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CHANGE THE WORLD FROM HERE

Perception

What We See vs What We Perceive

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MOTIVATION

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How many letter B's are on the next slide?

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How many letter B's are on the next slide?

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Motivation

- How much can we remember?
- How quickly can we process information?
- How effectively can we process information?
- What do we automatically infer?

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MEMORY

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Memory

- **Long-Term Memory**
  - Lasts for years or a life-time
  - Quick to retrieve, difficult to store
- **Short-Term Memory**
  - Lasts between a few seconds and a minute*
  - Limited storage capacity (5 to 7 elements)
  - Conscious, focused, attentive processing

* Rehearsed, short-term memory can last for hours.

Memory

- **Sensory Memory**
  - Impressions of sensor signals
    (e.g. vision, hearing, smell, taste, and touch)
  - Lasts between 250 and 500 milliseconds
- **Iconic Memory**
  - Visual sensory memory
  - Pre-attentive processing
    (e.g. precedes focused attention)

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Pre-Attentive Processing

- Independent of conscious control
  - *You will notice whether you want to or not*
- Information processed without need for focus
  - *Viewed from corner of your eye*
- Similar to a filter being applied to iconic memory
  - *Only draw attention to what is important*

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E O H A N E
L B I D C H A
V I D H T J P S
P Q F N Y G R A O Q D
B T A B Q A C K A A
M A A U A P B X V Z G
A D V D U E A S
I E A G C Y A A
R F S C T A C O J G Q
A Z A P W X A A B F Z

PRE-ATTENTIVE ATTRIBUTES

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Pre-Attentive Attributes

- **Color**
  - Hue, intensity, etc.
- **Form**
  - Length, shape, etc.
- **Position**
  - Location, depth
- **Movement**
  - Blink, jitter, etc.

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Pre-Attentive Attributes

- Carefully map data to pre-attentive attributes
  - *Use strongest attribute wisely*
- Do not DISTRACT from data
  - *Do not abuse these attributes!*
- Keep in mind short-term memory
  - *Too many mappings will become confusing*

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Color

- Unique colors should represent unique data
- Similar colors should represent similar data
- Never use more colors than can be stored in short-term memory (5 to 7)
- Be mindful of color blindness

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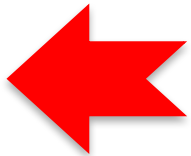
Color Resources

- "A Field Guide to Digital Color" by Maureen C. Stone, 2003.
- Choosing Colors for Data Visualization
  http://www.b-eye-network.com/newsletters/ben/2235
- Color Advice for Cartography
  http://colorbrewer2.org/
- Colorblind Vision Simulator
  http://www.vischeck.com/



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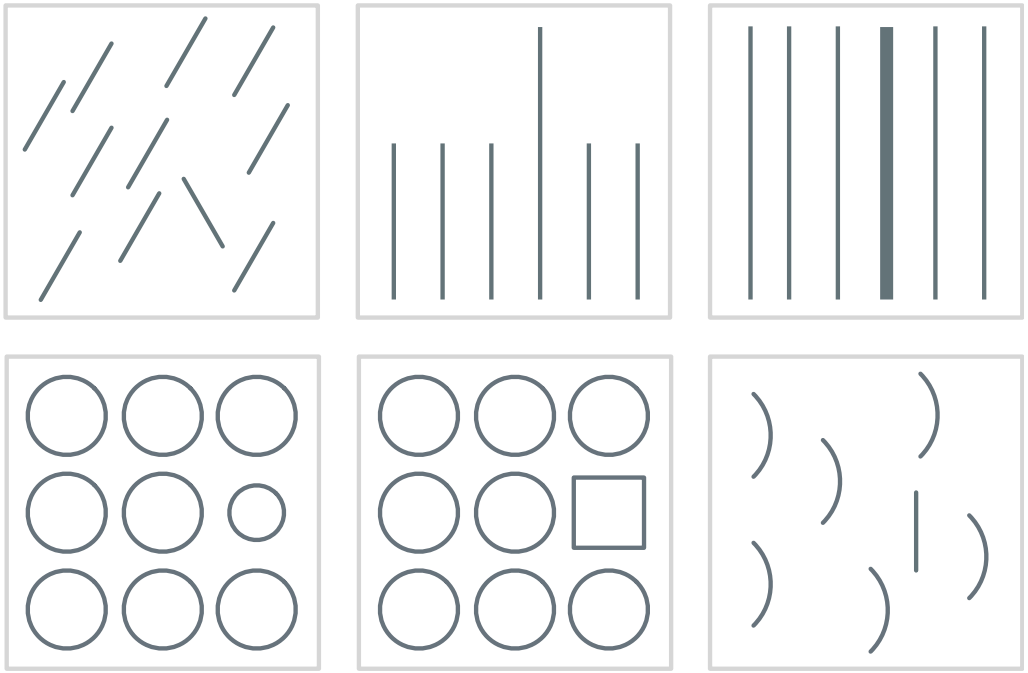
Form

- Orientation
- Length
- Width
- Size
- Shape
- Curvature



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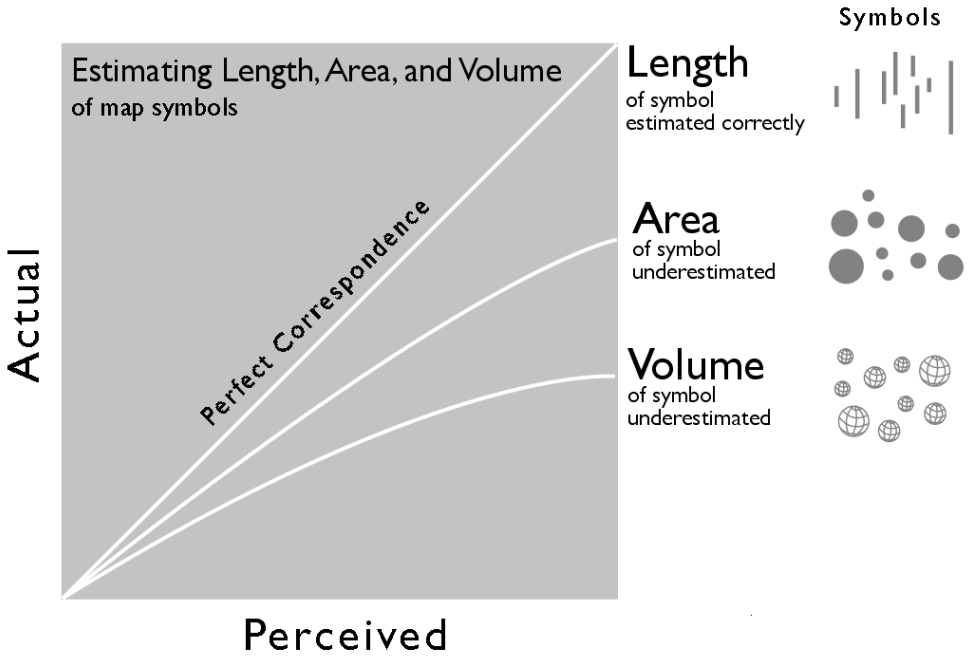
Form: Shape and Size



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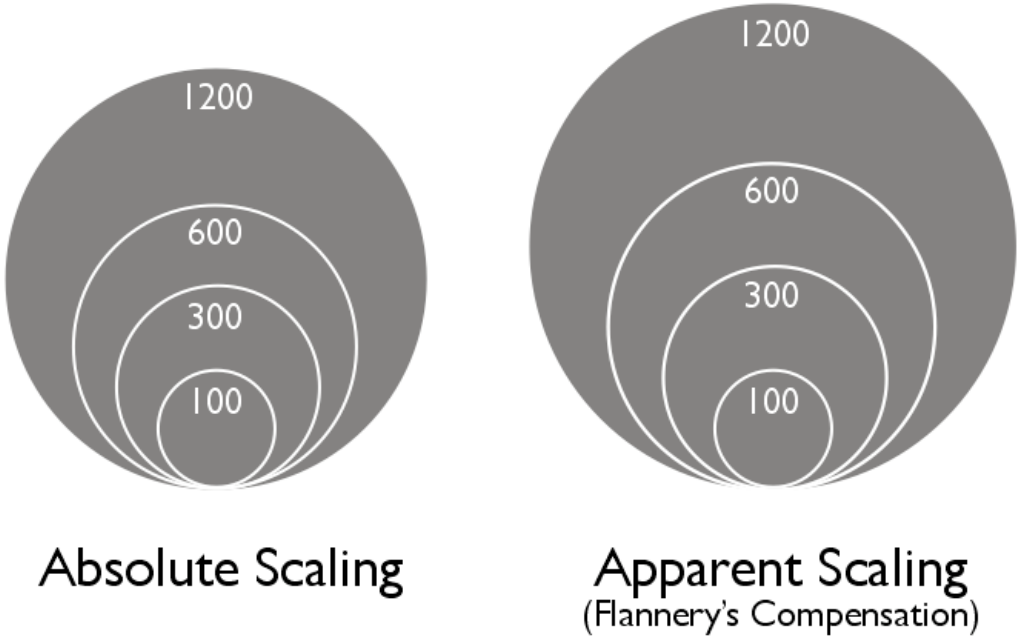

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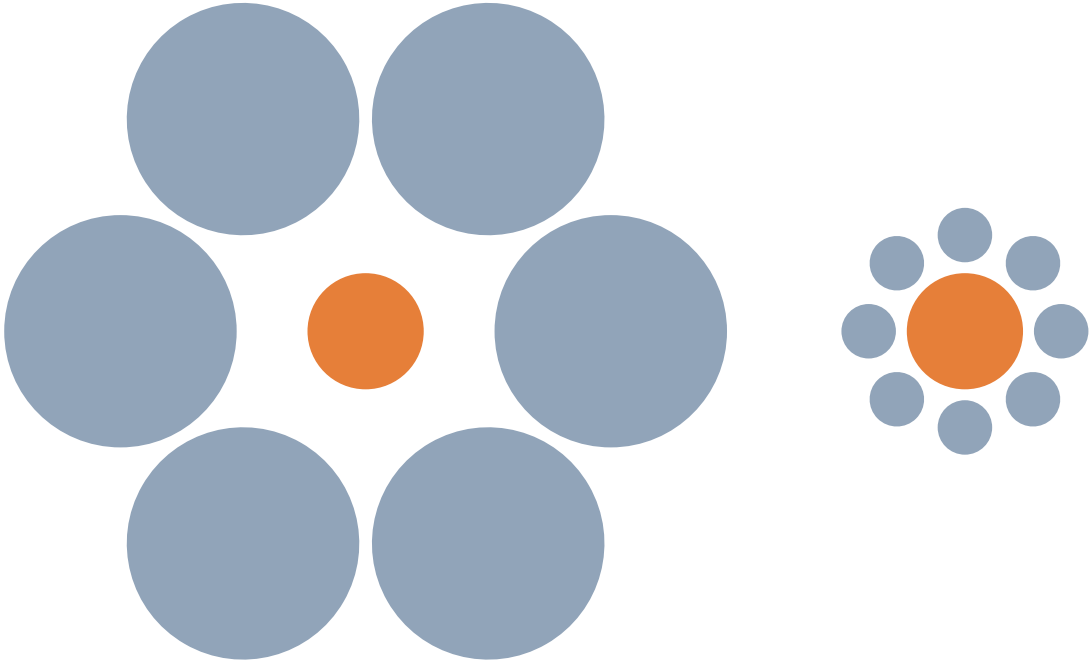
Form: Shape and Size



http://en.wikipedia.org/wiki/Ebbinghaus_illusion

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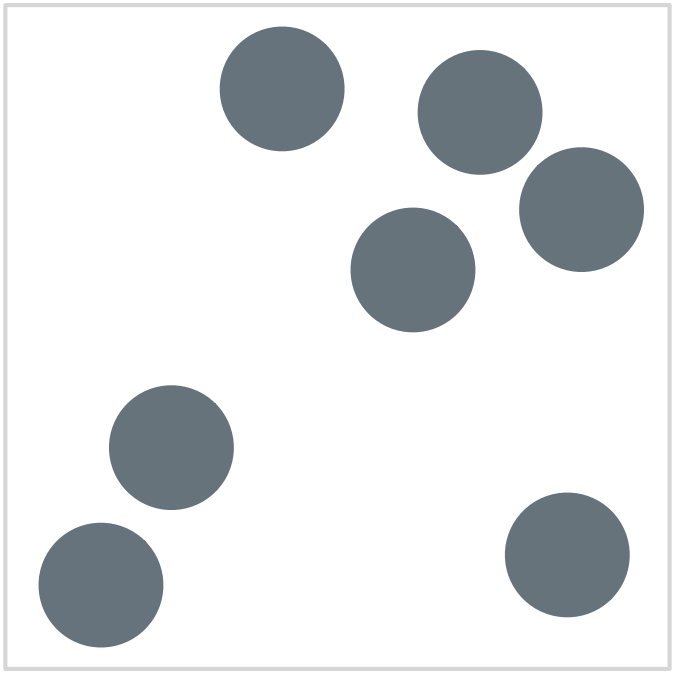
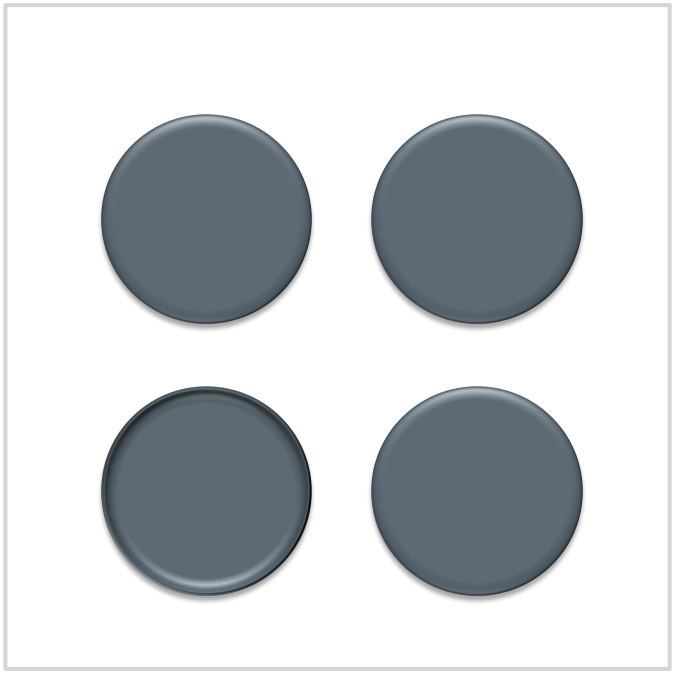
Position: 2D Position and Depth





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Movement

- Two Attributes
  - Flicker (disappear and reappear)
  - Motion (moving in position)
- One of most effective ways of getting attention
- Most often abused in marketing

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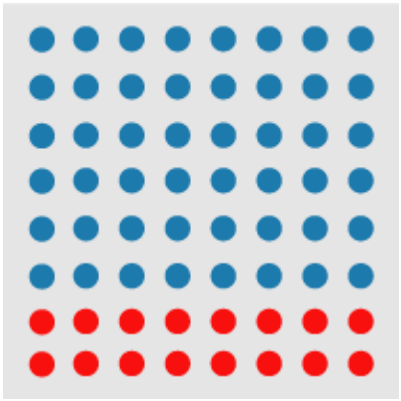
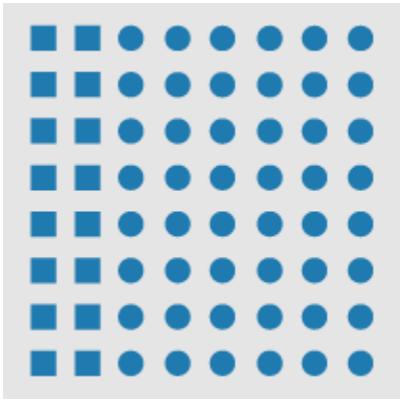
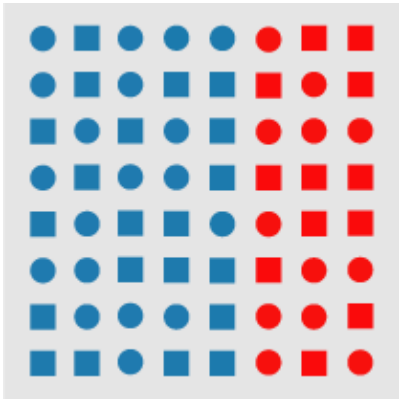
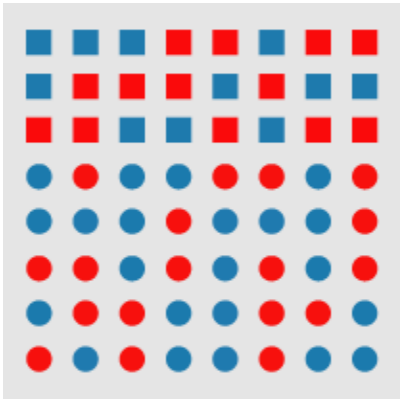
Boundaries

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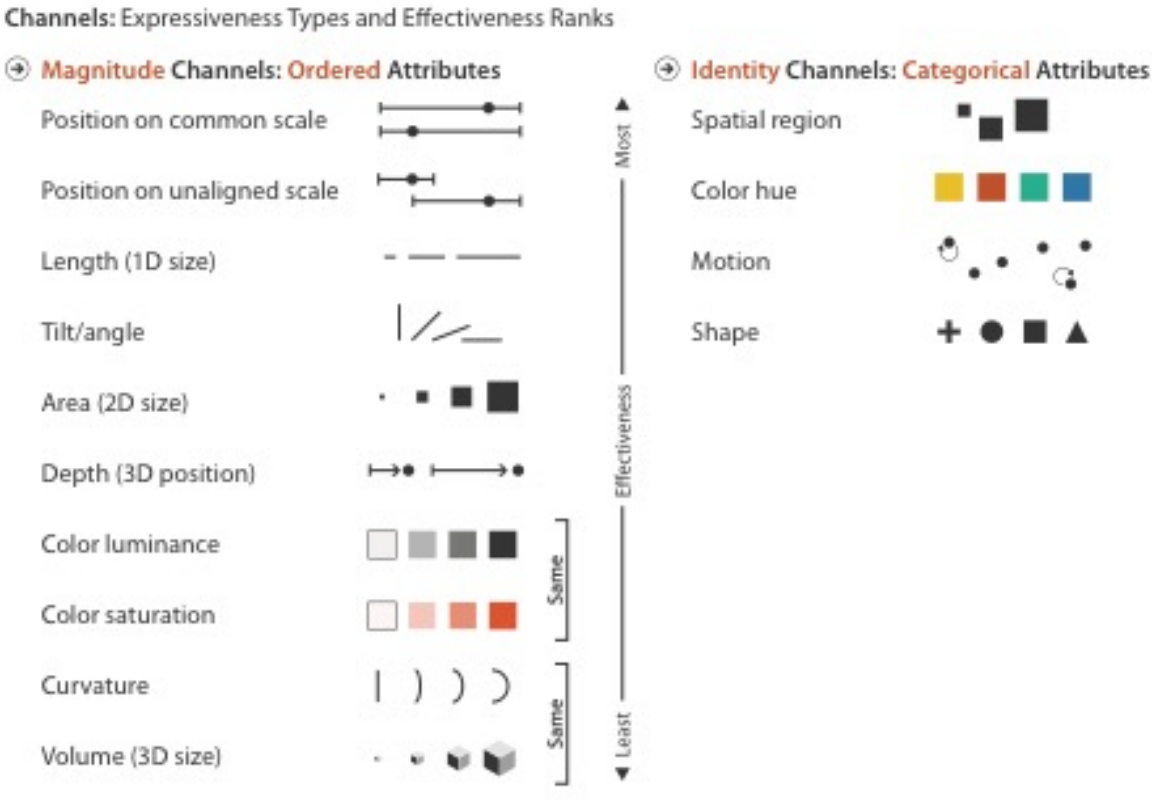

Figure 5.6, Visualization Analysis and Design. Tamara Munzner, with illustrations by Eamonn Maguire. A K Peters Visualization Series, CRC Press, 2014.

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GESTALT PRINCIPLES

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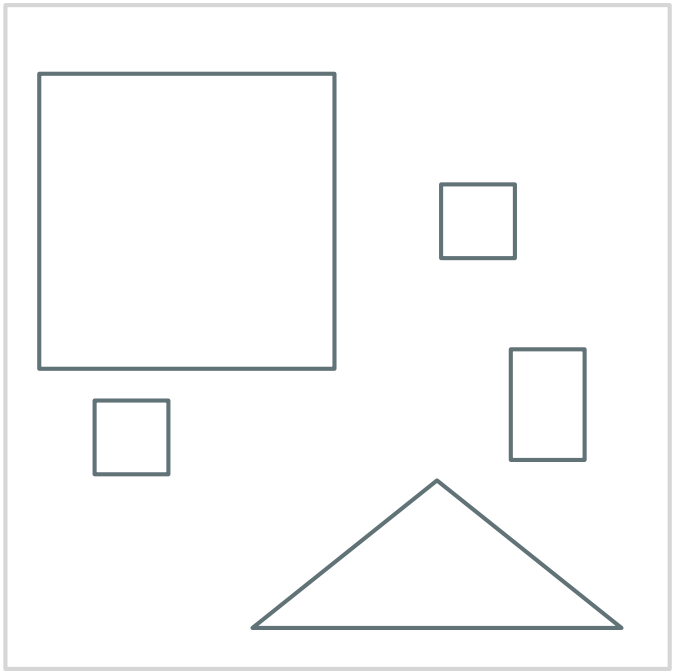
Gestalt Principles



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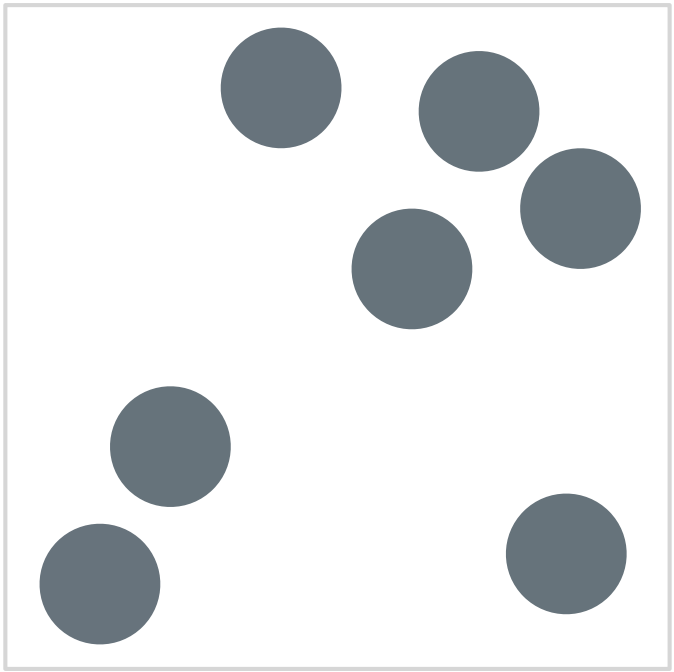
Proximity



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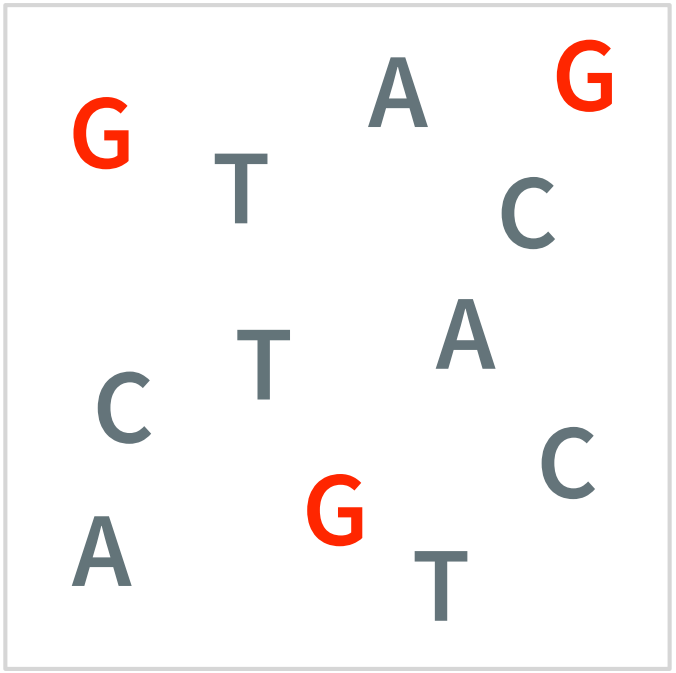
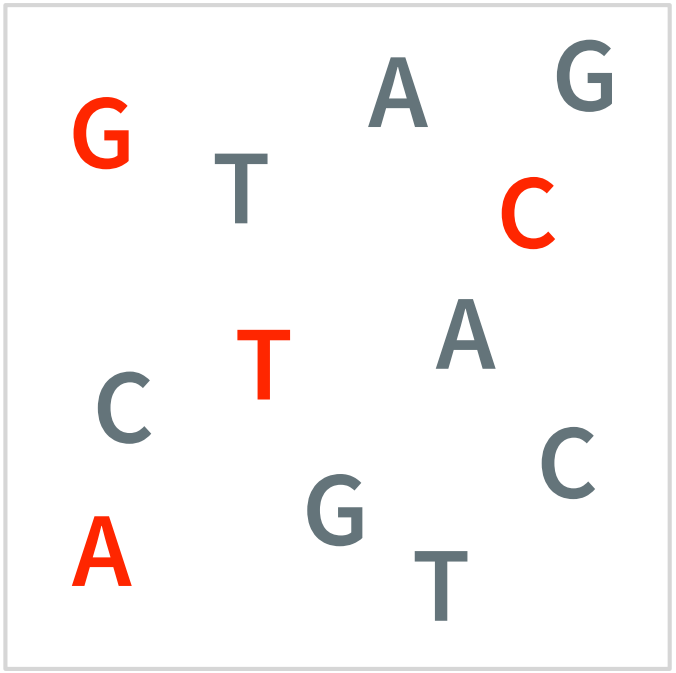
Similarity





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Closure

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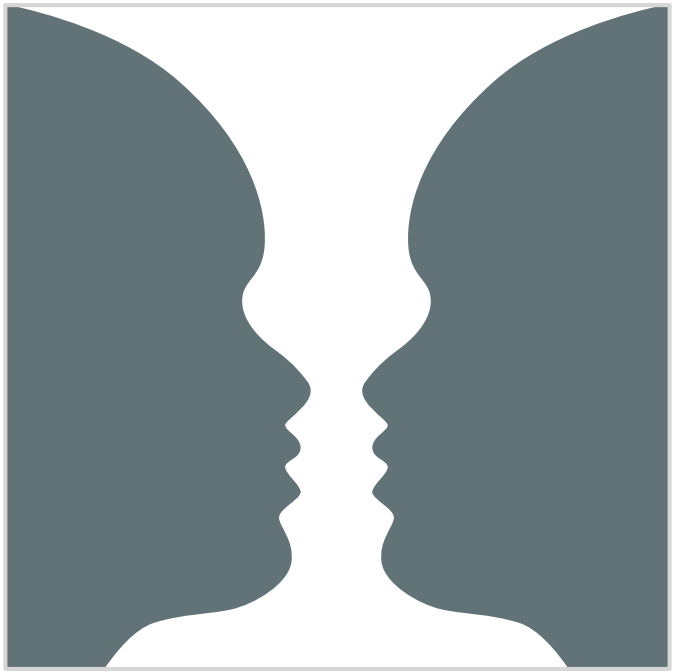
Figure and Ground



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SHORT-TERM MEMORY

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Short-Term Memory

- Attention/focus transfers information from sensory memory to short-term memory
- Lasts from a few seconds to a minute
- Limited storage capacity
  - Minimum: 5 elements
  - Average: 7 elements
  - Maximum: 9 elements

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Practical Indications

- Can reliably use 5 distinct attributes
- Should use no more than 7 to be accessible
  - *No more than 7 distinct colors or shapes*
- Attributes are cumulative
  - *3 shapes, 4 colors = 7 attributes*
- Once lose focus, forget information
  - *Distraction is costly*

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Grouping

- Grouping/chunking can increase capacity
  – 4154224174 versus (415) 422-4174
- Group sizes must be kept small
- Grouping can also improve speed of processing

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Find the unique color.

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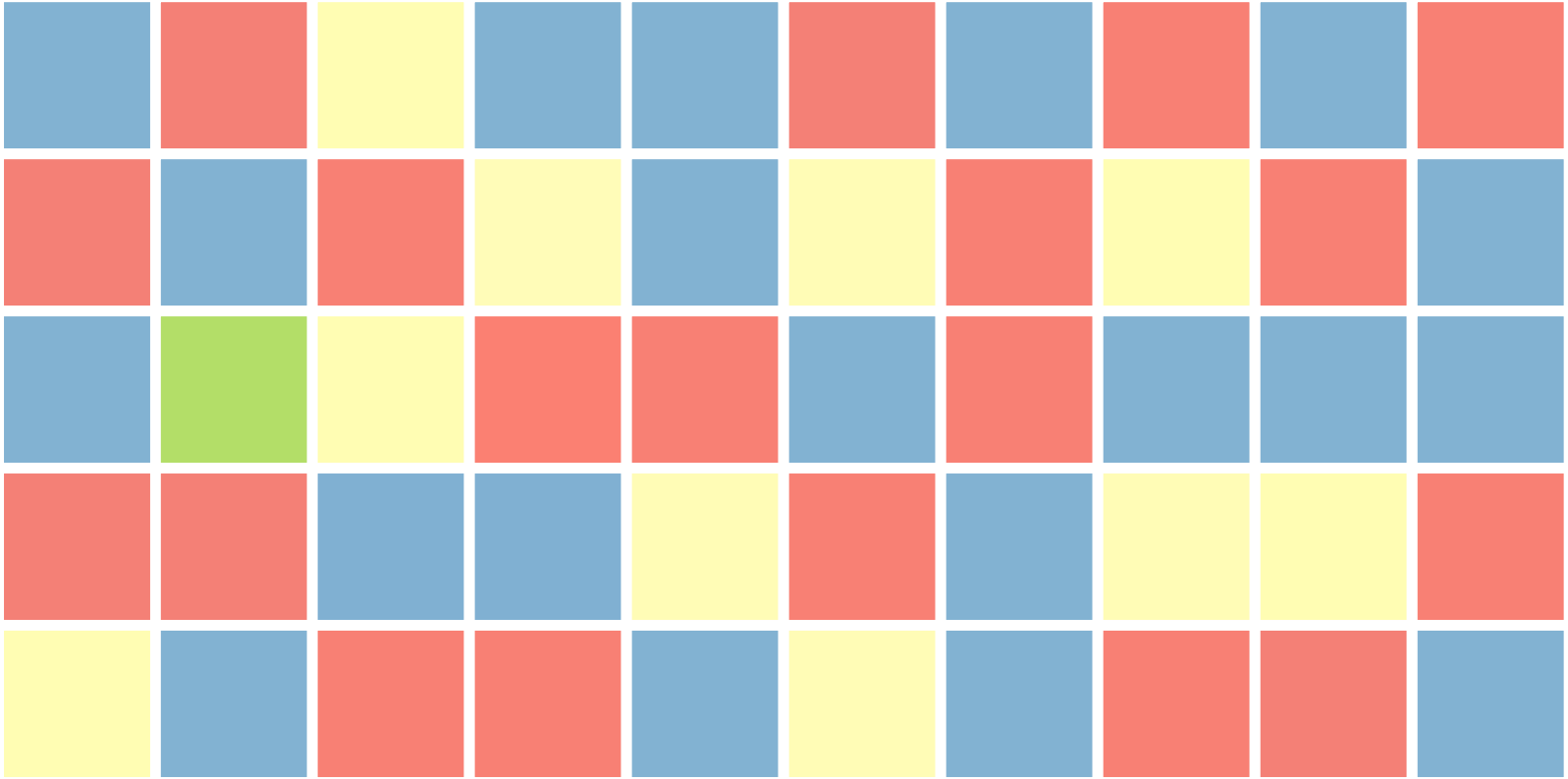

http://steveharoz.com/research/attention/

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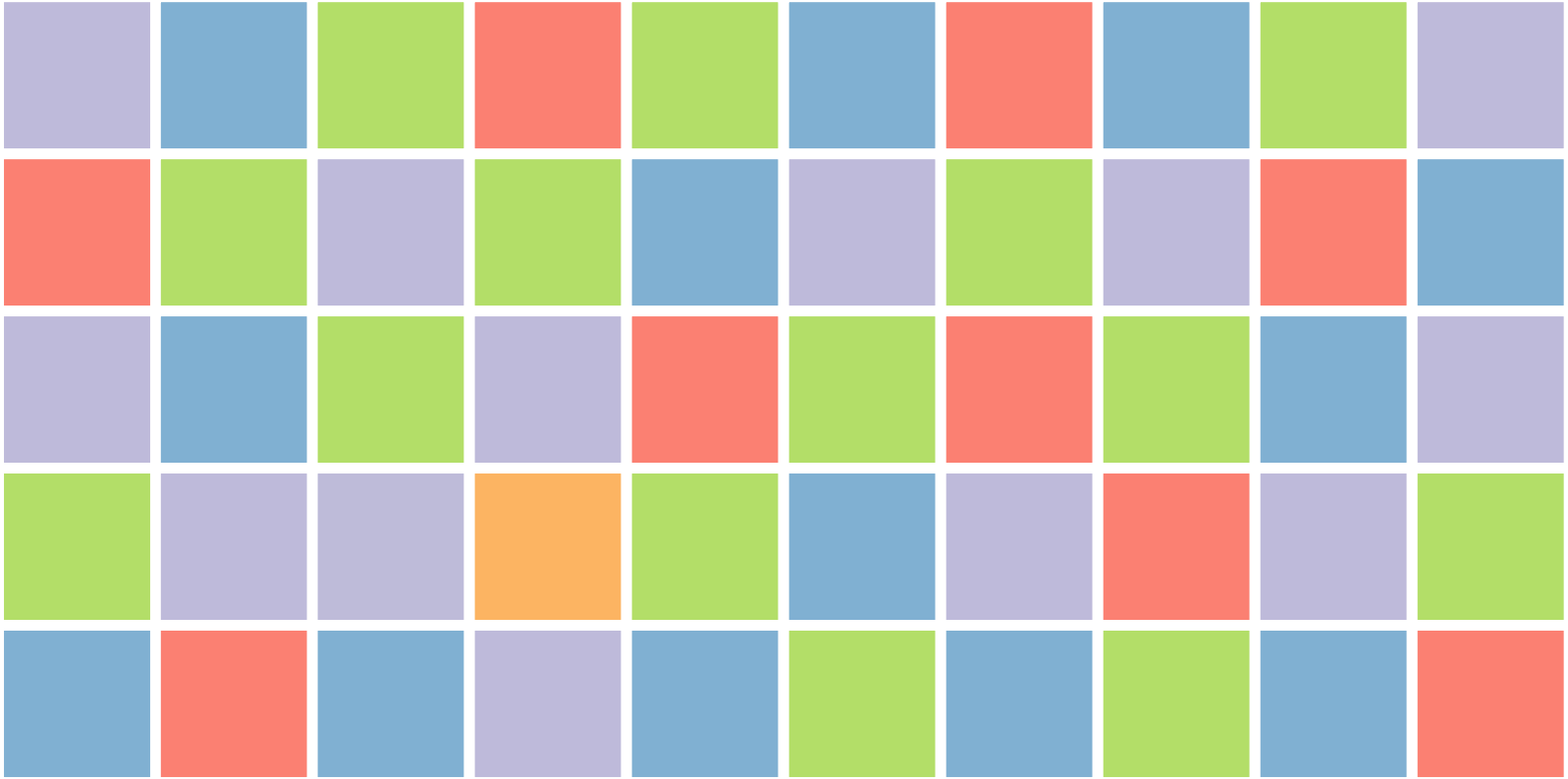

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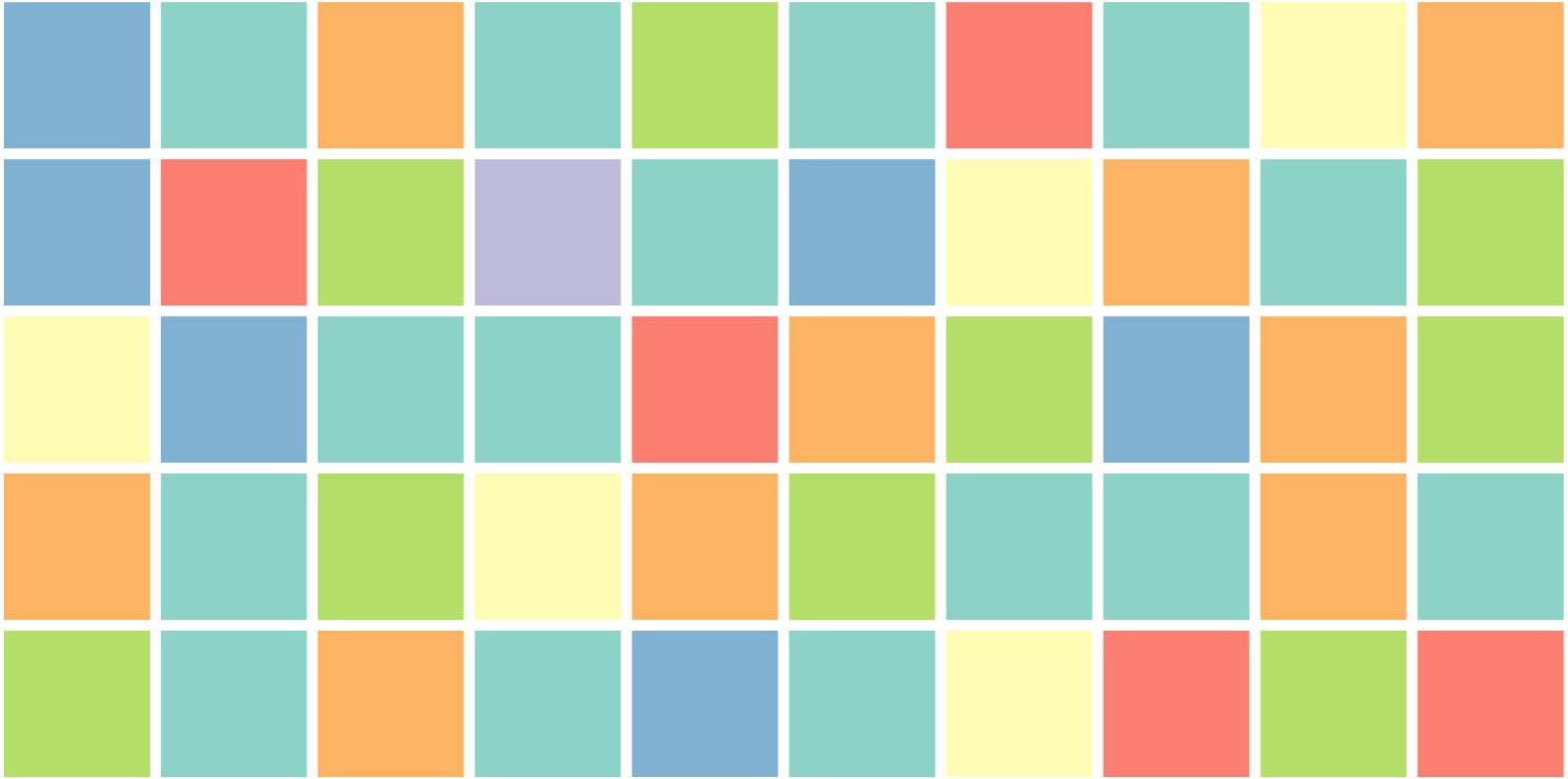

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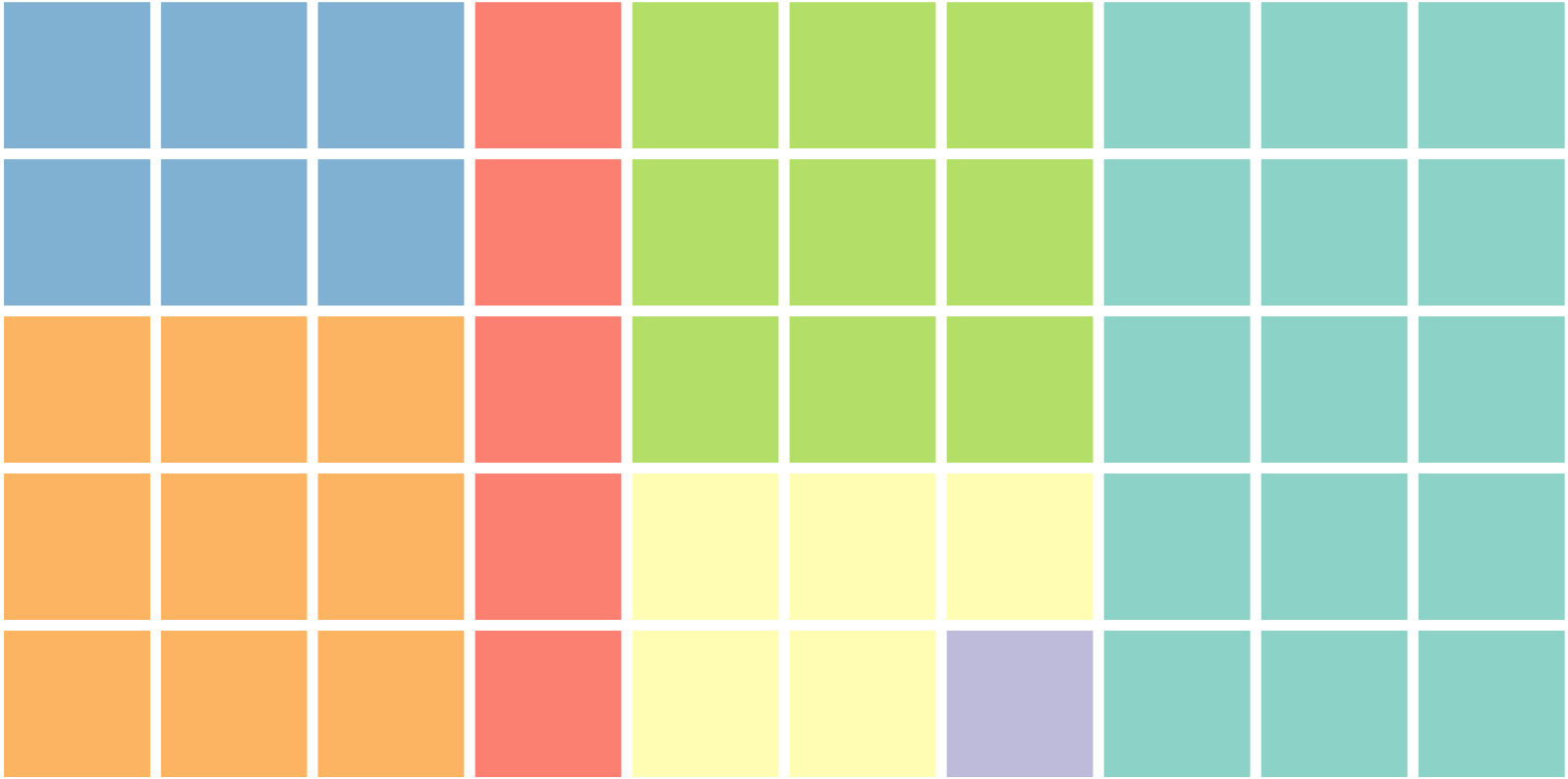

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Grouping

- Improves ability to detect outliers
- Especially important as short-term capacity is strained *(approaching 7 colors)*
- Works for other pre-attentive attributes *(e.g. motion video)*
- Does not seem to help with search tasks

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Find all of the red squares.

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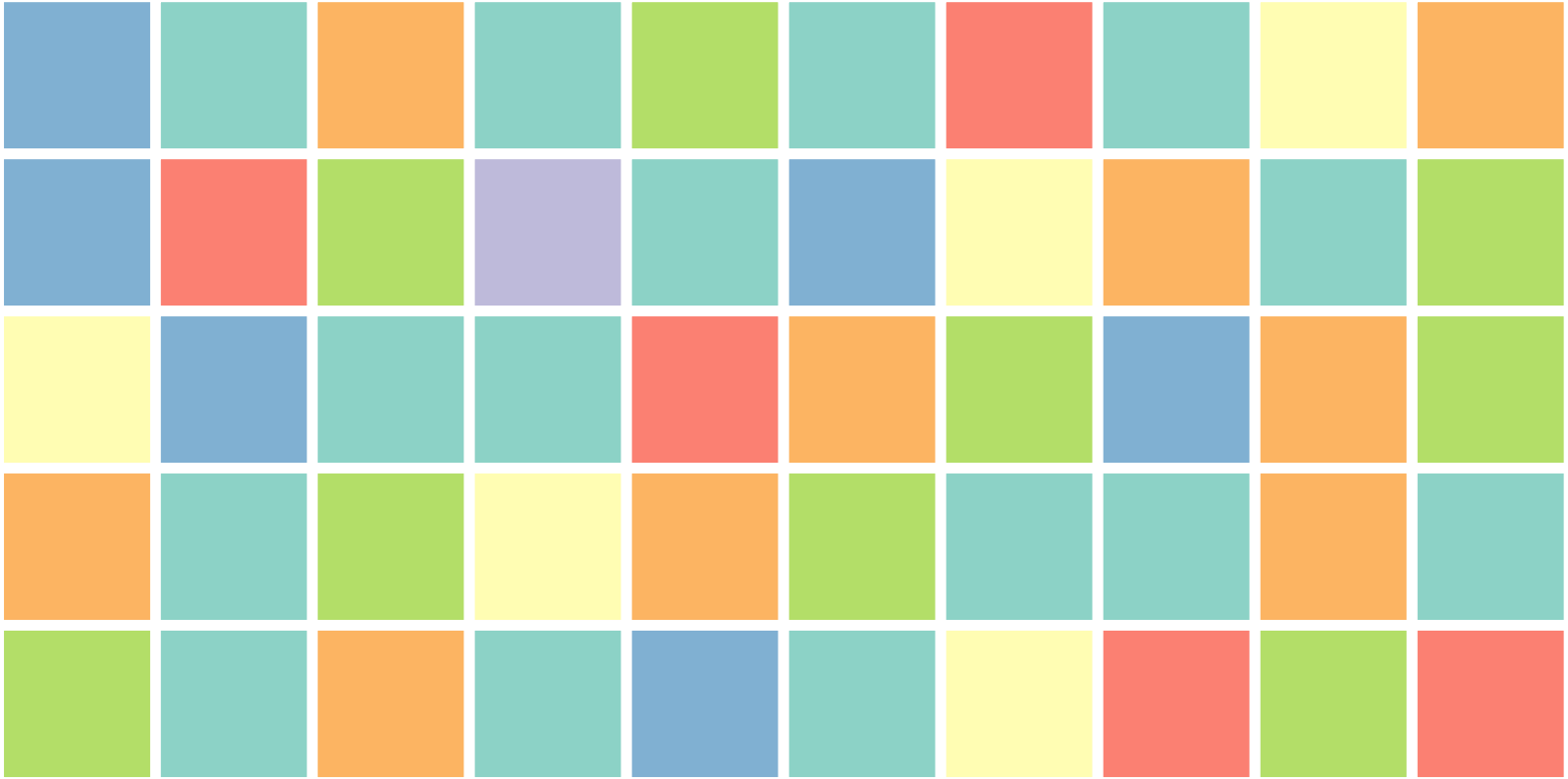

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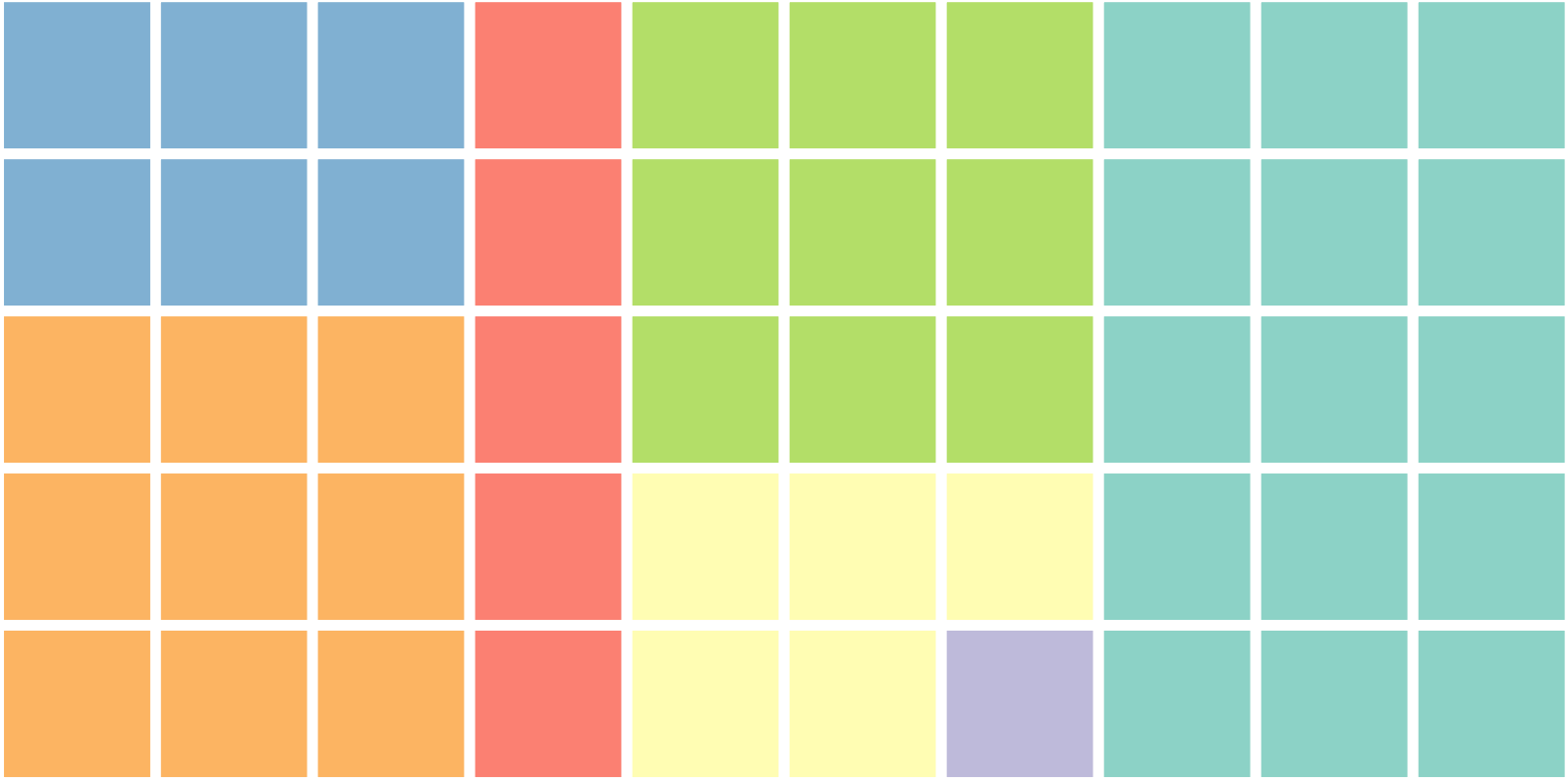

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Change Blindness

- To notice change, must pay attention to or focus on area of change
- Can break focus with flicker, making it difficult to detect change
- For visualization, must be careful to direct the eye where it is important

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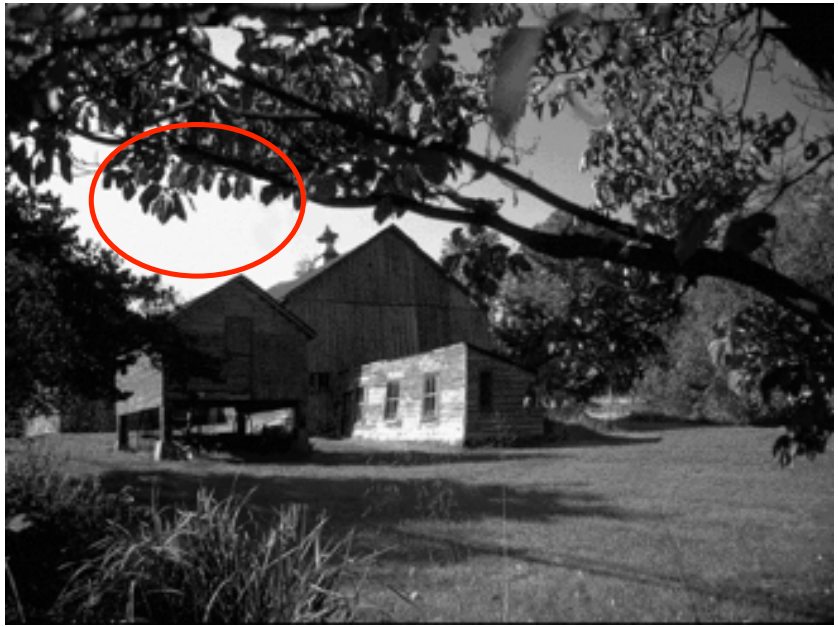
Change Blindness



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http://www.cogsci.uci.edu/~ddhoff/cbvenice.html

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REFERENCES

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DOI: 10.1109/TVCG.2011.127 URL: http://steveharoz.com/research/attention/

How Capacity Limits of Attention Influence Information Visualization Effectiveness
Steve Haroz and David Whitney, in *IEEE Transactions on Visualization and Computer Graphics (IEEE TVCG)*, Volume 18, Issue 12, Pages 2402 – 2410, December 2012.
DOI: 10.1109/TVCG.2012.233 URL: http://www.csc.ncsu.edu/faculty/healey/PP/

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