

Visualization Design Methods

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University of British Columbia

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January 24 2017, San Diego CA*

<http://www.cs.ubc.ca/~tmm/talks.html#ucsd17>

[@tamaramunzner](#)

Visualization (vis) defined & motivated

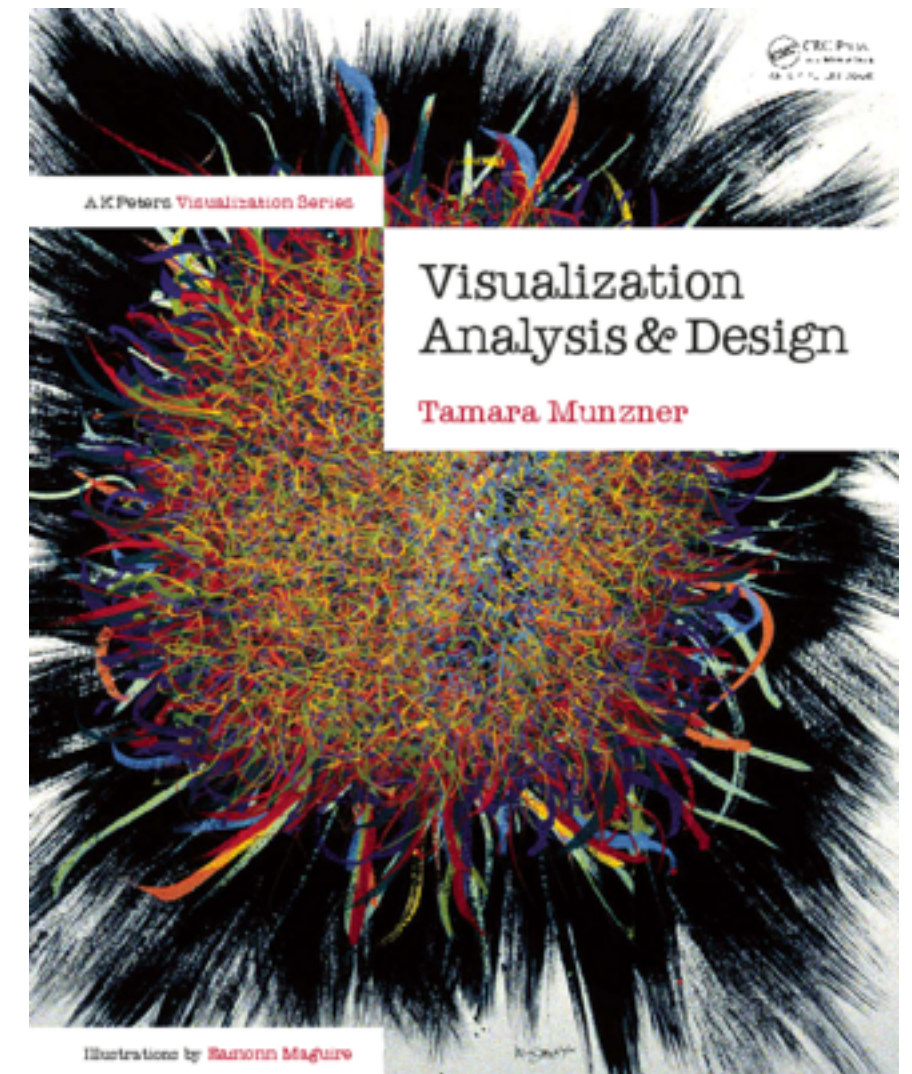
Computer-based visualization systems provide visual representations of datasets designed to help people carry out tasks more effectively.

Visualization is suitable when there is a need to augment human capabilities rather than replace people with computational decision-making methods.

- human in the loop needs the details
 - doesn't know exactly what questions to ask in advance
 - longterm exploratory analysis
 - presentation of known results
 - stepping stone towards automation: refining, trustbuilding
- external representation: perception vs cognition
- intended task, measurable definitions of effectiveness

more at:

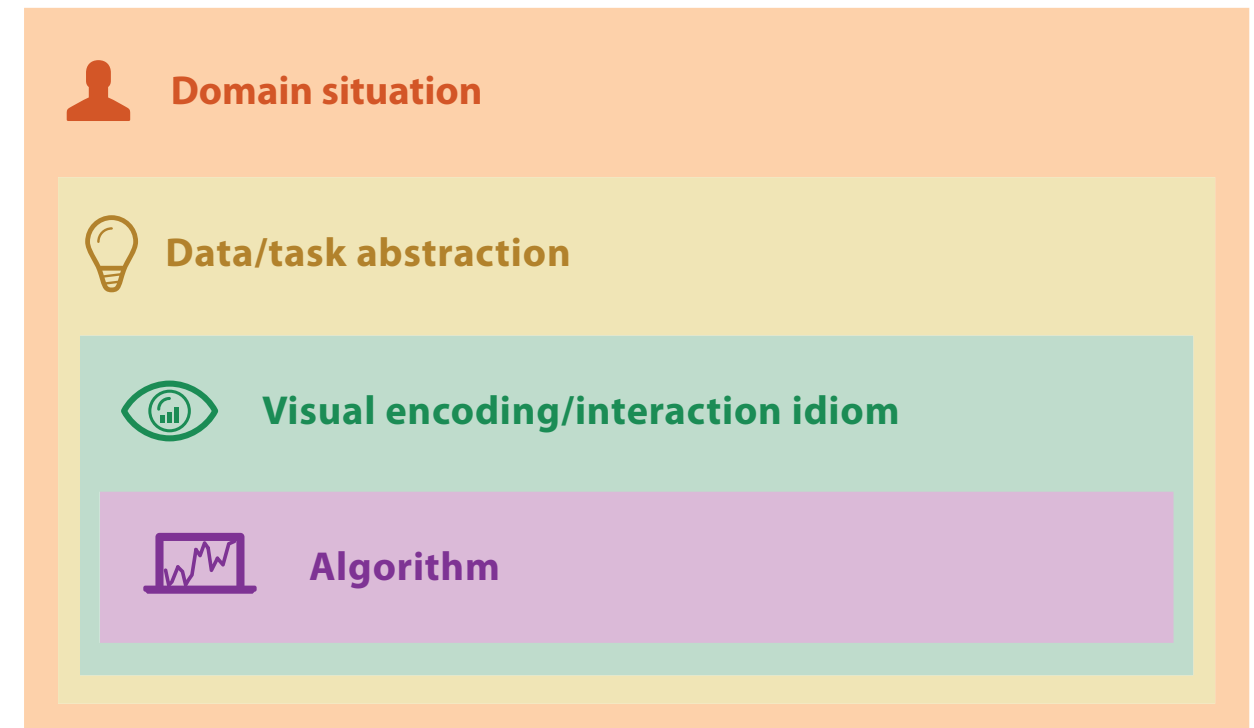
Visualization Analysis and Design, Chapter 1.
Munzner. AK Peters Visualization Series, CRC Press, 2014.



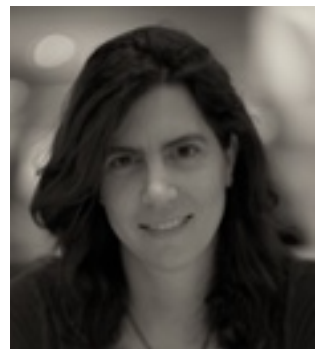
A Nested Model

for Visualization Design and Validation

<http://www.cs.ubc.ca/labs/imager/tr/2009/NestedModel>



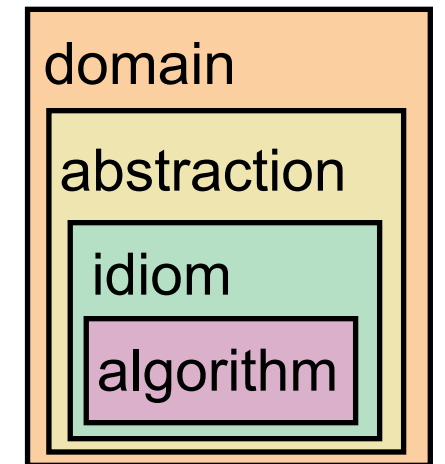
Tamara Munzner
@tamaramunzner



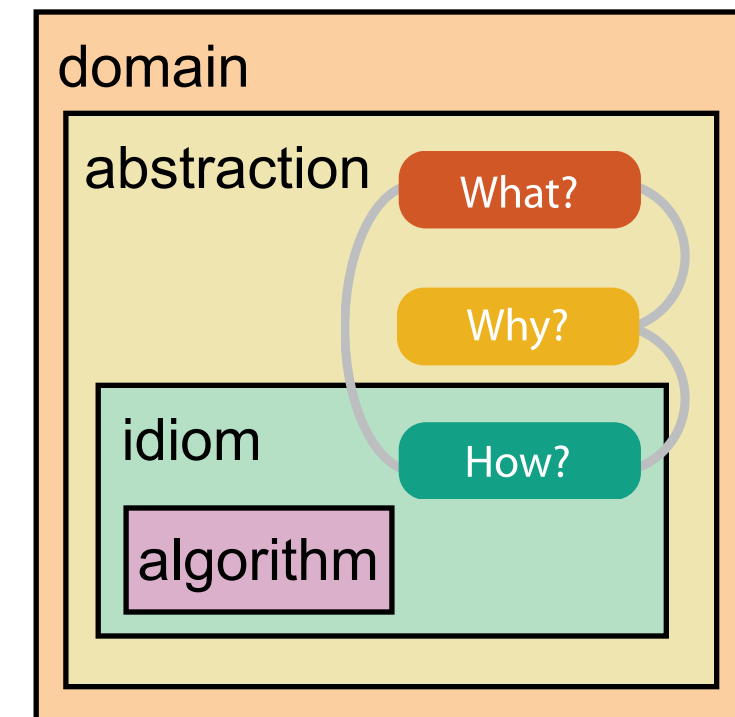
A Nested Model for Visualization Design and Validation.
Munzner. *IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 09)*, 15(6):921-928, 2009.

Analysis framework: Four levels, three questions

- *domain* situation
 - who are the target users?
- *abstraction*
 - translate from specifics of domain to vocabulary of vis
 - **what** is shown? **data abstraction**
 - often don't just draw what you're given: transform to new form
 - **why** is the user looking at it? **task abstraction**
- *idiom*
 - **how** is it shown?
 - **visual encoding idiom**: how to draw
 - **interaction idiom**: how to manipulate
- *algorithm*
 - efficient computation



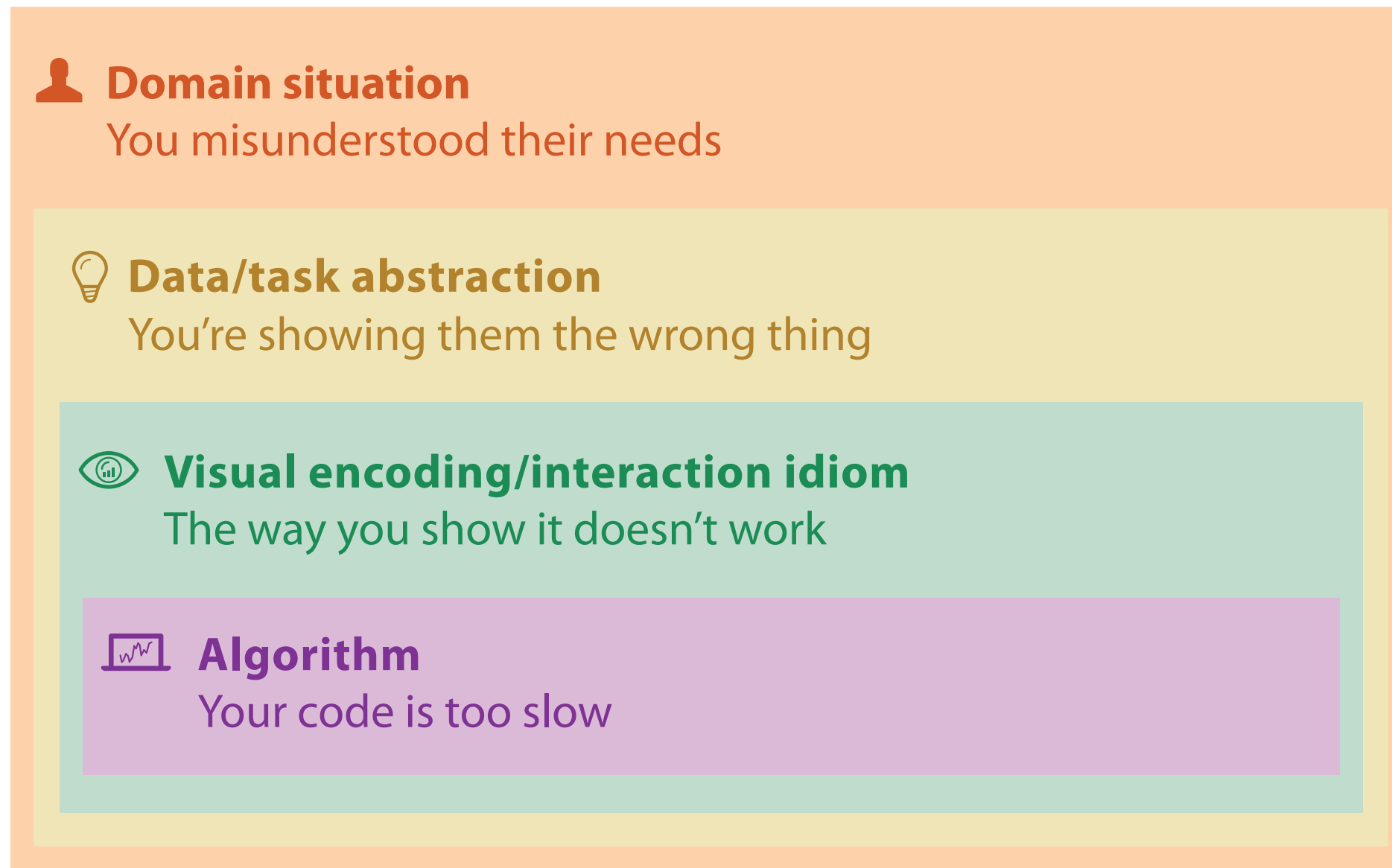
[A Nested Model of Visualization Design and Validation.
Munzner. *IEEE TVCG* 15(6):921-928, 2009
(Proc. InfoVis 2009).]



[A Multi-Level Typology of Abstract Visualization Tasks
Brehmer and Munzner. *IEEE TVCG* 19(12):2376-2385, 2013 (Proc. InfoVis 2013).]

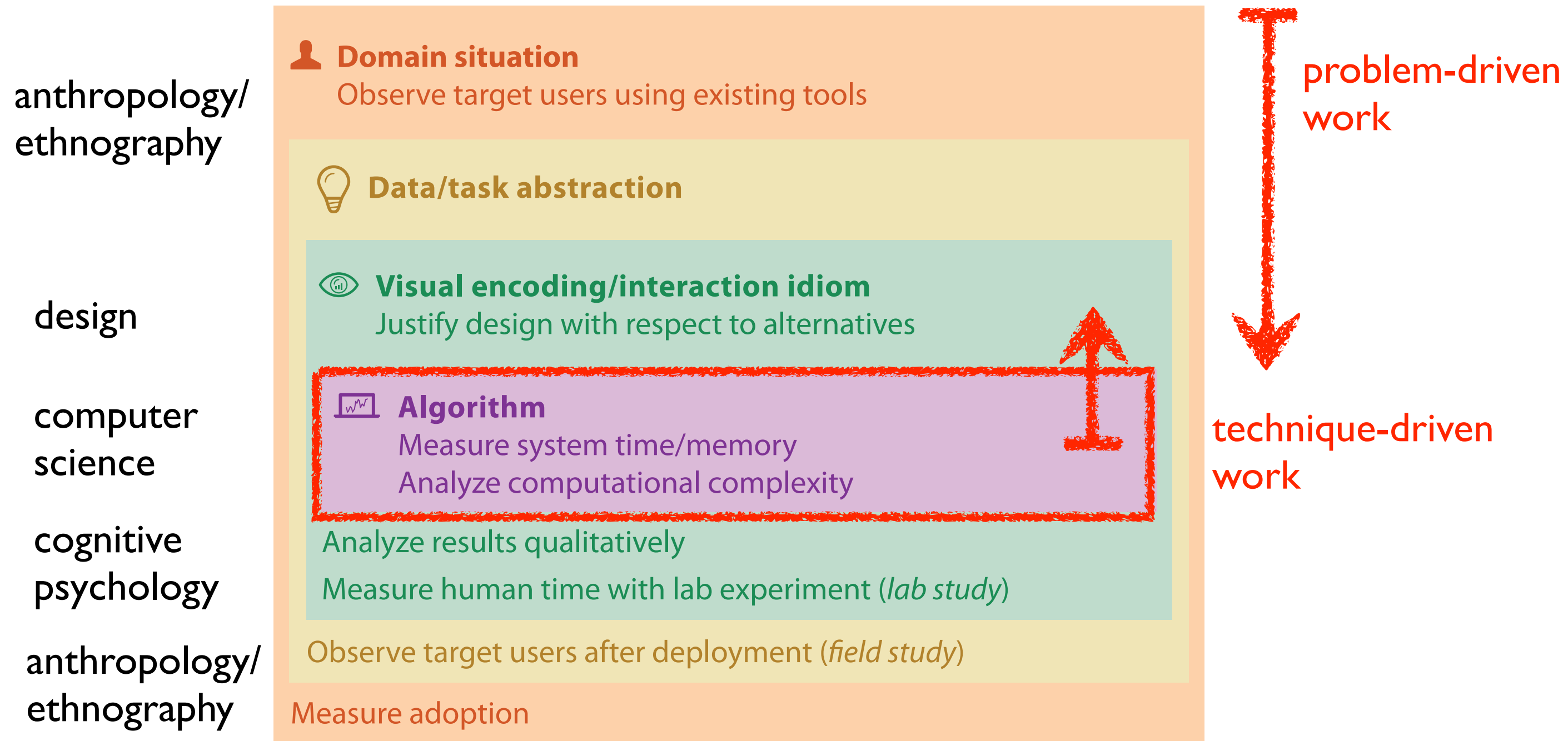
Why is validation difficult?

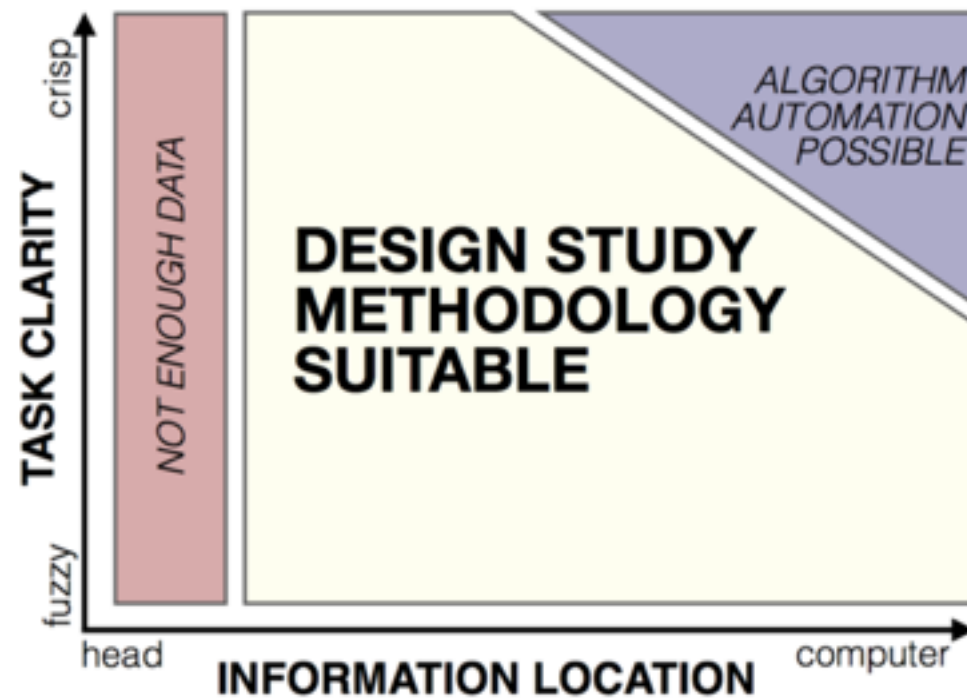
- different ways to get it wrong at each level



Validation solution: use methods from appropriate fields at each level

- avoid mismatches!





Michael Sedlmair



Miriah Meyer

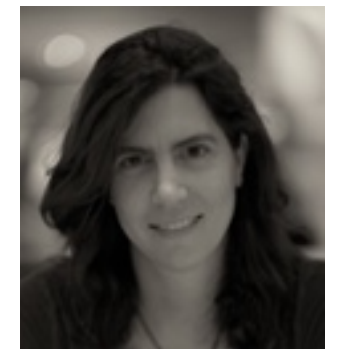


Design Study Methodology

Reflections from the Trenches and from the Stacks

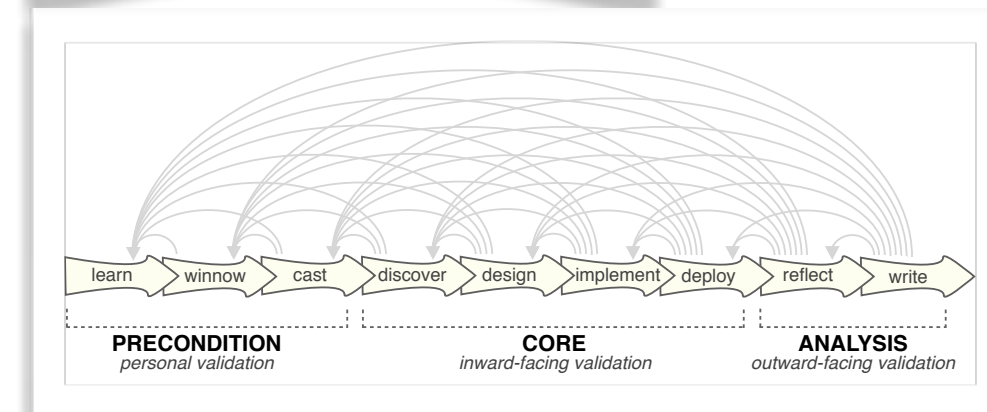
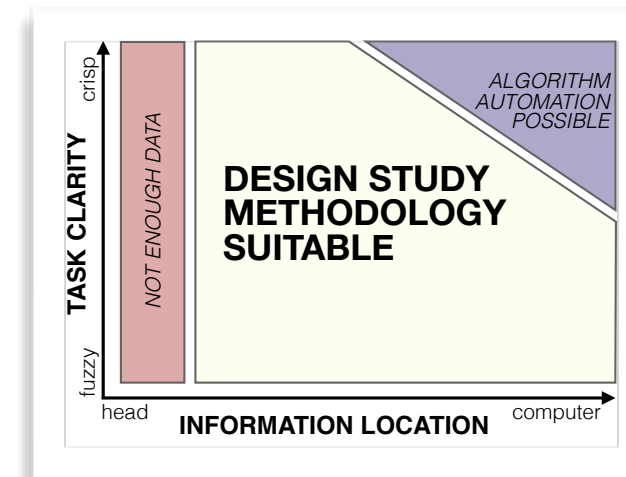
<http://www.cs.ubc.ca/labs/imager/tr/2012/dsm/>

Tamara Munzner
@tamaramunzner



Methodology for problem-driven work

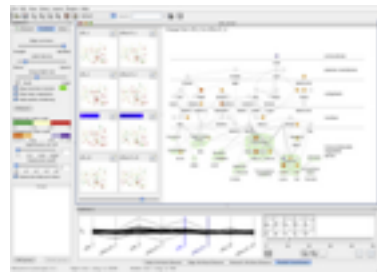
- definitions
- 9-stage framework
- 32 pitfalls & how to avoid them
- comparison to related methodologies



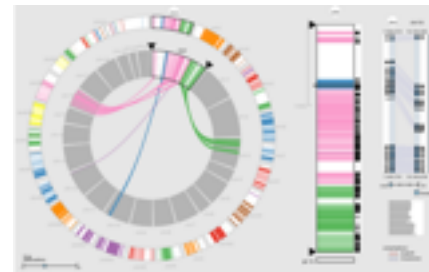
PF-1	premature advance: jumping forward over stages	general
PF-2	premature start: insufficient knowledge of vis literature	learn
PF-3	premature commitment: collaboration with wrong people	winnow
PF-4	no real data available (yet)	winnow
PF-5	insufficient time available from potential collaborators	winnow
PF-6	no need for visualization: problem can be automated	winnow
PF-7	researcher expertise does not match domain problem	winnow
PF-8	no need for research: engineering vs. research project	winnow
PF-9	no need for change: existing tools are good enough	winnow



Lessons learned from the trenches: 21 between us



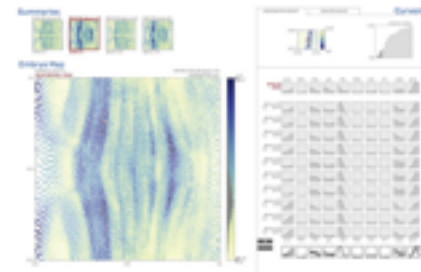
Cerebral
genomics



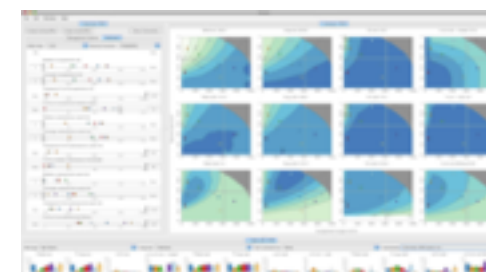
MizBee
genomics



Pathline
genomics



MulteeSum
genomics



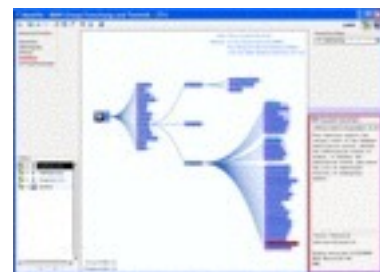
Vismon
fisheries management



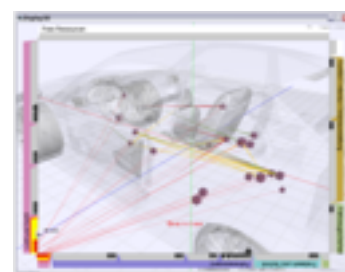
QuestVis
sustainability



WiKeVis
in-car networks



MostVis
in-car networks



Car-X-Ray
in-car networks



ProgSpy2010
in-car networks



ReEx
in-car networks



Cardiogram
in-car networks



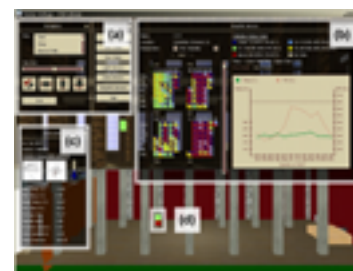
AutobahnVis
in-car networks



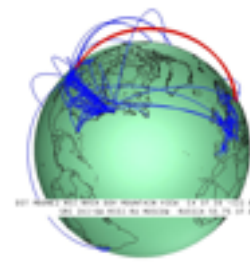
VisTra
in-car networks



Constellation
linguistics



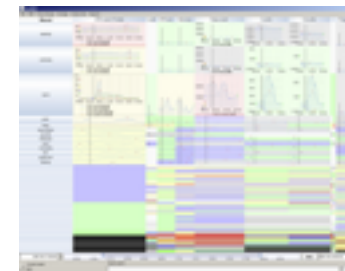
LibVis
cultural heritage



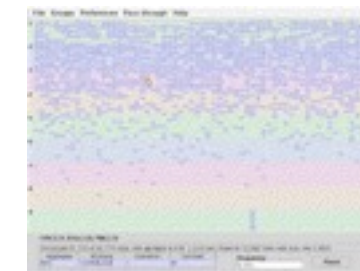
Caidants
multicast



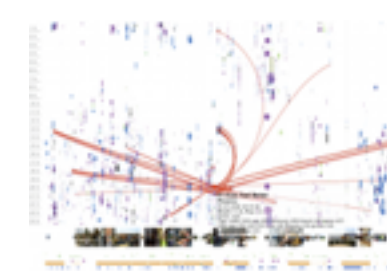
SessionViewer
web log analysis



LiveRAC
server hosting

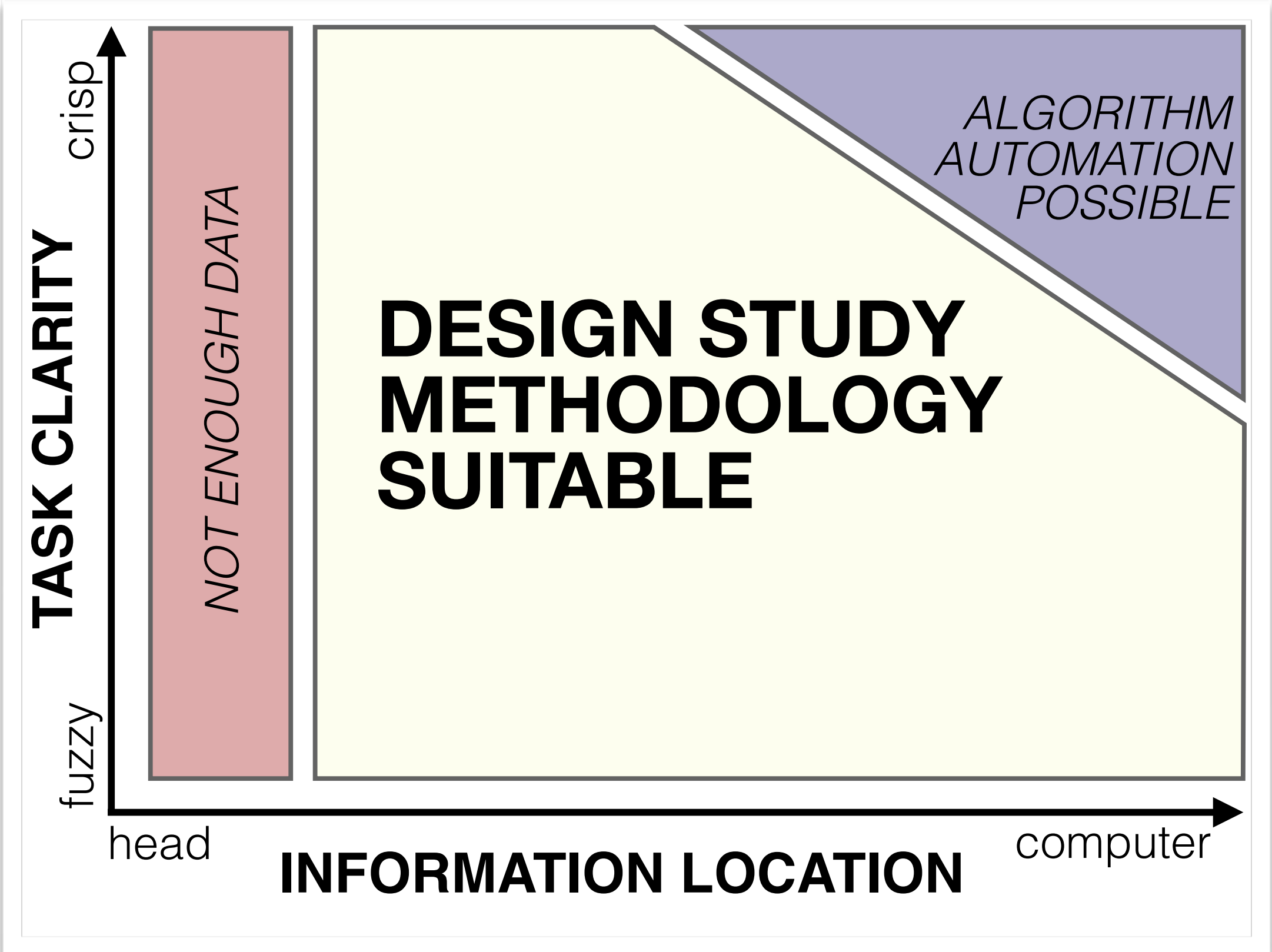


PowerSetViewer
data mining

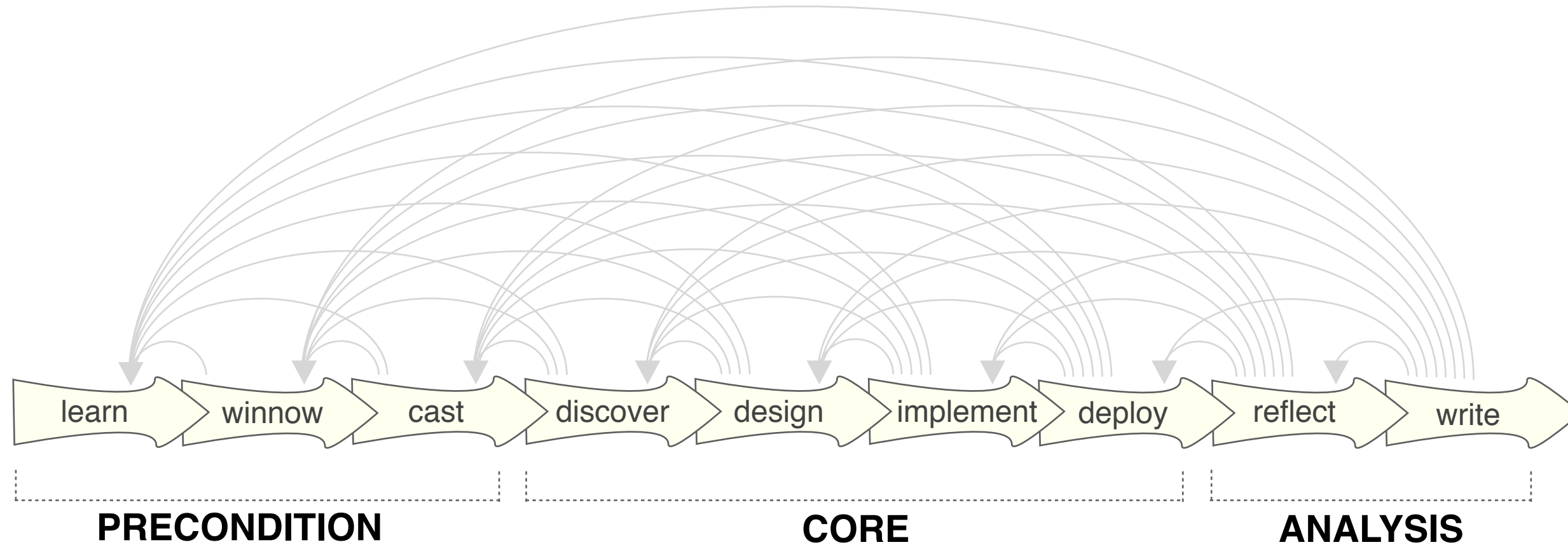


LastHistory
music listening

Design study methodology: definitions

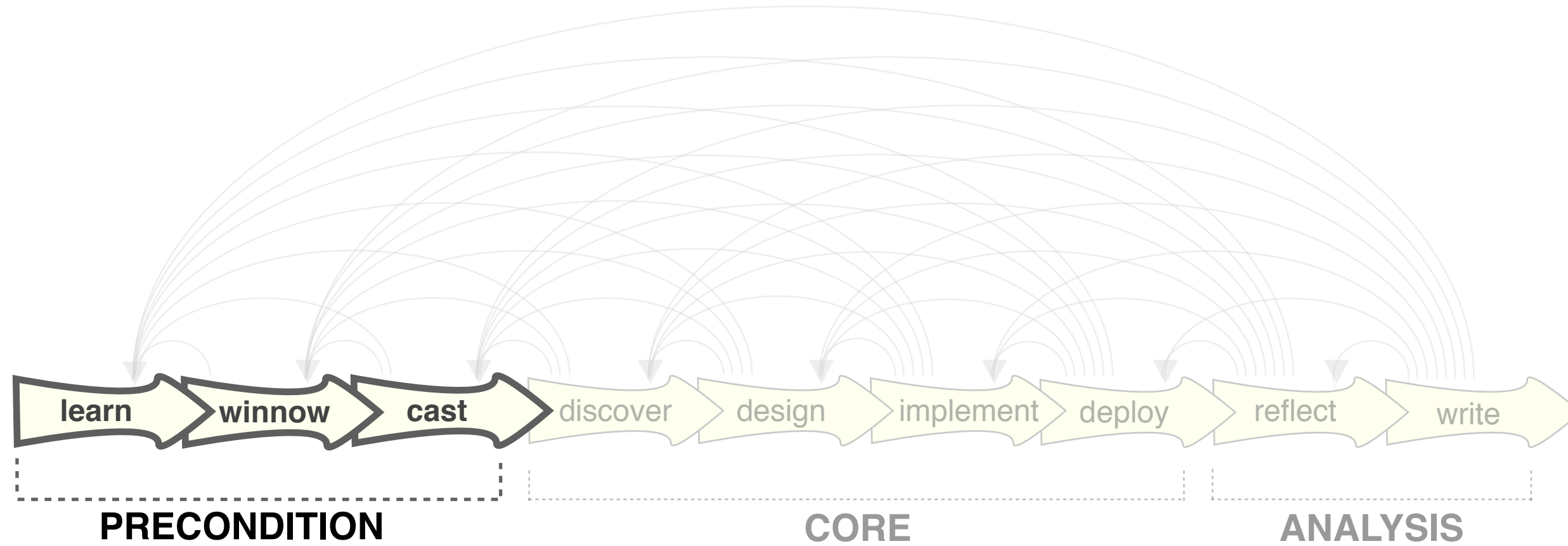


9 stage framework



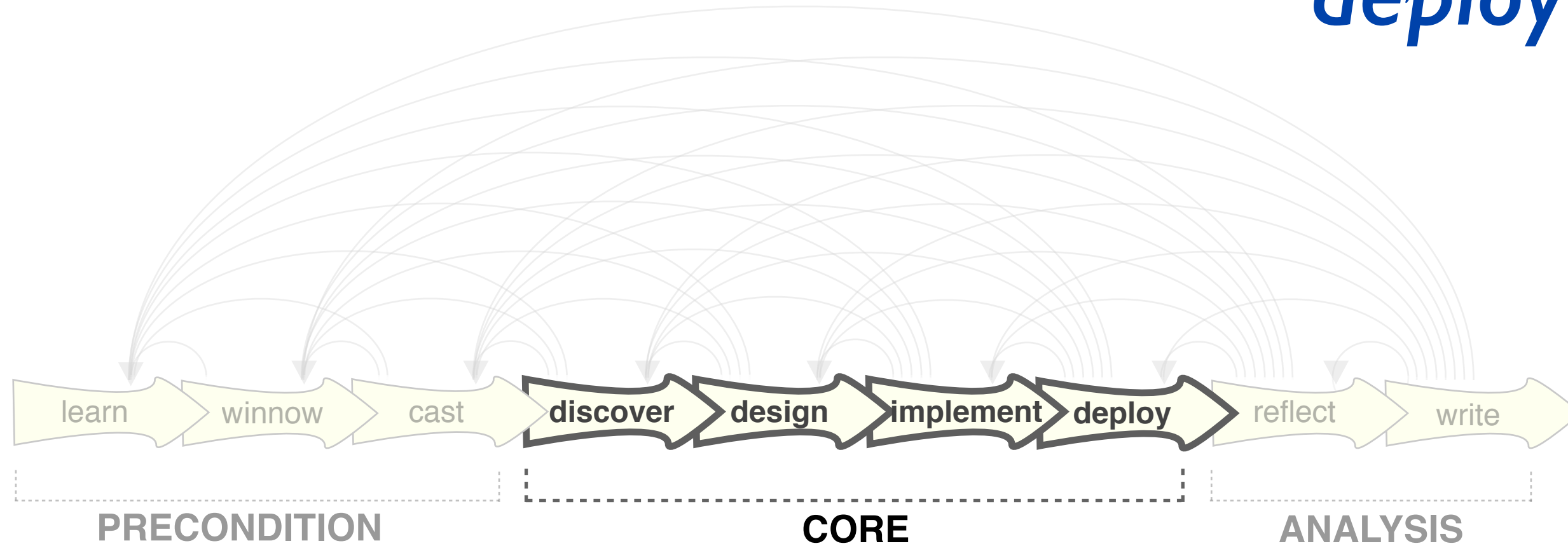
9-stage framework

learn
winnow
cast



9-stage framework

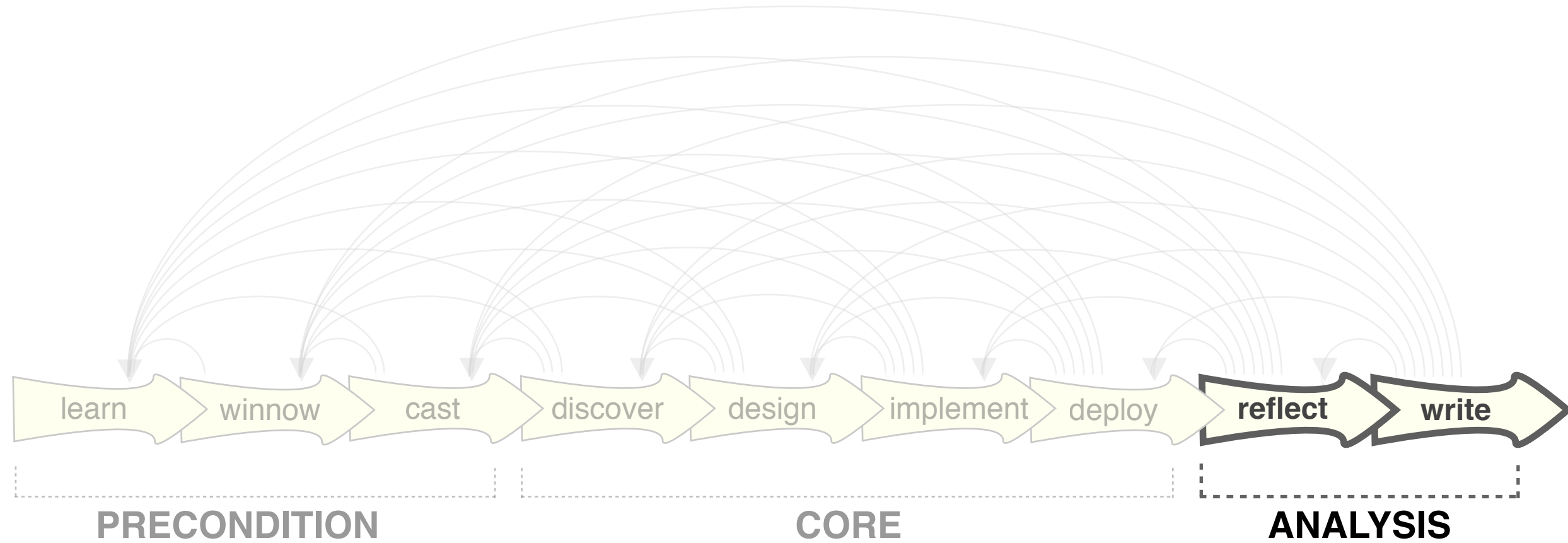
discover
design
implement
deploy



9-stage framework

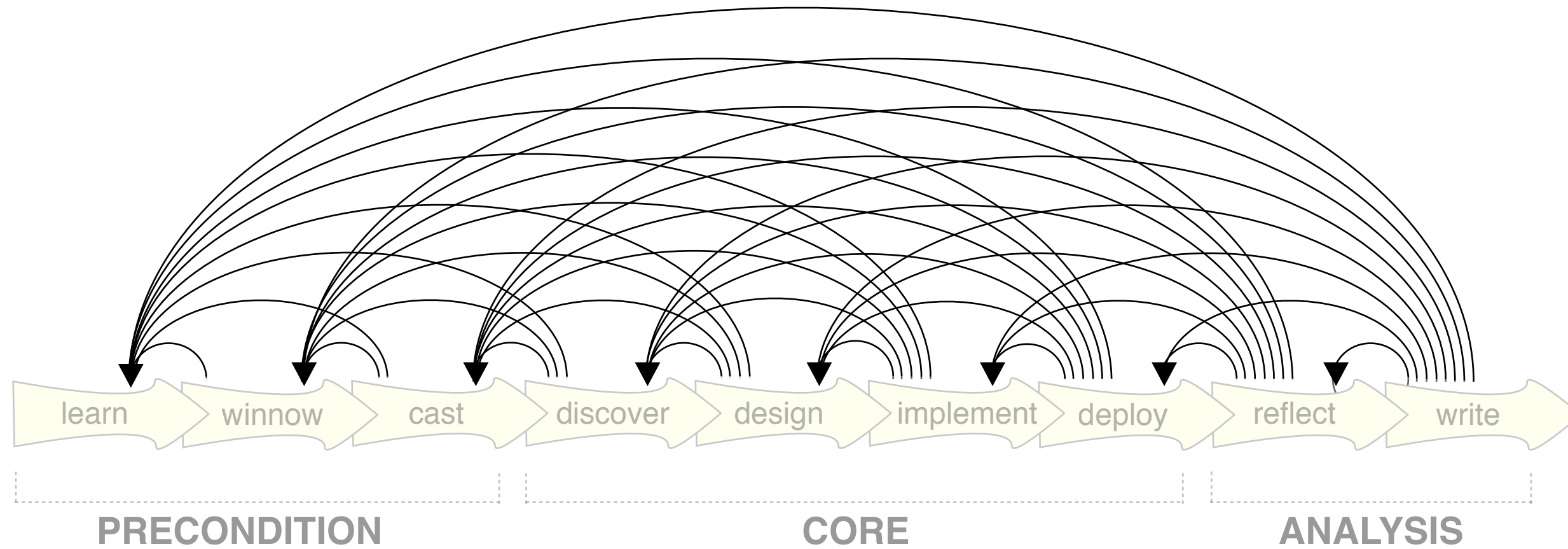
- guidelines: confirm, refine, reject, propose

reflect
write



9-stage framework

iterative



Design study methodology: 32 pitfalls

- and how to avoid them

PF-1	premature advance: jumping forward over stages	general
PF-2	premature start: insufficient knowledge of vis literature	learn
PF-3	premature commitment: collaboration with wrong people	winnow
PF-4	no real data available (yet)	winnow
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PF-9	no need for change: existing tools are good enough	winnow

I'm a domain expert!
Wanna collaborate?



COLLABORATOR

Of course!!!



MR. VIS

considerations



Have **data**?
Have **time**?
Have **need**?
...



roles



Are you a **user???**

... or maybe a **fellow tool builder?**

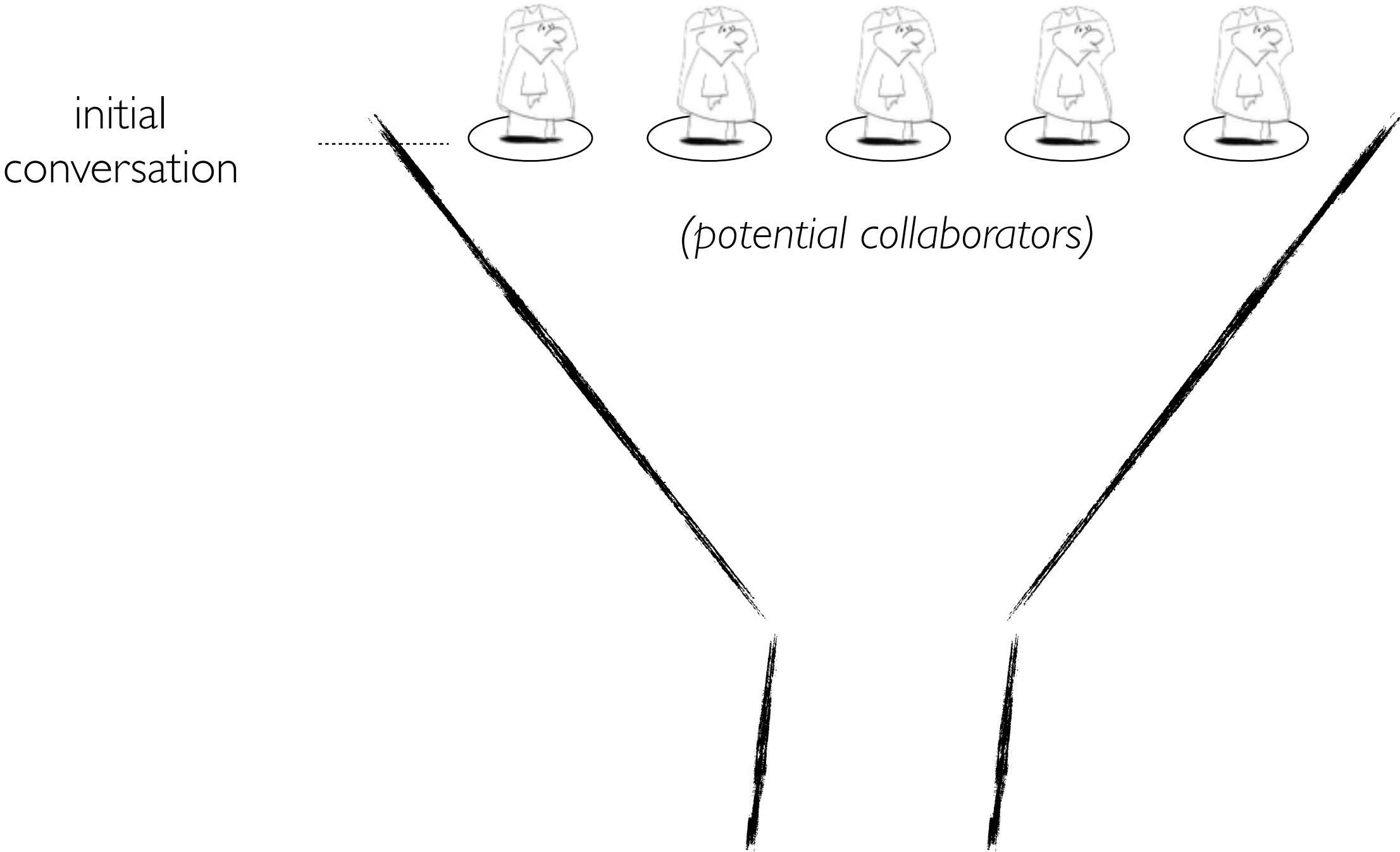


METAPHOR

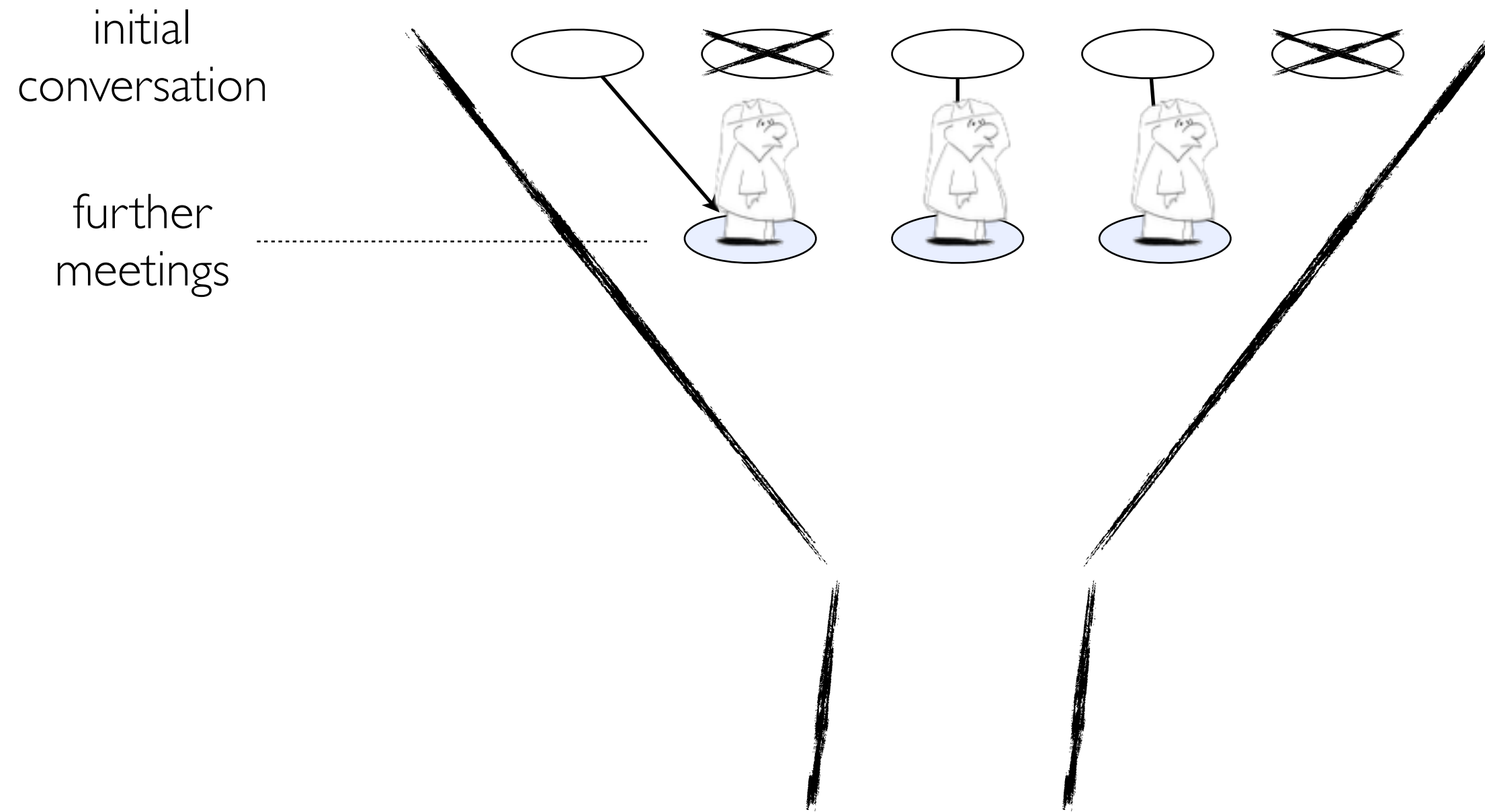
Winnowing



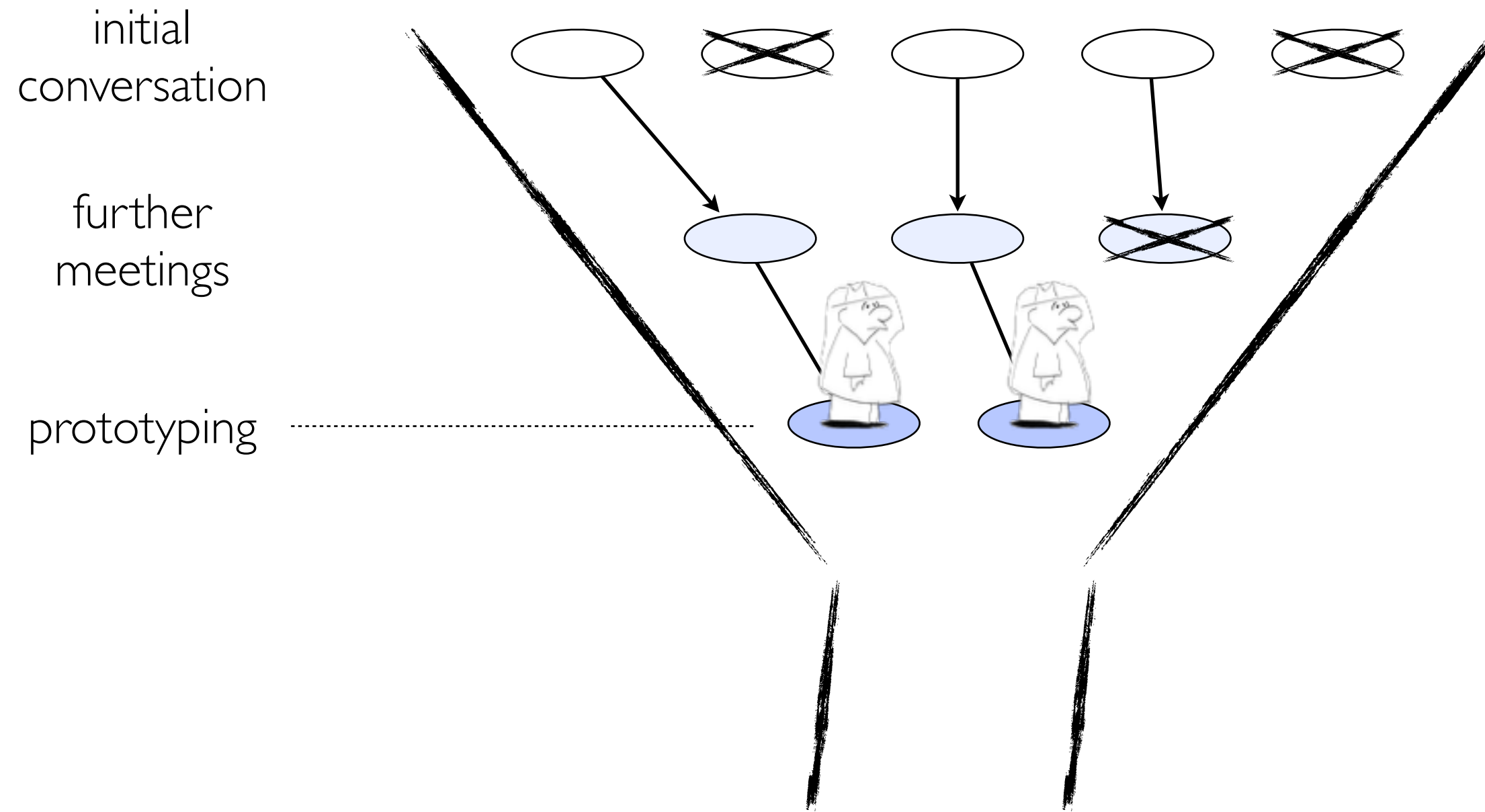
Collaborator winnowing



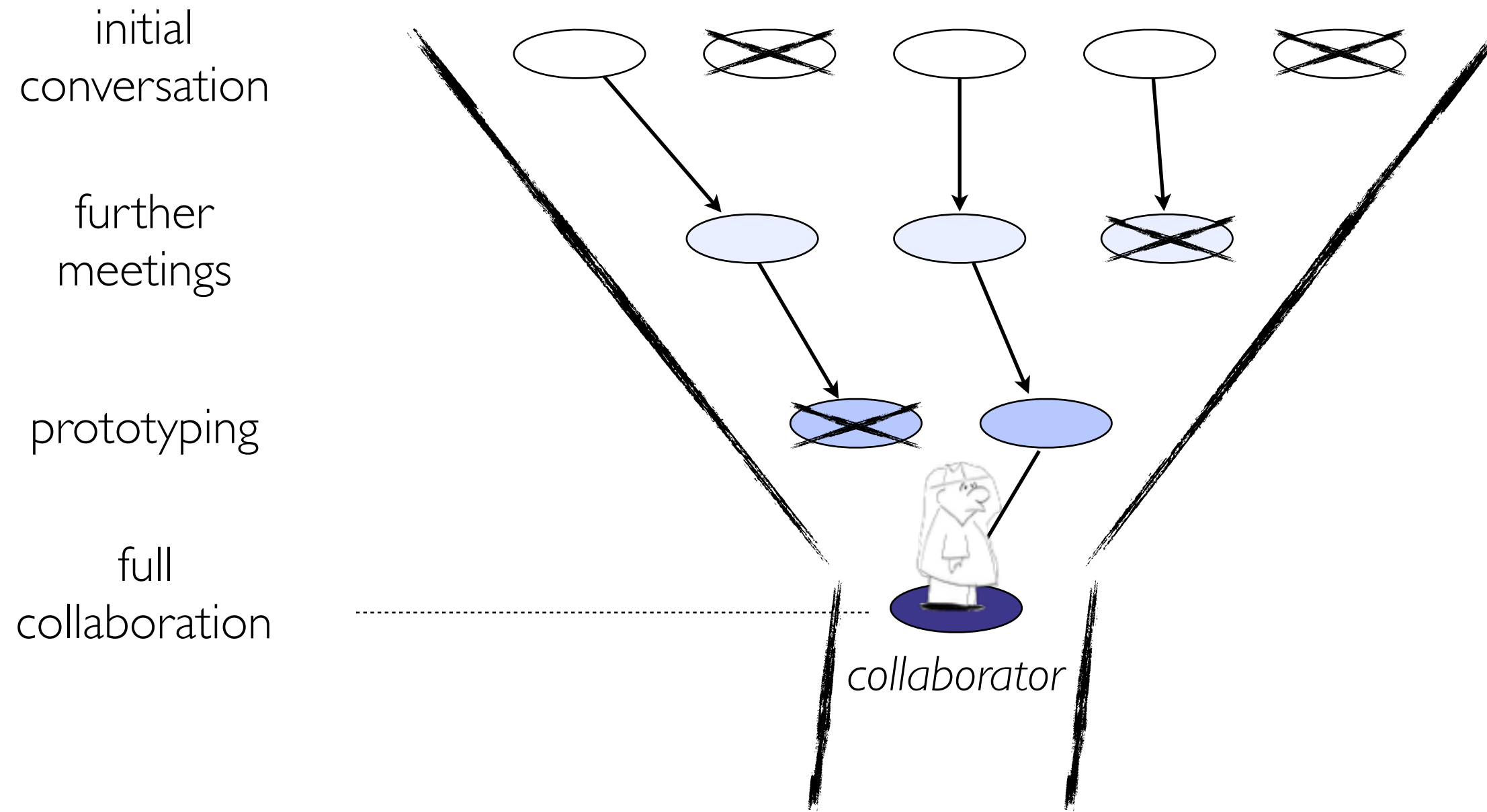
Collaborator winnowing



Collaborator winnowing



Collaborator winnowing



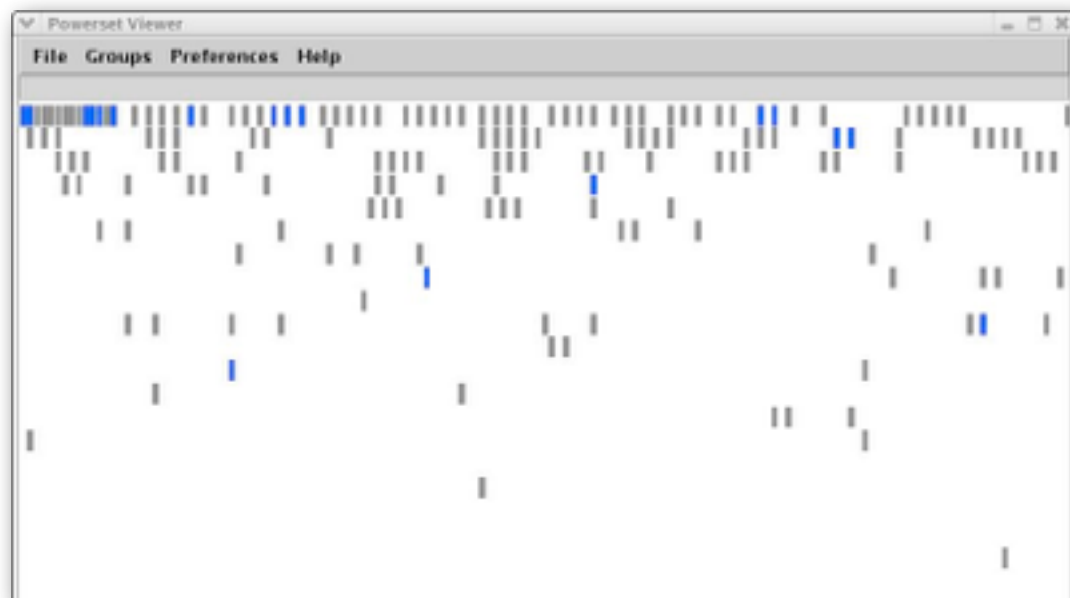
Collaborator winnowing



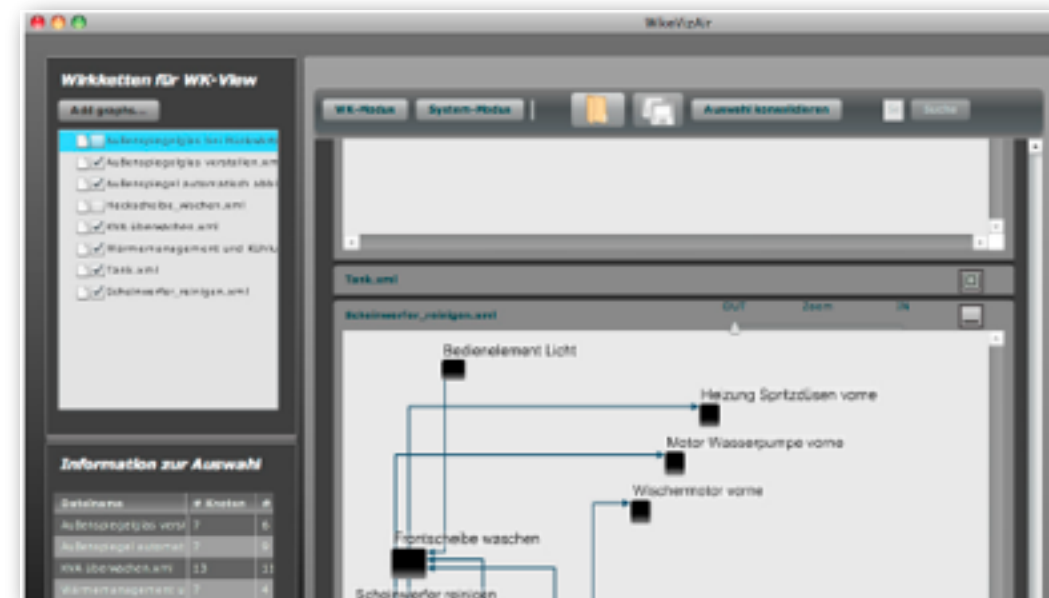
EXAMPLE FROM THE TRENCHES

Premature Collaboration!

PowerSet Viewer
2 years / 4 researchers



WikeVis
0.5 years / 2 researchers



EXAMPLE FROM THE TRENCHES

Premature Collaboration!

PowerSet Viewer
2 years / 4 researchers

WikeVis
0.5 years / 2 researchers



- Fellow tool builders
- Data promised

Design study methodology: 32 pitfalls

PF-10	no real/important/recurring task	winnow
PF-11	no rapport with collaborators	winnow
PF-12	not identifying front line analyst and gatekeeper before start	cast
PF-13	assuming every project will have the same role distribution	cast
PF-14	mistaking fellow tool builders for real end users	cast
PF-15	ignoring practices that currently work well	discover
PF-16	expecting <i>just talking</i> or <i>fly on wall</i> to work	discover
PF-17	experts focusing on visualization design vs. domain problem	discover
PF-18	learning their problems/language: too little / too much	discover
PF-19	abstraction: too little	design
PF-20	premature design commitment: consideration space too small	design

PITFALL

**PREMATURE DESIGN
COMMITMENT**

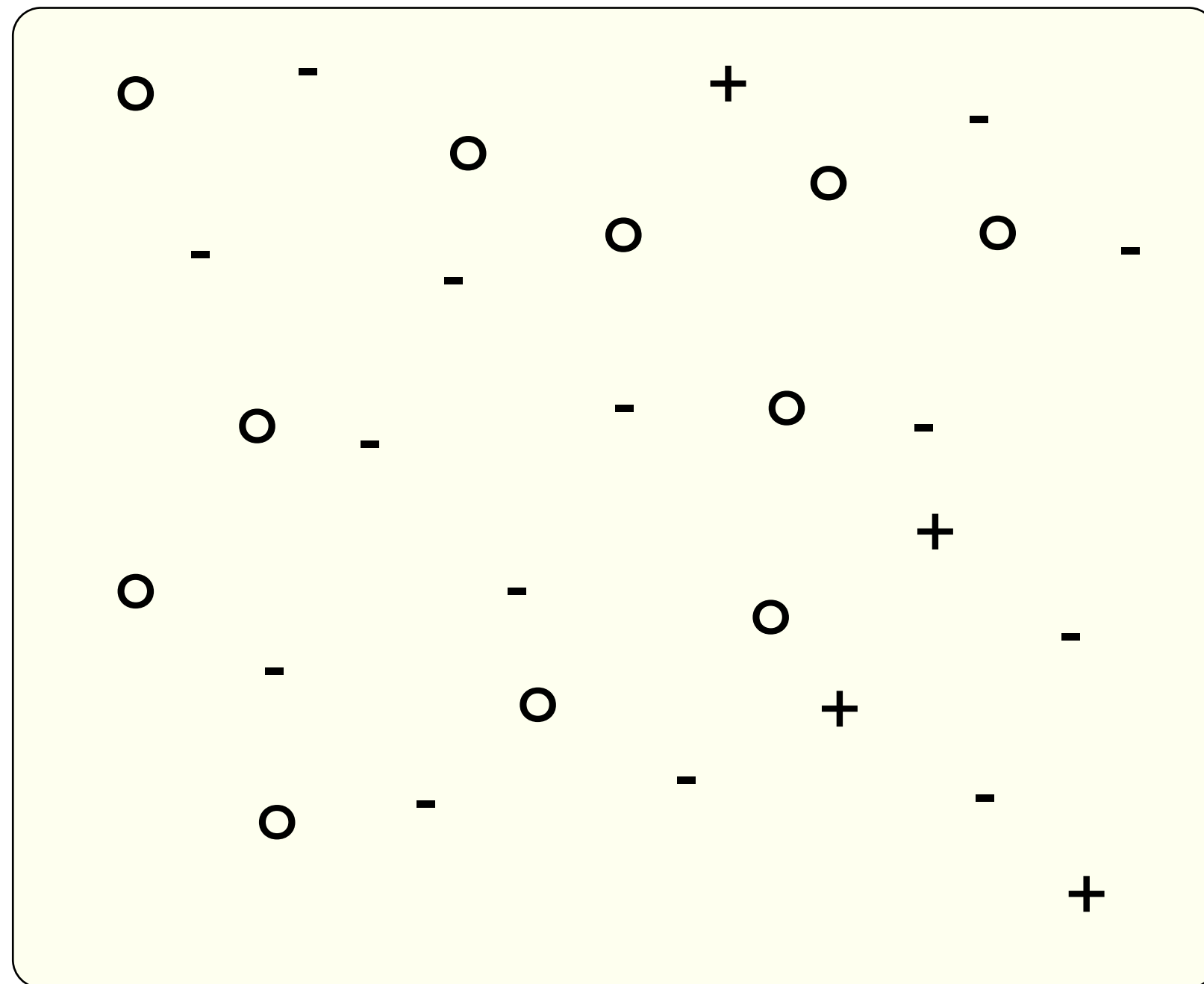
Of course they need the cool
technique I built last year!



MR. VIS

METAPHOR

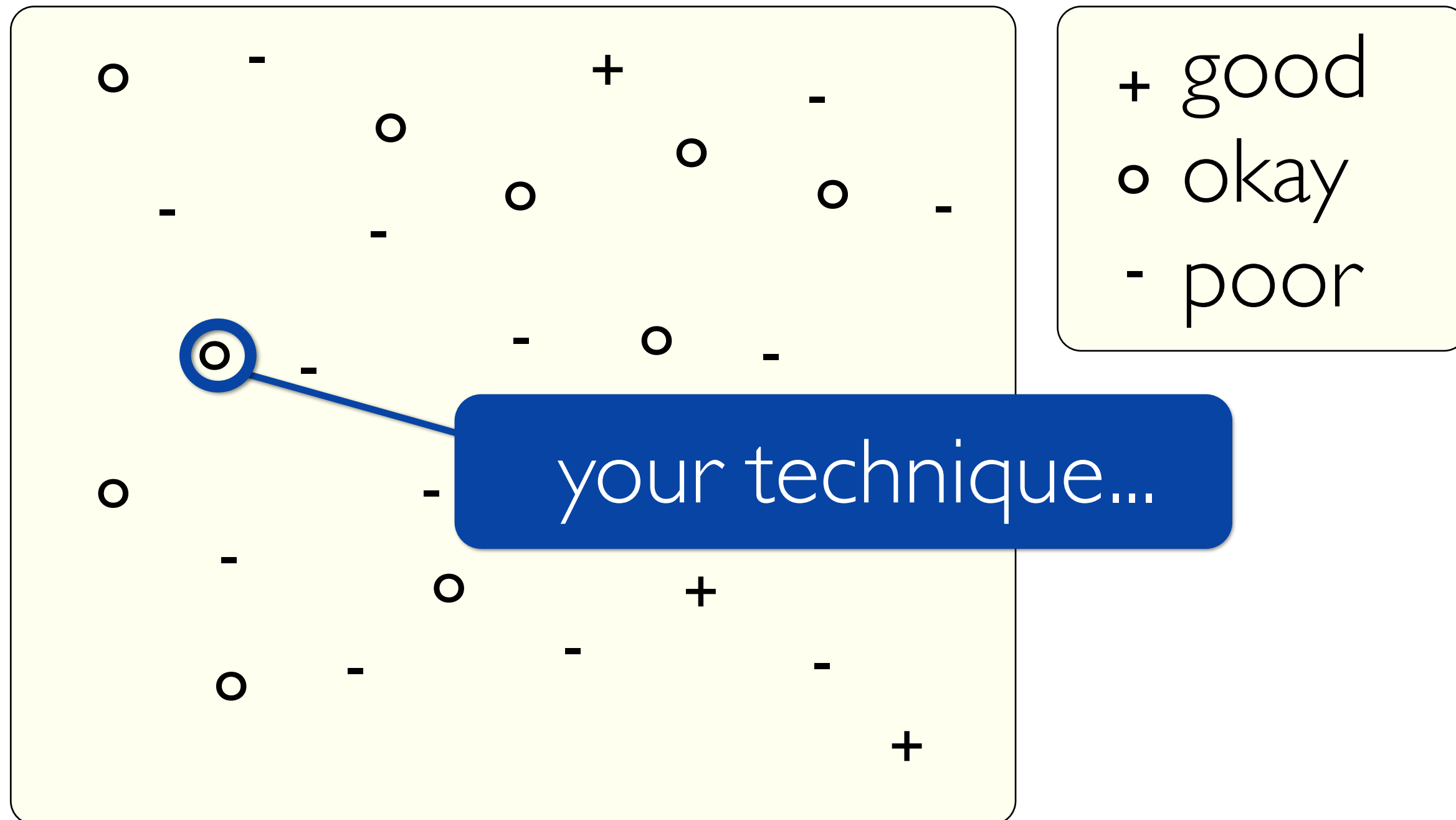
Design Space



+ good
o okay
- poor

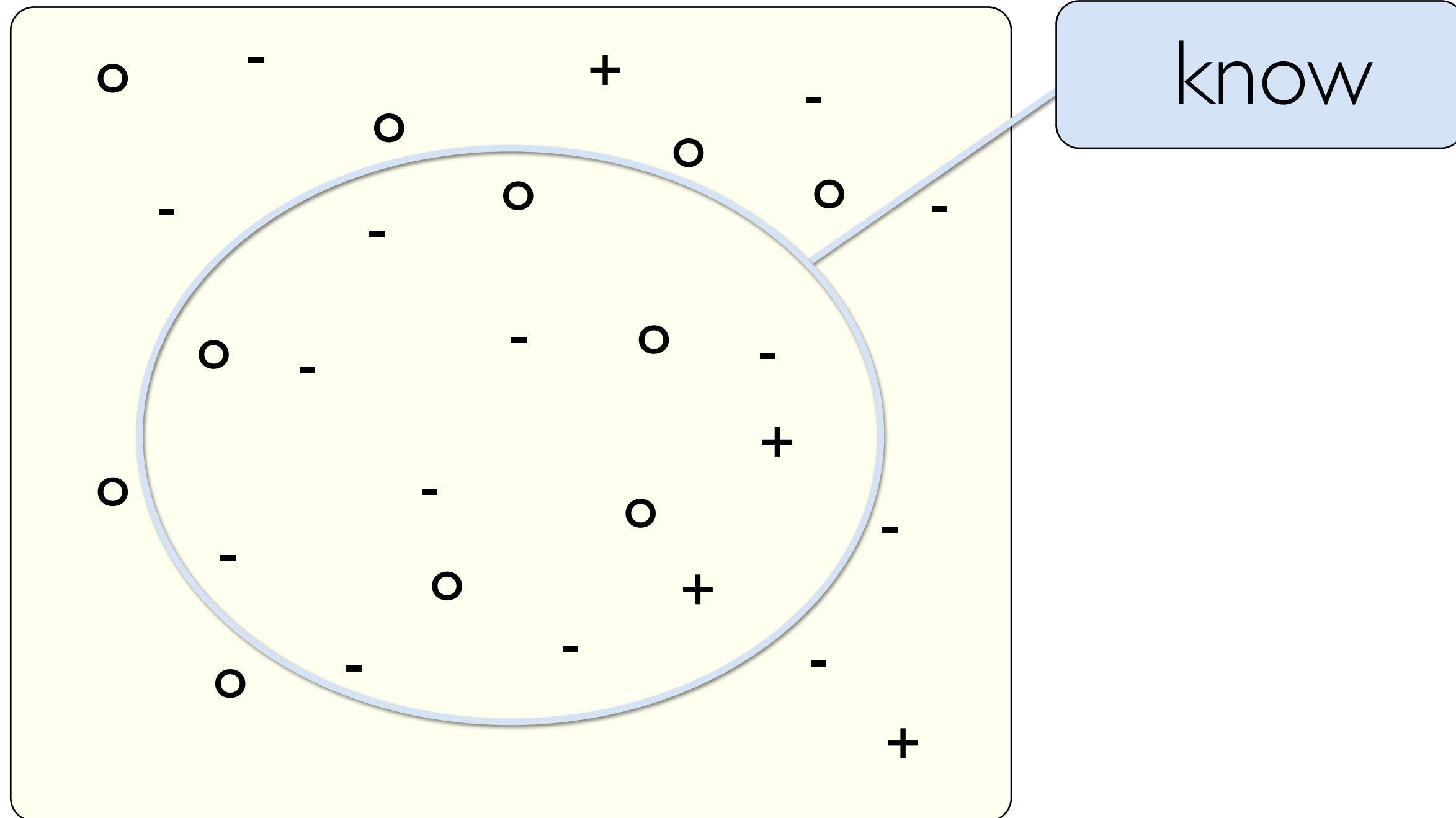
METAPHOR

Design Space



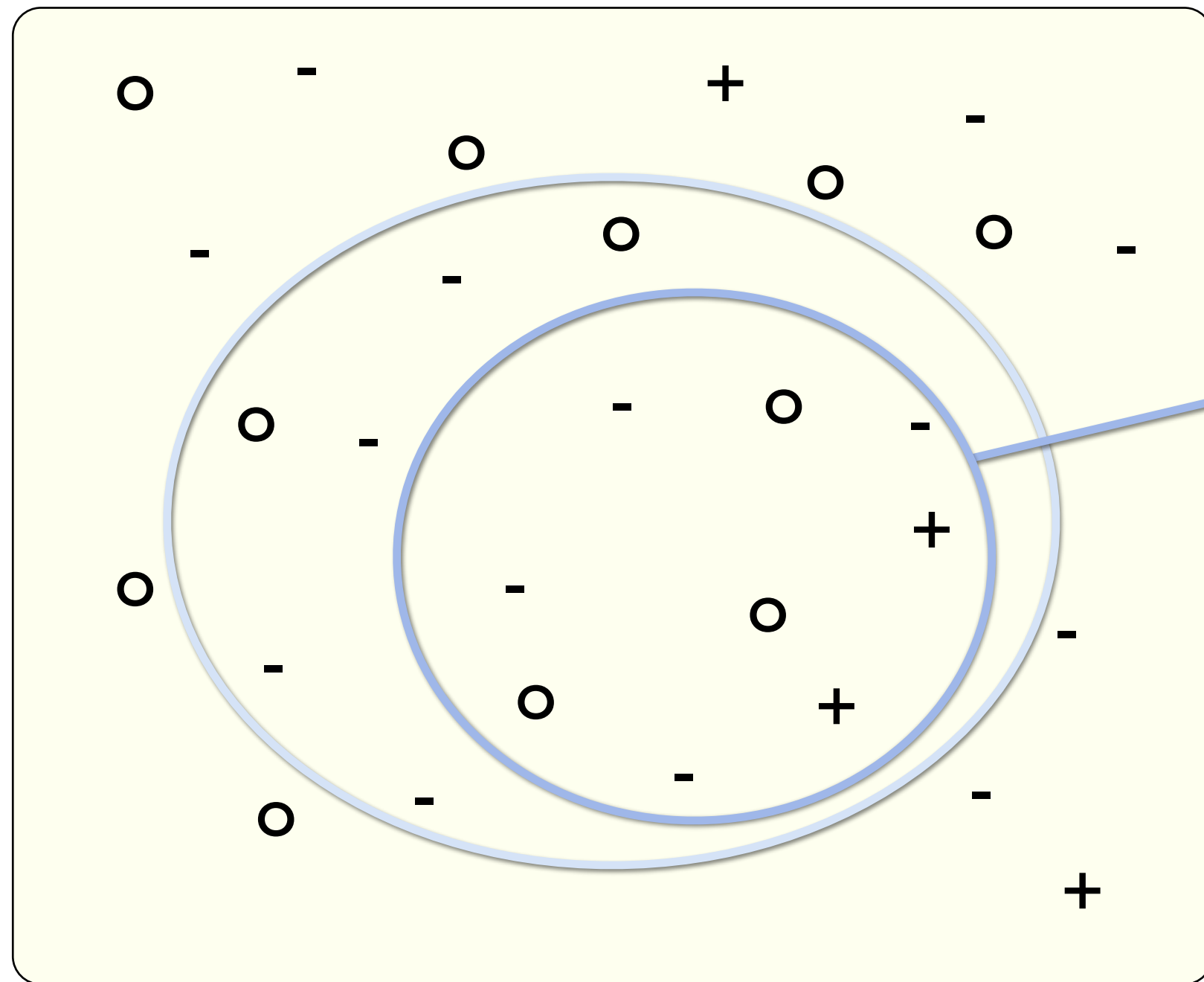
METAPHOR

Design Space



METAPHOR

Design Space

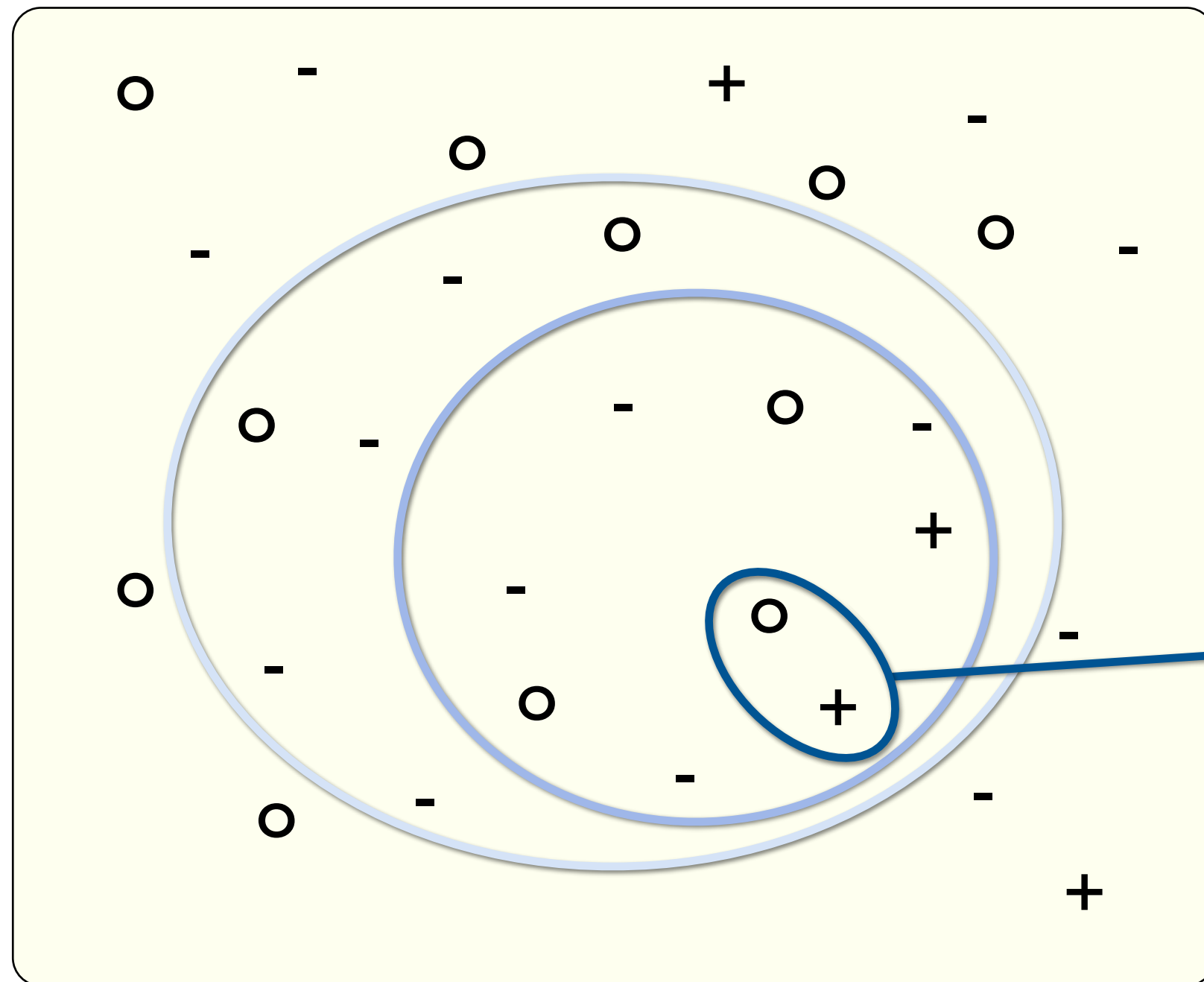


know

consider

METAPHOR

Design Space



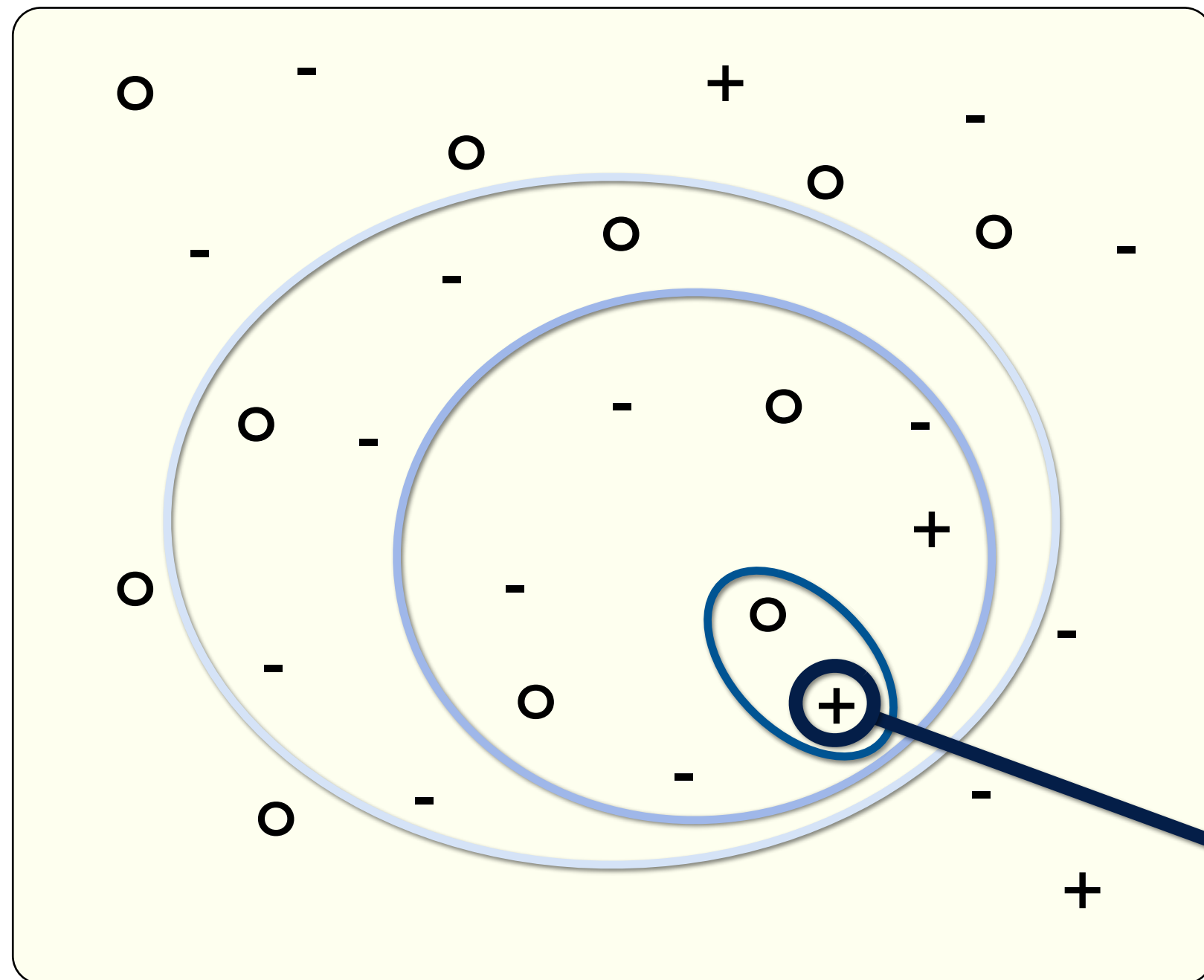
know

consider

propose

METAPHOR

Design Space



know

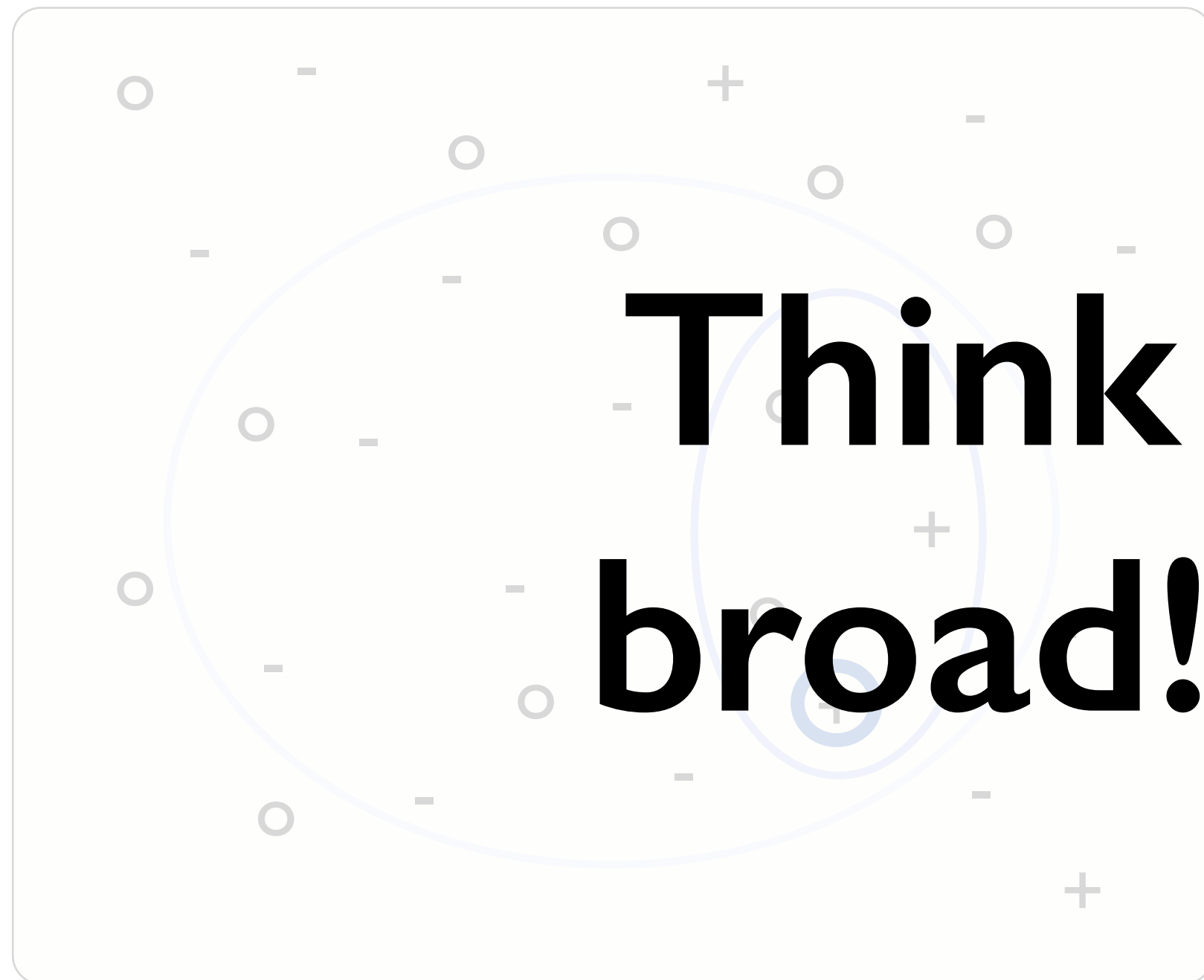
consider

propose

select

METAPHOR

Design Space



+ good
o okay
- poor

consider

propose

select

Design study methodology: 32 pitfalls

PF-21	mistaking technique-driven for problem-driven work	design
PF-22	nonrapid prototyping	implement
PF-23	usability: too little / too much	implement
PF-24	premature end: insufficient deploy time built into schedule	deploy
PF-25	usage study not case study: non-real task/data/user	deploy
PF-26	<i>liking</i> necessary but not sufficient for validation	deploy
PF-27	failing to improve guidelines: confirm, refine, reject, propose	reflect
PF-28	insufficient writing time built into schedule	write
PF-29	no technique contribution \neq good design study	write
PF-30	too much domain background in paper	write
PF-31	story told chronologically vs. focus on final results	write
PF-32	premature end: win race vs. practice music for debut	write

PITFALL

**PREMATURE
PUBLISHING**

I can write a design study **paper**
in a week!



“writing is research”

[Wolcott: Writing up qualitative research, 2009]

METAPHOR

Horse Race vs. Music Debut

Must be first!



technique-driven

Am I ready?

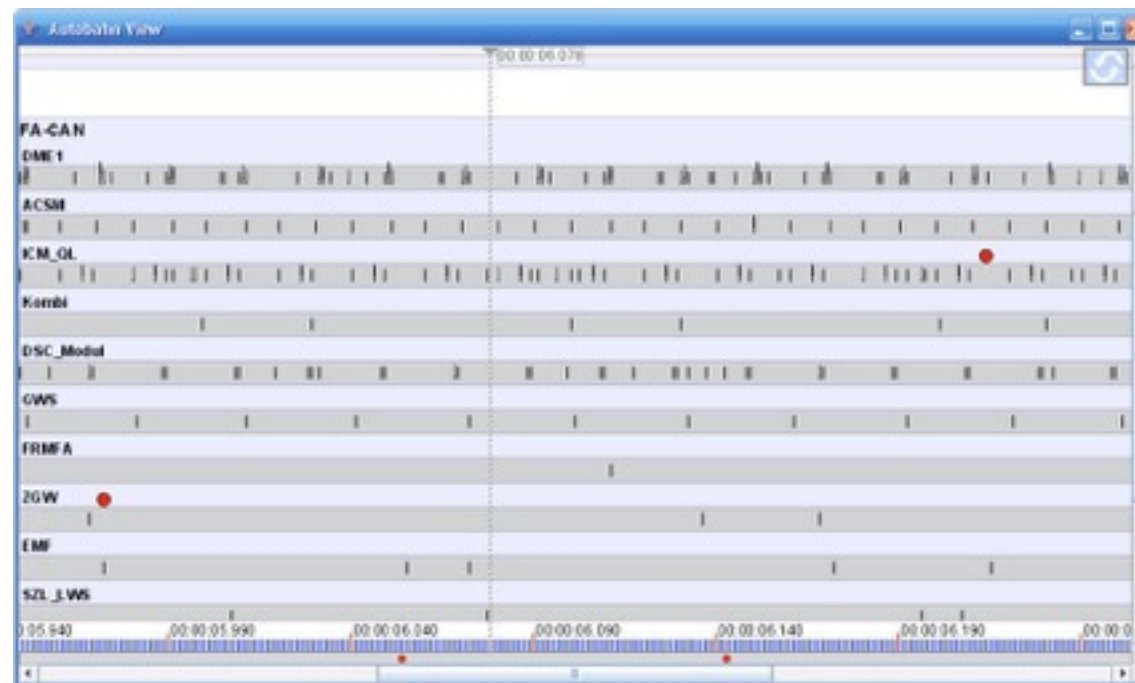


problem-driven

EXAMPLE FROM THE TRENCHES

Don't step on your own toes!

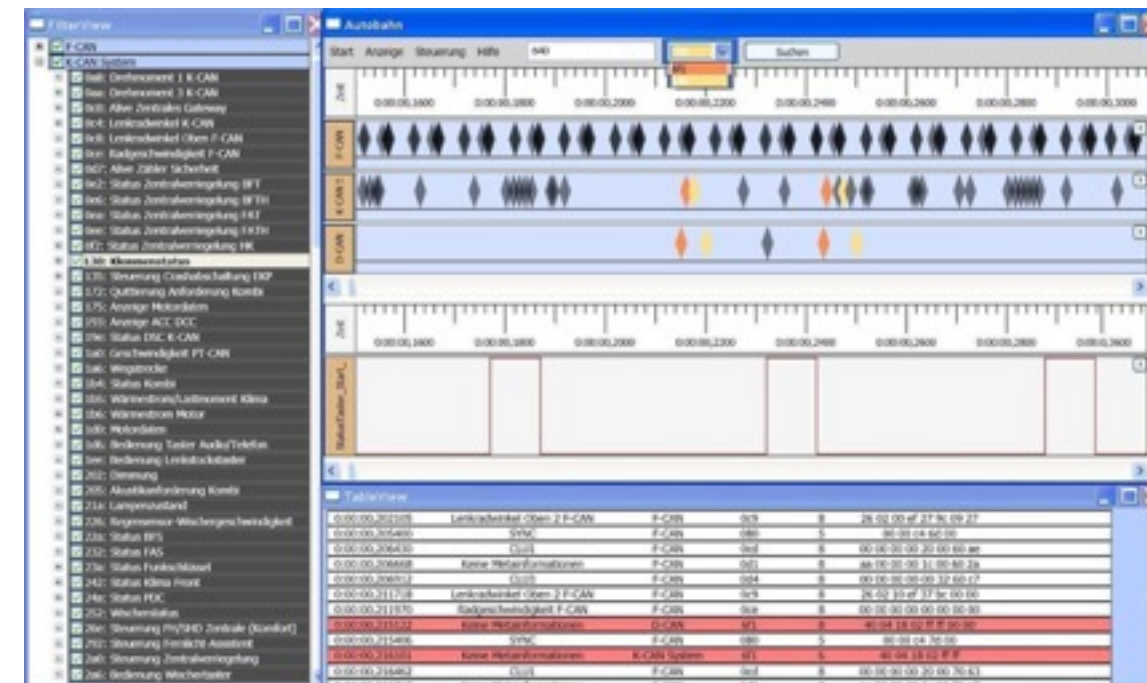
First design round published



AutobahnVis 1.0

[Sedlmair et al., Smart Graphics, 2009]

Subsequent work not stand-alone paper



AutobahnVis 2.0

[Sedlmair et al., Information Visualization 10(3), 2011]

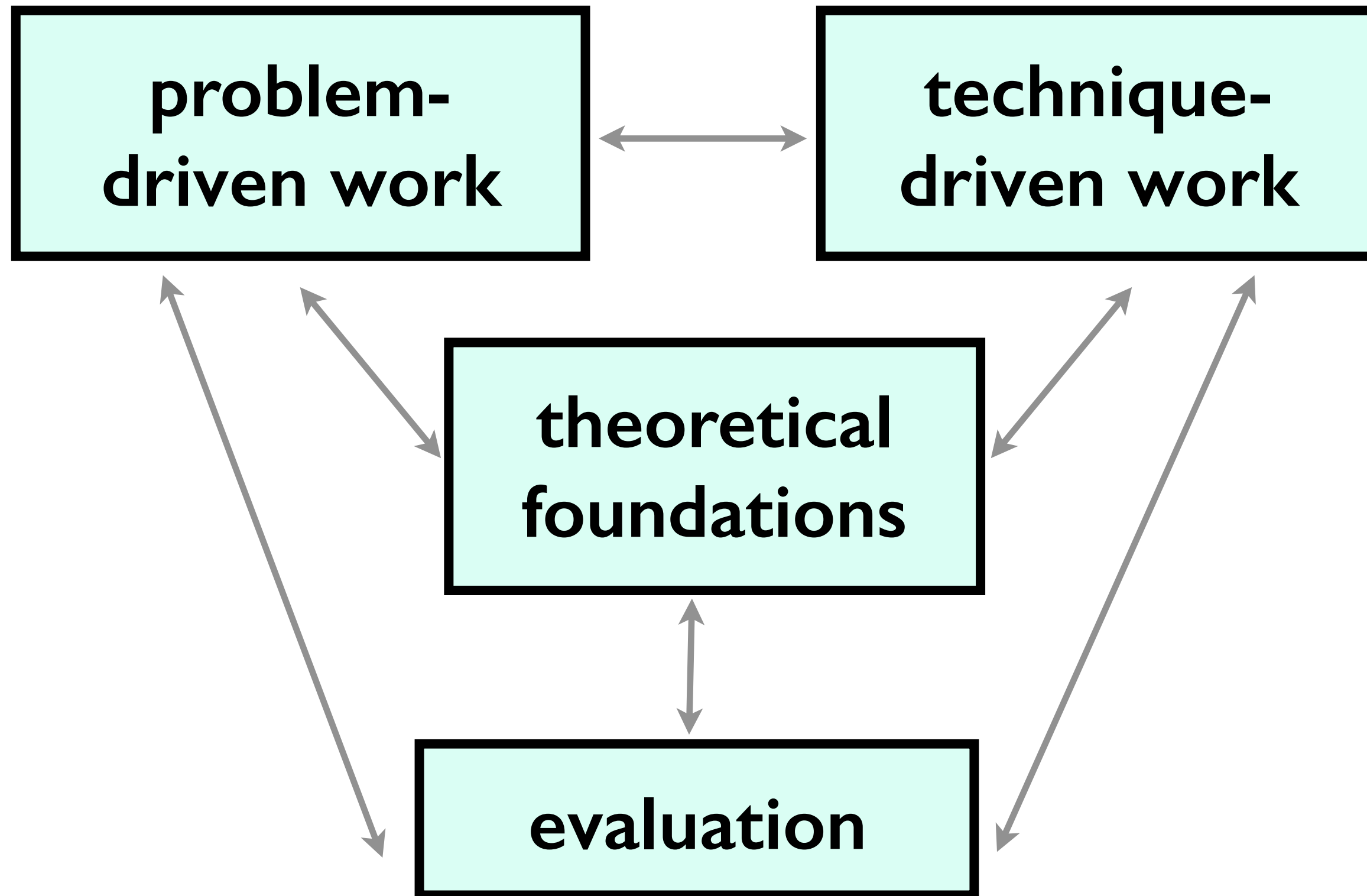
Reflections from the stacks: Wholesale adoption inappropriate

- ethnography
 - rapid, goal-directed fieldwork
- grounded theory
 - not empty slate: vis background is key
- action research
 - aligned
 - intervention as goal
 - transferability not reproducibility
 - personal involvement is key
 - opposition
 - translation of participant concepts into visualization language
 - researcher lead not facilitate design
 - orthogonal to vis concerns: participants as writers, adversarial to status quo, postmodernity



Angles of attack: My own work

Angles of attack

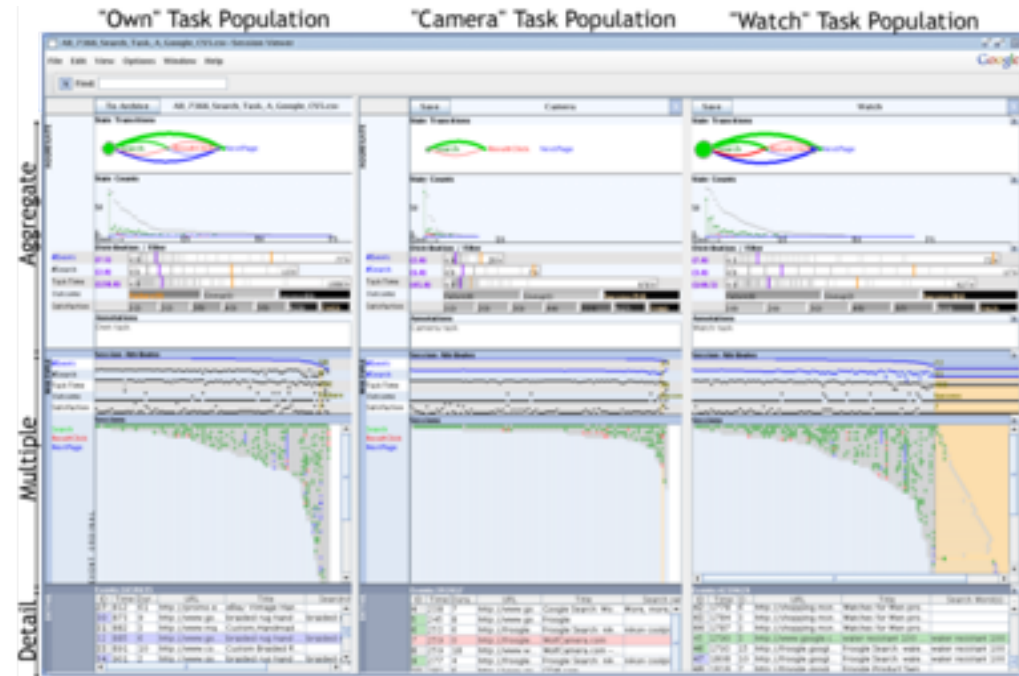


Problem-driven work

- design studies
 - in collaboration with target users
 - real data, real tasks
 - intensive requirements analysis
 - iterative refinement
 - deploy tools/systems
 - typical evaluation: case studies, field studies
- my strategy: opportunistic collaboration
 - many domains
 - both industrial and academic partners

Problem-driven: Tech industry

T F P
F
E



Heidi Lam



Diane Tang
(Google)



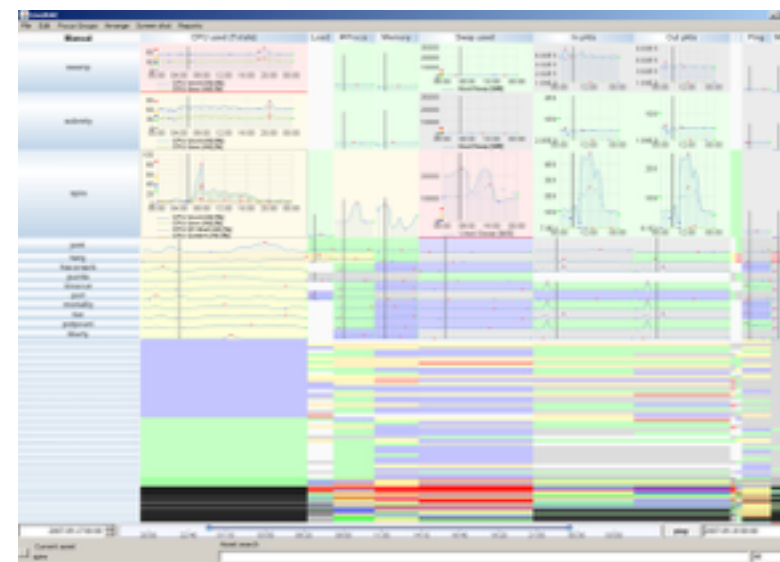
SessionViewer: web log analysis

<https://youtu.be/T4MaTZd56G4>

Peter McLachlan



Stephen North
(AT&T Research)

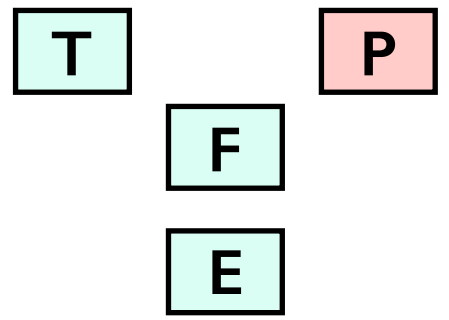


LiveRAC: systems time-series logs

<https://youtu.be/ld0c3H0VSkw>

methods reflection:
staged model of access
to target users

Problem-driven: Energy, sustainability



Matt Brehmer

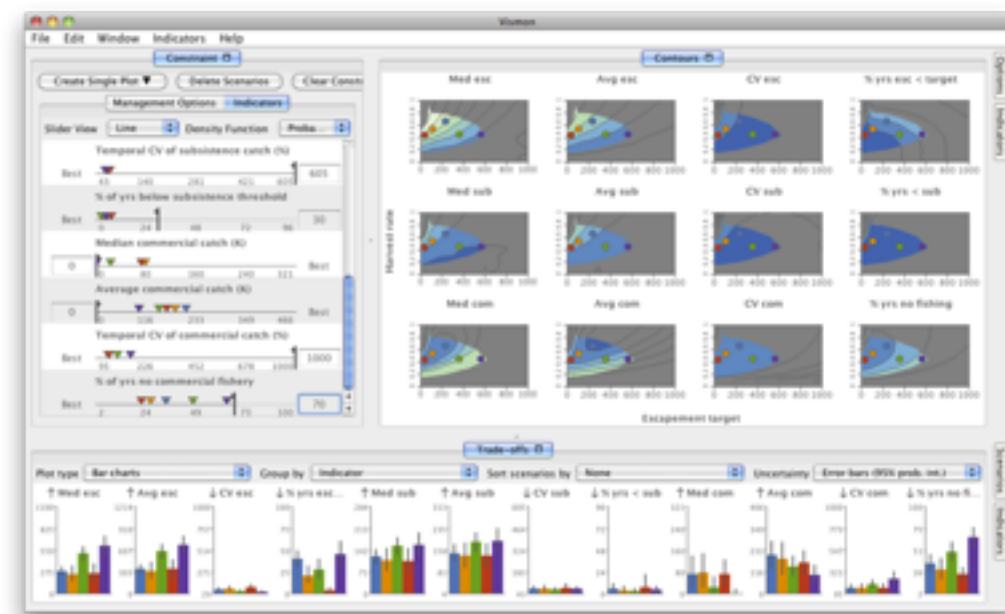


Kevin Tate
(Pulse/EnerNOC)



redesign success: industrial
swdev resources committed

Energy Manager



Maryam Booshehrian



Torsten Moeller (SFU)



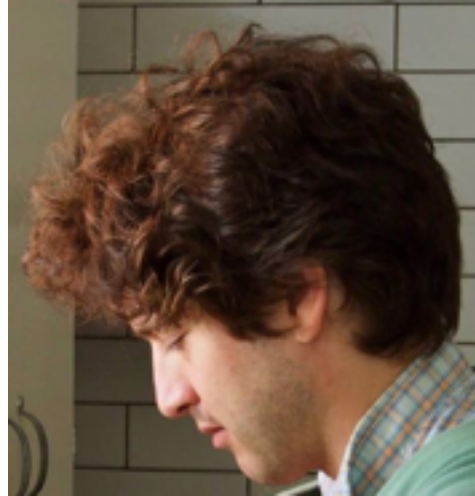
Vismon

<https://youtu.be/h0kHoS4VYmk>

Problem-driven: Genomics

T F E P

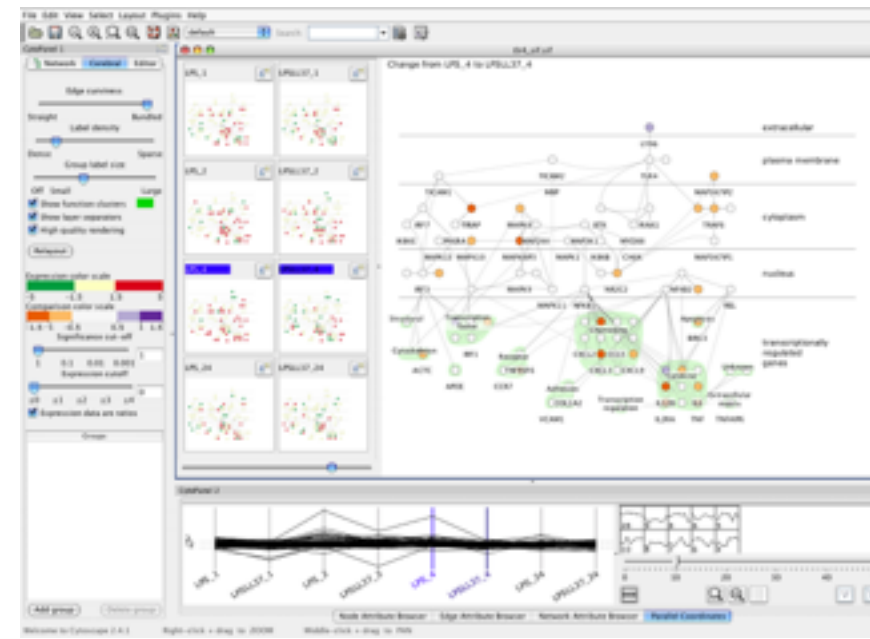
Aaron Barsky



Jenn Gardy
(UBC Micro)



Robert Kincaid
(Agilent)

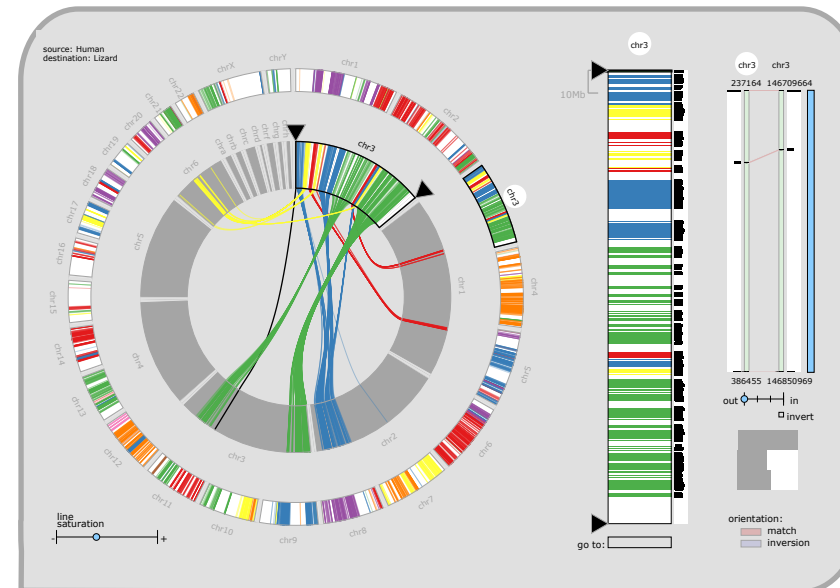


Cerebral
<https://youtu.be/76HhG1FQnql>

Miriah Meyer

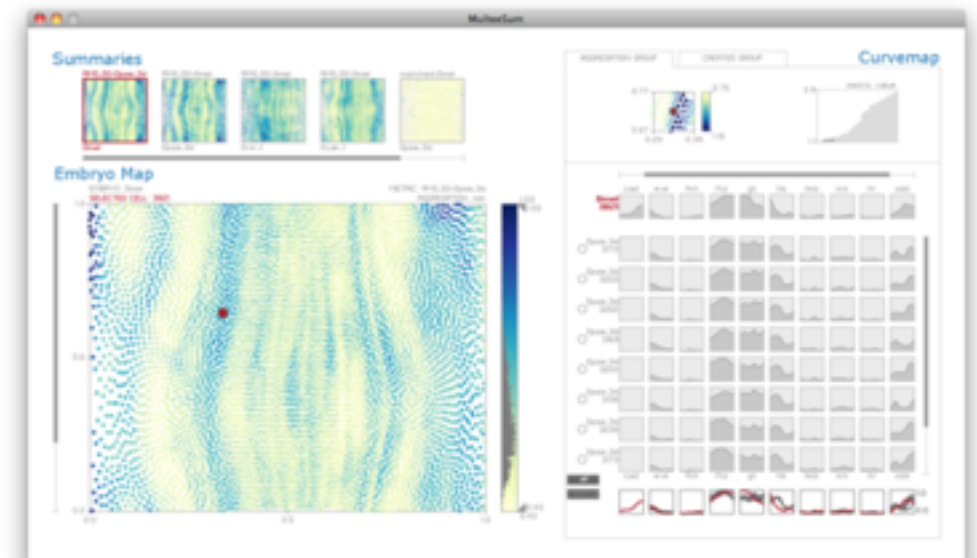


Hanspeter Pfister
(Harvard)



MizBee

<https://youtu.be/86p7brwuz2g>



MulteeSum, Pathline

Problem-driven: Genomics, journalism

T

P

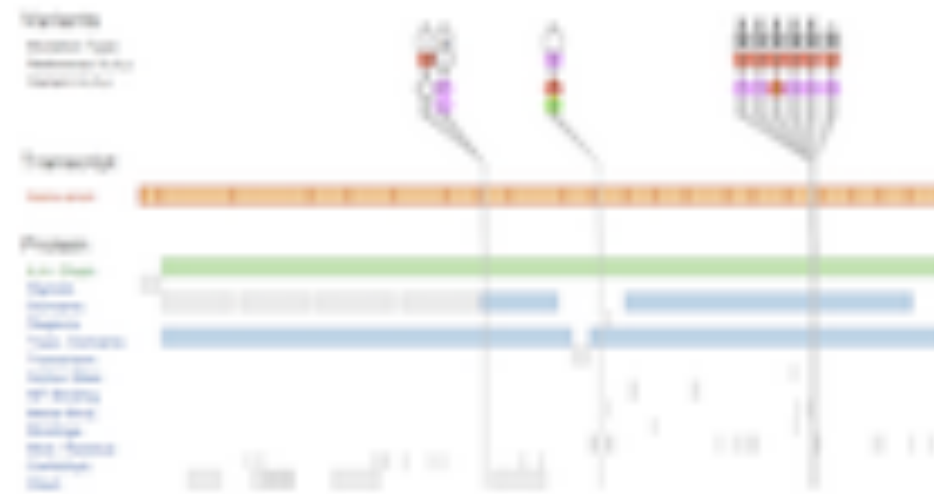
F

E

Joel Ferstay



Cydney Nielsen
(BC Cancer)



Variant View

https://youtu.be/AHDnv_qMXxQ

Jonathan Stray
(Assoc Press)

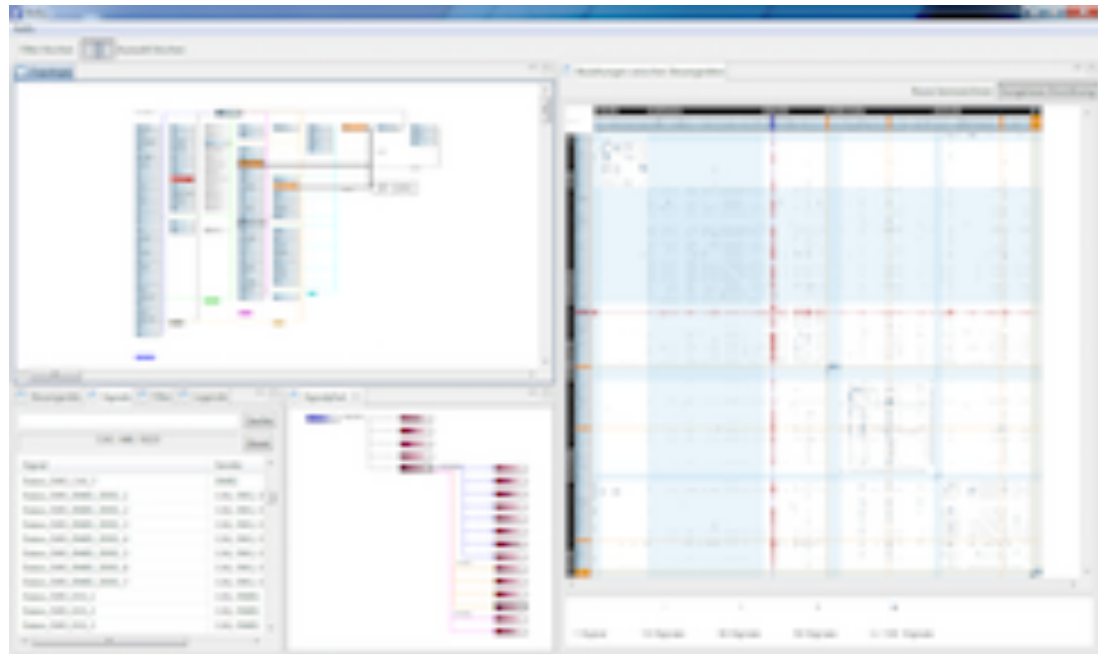


Overview

<https://vimeo.com/71483614>

Problem-driven: Autos, e-commerce

T F P
F
E



Michael Sedlmair



RelEx (BMW)

<https://youtu.be/89lsQXc6Ao4>

current work:

Mobify clickstream collaboration

Kimberly Dextras-Romagnino





Matthew Brehmer
@mattbrehmer



Stephen Ingram
@FroweFace



Overview

The Design, Adoption, and Analysis of a Visual Document Mining Tool For Investigative Journalists

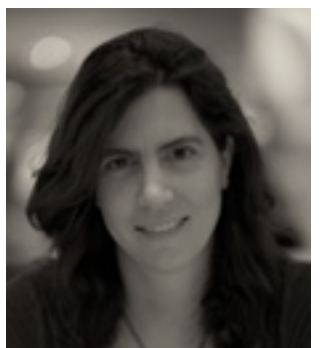
<http://www.cs.ubc.ca/labs/imager/tr/2014/Overview/>

<https://www.overviewdocs.com>

Jonathan Stray
@jonathanstray



Tamara Munzner
@tamaramunzner



Overview: The Design, Adoption, and Analysis of a Visual Document Mining Tool For Investigative Journalists. Brehmer, Ingram, Stray, and, Munzner. *IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2014)*, 20(12):2271-2280, 2014.

From design

Case Study

#1

Document
Collection

4,500 pages
from FOIA

Question

*What did
security
contractors
do during
Iraq war?*

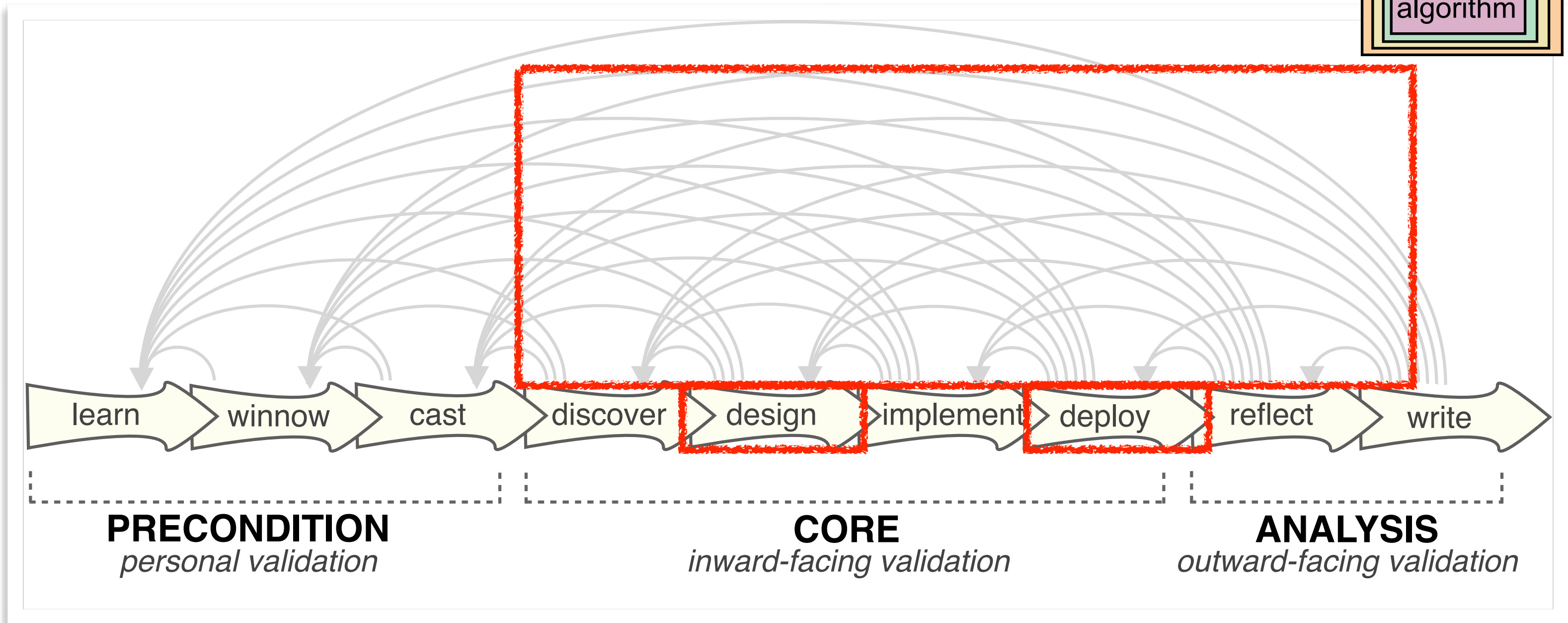
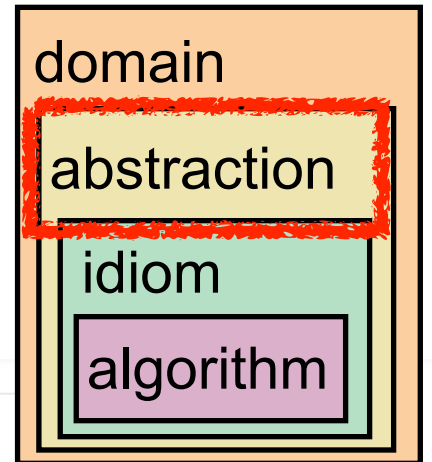
From design, to deploy, ...

Case Study	#1	#2	#3	#4	#5	#6
Document Collection	4,500 pages from FOIA	5,996 emails from FOIA	8,680 pages from FOIA	1,278 survey comments	4,653 emails from FOIA	1,680 bills
Question	<i>What did security contractors do during Iraq war?</i>	<i>Were municipal police funds mismanaged?</i>	<i>Were Paul Ryan's campaign statements hypocritical?</i>	<i>What is the gun ownership debate about?</i>	<i>Was gov't response to emergency incident effective?</i>	<i>Did gov't fail to pass bills addressing police misconduct?</i>

... to redesign, to reflect on task abstractions...

Case Study	#1	#2	#3	#4	#5	#6
Document Collection	4,500 pages from FOIA	5,996 emails from FOIA	8,680 pages from FOIA	1,278 survey comments	4,653 emails from FOIA	1,680 bills
Question	<i>What did security contractors do during Iraq war?</i>	<i>Were municipal police funds mismanaged?</i> find the needle in the haystack	<i>Were Paul Ryan's campaign statements hypocritical?</i>	<i>What is the gun ownership debate about?</i>	<i>Was gov't response to emergency incident effective?</i>	<i>Did gov't fail to pass bills addressing police misconduct?</i> prove haystack contains no needles!

... to achieve adoption (after iteration)



Technique-driven work

- **scalable algorithms & systems**
 - typical evaluation: computational benchmarks
- **new layout & interaction idioms**
 - typical evaluation: usage scenarios
 - typical evaluation/characterization: controlled experiments on human subjects

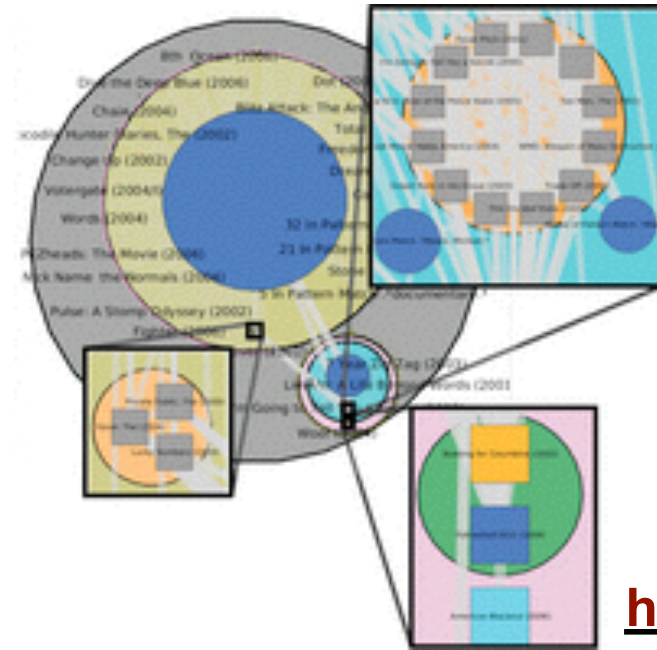
Technique-driven: Graph drawing

T F P
F E

Daniel Archambault

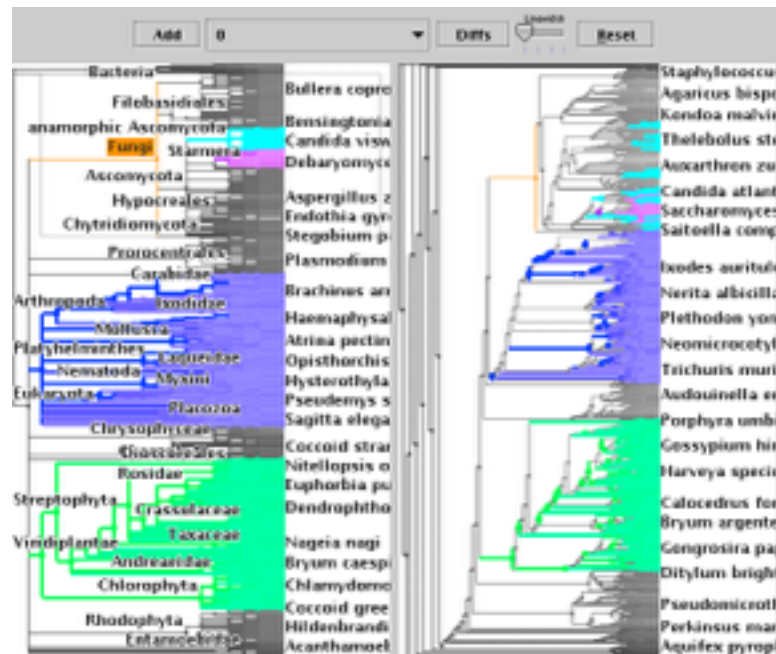


David Auber
(Bordeaux)



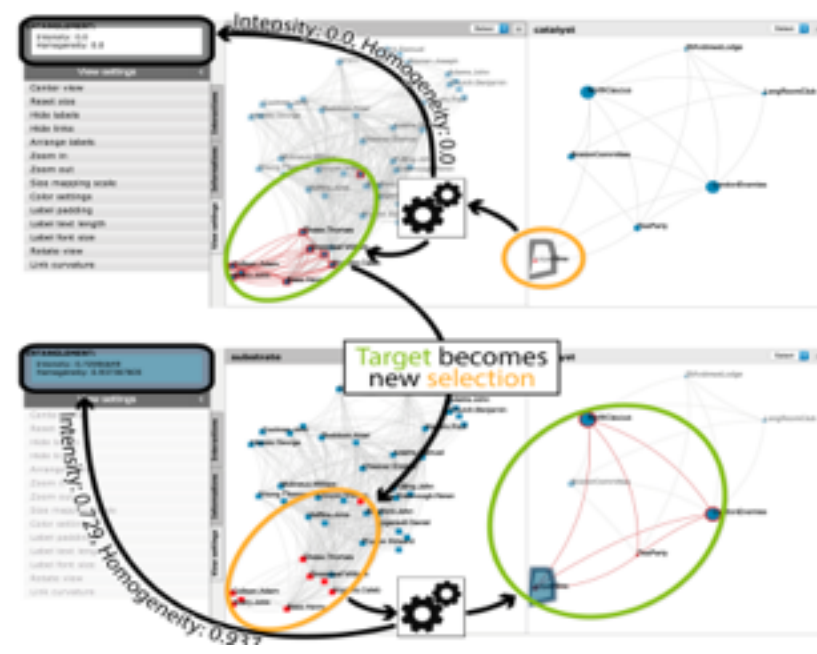
TopoLayout
SPF
Grouse
GrouseFlocks
TugGraph

<https://youtu.be/AWXAe8zvkt8>



TreeJuxtaposer

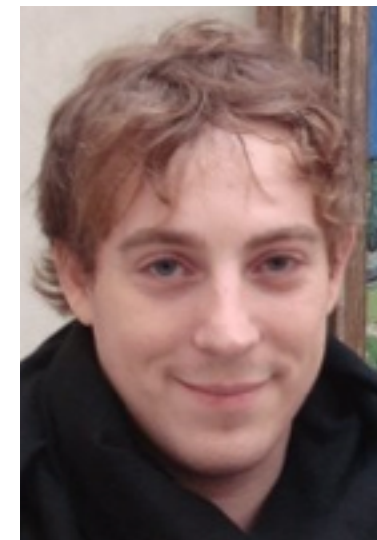
<https://youtu.be/GdaPj8a9QEO>



Detangler

<https://youtu.be/QOtnHSsUV6k>

Benjamin Renoust



Guy Melançon
(Bordeaux)



Evaluation experiments: Graph drawing

T F P
E

Dmitry Nekrasovski Adam Bodnar



Joanna McGrenere



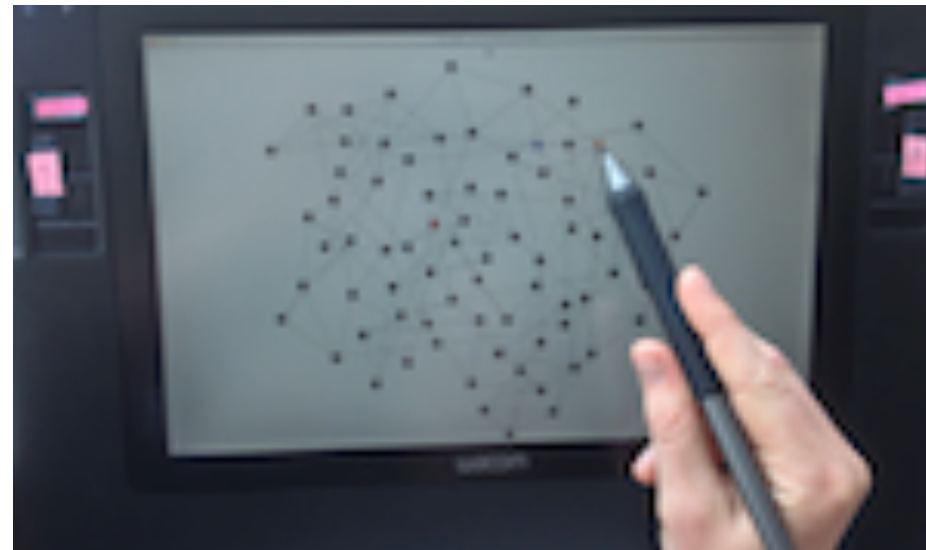
Stretch and squish navigation

outcome:
increasingly
disenchanted with
“focus+context”
idioms

Jessica Dawson



Joanna McGrenere



Search set model of path tracing

- 1 qualitative study: coding observational video
- 2 create & implement behavioral model
- 3 multiple regression to untangle factor relationships

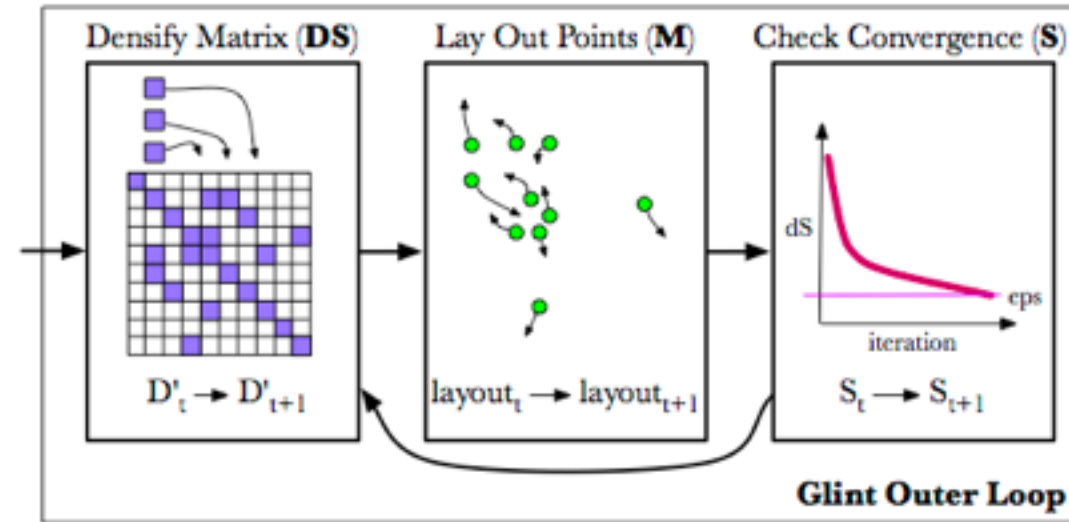
Technique-driven: Dimensionality reduction

T F E P

Stephen Ingram



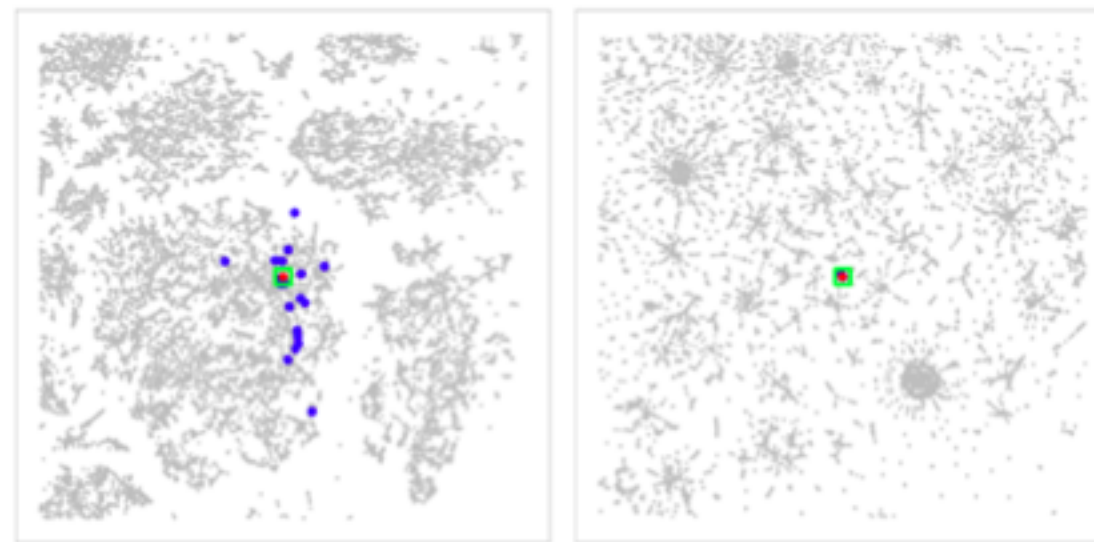
Glimmer



Glint



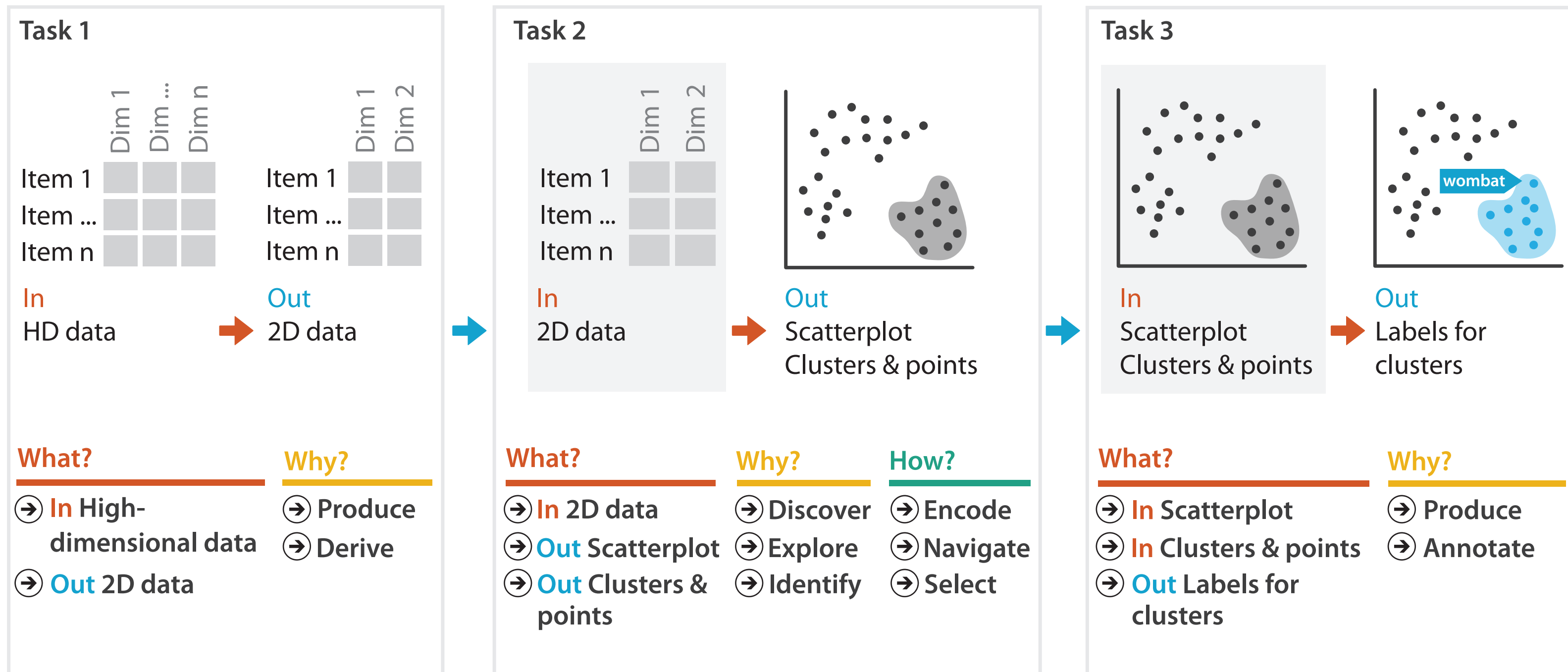
DimStiller



QSNE

Dimensionality reduction for documents

- derive low-dimensional target space from high-dimensional measured space



Evaluation experiments: Dimensionality reduction

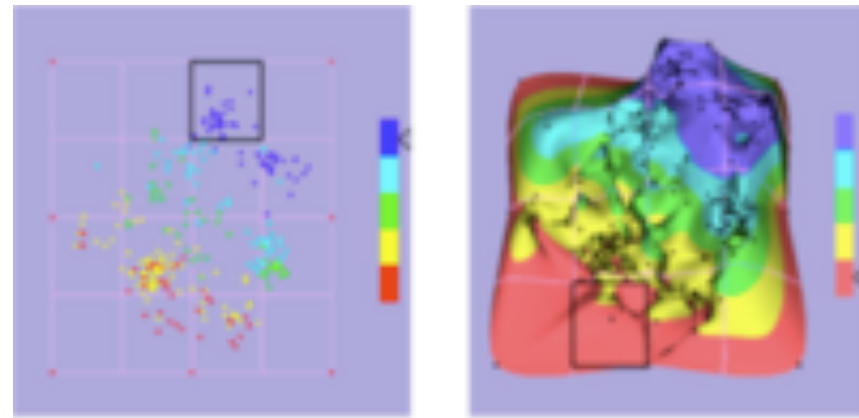
T

P

F

E

Melanie Tory



Points vs landscapes for dimensionally reduced data

traditional user study:
many people for short time,
few datasets

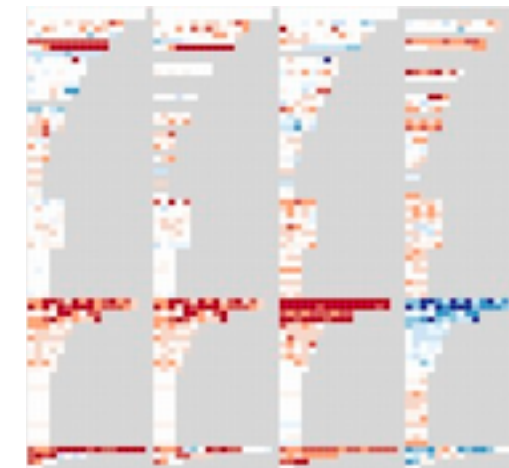
data studies: many datasets, few people for
long time (experts qual+quant coding)

Michael Sedlmair

Melanie Tory



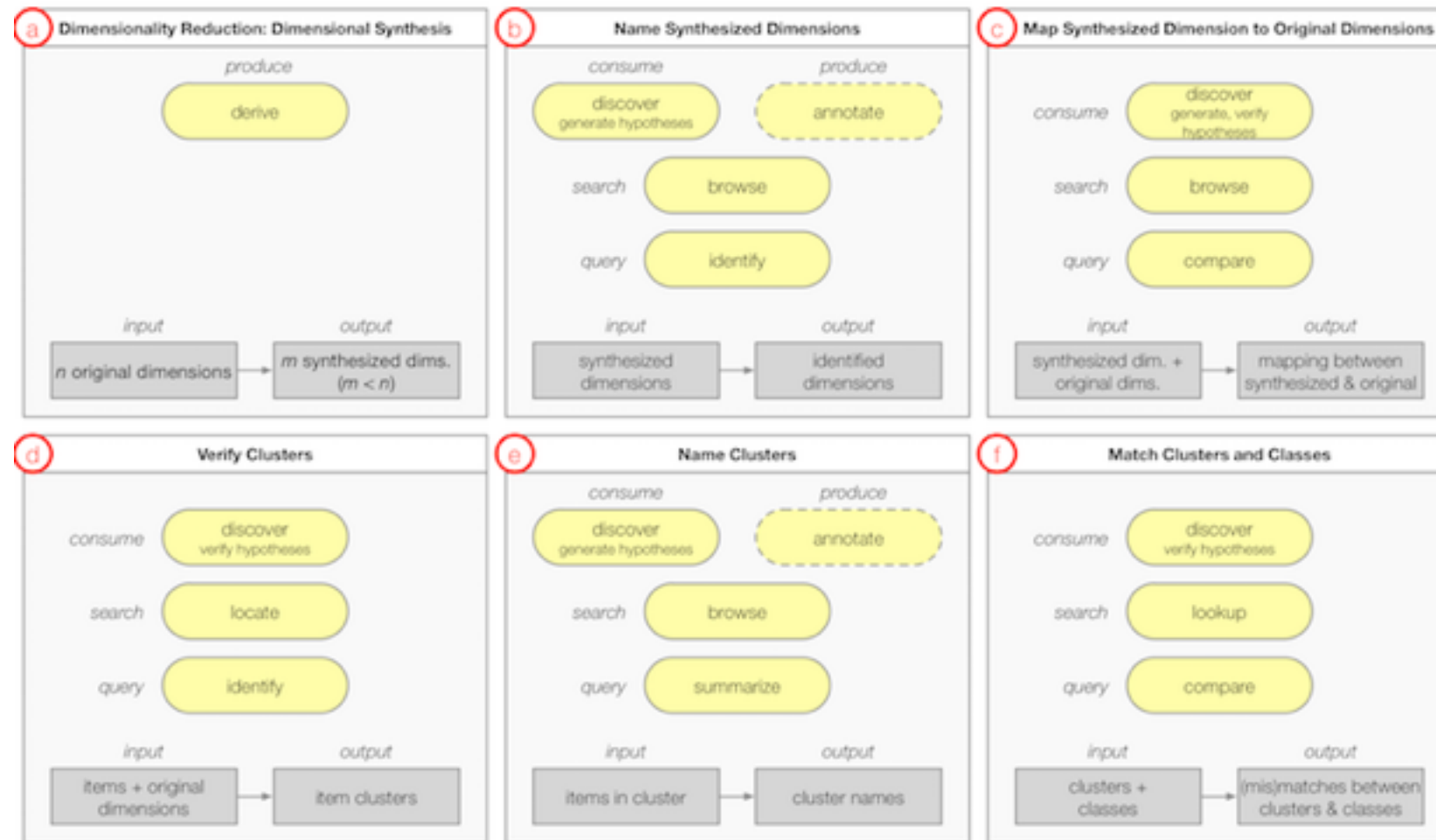
Taxonomy of cluster separation factors



Guidance on DR & scatterplot choices

Evaluation in the field: Dimensionality reduction

T
F
E
P



DR in the Wild

interview study & qualitative coding led to task abstractions: specific to data type, agnostic to domain

Matt Brehmer



Michael Sedlmair



Melanie Tory



Stephen Ingram



Curation & Presentation: Timelines

T F E P



Matt Brehmer

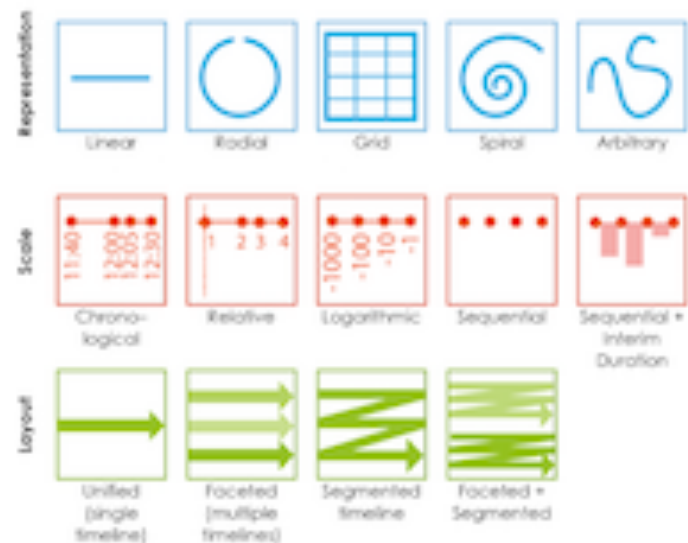


Johanna Fulda
(Sud. Zeitung)



TimeLineCurator

<https://vimeo.com/123246662>



Matt Brehmer



Bongshin Lee
(Microsoft)



Benjamin Bach
(Microsoft)



Nathalie Henry-Riche
(Microsoft)



Timelines Revisited

timelinesrevisited.github.io/



Johanna Fulda
@jofu_



Matthew Brehmer
@mattbrehmer



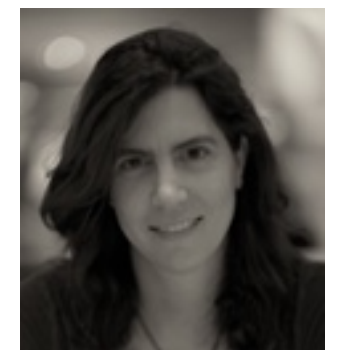
TimeLineCurator

Interactive Authoring of Visual Timelines from Unstructured Text

<http://about.timelinecurator.org>

<http://timelinecurator.org>

Tamara Munzner
@tamaramunzner



TimeLineCurator: Interactive Authoring of Visual Timelines from Unstructured Text.
Fulda, Brehmer, Munzner. *IEEE Trans. Visualization and Computer Graphics (Proc IEEE VAST 2015)* 22(1):300-309, 2015.

TimeLineCurator

visual & browser-based

<https://vimeo.com/jofu/tlc>

Manual creation process



Mighty Mouse
In 1980, Apple Computer asked a group of guys fresh from Stanford's product design program to take a \$400 device and make it mass-producible, reliable and cheap.
Their work transformed personal computing.
By Alex Seung Kim-Pang
Dean Hovey was hungry. His young industrial design firm, Hovey-Kelly Design, had been working on projects for Apple Computer for a couple of years but wanted to develop entire products, not just casings and keyboards. Hovey had come to pitch Apple co-founder Steven Jobs some ideas. But before he could get started, the legendary high-tech pioneer interrupted him. "Stop, Steve," Hovey recalls Jobs saying. "What you guys need to do, what we need to do together, is build a mouse."
Hovey was dumbfounded. A what? Jobs told him about an amazing computer, code-named Alto, he had just seen at Xerox's Palo Alto Research Center (PARC). In early 1980, most computers (including Apple's) required users to memorize text commands to perform tasks. The Alto had a graphical user interface—a symbolic world with little pictures of folders, documents and other icons—that users navigated with a handheld input device called a mouse. Jobs explained that Apple was working on two computers, named Lisa and Macintosh, that would bring that technology to market. The mouse would help revolutionize computers, making them more accessible to ordinary people. "When I walked out that door," recalls Hovey, "I was ready to change the world."
Just one problem: a commercial mouse based on the Xerox technology cost \$400, malfunctioned regularly and was nearly impossible to clean. That device—a descendant of the original computer mouse invented by Douglas Engelbart at the Stanford Research Institute in the early 1960s—was a masterpiece of high-concept technology, but a hopeless product. Jobs wanted a mouse that could be mass-produced for \$12 to \$25, survive everyday use and work on his terms. "We

1868 The Typewriter
Invented by Christopher Sholes, typewriters quickly became indispensable tools for practically all writing other than personal correspondence. They were widely used by professional writers, in offices, and for business correspondence in private homes.
we only have 2 columns for this piece
Why is there such a big gap that wastes white space and we only have 2 columns

1897 The Mouse
Some additional information here
can we not have as much white space here?

1977 The Mouse
was there anything else happening in the time between Mouse and Stylus?!

1986 The Mouse
Some additional information here

1997 The Stylus
a small pen-shaped instrument that is used to input commands to a computer screen, mobile device or graphics tablet

2007 Multi Touch
With the start of iPhones Multi-touch became a thing
has to be mentioned here, since it's the new shit

2012 Speech Recognition
3D Touch

Handwritten notes on lined paper:
Christopher Sholes
1868
Type writer
"QUERY" Ch. 10
Douglas C. Engelbart '68
Mouse
+ One Button Computer
Stylus (1997)
Multi touch (2007)
Speech Recogn. (2012)

Structured creation process

















	A	B	C	D	E	F
	Start Date	End Date	Headline	Text	Media	Media Credit
1				Zuckerberg wrote a program called Facemash on October 28, 2003 while attending Harvard as a sophomore	http://dubindigital.ie/wp-content/uploads/2011/03/facemash-2003-2009.jpg	Dublin Digital
2	10/28/2003		Facemash	The following semester, Zuckerberg began writing code for a new website in January 2004		
3	1/1/2004		new website	On February 4, 2004, Zuckerberg launched "thefacebook", originally located at thefacebook.com		
4	2/4/2004		thefacebook.com	Six days after the site launched, three Harvard seniors (Cameron Winklevoss, Tyler Winklevoss, and Divya Narendra) accused Zuckerberg of intentionally misleading them into believing he would help them build a social network called HarvardConnection.com	http://www.capitoberg.com/wp-content/uploads/2011/05/3Harvard-wider.jpg	Capital Berg
5	2/10/2004		Harvard Connection accusations	They later filed a lawsuit against Zuckerberg, subsequently settling in 2008[17] for 1.2 million shares (worth \$300 million at Facebook's IPO)	http://4.bp.blogspot.com/_KMKs4_C0jys/YY5336_YFsi/AAAAAAAAAT8/bitao-c5Q3TAx26005.jpg	Estymese
6	1/1/2008	12/31/2008	Harvard Connection	Membership was initially restricted to students of Harvard College; within the first month, more than half the undergraduates at Harvard were registered on the service		
7	2/4/2004	3/4/2004	thefacebook at Harvard only	In March 2004, Facebook expanded to the universities of Columbia, Stanford, and Yale [20]		
8	3/1/2004	3/31/2004	thefacebook expands to other universities	In mid-2004, entrepreneur Sean Parker (an informal advisor to		

TimelineJS

timeline.knightlab.com/

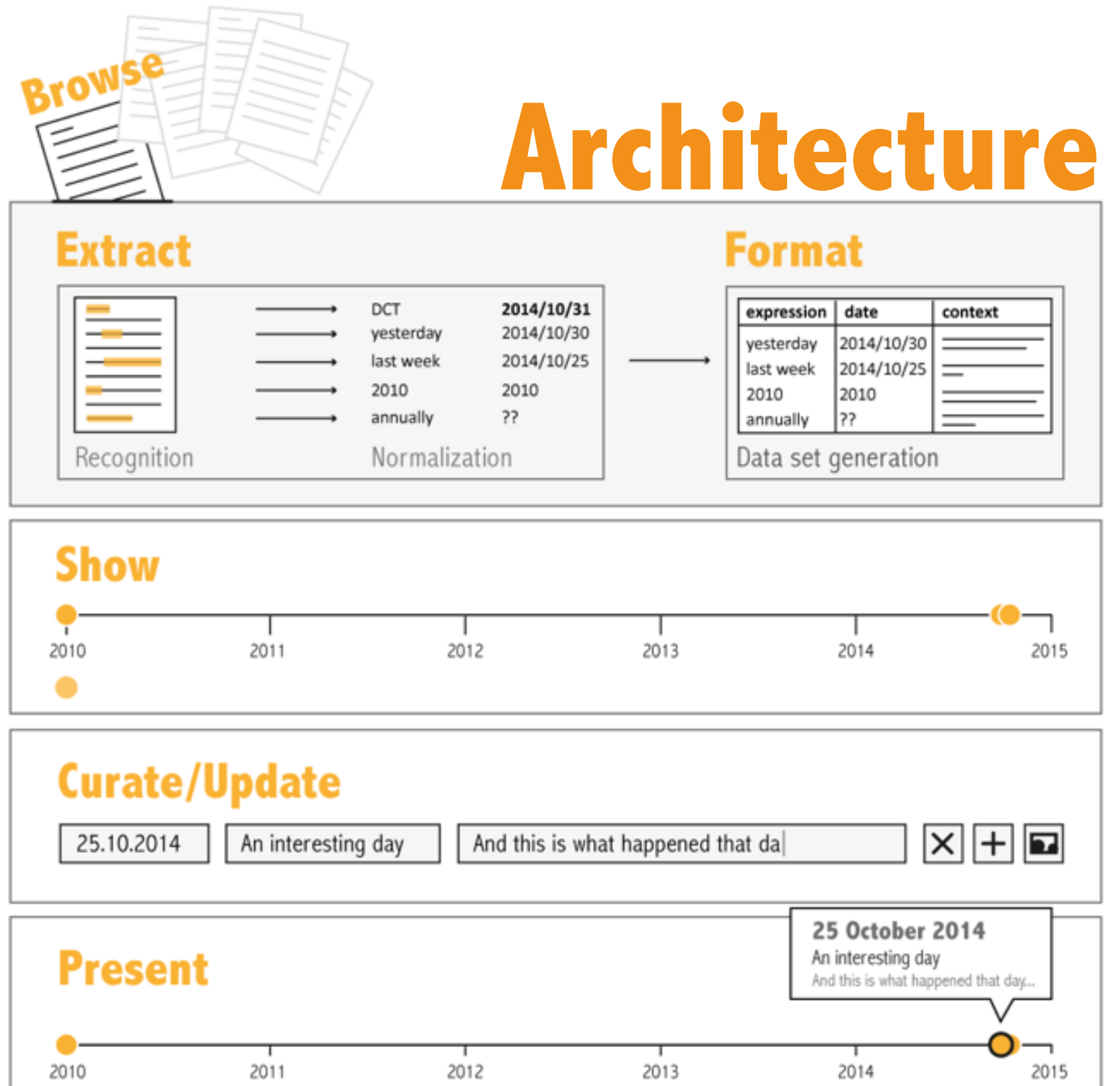
Timeline authoring model

- time required for each task

	Browse	Extract	Format	Show	Update
Manual Drawing	 slow	 slow		 slow	 slow
Structured Creation	 slow	 slow	 slow	 automated	 fast
TimeLine Curator	 fast	 automated	 automated	 fast	 fast

The general case for curation

- build for human in the loop as continuing need
 - automatic processing to accelerate not replace
 - assume computational results good but not perfect
 - for the indefinite future!
 - visual feedback to accelerate



The importance of being brisk

- sexy use case: eureka moment
 - success: enable what was impossible before
 - vis tools for new insights & discoveries
- workhorse use case: workflow speedup
 - success: vis tools accelerate your prior workflow
 - sometimes enables the previously infeasible
- TLC use cases
 - started with speedup use case, for presentation
 - make this doc into a timeline now!
 - two other use cases nudge towards exploration
 - comparison between multiple timelines
 - speculative browsing

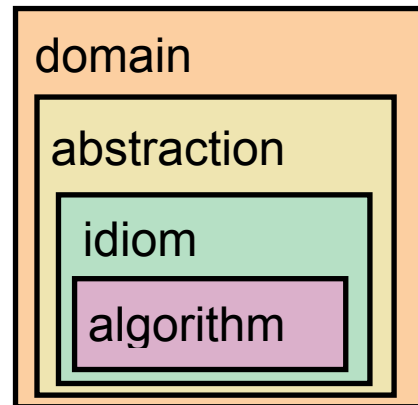


TimeLineCurator: Speculative Browsing

s p e c u l a t i v e b r o w s i n g

Theoretical foundations

T F E P



Nested Model



Design Study Methodology

Michael Sedlmair



Miriah Meyer

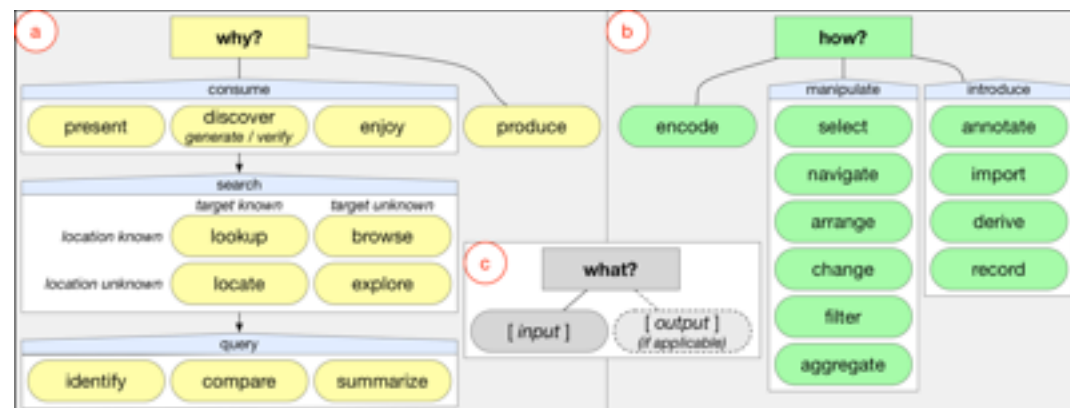


- Type Pitfalls
 - Design in Technician's Clothing
 - Application Bingo versus Design Study
 - All That Coding Means I Deserve A Systems Paper
 - Neither Fish Nor Fowl
- Visual Encoding Pitfalls
 - Unjustified Visual Encoding
 - Hammer In Search Of Nail
 - 2D Good, 3D Better
 - Color Catastrophes
- Results Pitfalls
 - Unfettered By Time
 - Fear and Loathing of Complexity
 - Spore Mat Comparison
 - Tiny Toy Datasets
 - But My Friends Liked It
 - Unjustified Tasks
- Writing Style Pitfalls
 - Deadly Detail Dump

Papers Process & Pitfalls

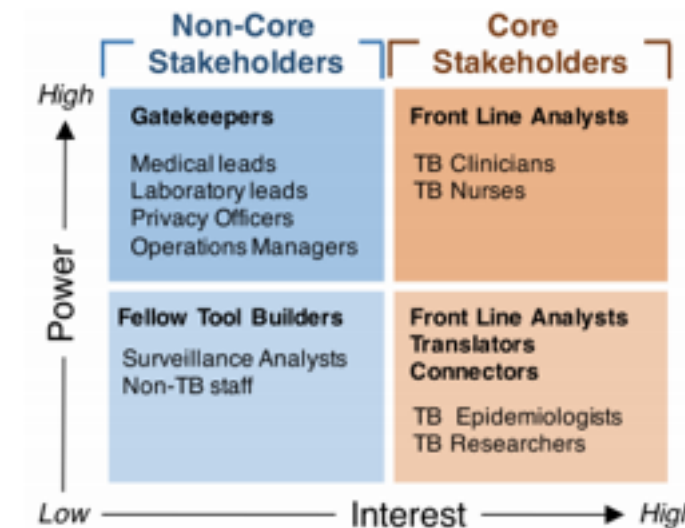
handling contexts where common methods considered harmful: hypothesis generation, agile development

Anamaria Crisan



Abstract Tasks

Matt Brehmer



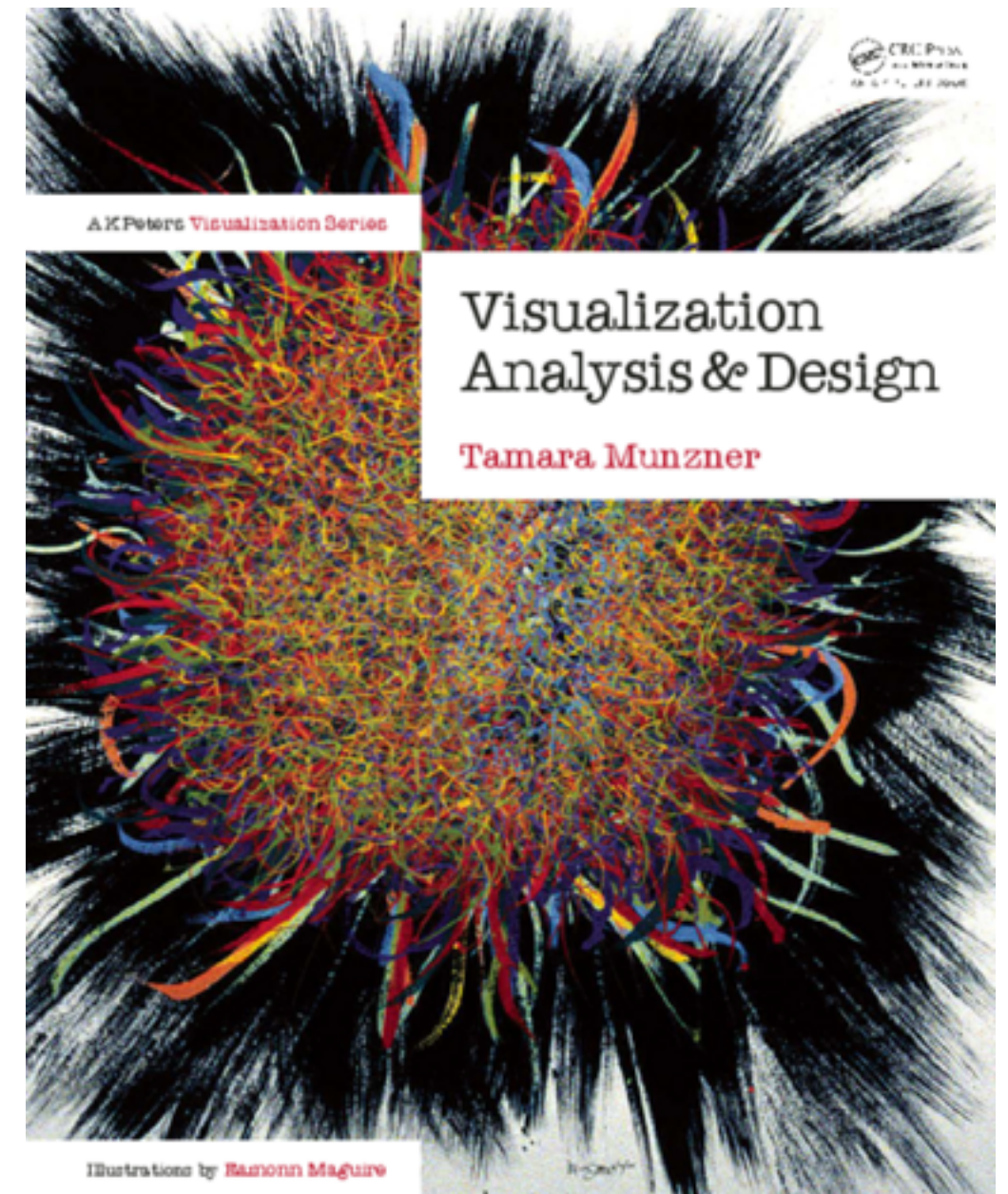
Regulatory & Organizational Constraints



More information

@tamaramunzner

- theoretical foundations: book
(+ free tutorial/course lecture slides)
<http://www.cs.ubc.ca/~tmm/vadbook>
 - 20% promo code for book+ebook combo:
HVN17
 - <http://www.crcpress.com/product/isbn/9781466508910>
- this talk
<http://www.cs.ubc.ca/~tmm/talks.html#ucsd17>
- papers, videos, software, talks, courses
<http://www.cs.ubc.ca/group/infovis>
<http://www.cs.ubc.ca/~tmm>



Visualization Analysis and Design.
Munzner. A K Peters Visualization Series, CRC Press, Visualization Series, 2014.