User Tasks & Analysis

CS 7450 - Information Visualization

October 3, 2016

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Learning Objectives

- Understand the importance of tasks, goals, and objectives for visualization
- Identify the common "low-level" tasks for visualizations
- Identify important "high-level" tasks for visualizations
- Understand the components of a successful design study

What for?

- In order to build better visualizations, we need to understand what people might use them for
  - What tasks do they want to accomplish?

An Example

- search vs. browsing

- Value of Vis day (coming up):
  - Exploratory data analysis
  - Identifying better questions
  - Understanding, awareness, context, trust

Browsing vs. Search

- Important difference in activities
- Appears that information visualization may have more to offer to browsing

- But…browsing is a softer, fuzzier activity
- So, how do we articulate utility?
  - Maybe describe when it's useful
  - When is browsing useful?

Browsing

- Useful when
  - Good underlying structure so that items close to one another can be inferred to be similar
  - Users are unfamiliar with collection contents
  - Users have limited understanding of how system is organized and prefer less cognitively loaded method of exploration
  - Users have difficulty verbalizing underlying information need
  - Information is easier to recognize than describe

Lin '97

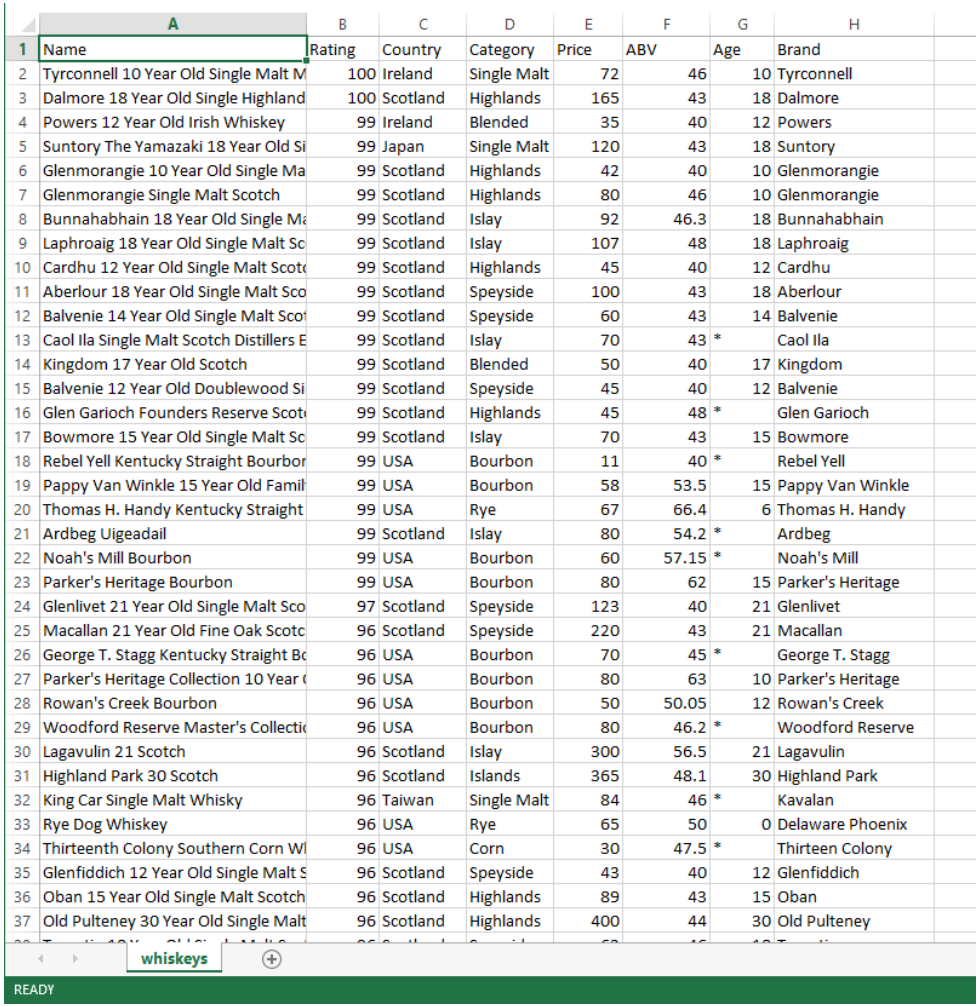
Thought

- Maybe infovis isn't about answering questions or solving problems… hmmm
- Maybe it's about asking better questions

Tasks

- OK, but browsing and search are very high level
- Let's be more specific…

Challenge



	A	B	C	D	E	F	G	H
1	Name	Rating	Country	Category	Price	ABV	Age	Brand
2	Tyrconnell 10 Year Old Single Malt M	100	Ireland	Single Malt	72	46	10	Tyrconnell
3	Dalmore 18 Year Old Single Highland	100	Scotland	Highlands	165	43	18	Dalmore
4	Powers 12 Year Old Irish Whiskey	99	Ireland	Blended	35	40	12	Powers
5	Suntory The Yamazaki 18 Year Old Si	99	Japan	Single Malt	120	43	18	Suntory
6	Glenmorangie 10 Year Old Single Ma	99	Scotland	Highlands	42	40	10	Glenmorangie
7	Glenmorangie Single Malt Scotch	99	Scotland	Highlands	80	46	10	Glenmorangie
8	Bunnahabhain 18 Year Old Single Ma	99	Scotland	Islay	92	46.3	18	Bunnahabhain
9	Laphroaig 18 Year Old Single Malt Sc	99	Scotland	Islay	107	48	18	Laphroaig
10	Cardhu 12 Year Old Single Malt Scot	99	Scotland	Highlands	45	40	12	Cardhu
11	Aberlour 18 Year Old Single Malt Sco	99	Scotland	Speyside	100	43	18	Aberlour
12	Balvenie 14 Year Old Single Malt Scot	99	Scotland	Speyside	60	43	14	Balvenie
13	Caol Ila Single Malt Scotch Distillers E	99	Scotland	Islay	70	43	*	Caol Ila
14	Kingdom 17 Year Old Scotch	99	Scotland	Blended	50	40	17	Kingdom
15	Balvenie 12 Year Old Doublewood Si	99	Scotland	Speyside	45	40	12	Balvenie
16	Glen Garioch Founders Reserve Scot	99	Scotland	Highlands	45	48	*	Glen Garioch
17	Bowmore 15 Year Old Single Malt Sc	99	Scotland	Islay	70	43	15	Bowmore
18	Rebel Yell Kentucky Straight Bourbor	99	USA	Bourbon	11	40	*	Rebel Yell
19	Pappy Van Winkle 15 Year Old Famil	99	USA	Bourbon	58	53.5	15	Pappy Van Winkle
20	Thomas H. Handy Kentucky Straight	99	USA	Rye	67	66.4	6	Thomas H. Handy
21	Ardbeg Uigeadail	99	Scotland	Islay	80	54.2	*	Ardbeg
22	Noah's Mill Bourbon	99	USA	Bourbon	60	57.15	*	Noah's Mill
23	Parker's Heritage Bourbon	99	USA	Bourbon	80	62	15	Parker's Heritage
24	Glenlivet 21 Year Old Single Malt Sco	97	Scotland	Speyside	123	40	21	Glenlivet
25	Macallan 21 Year Old Fine Oak Scotc	96	Scotland	Speyside	220	43	21	Macallan
26	George T. Stagg Kentucky Straight Bc	96	USA	Bourbon	70	45	*	George T. Stagg
27	Parker's Heritage Collection 10 Year (	96	USA	Bourbon	80	63	10	Parker's Heritage
28	Rowan's Creek Bourbon	96	USA	Bourbon	50	50.05	12	Rowan's Creek
29	Woodford Reserve Master's Collectic	96	USA	Bourbon	80	46.2	*	Woodford Reserve
30	Lagavulin 21 Scotch	96	Scotland	Islay	300	56.5	21	Lagavulin
31	Highland Park 30 Scotch	96	Scotland	Islands	365	48.1	30	Highland Park
32	King Car Single Malt Whisky	96	Taiwan	Single Malt	84	46	*	Kavalan
33	Rye Dog Whiskey	96	USA	Rye	65	50	0	Delaware Phoenix
34	Thirteenth Colony Southern Corn Wl	96	USA	Corn	30	47.5	*	Thirteen Colony
35	Glenfiddich 12 Year Old Single Malt S	96	Scotland	Speyside	43	40	12	Glenfiddich
36	Oban 15 Year Old Single Malt Scotch	96	Scotland	Highlands	89	43	15	Oban
37	Old Pulteney 30 Year Old Single Malt	96	Scotland	Highlands	400	44	30	Old Pulteney

whiskeys

READY

Whiskeys

Come up with analytic queries, tasks, goals…

Follow-on

- What are the (types of) tasks being done here?
  - Abstract away the domain
- Can you think of others?

Task Taxonomies

- Number of different ones exist, important to understand what process they focus on
  - Creating an artifact
  - Human tasks
  - Tasks using visualization system
  - …

User Tasks

- Wehrend & Lewis created a low-level, domain independent taxonomy of user tasks in visualization environments
- Eleven basic actions
  - identify, locate, distinguish, categorize, cluster, distribution, rank, compare within relations, compare between relations, associate, correlate

Wehrend & Lewis
Vis '90

Another Perspective

- Shneiderman proposed task × data type taxonomy to understand what people do with visualization
- Mantra: "Overview first, zoom and filter, then details on demand"
  - Design paradigm for infovis systems

Shneiderman
VL '96

Taxonomy

- Data Types
  1. 1D
  2. 2D
  3. 3D
  4. Temporal
  5. ND
  6. Tree
  7. Network
- Tasks
  1. Overview
  2. Zoom
  3. Filter
  4. Details-on-demand
  5. Relate
  6. History
  7. Extract

Another Task Taxonomy

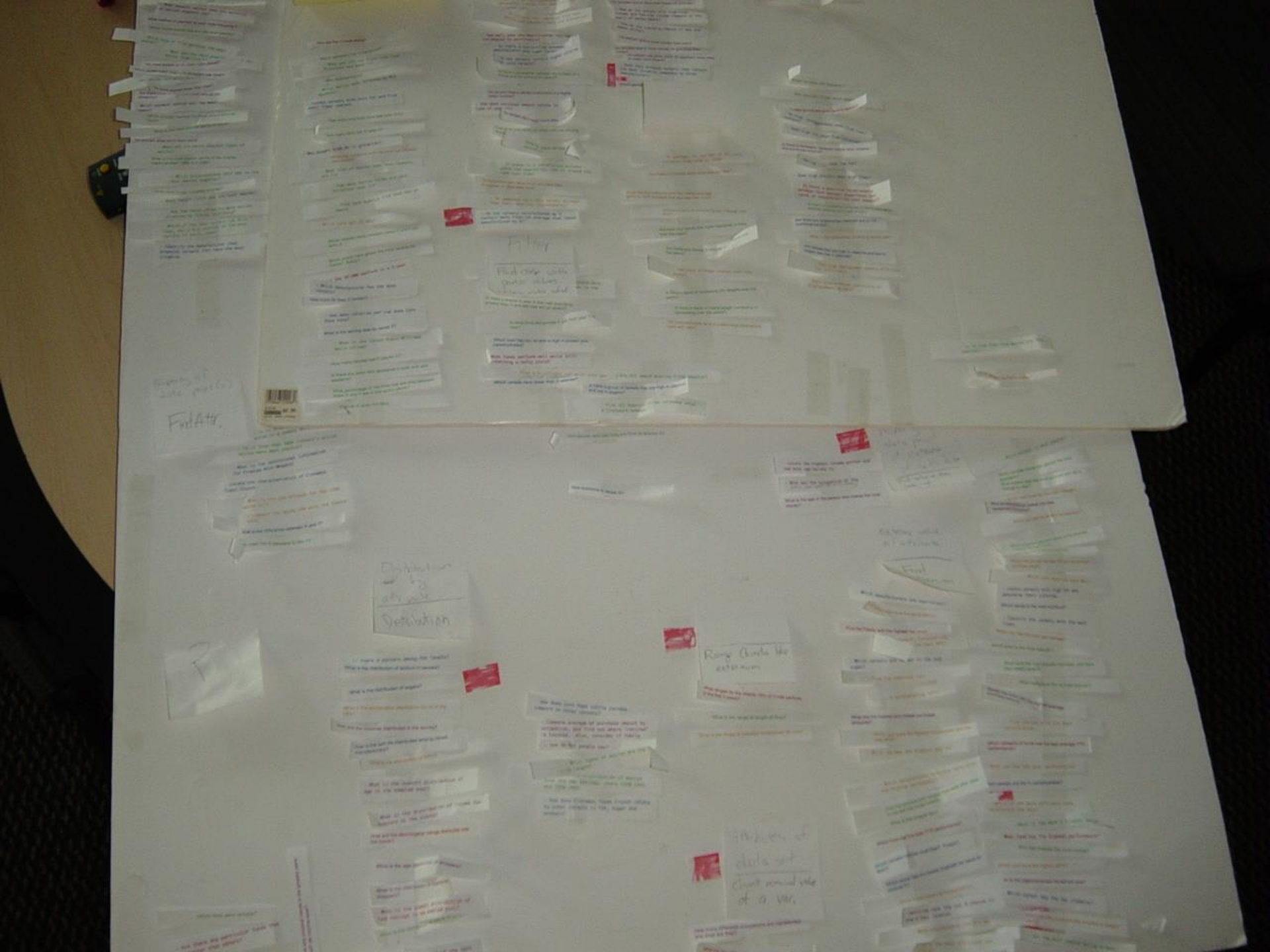
- Amar, Eagan, & Stasko – InfoVis ’05

Background

- Use "commercial tools" class assignment from this class
- Students generate questions to be answered using commercial infovis systems
- Data sets:

Domain	Data cases	Attributes	Questions Generated
Cereals	78	15	107
Mutual funds	987	14	41
Cars	407	10	153
Films	1742	10	169
Grocery surveys	5164	8	126

- Generated 596 total analysis tasks



extreme value of attribute

Find extremum

Range (kinda like extremum)

- Which manufacturers are healthiest?

Do the heaviest cars have the worst MPG?

Find the Fidelity with the highest net asset

Japanese, European and have the best MPG?

- Which cereals ... west in fat and sugar?

- Find the heaviest car.

... 5 accelerating cars.

What ranges do the middle 75% of funds perform in the first 3 years?

What is the range of length of films?

What is the range of possible horsepower for cars?

What are the highest and lowest purchase amounts?

Which cars have the highest horsepower and the best MPG?

- Which car has the biggest engine?

- Which manufacturer has the cars with the highest horsepower?

Find the shortest and longest films made after year X that are not music videos.

What is the longest film?

Which is the ... movie in the ...

What is the car ... and lower weig...

- Which ...

- Locate cereals ... determine their ...

Which cereal is the ...

- Identify the ... fiber.

Which car has the best ...

Which actor is the most pop...

What were the most p... they mostly recent?

What category ...

Identify the chain with the highest a... purchase amount.

- Find the car with ... acceleration.

Which category of funds has the be... performance?

- What car has the best accele...

Which cereals are low in carbohydrates...

Which of the more efficient ... accelerate the best?


SAVE
Please do not erase
Computed meta-value
Outliers
Categorical Correlation
Correlation
Browse
Filter
Extremum
Count
Range
Sort
Organizational operations
(filter, cluster, categ.)
vs.
transformation ops
(avg, count, ...)
1-1
n-1
find extremum
look-up value(s)
(find entity)
Simple Comparison
Distribution
Clustering
aggregate
Filter
Cluster
Categorize
What is the car w/ highest MPG?
What director has won the most awards?
What film has release date ↑?
What Robin Williams film has release date ↑?
→ case(s) at extreme of range of attr(s)
→ What is mpg of Audi TT?
→ How long is Gone w/ Wind?
→ Given case(s), what are some attributes?
→ compare scalar values
→ compare the avg MPG of American and Japanese cars.
→ What kelloggs cereals have >3g fiber?
→ What comedies have won awards?
→ mapping from attr → case(s)
→ What funds underperformed S&P 500?
How many films are 127 mins long?
How many manufacturers of cars are there?
→ Find cardinality of set of cases
→ Extremum of a set of numerics
→ What mfg has largest # of cereals?
→ Who starred in most films in 1978?
→ correlation of 2 numeric attributes?
→ Is there a correlation between CARBS and fat?
→ Are newer films more popular?
→ Loosely guided exploration of data.
→ Do any variables correlate w/ fat?
→ Are there trends across countries or all yrs?
→ range of an attribute in a set of cases
→ What is the range of the length of films?
→ What is the range of horsepower of cars?
→ order a set of cases by some metric
→ Order the cars by weight
→ Rank the cereals by calories
→ Characterization of distribution of an attribute over set of cases
→ What is the distribution of carbs in cereals?
→ What is age distribution of shoppers?
→ Find clusters of attribute values in a set of cases
→ Are there groups of cereals w/ similar fat/cal/sugar?
→ Is there a cluster of typical film lengths
trend vs. correlate
yee!
extreme num

Terminology

- *Data case* – An entity in the data set
- *Attribute* – A value measured for all data cases
- *Aggregation function* – A function that creates a numeric representation for a set of data cases (eg, average, count, sum)

1. Retrieve Value

General Description:

Given a set of specific cases, find attributes of those cases.

Examples:

- What is the mileage per gallon of the Audi TT?
- How long is the movie Gone with the Wind?

2. Filter

General Description:

Given some concrete conditions on attribute values,
find data cases satisfying those conditions.

Examples:

- What Kellogg's cereals have high fiber?
- What comedies have won awards?
- Which funds underperformed the SP-500?

3. Compute Derived Value

General Description:

Given a set of data cases, compute an aggregate numeric representation of those data cases.

Examples:

- What is the gross income of all stores combined?
- How many manufacturers of cars are there?
- What is the average calorie content of Post cereals?

4. Find Extremum

General Description:

Find data cases possessing an extreme value of an attribute over its range within the data set.

Examples:

- What is the car with the highest MPG?
- What director/film has won the most awards?
- What Robin Williams film has the most recent release date?

5. Sort

General Description:

Given a set of data cases, rank them according to some ordinal metric.

Examples:

- Order the cars by weight.
- Rank the cereals by calories.

6. Determine Range

General Description:

Given a set of data cases and an attribute of interest, find the span of values within the set.

Examples:

- What is the range of film lengths?
- What is the range of car horsepowers?
- What actresses are in the data set?

7. Characterize Distribution

General Description:

Given a set of data cases and a quantitative attribute of interest, characterize the distribution of that attribute's values over the set.

Examples:

- What is the distribution of carbohydrates in cereals?
- What is the age distribution of shoppers?

8. Find Anomalies

General Description:

Identify any anomalies within a given set of data cases with respect to a given relationship or expectation, e.g. statistical outliers.

Examples:

- Are there any outliers in protein?
- Are there exceptions to the relationship between horsepower and acceleration?

9. Cluster

General Description:

Given a set of data cases, find clusters of similar attribute values.

Examples:

- Are there groups of cereals w/ similar fat/calories/sugar?
- Is there a cluster of typical film lengths?

10. Correlate

General Description:

Given a set of data cases and two attributes, determine useful relationships between the values of those attributes.

Examples:

- Is there a correlation between carbohydrates and fat?
- Is there a correlation between country of origin and MPG?
- Do different genders have a preferred payment method?
- Is there a trend of increasing film length over the years?

Discussion/Reflection

- Compound tasks
  - "Sort the cereal manufacturers by average fat content"

    Compute derived value; Sort

  - "Which actors have co-starred with Julia Roberts?"

    Filter; Retrieve value

Discussion/Reflection

- What questions were left out?
  - Basic math
    "Which cereal has more sugar, Cheerios or Special K?"
    "Compare the average MPG of American and Japanese cars."
  - Uncertain criteria
    "Does cereal (X, Y, Z…) sound tasty?"
    "What are the characteristics of the most valued customers?"
  - Higher-level tasks
    "How do mutual funds get rated?"
    "Are there car aspects that Toyota has concentrated on?"
  - More qualitative comparison
    "How does the Toyota RAV4 compare to the Honda CRV?"
    "What other cereals are most similar to Trix?"

Concerns/Limitations

- InfoVis tools may have influenced students' questions
- Graduate students as group being studied
  - How about professional analysts?
- Subjective – Not an exact science
- Data was really quantitative so may get a different set of tasks for relational/graph data
  - See Lee et al, BELIV '06

Contributions

- Set of grounded low-level analysis tasks
- Potential use of tasks as a language/vocabulary for comparing and evaluating infovis systems

Another Perspective

- Taxonomy proposed
- "…used specifically for multidimensional visualizations, taking into account the generic objectives that a user has when using such techniques to perform exploratory analyses as a previous step of statistical analysis."

Valiati et al
BELIV '06

Task Taxonomy

- 7 tasks in 2 categories
  - User goals
    - Identify – Find, discover new information
    - Determine – Calculate, define a precise value
    - Compare – Compare data & values
    - Infer – Infer knowledge, generate hypotheses
    - Locate – Search and identify information
  - Intermediate level tasks to support analysis
    - Visualize – Represent the data a certain way
    - Configure – Normalize, filter, reorder, etc.

More Details

- Each task has "parameters"
  - Identify
    - clusters
    - correlations
    - categories
    - properties
    - patterns
    - characteristics
    - thresholds
    - similarities
    - differences
    - dependencies
    - uncertainties
    - variations

Interaction

- User goals and tasks carried out through interaction with visualization
  - The interactive dialog helps people explore

Interaction Framework

- Organized along *user intent*
- 7 categories
  - Select
  - Explore
  - Reconfigure
  - Encode
  - Abstract/elaborate
  - Filter
  - Connect

We saw this earlier

Yi et al
TVCG '07

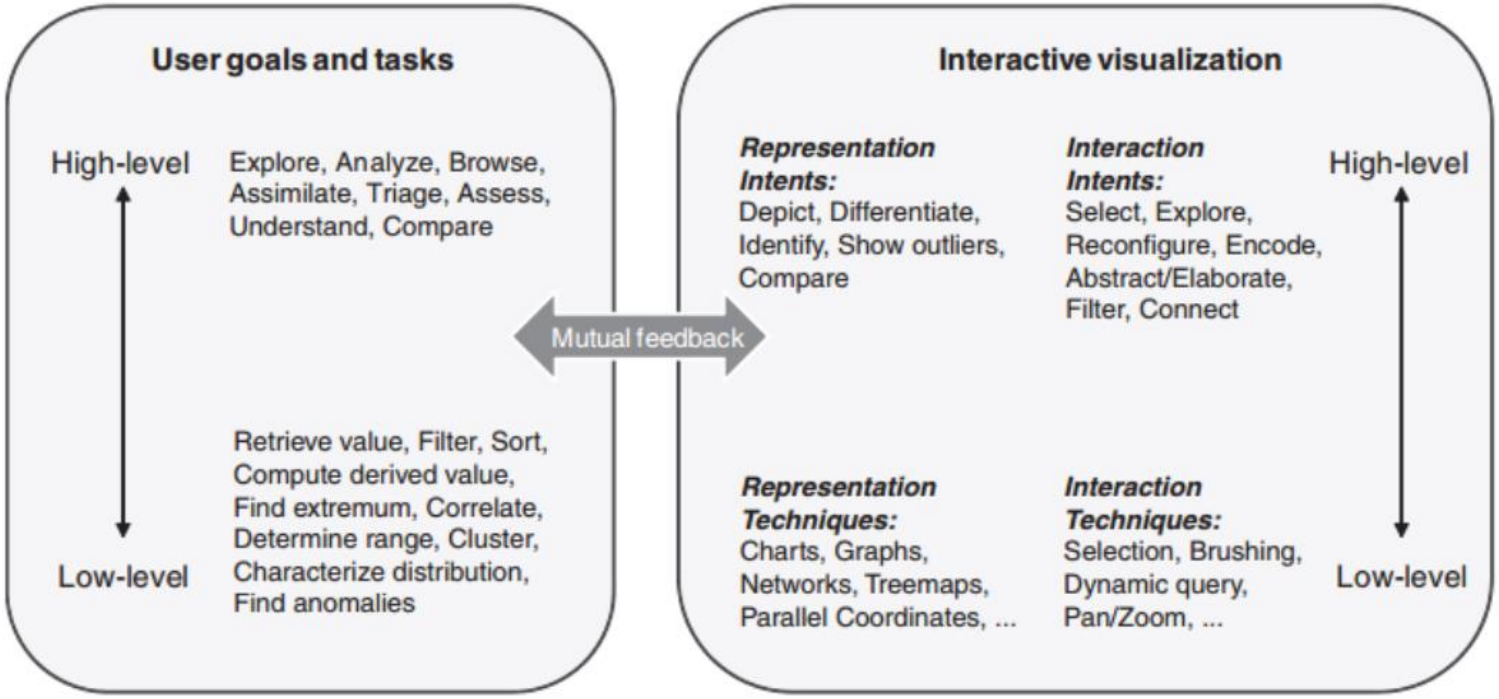
Interactive Dynamics

- "taxonomy of interactive dynamics that contribute to successful analytic dialogues"
  - part interaction, part task

Data and View Specification	**Visualize** data by choosing visual encodings.
	Filter out data to focus on relevant items.
	Sort items to expose patterns.
	Derive values or models from source data.
View Manipulation	**Select** items to highlight, filter, or manipulate them.
	Navigate to examine high-level patterns and low-level detail.
	Coordinate views for linked, multidimensional exploration.
	Organize multiple windows and workspaces.
Process and Provenance	**Record** analysis histories for revisitation, review, and sharing.
	Annotate patterns to document findings.
	Share views and annotations to enable collaboration.
	Guide users through analysis tasks or stories.

Heer & Shneiderman
CACM '12

A Science of Interaction



Blend of interaction and tasks

Pike, Stasko, Chang, O'Connell
Information Visualization '08

Abstract Tasks

Framework/Typology of abstract visualization tasks

2376 IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS, VOL 19, NO. 12, DECEMBER 2013

A Multi-Level Typology of Abstract Visualization Tasks

Matthew Brehmer and Tamara Munzner, *Member, IEEE*

Abstract—The considerable previous work characterizing visualization usage has focused on low-level tasks or interactions and high-level tasks, leaving a gap between them that is not addressed. This gap leads to a lack of distinction between the ends and means of a task, limiting the potential for rigorous analysis. We contribute a multi-level typology of visualization tasks to address this gap, distinguishing *why* and *how* a visualization task is performed, as well as *what* the task inputs and outputs are. Our typology allows complex tasks to be expressed as sequences of interdependent simpler tasks, resulting in concise and flexible descriptions for tasks of varying complexity and scope. It provides abstract rather than domain-specific descriptions of tasks, so that useful comparisons can be made between visualization systems targeted at different application domains. This descriptive power supports a level of analysis required for the generation of new designs, by guiding the translation of domain-specific problems into abstract tasks, and for the qualitative evaluation of visualization usage. We demonstrate the benefits of our approach in a detailed case study, comparing task descriptions from our typology to those derived from related work. We also discuss the similarities and differences between our typology and over two dozen extant classification systems and theoretical frameworks from the literatures of visualization, human-computer interaction, information retrieval, communications, and cartography.

Index Terms—Typology, visualization models, task and requirements analysis, qualitative evaluation

1 Introduction

Consider a person who encounters a choropleth map while reading a blog post in the aftermath of last year's American presidential election. This particular map is static and visually encodes two attributes, candidate and margin of victory, encoded for each state using a bivariate colour mapping. This person decides to compare the election results of Texas to those of California, motivated not by an explicit need to generate or verify some hypothesis, nor by a need to present the visualization to an audience, but rather by a casual interest in American politics and its two most populous states. How might we describe this person's *task* in an abstract rather than domain-specific way?

According to the nested model for visualization design and validation [43], abstract tasks are domain- and interface-agnostic operations performed by users. Disappointingly, there is little agreement as to the appropriate granularity of an abstract task among the many extant classifications of user behaviour in the visualization, human-computer interaction, cartography, and information retrieval literature [2, 3, 5, 10, 11, 12, 13, 14, 15, 19, 23, 29, 31, 37, 39, 42, 50, 51, 56, 57, 59, 61, 64, 66, 72, 73, 75, 78, 82, 83]. One of the most frequently cited of these [2] would classify the above example as being a series of value retrieval tasks. This low-level characterization does not describe the user's context or motivation; nor does take into account prior experience and background knowledge. For instance, a description of this task might differ if the user was unfamiliar with American geography; the user must locate and identify these states before comparing their values. Conversely, high-level descriptions of exploratory data analysis and presentation emanating from the sensemaking literature [3, 11, 31, 51] cannot aptly describe this user's task.

The gap between low-level and high-level classification leaves us unable to abstractly describe user tasks in a useful way [41], even for the simple static visualization in the above example. This gap widens when interactive visualization is considered, and the complexity of its usage is compounded over time. We must move beyond describing a single task in isolation, to a description that designates when one task ends and another begins. To close this gap, visualization tasks must be describable in an abstract way across multiple levels.

The primary contribution of this paper is a multi-level typology of abstract visualization tasks that unites the previously disconnected scopes of low-level and high-level classification systems by proposing multiple levels of linkage between them. Our typology provides a powerful and flexible way to describe complex tasks as a sequence of interdependent simpler ones. While this typology is very much informed by previous work, it is also the result of new thinking and has many points of divergence with previous models. Central to the organization of our typology are three questions that serve to disambiguate the means and ends of a task: *why* the task is performed, *how* the task is performed, and *what* are the task's inputs and outputs. We have found that no prior characterization of tasks satisfactorily answers all of these questions simultaneously at multiple levels of abstraction. Typically, low-level classification systems provide a sense of *how* a task is performed, but not *why*; high-level classification systems are the converse. One major advantage of our typology over prior work is in providing linkage between these two questions. Another advantage is the ability to link sequences of tasks, made possible by the consideration of *what* tasks operate on.

Our typology provides a consistent lexicon for description that supports making precise comparisons of tasks between different visualization tools and across application domains. Succinct and abstract descriptions of tasks are crucial for analysis of visualization usage. This analysis is an essential precursor to the effective design and evaluation of visualization tools, particularly in the context of problem-driven design studies [60]. In these studies, visualization practitioners work with users to identify *why* and *what*, subsequently drawing from their specialized knowledge of visual encoding and interaction techniques to design *how* that task is to be supported [41]. A need for task analysis also arises in visualization evaluation [34], particularly in observational studies of open-ended visualization usage. Our typology provides a multi-level code set for qualitatively describing user behaviour in such studies.

As we expect some readers to be unfamiliar with the context that motivated this work, we begin with a brief discussion of our current inability to succinctly describe and analyze visualization tasks. In Section 3 of this paper, we introduce our multi-level typology of abstract visualization tasks. In Section 4, we demonstrate the benefits of our approach with a detailed case study, in which we describe a sequence of interdependent tasks. In Section 5, we summarize our typology's connections to related work and to its theoretical foundations. In Section 6, we discuss the value and usage of this typology, as well as our plans for its further validation and extension. In Section 7, we offer our concluding remarks.

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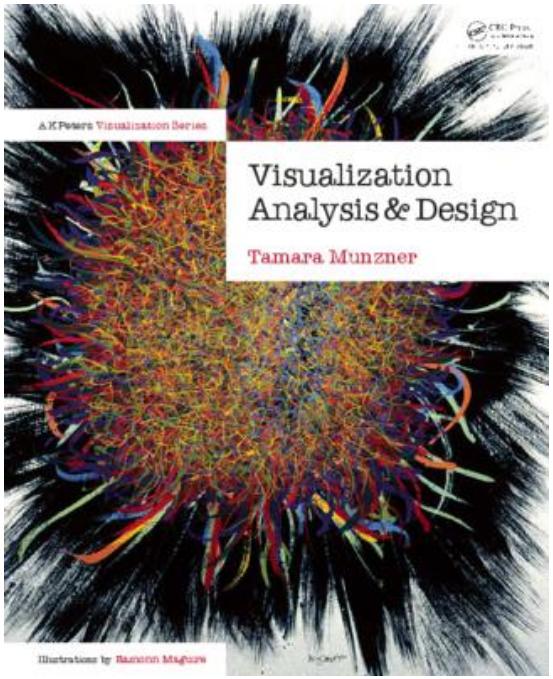
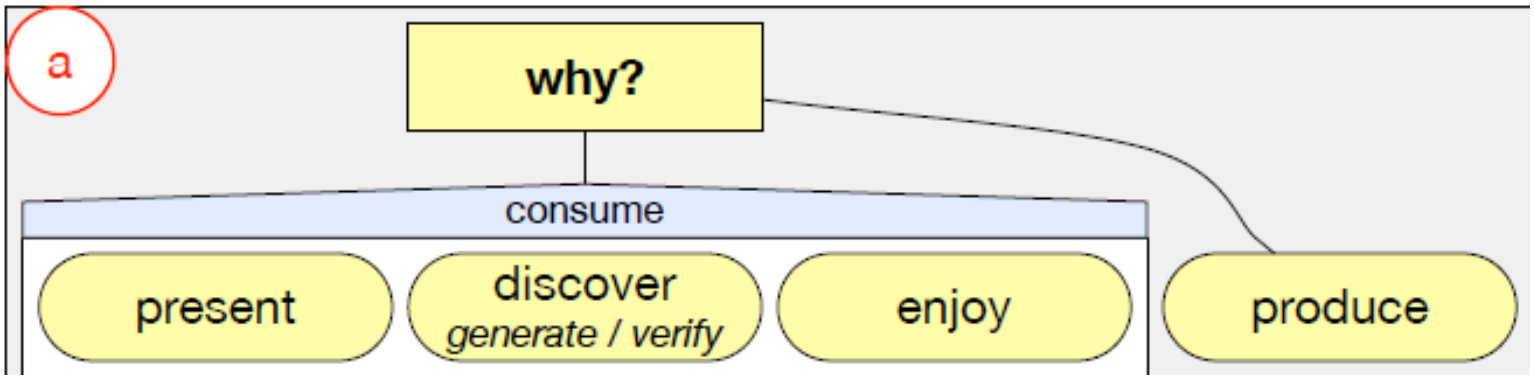
Brehmer & Munzner
TVCG (InfoVis) '13



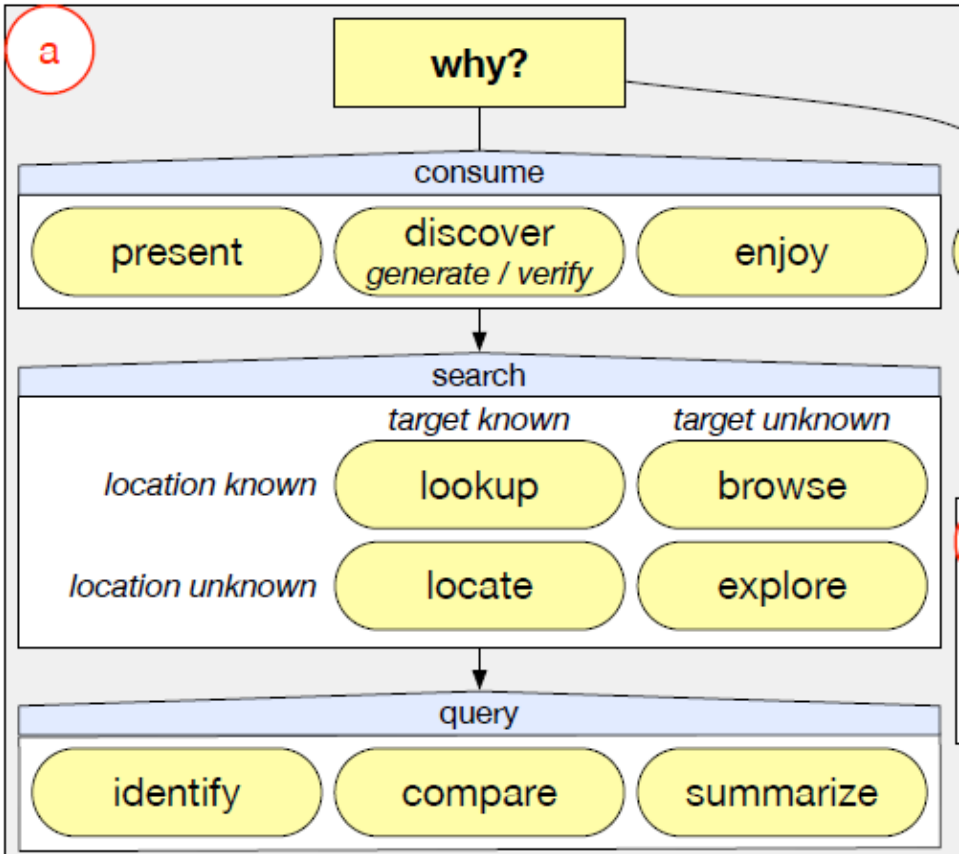
Chapter 3

Why?

What are the top-level categories (answers) to the "Why?" question?

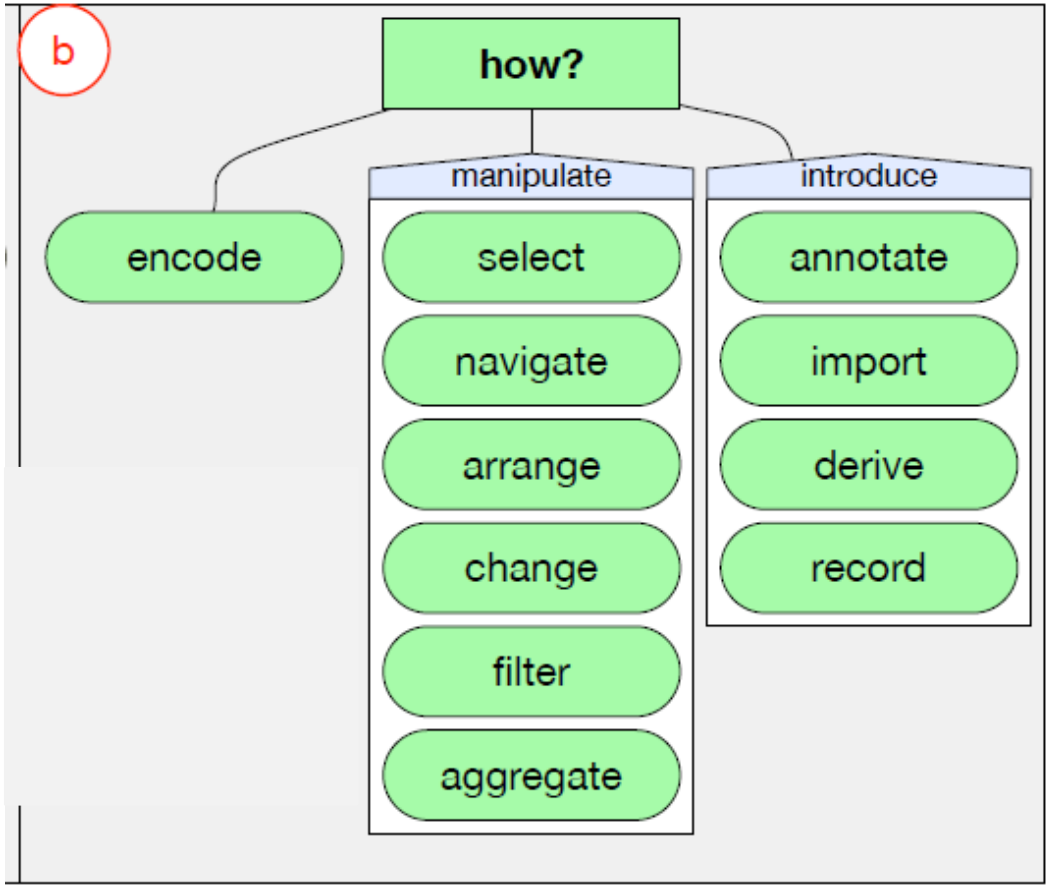


Discover



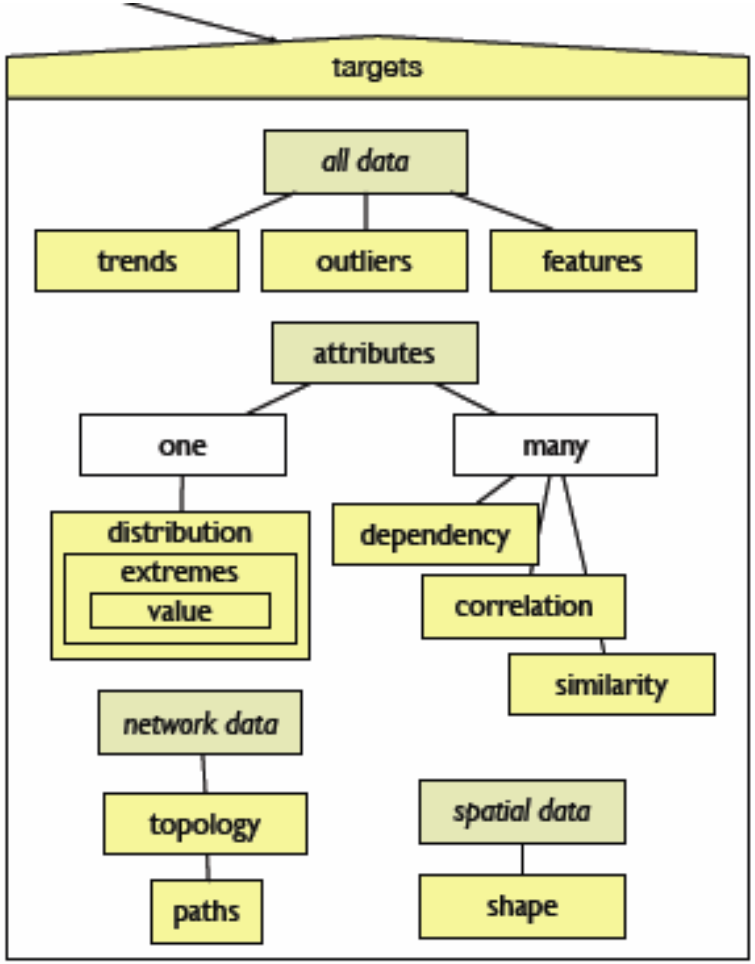
High to low level

How?

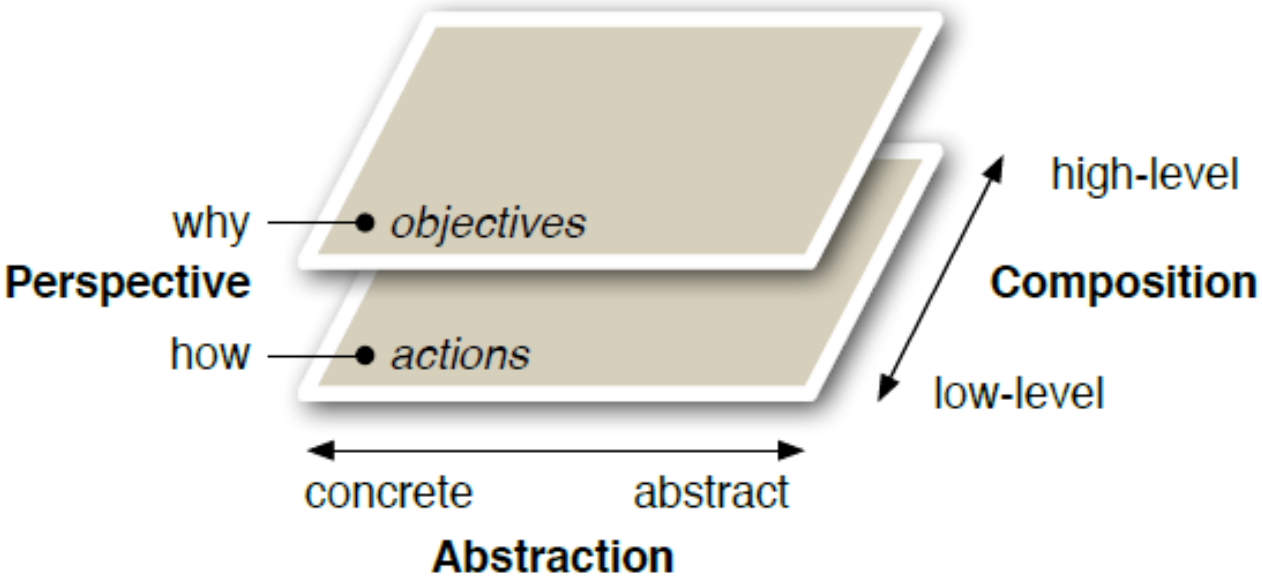

b
how?
manipulate
introduce
encode
select
navigate
arrange
change
filter
aggregate
annotate
import
derive
record

Targets

What are the types of targets?

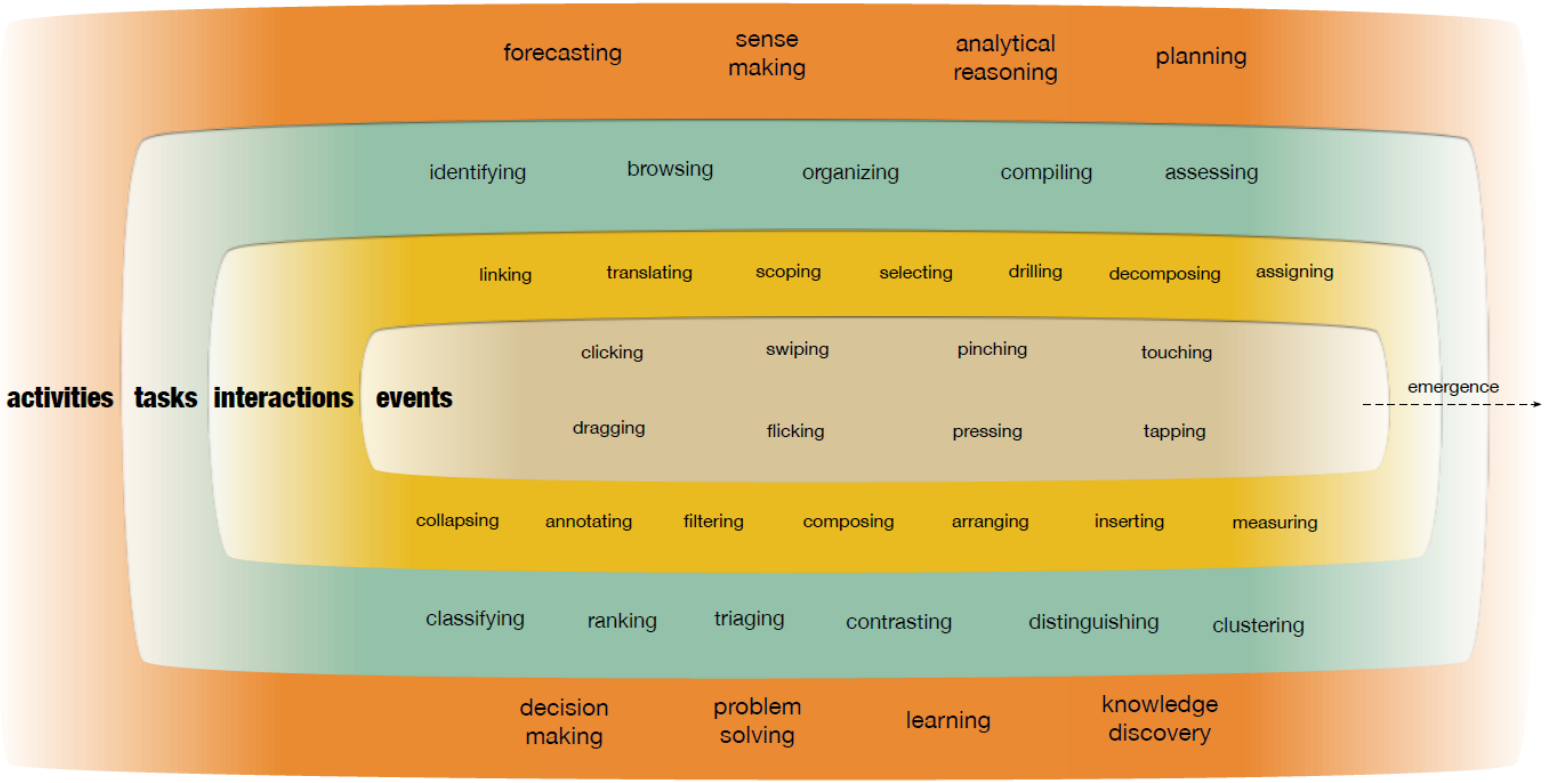


Task Cube



Rind et al
Information Visualization '15

Visual Analytic Activity



Sedig, Parsons, Babanski
JMPT '12

Another Question?

- Are the visualizations helping with exploratory analysis enough?
- Are they attempting to accomplish the right goals?

Status Quo Limitations

- Current Information Visualization systems inadequately support decision making:
  - Limited Affordances
  - Predetermined Representations
  - Decline of Determinism in Decision-Making

- "Representational primacy" versus "Analytic primacy"

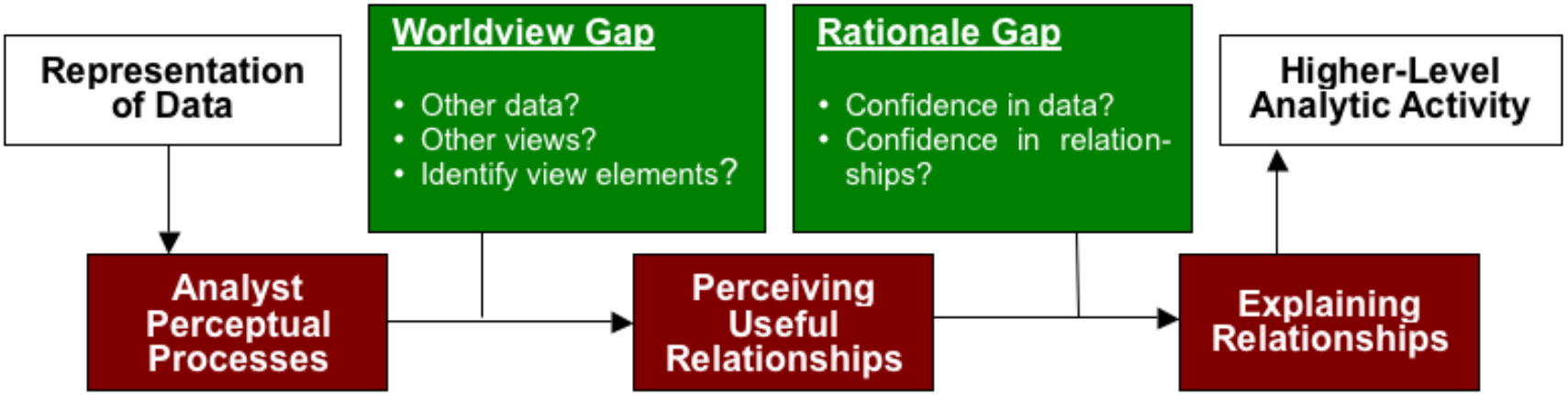
Amar & Stasko
TVCG '05

Goal: High-Level Tasks

- Complex decision-making, especially under uncertainty
- Learning a domain
- Identifying the nature of trends
- Predicting the future
- …

Analytic Gaps

- Analytic gaps – "obstacles faced by visualizations in facilitating higher-level analytic tasks, such as decision making and learning."
  - Worldview Gap
  - Rationale Gap



Knowledge Precepts

- For narrowing these gaps
  - Worldview-Based Precepts ("Did we show the right thing to the user?")
    - Determine Domain Parameters
    - Expose Multivariate Explanation
    - Facilitate Hypothesis Testing
  - Rationale-Based Precepts ("Will the user believe what they see?")
    - Expose Uncertainty
    - Concretize Relationships
    - Expose Cause and Effect

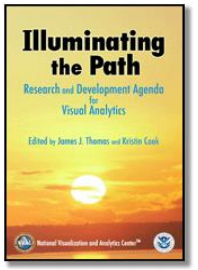
Put Them Together

- Combine the ideas:
  - Use computational, statistical analysis more
  - Cater to the user's analytic reasoning needs
- And put together with infovis

- Leads to…

Visual Analytics

- "The science of analytical reasoning facilitated by interactive visual interfaces"
- Combines
  - Data analysis
  - Infovis
  - Analytical reasoning
- Grew from view that infovis was neglecting these other aspects
  - True?



Thomas & Cook
Illuminating the Path

Visual Analytics

- Grew from stimulus in the homeland security area
  - Need for better data analysis methods
  - Really big data
- Topic for later in term…

Related Detour

- Your projects are "design studies"
  - Problem-driven visualization research
  - Assist clients with data who want to understand it better
  - Design and build visualization system
- How do you do it well?

Design Study Methodology: Reflections from the Trenches and the Stacks

Michael Sedlmair, *Member, IEEE*, Miriah Meyer, *Member, IEEE*, and Tamara Munzner, *Member, IEEE*

Abstract—Design studies are an increasingly popular form of problem-driven visualization research, yet there is little guidance available about how to do them effectively. In this paper we reflect on our combined experience of conducting twenty-one design studies, as well as reading and reviewing many more, and on an extensive literature review of other field work methods and methodologies. Based on this foundation we provide definitions, propose a methodological framework, and provide practical guidance for conducting design studies. We define a design study as a project in which visualization researchers analyze a specific real-world problem faced by domain experts, design a visualization system that supports solving this problem, validate the design, and reflect about lessons learned in order to refine visualization design guidelines. We characterize two axes—a *task clarity axis* from fuzzy to crisp and an *information location axis* from the domain expert's head to the computer—and use these axes to reason about design study contributions, their suitability, and uniqueness from other approaches. The proposed methodological framework consists of 9 stages: *learn*, *winnow*, *cast*, *discover*, *design*, *implement*, *deploy*, *reflect*, and *write*. For each stage we provide practical guidance and outline potential pitfalls. We also conducted an extensive literature survey of related methodological approaches that involve a significant amount of qualitative field work, and compare design study methodology to that of ethnography, grounded theory, and action research.

Index Terms—Design study, methodology, visualization, framework.

1 Introduction

Over the last decade design studies have become an increasingly popular approach for conducting problem-driven visualization research. Design study papers are explicitly welcomed at several visualization venues as a way to explore the choices made when applying visualization techniques to a particular application area [55], and many exemplary design studies now exist [17, 34, 35, 56, 94]. A careful reading of these papers reveals multiple steps in the process of conducting a design study, including analyzing the problem, abstracting data and tasks, designing and implementing a visualization solution, evaluating the solution with real users, and writing up the findings.

And yet there is a lack of specific guidance in the visualization literature that describes holistic methodological approaches for conducting design studies—currently only three paragraphs exist [49, 55]. The relevant literature instead focuses on methods for designing [1, 42, 66, 79, 82, 90, 91] and evaluating [13, 33, 39, 50, 68, 69, 76, 80, 85, 86, 95] visualization tools. We distinguish between methods and methodology with the analogy of cooking; *methods* are like ingredients, whereas *methodology* is like a recipe. More formally, we use Crotty's definitions that methods are "techniques or procedures" and a methodology is the "strategy, plan of action, process, or design lying behind the choice and use of particular methods" [18].

From our personal experience we know that the process of conducting a design study is hard to do well and contains many potential of visualization a good idea at all? How should we go about collaborating with experts from other domains? What are pitfalls to avoid? How and when should we write a design study paper? These questions motivated and guided our methodological work and we present a set of answers in this paper.

We conducted an extensive literature review in the fields of human computer interaction (HCI) [7, 8, 9, 12, 16, 19, 20, 21, 22, 25, 26, 27, 28, 29, 30, 31, 38, 47, 57, 63, 64, 65, 83] and social science [6, 14, 18, 24, 32, 62, 81, 87, 93] in hopes of finding methodologies that we could apply directly to design study research. Instead, we found an intellectual territory full of quagmires where the very issues we ourselves struggled with were active subjects of nuanced debate. We did not find any off-the-shelf answers that we consider suitable for wholesale assimilation; after careful gleaning we have synthesized a framing of how the concerns of visualization design studies both align with and differ from several other qualitative approaches.

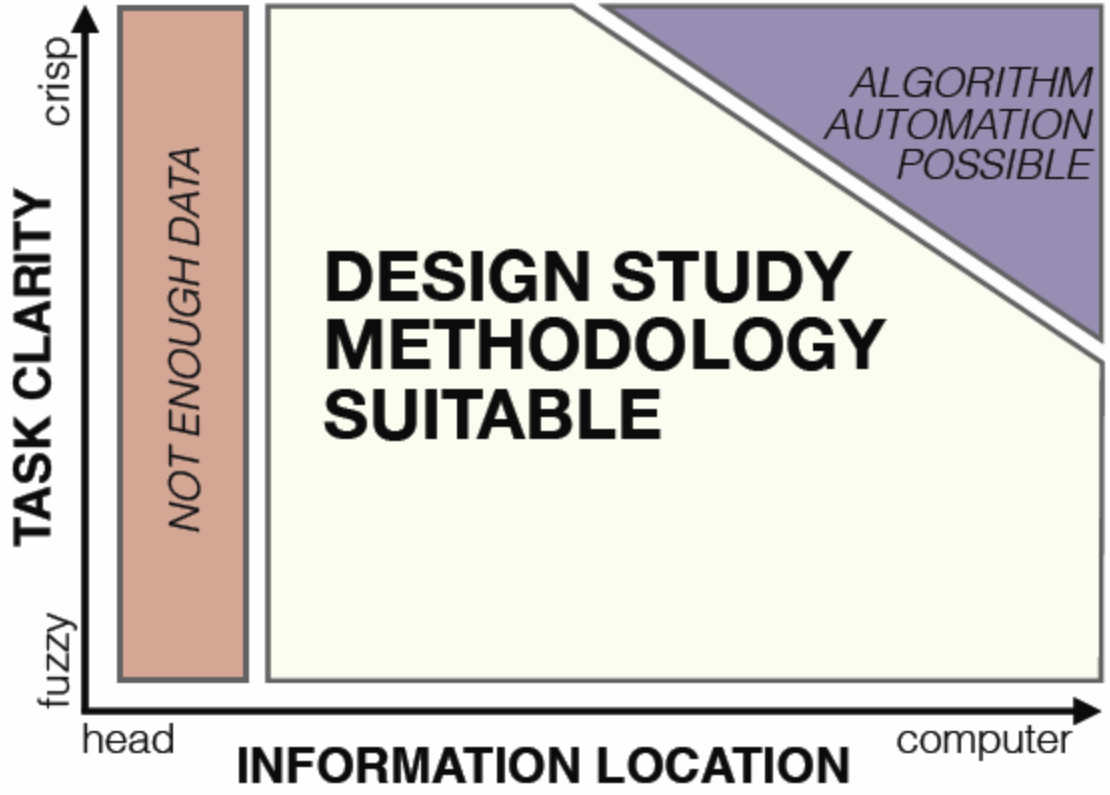
This paper is the result of a careful analysis of both our experiences in the "trenches" while doing our own work, and our foray into the library "stacks" to investigate the ideas of others. We provide, for the first time, a discussion about design study methodology, including a clear definition of design studies as well as practical guidance for conducting them effectively. We articulate two axes, *task clarity* and *information location*, to reason about what contributions design

Reflects on 21 design studies from 3 authors & reviewing others

Definition

- "A design study is a project in which visualization researchers analyze a specific real-world problem faced by domain experts, design a visualization system that supports solving this problem, validate the design, and reflect about lessons learned in order to refine visualization design guidelines."

Problem Suitability



Framework

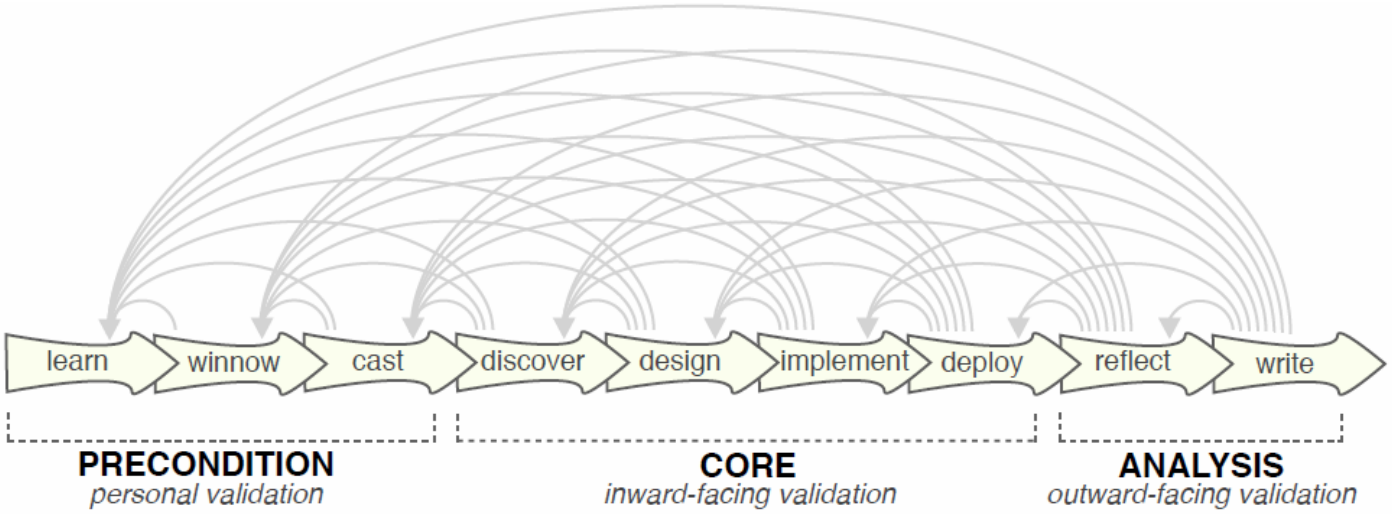


Fig. 2. Nine-stage design study methodology framework classified into three top-level categories. While outlined as a linear process, the overlapping stages and gray arrows imply the iterative dynamics of this process.

Considerations

- Practical
  - Data: Does data exist, is it enough, can you get it?
  - Engagement: How much time do they and you have for the project? How much time can you spend in their environment?
- Intellectual
  - Problem: Is there a vis research question lurking?
  - Need: Is there a real need or are existing approaches good enough?
  - Task: Are you addressing a real task? How long will need persist? How many people care?
- Interpersonal
  - What is your rapport with clients?

Pitfalls

- 32 pitfalls to design study projects listed, organized by framework phase
  - Examples
    - No real data available
    - No need for vis, problem can be automated
    - Nonrapid prototyping
    - Premature and insufficient deployment

Design Project

- Examples

Learning Objectives

- Understand the importance of tasks, goals, and objectives for visualization
- Identify the common "low-level" tasks for visualizations
- Identify important "high-level" tasks for visualizations
- Understand the components of a successful design study

Reading

- Brehmer & Munzner '13

HW 4

- Questions?

- Due next Weds, 12th
  - If you haven't started yet…

Upcoming

- Poster Session

- Fall Break
- Storytelling (don't miss it)

References

- Spence & CMS texts
- All referred to papers