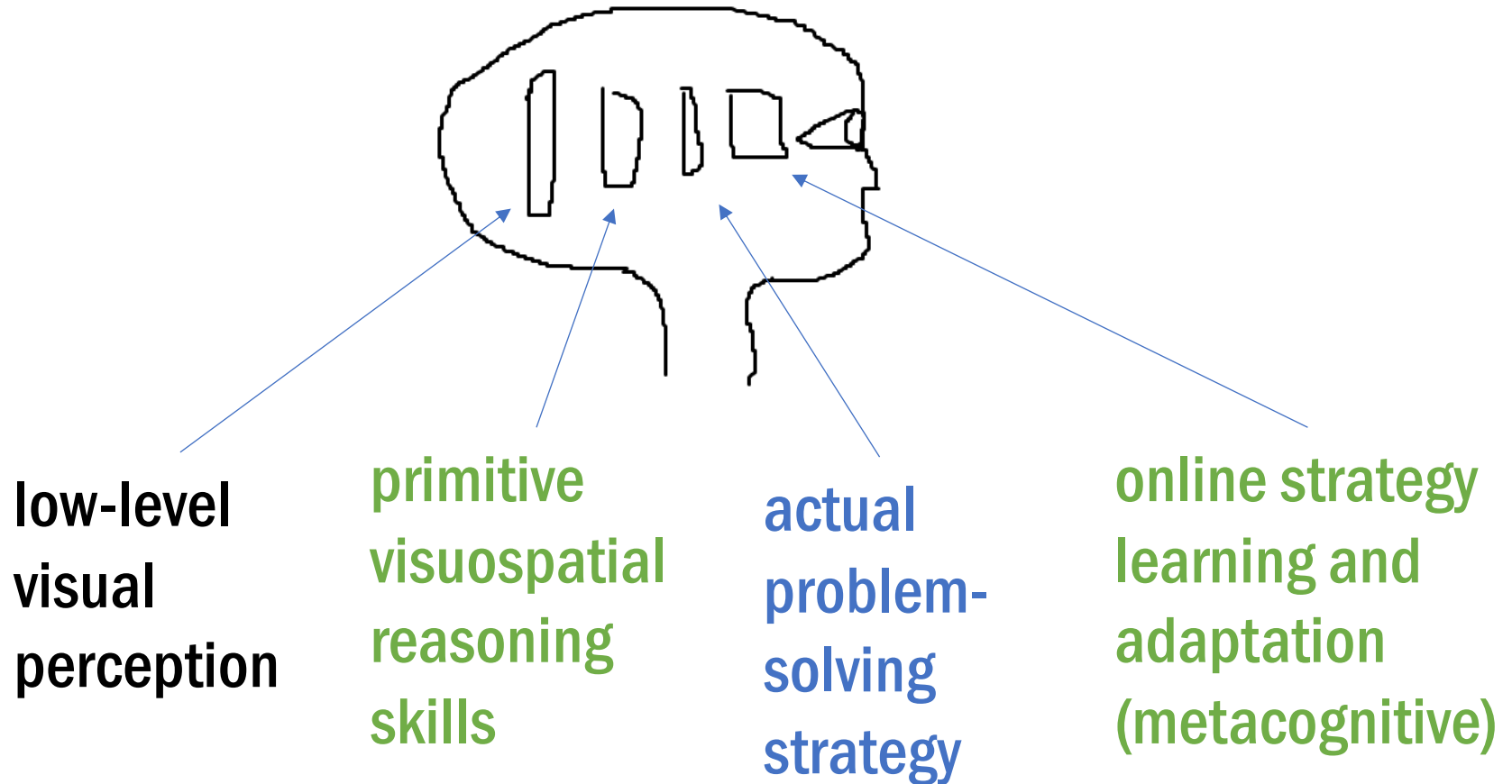
Latest results on the Leiter-R test battery (20 subtests)



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A recipe for visuospatial reasoning



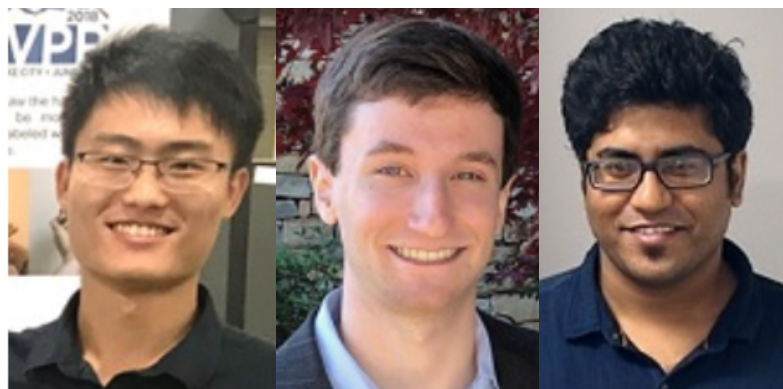
Learning primitive visuospatial reasoning skills from perceptual experience

With collaborator Linda Smith at Indiana University

Infant-view object play as the source of training inputs



Toybox Dataset



Tengyu Ma
Joel Michelson
Deepayan Sanyal

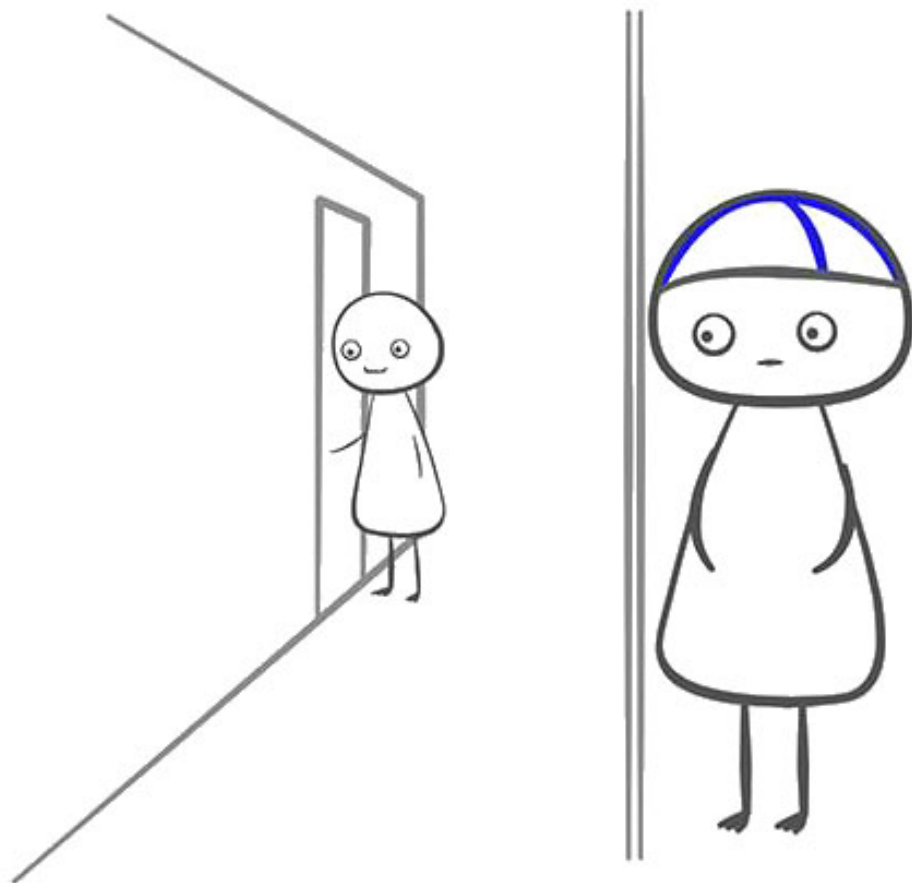
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FINNISH NIGHTMARES

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

Betty's Brain - Teachable Agents Group @ Vanderbilt University

The diagram illustrates the following causal relationships:

- vehicle use → makes (+) → burned fossil fuels
- burned fossil fuels → makes (+) → carbon dioxide
- garbage and landfills → result in (+) → methane
- methane → increases (+) → heat reflected to the earth
- carbon dioxide → increases (+) → heat reflected to the earth
- heat reflected to the earth → becomes (+) → absorbed heat energy
- absorbed heat energy → raises (+) → global temperature
- global temperature → melts (-) → sea ice
- sea ice → lowers (-) → ocean levels
- deforestation → destroys (-) → vegetation
- vegetation → absorbs (-) → carbon dioxide

Ask a Question Dialog:

What is the question?
 if **garbage and landfills** decrease, what happens to **sea ice**?

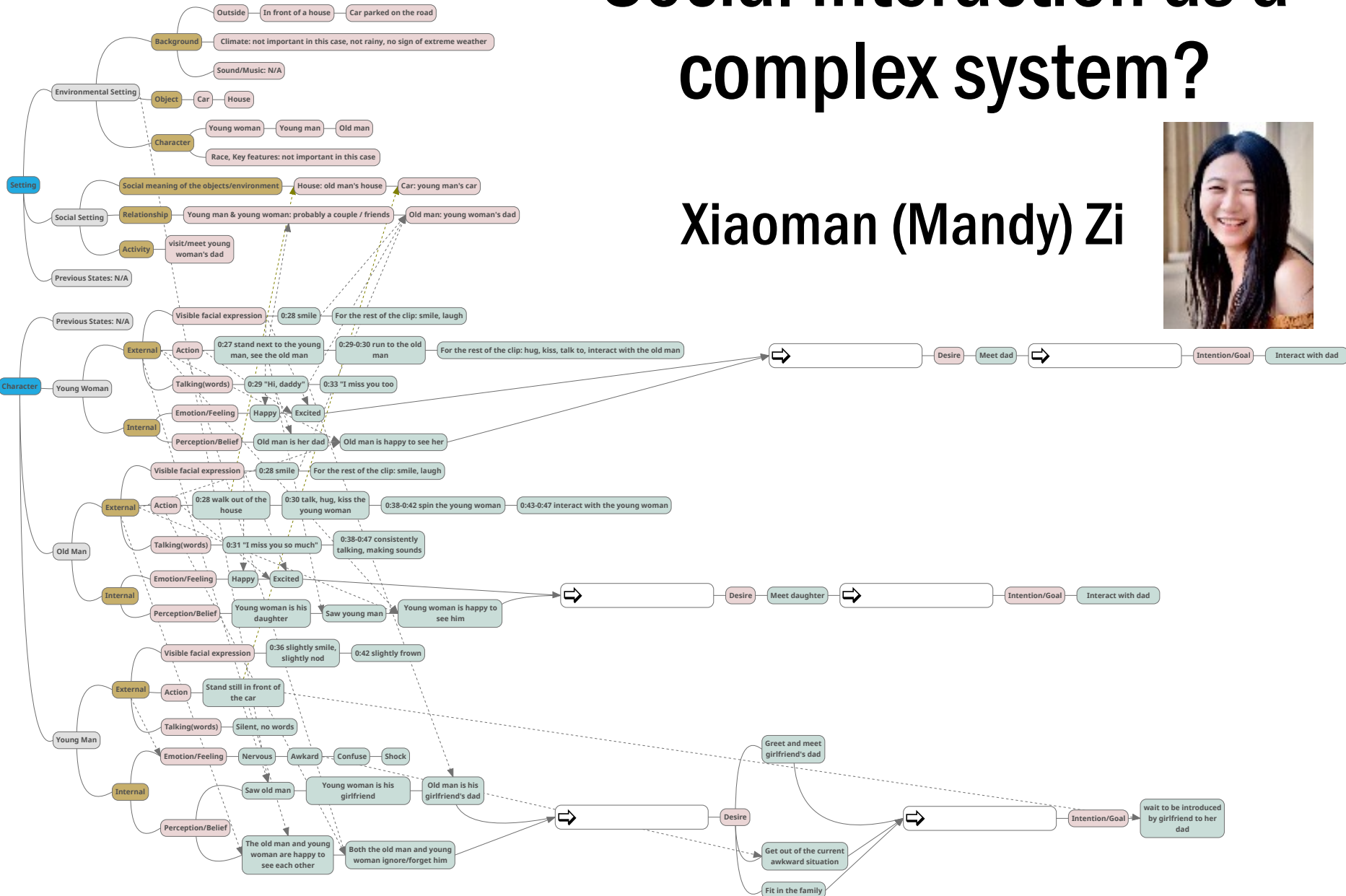
Talk Log:

Question	Answer	Action
✓ If deforestation increases, what happens to ocean levels?	increase	Re-ask question
✓ If vehicle use increases, what happens to ocean levels?	increase	Re-ask question
✗ If burned fossil fuels increase, what happens to vegetation?	unknown	Re-ask question
✗ If global temperature increases, what happens to heat reflected to the earth?	unknown	Re-ask question
✗ If global temperature increases, what happens to vegetation?	unknown	Re-ask question
✗ If sea ice increases, what happens to absorbed heat energy?	unknown	Re-ask question

Buttons: Ask, Explain, Take Quiz

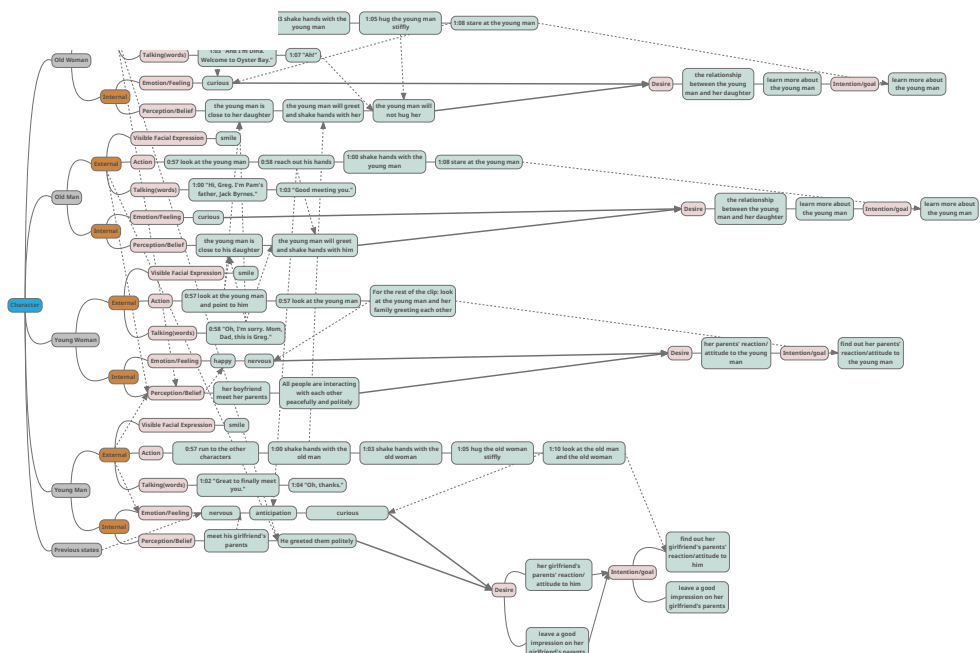
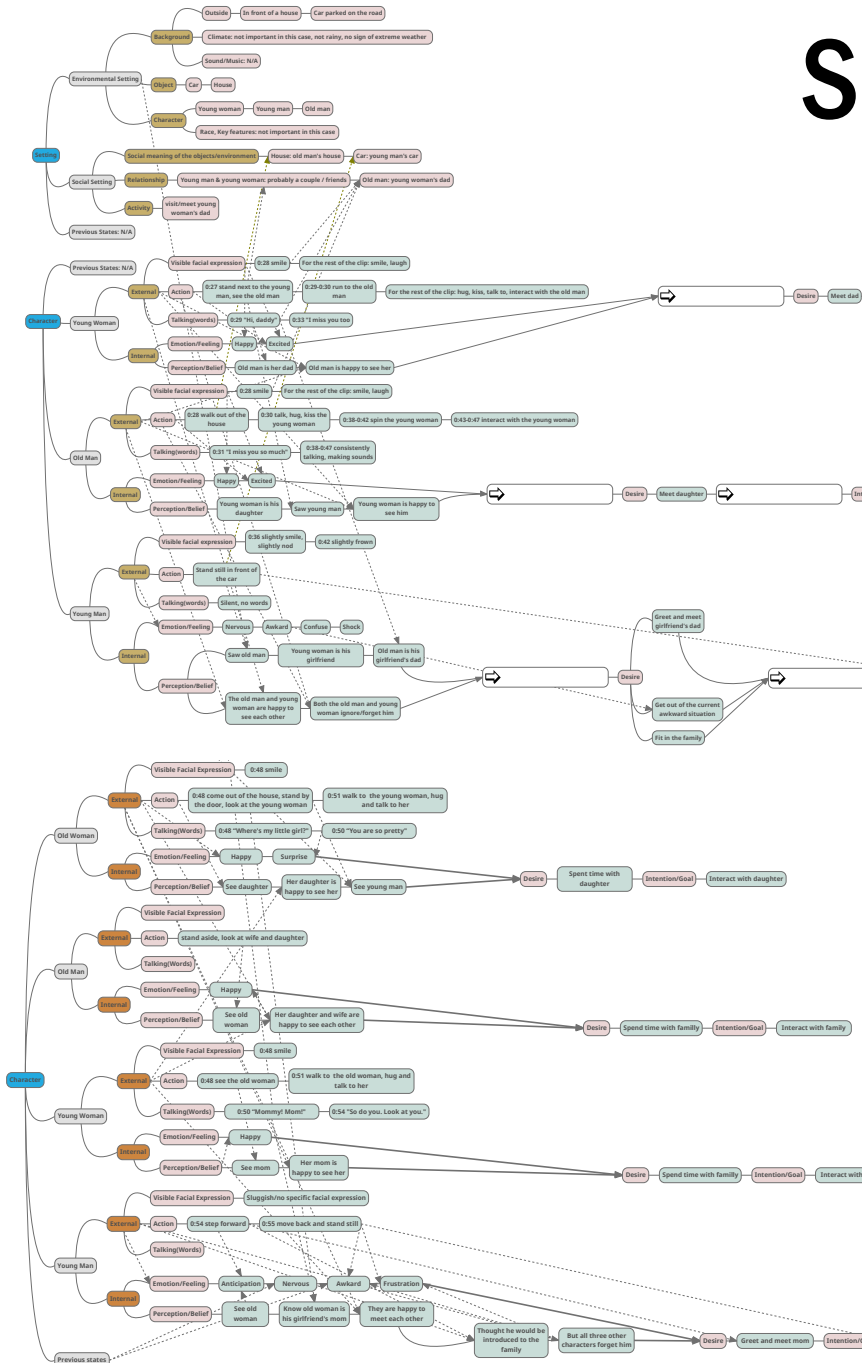
Social interaction as a complex system?

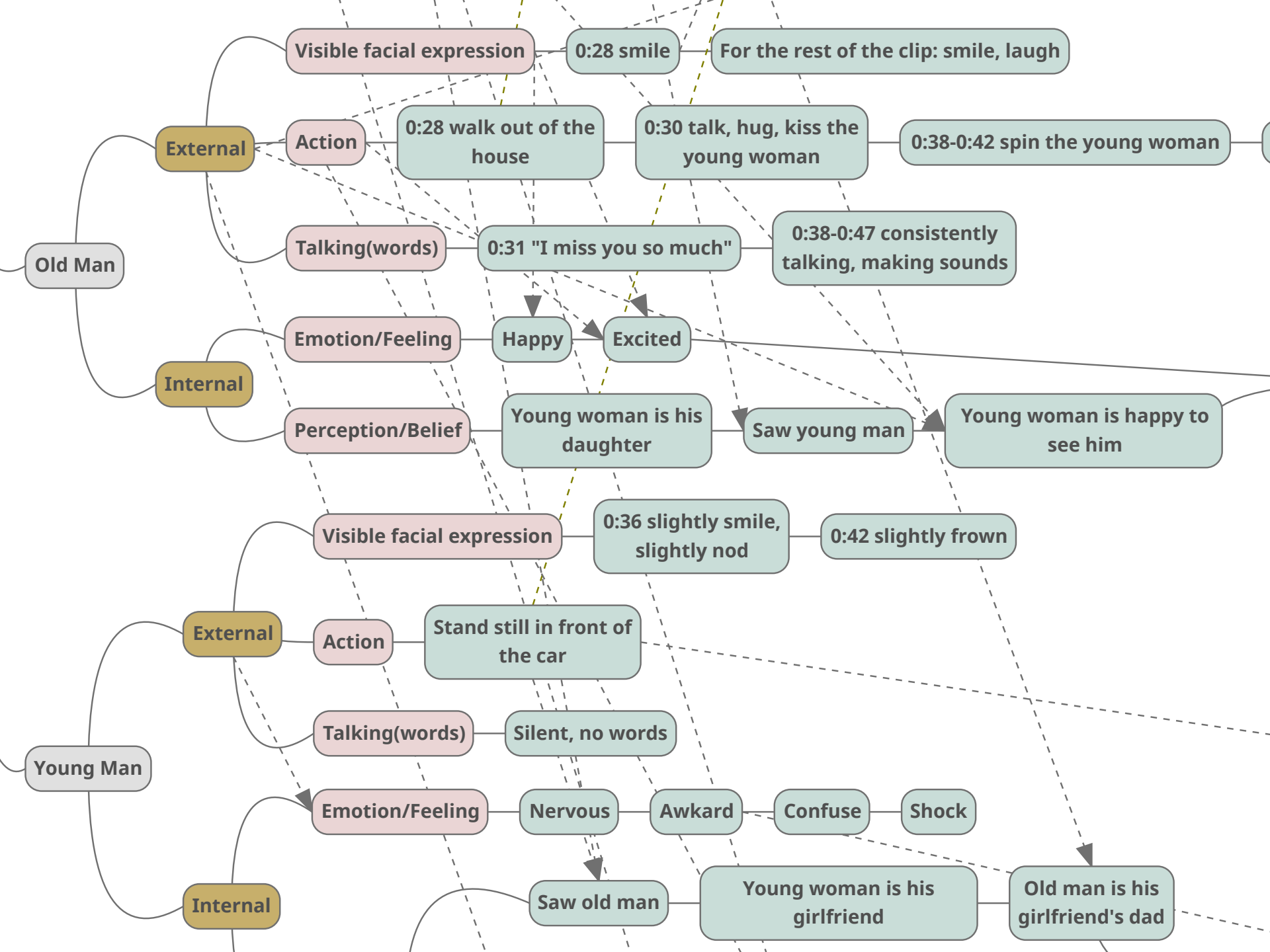
Xiaoman (Mandy) Zi



Social interaction as a complex system?

Xiaoman (Mandy) Zi





Old Man

External

Visible facial expression

0:28 smile

For the rest of the clip: smile, laugh

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

Internal

Emotion/Feeling

Happy

Excited

Perception/Belief

Young woman is his daughter

Saw young man

Young woman is happy to see him

Young Man

External

Visible facial expression

0:36 slightly smile, slightly nod

0:42 slightly frown

Action

Stand still in front of the car

Talking(words)

Silent, no words

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



[Home Page](#)

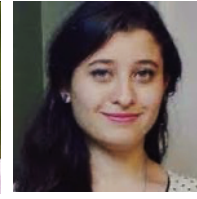
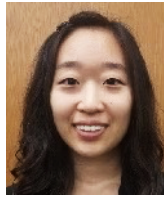
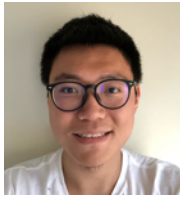
[Research](#)

[Storyline](#)

[Publications](#)

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Department of Electrical Engineering and Computer Science



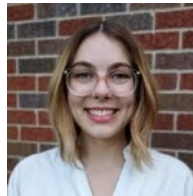
Artificial Intelligence and Visual Analogical Systems

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)

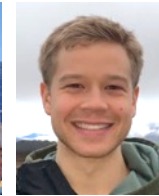
Vanderbilt Kennedy Center



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)

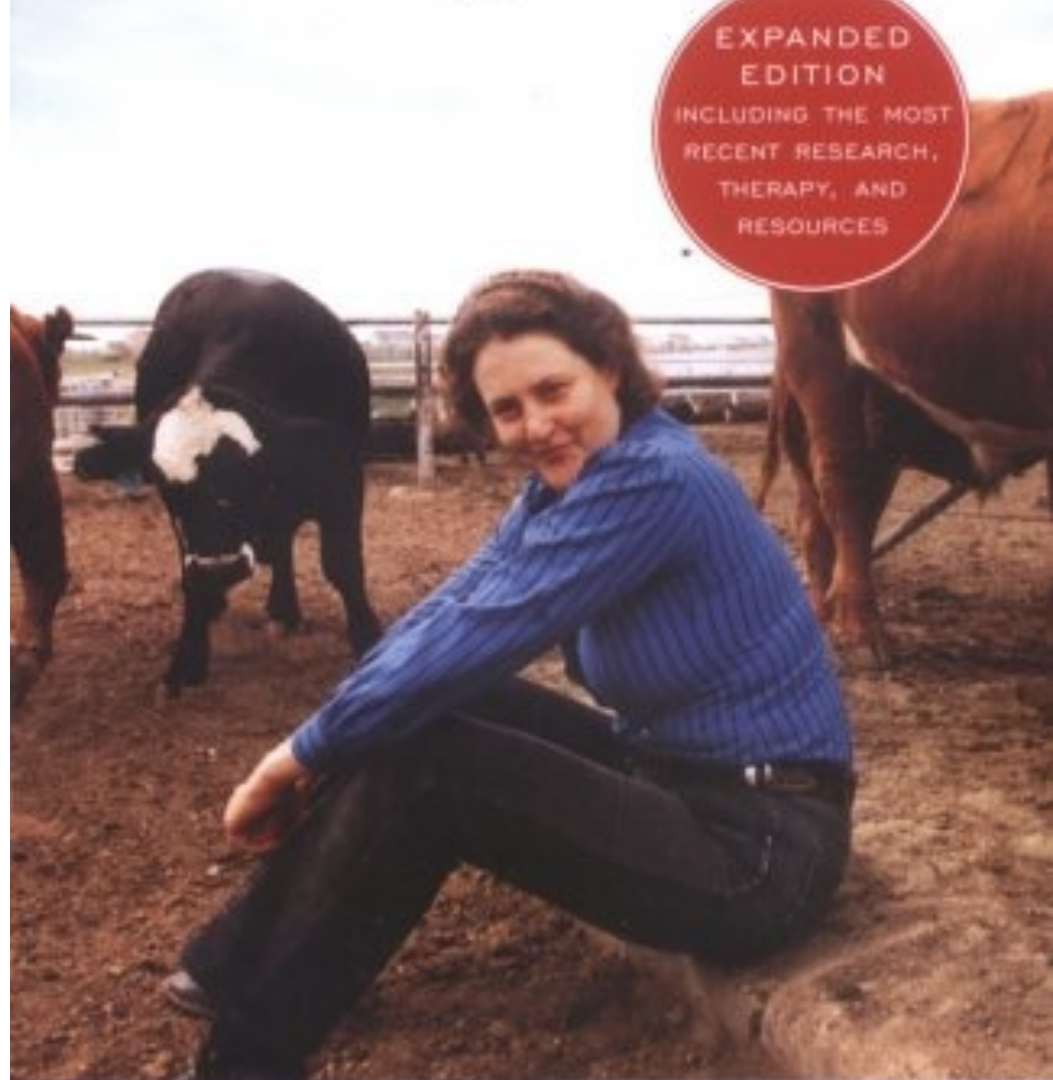


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**“The world needs
all kinds of minds.”**

- Temple Grandin



THINKING IN PICTURES

MY LIFE WITH AUTISM

TEMPLE GRANDIN