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

Good Friday: UBC closed!

MSV

Design Competition (next Tues) will be held in DFP Classroom - FSC 2300
- 2nd Floor, Forestry building, 2424 Main Mall
- Directions: Once you are inside the Forestry Science building walk to the rear (south-east) of the building by passing through the large open study area and up the stairs to the 2nd level student ("treetop") lounge area. Turn left, pass through a double door and the lab is 1st on the right.

Schedule
- 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 Thursday: student name and team name

- testing presentation is required – availability of FSC 2300 for testing will be posted on Piazza (will be earlier in day Tues)

- fantastic design jury:
  - Barry Po: Senior Director, Product and Business Development, NGRAIN (PhD in Computer Science, HCI, 2005)
  - Diane Tam: UX/UI Designer, New Hippo Health (MSc in Computer Science, HCI, 2012)
  - Hasti Seifi: Postdoctoral Researcher, Max Planck Institute for Intelligent Systems in Germany (PhD in Computer Science, HCI, 2017)

- will be a short break ~ halfway through – opportunity to chat with jury members, as well as at social afterwards (once judging is done)
TODAY

– 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

RETINA

• interplay of rods/cones with ganglion cells: specialized nerve cells, 2 types

• X-cells
  – concentrated in fovea
  – responsible for early detection of pattern

• Y-cells
  – widely distributed in the retina
  – Responsible for early detection of movement

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

VISIBLE SPECTRUM

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 (or so the theory goes)
COLOR SENSITIVITY

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.

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Color sensitivity as we age...

• lens yellows & absorbs shorter wavelengths—sensitivity to blue is even more reduced

• fluid between lens and retina absorbs more light—perceive a lower level of brightness

• thus 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?

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.
TRICHRONYACRY 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, blueish-yellow or yellowish-blue
- yellowish-red, yes; Bluish-red, yes
- after image effects (see next)
Opponent Colors

- B (Blue) vs. R (Red)
- B (Blue) vs. Y (Yellow)
- Y (Yellow) vs. R (Red)
- G (Green) vs. R (Red)

Opponent Process Theory

Color Channels:

- Long wavelength sensitive cones
- Medium wavelength sensitive cones
- Short wavelength sensitive cones

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

Can you identify the unique hues?
- (blue, green, yellow... what about red?)
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

– 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
– 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
how to use color effectively?

RELATION OF OPPOSING CHANNELS

can you identify the unique hues?
(blue, green, yellow . . . what about red?)
screenshot from C Blackwell (2012) https://www.youtube.com/watch?v=VeDQgG895ZY

COLOR IS GREAT FOR CLASSIFICATION:
– rapid visual segmentation
– helps determine type
• colour mapping can be used to extend the number of displayable data dimensions to 5 or 6 in a single scatter plot

COLOR GUIDELINES

• 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

• 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 as there is high luminance contrast
COLOR GUIDELINES

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

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

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

this is a more detailed version of Fig 2.1 in Ware reading
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 1)

• 10 ms or better per item
  – rates for non pre-attentive 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

> response time
> number of distractors

non pre-attentive feature

pre-attentive feature

IDENTIFY “SPECIAL” OBJECT IN UPCOMING SLIDES

- how fast can you do it?

COLOR
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

COMPOUND FEATURES (DO NOT POP OUT)

MORE PREAMTENTIVE CHANNELS
• Length
• Width
• Parallelism
• Enclosure
• Curvature
• Spatial grouping
• Added marks
• Number

...except for one, can you tell?
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

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

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

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 user see patterns in visual images
  – should be mostly review from 344

Machinery of Perception

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

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

redrawn from Tidwell. (2012). Designing Interfaces.
**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

**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?


**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

**common fate:** Objects that move together are perceptually grouped.
MACHINERY OF PERCEPTION

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STAGE 3

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

... Design Competition!!!