

# Visualization Task Abstraction from Multiple Perspectives

Matthew Brehmer  
VIS Doctoral Colloquium  
14 / 11 / 08



a place of mind  
THE UNIVERSITY OF BRITISH COLUMBIA

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# About Me



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[~2009]

B. Comp in **Cognitive Science**, Queen's University,  
UX design in industry

[2009–2011]

M.Sc in **Human-Computer Interaction**,  
University of British Columbia (UBC)



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[May 2014]

Defended thesis proposal

[Fall 2015]

Expected thesis defence

# Evolution of Research Question

[2011]

How could we better **evaluate** visualization systems  
beyond time and error?



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[2012]

Evaluation and tasks: can we have a better understanding of user **tasks** across domains?

# Evolution of Research Question

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How could we better ***evaluate*** visualization systems beyond time and error?

[2012]

Evaluation and tasks: can we have a better understanding of user ***tasks*** across domains?

[2013++]

Can this abstract ***analysis*** of tasks help with visualization ***design*** and ***evaluation***?



## What is a **Task**?

An event in which an **actor** attempts to accomplish some **ends** by some **means**, given some **constraints**.



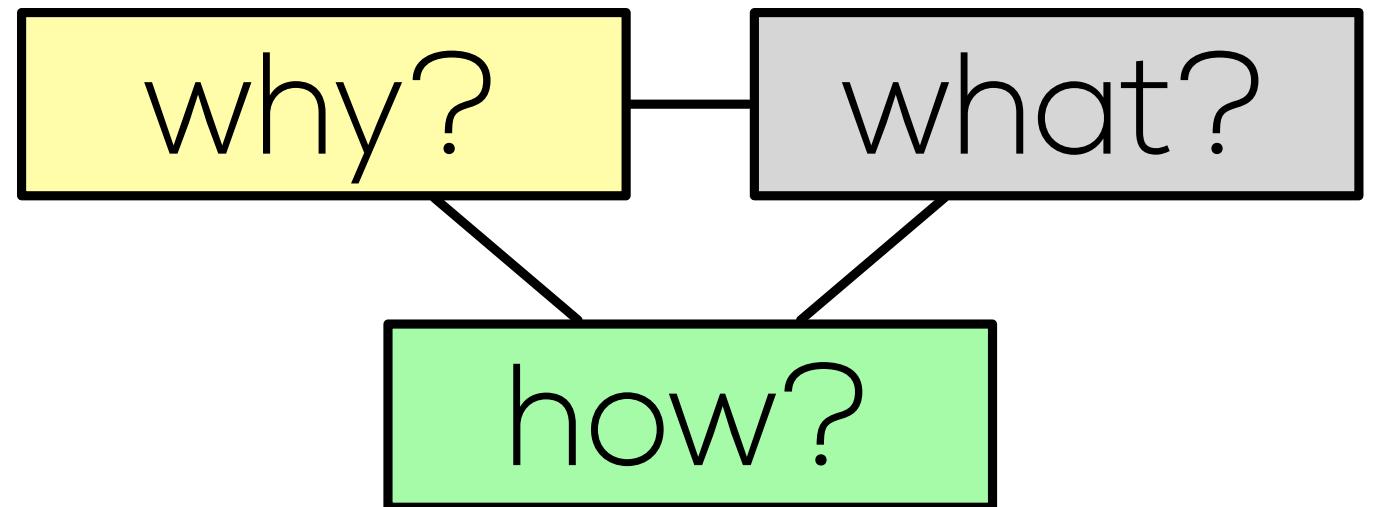
# Characterizing visualization **Tasks**

**Why** is a task being performed?

**What** are the inputs and outputs?

**How** is a task supported?

Characterizing **sequences**  
of interdependent tasks.



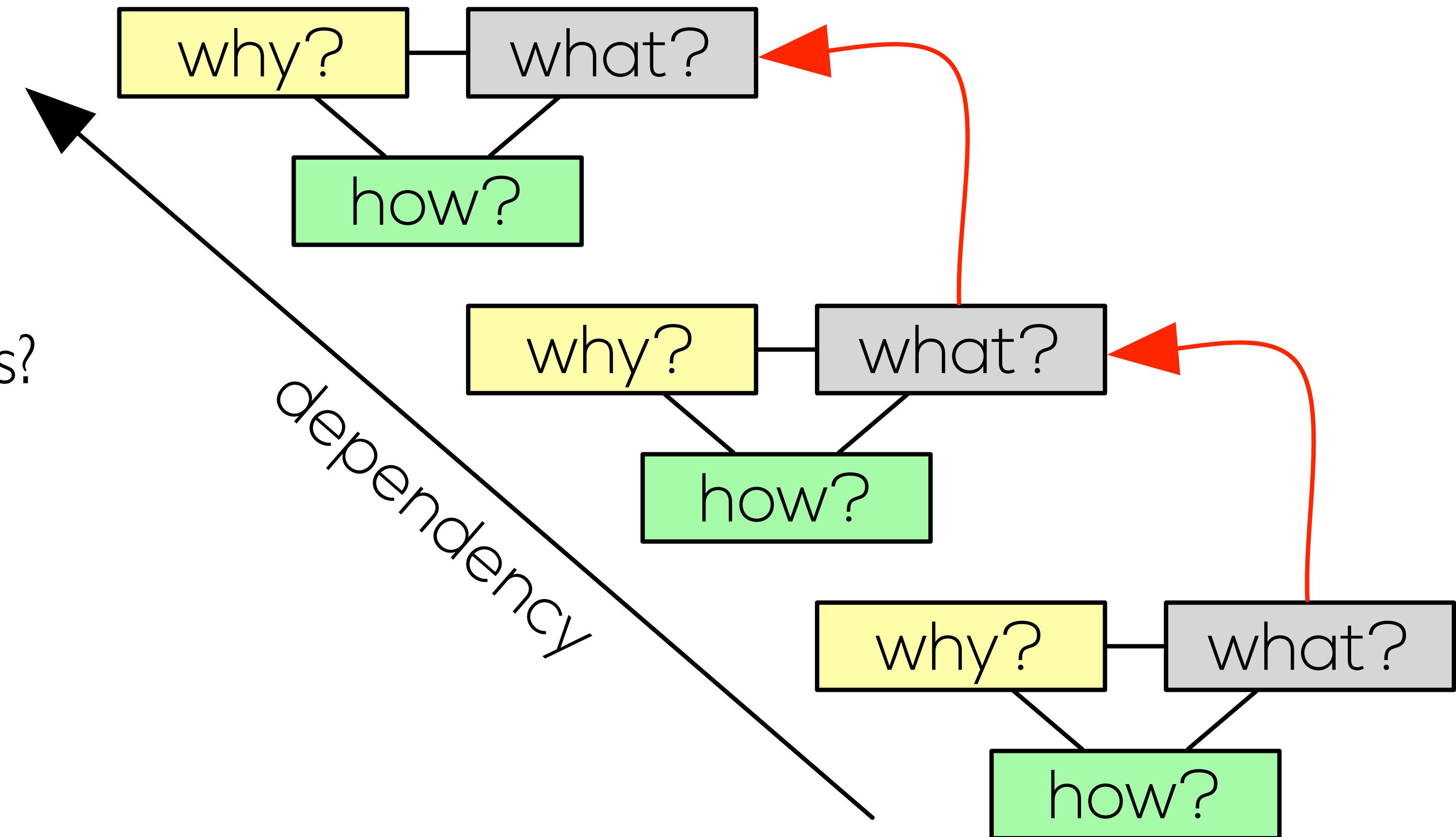
# Characterizing visualization Tasks

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# Characterizing visualization **Tasks**

**Why** is a task being performed?

**What** are the inputs and outputs?

**How** is a task supported?

Characterizing **sequences** of interdependent tasks.

## **Thesis statement:**

this form of task abstraction will facilitate visualization **analysis, design, and evaluation.**



# Four Perspectives



# Four Perspectives



*Synthesis:*  
**A Multi-Level Typology of Abstract Visualization Tasks**

presented at IEEE InfoVis '13

# Four Perspectives



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*Field Study:*  
**Use of typology to Evaluate an existing system**

to appear in IEEE InfoVis '14

# Four Perspectives



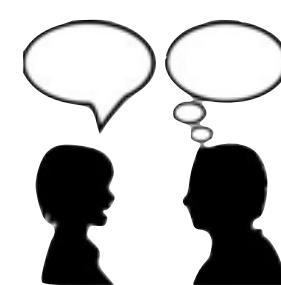
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**Use of typology to Analyze behaviour across multiple domains**

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# Four Perspectives



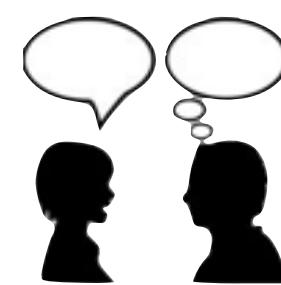
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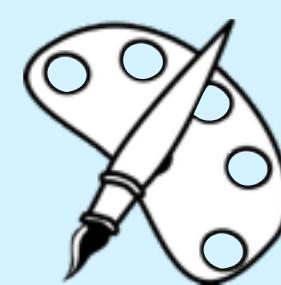
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*Design Study:*  
**Use of typology in requirements analysis for Design**

work in progress



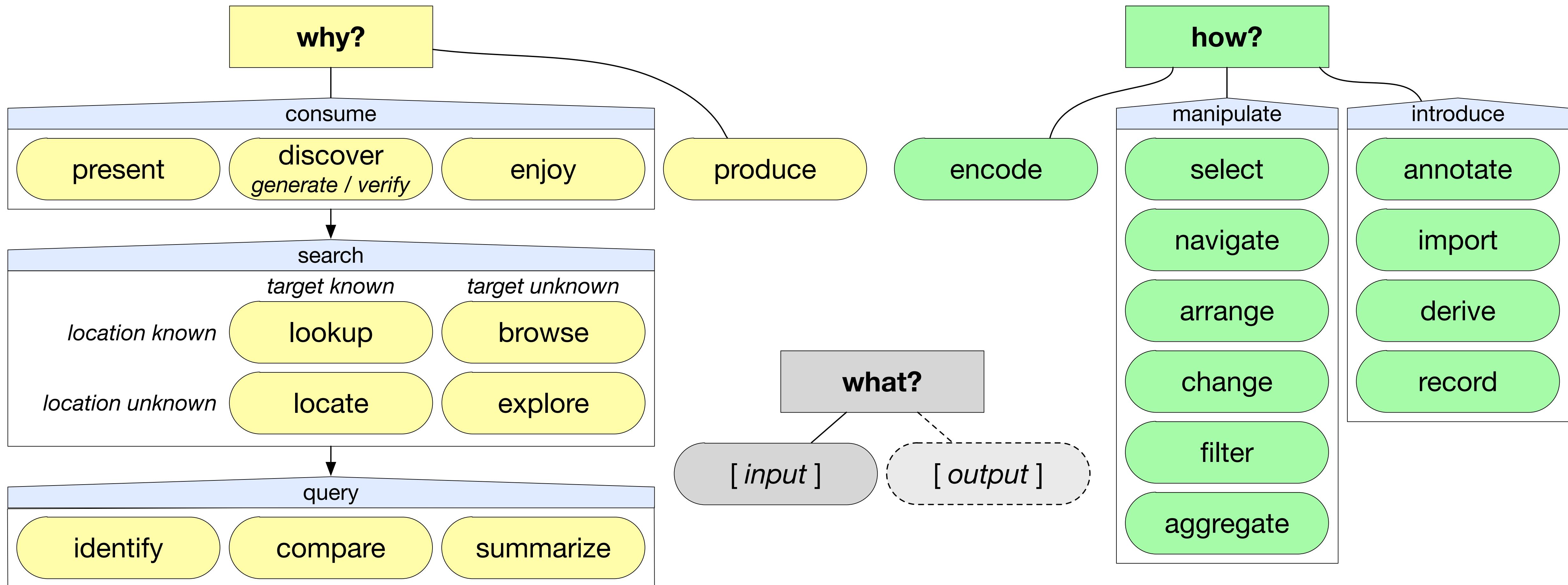
## Perspective 1: **Synthesis**

### A Multi-Level Typology of Abstract Visualization Tasks



# Perspective 1: Synthesis

## A Multi-Level Typology of Abstract Visualization Tasks

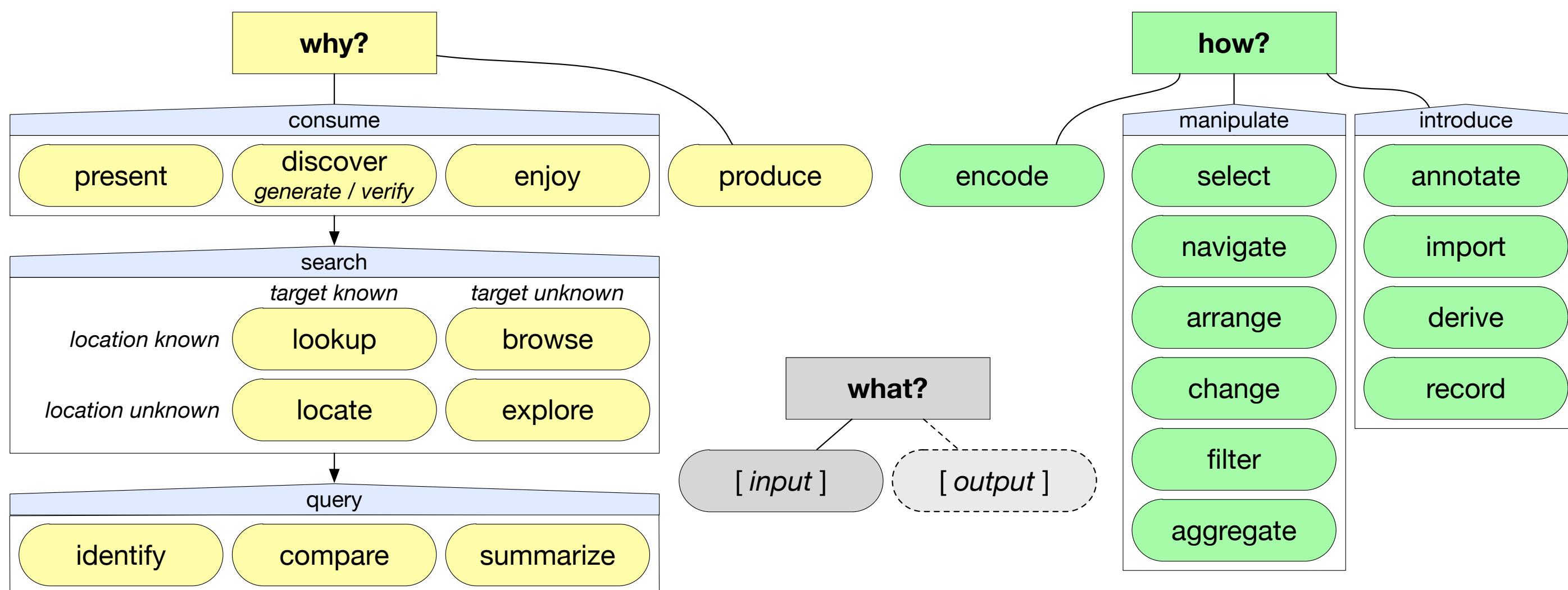


Brehmer & Munzner. IEEE TVCG / Proc. InfoVis 2013.



# Perspective 1: Synthesis

## A Multi-Level Typology of Abstract Visualization Tasks



**30** prior taxonomies,  
**20** additional references,  
**84** total references  
**5** disciplines  
**20** citations since VIS '13

**Q:** in what other ways can we validate this typology?

## Perspective 2: Field Study

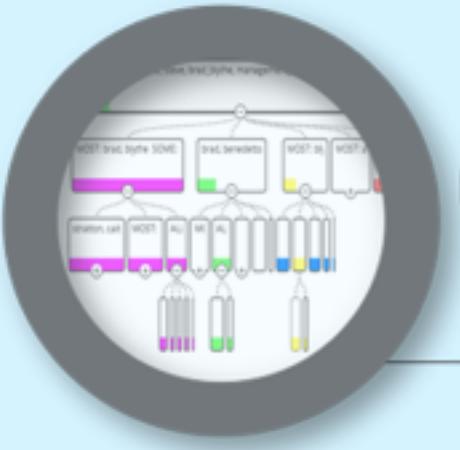


*Overview: The Design, Adoption, and Analysis of a Visual Document Mining Tool For Investigative Journalists*



# Perspective 2: Field Study

## case studies with 6 journalists



# overview

Search all documents  Search

brad, letter, cheri, blythe, gas, oil, program, ocs, hunter, leases

[Back to list](#)

Document 21 of 66  
in folder ALL: letter, urging, president\_obama, gas\_exploration MOST: decision, comments, open\_oil...

MMS6 Pdf 40 85 85

Key words: decision, department, oil, congress, program, suggestions\_comments

DOCUMENT TEXT

p. 1

United States Department of the Interior  
MINERALS MANAGEMENT SERVICE  
Washington, DC 20240

The Honorable Jerry Moran  
House of Representatives  
Washington, D.C. 20515

Dear Congressman Moran:

Thank you for your letter dated February 3, 2009, to President Obama, cosigned by 69 other Members of Congress, urging that areas of the Outer Continental Shelf (OCS) be left open for oil and gas exploration and development while the Administration reviews the 5-year offshore drilling plan. As Acting Director of the Minerals Management Service (MMS), I have been asked to respond. A similar letter is being sent to each signer of your letter.

The Administration and the Department of the Interior have made developing a comprehensive energy strategy for the Nation a top priority. In fact, as a result of the decision by Congress not to renew the OCS moratorium last year, we are exploring offshore oil and gas development in more areas than ever before. Let me assure you that Secretary Ken Salazar's decision to extend the comment period on the Draft Proposed OCS Oil and Gas Leasing Program for 2010–2015 does not affect the current leasing program. In fact, to date, seven sales have been held under this program. The most recent sale was Central Gulf Sale 208, which received over \$700 million in high bids. Fourteen lease sales remain on the schedule under the current program. We recognize that the OCS continues to play a major role in the energy mix for our country and provides 27 percent of the oil and 14 percent of the natural gas produced domestically.

The recent decision of the 10th Circuit Court, which found that the current offshore leasing plan is deficient, is a major concern. Consequently, the Department is working hard to clarify the implications of that decision and to remedy the situation with as little impact as possible.

If any Member of Congress has particular suggestions or comments related to the new 5-year plan now in progress, please be aware that we are accepting comments until September 21, 2009. We welcome any suggestions or comments you may have regarding the development of a comprehensive energy program for the OCS and the Nation.

Thank you for your interest in the offshore energy program. We look forward to working with you on this issue. If you have any questions, please contact me at (202) 208-3500, or Ms. Lyn Herdt, Chief, MMS Office of Congressional Affairs, at (202) 208-3502.

Sincerely,

*Walter D. Crisler*

Tags: Atlantis, FOIA request, Independence visit, Obama letter, tag name, Create new tag, Show untagged, Organize tags...

Adoption and appropriation are difficult to study

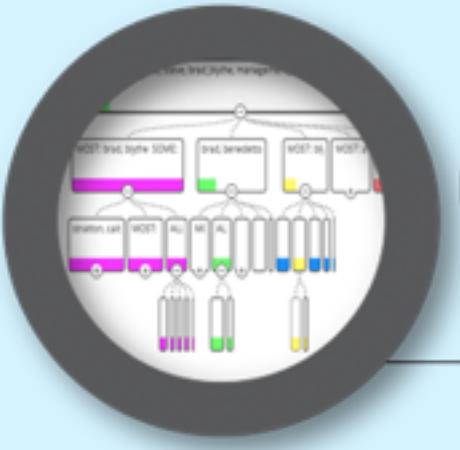
A need for an analysis framework

Brehmer, Ingram, Stray, & Munzner.  
IEEE TVCG / Proc. InfoVis 2014.



# Perspective 2: Field Study

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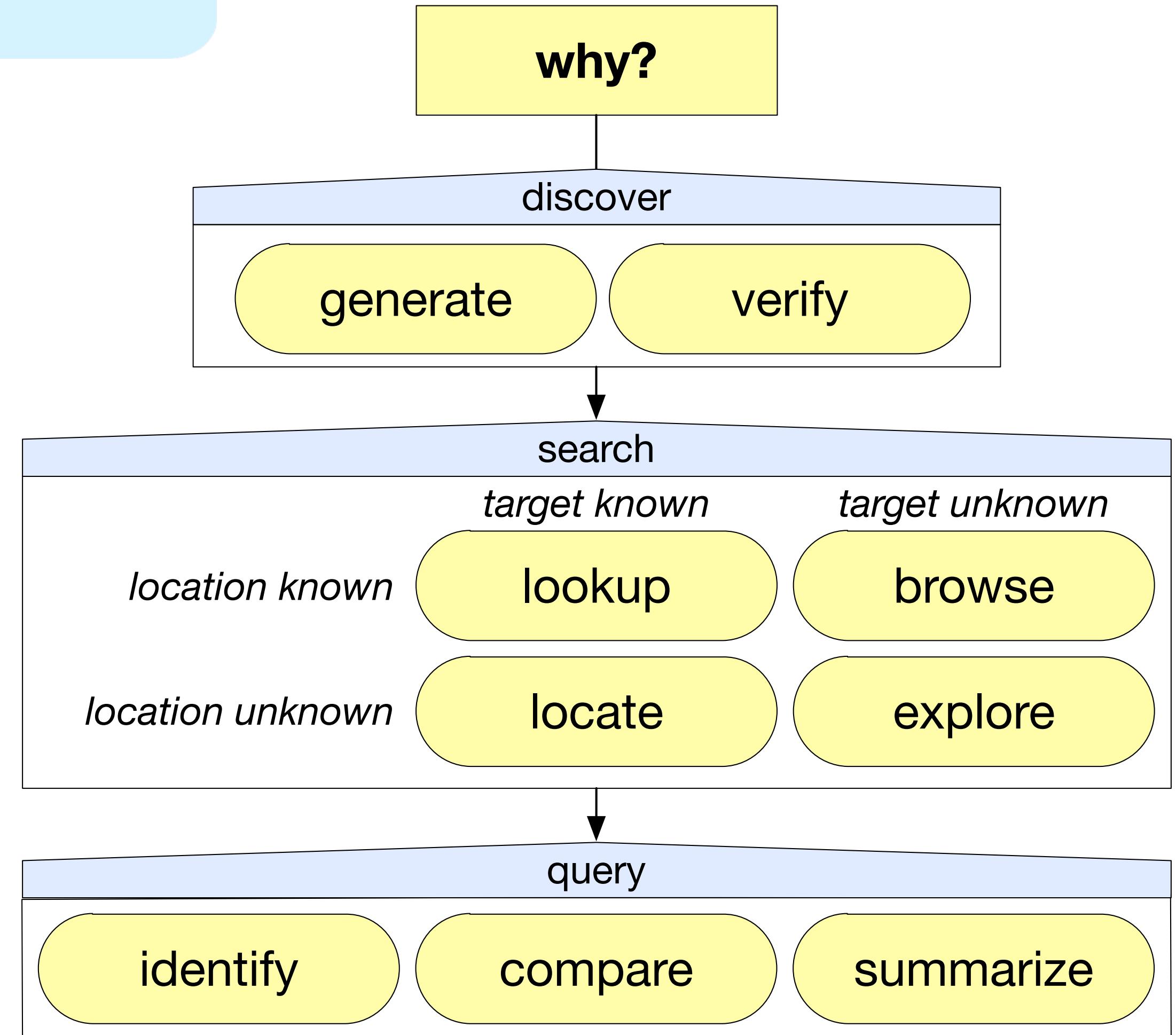
# Perspective 2: Field Study

## case studies with 6 journalists

Use of typology to analyze field data

**2** tasks, not **1**, not **6**...

**Q:** how to improve the study of adoption?



Brehmer, Ingram, Stray, & Munzner. IEEE TVCG / Proc. InfoVis 2014.



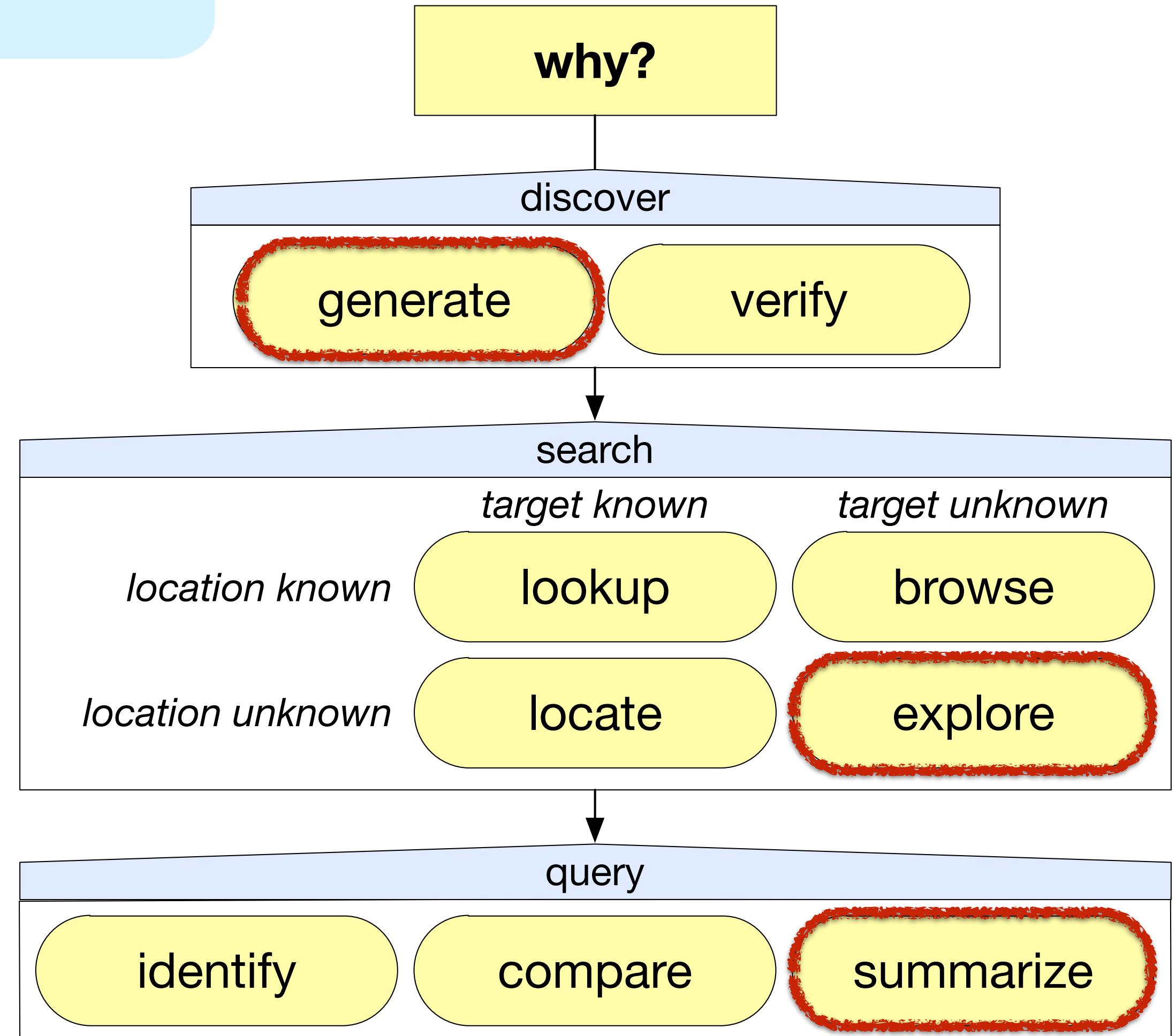
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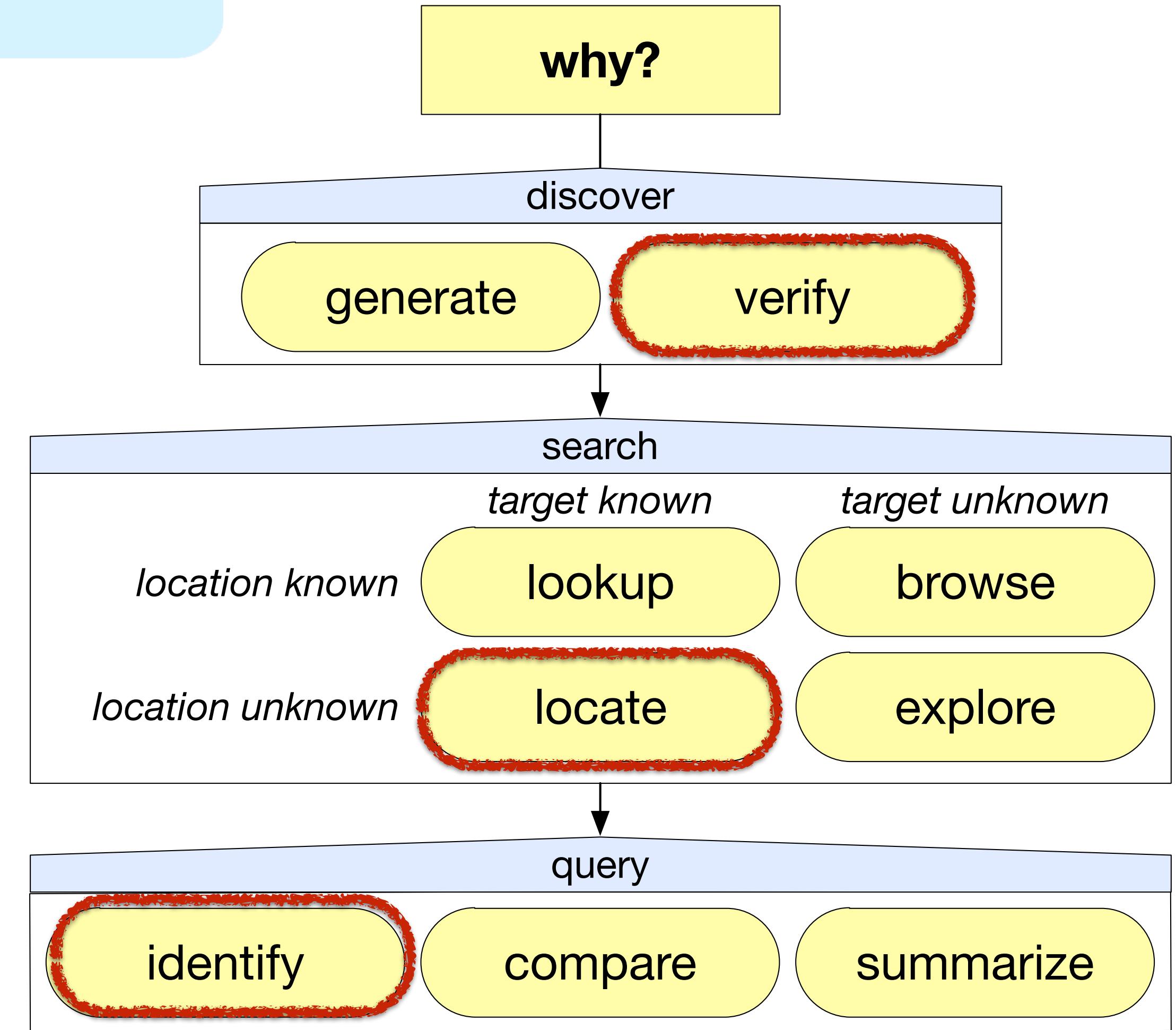
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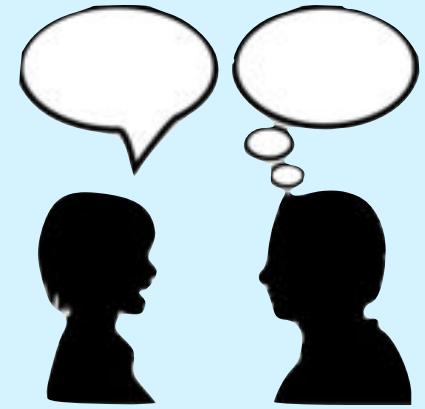
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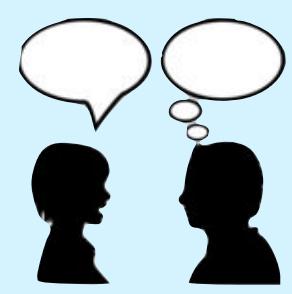


Brehmer, Ingram, Stray, & Munzner. IEEE TVCG / Proc. InfoVis 2014.

## Perspective 3: Interview Study

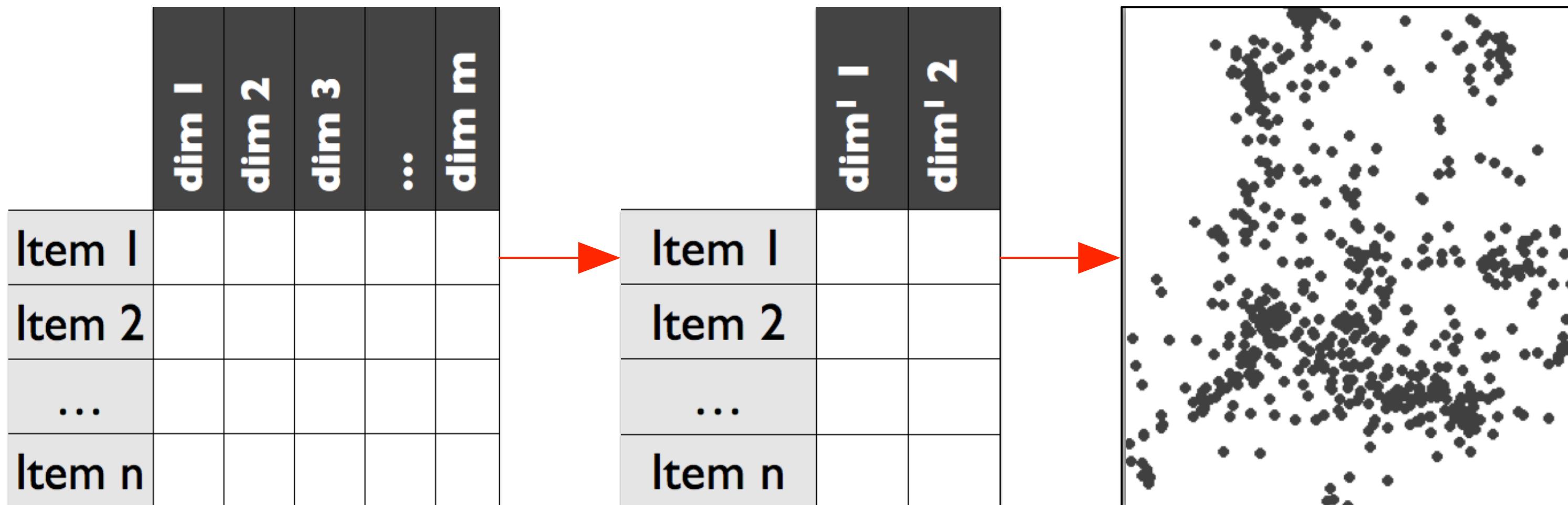


**Visualizing Dimensionally Reduced Data:**  
Interviews with Analysts and a Characterization of Task Sequences



# Perspective 3: Interview Study

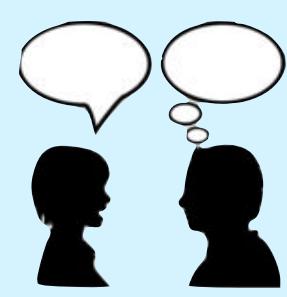
Interviews with 10 analysts from 6 domains



A **domain-independent** yet  
**data-abstraction-specific** task  
characterization...

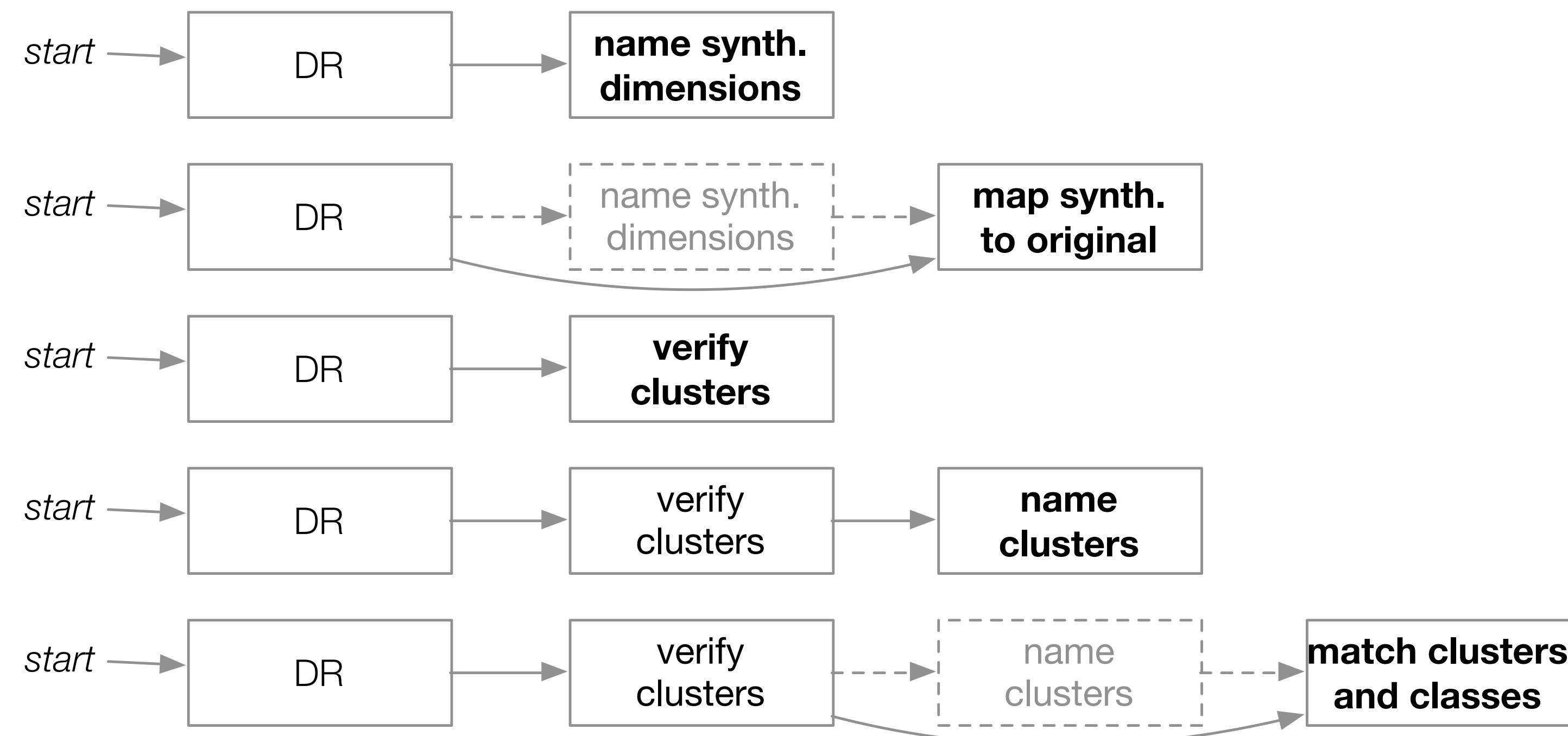
...but in need of the  
right words.

Brehmer, Sedlmair, Ingram, & Munzner. Proc. BELIV 2014.



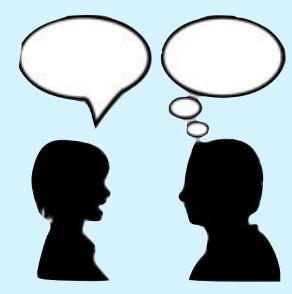
# Perspective 3: Interview Study

## Why visualize dimensionally-reduced data?



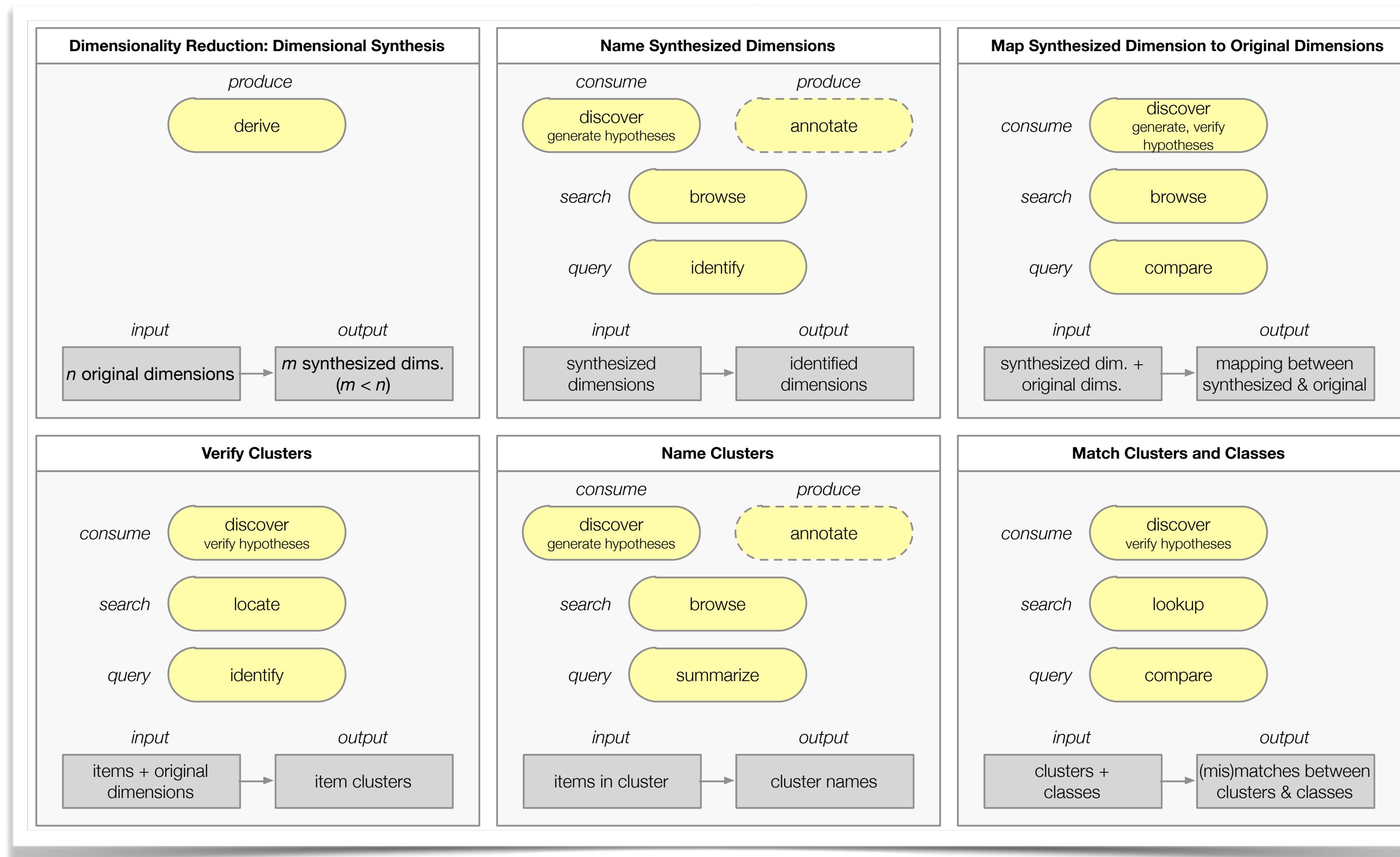
The task typology allowed us to compare tasks **across application domains**, those having a **common data abstraction**.

Brehmer, Sedlmair, Ingram, & Munzner. Proc. BELIV 2014.



# Perspective 3: Interview Study

## Why visualize dimensionally-reduced data?



**Q:** as with the typology, how could I apply or validate this data-abstraction-specific task characterization?

Brehmer, Sedlmair, Ingram, & Munzner. Proc. BELIV 2014.

## Perspective 4: Design Study

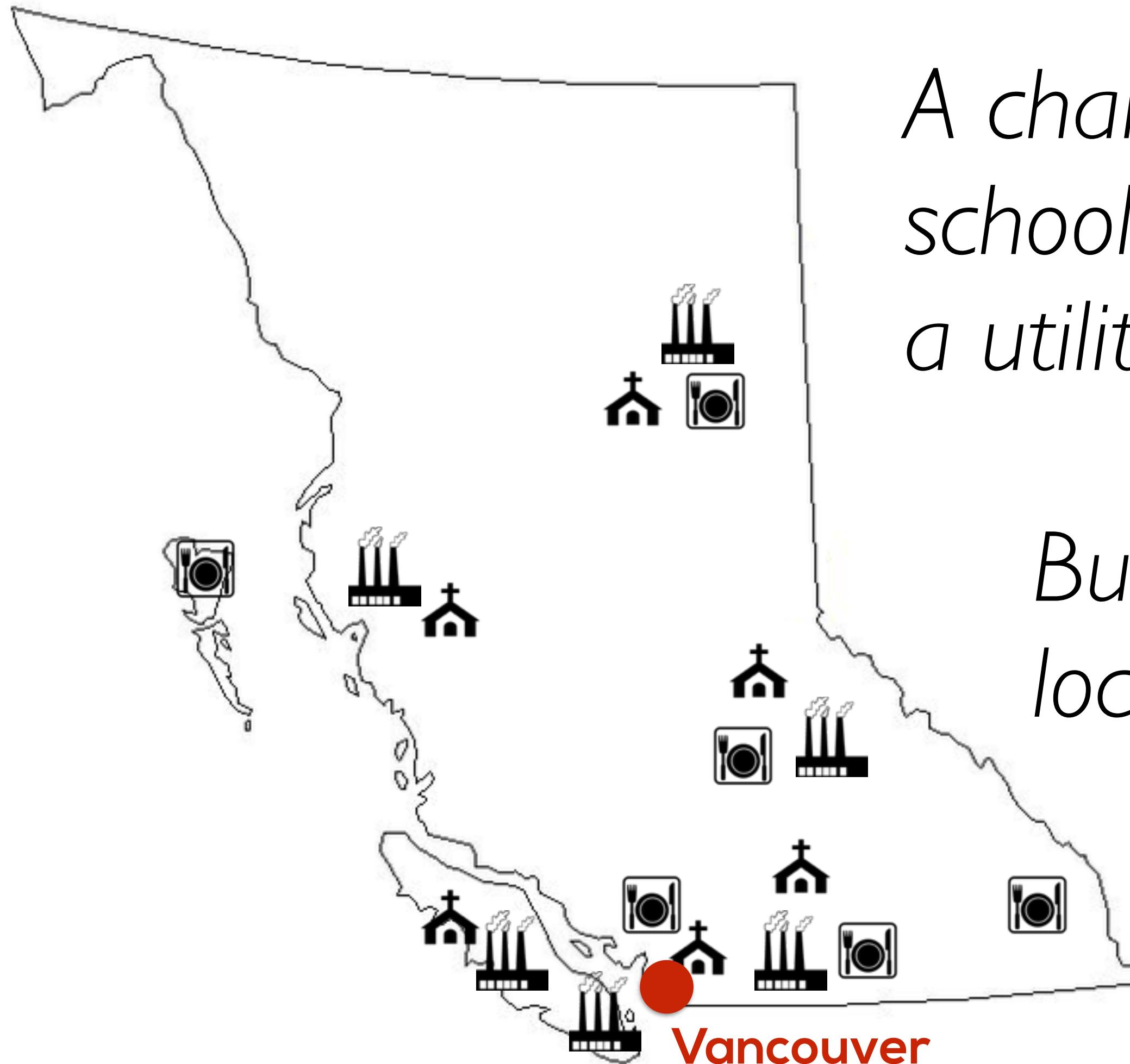


Visualization for Large-Scale  
Energy Consumption Analysis



# Perspective 4: Design Study

## Large-Scale Energy Consumption Analysis



*A chain of restaurants or hotels... a school board... a university campus... a utility company portfolio...*

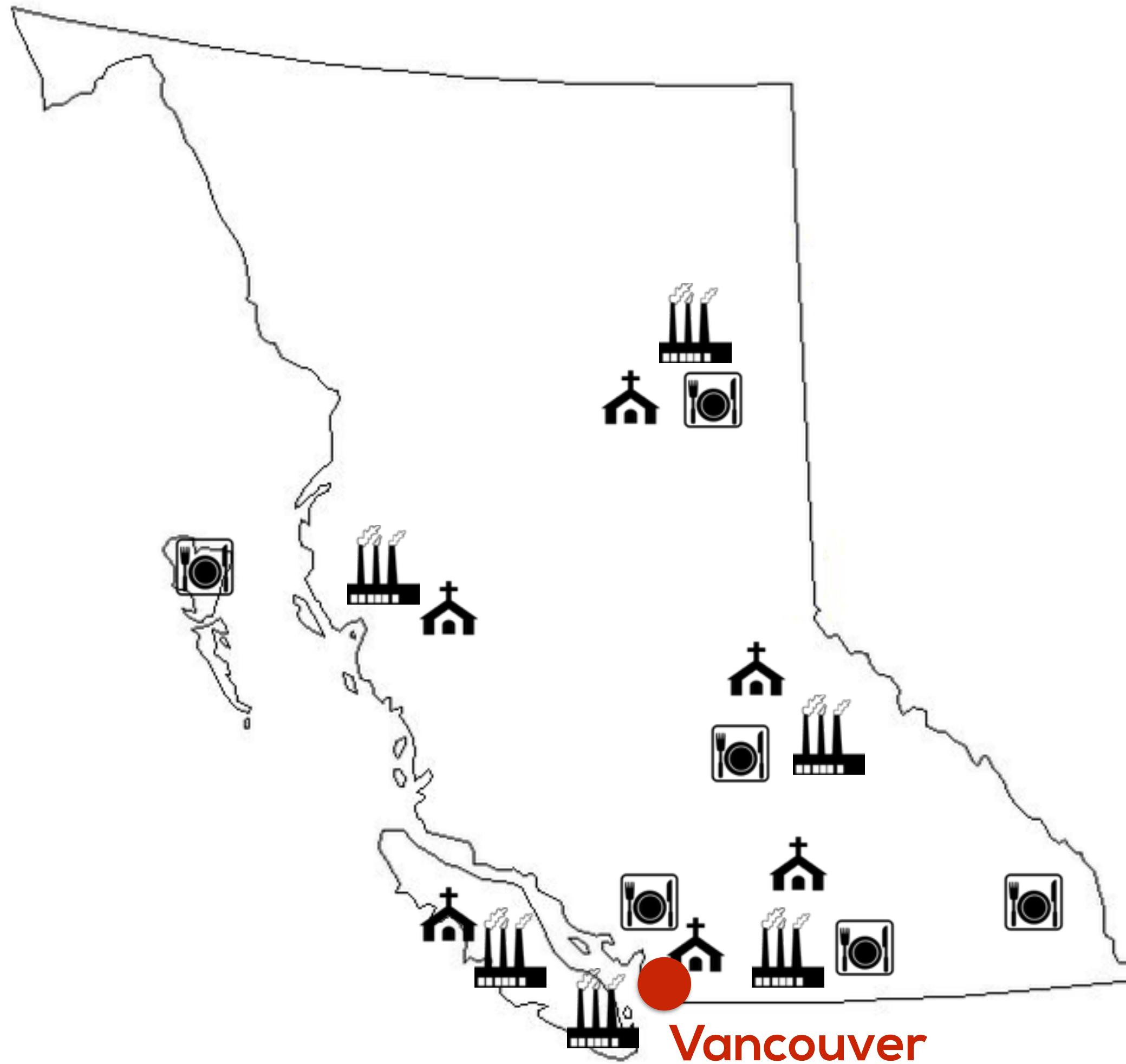
*Building use type, age, occupancy, location, size, climate data.*

*Real-time data, multiple resources*



# Perspective 4: Design Study

## Large-Scale Energy Consumption Analysis



Complex data abstractions

Replacing existing software

Diverse user base, domain conventions



# Perspective 4: Design Study

Interviews with 9 current users: diverse roles / skill sets

Energy Manager / Analyst / Specialist / Efficiency Engineer

Climate and Energy Engineer

Student Energy Researcher

Automation Maintenance Engineer

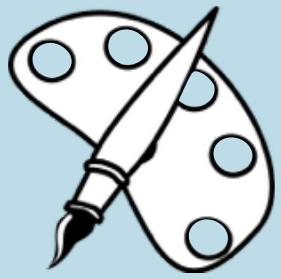
Building Automation Software Specialist



# Perspective 4: Design Study

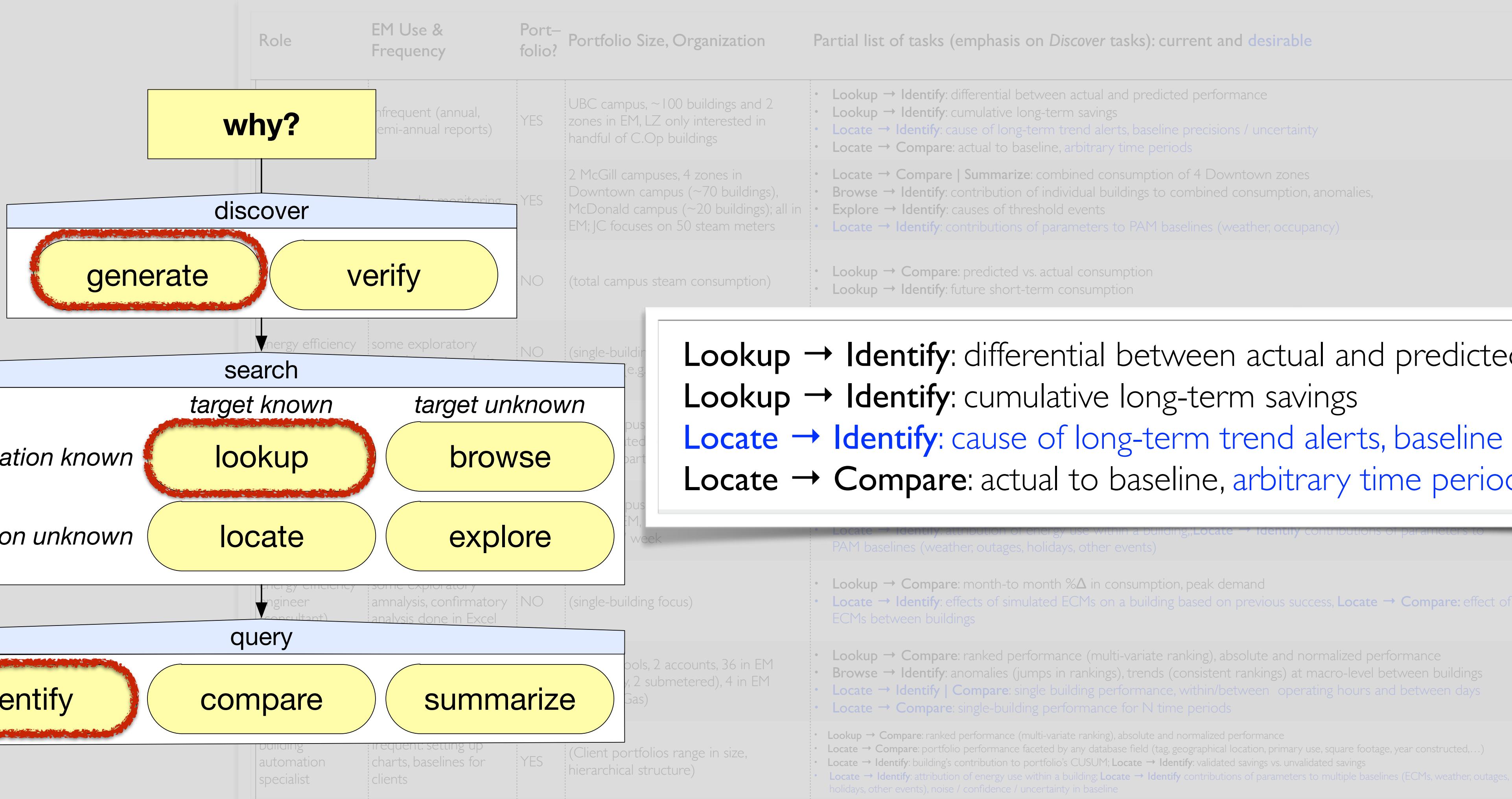
## Task Abstraction Analysis: the Why?

Role	EM Use & Frequency	Port-folio?	Portfolio Size, Organization	Partial list of tasks (emphasis on Discover tasks): current and desirable
climate and energy engineer	infrequent (annual, semi-annual reports)	YES	UBC campus, ~100 buildings and 2 zones in EM, LZ only interested in handful of C.Op buildings	<ul style="list-style-type: none"><li>• Lookup → Identify: differential between actual and predicted performance</li><li>• Lookup → Identify: cumulative long-term savings</li><li>• Locate → Identify: cause of long-term trend alerts, baseline precisions / uncertainty</li><li>• Locate → Compare: actual to baseline, arbitrary time periods</li></ul>
energy manager	day-to-day monitoring	YES	2 McGill campuses, 4 zones in Downtown campus (~70 buildings), McDonald campus (~20 buildings); all in EM; JC focuses on 50 steam meters	<ul style="list-style-type: none"><li>• Locate → Compare   Summarize: combined consumption of 4 Downtown zones</li><li>• Browse → Identify: contribution of individual buildings to combined consumption, anomalies,</li><li>• Explore → Identify: causes of threshold events</li><li>• Locate → Identify: contributions of parameters to PAM baselines (weather, occupancy)</li></ul>
researcher	none, data export from API	NO	(total campus steam consumption)	<ul style="list-style-type: none"><li>• Lookup → Compare: predicted vs. actual consumption</li><li>• Lookup → Identify: future short-term consumption</li></ul>
energy efficiency engineer (consultant)	some exploratory analysis, most analysis done in Excel	NO (small)	(single-building focus or small group of buildings (e.g. 5))	<ul style="list-style-type: none"><li>• Explore   Browse → Identify: load profile of building, anomalies;</li><li>• Lookup   Locate → Compare: within and across buildings: monthly and seasonal differences in consumption / schedule / demand; OAT vs. demand for occupied and unoccupied periods, Lookup → Summarize: distribution of OAT, demand</li><li>• Locate → Identify: attribution of energy use within a building; Locate → Identify   Compare: effects of simulated ECMs on building performance</li></ul>
energy analyst	several hours a week, additional analysis in Excel	YES	UCB campus: ~100 buildings (90% concentrated on single campus), subset in EM, departments cross-cuts buildings	<ul style="list-style-type: none"><li>• Locate → Compare: consumption of [largest buildings, libraries, mid-size buildings]</li><li>• Locate → Identify: causes of threshold events in reference to OAT</li><li>• Lookup → Compare: ranked building performance</li><li>• Locate → Compare: before after ECMs, Locate → Compare OAT-demand regression curves before, after ECMs</li><li>• Locate → Identify: attribution of energy use within a building; Locate → Identify contribution of department(s) to building consumption;</li><li>• Locate → Compare: consumption of UCB to other universities; Lookup → Identify weather predictions, trends</li></ul>
head maintenance engineer; automation	daily email digest, follow-up in EM ~3-4 hrs / week	YES	UBC campus, ~100 buildings and 2 zones in EM, monitors about 10 buildings / week	<ul style="list-style-type: none"><li>• Lookup → Compare: ranked building performance</li><li>• Explore → Identify: anomalies, causes of threshold events / alerts</li><li>• Locate → Identify: attribution of energy use within a building; Locate → Identify contributions of parameters to PAM baselines (weather, outages, holidays, other events)</li></ul>
energy efficiency engineer (consultant)	some exploratory analysis, confirmatory analysis done in Excel	NO	(single-building focus)	<ul style="list-style-type: none"><li>• Lookup → Compare: month-to month %Δ in consumption, peak demand</li><li>• Locate → Identify: effects of simulated ECMs on a building based on previous success, Locate → Compare: effect of ECMs between buildings</li></ul>
energy specialist	EM for data export; analysis done in Excel, EM analysis offloaded to student volunteers	YES	~130 schools, 2 accounts, 36 in EM (Electricity, 2 submetered), 4 in EM (Natural Gas)	<ul style="list-style-type: none"><li>• Lookup → Compare: ranked performance (multi-variate ranking), absolute and normalized performance</li><li>• Browse → Identify: anomalies (jumps in rankings), trends (consistent rankings) at macro-level between buildings</li><li>• Locate → Identify   Compare: single building performance, within/between operating hours and between days</li><li>• Locate → Compare: single-building performance for N time periods</li></ul>
building automation specialist	frequent: setting up charts, baselines for clients	YES	(Client portfolios range in size, hierarchical structure)	<ul style="list-style-type: none"><li>• Lookup → Compare: ranked performance (multi-variate ranking), absolute and normalized performance</li><li>• Locate → Compare: portfolio performance faceted by any database field (tag, geographical location, primary use, square footage, year constructed,...)</li><li>• Locate → Identify: building's contribution to portfolio's CUSUM; Locate → Identify: validated savings vs. unvalidated savings</li><li>• Locate → Identify: attribution of energy use within a building; Locate → Identify contributions of parameters to multiple baselines (ECMs, weather, outages, holidays, other events), noise / confidence / uncertainty in baseline</li></ul>



# Perspective 4: Design Study

## Task Abstraction Analysis: the Why?



**Lookup → Identify:** differential between actual and predicted performance  
**Lookup → Identify:** cumulative long-term savings  
**Locate → Identify:** cause of long-term trend alerts, baseline precisions / uncertainty  
**Locate → Compare:** actual to baseline, arbitrary time periods

- Locate → Identify: attribution of energy use within a building; Locate → Identify contributions of parameters to PAM baselines (weather, outages, holidays, other events)
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- Locate → Identify | Compare: single building performance, within/between operating hours and between days
- Locate → Compare: single-building performance for N time periods
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# Perspective 4: Design Study

## Data Abstraction Analysis: the What?

**Data Abstractions:** † = not configurable in EM | [possible extensions]

### aggregate item [portfolio] [S\*]

- (aggregate items [groups of spaces])
  - individual item [space] [S]
  - (partial item [space submeter])
    - links
      - [point 1]
      - [point 2]
      - ...
      - [point n]
  - categorical attributes
    - [primary use]
    - [space type]
    - [use\_type]<sup>†</sup>
    - [weather station ID]
    - [TMY (Typical Meteorological Year) data source]
    - [floor space unit]
    - [custom descriptor tag(s)]
    - ~~[end-use(s)]~~
  - spatial attributes
    - [address (location)]
    - [city]<sup>†</sup>
    - [province]<sup>†</sup>
    - [latitude]<sup>†</sup>
    - [longitude]<sup>†</sup>
    - [time zone]<sup>†</sup>
  - static quantitative attributes
    - [# occupants]
      - [# occupants subdivided by descriptor tag]
    - [year constructed (space age)]

### item [point] [P]

- temporal quantitative attribute
  - [point value]
- categorical attributes
  - [resource] (e.g. electricity, steam)
  - [quantity] (e.g. energy, mass, avg. power)
  - [type] (e.g. monitored, conversion, baseline)
  - [unit] (e.g. kW, kWh, GJ, lb, lb/h)
  - [direction] (consumption vs. generation)
- static quantitative attributes
  - [update frequency]
- links
  - [space i]
  - [datalogger j]
  - [connector k]

### item [space-point dyad] [S-P]

- static quantitative attributes
  - [cost conversion ratio]
  - [energy conversion ratio]
  - [Green House Gas conversion ratio]
  - [normal range ±%]
    - [coarse-grained normal range ±%]
    - [fine-grained normal range ±%]

### weather [W]

- temporal quantitative attribute
  - [OAT: outside air temperature]
  - [relative humidity]
  - [wind speed]
  - [precipitation]
  - ...
- temporal categorical attribute
  - [wind direction]

### temporal intervals [T]

### derived attributes [D1] [items [P] + temporal interval [T]]

- quantitative attribute: average, sum, distribution, range, SD
  - [consumption]
  - [cost]
  - [average demand]
  - [peak demand]
  - [absolute savings / waste: point value 1 – point value 2]
  - [relative savings / waste: point value 1 / point value 2]
  - [cumulative savings]
- temporal quantitative attribute
  - [schedule: derivative of demand]

see CG Excel charts

### derived attributes [D2] [item [S] + weather [W] + [T]]

- quantitative attribute
  - [HDD: base temperature – OAT]
  - [CDD: OAT – base temperature]

### derived attributes [D3]

[item [S + P] + derived attributes [D1, D2] + temporal interval [T]]

- quantitative attribute
  - [attribute [D1] per area]  
(e.g. energy intensity: consumption normalized by square footage)
  - [average baseload]
  - [attribute [D1] normalized by HDDs, CDDs]
  - [attribute [D1] normalized by # occupants]
  - [attribute [D1] normalized by # operating hours]
  - [attribute [D1] faceted by schedule interval]
  - ~~[end-use disaggregation]~~

out of scope for now

### derived attributes [D4] [multiple items [S + P] + [D1, D2, D3]]



# Perspective 4: Design Study

## Data Abstraction Analysis: the What?

### Data Abstraction

aggregate item [p]

• (aggregate item)

• individual

• (partial)

• link

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• cat

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Hierarchies: portfolios of buildings

Items have spatial, categorical, quantitative metadata

Each item has multiple time-varying attributes

Multiple time granularities of interest

Many derived attributes

temporal categorical attribute

• [wind direction]

• [end-use disaggregation]

temporal intervals [T]

22

derived attributes [D4] [multiple items [S + P] + [DI, D2, D3]]

out of scope for now

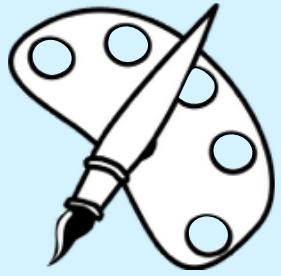


## Perspective 4: Design Study

### 2 Analysis Tasks of focus (in domain language)

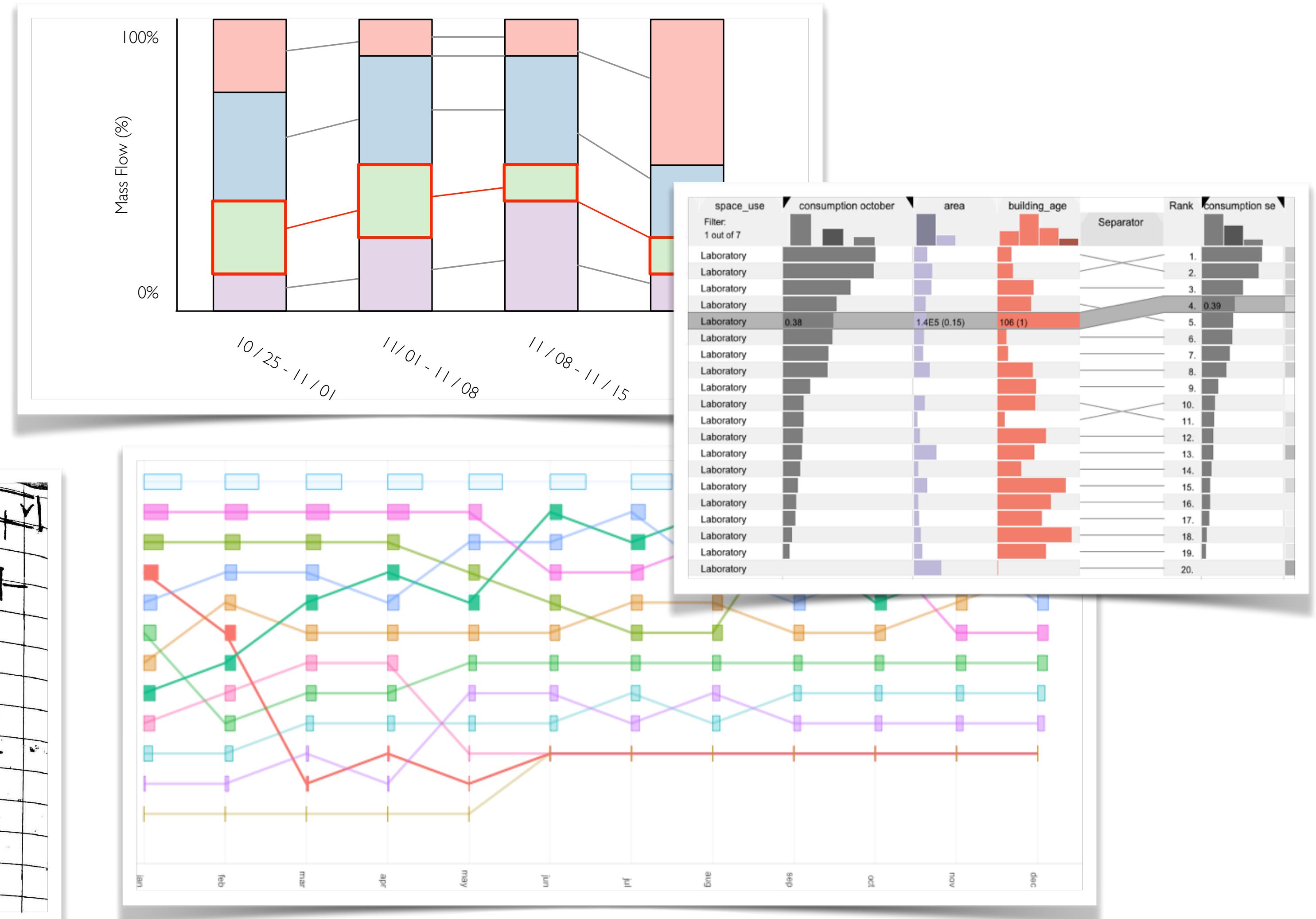
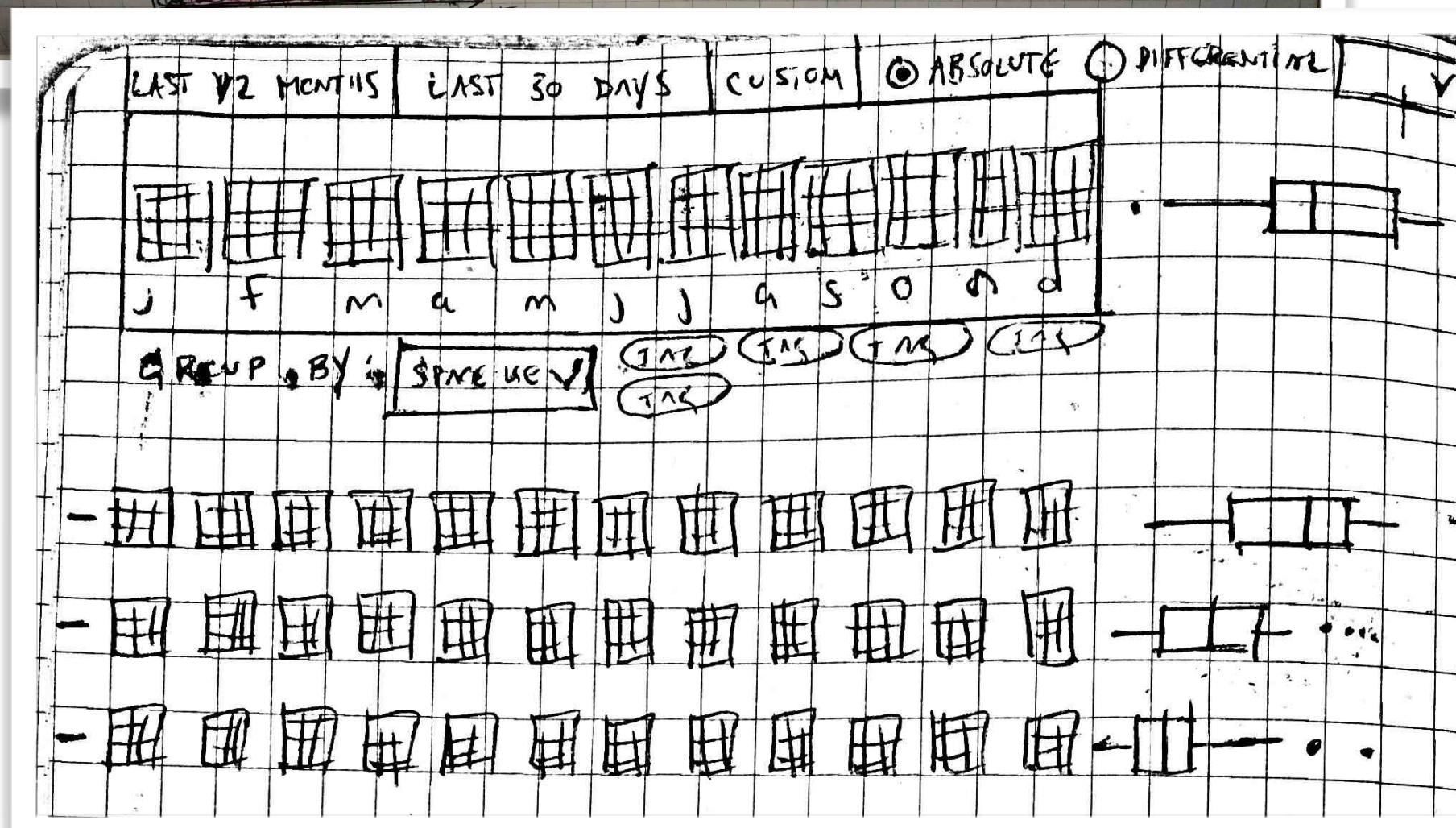
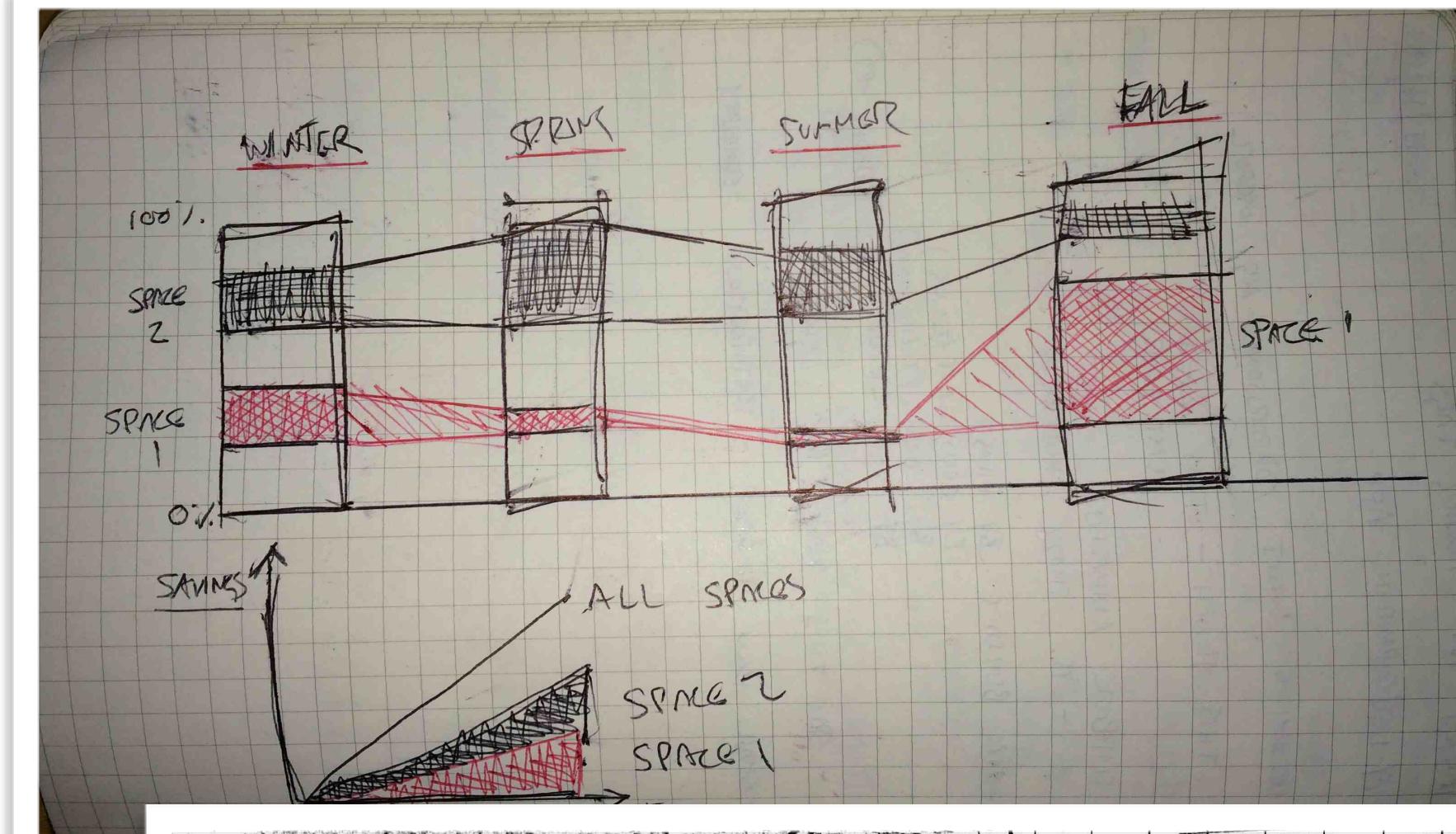
Compare absolute and relative performance for a portfolio of buildings over time, faceted by building or by grouping buildings with shared attributes.

Compare individual building performance over time.



# Perspective 4: Design Study

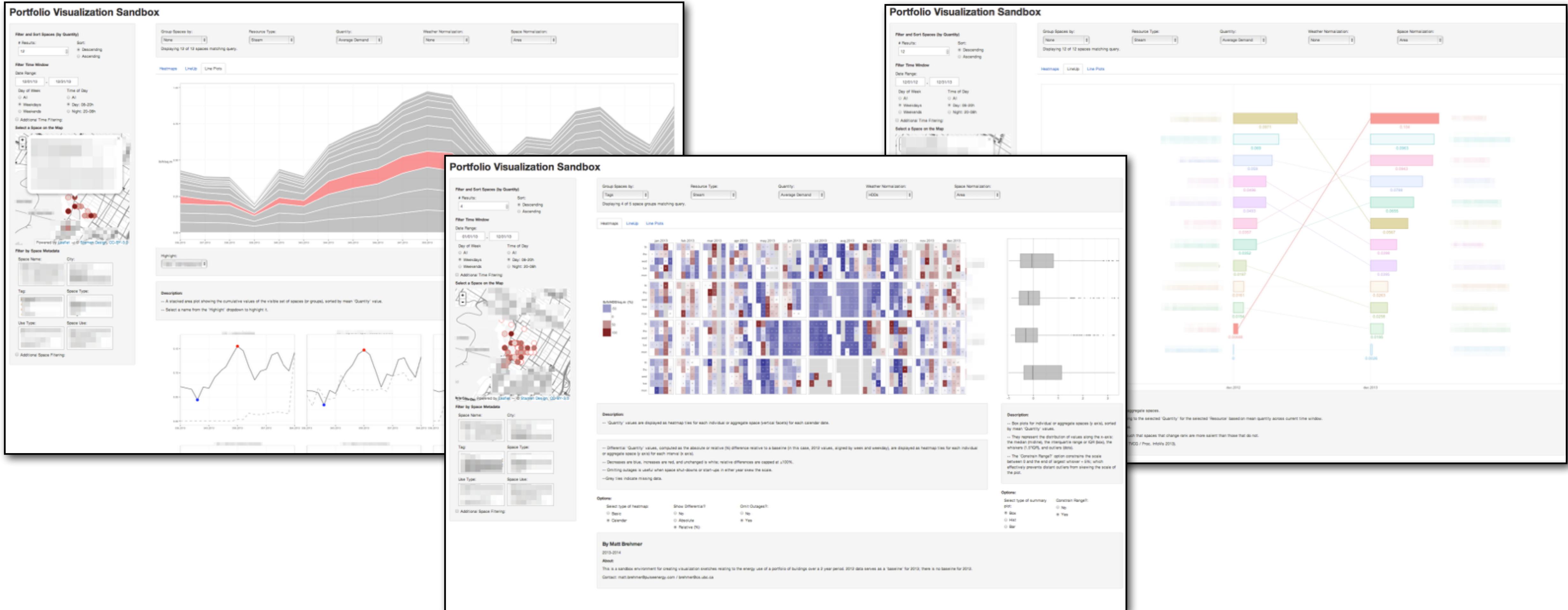
## Early Visualization Design Sketching





# Perspective 4: Design Study

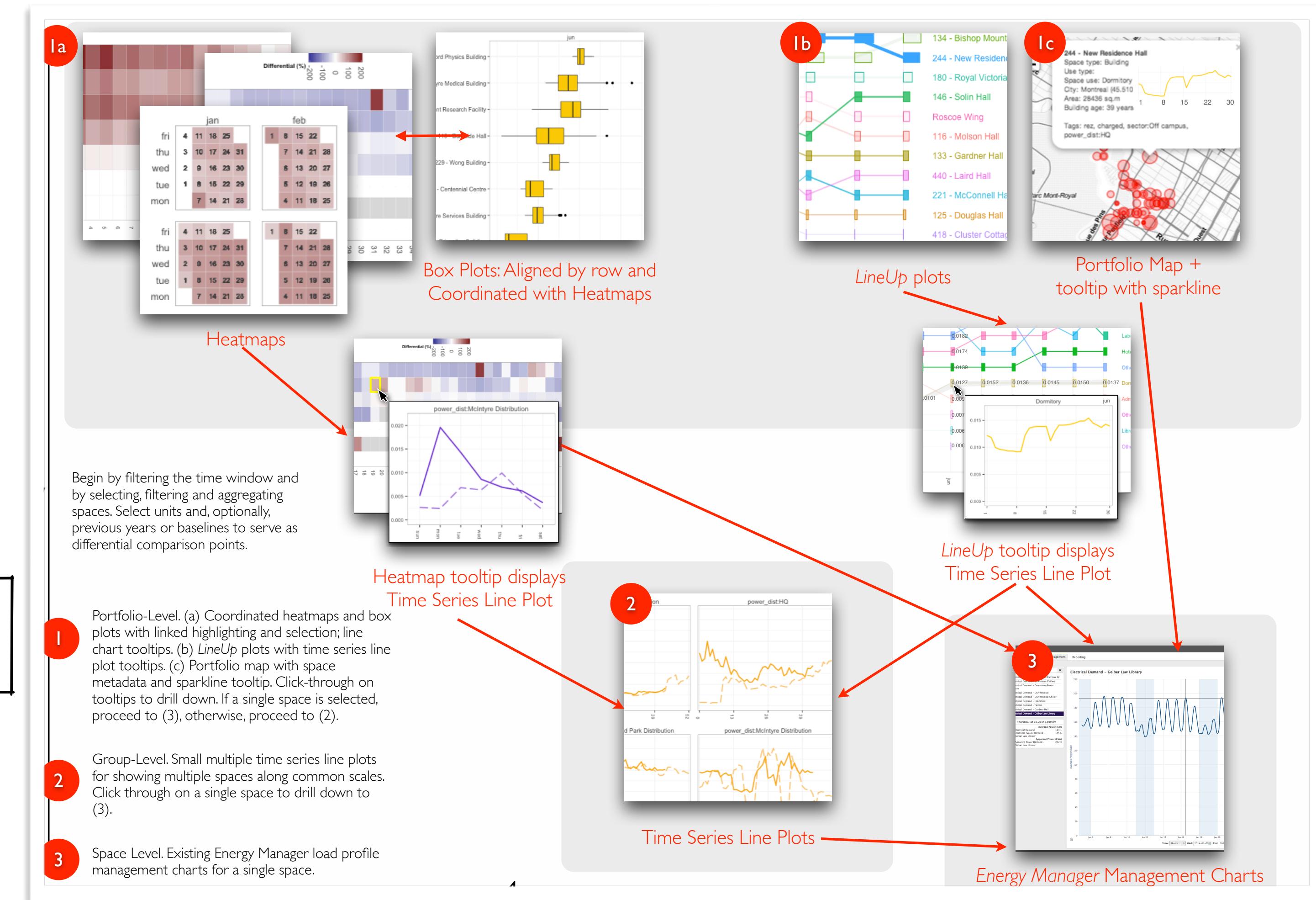
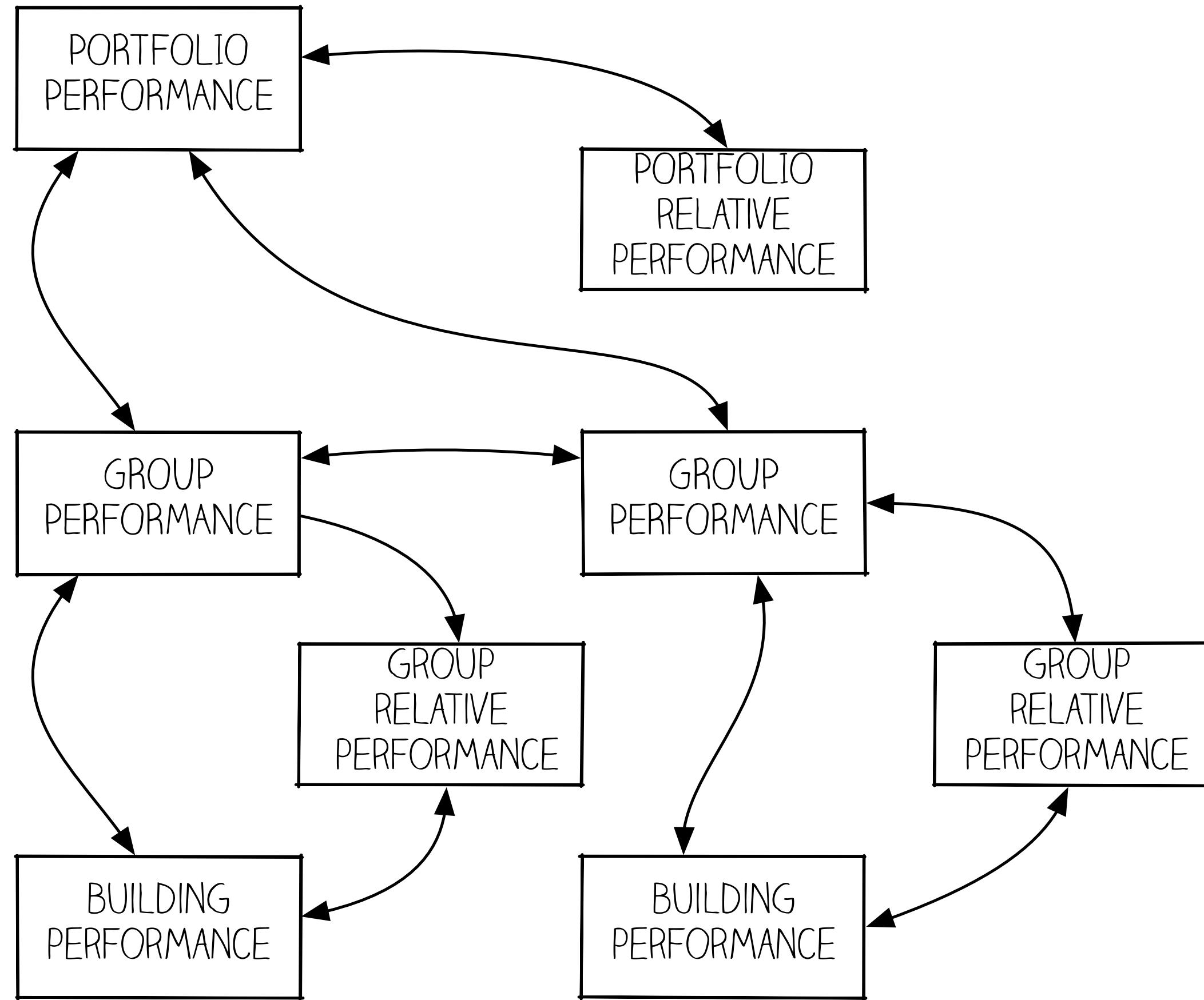
## Later: Visualization Design Sketching





# Perspective 4: Design Study

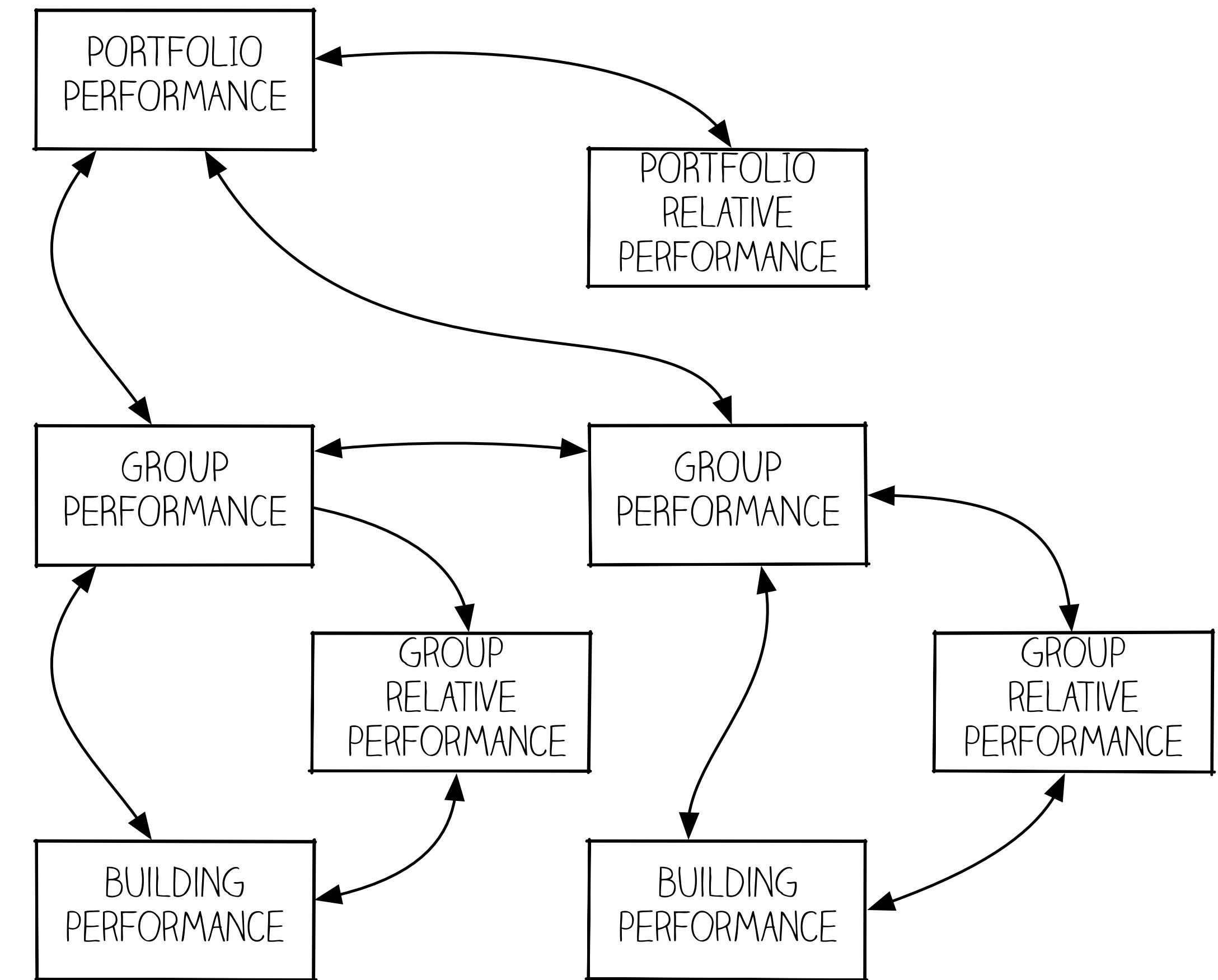
## Designing Workflows





# Perspective 4: Design Study

## Designing Workflows



**Q:** How do I combine visual encoding and interaction design choices into coherent workflows for a diverse user population?

**Q:** How do I confront legacy software bias and domain convention?

# Summary



# Four Perspectives Revisited



# Four Perspectives Revisited



## Synthesis:

How should I validate this visualization task typology?

# Four Perspectives Revisited



## **Synthesis:**

How should I validate this visualization task typology?



## **Field Study:**

How should I study the adoption and appropriation of visualization in the wild?

# Four Perspectives Revisited



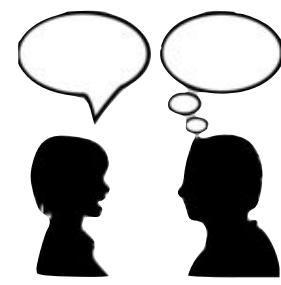
## **Synthesis:**

How should I validate this visualization task typology?



## **Field Study:**

How should I study the adoption and appropriation of visualization in the wild?



## **Interview Study:**

How should I validate domain-agnostic data-abstraction-specific task characterization?

# Four Perspectives Revisited



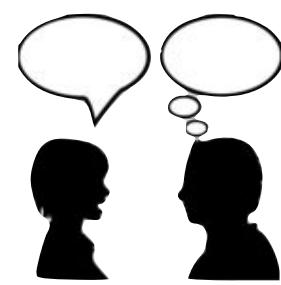
## Synthesis:

How should I validate this visualization task typology?



## Field Study:

How should I study the adoption and appropriation of visualization in the wild?



## Interview Study:

How should I validate domain-agnostic data-abstraction-specific task characterization?



## Design Study:

How should I effectively combine visualizations into coherent workflows for diverse users?

# Big Picture Questions



# Big Picture Questions

**Q:**The typology: *do you buy it?* What else might I do to validate or apply the typology?  
Where else should we extend it?



# Big Picture Questions

**Q:** The typology: *do you buy it?* What else might I do to validate or apply the typology?  
Where else should we extend it?

**Q:** How can I continue to apply this typology and task-centred design and evaluation methods post-PhD?

# Big Picture Questions

**Q:** The typology: *do you buy it?* What else might I do to validate or apply the typology?  
Where else should we extend it?

**Q:** How can I continue to apply this typology and task-centred design and evaluation methods post-PhD?

**Q:** Given my interests, I am attracted to design studies. How (and where) can I do design study-flavoured work in industry?

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Michelle Borkin, Johanna Fulda, Heidi Lam, Michael Sedlmair,  
Stephen Ingram, Jonathan Stray, Pulse Energy

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# Big Picture Questions

**Q:** The typology: *do you buy it?* What else might I do to validate or apply the typology?  
Where else should we extend it?

**Q:** How can I continue to apply this typology and task-centred design and evaluation methods post-PhD?

**Q:** Given my interests, I am attracted to design studies. How (and where) can I do design study-flavoured work in industry?

# Supplemental





# Perspective 4: Design Study

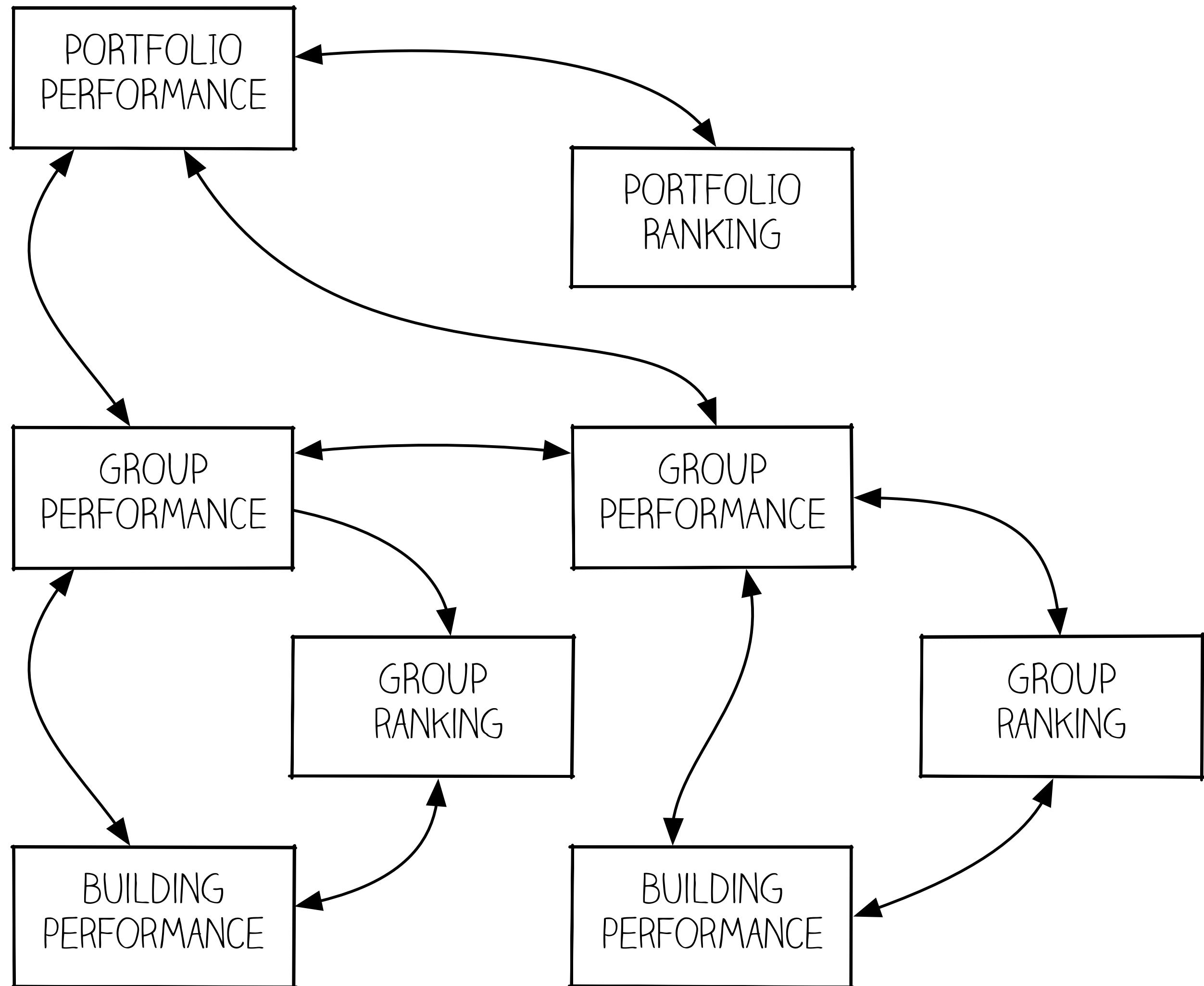
## Process: Design and Feedback Cycle

- Project Scope Discussion
- For Internal Feedback (Collaborator)
- For External Feedback (Original Interviewees)
- For External Feedback (New Prospective Users)

<p>May</p> <p><b>Potential Research Projects: HCI &amp; Visualization</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer and Tamara Munzner May 30, 2013</p> <p> pulse*energy</p>	<p>Nov</p> <p><b>Pulse Energy Manager Interview Findings &amp; Requirements Analysis July–Nov 2013</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer Nov 04, 2013</p> <p> pulse*energy</p>	<p>Nov</p> <p><b>Multifaceted Comparisons and Rankings for Portfolios in Pulse Energy Manager: Task and Data Abstractions</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer Nov 15, 2013</p> <p> pulse*energy</p>	<p>Nov</p> <p><b>Multi-Attribute Rankings and Multifaceted Comparisons for Portfolios in Energy Manager</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer Nov 22, 2013</p> <p> pulse*energy</p>
<p>Dec</p> <p><b>Multi-Attribute Rankings and Multifaceted Comparisons for Portfolios in Energy Manager</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer Dec 6, 2013 for</p> <p> pulse*energy</p>	<p>Jan</p> <p><b>Portfolio Visualization Design Sketches</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer Jan 14 2014</p> <p> pulse*energy</p>	<p>Jan</p> <p><b>Portfolio Analysis in Energy Manager: Visualization Design Sketches</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer for Jan 28 2014</p> <p> pulse*energy</p>	<p>Jan</p> <p><b>Rankings and Comparisons for Portfolios: Visualization Sketches</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer for Jan 29 2014 (+ comments)</p> <p> pulse*energy</p>
<p>Jan</p> <p><b>Rankings and Comparisons for Portfolios: Visualization Sketches</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer For Jan 29 2014 (+ comments)</p> <p> pulse*energy</p>	<p>Jan</p> <p><b>Portfolio Visualization Design Sketches</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer Jan 30 2014 (+ comments)</p> <p> pulse*energy</p>	<p>Feb</p> <p><b>Portfolio Visualization Design Sketches: Feedback and Workflows</b></p> <p>InfoVis @ UBC and Pulse Energy Matt Brehmer Feb 06 2014</p> <p> pulse*energy</p>	<p>Feb</p> <p><b>Visualizing Portfolios in Energy Manager: Design Sketches</b></p> <p>A research collaboration between InfoVis @ UBC and Pulse Energy Matt Brehmer (matt.brehmer@pulseenergy.com   http://cs.ubc.ca/~brehmer) Prepared for Feb 20 2014</p> <p> pulse*energy</p>



## Perspective 4: *Design Study* Open Questions

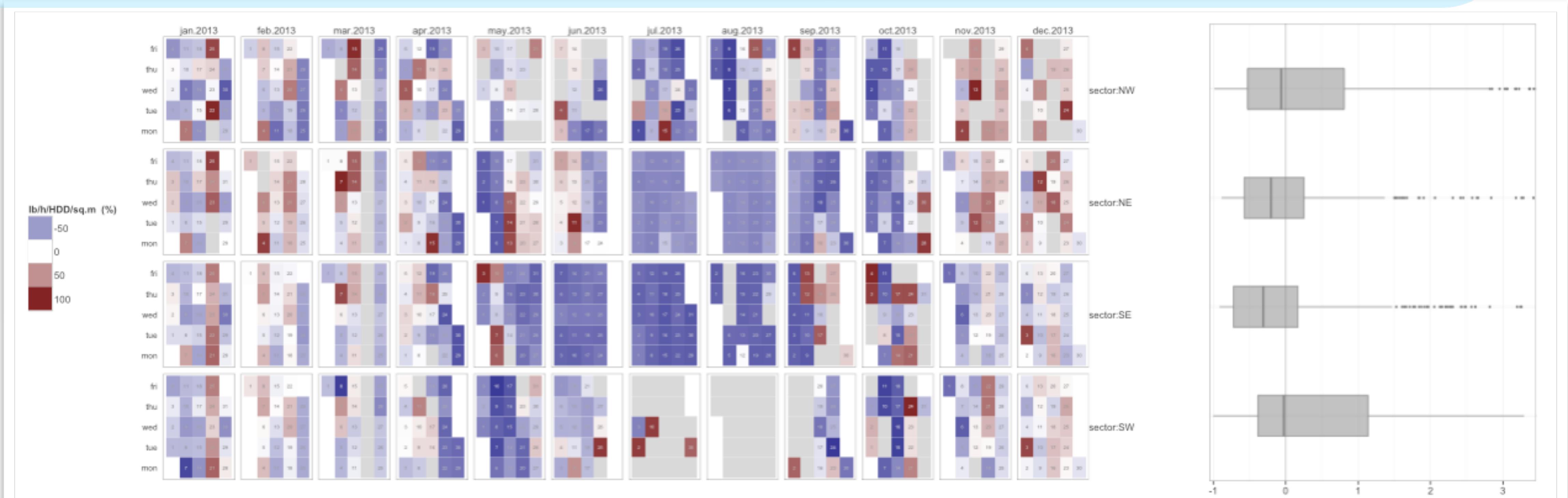


**Q:** If rapidly-developed “data sketches” serve to explore the space of visual encoding design, is there an analogous way to develop “interaction sketches” with real underlying data that serve to explore the space of possible interactive workflows?



# Perspective 4: Design Study

## Open Questions

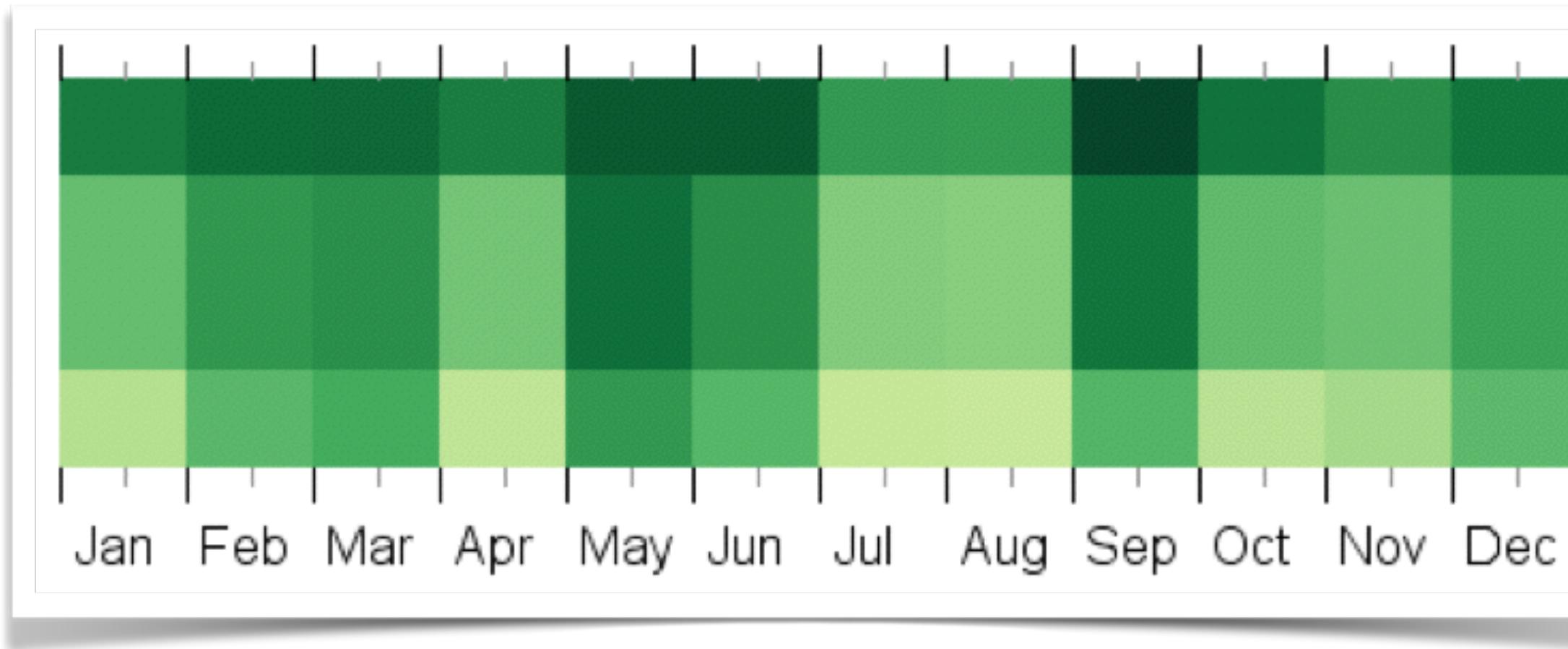


*Q: do effective combinations of visual encoding and interaction techniques exist for facilitating multiple simultaneous comparisons of statistical summaries and time-varying values?*

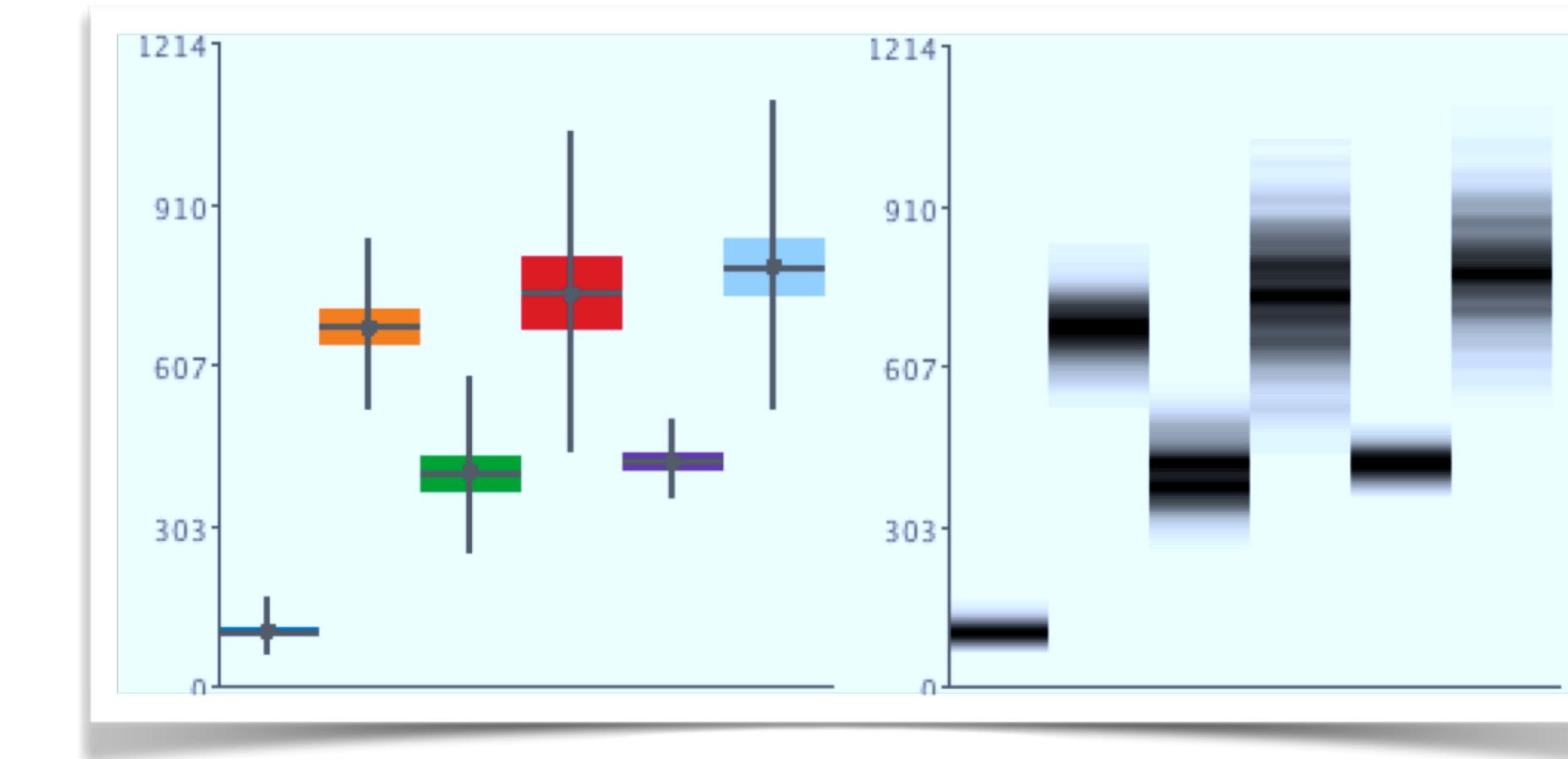


# Perspective 4: Design Study

## Open Questions



Albers et al. Proc. CHI '14



Booshehrian et al. Proc. EuroVis '12

*Q: do effective combinations of visual encoding and interaction techniques exist for facilitating multiple simultaneous comparisons of statistical summaries and time-varying values?*

# Cross-Cutting Questions

A question for you to keep in the back of your mind while I continue this talk is the question of how we as visualization practitioners can apply and validate this contribution.

how do we effectively study the adoption and use of deployed systems in the field?

One of the discussion points of this paper is the relationship between task characterization and different forms of evaluation, and I'd like to hear your feedback on how to strengthen and highlight these relationships in future paper submissions. OR: From the interview study perspective: How can emphasize the importance of task characterization for evaluation?

Q: do effective combinations of visual encoding and interaction techniques exist for facilitating multiple simultaneous comparisons of statistical summaries and time-varying values?

However, with novel visual encodings I'm running into problems of visualization legacy bias and domain convention, and visualization literacy issues in general. I'm curious to hear about what you think with respect to this issue.

Q: If rapidly-developed "data sketches" serve to explore the space of visual encoding design, is there an analogous way to develop "interaction sketches" with real underlying data that serve to explore the space of possible interactive workflows?

I like design studies. How can I do design study-flavoured work in industry?

