

Visual Perception



CS/PSYC 3750/6750 – UI Design

CS 4460 - Information Visualization

Last update: November 2015

Agenda – Visual Perception



- Pre-attentive processing
- Color
- Data Mark effectiveness and the four data types (what are they??)

Preattentive Processing



- How does human visual system analyze images?
 - Some things seem to be done preattentively, without the need for focused attention
 - Generally less than 200-250 msec
 - Eye movements (saccades) take 20 -200 msec
 - Seems to be done in parallel by low-level vision system

Preattentive visual patterns

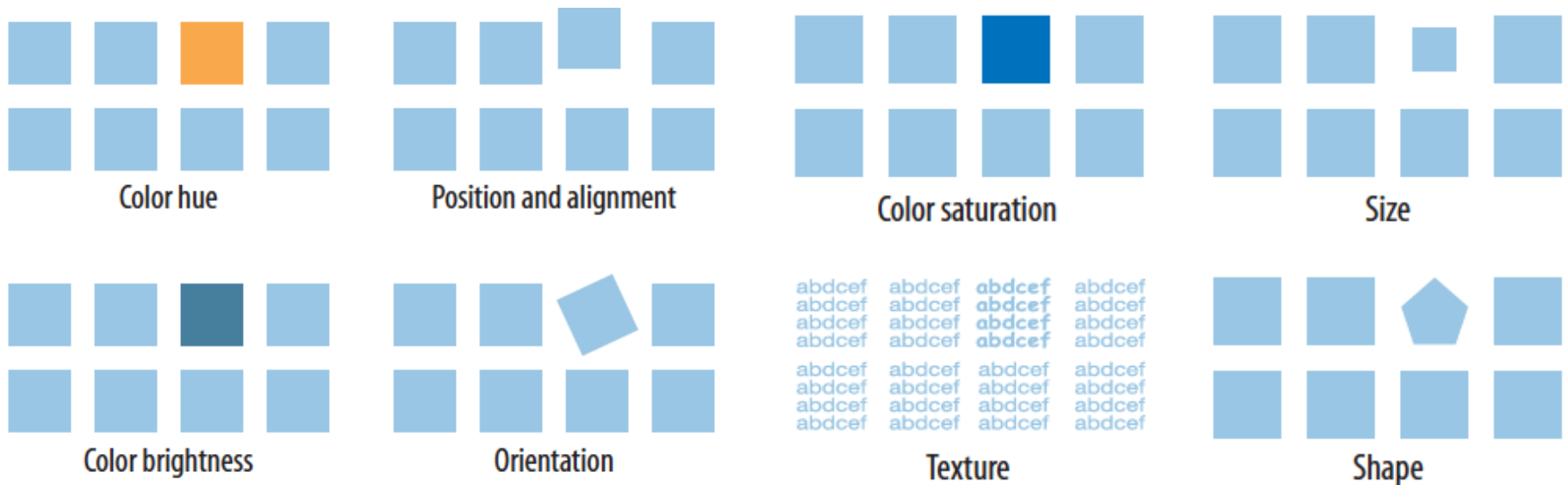


Figure 7-5. *Eight preattentive variables*

From J. Tidwell, *Designing Interfaces 2nd Ed.*, O'Reilly

How Many 3's?



1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686

How Many 3's?



12817687561**3**8976546984506985604982826762
980985845822450985645894509845098094**3**585
90910**3**0209905959595772564675050678904567
8845789809821677654876**3**64908560912949686

What Kinds of Tasks?



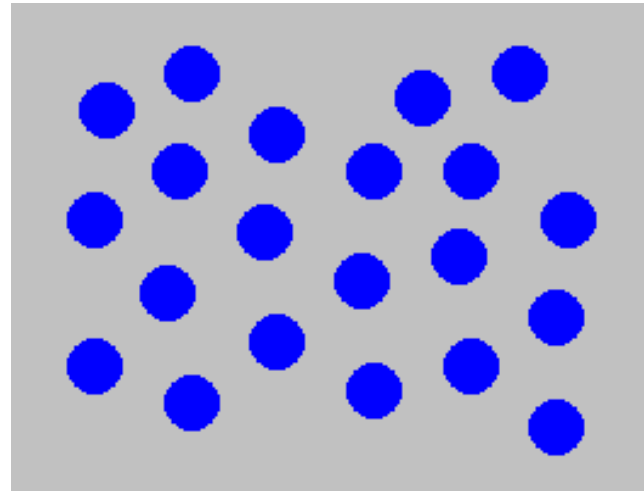
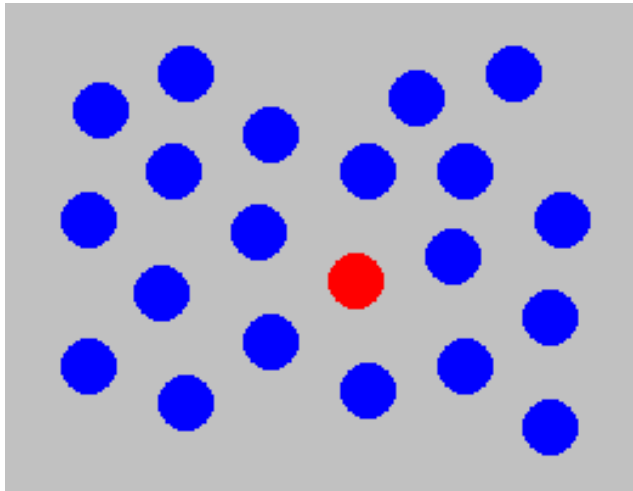
- Target detection
 - Is something there?
- Boundary detection
 - Can the elements be grouped?
- Counting
 - How many elements of a certain type are present?

Example - Hue



- Determine if a red circle is present

Hue



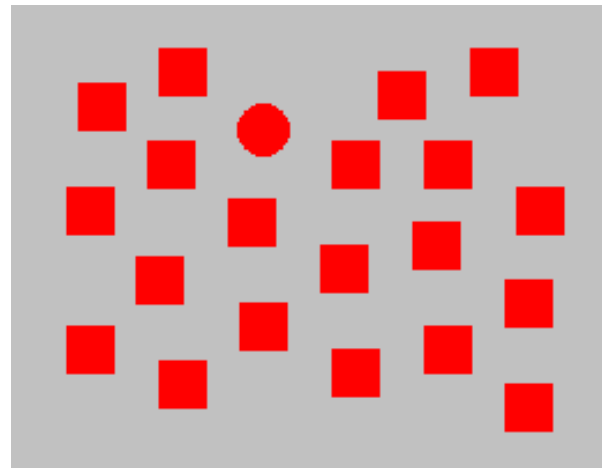
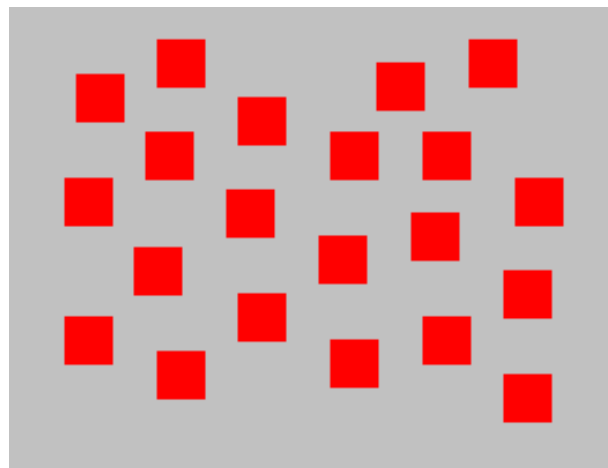
Can be done rapidly (preattentively) by people
Surrounding objects called “distractors”

Example - Shape



- Determine if a red circle is present

Shape



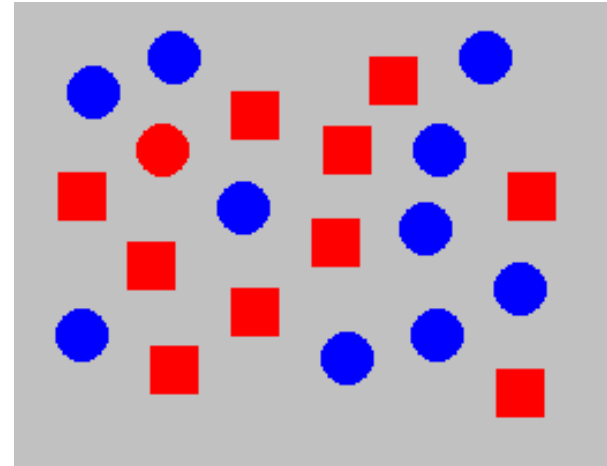
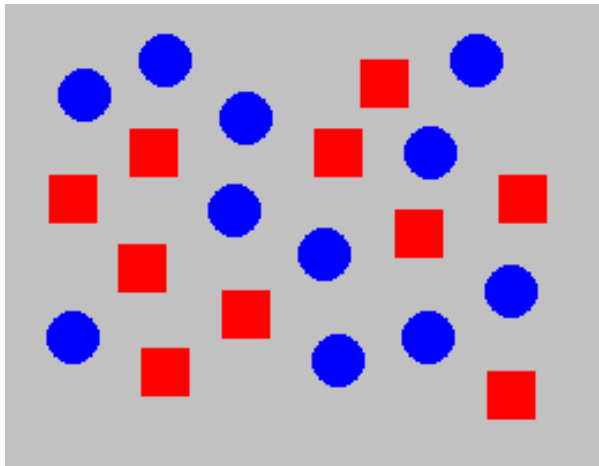
Can be done preattentively

Example - Hue and Shape



- Determine if a red circle is present

Hue and Shape – Problem!



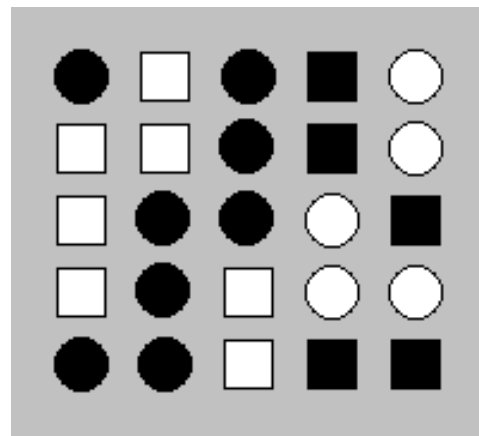
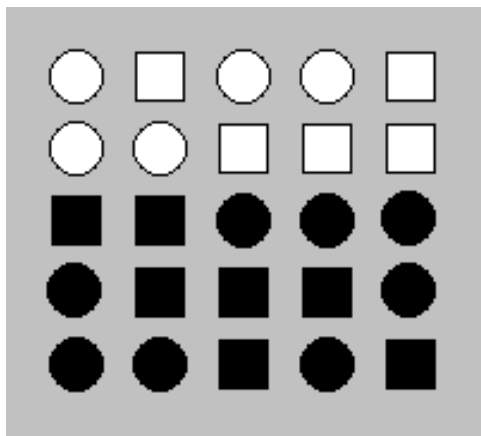
- **Cannot** be done preattentively
- Must perform a sequential search
- Conjunction of features (shape and hue) causes it

Example - Fill and Shape



- Is there a boundary in the display?

Fill and Shape



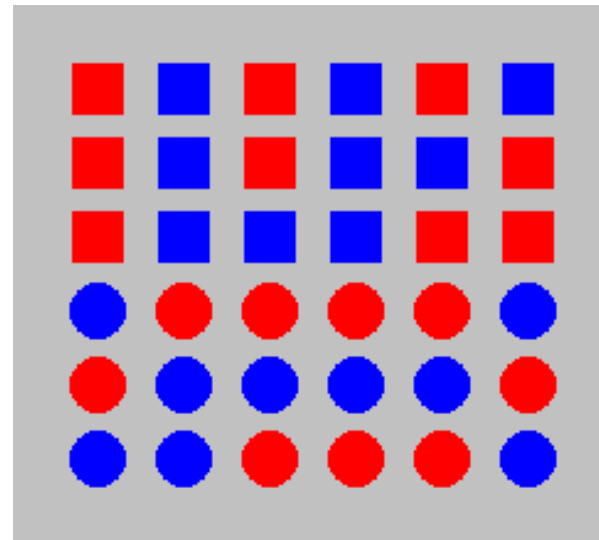
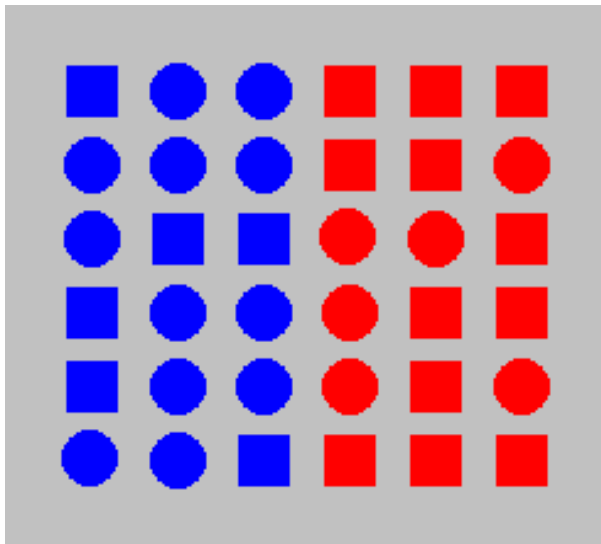
- Left can be done preattentively since each group contains one unique feature
- Right cannot (there is a boundary!) since the two features are mixed (fill and shape)

Example - Hue vs. Shape



- Is there a boundary in the display?

Hue versus Shape



Left: Boundary detected preattentively based on hue regardless of shape

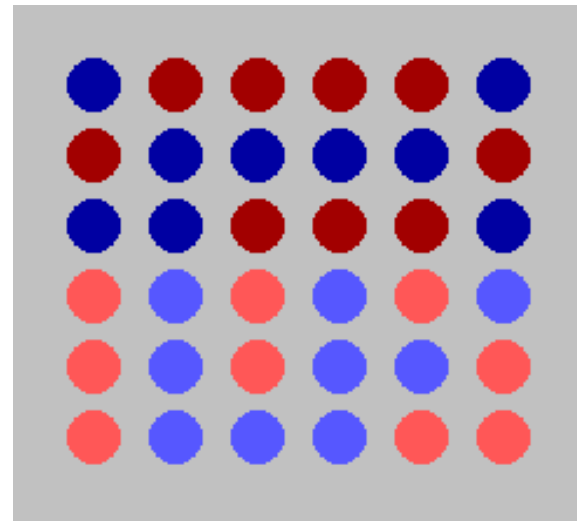
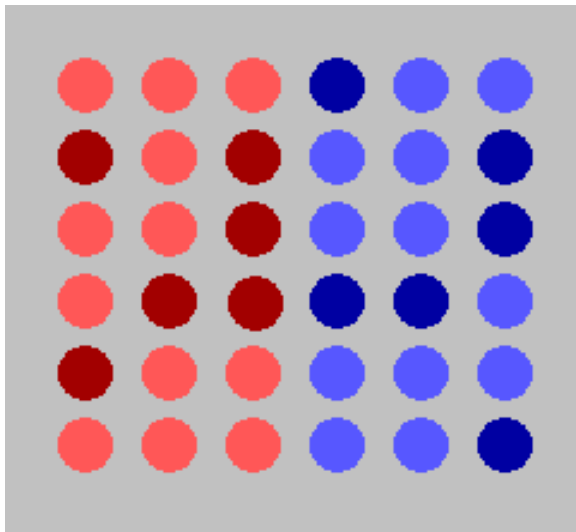
Right: Cannot do mixed color shapes preattentively

Example - Hue vs. Brightness



- Is there a boundary?

Hue versus brightness



Left: Varying brightness seems to interfere
Right: Boundary based on brightness can be
done preattentively

Example Applet

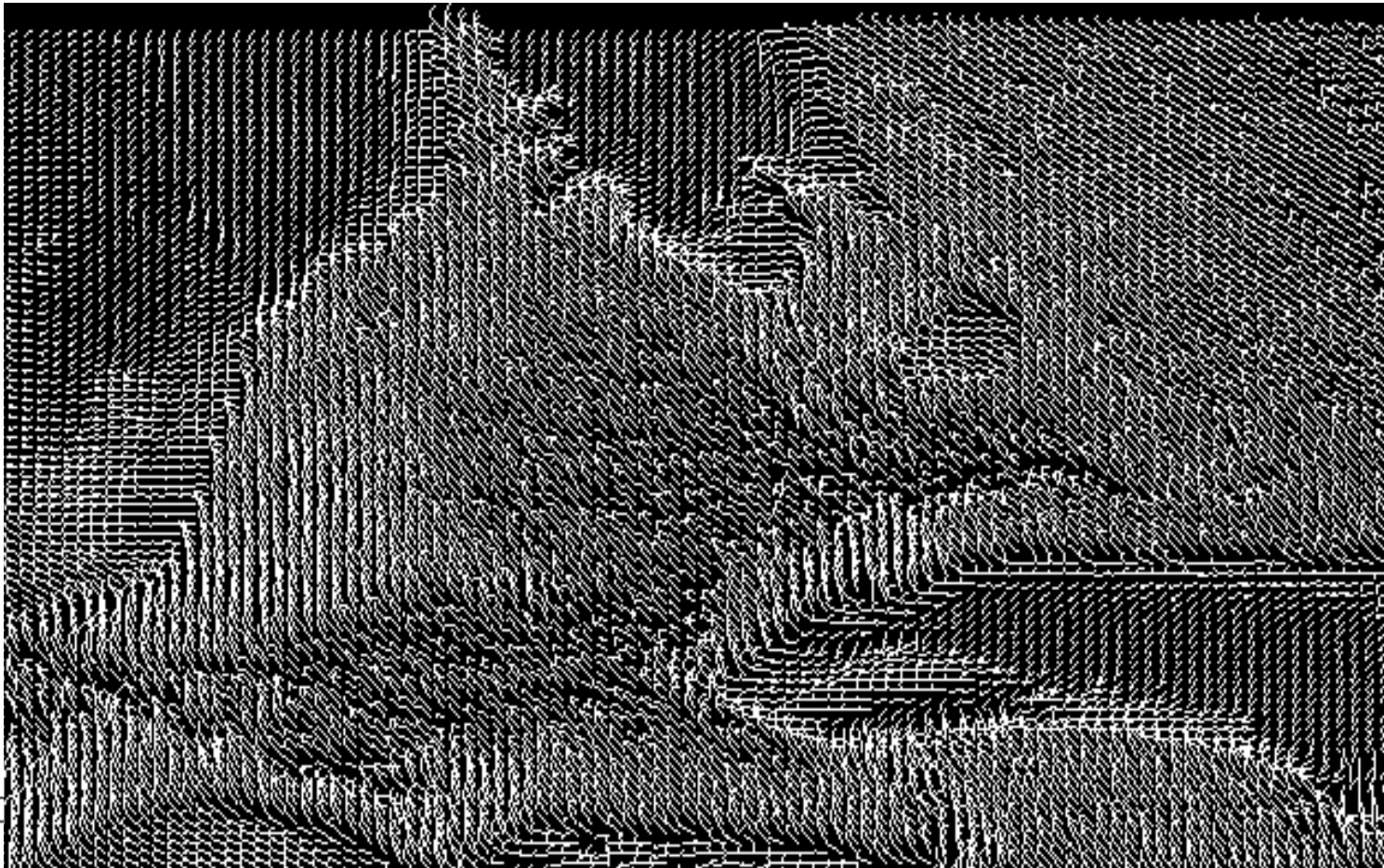


- Nice on-line tutorial and example applet
 - <http://www.csc.ncsu.edu/faculty/healey/PP/index.html>
 - Chris Healey, NC State
 - Prior pictures taken from site

Glyphs



- Preattentive processes at work



Pre-attentive Features



- What features to use to take advantage of pre-attentive processing??
- Certain visual forms lend themselves to pre-attentive processing, others do not

Potential Pre-attentive Features



length

width

size

curvature

number

terminators

intersection

closure

hue

intensity

flicker

direction of motion

binocular lustre

stereoscopic depth

3-D depth cues

lighting direction

- Note overlap with Gestalt ideas

Key Perceptual Properties



- Brightness
- Color
- Texture
- Shape

Luminance/Brightness



- Luminance
 - Measured amount of light coming from some place
- Brightness
 - *Perceived* amount of light coming from source

Brightness



- Perceived brightness is non-linear function of amount of light emitted by source
 - Typically a power function
 - $S = aI^n$
 - S - sensation
 - I - intensity
- Very different on screen versus paper

Grayscale



- Probably not best way to encode data because of contrast issues
 - Surface orientation and surroundings matter a great deal
 - Luminance channel of visual system is so fundamental to so much of perception
 - We can get by without color discrimination, but not luminance

Characterizing Color - HSV Model



- Hue
 - basic color, pigment
- Saturation
 - relative purity, brightness, or intensity of a color
- Value
 - lightness or darkness of a color
- Most commonly-used model

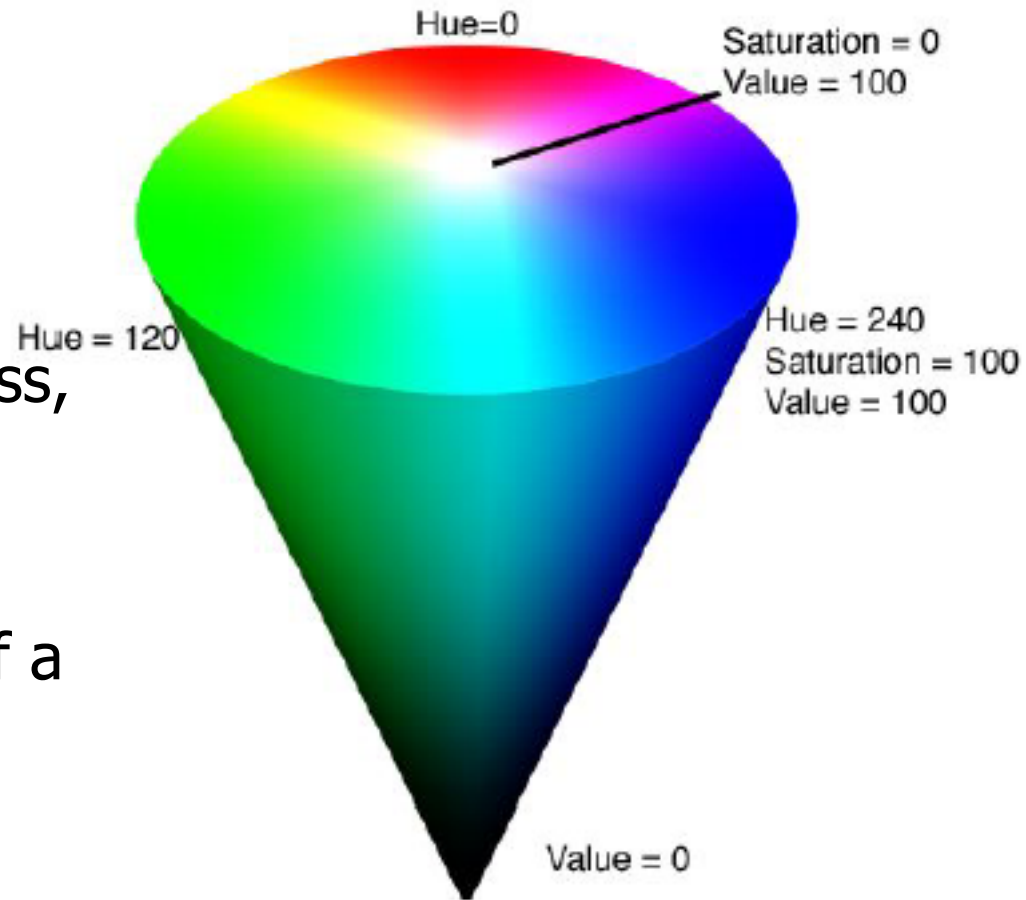

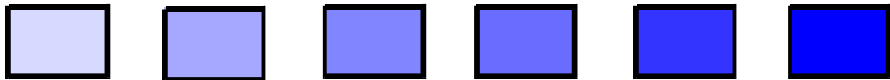
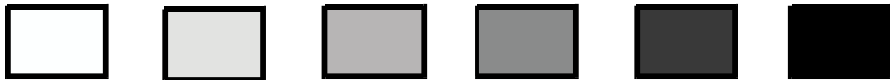


Figure 2: The HSV Cone

Image from: *Adventures in HSV Space*,
Darrin Cardani, dcardani@buena.com

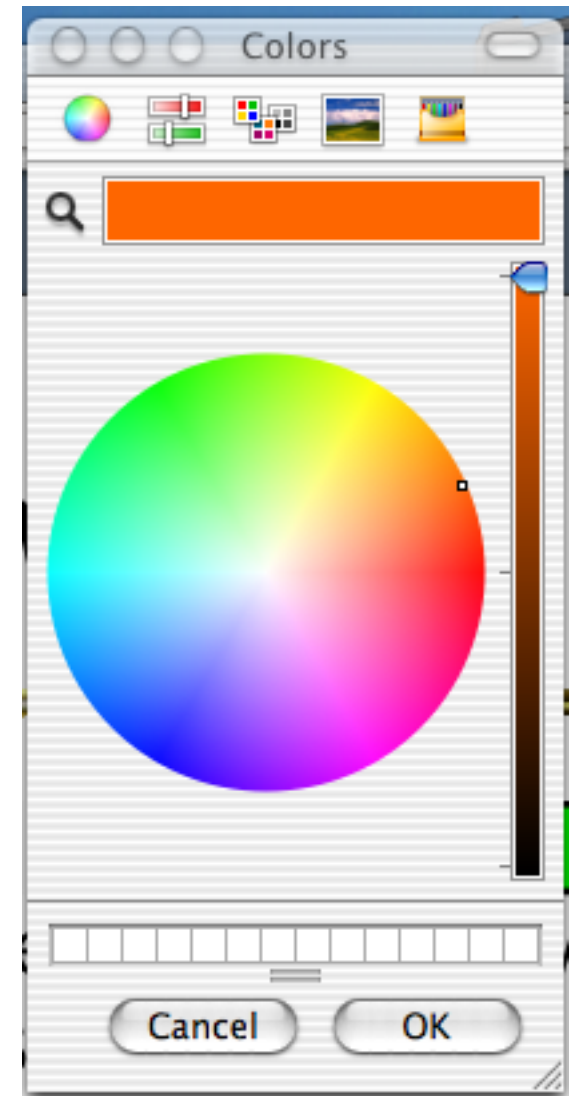
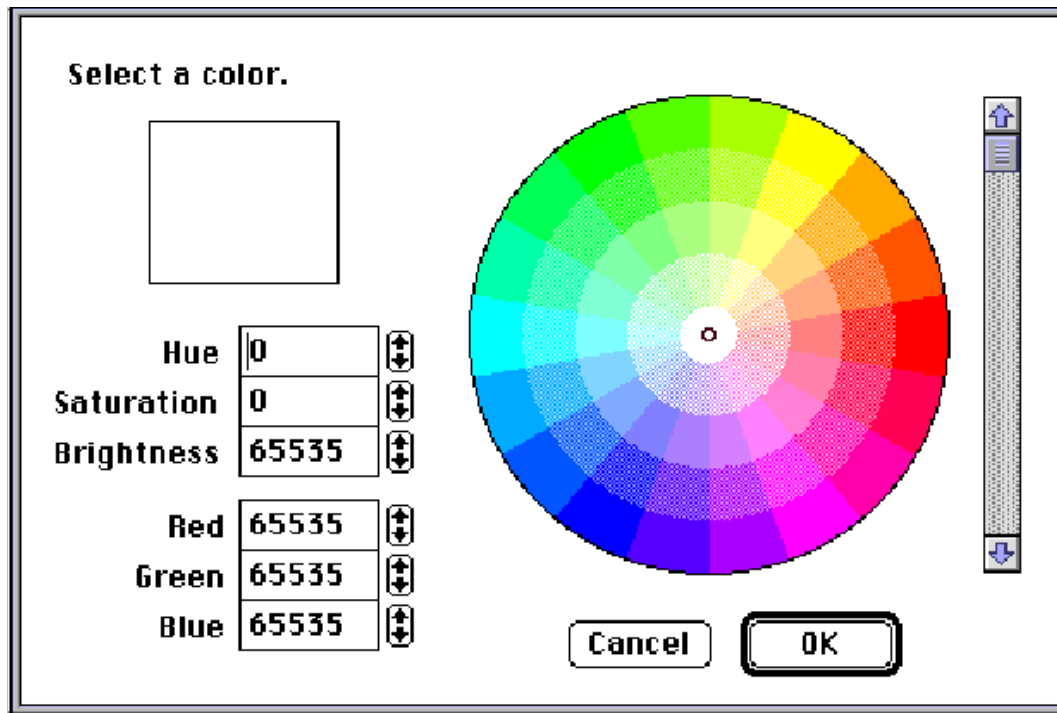
HSV Color Model



- Hue 
 - Wavelength (red, green, yellow, blue)
 - Spectrum (VIBGYOR)
- Saturation 
 - Pastel versus strong (baby blue, sky blue, royal blue)
- Value 
 - amount of energy (white, light gray, dark gray, black)
 - Usually $V = 0.299 * R + 0.587 * G + 0.114 * B$

HSV Color Space

- Typical color selection tools



Luminance



- Important for fg-bg colors to differ in brightness

Hello, here is some text. Can you read what it says?

Hello, here is some text. Can you read what it says?

Hello, here is some text. Can you read what it says?

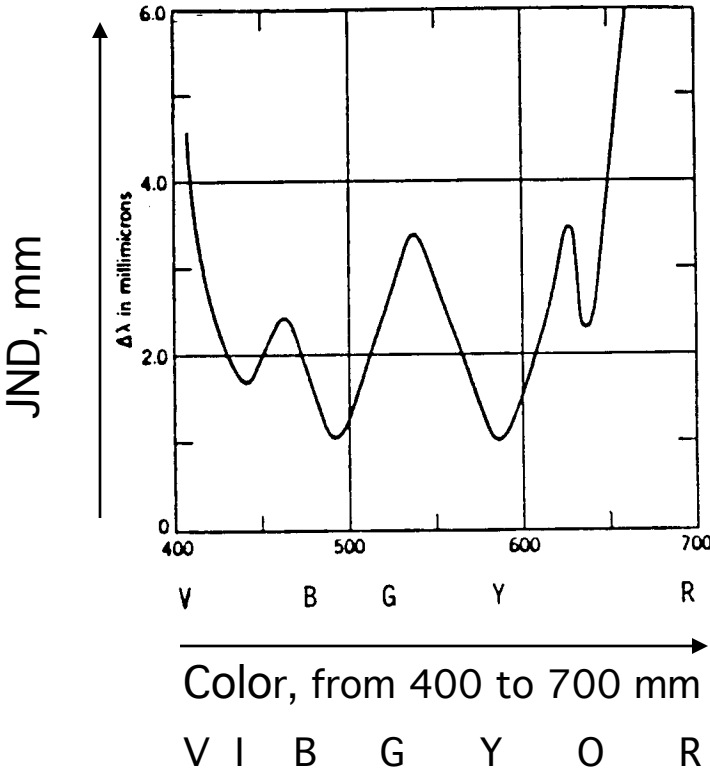
Hello, here is some text. Can you read what it says?

Hello, here is some text. Can you read what it says?

Hello, here is some text. Can you read what it says?

Hello, here is some text. Can you read what it says?

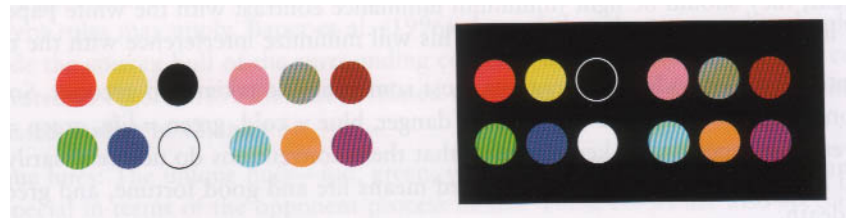
Color JND



Color for Categories



- Can different colors be used for categorical variables?
 - Yes (with care)
 - Ware's suggestion: 12 colors
red, green, yellow, blue, black, white, pink, cyan,
gray, orange, brown, purple



From Ware '04

Color for Sequences



Can you order these (low->hi)

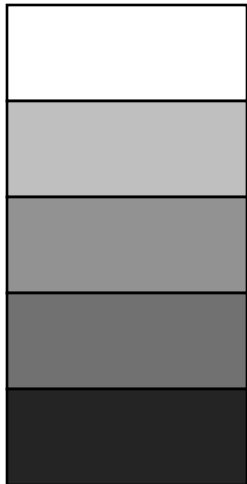


Possible Color Sequences



Which are easiest to interpret?

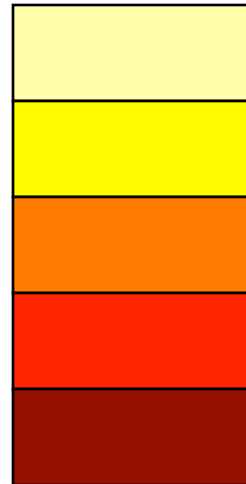
Gray scale



Full spectral scale



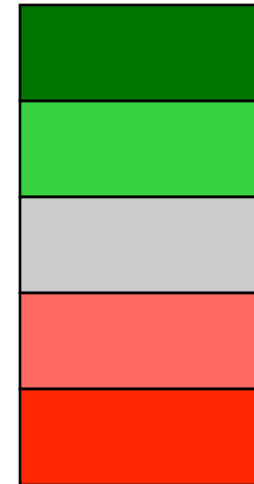
Single sequence
part spectral scale



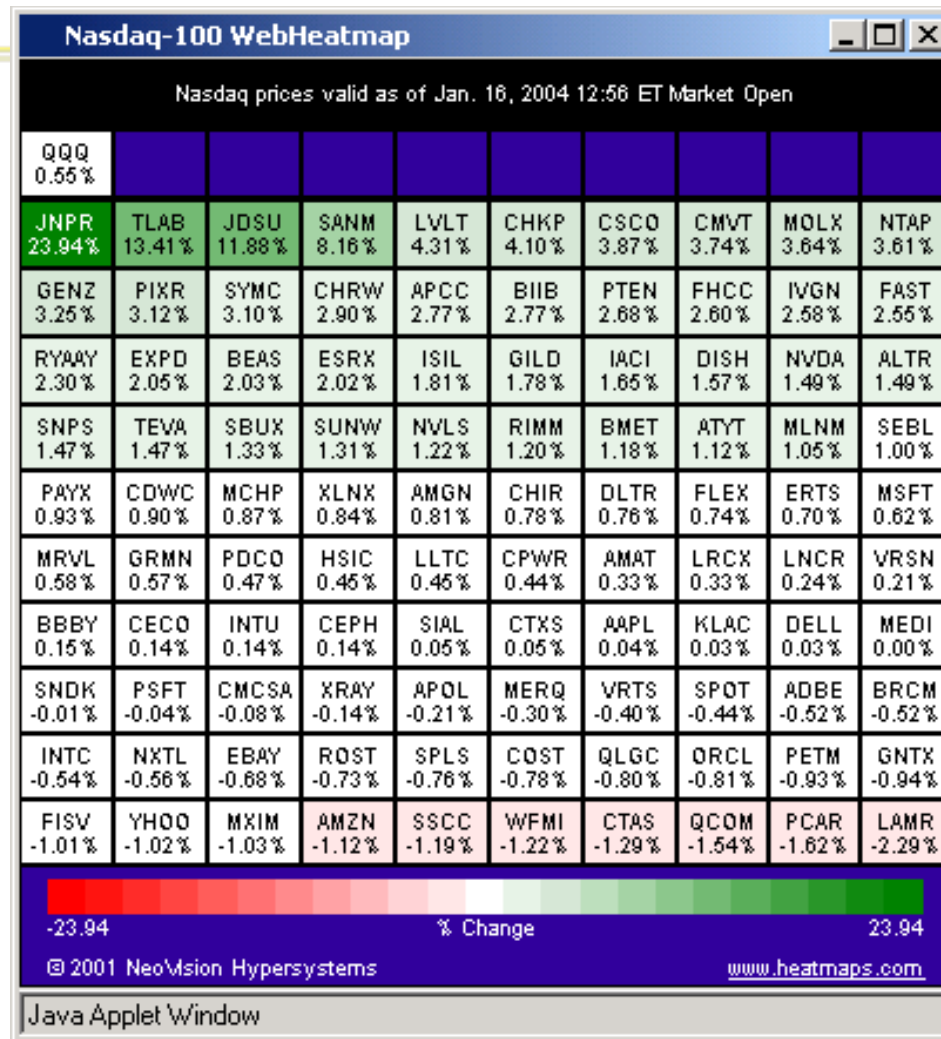
Single sequence
single hue scale



Double-ended
multiple hue scale



HeatMap



Why not run color scale from -2.29 up to 23.94?

- http://screening.nasdaq.com/heatmaps/heatmap_100.asp

ColorBrewer



ColorBrewer - Selecting Good Color Schemes for Maps - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites RSS Print Mail

Address <http://www.personal.psu.edu/faculty/c/a/cab38/ColorBrewer/ColorBrewer.html> Go

Links Customize Links weather.com Georgia Navigator KPLU Jazz Google Free AOL & Unlimited Internet Free Hotmail RealPlayer

number of classes Step1

learn more

Step2 legend type

sequential diverging

qualitative learn more

mini legends Step3

ColorBrewer dg QG

how to use updates

about map credits

reset view

map zoom map borders on off city symbols on off road network on

background color border color white black road network color

learn more

Printed ColorBrewer charts and RGB Excel file are available ... click 'updates' button (upper right)

This material is based upon work supported by the National Science Foundation under Grant No. 9983451, 9983459, 9983461

Done Internet

Help with selecting colors for maps

<http://colorbrewer2.org/>

Color Purposes

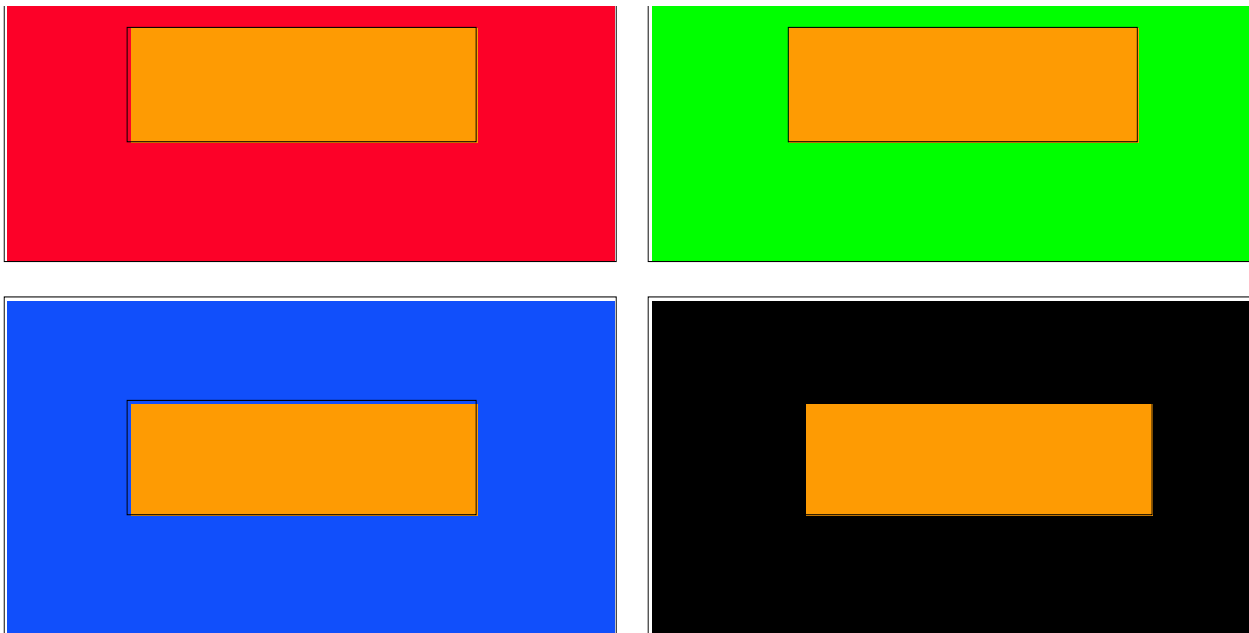


- Call attention to specific data
- Increase appeal, memorability
- Increase number of dimensions for encoding data
 - Example, Ware and Beatty '88
 - x,y - variables 1 & 2
 - amount of r,g,b - variables 3, 4, & 5

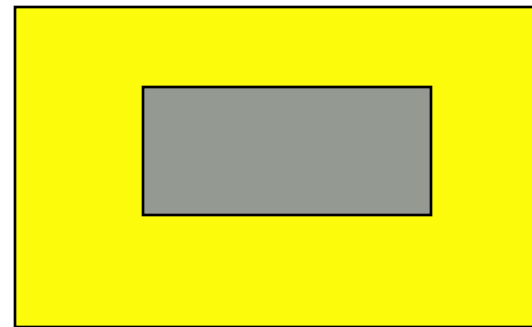
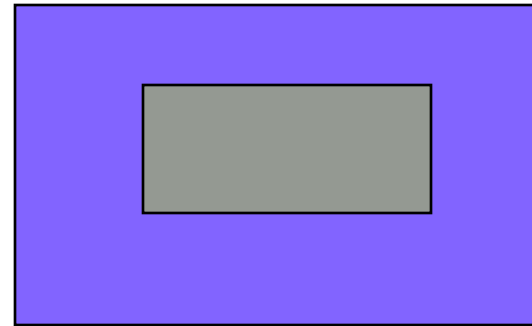
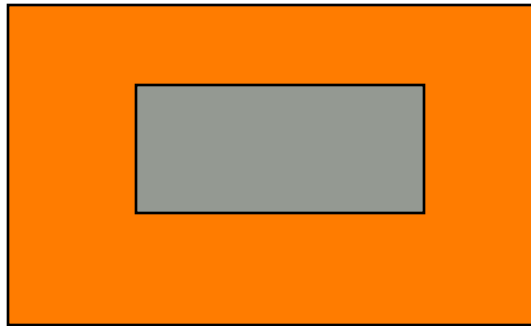
Color Surround Effect



- Our perception of a color is affected by the surrounding color



Color Surround



What is the implication? So what?




Using Color



- Modesty! Less is more
- Use blue in large regions, not for thin lines
- Use red and green in the center of the field of view (edges of retina not sensitive to these)
- Use black, white, yellow in periphery
- Use adjacent colors that vary in hue & value
- Make sure can make sense in gray-level image

Using Color

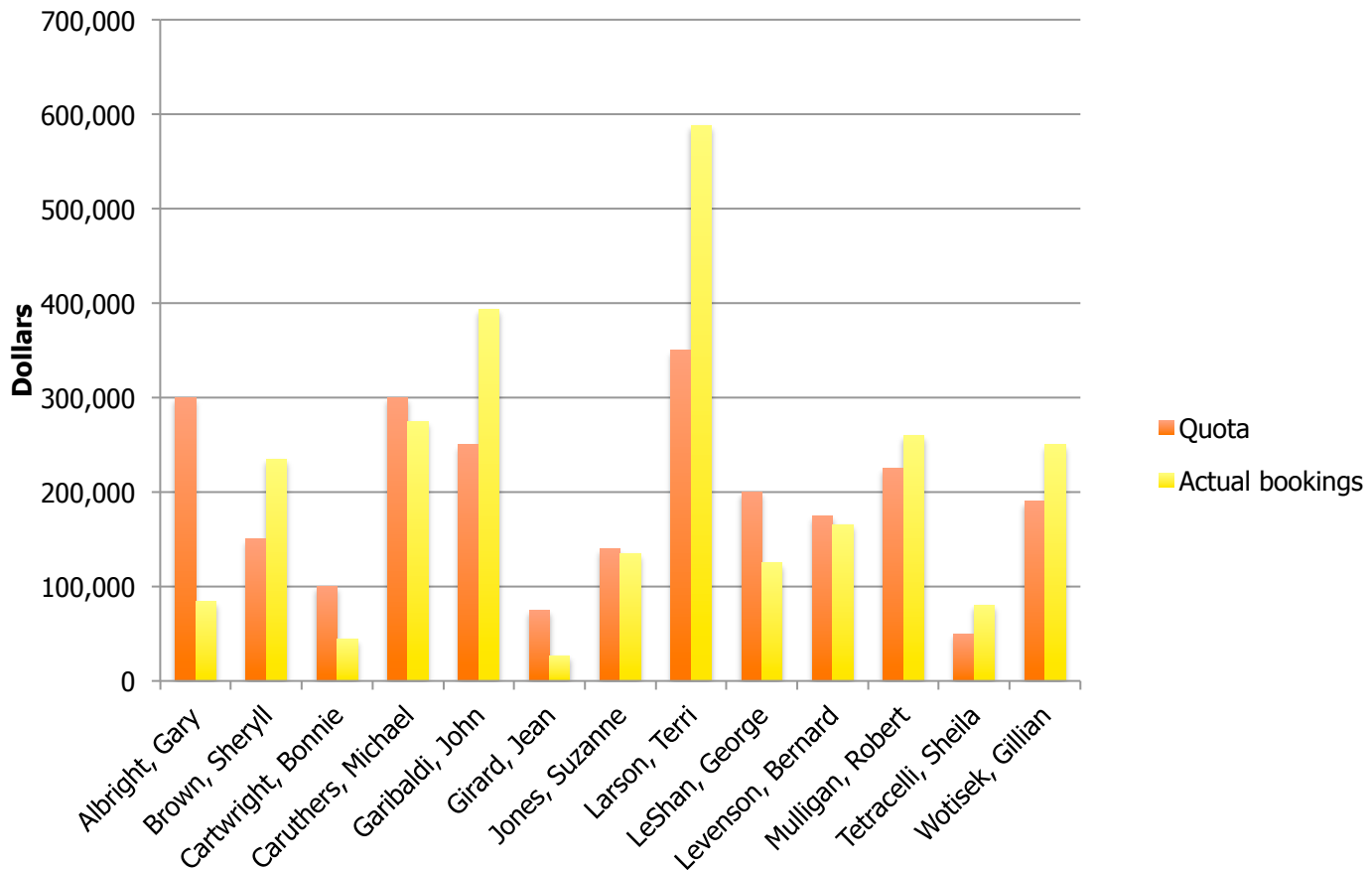


- Do not use adjacent colors that vary in amount of blue
- Do not expect color of very small areas to be discriminable   
- Don't use high saturation, spectrally extreme colors together (causes after images)
- Use color for grouping and search
- Beware effects from adjacent color regions

Good Use of Color?



Sales by Person, Quota vs. Actual

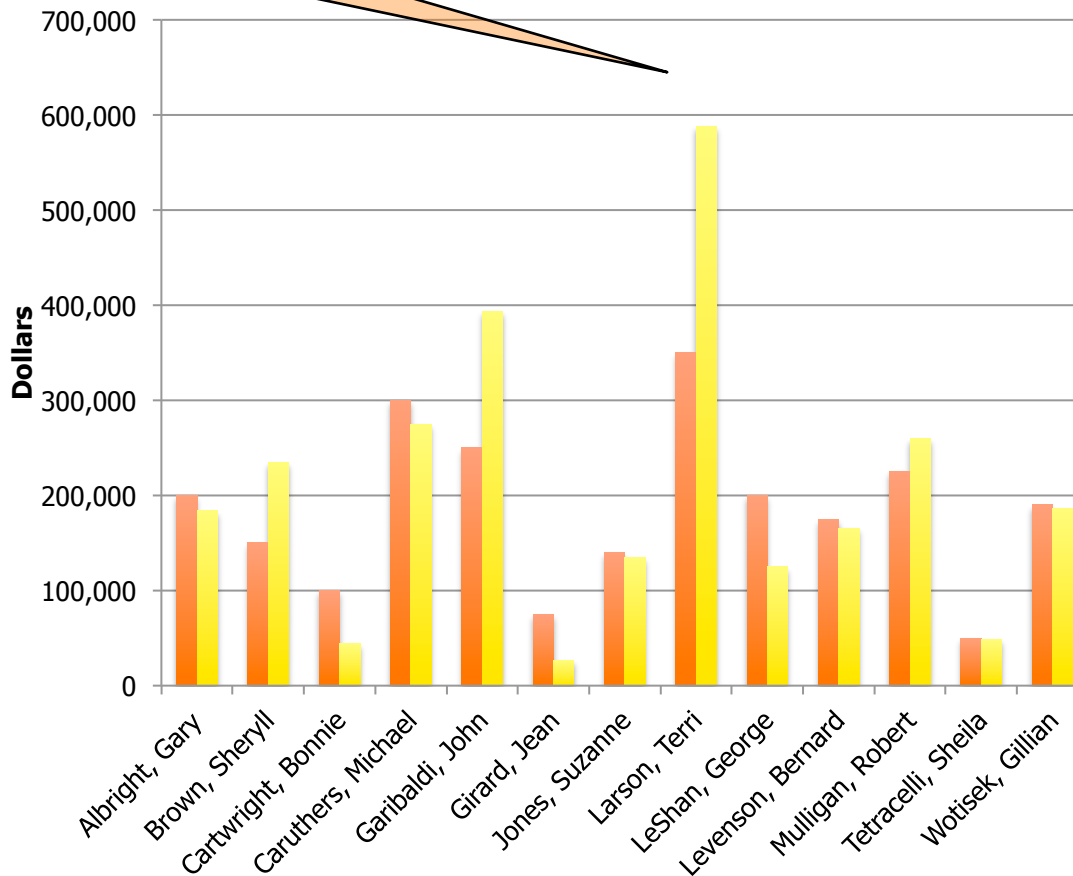


Good Use of Color?



Where is the top;
light colors on white
background

Sales by Person, Quota vs. Actual



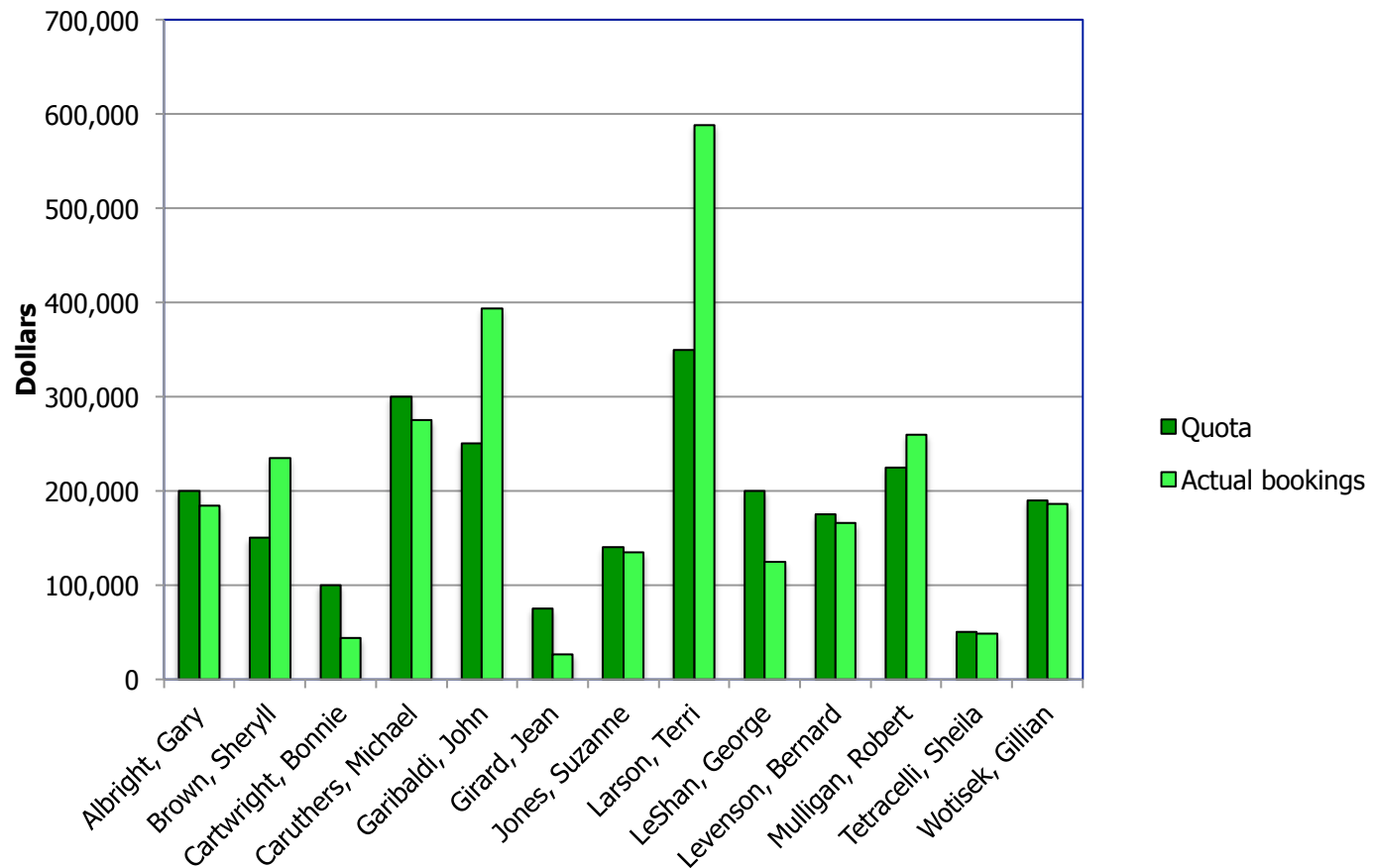
Color swatches too
small; light colors on
white background

Quota
Actual bookings

Better Use of Color



Sales by Person, Quota vs. Actual



Using Color



- Modesty! Less is more
- Use blue in large regions, not thin lines
- Use red and green in the center of the field of view (edges of retina not sensitive to these)
- Use black, white, yellow in periphery
- Use adjacent colors that vary in hue & value

Summary – Key Points



- Preattentive processing – what is it, what good for?
- When and how to use (and not to use) color