# Data Visualization as a Driver for Visual Cognition Research

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*Workshop on Object Perception, Attention, and Memory (OPAM) 2017,*
*Interdisciplinary Research Panel: Discover Pasteur's Quadrant: Four research communities that will inspire your work*
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www.cs.ubc.ca/~tmm/talks.html#opam17 @tamaramunzner

# Interleaved structure

- Things I Currently Say TICS
  - that draw on findings from visual cognition about how to visually encode and interact with information

- Things I Wish I Knew TIWIK
  - where I'd love to see the visual cognition community do more work!
    - or to hear that the work exists and get pointers to it

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# We have many…

- **objects** (marks) on the display at once
- **visual channels** in use at the same time
- **views** visible side by side
- **tasks** that users switch between

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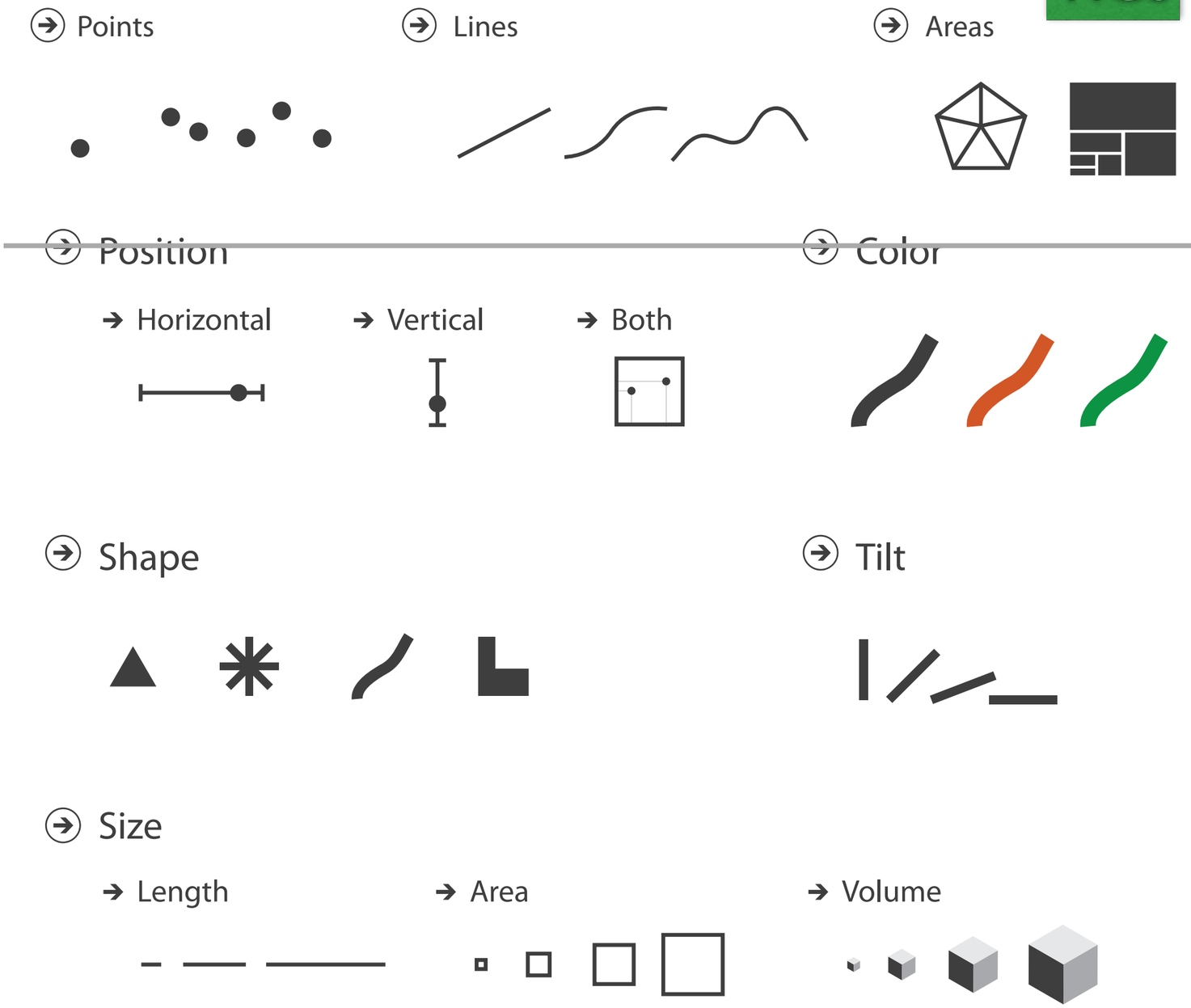
# Objects & channels

- marks (objects)
  - geometric primitives
- channels
  - visual depictions of magnitudes or categories
  - control appearance of marks to convey information

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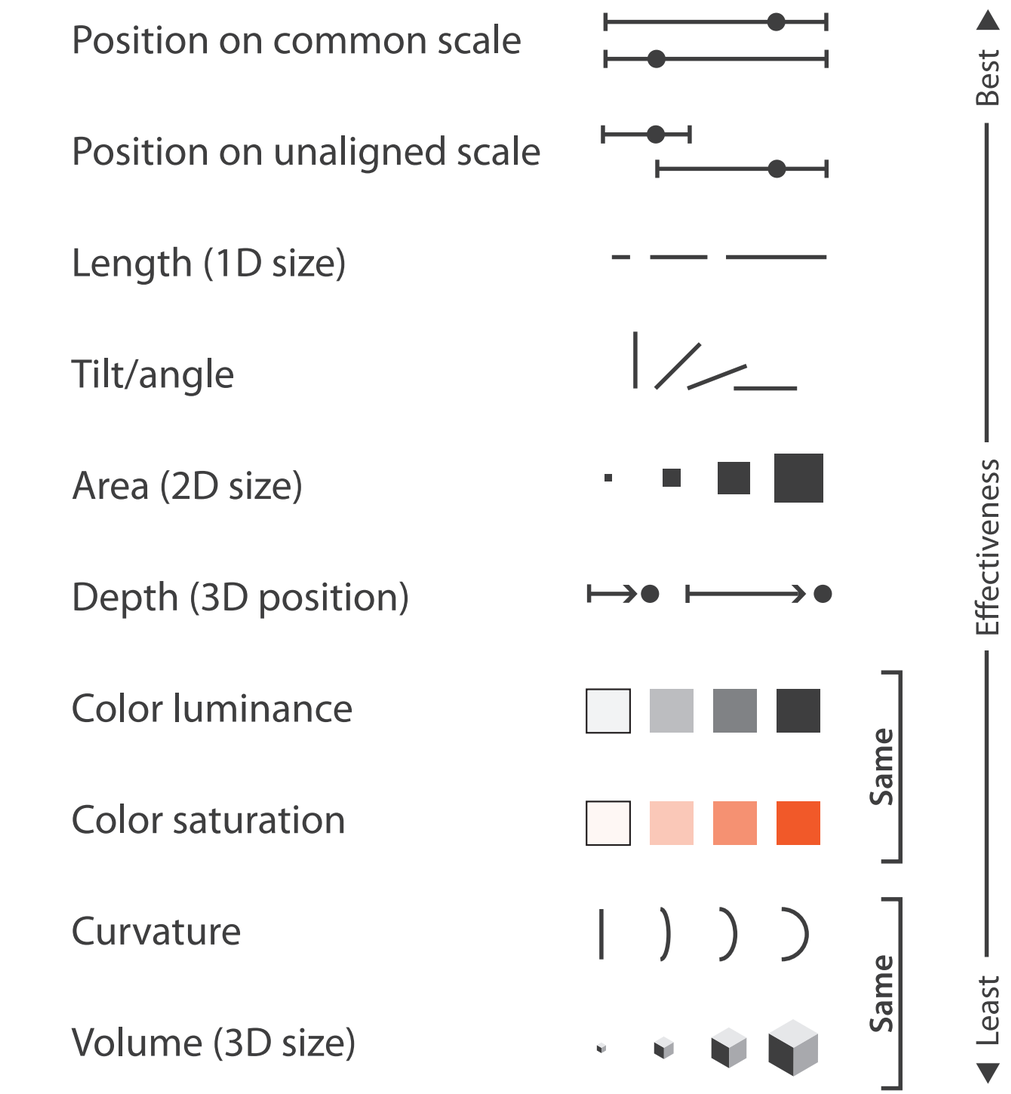
*[Fig 5.2, 5.3. Visualization Analysis & Design. Munzner. CRC Press 2014.]*

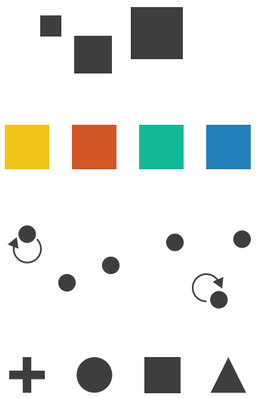
# Channels: Expressiveness types and effectiveness rankings

TICS

**Magnitude Channels: Ordered Attributes**




**Identity Channels: Categorical Attributes**




- channel rankings
  - what's the order?
  - what are the rough equivalence classes? *(are these right?)*
  - ***what are the metric distances between them?***
  - wrt time (RT)? wrt error (accuracy)? tradeoffs?
- channel capacity
  - how many discriminable steps/bins/levels are there in each channel?
  - ***how does this change when multiple channels at once?***

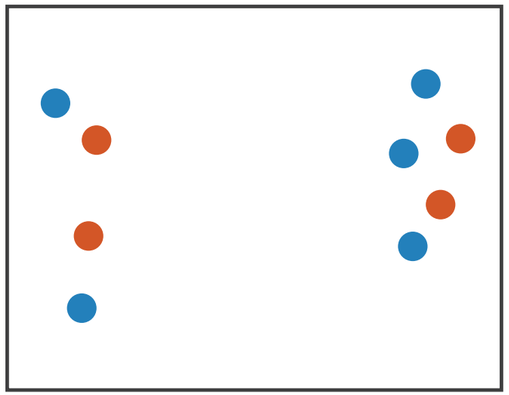
TIWIK

*[Fig 5.5, 5.6, 5.9. Visualization Analysis & Design. Munzner. CRC Press 2014.]*

# Channels: Separability vs integrality

TICS

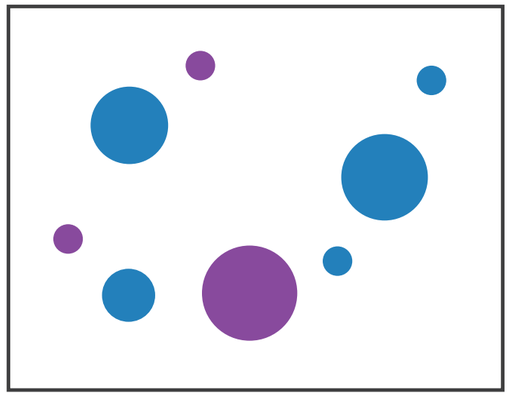
Position
+ Hue (Color)



Fully separable

2 groups each

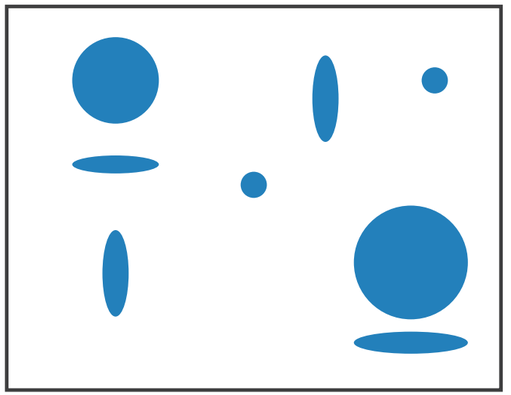
Size
+ Hue (Color)



Some interference

2 groups each

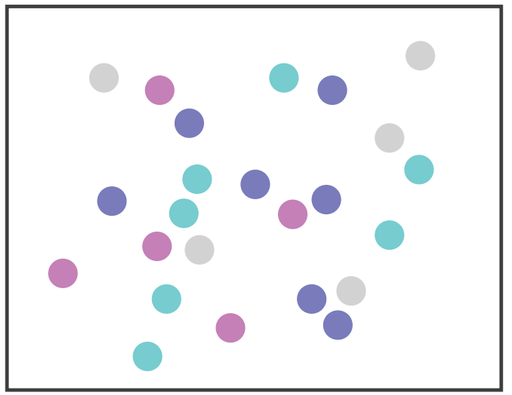
Width
+ Height



Some/significant interference

3 groups total: integral area

Red
+ Green



Major interference

4 groups total: integral hue

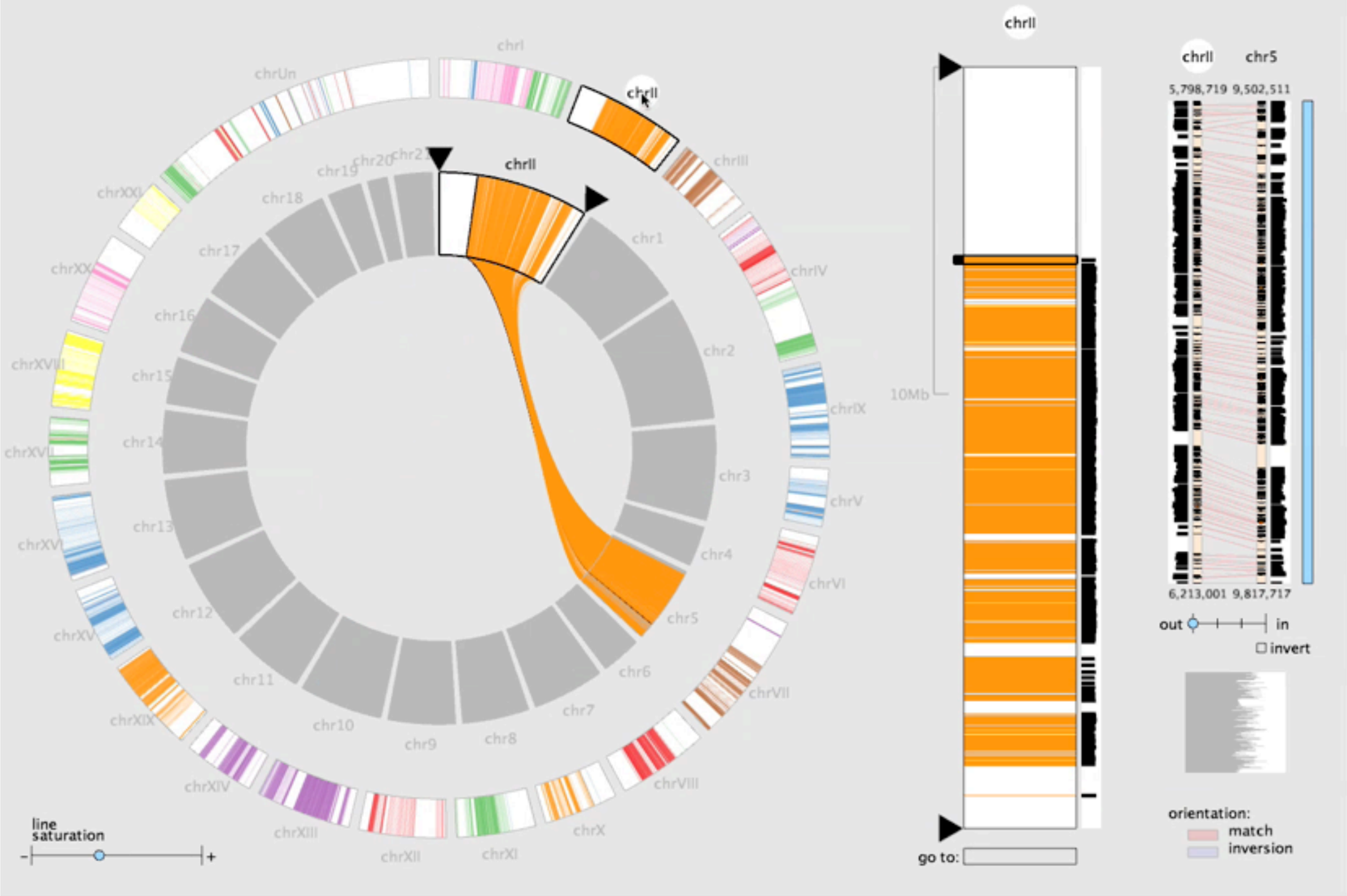
TIWIK

- how (& how much) do the channels interfere with each other?
  - what other pairs? to what extent? ***what's the effect for # discriminable steps?***
  - ***what about triples? n-way interactions for n up to at least 5-6?***
  - ***what about when there's a lot of visual complexity in the scene: many objects?***
    - *100? 1000? 10K? 1M?*



*[Fig 5.10. Visualization Analysis & Design. Munzner. CRC Press 2014.]*

# Many marks/objects, many channels, many tasks, many views




**MizBee**

https://youtu.be/86p7brwuz2g

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# Channels: Shape

TICS

- shape
  - complex combination of lower-level primitives
  - many bins

- how does shape decompose into elements?

TIWIK

  - I want equivalent of L*a*b* color space, for "shape space"
    - *quantitative metric with equal JNDs along axes*
      - eg pointy-ness vs smoothness; open vs closed; …
    - use for deciding on encoding
    - use for interpolating values

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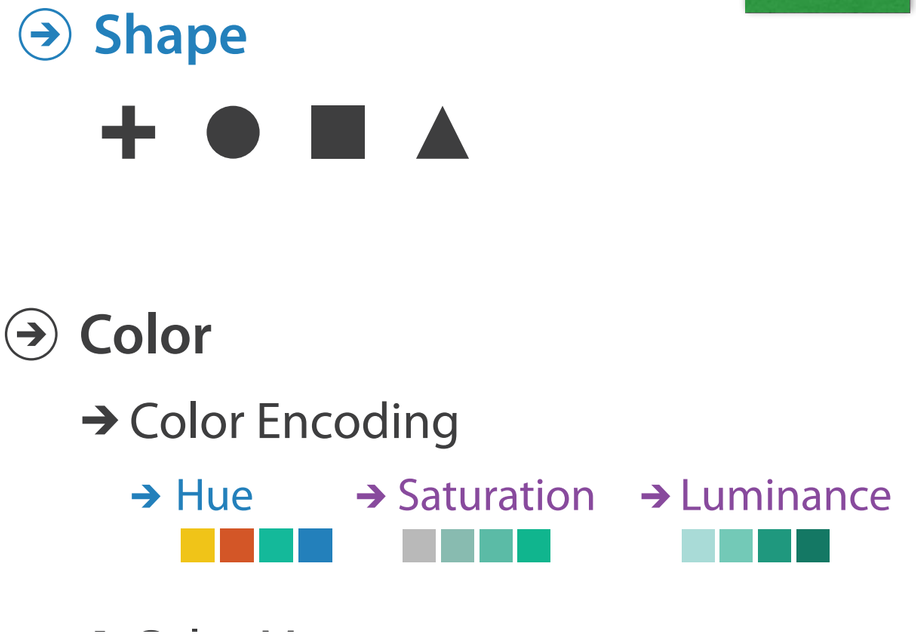
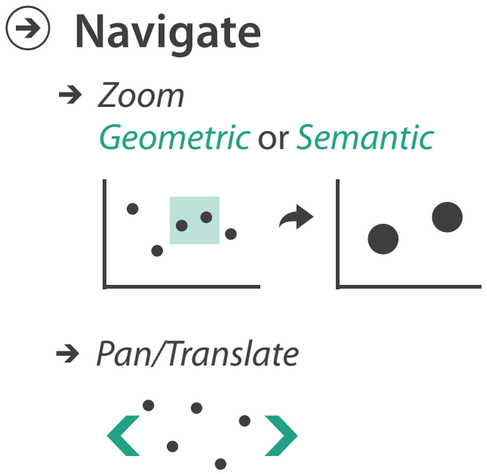



*[Fig 10.1. Visualization Analysis & Design. Munzner. CRC Press 2014.]*

# Views: memory vs eyes

TICS

- interactive navigation within view
  - leverage spatial cognition, but rely on memory for previous states

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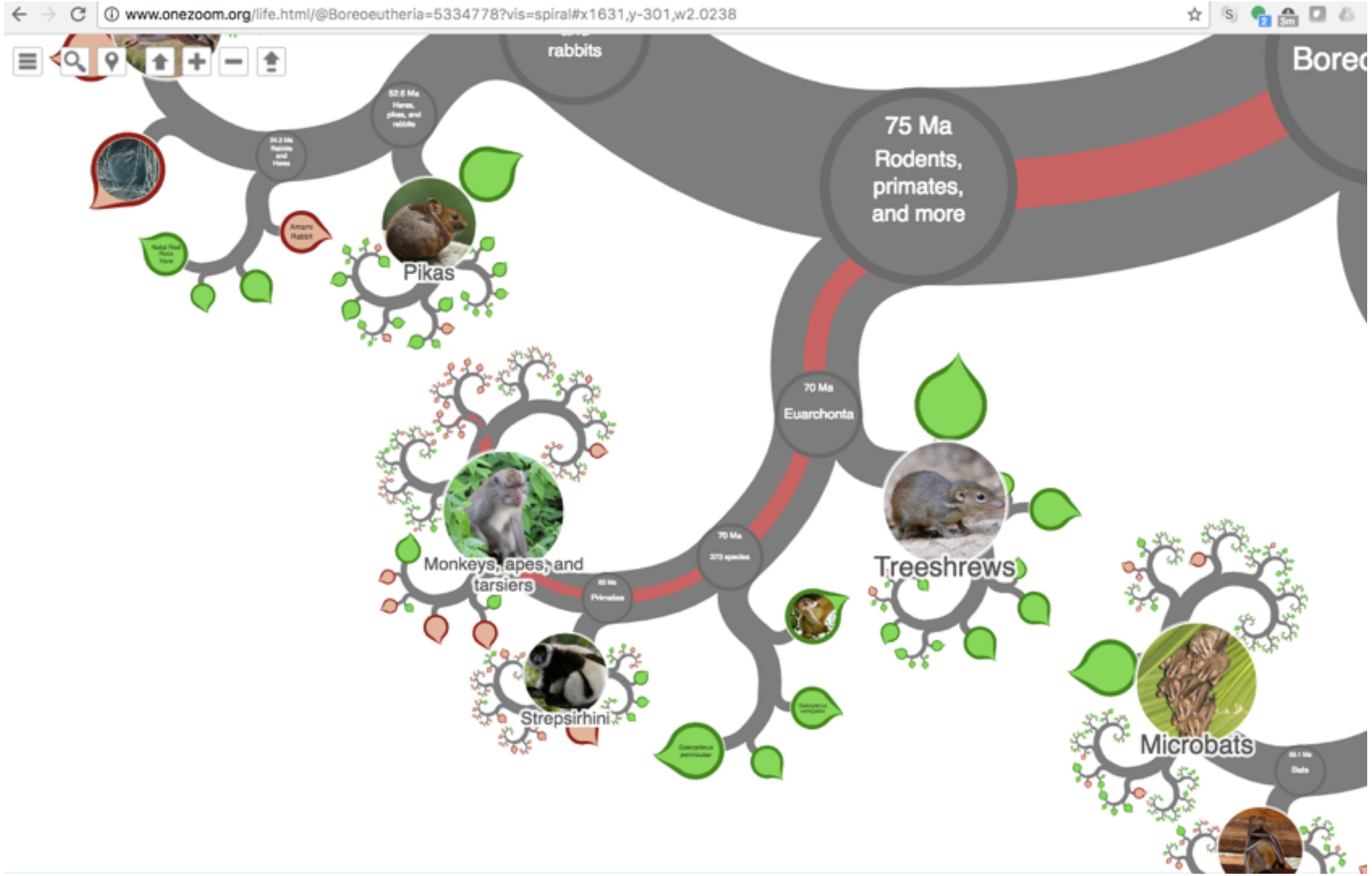
*[Fig 11.1. Visualization Analysis & Design. Munzner. CRC Press 2014.]*

# Views: Interactive navigation within view




http://www.onezoom.org

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# Views: memory vs eyes

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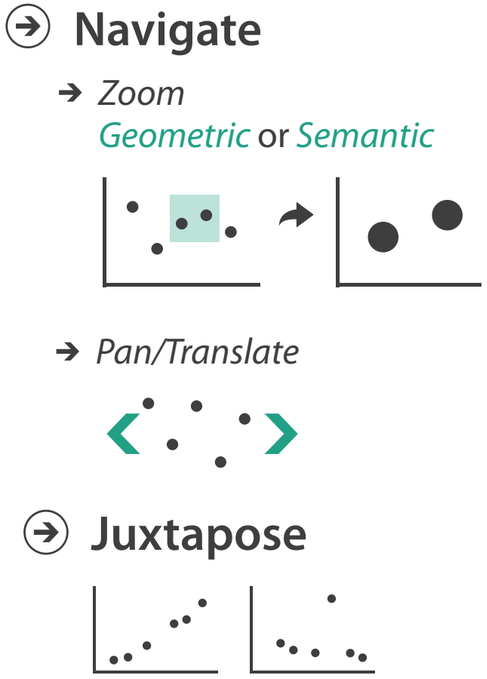
- interactive navigation within view

  http://www.onezoom.org

  – leverage spatial cognition, but rely on memory for previous states
- side by side views
  – low cognitive load to move eyes between juxtaposed views
  – but reduced display area, each view has 1/N pixel budget

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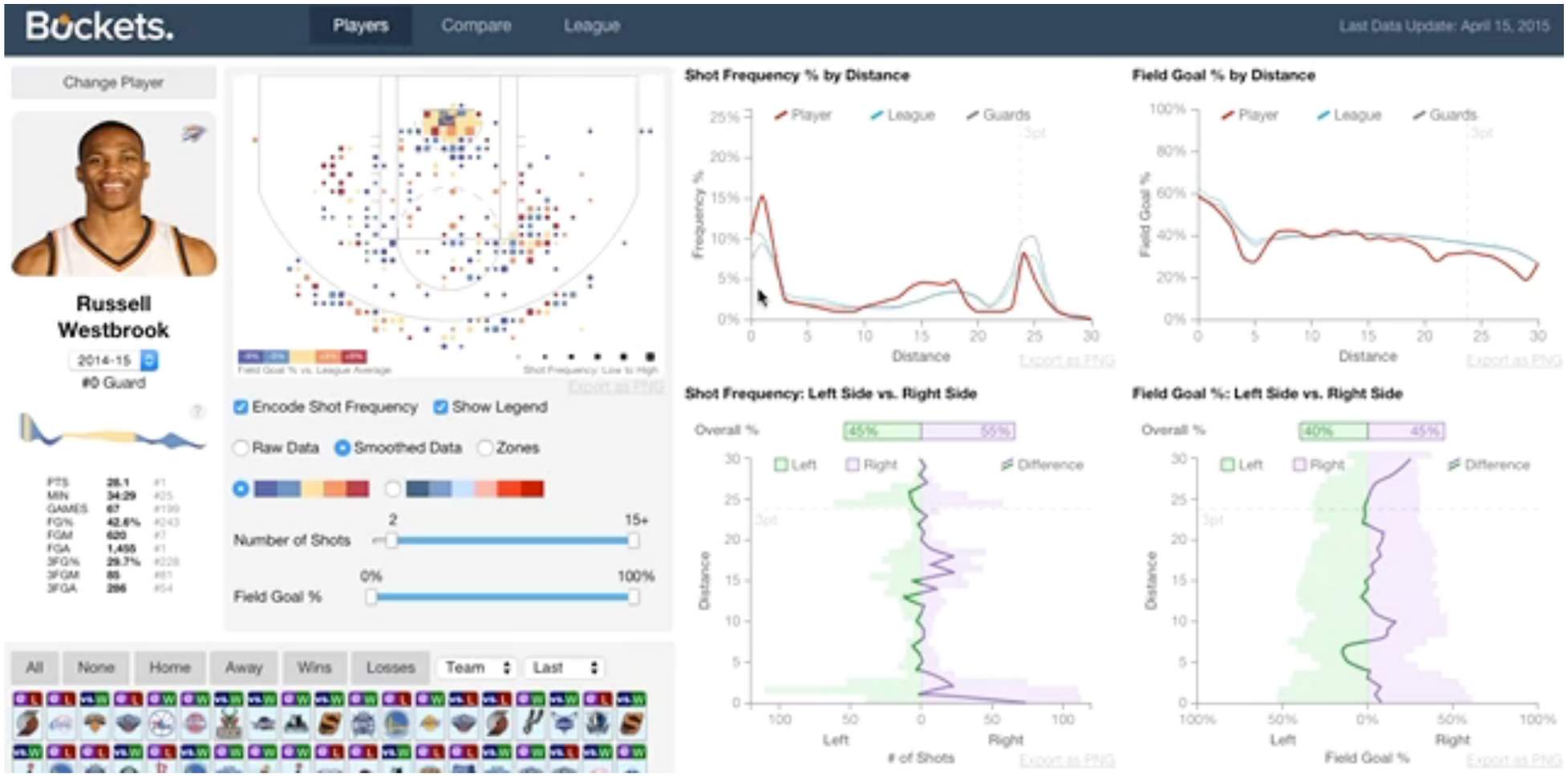
*[Fig 11.1. Visualization Analysis & Design. Munzner. CRC Press 2014.]*

# Views: Multiple linked side by side




http://buckets.peterbeshai.com/

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# Views: memory vs eyes

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- interactive navigation within view
  - leverage spatial cognition, but rely on memory for previous states

http://www.onezoom.org

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http://buckets.peterbeshai.com

TIWIK

- ***what's the cost-benefit tradeoff*** of interactive navigation vs switching between multiple side by side views?
  - what mechanisms matter?
    - attention? memory? change detection?
  - ***does task switching between views affect how many objects people can track? can remember?***
    - between 2 views? ***3 views? 4? 5-10?***

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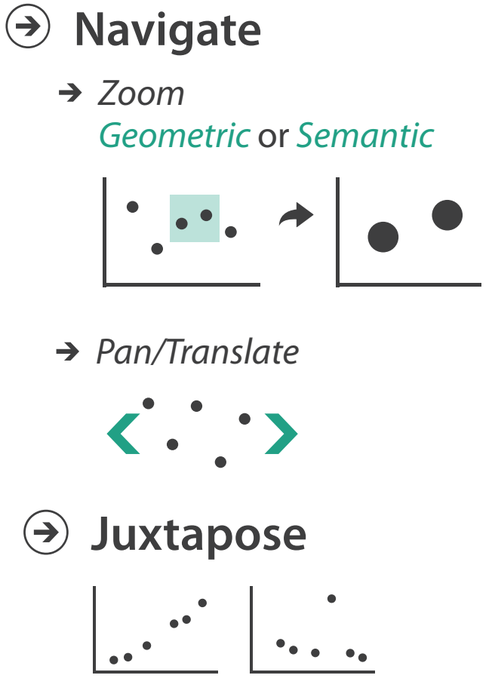


*[Fig 11.1. Visualization Analysis & Design. Munzner. CRC Press 2014.]*

# Tasks

- all possible pairs of {action, target}
  - discover distribution
  - compare trends
  - locate outliers
  - browse topology
  - compare shapes

- visual cognition concerns as lower-level operators
  - visual search
  - comparison
  - ensemble processing
  - *what else?…*

TIWIK

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**Why?**

TICS

**Actions**

**Search**

visual search

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

**Query**

→ Identify → Compare → Summarize

one — few — all

visual search

ensemble processing

comparison

**Targets**

**All Data**

→ Trends → Outliers → Features

**Attributes**

→ One → Many

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

→ *Extremes*

**Network Data**

→ Topology

→ *Paths*

**Spatial Data**

→ Shape

*[Fig 3.1. Visualization Analysis & Design. Munzner. CRC Press 2014.]*

What? Why? How?

# Summary



- (many) channels & objects
  - ranking, classes, metric distances, capacity
  - separability / interference
  - shape space
- views
  - tradeoffs of multiple views vs interactive navigation
- tasks
  - from low-level vision operators to high-level vis tasks

- book http://www.cs.ubc.ca/~tmm/vadbook
- papers, videos, software, talks, courses
  http://www.cs.ubc.ca/group/infovis
  http://www.cs.ubc.ca/~tmm

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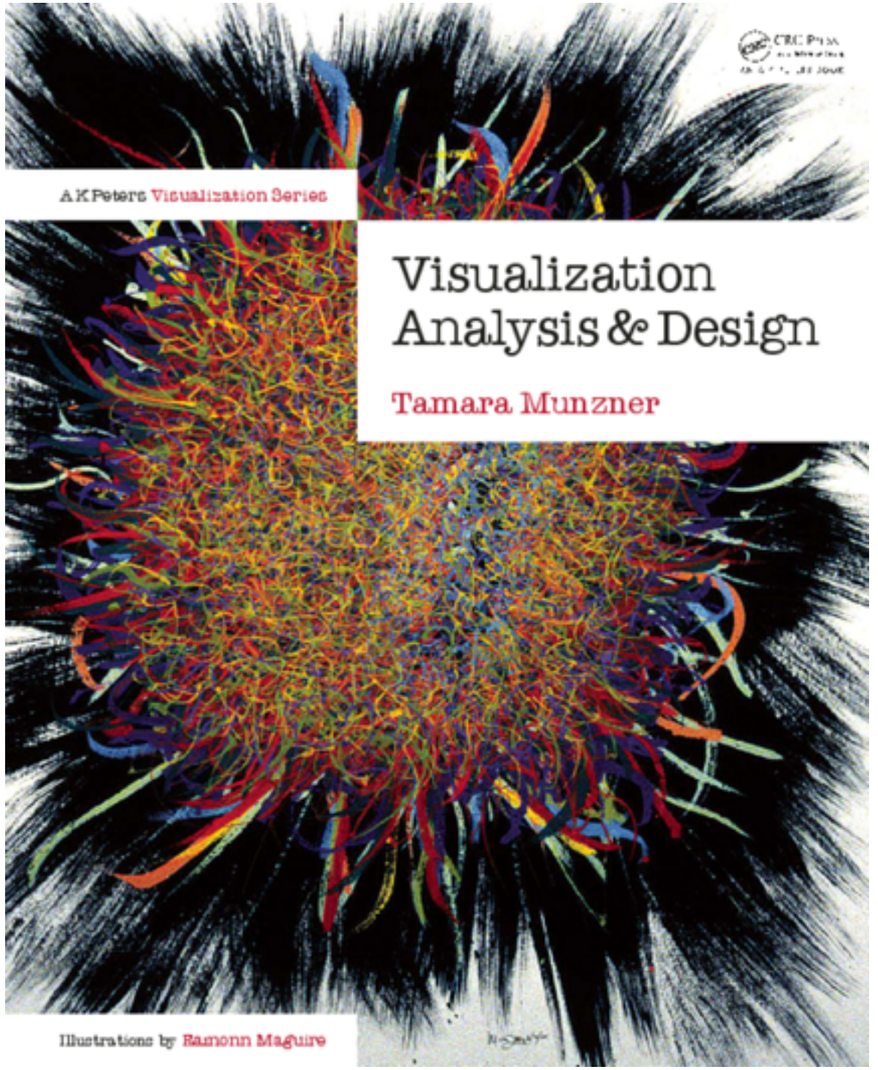


Visualization Analysis and Design.
*Munzner. A K Peters Visualization Series, CRC Press, Visualization Series, 2014.*