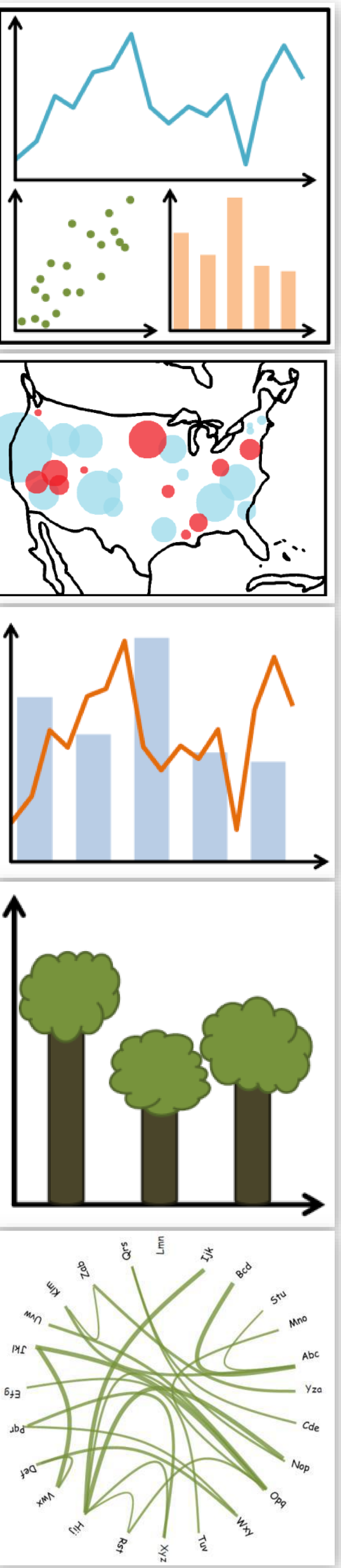


Evaluation

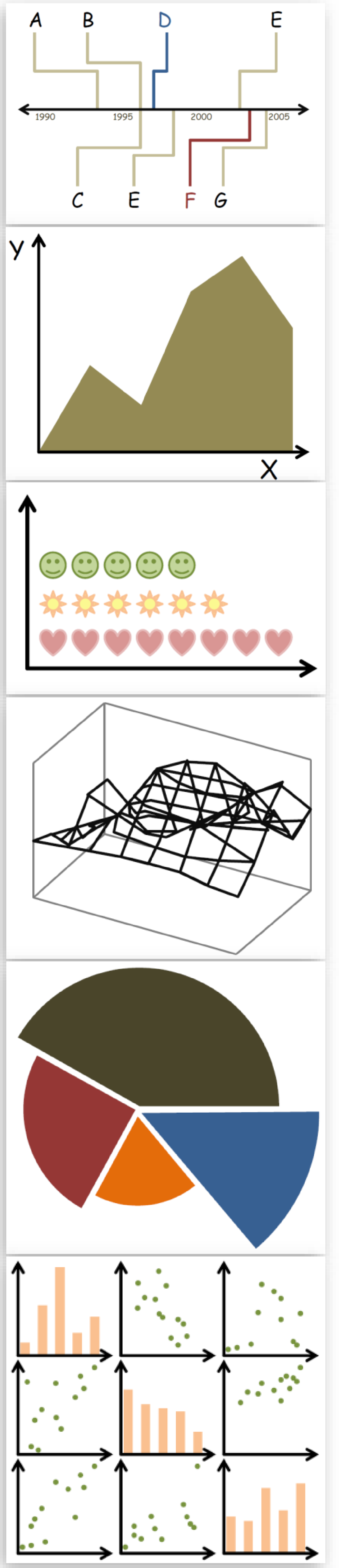
DS 4200

FALL 2020

Prof. Cody Dunne

NORTHEASTERN UNIVERSITY

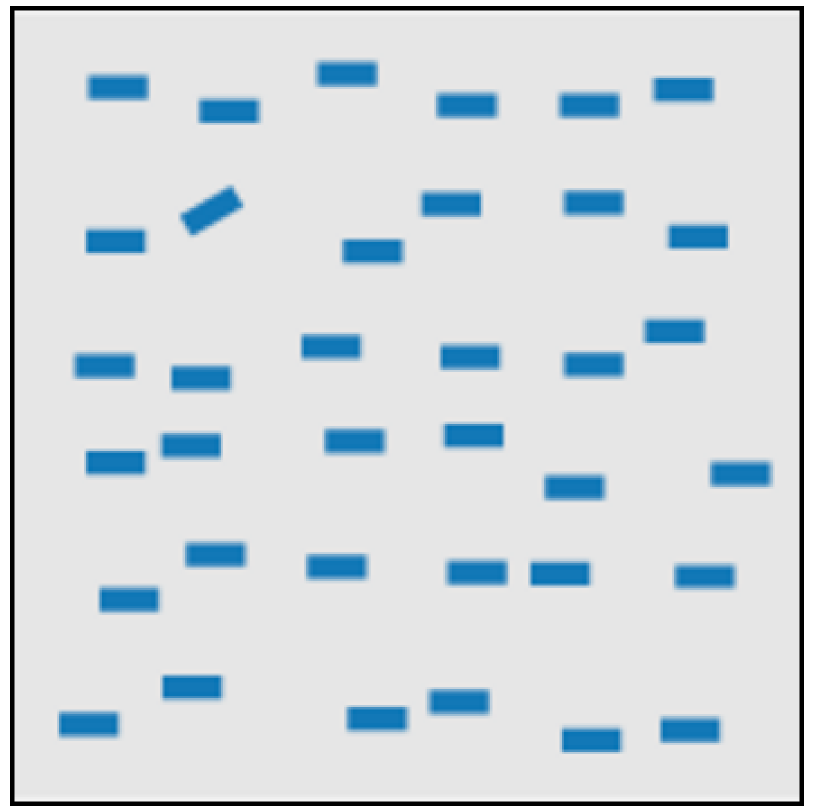
Slides and inspiration from Michelle Borkin, Krzysztof Gajos, Hanspeter Pfister, Miriah Meyer, Jonathan Schwabish, and David Sprague



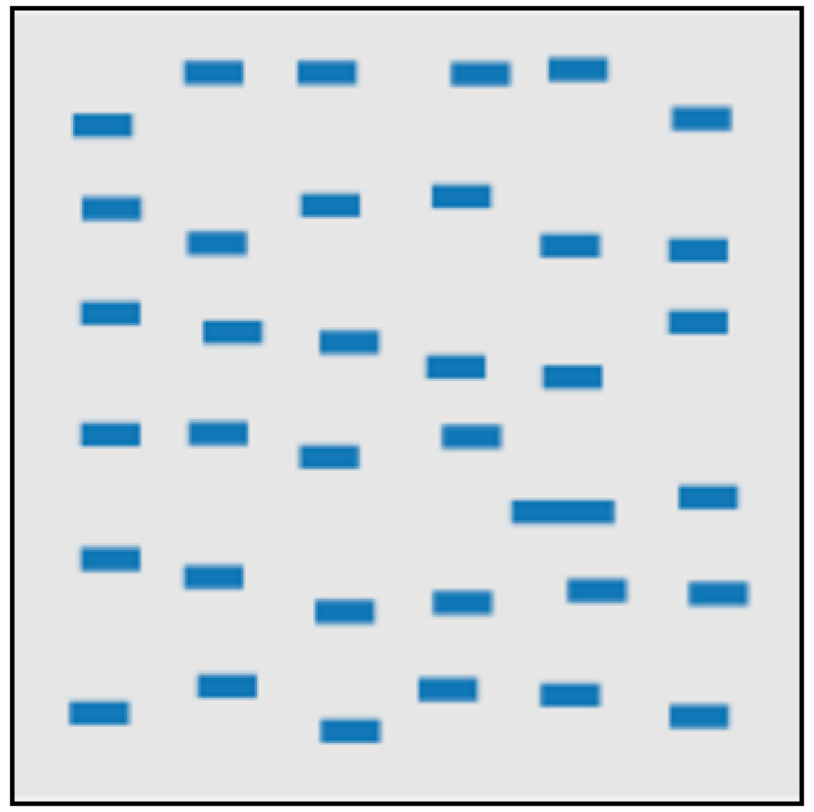
Check-in

Previously, on DS 4200…

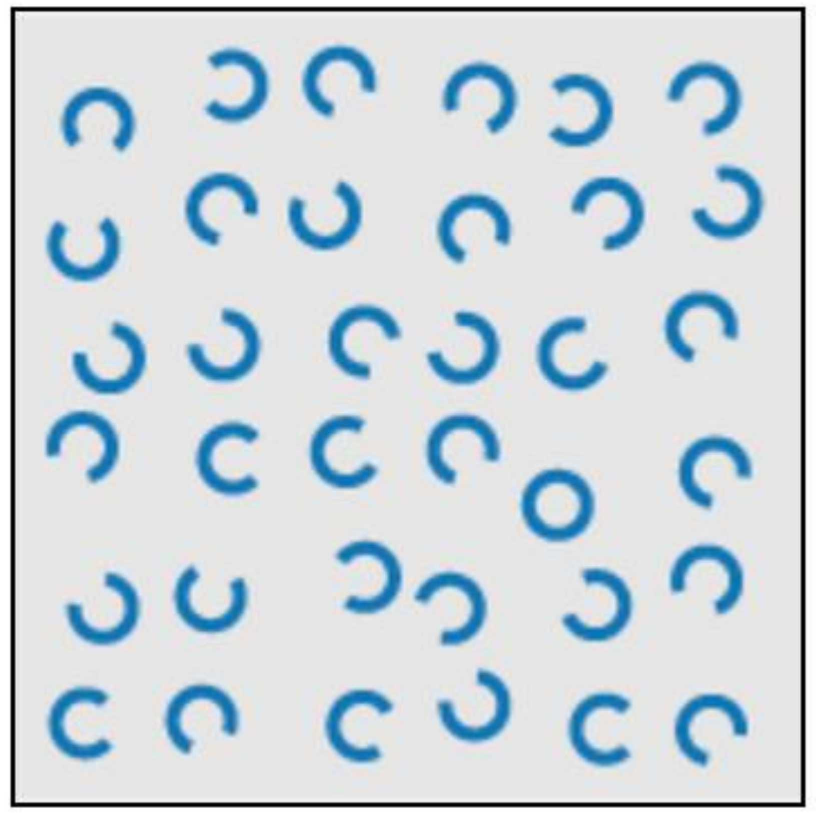
Pop-Out Effects



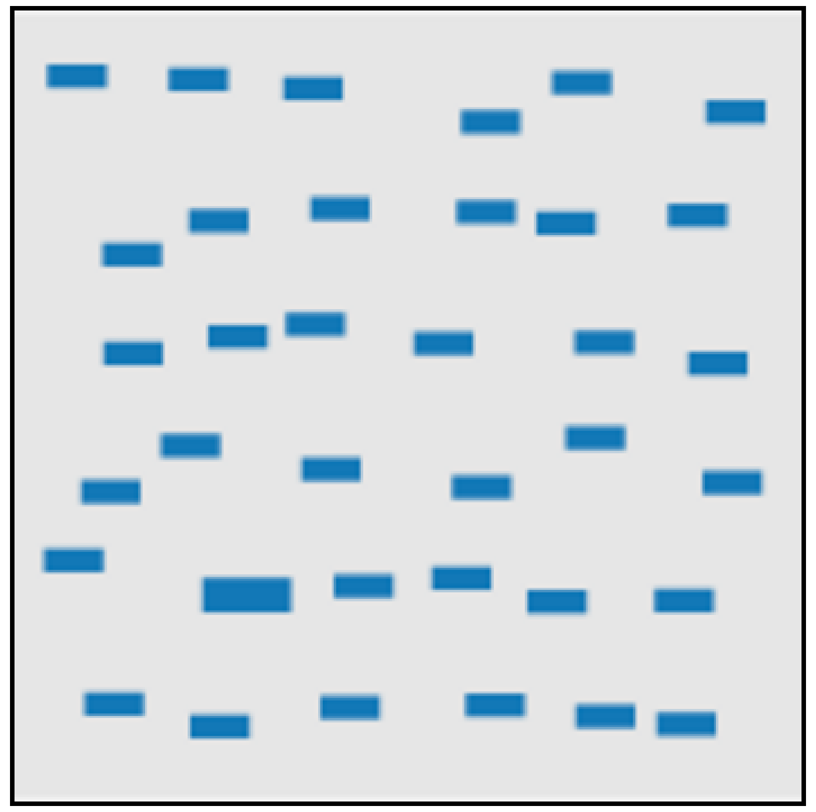
line (blob) orientation
Julész & Bergen 83; Sagi & Julész 85a, Wolfe et al. 92; Weigle et al. 2000



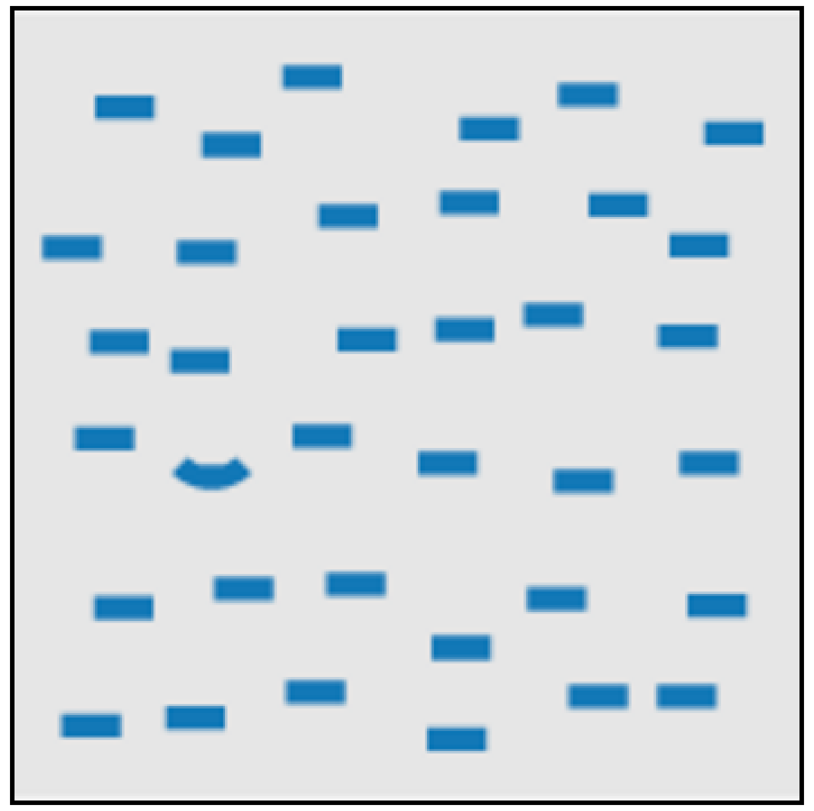
length, width
Sagi & Julész 85b; Treisman & Gormican 88



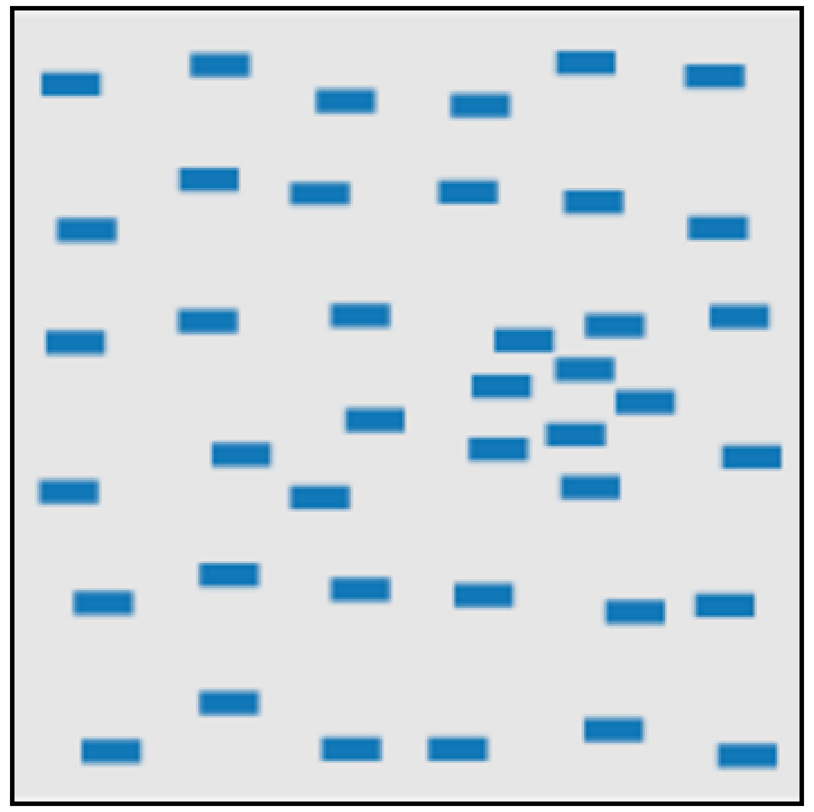
closure
Julész & Bergen 83



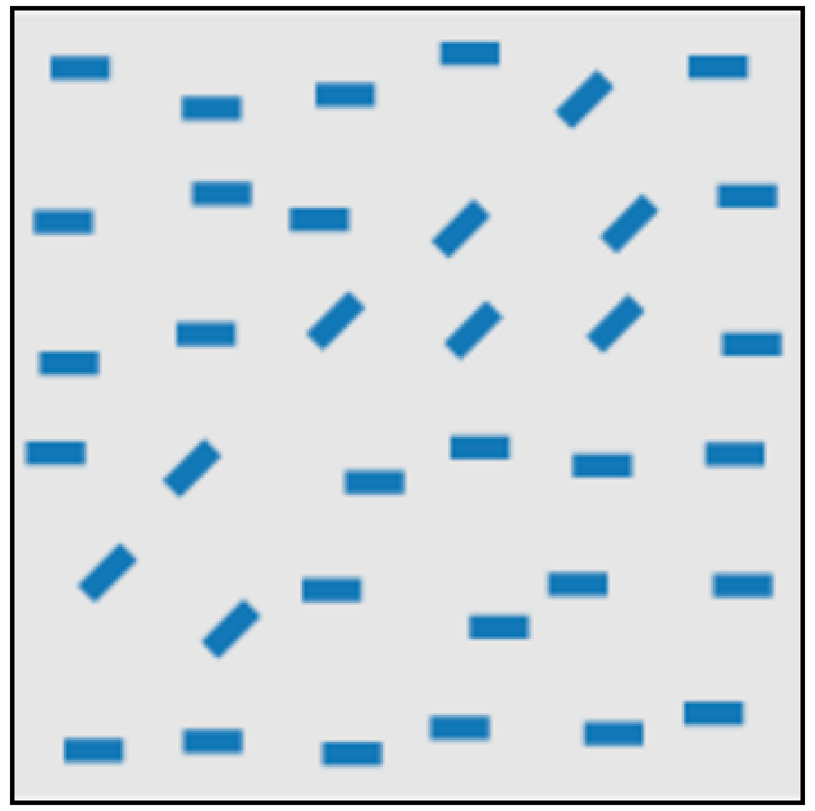
size
Treisman & Gelade 80; Healey & Enns 98; Healey & Enns 99



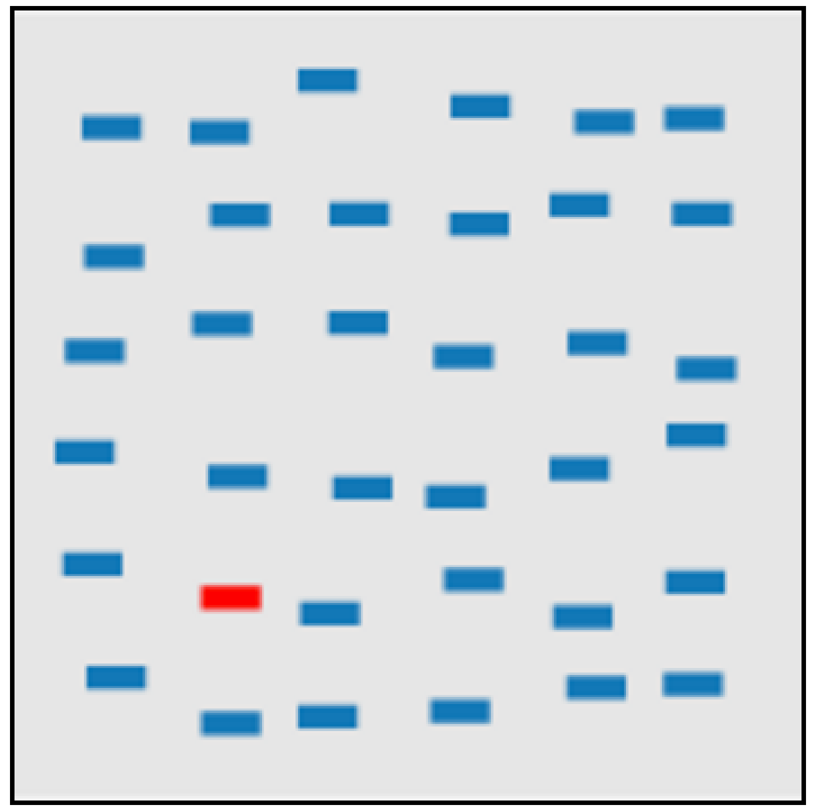
curvature
Treisman & Gormican 88



density, contrast
Healey & Enns 98; Healey & Enns 99



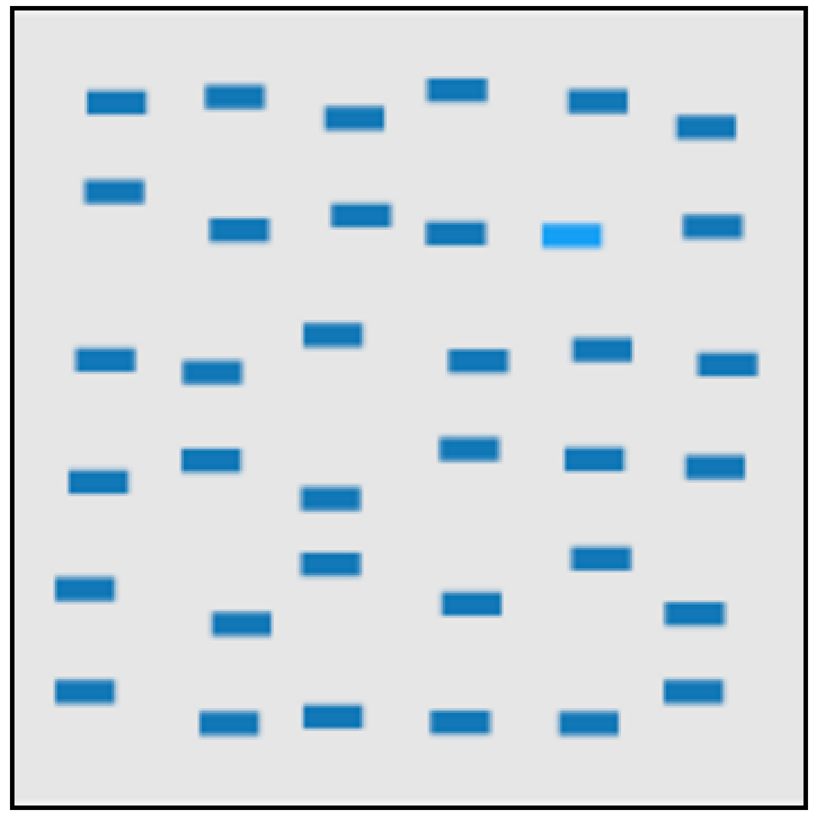
number, estimation
Sagi & Julész 85b; Healey et al. 93; Trick & Pylyshyn 94



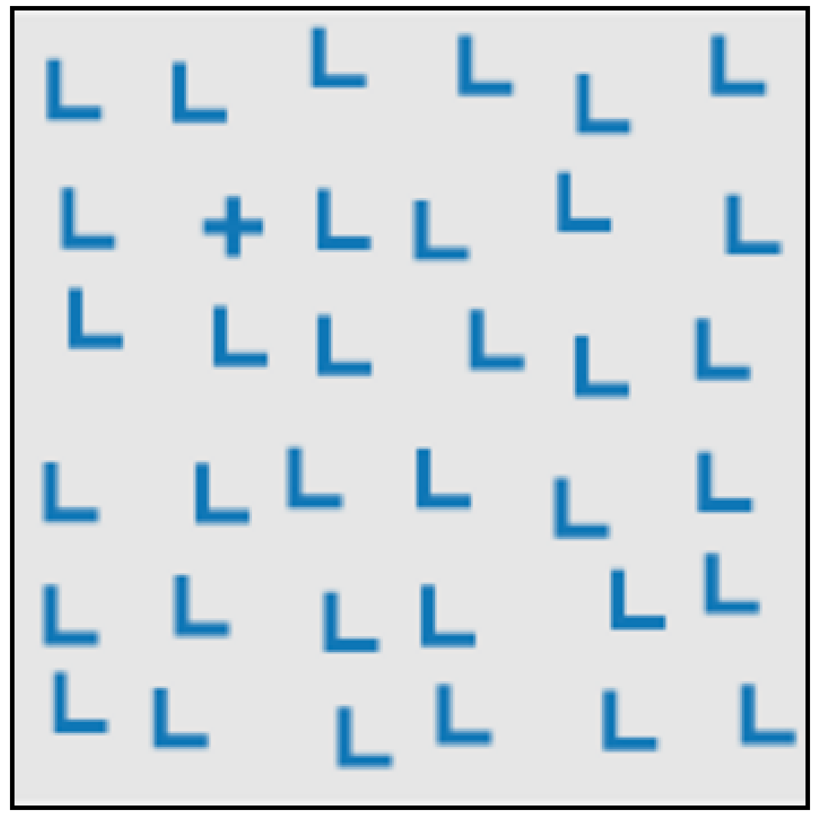
colour (hue)
Nagy & Sanchez 90; Nagy et al. 90; D'Zmura 91; Kawai et al. 95; Bauer et al. 96; Healey 96; Bauer et al. 98; Healey & Enns 99

Healey, 2012

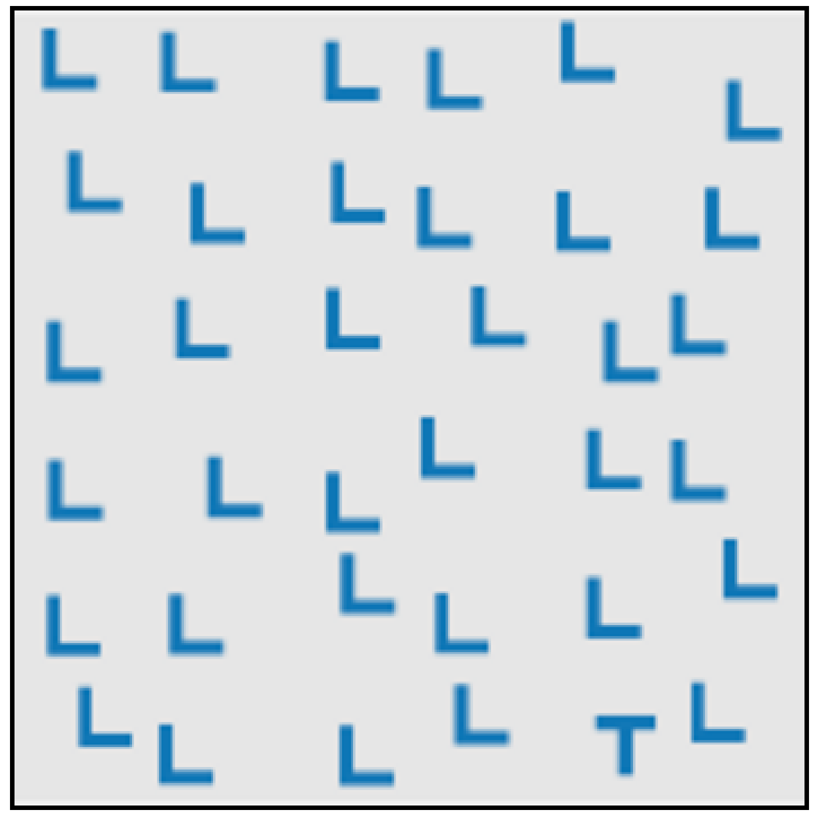
Pop-Out Effects



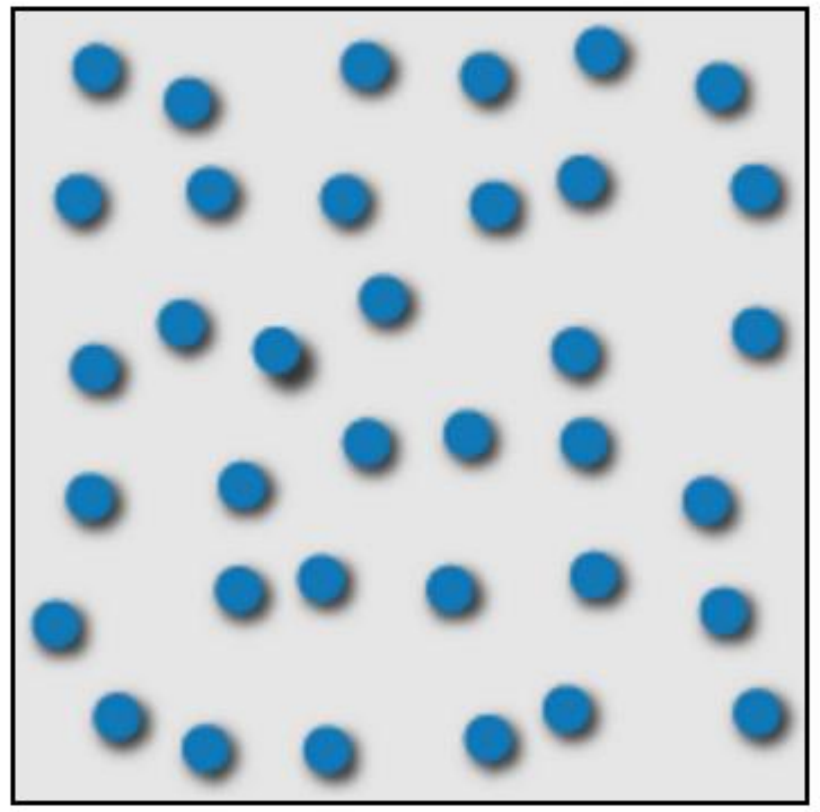
intensity, binocular lustre
Beck et al. 83; Treisman & Gormican 88; Wolfe & Franzel 88



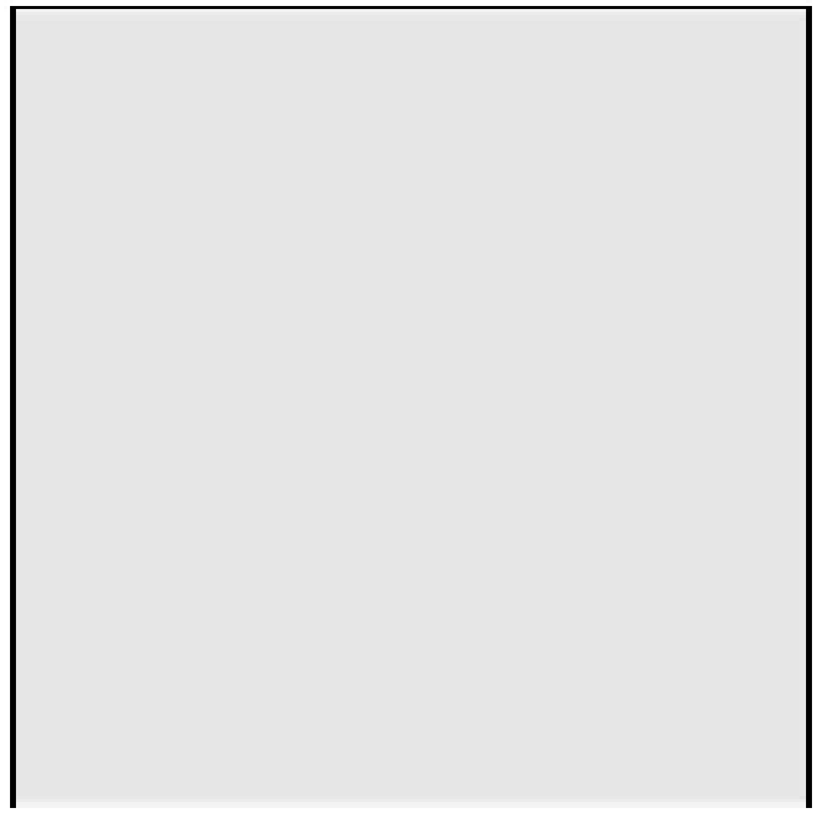
intersection
Julész & Bergen 83



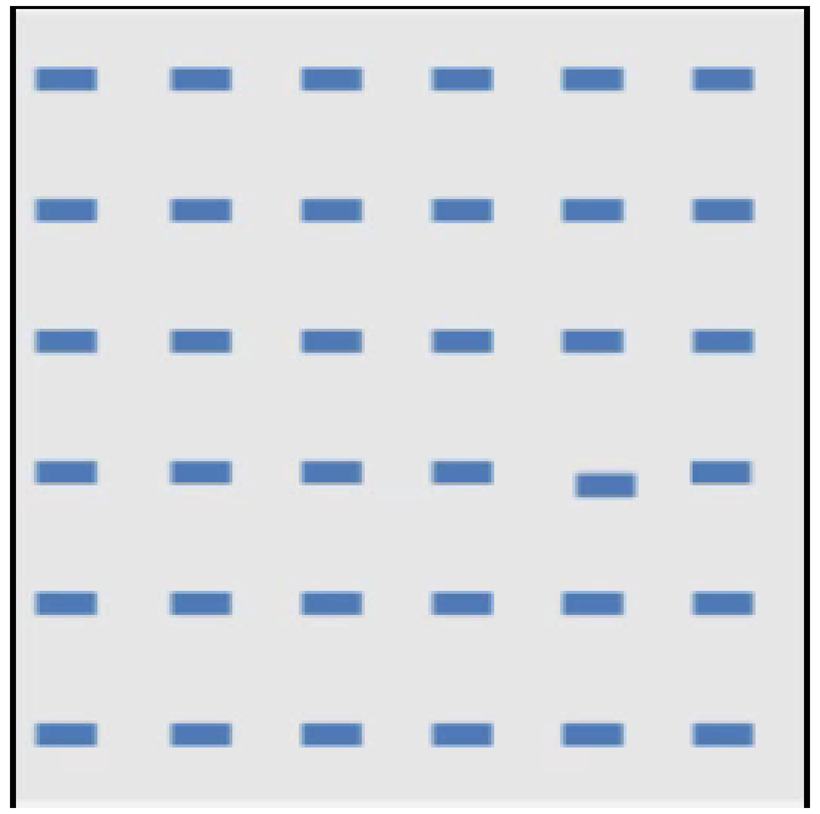
terminators
Julész & Bergen 83



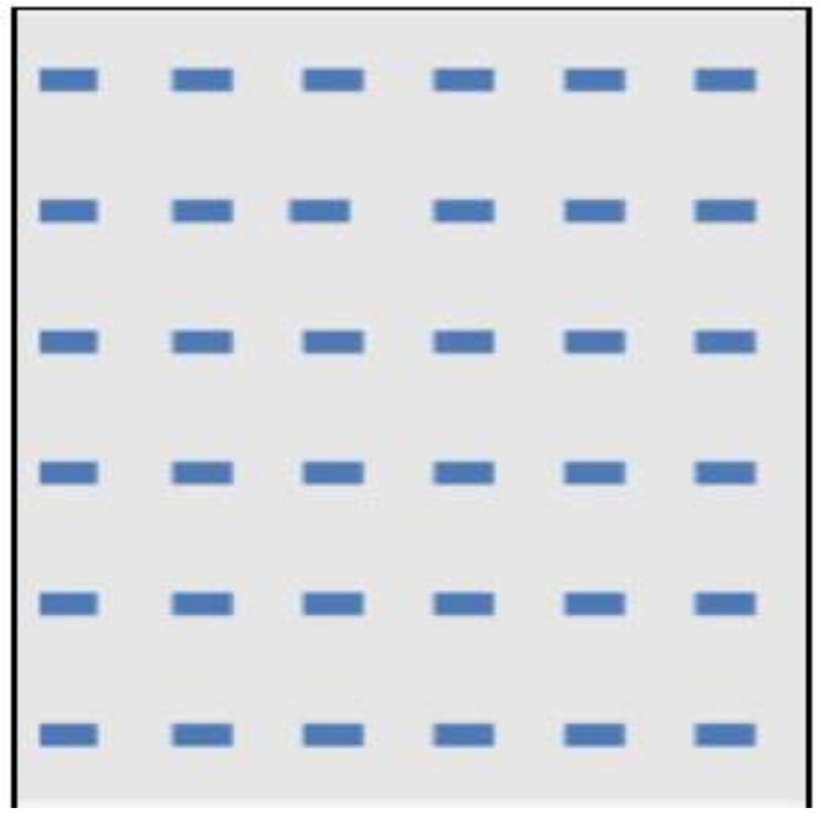
3D depth cues
Enns 90b; Nakayama & Silverman 86



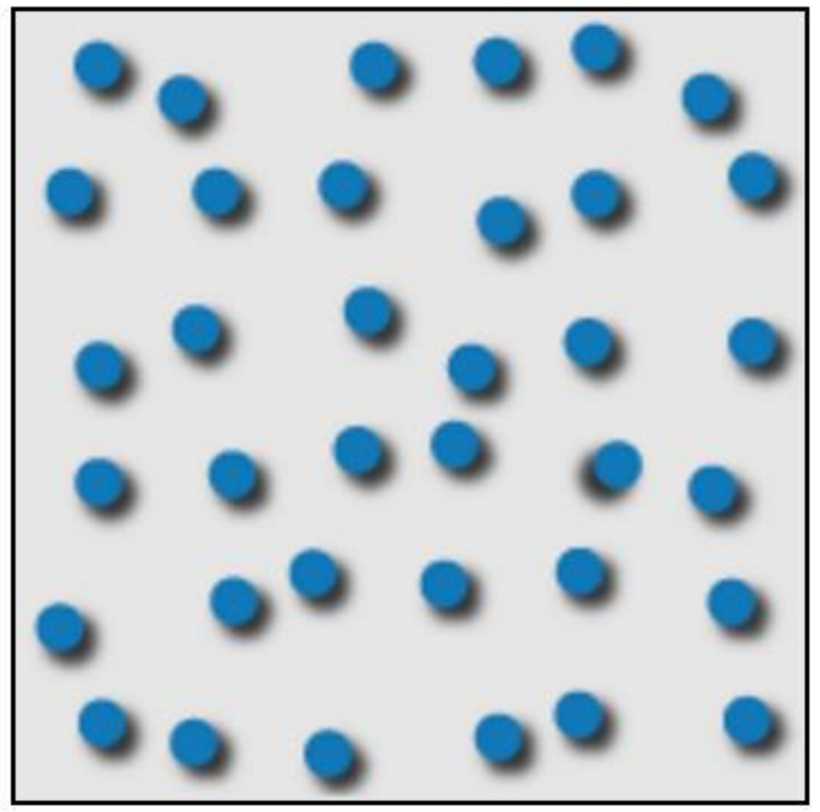
flicker
Gebb et a. 55; Mowbray & Gebhard 55; Brown 65; Julész 71; Huber & Healey 2005



direction of motion
Nakayama & Silverman 86; Driver & McLeod 92; Huber & Healey 2005



velocity of motion
Tynan & Sekuler 82; Nakayama & Silverman 86; Driver & McLeod 92; Hohnsbein & Mateeff 98; Huber & Healey 2005



lighting direction
Enns 90a

Healey, 2012

Interaction

Why interaction?

- Complexity reduction
- Static = specific story told to you, versus interactive = viewer discovers the story
- Enables data exploration, insight, reasoning for oneself
- Makes it personal to the viewer
- Dive deeper!

Interaction

A few footnotes...

- Interaction requires human time and attention
- Human-guided search vs. Automatic feature detection vs. Interactive visualizations
- Find balance between automation and relying on the human in the loop to detect patterns

Interaction

Shneiderman Mantra:

- Overview - provide high-level view/summary
- Zoom and Filter - enable data discovery and exploration, support search/tasks
- Details on Demand - do not overwhelm the viewer by providing extra information as needed

Interaction

van Ham & Perer approach:

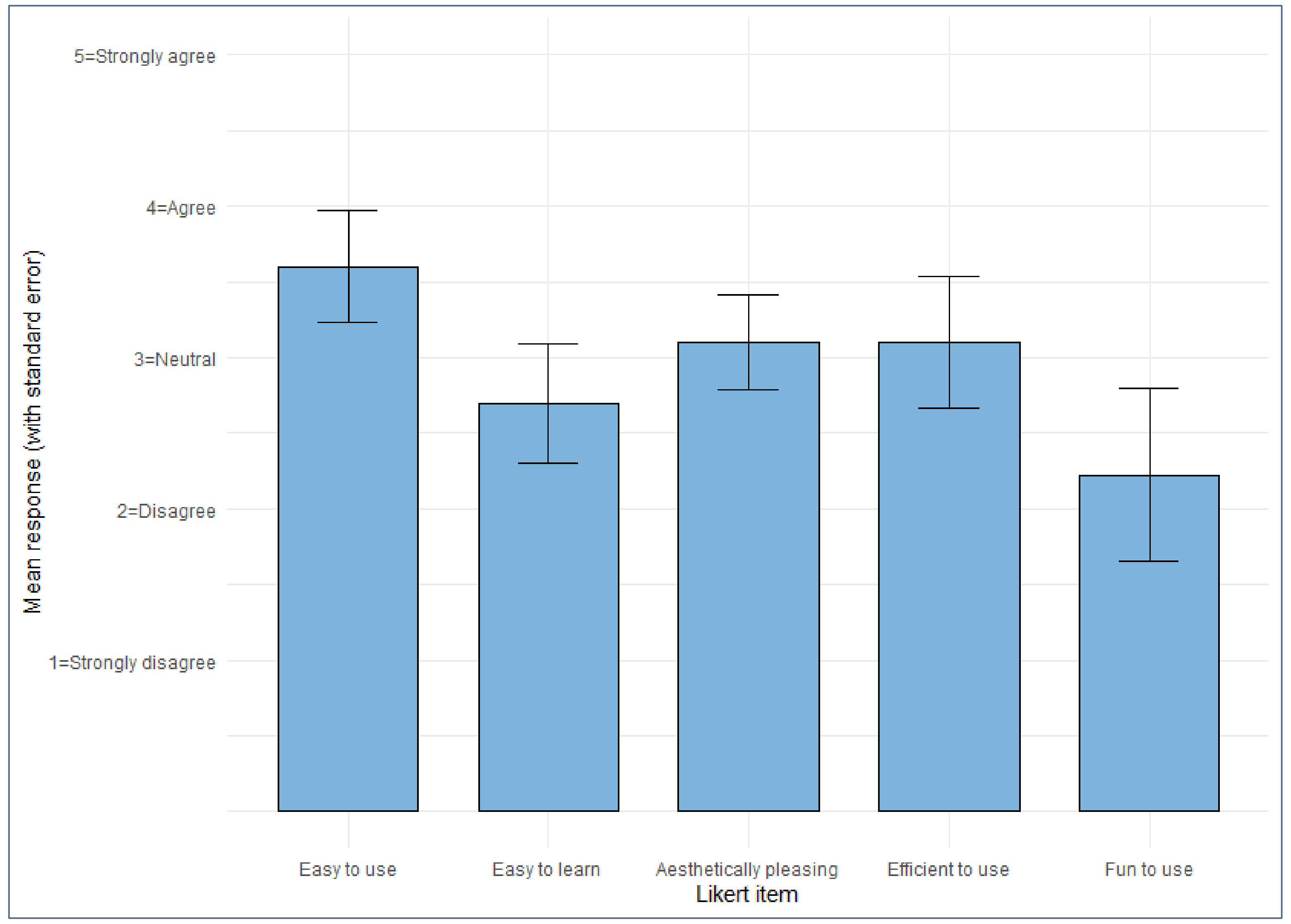
- Search — pick subset of data to focus on.
- Show context — show connected or relevant data for the user's current interests.
- Expand on demand — user chooses to expand the context in a direction of interest.

van Ham & Perer, 2009

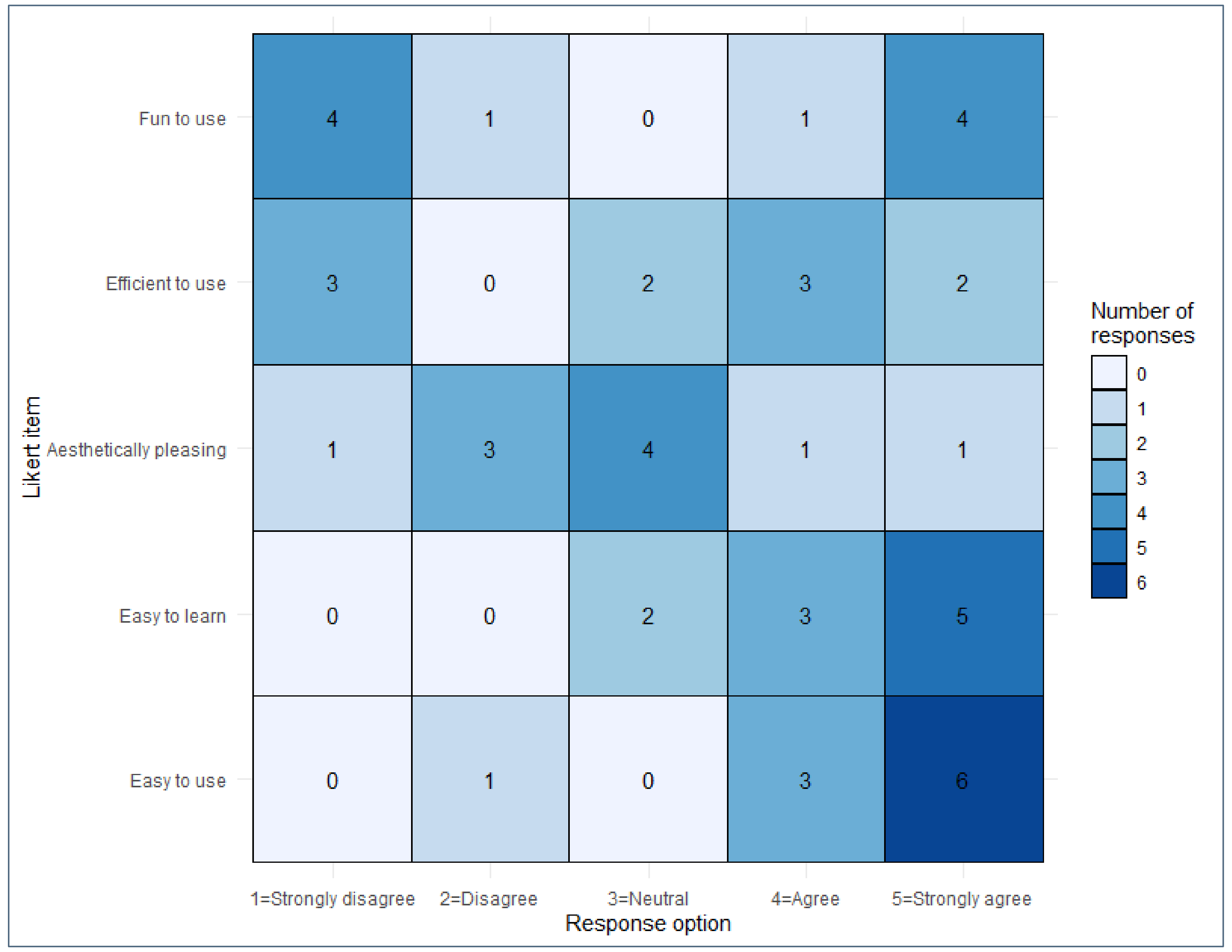
Now, on DS 4200…

In-Class Experiment — Likert Scale Visualization

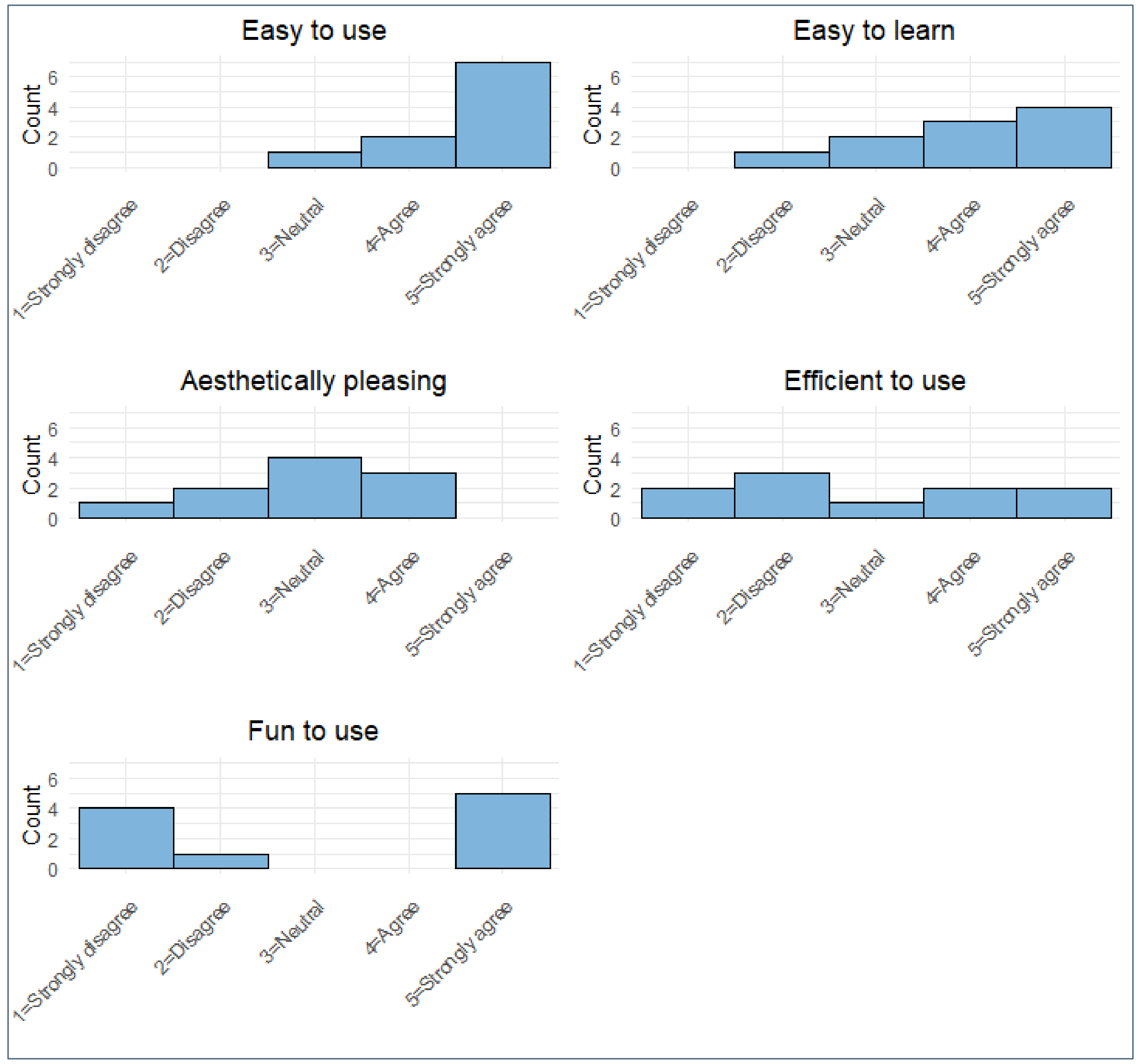
~20 min



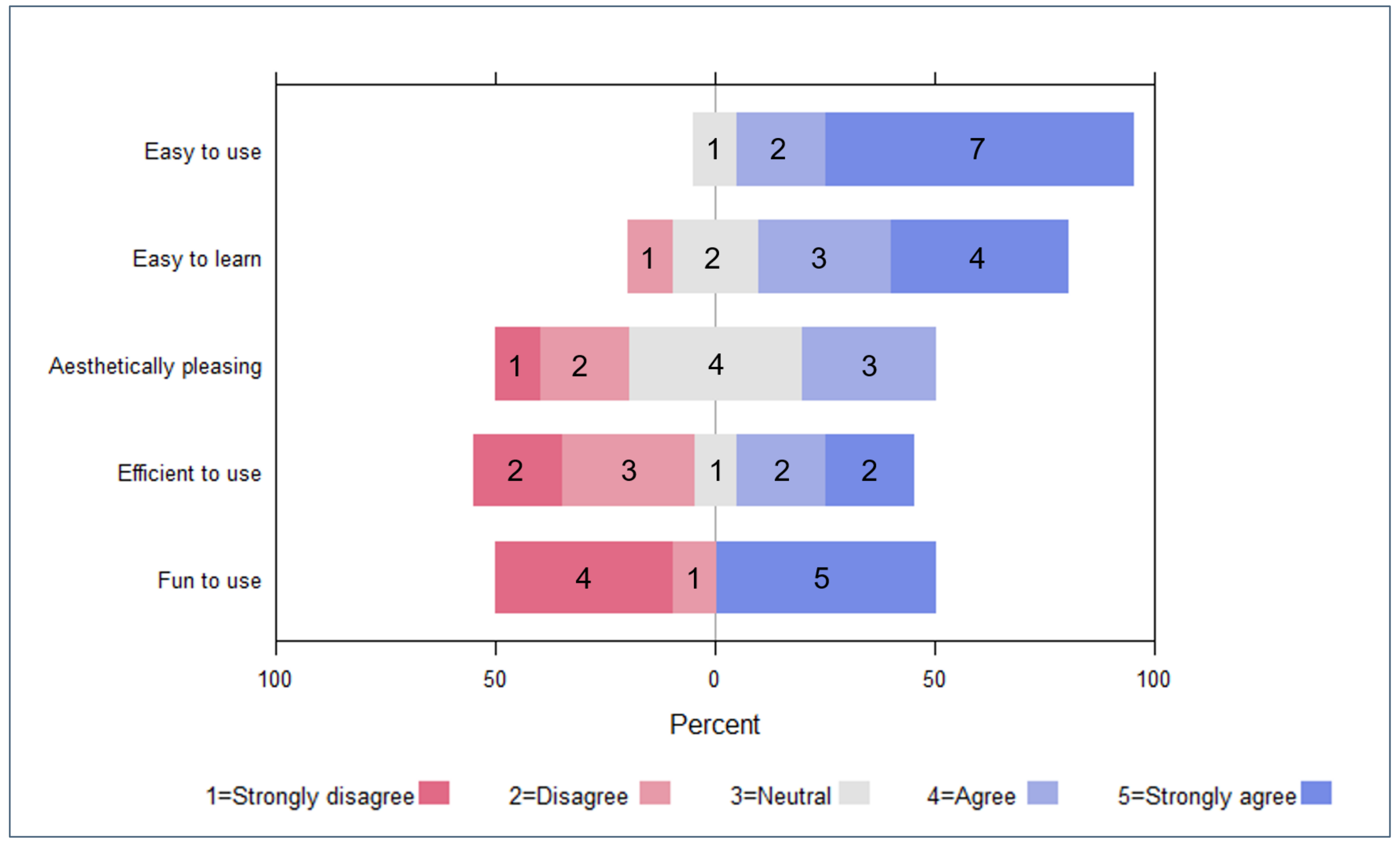
5=Strongly agree
4=Agree
3=Neutral
2=Disagree
1=Strongly disagree
Mean response (with standard error)
Easy to use
Easy to learn
Aesthetically pleasing
Efficient to use
Fun to use
Likert item



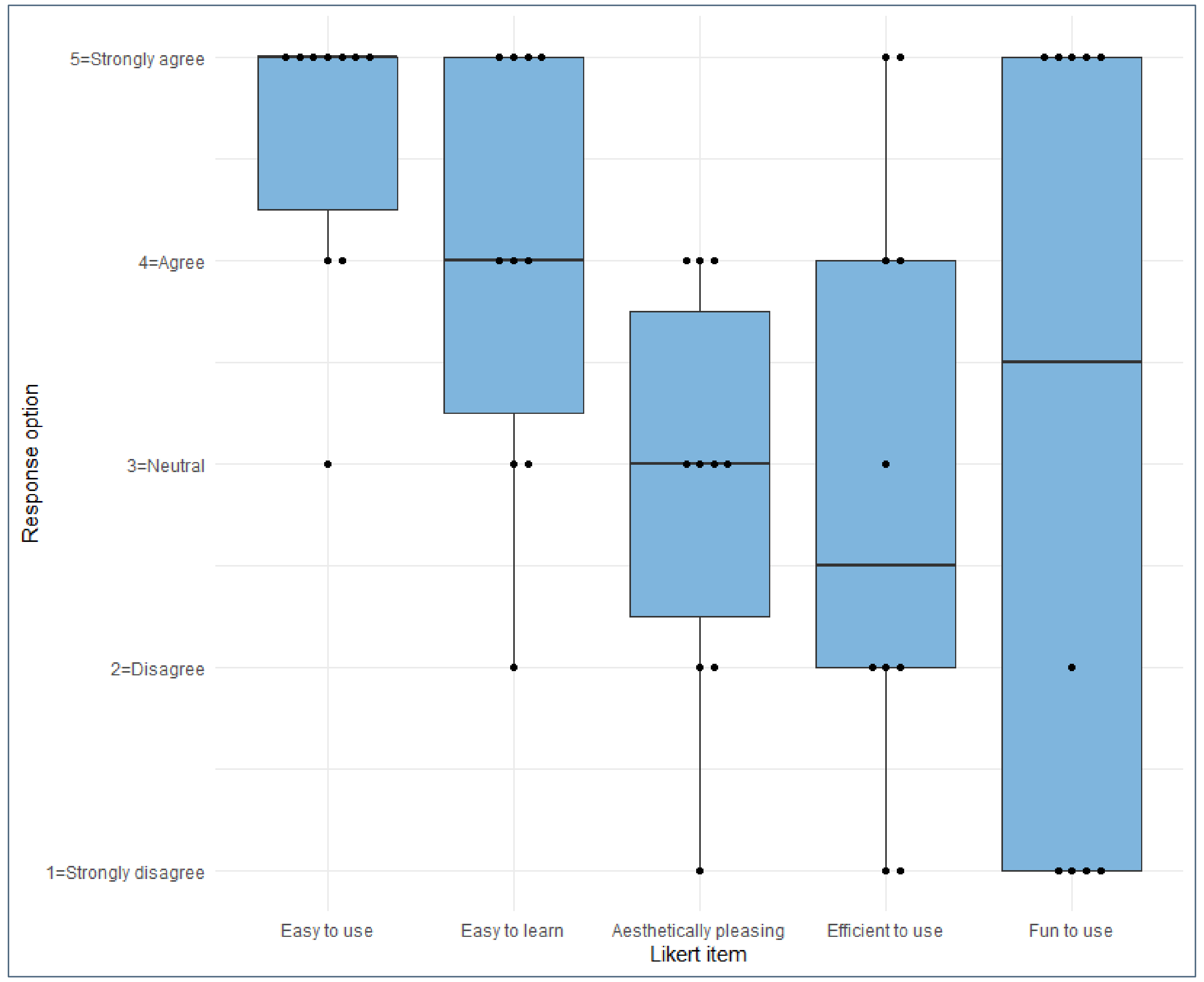
Fun to use
Efficient to use
Aesthetically pleasing
Easy to learn
Easy to use
Likert item
1=Strongly disagree
2=Disagree
3=Neutral
4=Agree
5=Strongly agree
Response option
Number of responses



Easy to use
Easy to learn
Aesthetically pleasing
Efficient to use
Fun to use
Count
1=Strongly disagree
2=Disagree
3=Neutral
4=Agree
5=Strongly agree



Easy to use
Easy to learn
Aesthetically pleasing
Efficient to use
Fun to use
Percent
1=Strongly disagree
2=Disagree
3=Neutral
4=Agree
5=Strongly agree

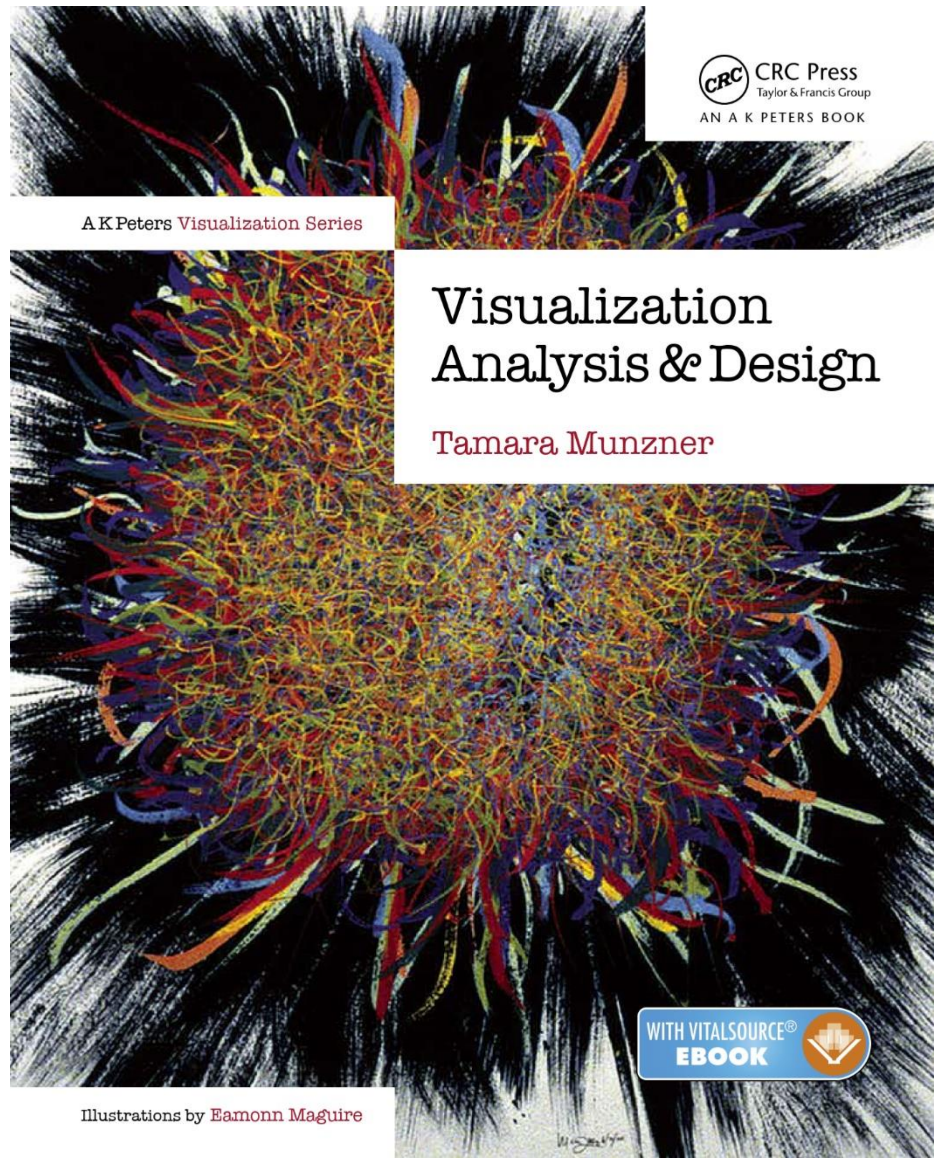


5=Strongly agree
4=Agree
3=Neutral
2=Disagree
1=Strongly disagree
Response option
Easy to use
Easy to learn
Aesthetically pleasing
Efficient to use
Fun to use
Likert item

Example Usability Test with a Paper Prototype

BlueDuckLabs, 2010 14

The Nested Model for Visualization Validation



“Nested Model”

Domain situation
Observe target users using existing tools

Data/task abstraction

Visual encoding/interaction idiom
Justify design with respect to alternatives

Algorithm
Measure system time/memory
Analyze computational complexity

Analyze results qualitatively

Measure human time with lab experiment (*lab study*)

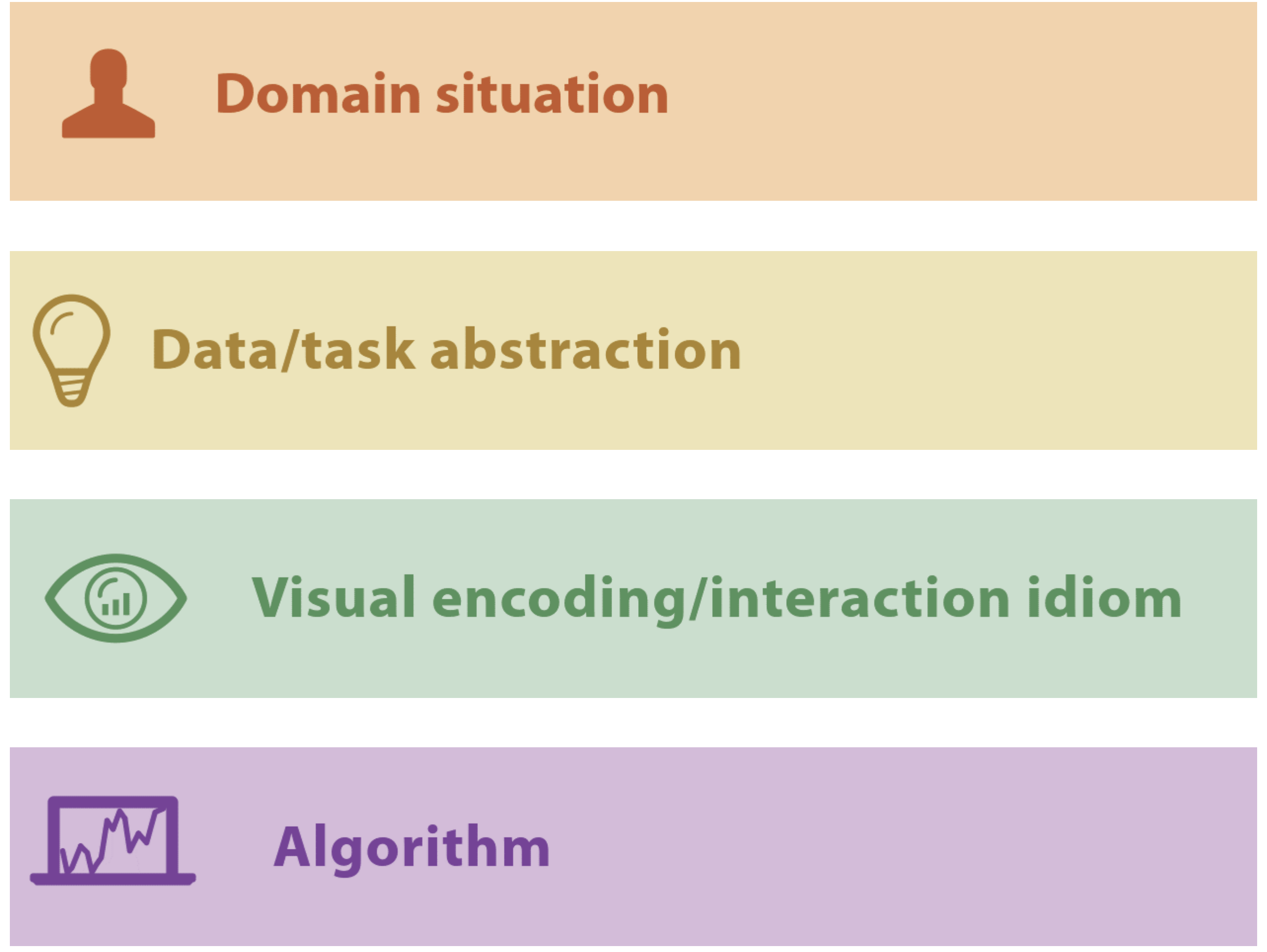
Observe target users after deployment (*field study*)

Measure adoption


Tamara Munzner

Threats to Validity

✓ *Final Project validation*



"Evaluation"

Usability Testing

In-Class Activity, Project Follow-Up

Empirical Studies in Information Visualization: Seven Scenarios

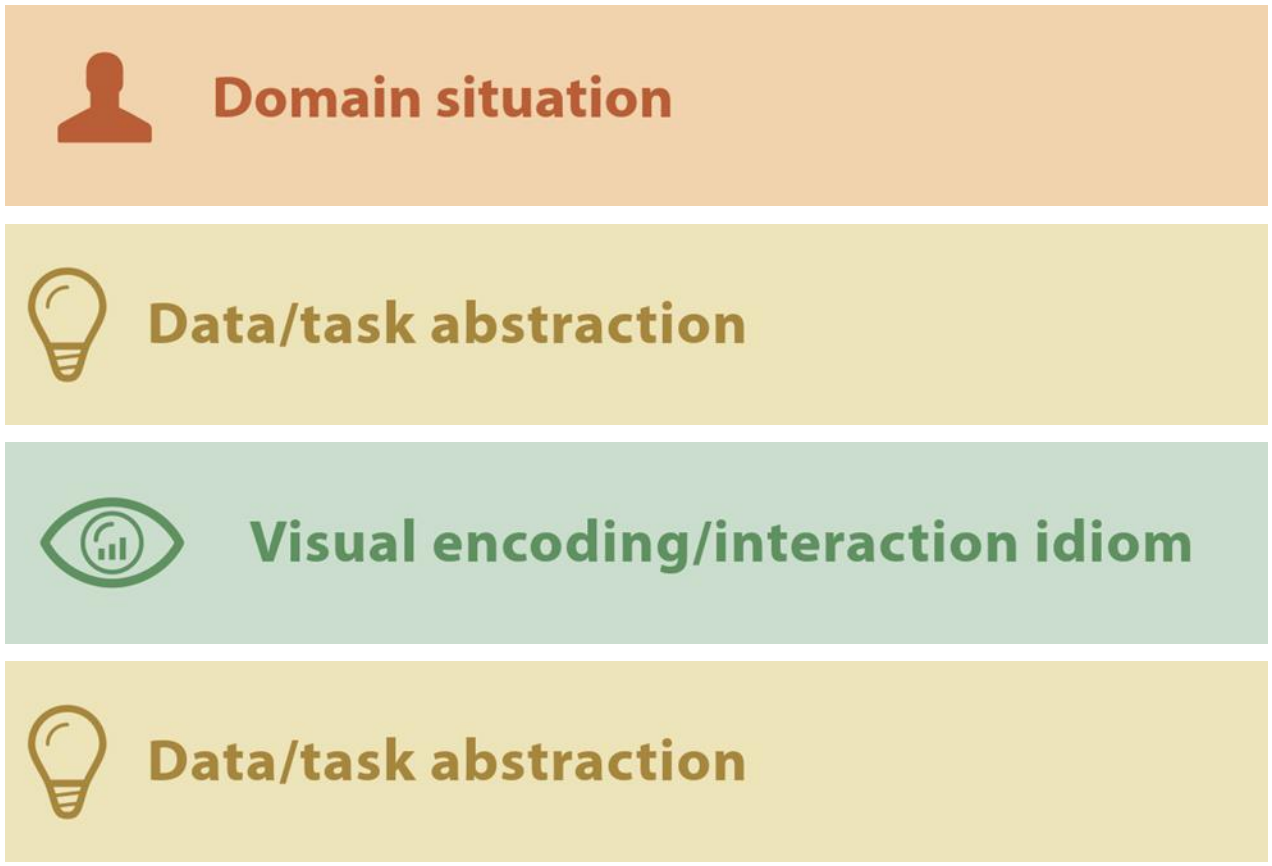
Empirical Studies in Information Visualization: Seven Scenarios

Lam et al., 2012

7 Evaluation Scenarios

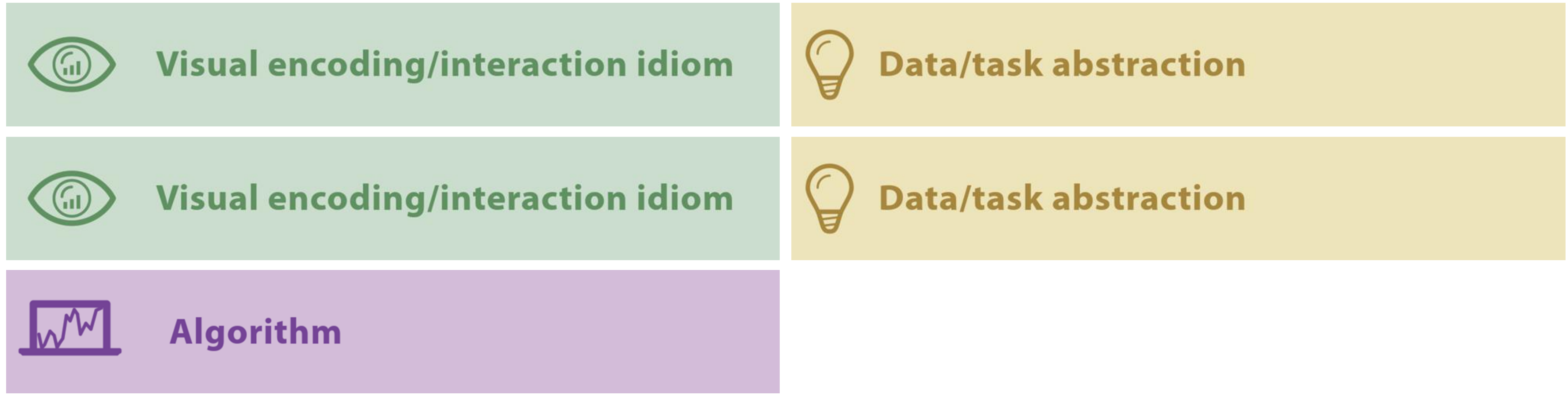
How to understand your data:

- Understanding Environments and Work Practices
- Evaluating Visual Data Analysis and Reasoning
- Evaluating Communication Through Visualization
- Evaluating Collaborative Data Analysis



How to understand your visualization:

- Evaluating User Performance
- Evaluating User Experience
- Evaluating Visualization Algorithms



Lam et al., 2012

Understanding environments and work practices

- Goals & outputs
  - Understand work, analysis, or information processing practices of people
  - Without software in use: inform design
  - With software in use: assess factors for adoption, how appropriated for future design
- Evaluation Questions
  - Context of use?
  - Integrate into which daily activities?
  - Supported analyses?
  - Characteristics of user group and environment?
  - What data & tasks?
  - What visualizations/tools used?
  - How current tools solve tasks?
  - Challenges and usage barrier?

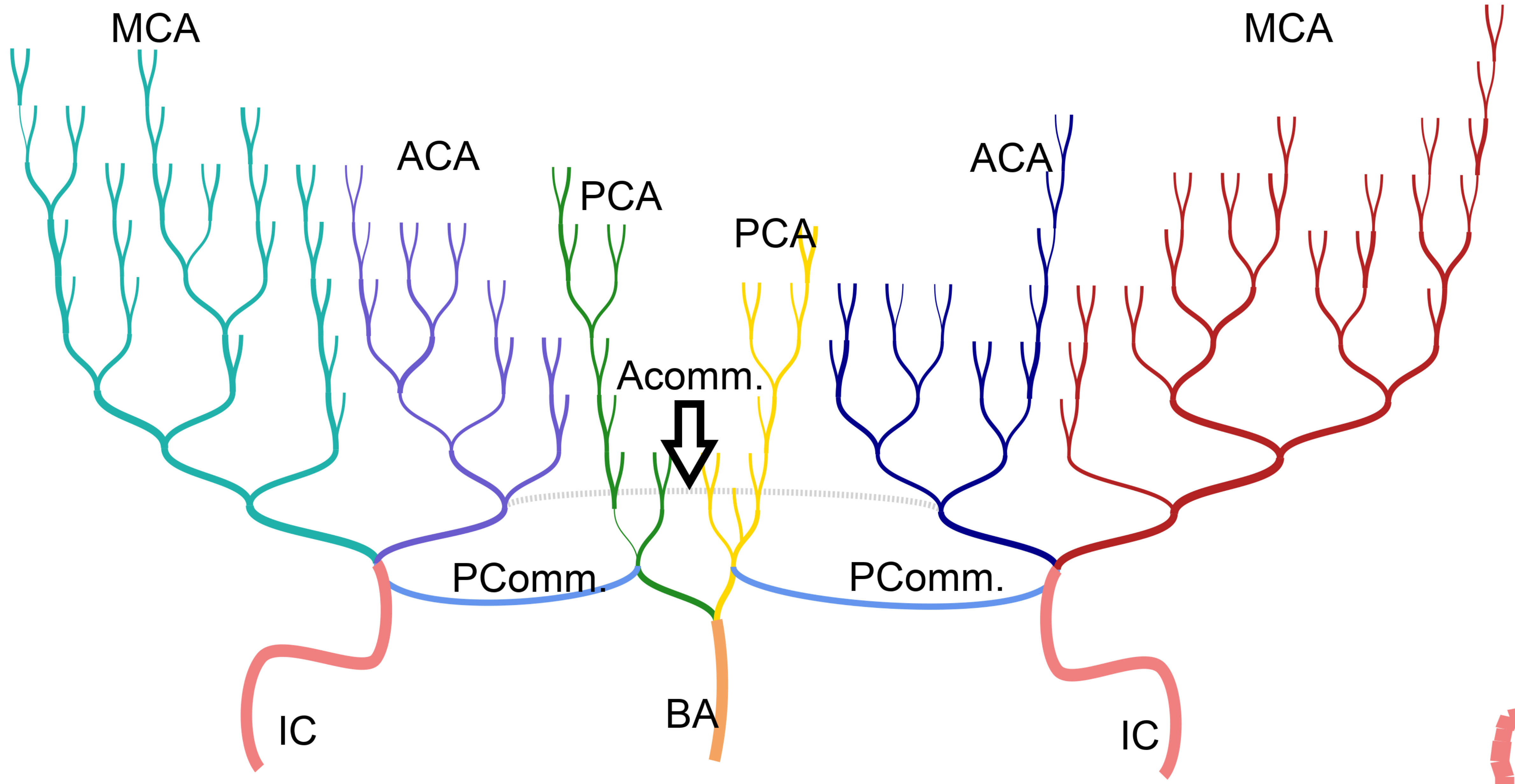
Lam et al., 2012

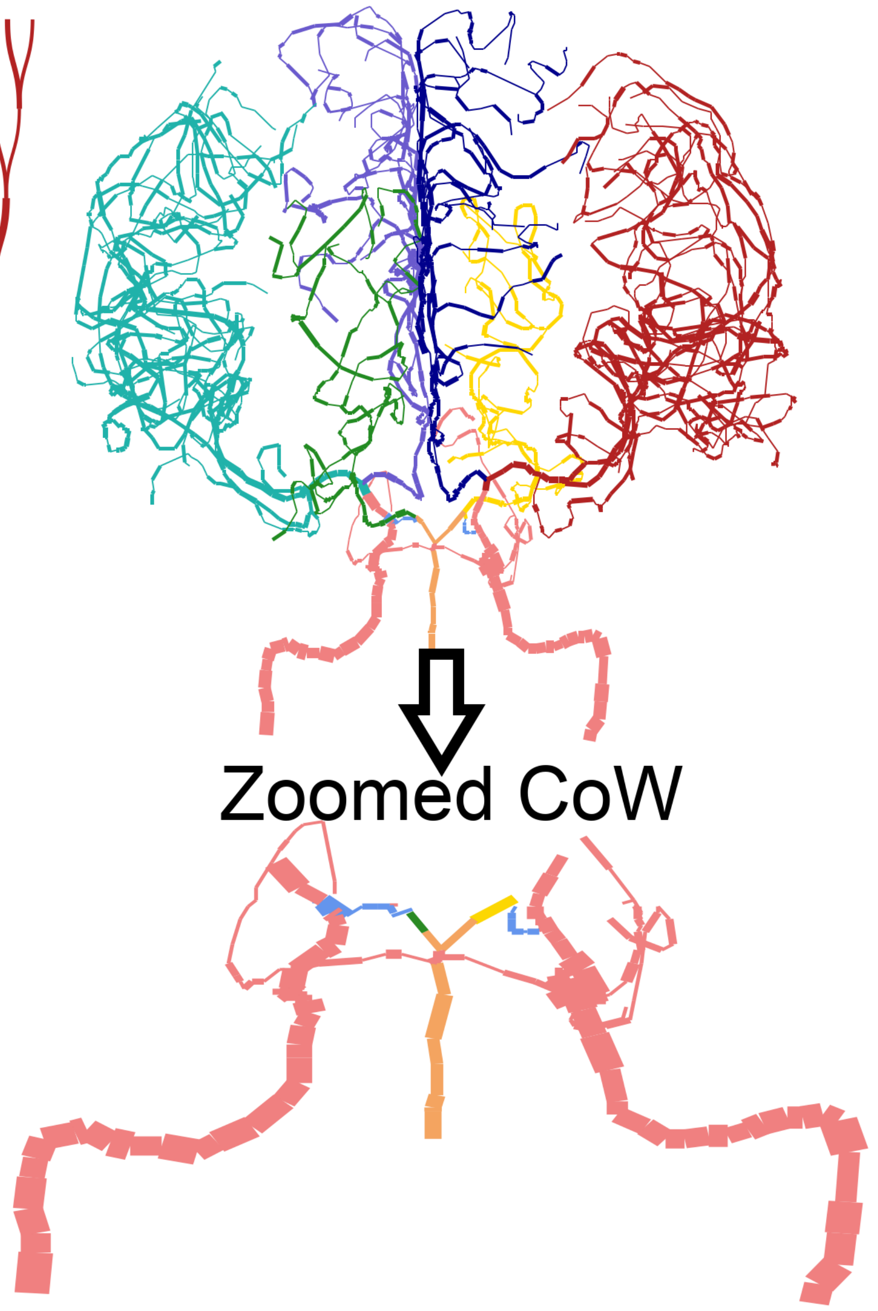
Understanding environments and work practices

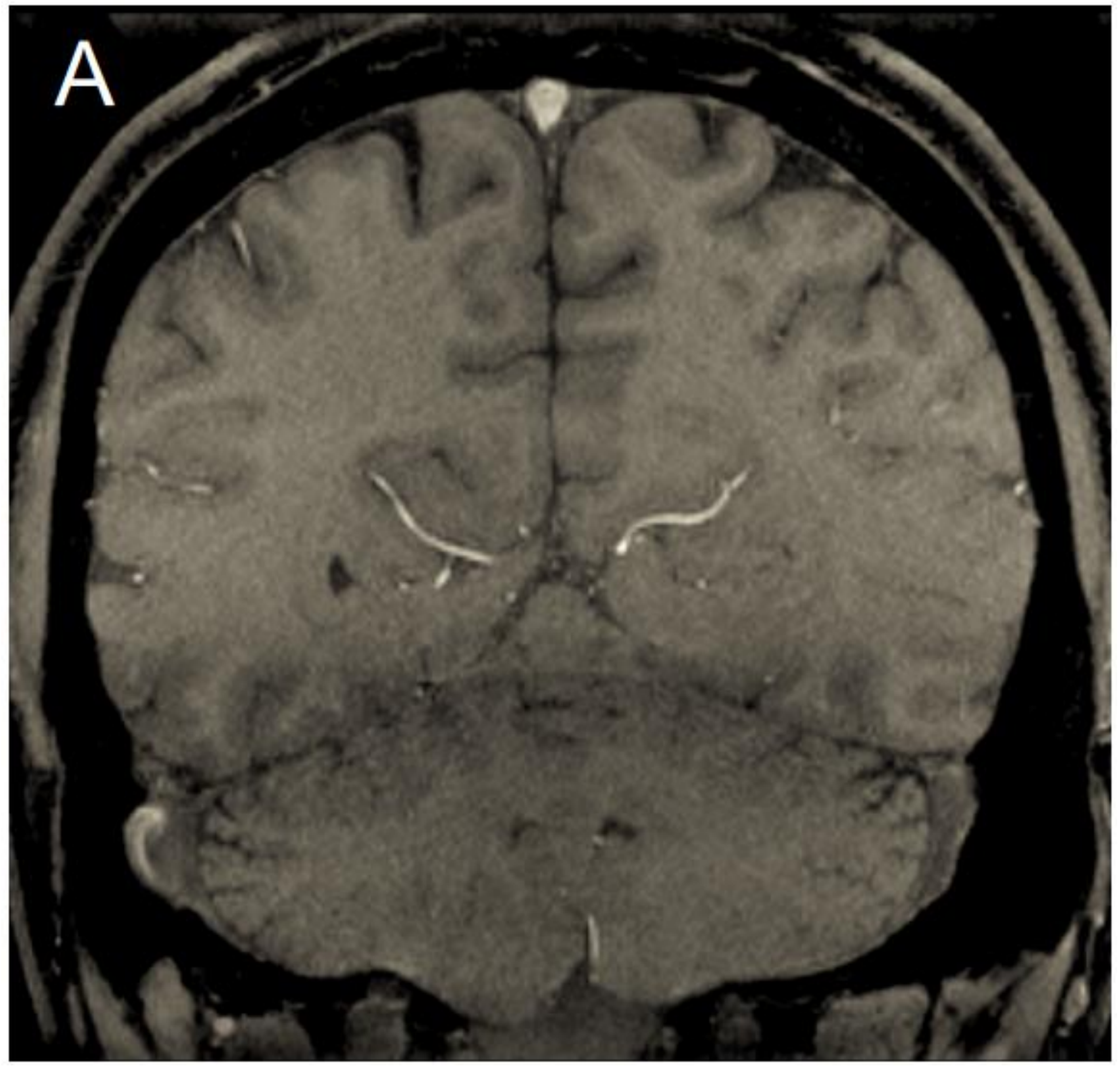
- Methods
  - Field Observation
    - Real world, free use of tool
    - Derive requirements
  - Interviews
    - Contextual inquiry: interview then observe in routines, with little interference
    - Pick the right person
    - Laboratory context w/domain expert
  - Laboratory Observation
    - How people interact with each other, tools
    - More control of situation

Lam et al., 2012

Understanding environments and work practices: Example







Pandey, Dunne, et al., 2019

Evaluating visual data analysis and reasoning

Data/task abstraction

- Goals & outputs
  - Assess visualization tool's ability to support visual analysis and reasoning
    - As a whole! Not just a technique
  - Quantifiable metrics or subjective feedback
- Evaluation Questions: Does it support…
  - Data exploration?
  - Knowledge discovery?
  - Hypothesis generation?
  - Decision making?

Lam et al., 2012

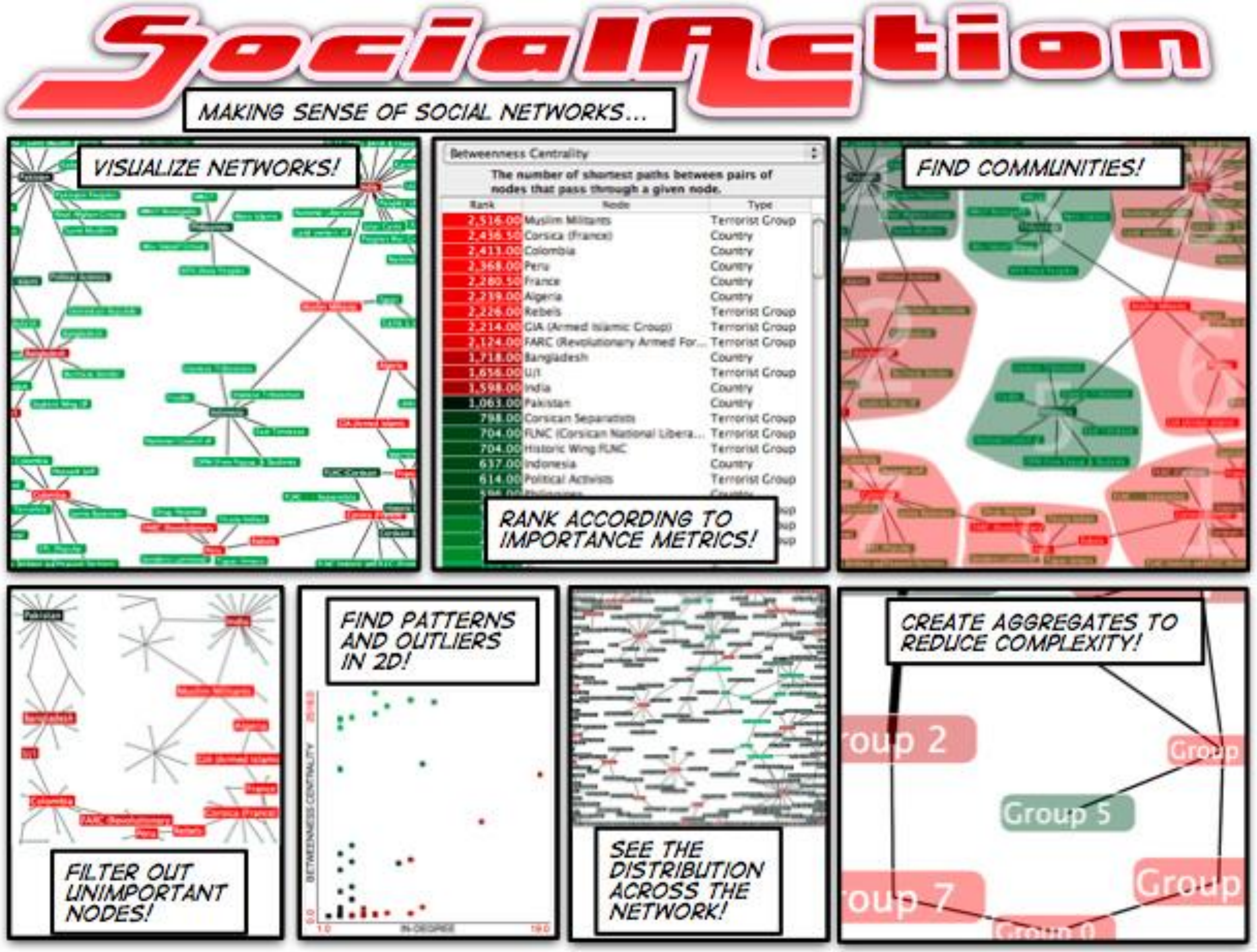
Evaluating visual data analysis and reasoning

Data/task abstraction

- Methods
  - Case studies
    - Motivated experts with own data in own environment
    - Can be longitudinal
    - Insight-Based (Saraiya et al., 2004)
      - Unguided, diary, debriefing meetings
    - MILCS: Multidimensional In-depth Long-term Case studies (Shneiderman & Plaisant, 2006)
      - Guided, observations, interviews, surveys, automated logging
      - Assess interface efficacy, user performance, interface utility
      - Improve system during
  - Lab observations and interviews
    - Code results
    - Think aloud
  - Controlled Experiment
    - Isolate important factors

Lam et al., 2012

Evaluating visual data analysis and reasoning



Perer et al., 2006

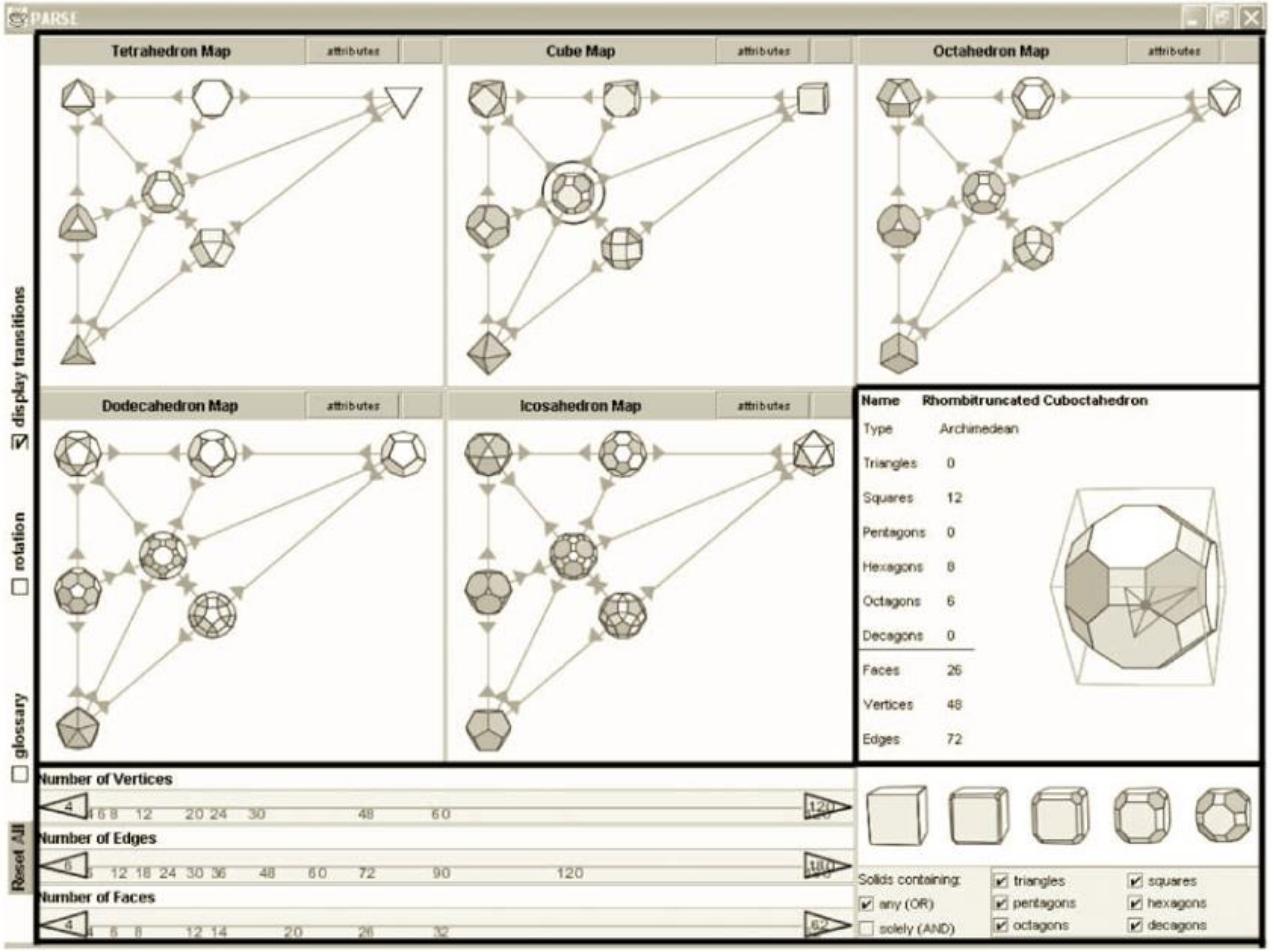
Evaluating communication through visualization

Visual encoding/interaction idiom

- Goals & outputs
  - How effectively is a message delivered and acquired
- Evaluation Questions
  - Quantitative: learning rate, information retention and accuracy
  - Qualitative: interaction patterns
- Methods
  - Controlled experiments
  - Field observation & interviews

Lam et al., 2012

Evaluating communication through visualization: Example



Evaluating Collaborative Data Analysis

Data/task abstraction

- Goals & outputs
  - Evaluate support for taskwork and teamwork
  - Holistic understanding of group work processes or tool use
  - Derive design implications
- Evaluation Questions
  - Effective and efficient?
  - Satisfactorily support or stimulate group sensemaking?
  - Support group insight?
  - Is social exchange and communication facilitated?
  - How is the tool used? Features, patterns…
  - What is the process? User requirements?

Lam et al., 2012

Evaluating Collaborative Data Analysis

Data/task abstraction

- Methods
  - Context critical, but early formative studies less dependant
  - Heuristic evaluation
    - Heuristics: actions, mechanics, interactions, locales needed
  - Log analysis
    - Distributed or web-based tools
    - Combine with questionnaire or interview
    - Hard to evaluate unlogged & qualitative aspects
  - Field or laboratory observation
    - Involve group interactions and harmony/disharmony
    - Combine with insight-based?

Lam et al., 2012

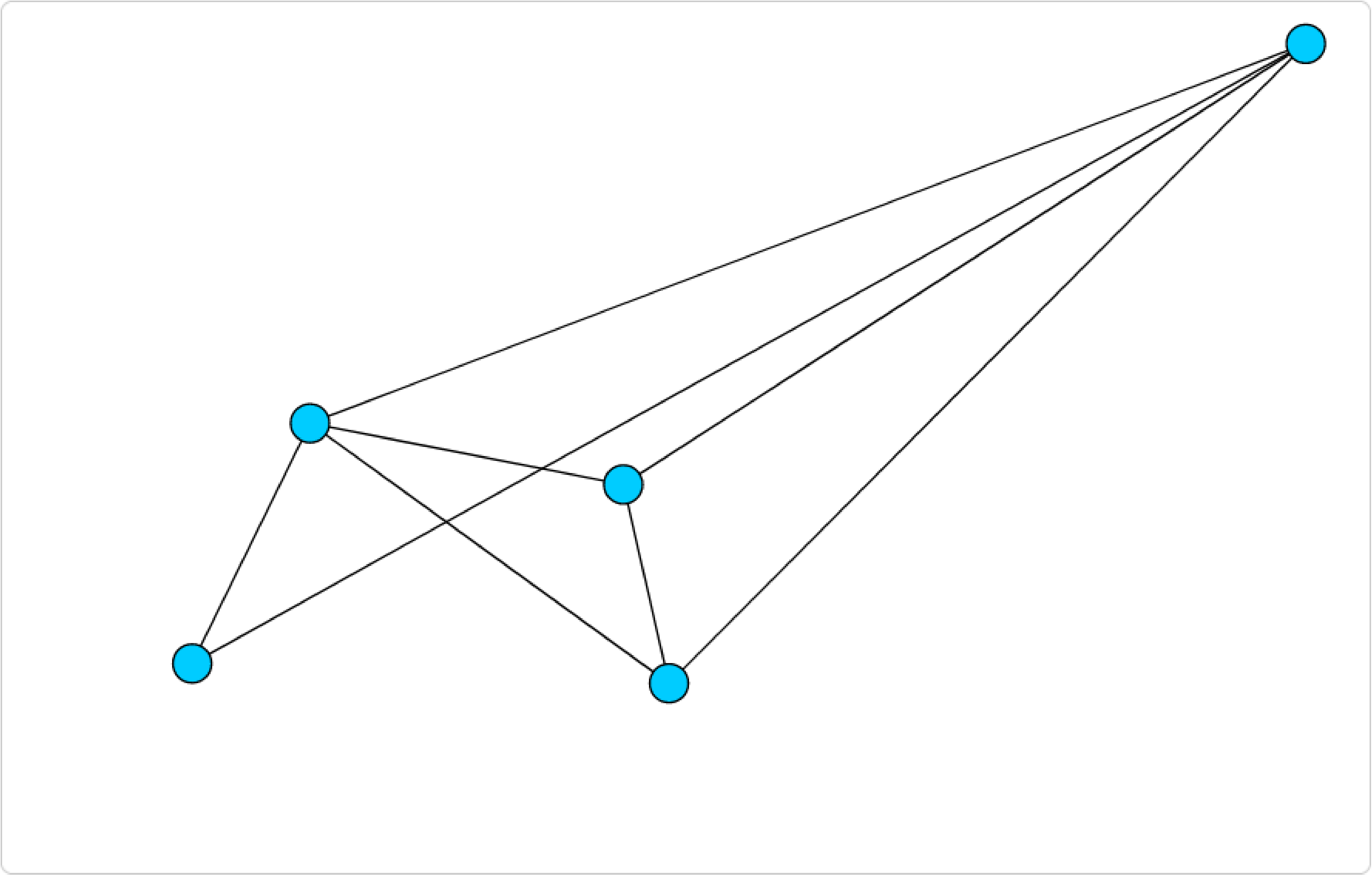
Evaluating Collaborative Data Analysis: Examples

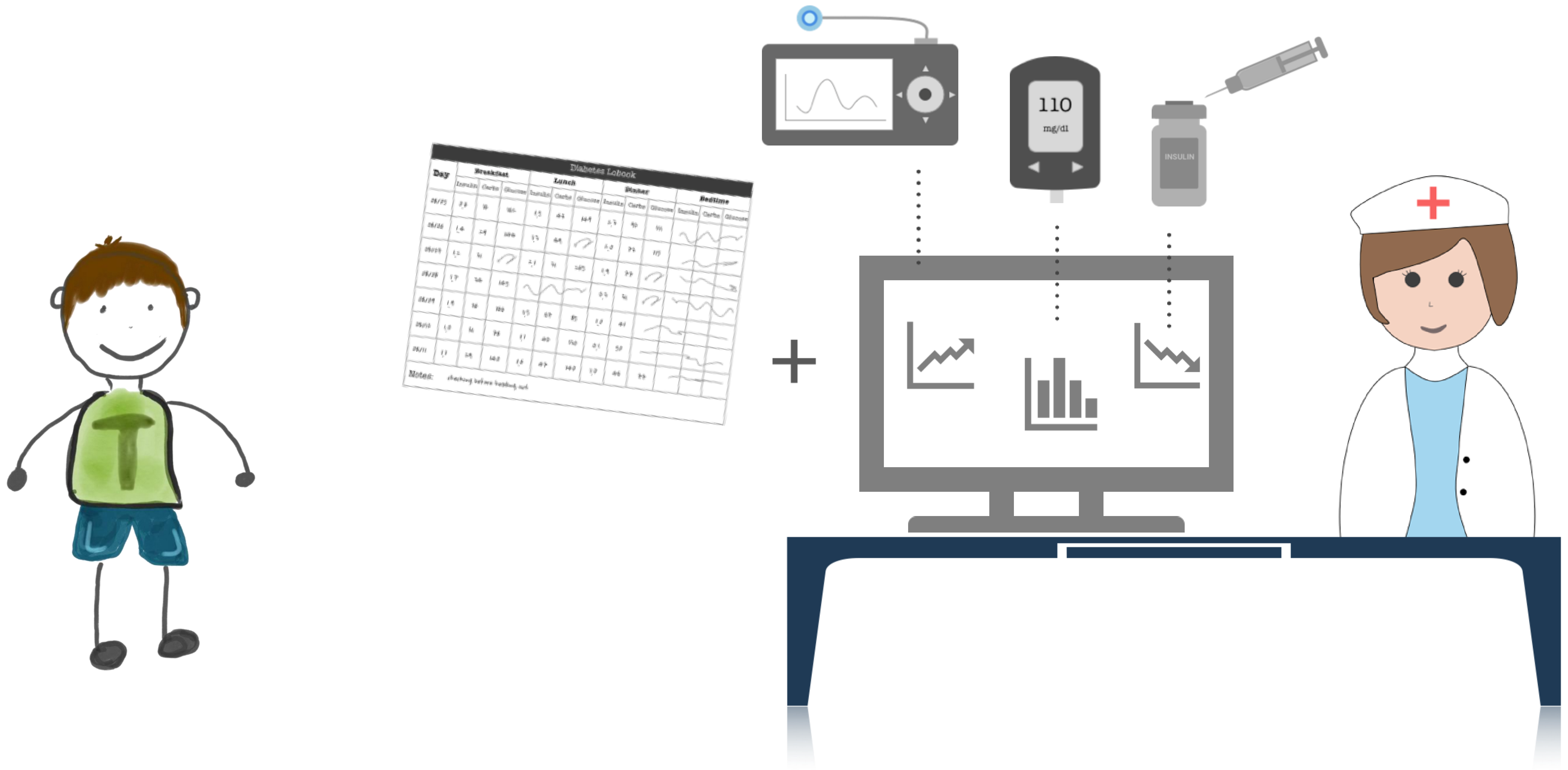
Planarity Party

Can you untangle the graph? See if you can position the vertices so that no two lines cross.

Level 1. Number of line crossings detected: 2.

0 moves. Next Level





Schwab, … Dunne, … et al., 2020

Zhang, … Dunne, … et al., 2018

Evaluating User Performance

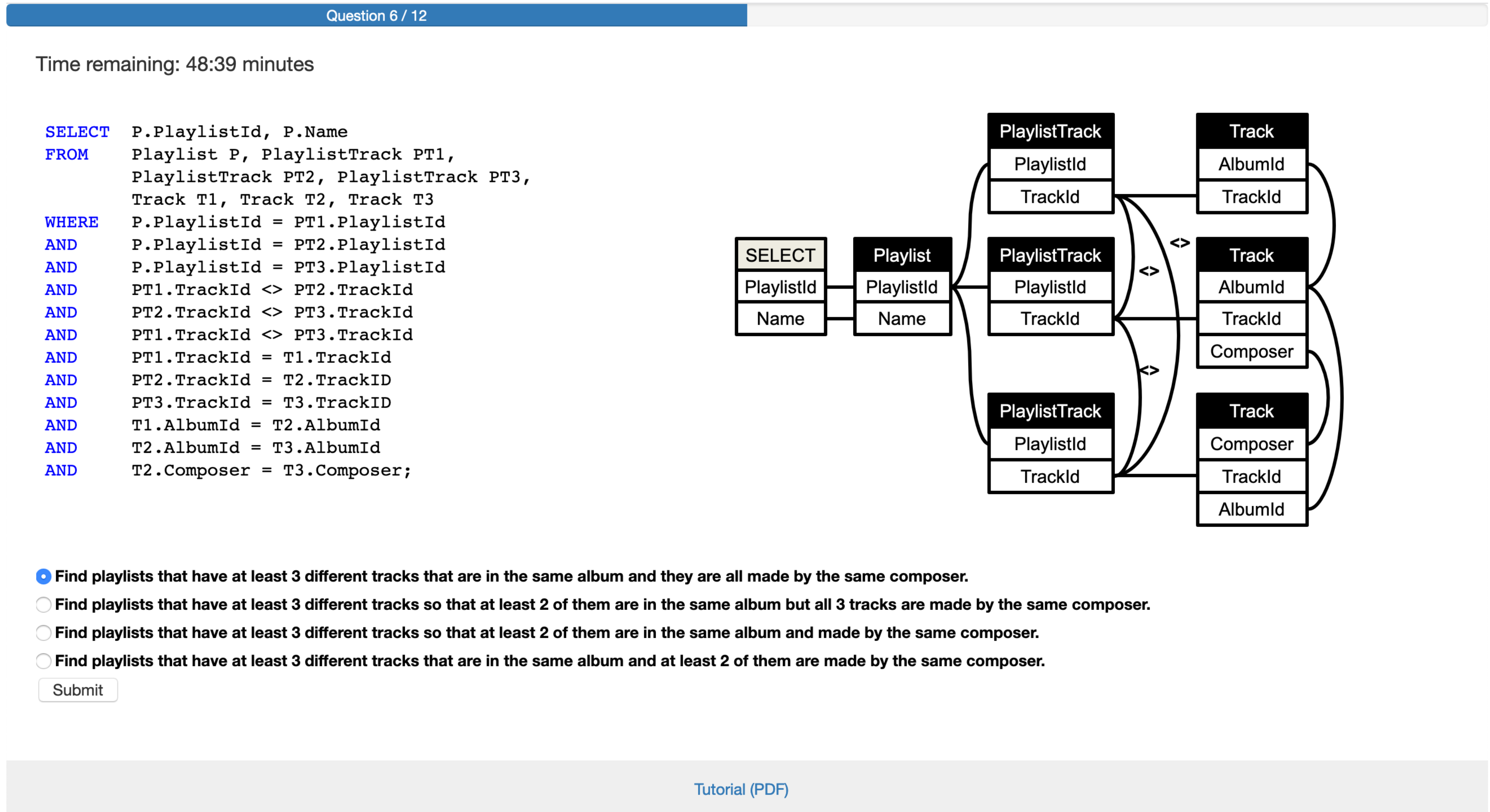
Data/task abstraction

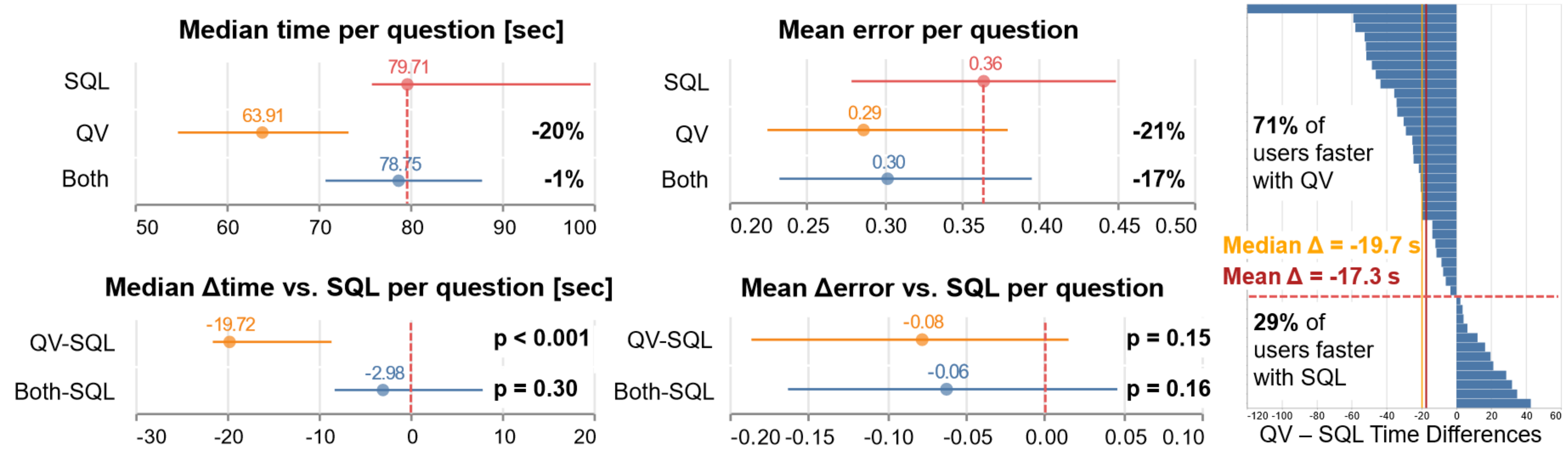
Visual encoding/interaction idiom

- Goals & outputs
  - Measure specific features
  - Time, accuracy, and error; work quality (if quantifiable); memorability
  - Descriptive statistics results
- Evaluation Questions
  - What are the limits of human perception and cognition?
  - How do techniques compare?
- Methods
  - Controlled experiment → design guideline, model, head-to-head
    - Few variables
    - Simple tasks
    - Individual differences matter
  - Field logs
    - Suggest improvements, recommendation systems

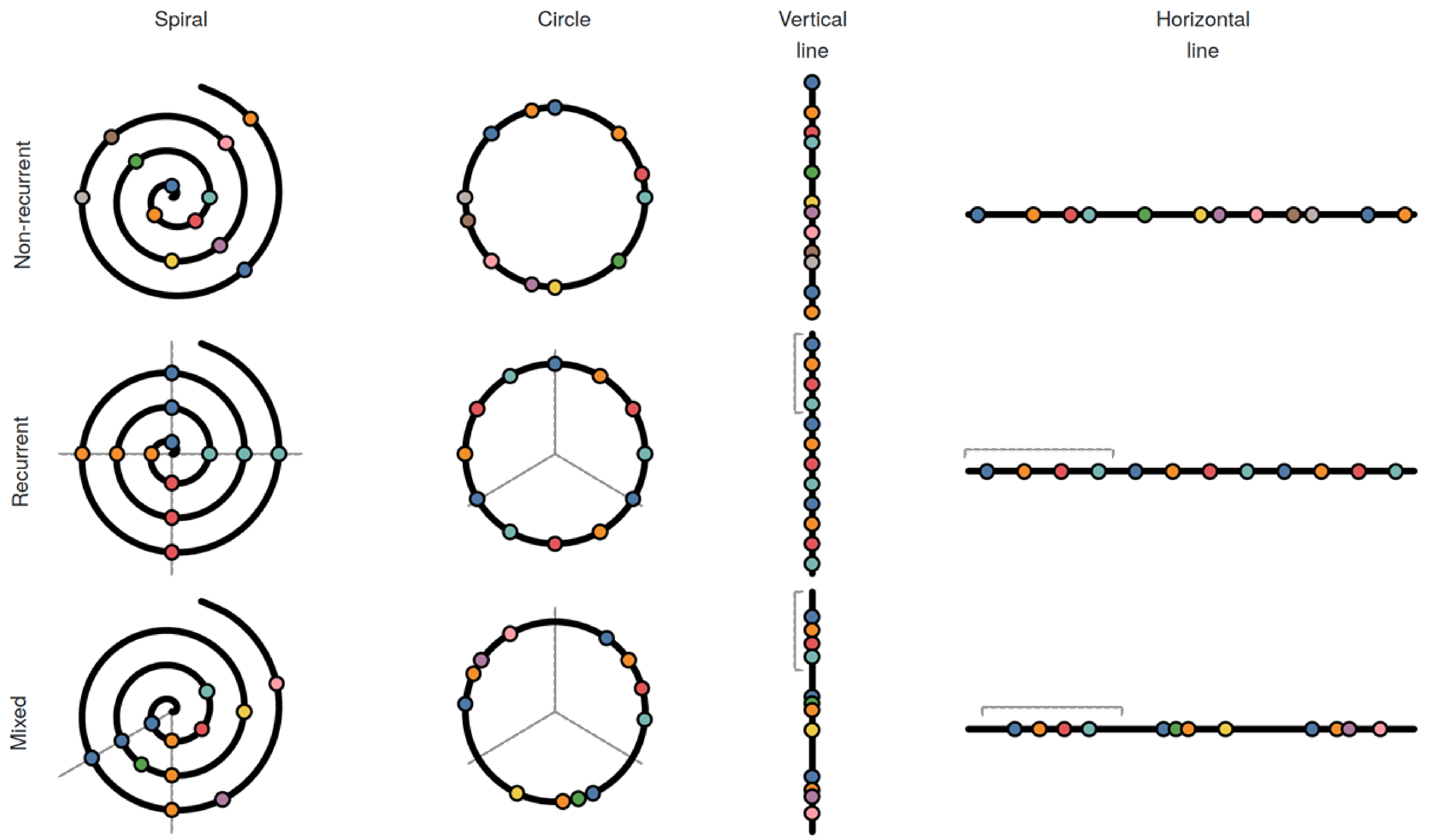
Lam et al., 2012

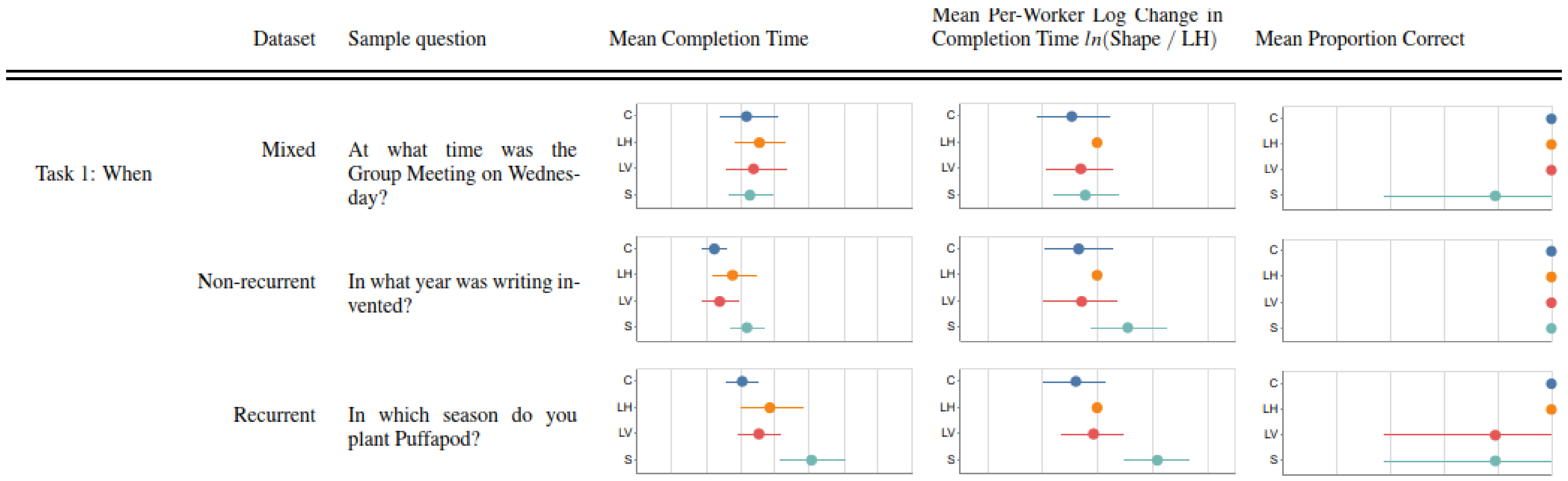
Evaluating User Performance: Examples





[Leventidis, Dunne, et al., 2020](#)





[Di Bartolomeo, Dunne, et al., 2020](#)

Evaluating User Experience

- Goals & outputs
  - Inform design: uncover gaps in functionality, limitations, directions for improvement
  - Subjective: user responses
    - Effectiveness, efficiency, correctness, satisfaction, trust, features liked/disliked
  - Objective: body sensors, eye tracking
- Evaluation Questions
  - Features: useful, missing, to rework?
  - Are there limitations that hinder adoption?
  - Is the tool understandable/learnable?

Data/task abstraction

Visual encoding/interaction idiom

Lam et al., 2012

Evaluating User Experience

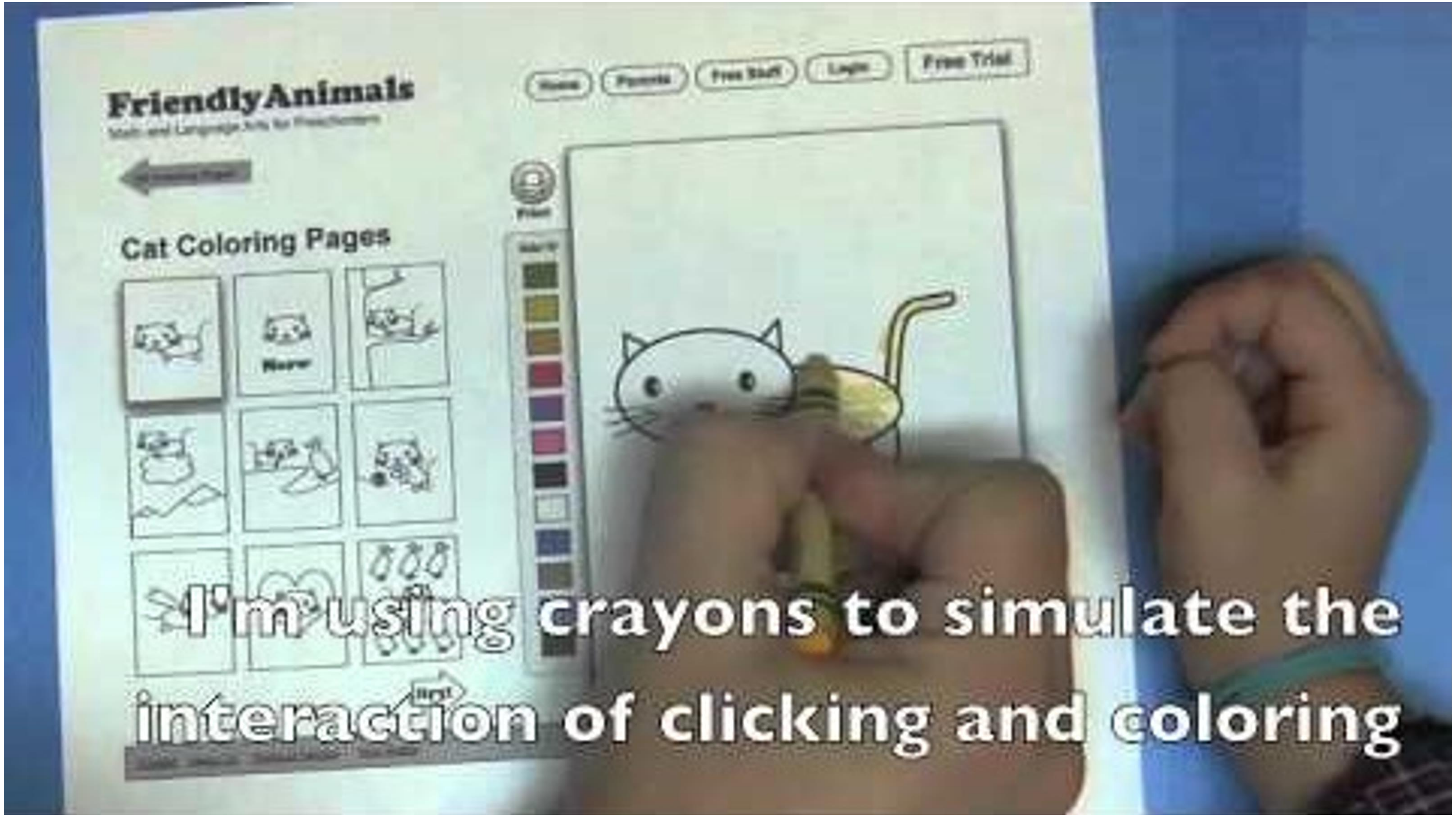
Data/task abstraction

Visual encoding/interaction idiom

- Methods
  - Informal evaluation
    - Demo for domain experts (usually) and collect feedback
  - Usability test
    - Watch (video) how participants perform set of tasks to perfect design
    - Take note of behaviors, remarks, problems
    - Carefully prepare tasks, interview script, questionnaires
  - Field observation
    - Understand interaction in real setting
  - Laboratory questionnaire
    - Likert scale
    - Open ended

Lam et al., 2012

Evaluating User Experience: Example



Evaluating Visualization Algorithms

Data/task abstraction

Visual encoding/interaction idiom

- Goals & outputs
  - Quantitatively or qualitatively judge generated output quality (metrics) & performance
  - How scores vs. alternatives
  - Explore limits & behavior
- Evaluation Questions
  - Which shows interesting patterns best?
  - Which is more truthful?
  - Which is less cluttered?
  - Faster, less memory, less money?
  - How does it scale?
  - Extreme cases?

Lam et al., 2012

Evaluating Visualization Algorithms

Data/task abstraction

Visual encoding/interaction idiom

- Methods
  - Visualization quality assessment
    - Readability metrics, image quality measures
  - Algorithmic performance
    - Varied data, size, complexity, corner cases
    - Benchmark data sets

Lam et al., 2012

Evaluating Visualization Algorithms: Example

Type	Name	$recn_\Gamma$				
		GVA	FM³	FMS	ACE	HDE
Kind Arti-ficial	rnd_grid_032	3.82	**0**	**0**	**0**	<0.01
	rnd_grid_100	14.75	**0**	**0**	**0**	<0.01
	rnd_grid_320	181.51	**0**	(N)	<0.01	<0.01
	sierpinski_06	2.00	0.05	<0.01	**0**	0.02
	sierpinski_08	9.49	0.07	**0.01**	0.02	0.08
	sierpinski_10	99.97	0.09	(N)	0.27	**0.01**
Kind Real World	crack	30.82	<0.01	(N)	**0**	0.07
	fe_pwt	150.70	2.45	(N)	(N)	**1.61**
	finan_512	301.25	18.81	(N)	**12.27**	21.27
	fe_ocean	622.48	**7.13**	(N)	9.07	8.24
Chal-lenging Arti-ficial	tree_06_04	2.21	1.16	7.89	0.01	**0**
	tree_06_05	9.33	1.89	11.48	**0**	22.92
	tree_06_06	70.68	**3.31**	(N)	4.16	128.82
	snowflake_A	0.63	**0**	0.10	<0.01	0.62
	snowflake_B	1.46	**0**	8.18	(N)	6.92
	snowflake_C	15.53	**0**	(N)	(N)	195.87
	spider_A	15.62	16.55	**1.17**	6.60	1.25
	spider_B	154.70	132.96	1.64	**0**	**0**
	spider_C	2522.89	1029.64	(N)	**0**	**0**
	flower_A	46.71	49.08	5.63	**0.26**	0.55
	flower_B	64.90	51.57	1.90	**0.06**	0.34
	flower_C	578.22	53.39	(N)	(N)	**0.30**
Chal-lenging Real World	ug_380	22.93	19.55	13.67	20.99	**1.35**
	esslingen	47.52	23.71	28.42	20.81	**3.89**
	add_32	8.65	1.69	5.75	**0.89**	5.80
	dg_1087	1.74	**< 0.01**	37.07	5.92	6.49
	bcsstk_33	720.94	376.18	4171.05	413.56	**113.86**
	bcsstk_31	708.69	94.26	(N)	**63.00**	611.21

Table 3: The relative edge-crossing numbers ($recn_\Gamma$) of the drawings Γ computed by the tested algorithms. The entry (N) indicates that no drawing was computed. Best values are printed bold. Worst values are underlined.

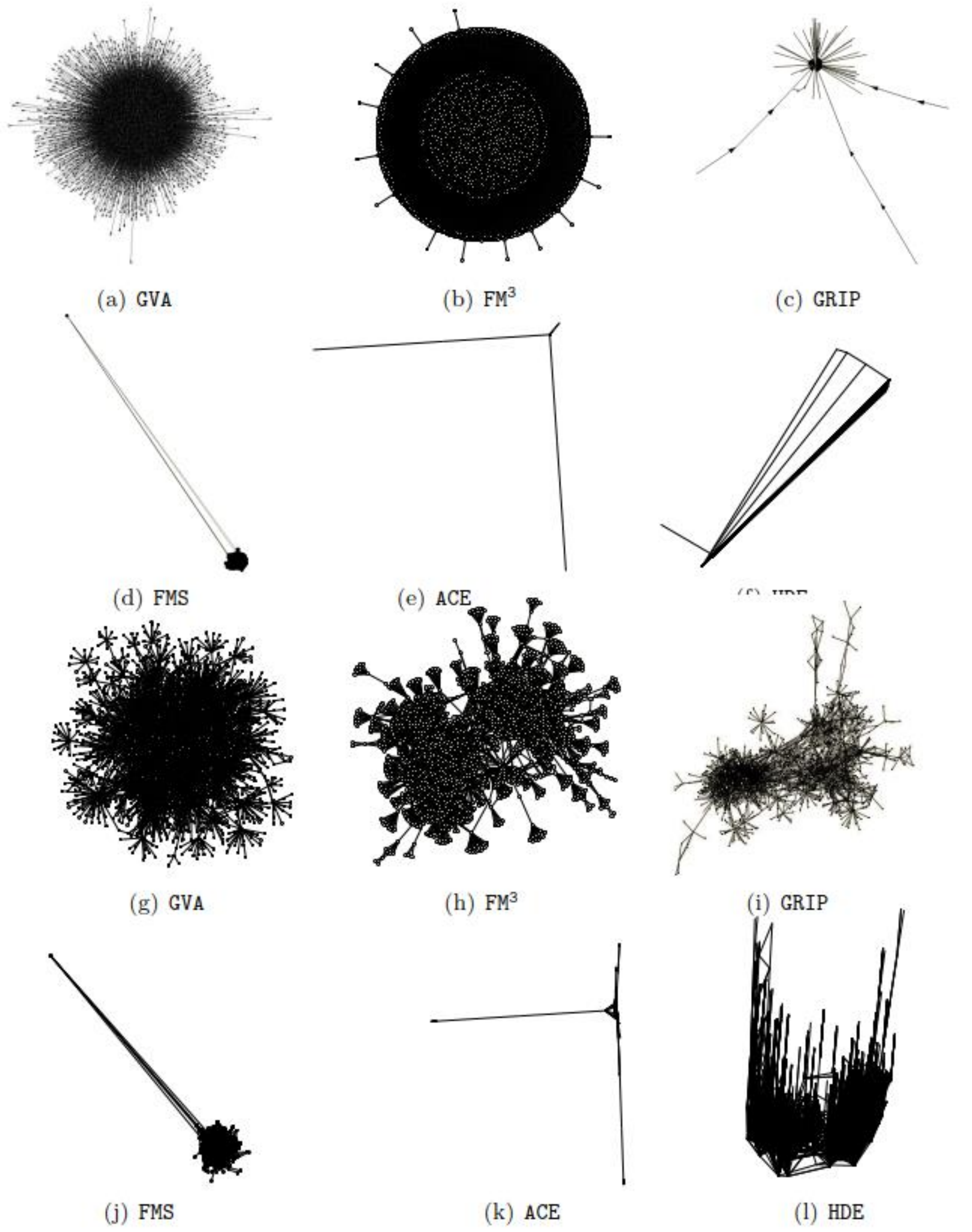


Figure 8: (a)-(f) Drawings of dg_1087 and (g)-(l) esslingen generated by different algorithms

Hachul & Jünger, 2007

7 Evaluation Scenarios

How to understand your data:

Scenario		
Understanding Environments and Work Practices	Domain situation	
Evaluating Visual Data Analysis and Reasoning	Data/task abstraction	
Evaluating Communication Through Visualization	Visual encoding/interaction idiom	
Evaluating Collaborative Data Analysis	Data/task abstraction	

How to understand your visualization:

Scenario		
Evaluating User Performance	Visual encoding/interaction idiom	Data/task abstraction
Evaluating User Experience	Visual encoding/interaction idiom	Data/task abstraction
Evaluating Visualization Algorithms	Algorithm	

Lam et al., 2012

7 Evaluation Scenarios

How to understand your data:

- Understanding Environments and Work Practices — Field Observations, Interviews
- Evaluating Visual Data Analysis and Reasoning — Case Studies, Controlled Experiment
- Evaluating Communication Through Visualization — Field Observation, Controlled Experiment
- Evaluating Collaborative Data Analysis — Field Observation, Heuristic Evaluation, Log Analysis

How to understand your visualization:

- Evaluating User Performance — Controlled Experiment, Log Analysis
- Evaluating User Experience — Informal Evaluation, Usability Test, Field Observation
- Evaluating Visualization Algorithms — Visualization Quality Assessment, Algorithm Performance

Lam et al., 2012

In-Class Validation — Final Project Evaluation

~35 min

Upcoming Assignments & Communication

A look at the upcoming assignments and deadlines

- Textbook, Readings & Reading Quizzes

- 2020-11-24 Project 8 — Sprint 3 & Prep for Usability Testing
- 2020-11-25 No Class — Thanksgiving

- 2020-11-30 In-Class Usability Testing — Final Projects

- 2020-12-06 Project 9 — Presentation and Video
- 2020-12-07 In-Class Project Presentations
- 2020-12-09 In-Class Project Presentations

- 2020-12-15 Project 10 — Final Project Deliverables and Sharing with Partners

https://c.dunne.dev/ds4200f20

Everyday Required Supplies:

- 5+ colors of pen/pencil
- White paper
- Laptop and charger

Use **Canvas Discussions** for general questions,
email the **instructor & TAs** for questions **specific to you**.

If you're emailing about a particular assignment, please include the URL of the Submission Details page. (Canvas documentation.)

If you have a project question, **give us your group number**. E.g., include: `Group ## — Topic` with '##' replaced by your group number and 'Topic' replaced by your topic.