Lecture 08 – Finding Information

Today’s Learning Objectives:

1. Describe the way that visual elements are processed.

2. Discuss how the brain finds elements easily findable and important.

3. List elements of visual distinctiveness for glyph and symbol design.

4. Describe pre-attentive processing and how it aids in rapid visual processing.

5. List the element combinations that can be used in conjunction while maintaining pre-attentive processing.

Follow up on color

Literally a real thing I've seen recently.

Please don't do this.

Model of Visual Perception

Stage 1: Parallel

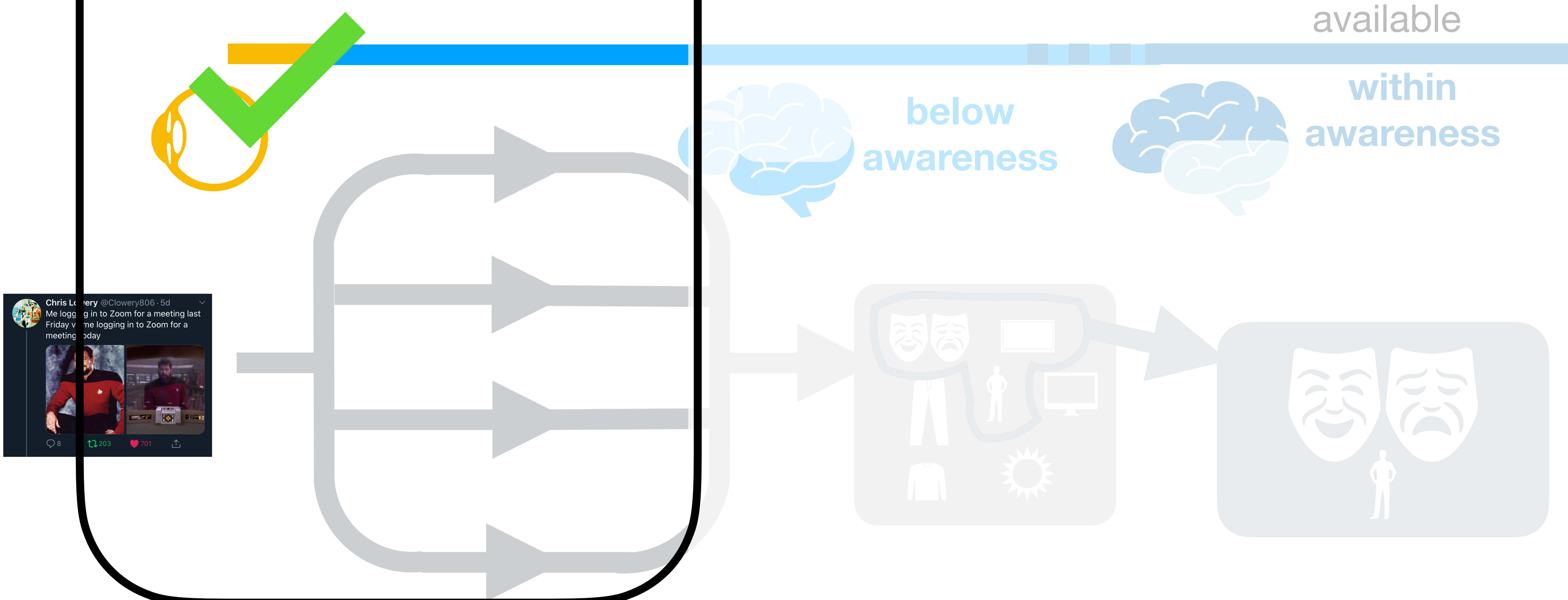
- First pass processing
- Parallel
- Transitory
- Rapid
- Extraction of features
- Bottom-up, data-driven
- Understand visual salience

Stage 2: Patterns

- Visual field is divided up, used for pattern finding
- Top-down attention
- Flexible
- Slower
- Serial
- Where/ what split

Stage 3: Visual Working Memory

- Small no. patterns (<4) passed to VWM
- Objects held in VWM by active attention
- Limited number of WM “slots” available



Pre-Attentive Visual Elements We've Learned So Far

List them here:

Searching Behavior

Saccadic movements – eye moves rapidly from fixation to fixation, relatively low-sweep (5 degrees of scanning a scene, 2 degrees for reading). Ballistic.

Smooth-pursuit – Locking on and tracking an object in motion.

Convergent movements –object moving closer causes eyes to converge (cross) and diverge when it moves away. Can be either saccadic or smooth.

How does the brain determine what is important?

***A priori* salience** – some patterns excite more neural activity in the feature map than others.

Top-down salience – top-down mechanisms rerun the feature maps to increase sensitivity to features. “Search image” seeing a pattern before a search can help you find the pattern more quickly.

Scene gist – scenes that are well-known and easily recognized will have easily accessible search patterns, learned through repeated use of a style of visualization.

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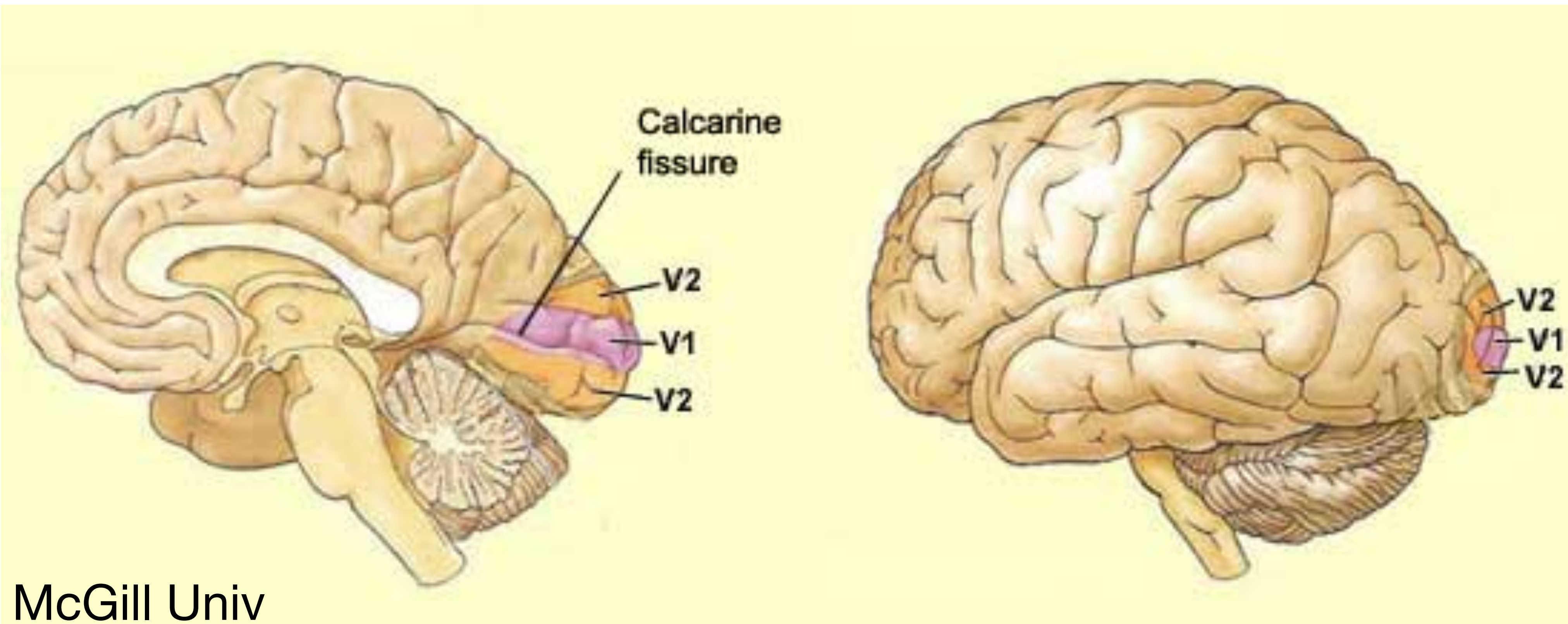


Primary visual cortex

Visual Areas 1 & 2 (V1 & V2) – collections of neurons that respond selectively to different features of the scene that preserves spacial arrangement of signal.

- Special cells that respond to each: orientation, size, relative luminance, color, local stereoscopic depth, local motion.

- These signals are preferentially and rapidly processed in parallel!

Spatial Frequency Channels

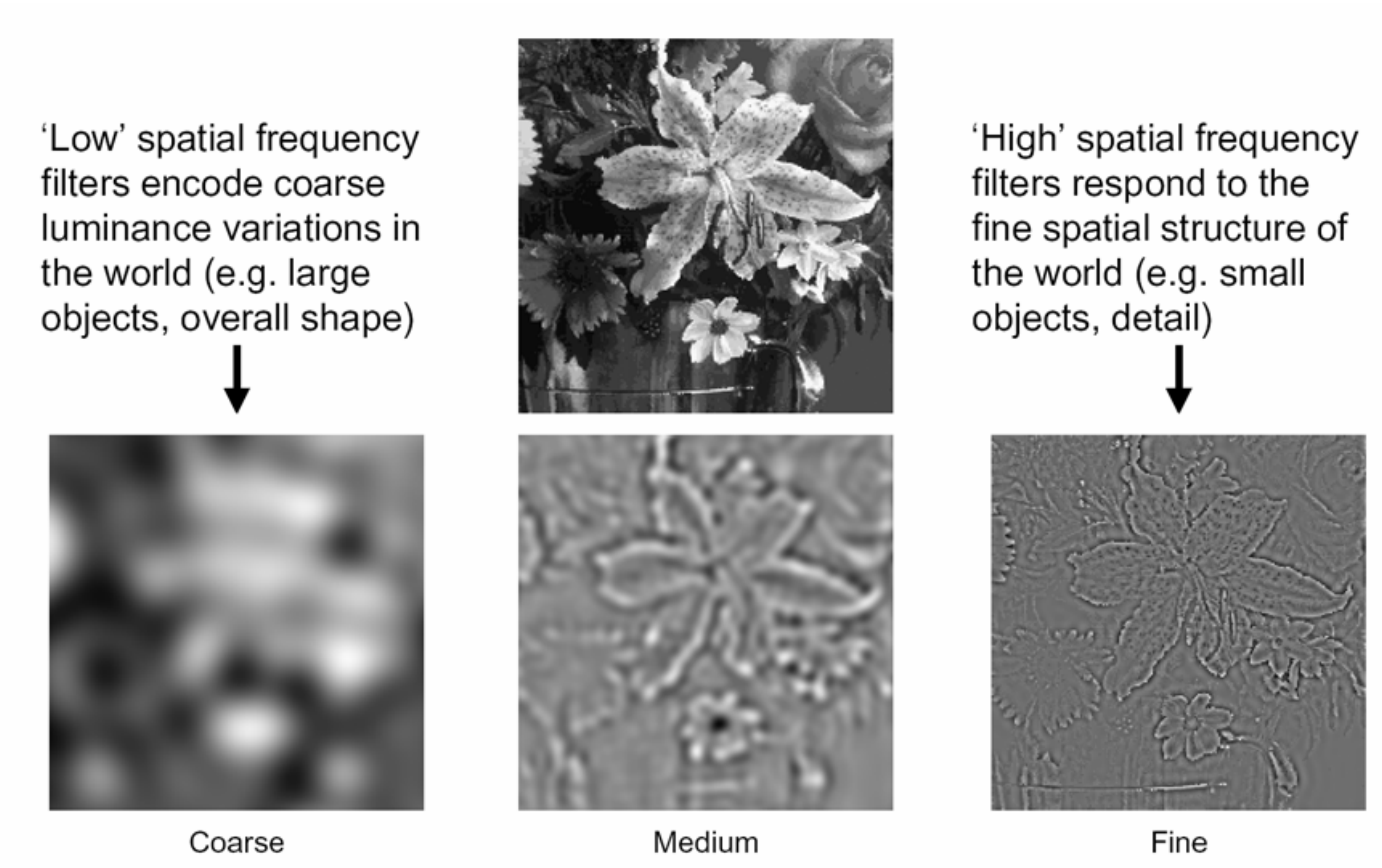
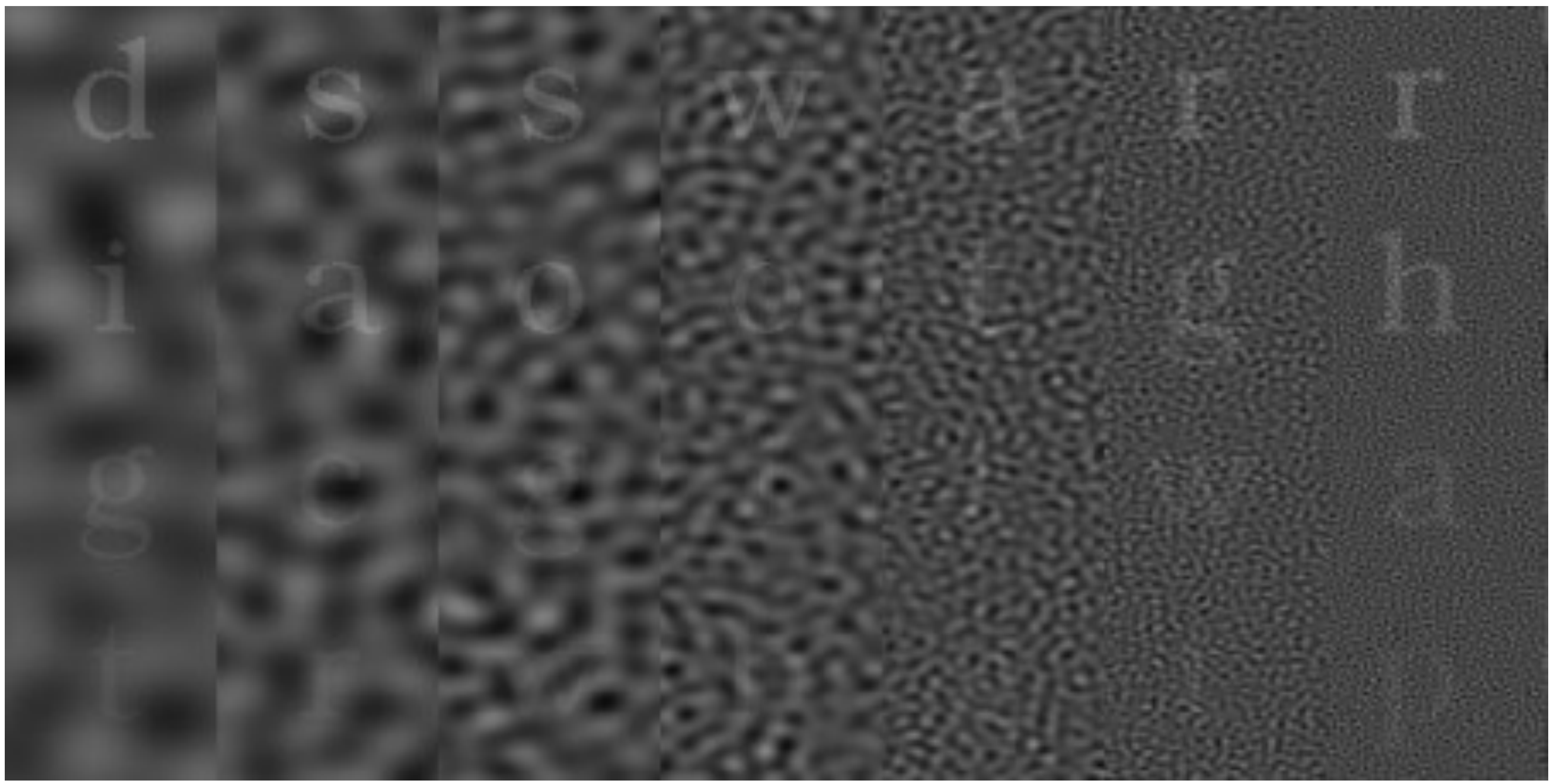


Image: M. Landy

Gabor model



What visual channels are these animals using to trick us? (And what channels are you using to figure them out?)

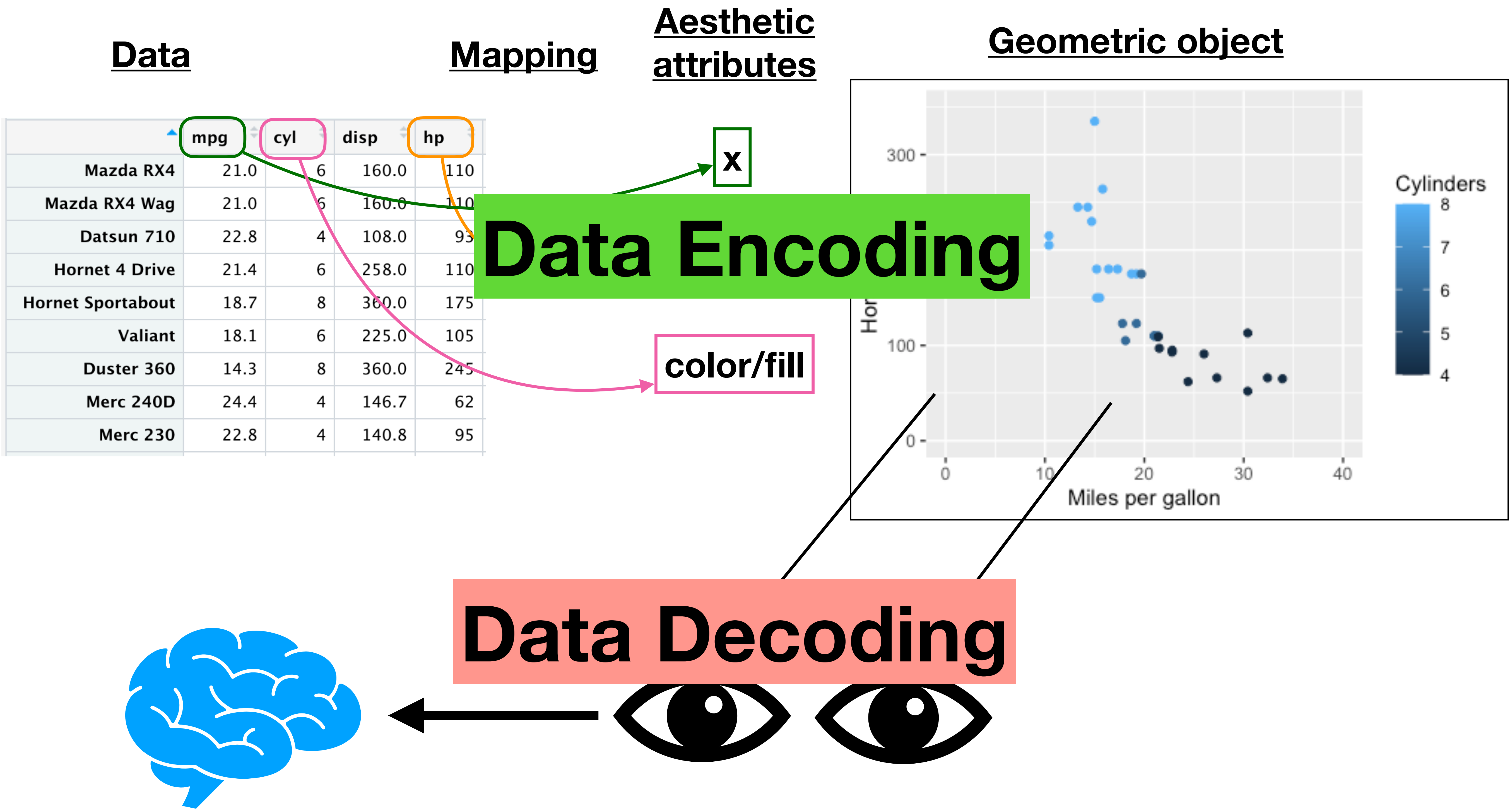
Adam Skowronski/Flickr

[andrea.com]

Find the snake!

Don’t make visualizations like this.

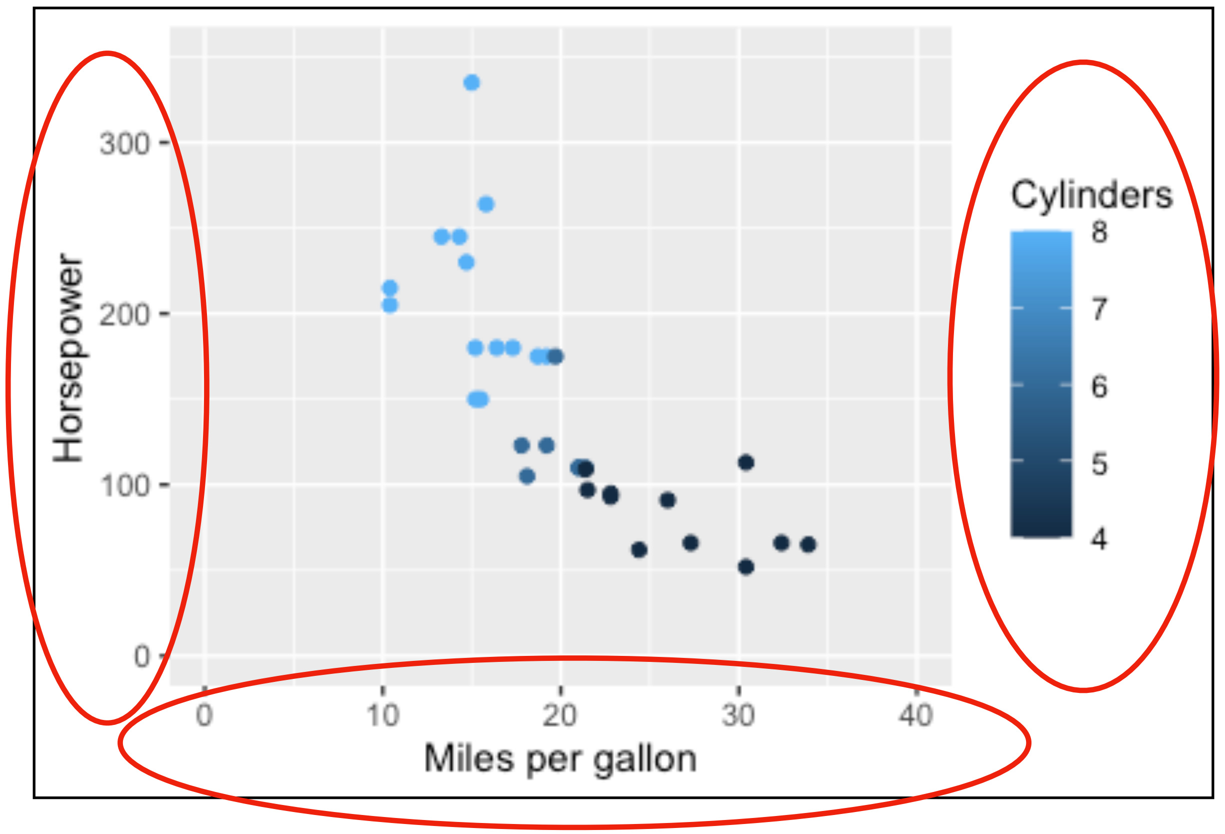
Converting Data to Understanding



	mpg	cyl	disp	hp
Mazda RX4	21.0	6	160.0	110
Mazda RX4 Wag	21.0	6	160.0	110
Datsun 710	22.8	4	108.0	93
Hornet 4 Drive	21.4	6	258.0	110
Hornet Sportabout	18.7	8	360.0	175
Valiant	18.1	6	225.0	105
Duster 360	14.3	8	360.0	245
Merc 240D	24.4	4	146.7	62
Merc 230	22.8	4	140.8	95

Visualization Guides

- Guides include any element that helps the viewer map elements back to data.



- Axis labels
- Legends
- Scales
- Guide lines
- Figure captions

Make sure they are accessible!

- Guides should be easy to read, clear, and descriptive, containing units where appropriate.

Make sure your guides are descriptive enough that a naïve viewer will understand what the elements represent!

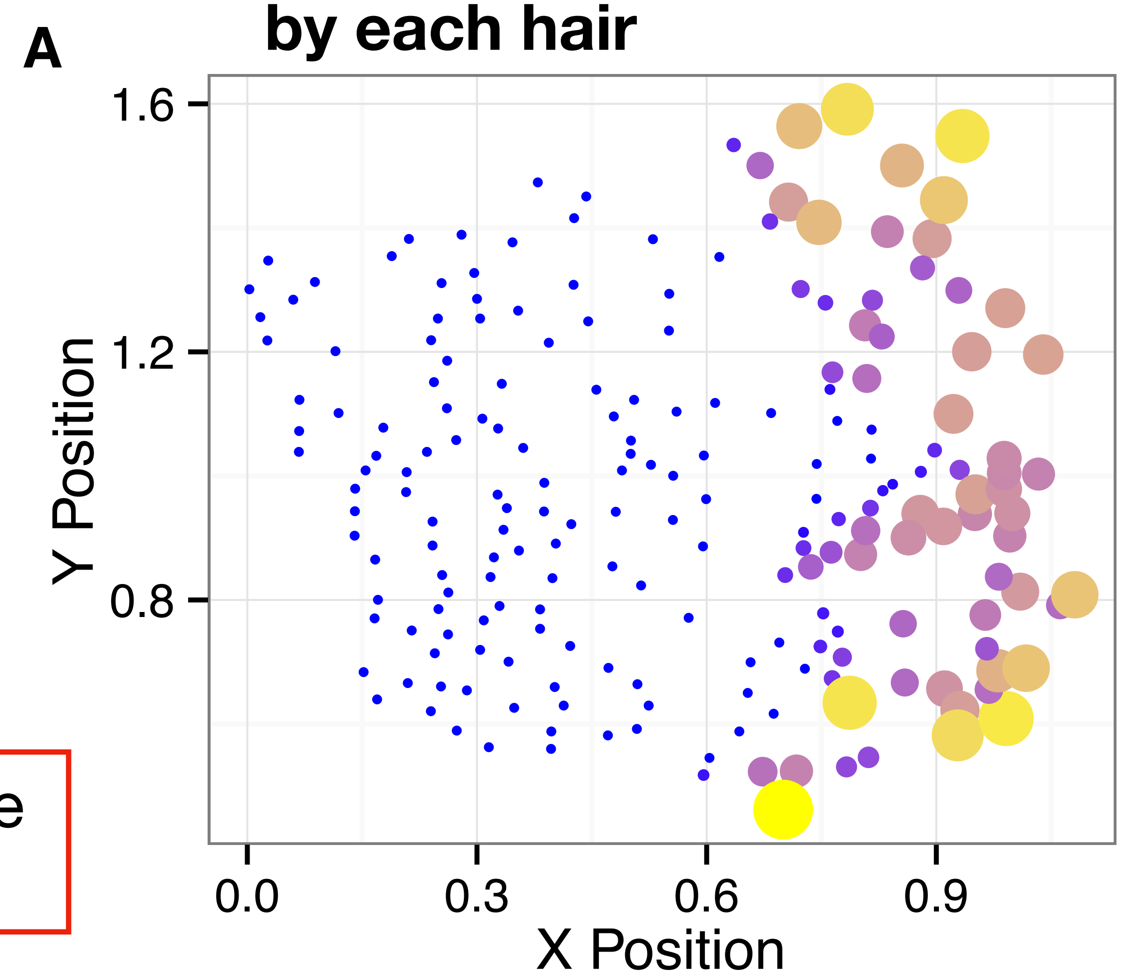
Putting Neuroscience into Practice: Designing Visualizations

- Creating visualizations requires encoding with two types of elements:

    - **Symbols**: a visual stand-in for a specific nominal object or idea, an icon. "This thing stands for that."

    - **Glyphs**: a visual object that represents an object or idea an also passes numerical information/ attributes.

1. **2D location of each hair in an array**
2. **How much odorant captured by each hair**



- **Important**: PAY ATTENTION to how you are ENCODING DATA for your viewers!

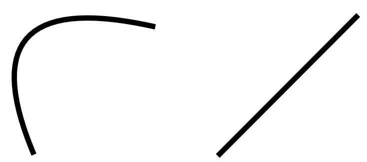
Putting Neuroscience into Practice: Designing Visualizations

- Elements of visual distinctness for symbols and graphs:
  - **Rely on V1 and V2 processing** – these take advantage of rapid processing.
    - Use **different visual channels** to display aspects of data so they are visually distinct.
    - More reliant on basic processing, the more they will stand out!
  - **Color** – make color vary on yellow-blue and red-green axes, use primary colors which are easy to identify.
  - **Gabor** – make things easy to find by relying on different textures, orientation, and sizes, distinct from background in terms of spatial channels.
  - **Local depth cues and stereoscopicity** – shading and other depth cues are processed quickly.

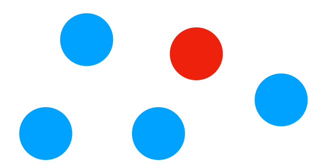
Putting Neuroscience into Practice: Designing Visualizations

- Specific examples of **pre-attentive processing**:

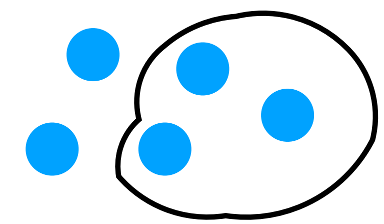
  - **curved/straight**



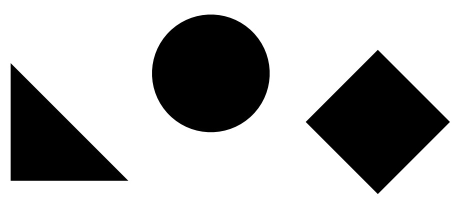
  - **color**



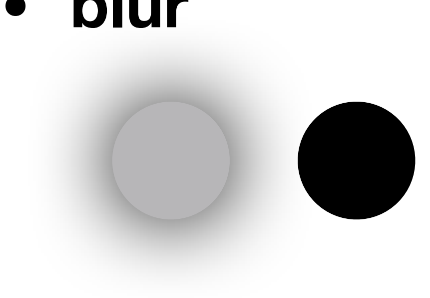
  - **enclosure**



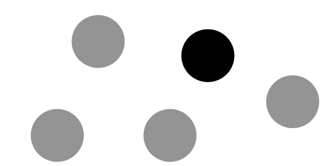
  - **shape**



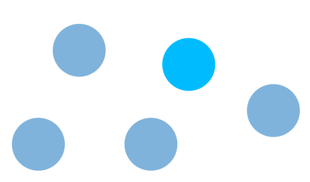
  - **blur**



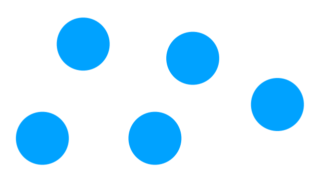
  - **light/dark**



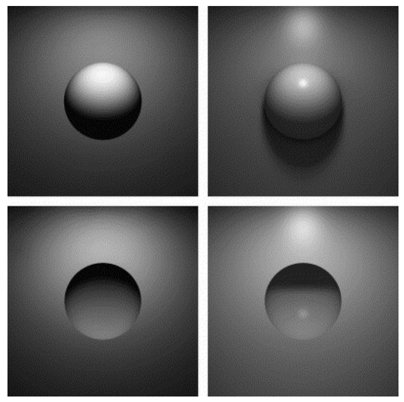
  - **hue intensity**



  - **motion**



  - **convex/concave**

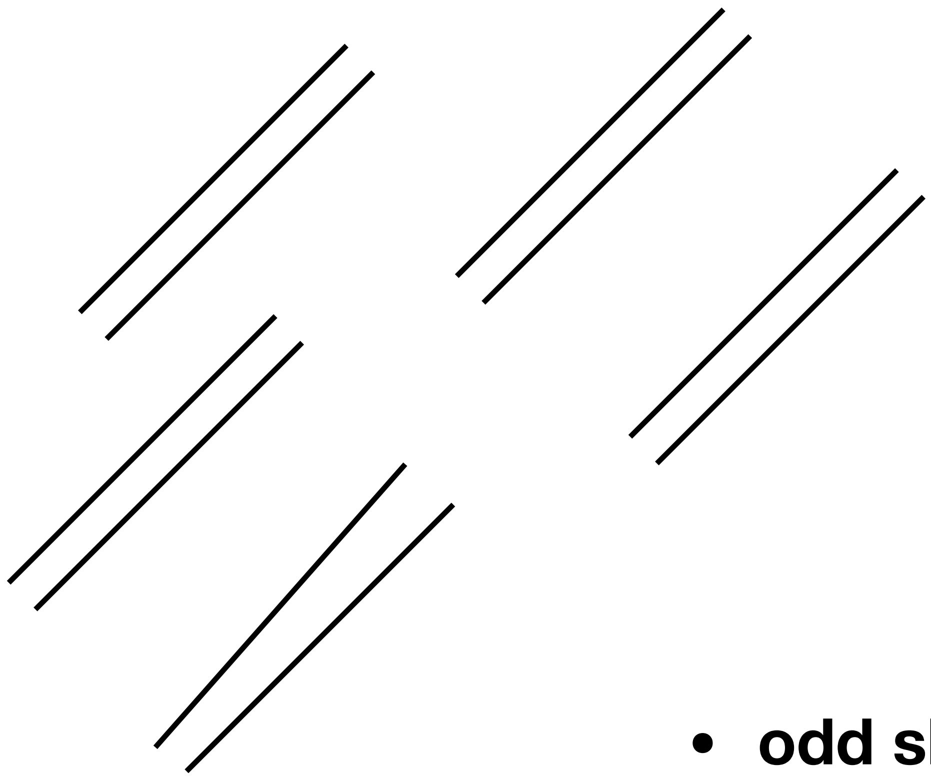


USE THESE

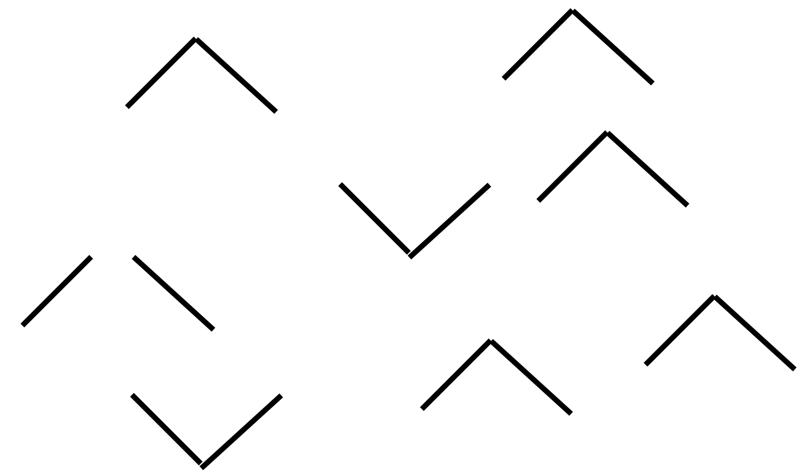
Putting Neuroscience into Practice: Designing Visualizations

- Specific examples of **non pre-attentive processing**:

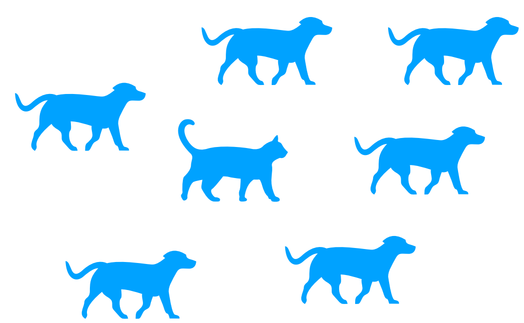
  - **parallelism**



  - **junctions**



  - **odd shapes**



AVOID THESE

Putting Neuroscience into Practice: Designing Visualizations

- Grouping is another pre-attentive process, but be careful how you do it.

Putting Neuroscience into Practice: Designing Visualizations

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Grouping vs color: guess which wins?

Putting Neuroscience into Practice: Designing Visualizations

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Grouping vs color: guess which wins?

Putting Neuroscience into Practice: Designing Visualizations

Grouping
vs
size:
guess which
wins?

Putting Neuroscience into Practice: Improving Visual Salience

- Improve visual salience of data by having redundant coding whenever possible (use more than one type of pre-attentive process to code for differences).

  Examples:

  - color and shape **(color & Gabor)**
  - color and blur **(color & local depth)**
  - shape and blur **(Gabor & Gabor)**

- If you need to encode for different data types, use different channels to encode to improve visual salience.

Group work:

1. Use the iris data set in R and create three graphs of Sepal.Length versus Sepal.Width. Each graph should highlight the *versicolor* species using a single pre-attentive process. Choose one process from each column.

Column 1	**Column 2**	**Column 3**
Orientation	Color	Texture/Blur
Curved/straight	Light/dark	Convex/concave
Shape	Enclosure	Added marks
Size	Hue	Stereoscopic depth

2. Create two additional graphs where two processes are used to indicate versicolor species in addition to the other two species.

Putting Neuroscience into Practice: Glyph Design

- Perceived differences can sometimes interact in ways we don't intend, so it's important to design glyphs to take this into account.

  - **Integral display dimensions** – two or more attributes of a visual object are perceived holistically and not independently.

    - Example: rectangle is perceived as a combination of width and height (not separately ever).

    - Example: a combination of green and red light is perceived as yellow light, and it is impossible to separate red and green out.

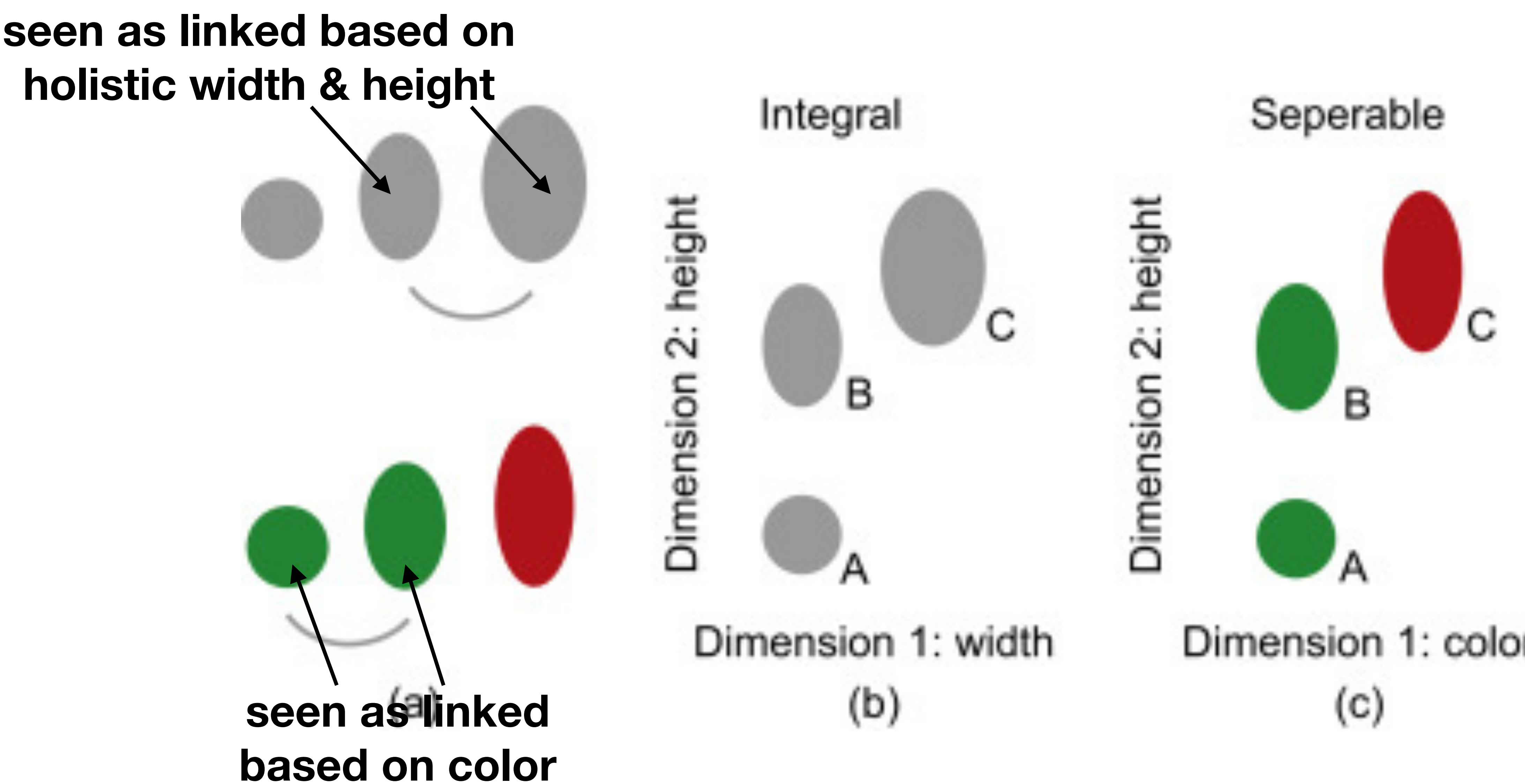
  - **Separable display dimensions** – two or more attributes of a visual object are perceived independently. People are able to make separate judgements about each attribute, called *analytic processing*.

    - Example: a green ball has a shape attribute (ball) and a color attribute (green) that can be considered separately.

Putting Neuroscience into Practice: Glyph Design

- If you have two attributes that need to be analyzed holistically, then use *integral glyph* design to encode the attributes so they are holistically analyzed by the user.

  - Alternatively, if you have attributes that need to be analyzed separately, use easily separable glyph design features.



Group work:

3. Create a visualization of the CO2 data set in R showing plant location (Type), Treatment, environmental concentration of CO2 (conc), and uptake of CO2 (uptake). Do not use a bar graph.

a) Which data are integral? separable?

b) How will you encode the integral variables? separable?

References

McGill University. “The Brain From Top to Bottom: The Eye.” https://thebrain.mcgill.ca/flash/d/d_02/d_02_cr/d_02_cr_vis/d_02_cr_vis.html