Information Visualization
Midterm Review

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Lect 16, Mar 5 2020

https://www.cs.ubc.ca/~tmm/courses/436V-20

Schedule

- phase change
  - phase 1 done: no more D3 videos, quizzes, programming exercises
  - phase 2 starts: project work
    - Milestone 1 due ~~Friday~~ Saturday (11:59pm)
    - foundations exercises continue in parallel
- schedule shift
  - midterm review & survey today
  - shift to Tuesday:
    - Aggregation 1 lecture
    - Foundations 6 release

Final project marks breakdown

- Final project 30% of total
  - breakdown: M1 15%, M2 35%, M3 50%
  - of total: M1 4.5%, M2 10.5%, M3 15%
- Milestone 1
  - Foundations 60% [Sec 1-5]
  - Project Management 15% [Sec 6]
  - Writeup 25% [overall]
- Milestone 2
  - 80% Programming Achievement
  - 5% Project Management
    - **(see update 3/4)**
  - 15% Writeup
- Milestone 3
  - Programming Achievement 40%
    - includes demo
  - Foundations 40%
  - Writeup 20%

Survey

- mid-semester survey
- anonymous

https://ubc.ca1.qualtrics.com/jfe/form/SV_50zwSEo5DihPzIV

- on socrative, pick true when done

Midterm Review

Midterm material covered

- Topics
  - Intro
  - Data & Task Abstractions
  - Marks & Channels
  - Tables
  - Interactive Views
  - Maps
  - Color
- Assignments
  - F1
  - F2
  - F3
  - F4 (will be returned Wed)

Midterm logistics

- time: 75 min
- materials allowed: one-sided "cheat sheat"
  - one side of 8.5"x11" paper
  - we'll check it when we check your ids
  - no other materials
- bags under desk, phones off and in bag
- do not open exam until told to do so

Midterm scope

- scope: emphasis on foundations material
  - What kind of attribute is X? (categorical, ordinal, quantitative)
  - What kind of dataset is X? (table, network, spatial)
  - What channels are in use in this visual encoding?
  - Map this domain-language description of tasks and data into abstractions
  - Analyze this existing visualizations by breaking down into marks and channels
  - Critique suitability of this existing visual encoding for abstract task+data combination
    - including scalability assessment for #items, #attributes, # levels within an attribute
  - Propose appropriate visual encoding for task+data combination
    - and provide rationale to justify your design choices versus key alternatives

Midterm scope

- scope: emphasis on foundations material
  - How is spatial position being used to arrange data?
    - express values
    - separate, order, align
    - use given spatial data
  - Discuss tradeoffs between major visual encoding choices
    - choropleth vs symbol maps vs cartograms for maps
    - rectilinear vs radial vs parallel layouts

Subtopics

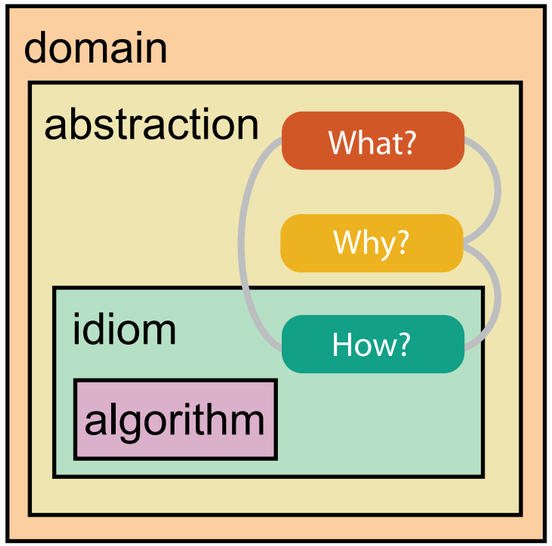
- Nested model
  - four levels: domain, abstraction, idiom, algorithm
- Data
  - items vs attributes
  - attribute types: categorical, ordered, quantitative
  - dataset types: tables, networks, spatial
- Tasks
  - action-target pairs
  - query: one/sum/all
- Marks and Channels
  - channel types (magnitude vs identity)
  - accuracy, discriminability, separability, popout
  - perceptual system mostly operates with relative judgements, not absolute

Subtopics

- Interactive Views
  - selection and highlighting strategies
  - navigation strategies
  - types of multiple views: multiform, overview/detail same encoding, overview/detail multiform, small multiples
  - strengths and weaknesses of juxtapose vs superimpose
  - impact of partitioning strategies
- Color
  - channel characteristics for hue, saturation, value
  - sequential vs diverging for quantitative attributes
  - univariate vs bivariate
  - color deficiency: nature of problem and strategies to address it

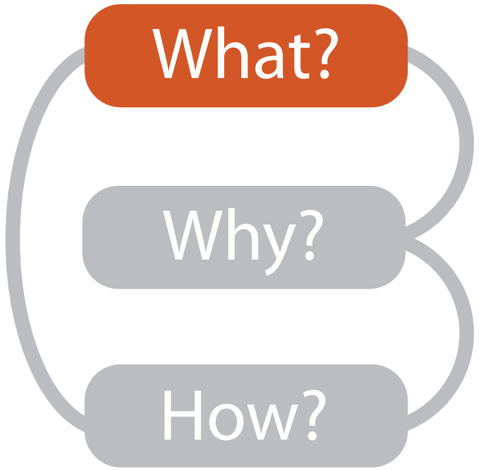
Nested model: Four levels of visualization design

- *domain situation*
  - who are the target users?
- *abstraction*
  - translate from specifics of domain to vocabulary of visualization
    - **what** is shown? **data** abstraction
    - **why** is the user looking at it? **task** abstraction
      - often must transform data, guided by task
- *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).]



What?

Datasets

Data Types

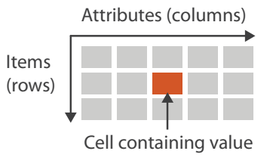
- Items
- Attributes
- Links
- Positions
- Grids

Data and Dataset Types

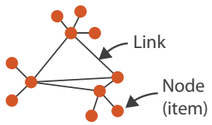
Tables	Networks & Trees	Fields	Geometry	Clusters, Sets, Lists
Items	Items (nodes)	Grids	Items	Items
Attributes	Links	Positions	Positions	
	Attributes	Attributes		

Dataset Types

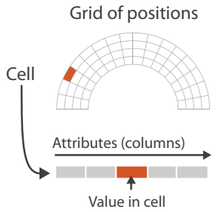
- Tables



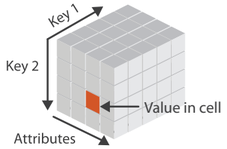
- Networks



- Fields (Continuous)



- *Multidimensional Table*



- *Trees*

- Geometry (Spatial)

Dataset Availability

- Static

- Dynamic

Attributes

Attribute Types

- Categorical

- Ordered
  - *Ordinal*

  - *Quantitative*

Ordering Direction

- Sequential

- Diverging

- Cyclic

Items & Attributes

- item: individual entity, discrete
  - eg patient, car, stock, city
  - "independent variable"
- attribute: property that is measured, observed, logged...
  - eg height, blood pressure for patient
  - eg horsepower, make for car
  - "dependent variable"

attributes: name, age, shirt size, fave fruit

Name	Age	Shirt Size	Favorite Fruit
Amy	8	S	Apple
Basil	7	S	Pear
Clara	9	M	Durian
Desmond	13	L	Elderberry
Ernest	12	L	Peach
Fanny	10	S	Lychee
George	9	M	Orange
Hector	8	L	Loquat
Ida	10	M	Pear
Amy	12	M	Orange

item: person

Attribute types

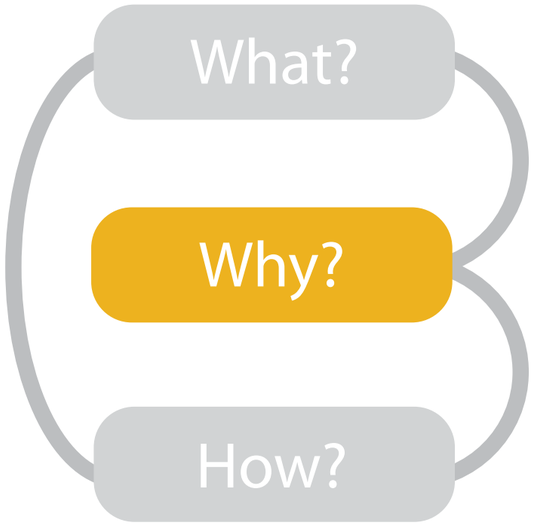
- which classes of values & measurements?
- categorical (nominal)
  - compare equality
  - no implicit ordering
- ordered
  - ordinal
    - less/greater than defined
  - quantitative
    - meaningful magnitude
    - arithmetic possible

Data abstraction: Three operations

- translate from domain-specific language to generic visualization language

- identify dataset type(s), attribute types
- identify cardinality
  - how many items in the dataset?
  - what is cardinality of each attribute?
    - number of levels for categorical data
    - range for quantitative data

- consider whether to transform data
  - guided by understanding of task



- {action, target} pairs
  - *discover distribution*
  - *compare trends*
  - *locate outliers*
  - *browse topology*

Why?

Actions

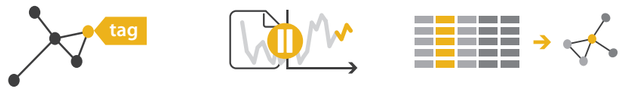
Analyze

→ Consume

→ *Discover* → *Present* → *Enjoy*

→ Produce

→ *Annotate* → *Record* → *Derive*

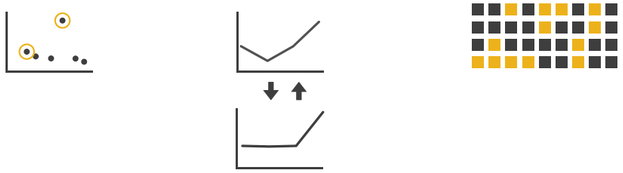


Search

	Target known	Target unknown
Location known	*Lookup*	*Browse*
Location unknown	*Locate*	*Explore*

Query

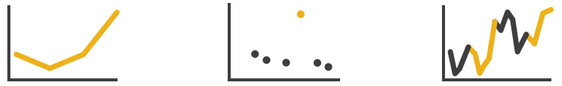
→ Identify → Compare → Summarize



Targets

All Data

→ Trends → Outliers → Features



Attributes

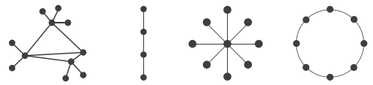
→ One → Many

→ *Distribution* → *Dependency* → *Correlation* → *Similarity*

→ *Extremes*

Network Data

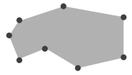
→ Topology

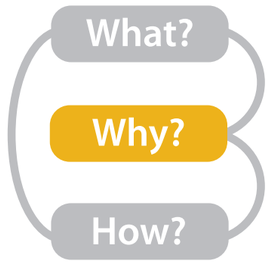


→ *Paths*

Spatial Data

→ Shape

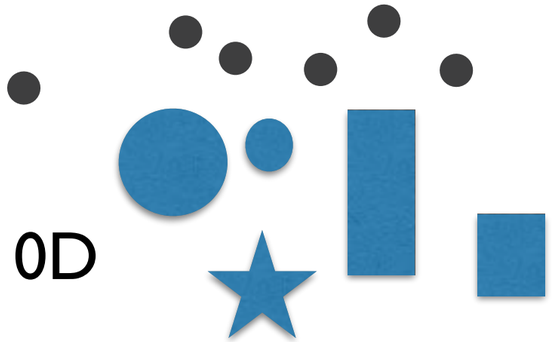




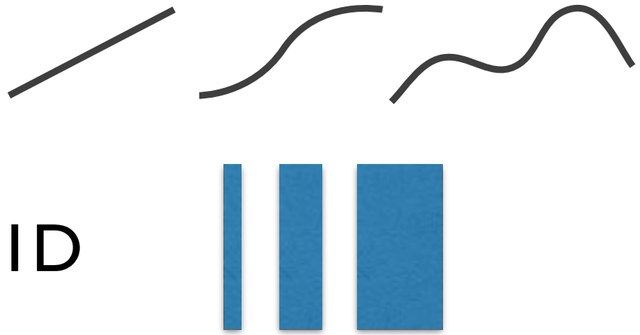
Marks: Constrained vs encodable

- math view: geometric primitives have dimensions

Points → 0D



Lines → 1D

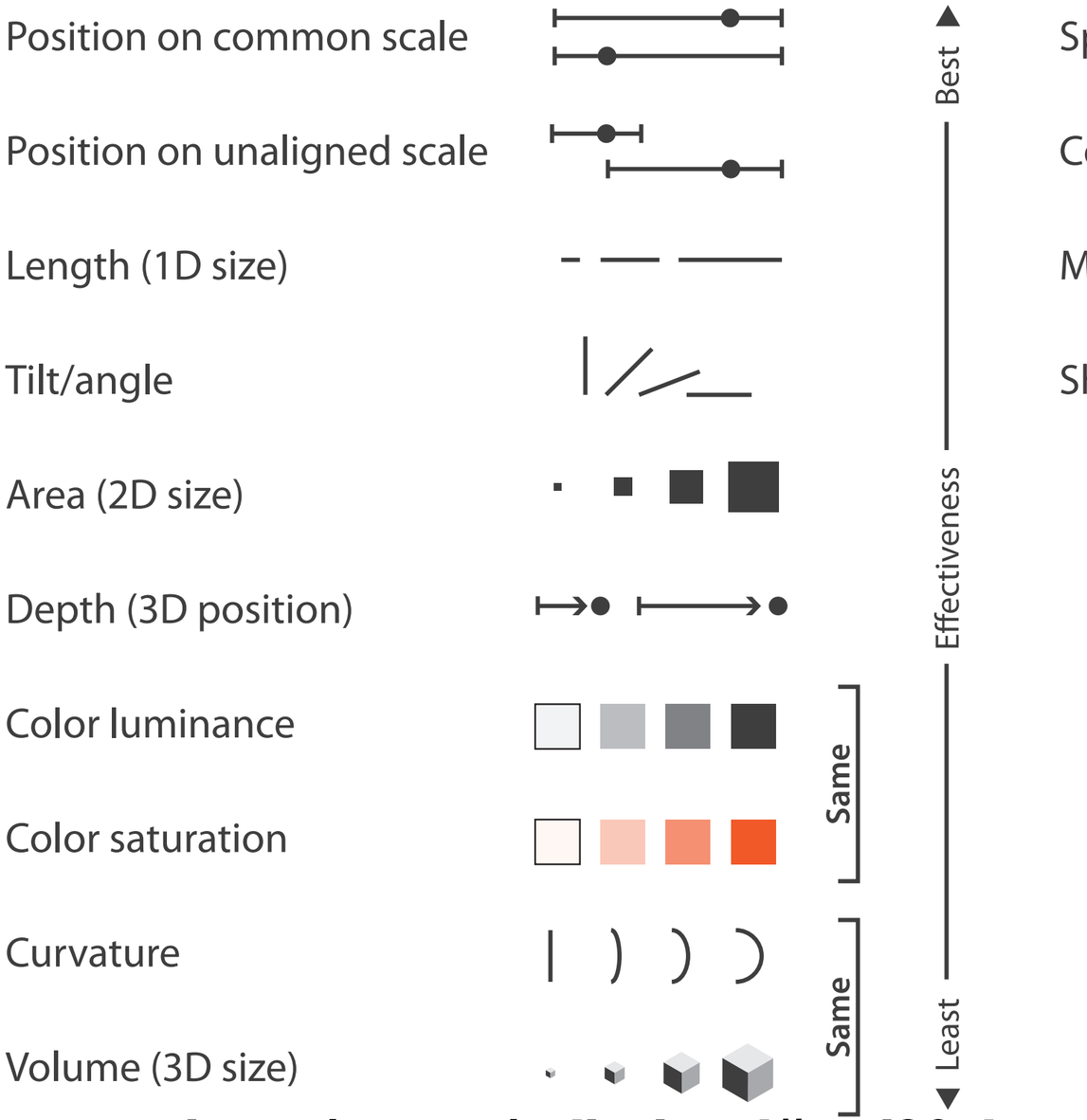


Areas → 2D

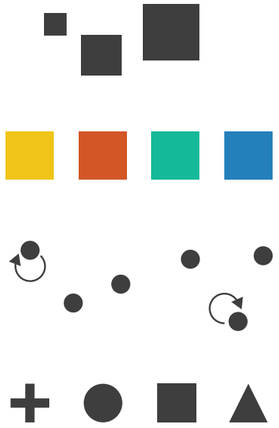
- constraint view: mark type constrains what else can be encoded
  - points: 0 constraints on size, can encode more attributes w/ size & shape
  - lines: 1 constraint on size (length), can still size code other way (width)
  - areas: 2 constraints on size (length/width), cannot size code or shape code
    - interlocking: size, shape, position
- quick check: can you size-code another attribute, or is size/shape in use?

Channels: Rankings

Magnitude Channels: Ordered Attributes



Identity Channels: Categorical Attributes



- expressiveness
  - match channel and data characteristics
- effectiveness
  - channels differ in accuracy of perception
- distinguishability
  - match available levels in channel w/ data

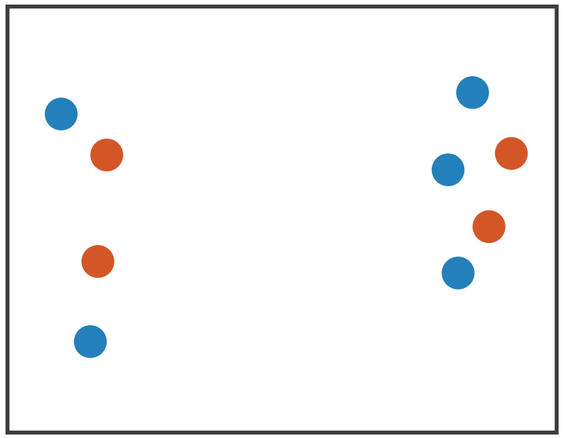
www.cs.ubc.ca/~tmm/talks.html#vad20alum

Channel effectiveness

- accuracy: how precisely can we tell the difference between encoded items?
- discriminability: how many unique steps can we perceive?
- separability: is our ability to use this channel affected by another one?
- popout: can things jump out using this channel?

Separability vs. Integrality

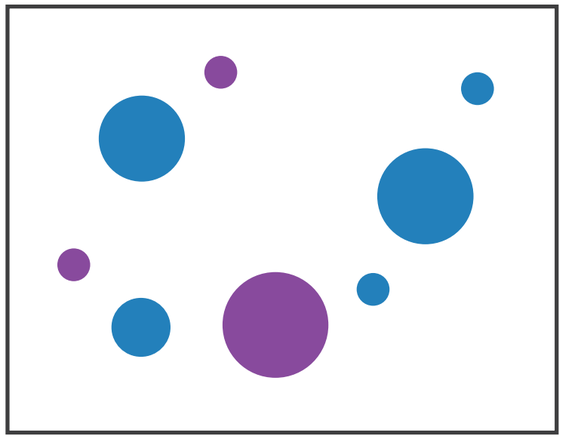
Position
+ Hue (Color)



Fully separable

2 groups each

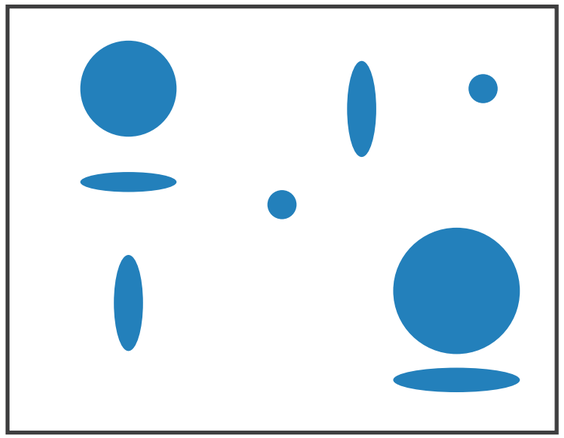
Size
+ Hue (Color)



Some interference

2 groups each

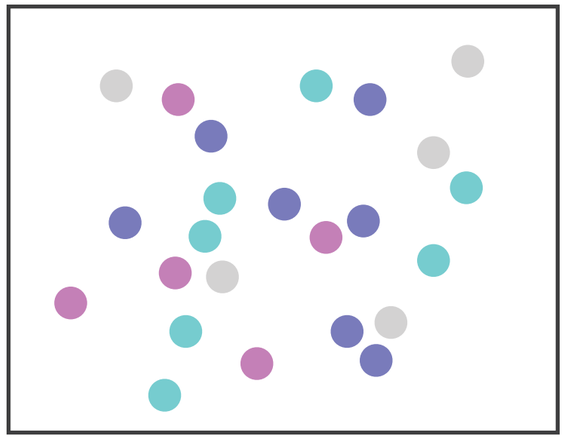
Width
+ Height



Some/significant interference

3 groups total: integral area

Red
+ Green



Major interference

4 groups total: integral hue

Grouping

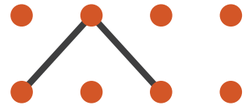
- containment
- connection

- proximity
  - same spatial region
- similarity
  - same values as other categorical channels

Marks as Links

Containment

Connection

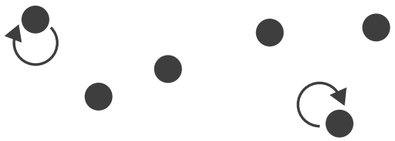


Identity Channels: Categorical Attributes

Spatial region

Color hue

Motion



Shape

How?

Encode

Arrange

- Express
- Separate
- Order
- Align
- Use

Map

from categorical and ordered attributes

- Color
  - *Hue*
  - *Saturation*
  - *Luminance*
- Size, Angle, Curvature, ...
- Shape
- Motion

Direction, Rate, Frequency, ...

Manipulate

- Change
- Select
- Navigate

Facet

- Juxtapose
- Partition
- Superimpose

Reduce

- Filter
- Aggregate
- Embed

What?

Why?

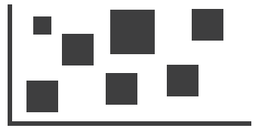
How?

Arrange tables

Express Values

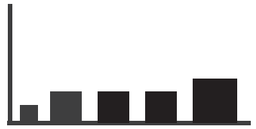
Separate, Order, Align Regions

Separate



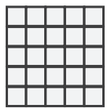
Order

Align



1 Key
List

2 Keys
Matrix

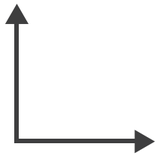


3 Keys
Volume

Many Keys
Recursive Subdivision

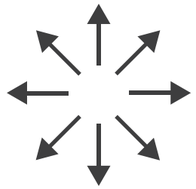
Axis Orientation

Rectilinear



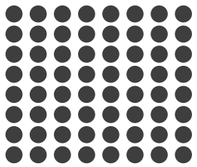
Parallel

Radial



Layout Density

Dense

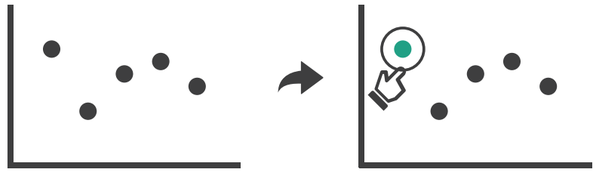


Space-Filling

Manipulate

Change over Time

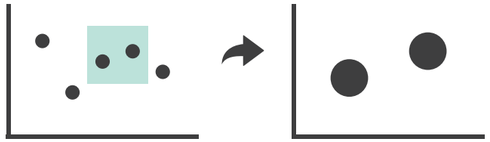
Select



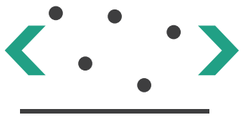
Navigate

Item Reduction

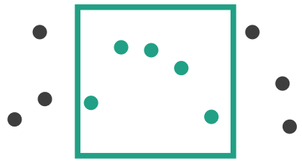
- *Zoom*
  Geometric or *Semantic*



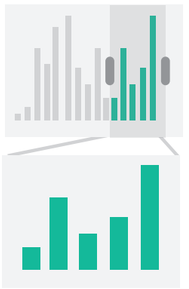
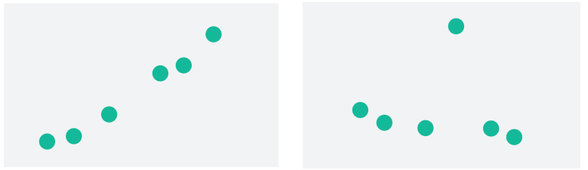
- *Pan/Translate*



- *Constrained*



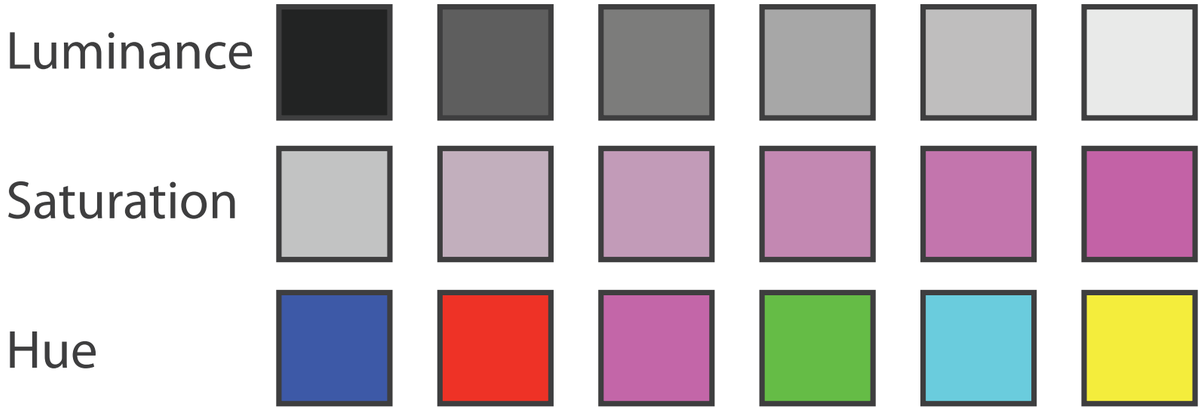
Coordinate views: Design choice interaction

		Data		
		All	Subset	None
Encoding	Same	Redundant	 Same form, Overview/ Detail	 Small Multiples
	Different	 Multiform	 Multiform, Overview/ Detail	No Linkage

Decomposing color

- first rule of color: do not talk about color!
  - color is confusing if treated as monolithic

- decompose into three channels
  - ordered can show magnitude
    - luminance: how bright
    - saturation: how colorful
  - categorical can show identity
    - hue: what color



- channels have different properties
  - what they convey directly to perceptual system
  - how much they can convey: how many discriminable bins can we use?

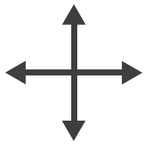
Colormaps

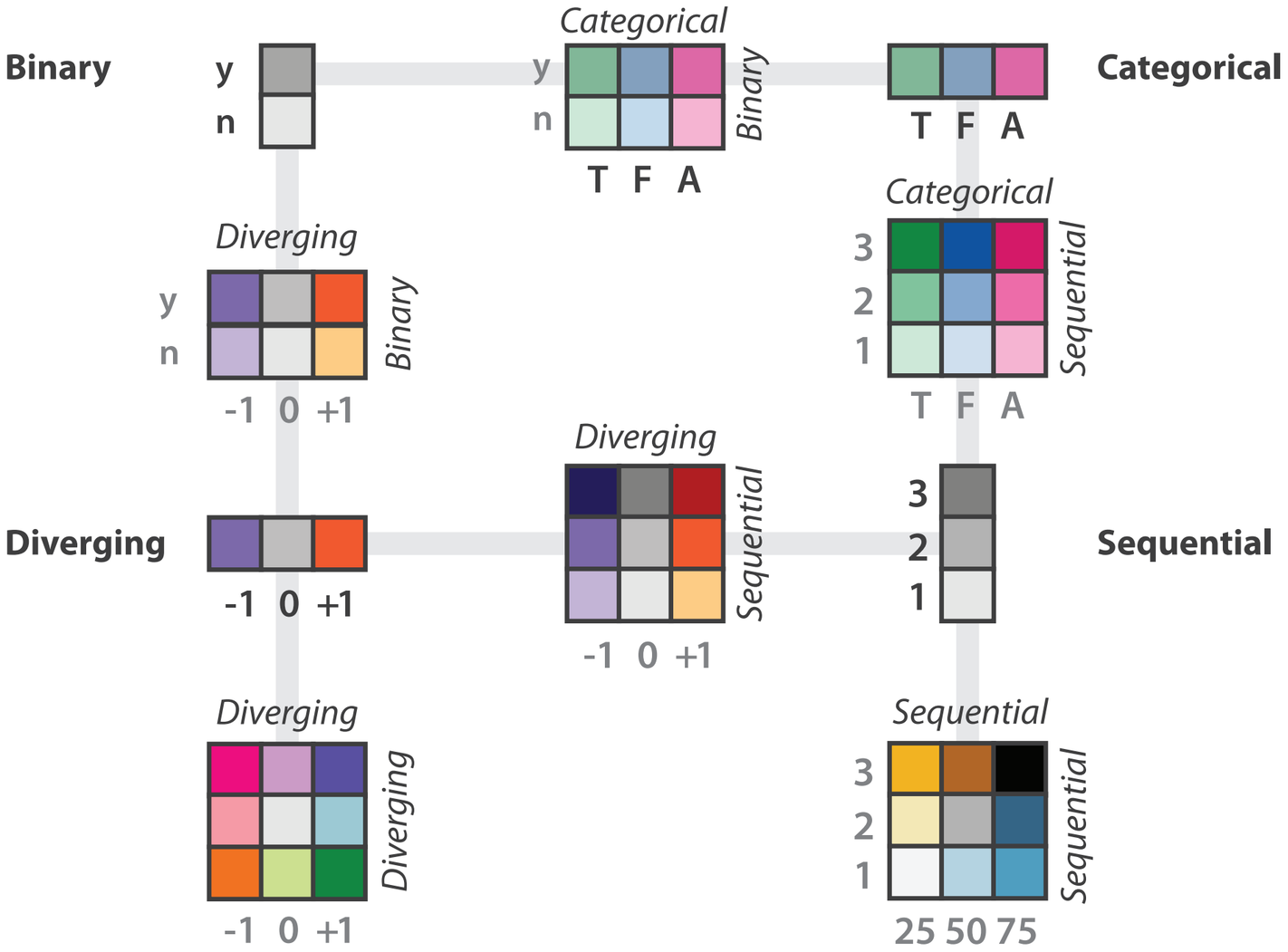
- Categorical

- Ordered
  - *Sequential*

  - *Diverging*

- Bivariate





after [Color Use Guidelines for Mapping and Visualization. Brewer, 1994. http://www.personal.psu.edu/faculty/c/a/cab38/ColorSch/Schemes.html]

How to handle complexity: 4 families of strategies

→ *Derive*

- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view

Manipulate

→ Change

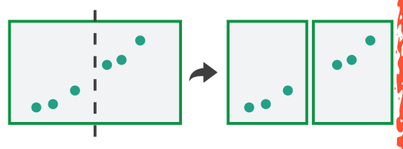
→ Select

→ Navigate

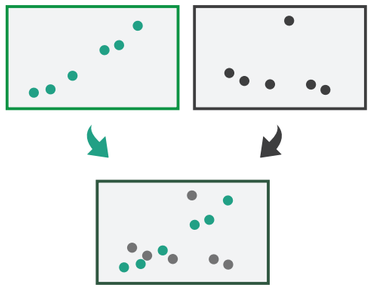
Facet

→ Juxtapose

→ Partition



→ Superimpose



Reduce

→ Filter

→ Aggregate

→ Embed