ADMINISTRIVIA

Project
– MSIV – Part A was just due
– MSIV – Part B due on Thurs
– MSIV – Part C (Video) due next Thursday
– design reviews on Friday
  • be prepared to show your prototype (if we have questions about how it changed)
  • be prepared to talk about presentations/video

MSV

• Design Competition (next Tues) will be held in this room (DMP 110)
  – Main presentations: 3:30 - 5:30 (mandatory)
  – Might go slightly past 5:30, social with nibbles, and judging to follow
  – If you have a team member who cannot stay past 5:30, you need to let me know (via piazza) by Friday
• testing presentation is required – availability of DMP 110 for testing will be posted on Piazza

MSV

• fantastic design jury:
  – Barry Po: Senior Director, Product and Business Development, NGRAIN (PhD in Computer Science, HCI, 2005)
  – Nicole Arksey: User Experience Researcher & Interaction Designer, IQmetrix (MSc in Computer Science, HCI, 2007)
  – Antoine Ponsard: UX Designer, PDFTron Systems Inc. (MSC in Computer Science, HCI, 2015)
• will be a short break ~ halfway through – opportunity to chat with jury members, as well as at social afterwards (once judging is done)
TODAY (AND NEXT TIME)

– color perception (stage 1)
– pre-attentive processing (stage 1)
– guidelines for design
– gestalt theories (stage 2)

many of the slides in this lecture are courtesy of Colin Ware "Information Visualization: Perception for Design", 2000

MACHINERY OF PERCEPTION

this is a more detailed version of Fig 2.1 in Ware reading

HUMAN VISUAL SYSTEM

• light passes through lens
• focused on retina

RETINA:

COVERED WITH LIGHT-SENSITIVE RECEPTORS

• rods
  – sensitive to broad spectrum of light
  – unable to resolve detail
  – over-stimulated in all but the dimmest light
  – can’t discriminate between colors
  – sense intensity or shades of gray
  – primarily for night vision & perceiving movement
  – 120 million per eye

• cones
  – less sensitive to light
  – used to sense color
  – 6 million per eye
**RETINA**

- center of retina (fovea) has most of the cones
  - allows for high acuity of objects focused at center

- edge of retina (periphery) is dominated by rods
  - allows detecting motion in periphery

**PERIPHERAL ACUITY**

With strict fixation of the center spot, each letter is equally legible because it is about ten times its threshold size. This is true at any viewing distance. Chart shows the increasingly coarse grain of the retinal periphery. Each letter is viewed by an equal area of visual cortex.


**WHY STUDY COLOR?**

- color can substantially improve user interfaces...

- but inappropriate use can severely reduce usability
COLOR COMPONENTS

hue
– property of the wavelengths of light (i.e., “color”)

intensity
– also luminance, lightness, brightness, value
– how much light appears to be reflected from a surface
– some hues are inherently lighter or darker

saturation
– purity of the hue
  • e.g., red is more saturated than pink
  • color is mixture of pure hue & achromatic color
    • portion of pure hue is the degree of saturation

TRICROMACY THEORY

• cone receptors used to sense color

• 3 types: Short, Medium, Long (really more yellow)
  • each sensitive to different band of spectrum
  • balance of activity between 3 types to achieve all colours in visible spectrum

DISTRIBUTION OF CONES

• not distributed evenly
  – mainly reds (64%) and greens (32%) & very few blues (4%)
    insensitive to short wavelengths, e.g. cyan to deep-blue

• center of retina (high acuity) has no blue cones
  – small blue objects you fixate on disappear
COLOR SENSITIVITY (CONT.)

implications:

- Blue text on a dark background to be avoided. We have few short-wavelength sensitive cones in the retina and they are not very sensitive. Older users need brighter colors.

- Blue text on a dark background to be avoided. We have few short-wavelength sensitive cones in the retina and they are not very sensitive.

- Older users need brighter colors.

- Showing small yellow text on a white background is a bad idea. Pure yellow excites both our M and L cones, making yellow the brightest of colours. Need a lot of luminance contrast as we age.

- older users often need even brighter colours (more luminance contrast) to see differences.

COLOR SENSITIVITY & IMAGE DETECTION

- most sensitive to the center of the spectrum
- brightness determined mainly by L+M
- implications?
  - harder to deal with blue edges & blue shapes

- -> avoid blue text is a widely mentioned guideline, but is it true?

COLOR SENSITIVITY (CONT.)

FOCUS

- wavelengths of light focus at different distances behind eye’s lens
  - need for constant refocusing (causes fatigue)
  - Aside: another reason why blue is harder to see, especially if there’s bright red or white nearby!

- Most people see the red closer than the BLUE but some see the opposite effect
TRICROMACY THEORY INSUFFICIENT

doesn’t explain:
- why we can read small blue text
- why there is no such thing as a reddish-green or greenish-red
- yellowish-red; yes Bluish-red, yes
- after image effects (see next...)

Stare at the white dot in the middle of next slide for 5 seconds...
**Opponent Colors**

- B | R
- B | Y
- Y | R
- G | R

**Relation of Opposing Channels**

- Blue, green, yellow... what about red?

**Color Channels: Opponent Process Theory**

- White
- Yellow
- Green
- Blue
- Black
- Red

**Luminance & Brightness**

- **Luminance** is the *measured* amount of light coming from some region of space.
  - but humans are not light meters
  - receptors bleach and become less sensitive with more light
  - takes up to half an hour to recover sensitivity

- **Brightness** refers to *perception* of amount of light coming from a source.
  - brightness perception is non-linear
SIMULTANEOUS LUMINANCE CONTRAST

contrast occurs because our brain is better at determining *differences* in the amount of light than measuring absolute light emitted.

SIMULTANEOUS CHROMATIC CONTRAST

both yellow bars are the same.

CONTRAST

implications:

• because colours are changed by appearance of adjacent colours
  – therefore can only use a small number of very different colours to symbolically label effectively
  – otherwise contrast effect causes color confusion

SHAPE FROM SHADING

• we understand 3D surfaces via shading patterns
• the luminance channel can determine shape from shading; chromatic channels cannot
• what are we seeing in the image below?

LUMINANCE “CHANNEL”

- carries ~2/3 more details than either of the chromatic channels
- therefore chromatic channels alone not suitable for fine details, small fonts, etc.

implications:
- luminance contrast critical for fine details
- harder to focus on edges created by color alone
  - best to use both luminance & color differences

Saturation

- how ‘pure’ a color is to the viewer
  - high-saturation colours are more pure (vivid)
    - strong signal on red/green or yellow/blue chromatic channels
  - low-saturation colours close to black/white/grey
- strong signals attract attention better than weak signals
  - saturated colours will stand out against unsaturated ones
  - easier to detect in small areas
  - unsaturated colours will have less dramatic contrast effects

Color Blindness

- trouble discriminating colors
  - around 9% of population (8% males, 1% females)
- different photopigment response
  - reduces ability to discern color diffs
    - particularly those of low luminance contrast
- red-green deficiency is best known
  - lack of either green or red photopigment
    - can’t discriminate colors dependent on R & G
- luminance contrast and careful color selection
  - e.g., avoid having reds and greens with similar luminance
- simulators available online can help you check your designs against most common deficiencies
RELATION OF OPPOSING CHANNELS

can you identify the unique hues?
[blue, green, yellow . . . what about red?]

COLOR IS GREAT FOR CLASSIFICATION:
– rapid visual segmentation
– helps determine type

COLOR GREAT FOR CLASSIFICATION (CONT.)

• colour mapping can be used to extend the number of displayable data dimensions to 5 or 6 in a single scatter plot
COLOR GUIDELINES

recommended colors for encoding categories of information:

- widely agreed upon names
- entire set correspond to most common color names across cultures
- when learnability matters: choose from set of first six (unique hues), then from second set of six

COLOR GUIDELINES

- large areas: low saturation
- small areas: high saturation (strong contrast with background)

COLOR GUIDELINES

- generally want to avoid single-color distinctions and encodings
  - e.g. ▲ ▼ better than □ □
- blue text is actually okay
  - so long is there is high luminance contrast

COLOR GUIDELINES

to increase contrast
pick non-adjacent colors on hue circle:
COLOR GUIDELINES

• take advantage of (and don’t go against) common symbolic uses or natural orderings of color

• e.g., color gradients generally understood to indicate an order (e.g., increasing/decreasing amount)

EXAMPLES

in each of the following, try to identify:

• 2 effective uses of color
• 2 ineffective (or less effective) uses of color

For each:

– Think about the reasons(s) for the identified aspects of the design.
– how could you improve the ineffective examples?
PRE-ATTENTIVE PROCESSING

MACHINERY OF PERCEPTION

PERCEPTION PRIMITIVES

- whole visual field processed in parallel
- can tell us what kinds of information is easily/quickly distinguished
- popout effects (prior to conscious attention)
PRE-ATTENTIVE PROCESSING (IN STAGE I)

• 10 ms or better per item
  – rates for non pre-attention features 40ms +

• exercise: count all the 3s, say answer aloud

PRE-ATTENTIVE PROCESSING

• 10 msec or better

• try the same thing again
PRE-ATTENTIVE PROCESSING

• the time taken to search for target is independent of the number of distractors

IDENTIFY “SPECIAL” OBJECT IN UPCOMING SLIDES

• how fast can you do it?

COLOR

ORIENTATION
MOTION

SIZE

SIMPLE SHADING

CONJUNCTION (DOES NOT POP OUT)
CONJUNCTIONS OF FEATURES

• when patterns get just a little more complex, search becomes more serial
• conjunctive search: when you have to search for more than one attribute
  – e.g. color AND shape

MORE PREATTENTIVE CHANNELS

<table>
<thead>
<tr>
<th>Shape</th>
<th>Length</th>
<th>Width</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Parallelism</th>
<th>Enclosure</th>
<th>Curvature</th>
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<table>
<thead>
<tr>
<th>Spatial grouping</th>
<th>Added marks</th>
<th>Number</th>
</tr>
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<tbody>
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</table>

...except for one, can you tell?

COMPOUND FEATURES (DO NOT POP OUT)

LAWS OF PREATTENTIVE DISPLAY

• must stand out on some simple dimension
  – color
  – simple shape = orientation, size
  – motion
  – depth
DISPLAYING INFORMATION AT A GLANCE: HIGHLIGHTING

Using **color** draws attention
So does using **Texture**
And, yes, **underlining** works too!

A flying box leads attention
**Blinking momentarily attracts attention**

Motion elicits an orienting response

to highlight effectively: use a dimension not heavily used in other parts of design

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PRE-ATTENTIVE CONJUNCTIONS

- most conjunctions are not pre-attentive
- very small number ARE pre-attentive
  - in general: spatial location and some aspect of form (color or shape)
  
  - examples:
    - stereo depth and color
    - color and motion
    - color and position
    - shape and position

we can rapidly search for conjunction of 'green circle and right cluster'

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EXAMPLES

in each of the following, identify:
- is there an actual pop-out effect?
- how effective is it for the given task?

Note: first two are videos shown in class.
GESTALT LAWS
MACHINERY OF PERCEPTION

stage 1
- Parallel processing of orientation, texture, color and motion features

stage 2
- Detection of 2D patterns, contours and regions

stage 3
- Object Identification, Working Memory

PATTERN PERCEPTION AND GESTALT LAWS

- by taking advantage of patterns that are easy to see, we can enhance display design and understandability

- gestalt laws: basis for most modern theories of pattern perception
  - describes how users see patterns in visual images
  - should be mostly review from 344

GESTALT LAWS

proximity: nearby things are perceived as related

similarity: things that are the same in size, shape, color etc. are perceived to be associated

GESTALT LAWS (CONT.)

closure: groups of things that create shapes/forms are often perceived as whole forms

continuity: users tend to perceive curved or straight lines caused by alignment
Gestalt Laws (Cont.)

**Symmetry:** symmetrical objects are more readily perceived

**Common Region:** objects within an enclosed space are grouped

**Connectedness:** objects connected by continuous contours are perceived as related

**Examples**

For the following, try to identify:

- 2 effective uses of perceptual groupings
- 2 ineffective (or less effective) uses perceptual groupings

For each:

- Think about the reasons(s) for the identified aspects of the design.
- How could you improve the ineffective examples?
STAGE 3

- where more complex visual objects can be stored in visual working memory
- where actually problem solving, reasoning, etc. about visual objects occurs

MACHINERY OF PERCEPTION

- Parallel processing of orientation, texture, color and motion features
- Detection of 2D patterns, contours and regions

Stage 1

Stage 2

Stage 3

Object Identification, Working Memory

this is a more detailed version of Fig 2.1 in Ware reading