Light as Stimulus

- Luminous intensity is measured in candelas (cd), or lumens, 1 cd = 12.57 lumens.
- Illuminance is the amount of light shining on an object, measured in foot-candles (fc): intensity/d²; d=distance in ft
- Luminance is the amount of light reflected from an object, measured in foot-lamberts (fL)
- Reflectance is determined by the surface and color properties of an object; how much light is absorbed or thrown back at the viewer. It's a ratio of:
  - The measured reflectance of the target surface,
  - The measured reflectance of a standard Kodak neutral test card = 0.9
  - Reflectance = 0.9 * L_target / L_standard

Vision: the eyes

- Lens focuses light to the retina
  - Light passes through the lens
  - Focused on the retina
  - Rod cells (periphery)
  - Cone cells (fovea)
- Central 1-2° gives foveal vision
- Remaining 180° gives peripheral vision
- Cone cells
  - Detect color and hi-res images
  - X-ganglia (wires from the cell to the brain) provide early pattern detection.
- Rod cells
  - Good for low levels of luminance
  - Y-ganglia permit early movement detection
  - Sense shades of grey but can't detect colors.

Inversion of Images

- Image projected upside down on retina, once it passes through lens
- Receptor cells in retina convert light into neural impulses, which are organized by brain into meaningful structures
- Vision is constructed by brain, rather than merely received
  - Retinal cells extremely sensitive and specialized
  - Feature detector neurons: nerve cells in the visual cortex that respond to very specific features of a stimulus, such as shape, angle, or movement

Visual Information Processing

- Serial vs. parallel processing
  - Serial processing: processing of information step-by-step in a specific order (e.g. computers, conscious problem solving)
  - Parallel processing: processing several aspects of information simultaneously (e.g. vision, many other brain activities)
- Brain simultaneously perceives color, depth, movement, and form (Livingstone & Hubel, 1988)
  - Integrates information “on-the-fly” and allows for almost instantaneous recognition of objects
Color vision

- Cone cells detect color (hue, saturation, value) through photo-pigments.
  - mainly reds (64%); few blues (4%).
  - Center of retina (high acuity) has no blue.
  - Means disappearance of small blue objects you fixate on.
- Brightness is determined mainly by R+G
- Shapes are detected by finding edges
  - combine brightness & color differences for sharpness
  - harder to deal with blue edges & blue shapes
- Color is a product of our brains’ transduction of light waves.
  - We can discriminate 7 million+ colors

How we see the world

Color vision

- Different wavelengths of light focused at different distances behind eye’s lens
  - need for constant refocusing → fatigue
  - be careful about color combinations
- More saturated colors = more focusing
  - don’t use saturated colors in UIs unless you really need something to stand out (warning)
  - pastel colors are cleaner
- Objects do not “possess” color (in a sense, the tomato isn’t red, it’s everything but red...)
  - Wavelengths of red light are reflected from the tomato
  - “The [light] rays are not coloured.” (Newton, 1704)

Visual disability

- Normal: 20/20: the ability to read letters of a certain size (the norm for one’s age) from the eye chart placed 20’ away
  - 20/40 = You need twice the size to read at 20’
- Registered blind = 20/200
- At least 1.5M blind and visually impaired Americans use computers
- Only 10% blind people read Braille
- The most common AT: screen magnifier/reader

Nearsightedness & Farsightedness

Visual disability

- Macular Degeneration
- Retinopathy (mostly caused by diabetes)

Color Blindness

- 8-10% male and 0.5% female populations experience some form of color deficiency
- Protanope
  - 1% males, “red-weakness”
- Deuteranope
  - 5% males, “green-weakness”
- Tritanope
  - blue/yellow deficit

Ageing-related

- Myopia
- Hypermetropia
- Cataracts
- Glaucoma

Objects do not “possess” color (in a sense, the tomato isn’t red, it’s everything but red...)
**Visual Disability**

- Normal vision
- Protanope
- Deuteranope
- Tritanope

Simulated using Vischeck
(http://www.vischeck.com/vischeck/vischeckURL.php)

**Designing with color**

- Before designing with colors, ask:
  - Does color add something that cannot be provided by black and white?
  - Is the chosen color appropriate for the text or object?
  - Does the color provide cues to improve understanding or memory?
  - Are there any visual problems that may make the information less legible (dyslexia, color blindness, aging)?

- On-screen color varies widely from device to device for two reasons
  - Device calibration (gamma setting, 1.8 for PC, 2.2 for Mac)
  - Inability to display certain color (color replacement)

- Use contrast for structure & hierarchy

- Color palettes
  - Monochromatic
  - Complementary
  - Analogous

- Kansei’s colors
  - Invented by Nagamachi in Japan in 1970
  - KANSEI study seeks the structure of emotions, which exists beneath human behaviors
  - Used a lot in customer product (first used in the US by Mazda)
  - Not just colors

- Color Meanings: Culturally Specific

<table>
<thead>
<tr>
<th>Color</th>
<th>Western European</th>
<th>Japanese</th>
<th>Chinese</th>
<th>Arabic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>Danger / Anger</td>
<td>Danger</td>
<td>Jiu</td>
<td>Jau</td>
</tr>
<tr>
<td>Yellow</td>
<td>Danger / Warmth</td>
<td>Warm</td>
<td>Sheng</td>
<td>Sul</td>
</tr>
<tr>
<td>Green</td>
<td>Harmony / Fresh</td>
<td>Peace</td>
<td>Jing</td>
<td>Jin</td>
</tr>
<tr>
<td>Blue</td>
<td>Security / Cool</td>
<td>Cool</td>
<td>Lián</td>
<td>Lián</td>
</tr>
<tr>
<td>White</td>
<td>Lightness / Clean</td>
<td>Clean</td>
<td>Shí</td>
<td>Shí</td>
</tr>
<tr>
<td>Black</td>
<td>Nurturance / Dead</td>
<td>Dead</td>
<td>Mó</td>
<td>Mó</td>
</tr>
</tbody>
</table>

http://www.princetonol.com/groups/iad/lessons/middle/color2.htm
Sensation and Perception

- Sensation = sensing our environment through touch, taste, sight, sound, and smell
- Perception = the way we interpret these sensations and therefore make sense of everything around us

Perception: “knowing”

- Gestalt psychology
  - Perceptions are formed by grouping of stimuli based on prior knowledge
- Object constancy
  - When landing, you just “know” that the houses are real (size)
  - You just ‘know’ that the door maintains its shape

Muller-Lyer Illusion

Depth Perception

- The ability to see objects in 3D, even though the images that strike the retina are in 2D
  - Allow us to judge distance
- Depth perception is at least partly innate
  - Visual cliff studies (Gibson & Walk, 1960)
  - Also in newborn animals
- Ability to perceive depth is due to:
  - Binocular cues
  - Monocular cues

Binocular Cues/Stereoscopic Vision

- Cues to depth perception that arise from the use of both eyes working together
- 2 eyes have slightly different views of the world because they are in slightly different places
  - Need to cross eyes slightly to focus object on fovea of both eyes
  - Doing so leads other objects to appear on different spots in the 2 retinas (retinal disparity: the difference between the images striking the retinas)
  - More disparity = closer object; less disparity = further object

Monocular Cues

- Relative size: closer object appears larger
- Relative clarity: hazy objects are perceived as being further away than clear objects (light scatters in the atmosphere)
- Texture gradient: objects far away seem smoother and more closely packed
- Relative height: objects higher in field of vision appear farther away

Monocular Cues

- Interposition: objects that block the view of another are perceived as being closer
- Relative motion (motion parallax): as we move, stationary objects seem to move backward → objects further away move at slower pace than closer objects.
- Linear perspective: parallel lines appear to converge with distance
- Light and shadow: nearby objects reflect more light to our eyes (dimmer objects seem further away)
Relative Usefulness of Depth Cues

Gestalt Psychology – Law of Perceptual Organization

1) Proximity (grouping)
2) Similarity (color/shape)
3) Closure

Perceptual Organization

- Preattentive processing
  - objects and groups of objects are segregated
  - figure-ground relationships established
  - course level of detail (global)
  - automatic: requires no attentional resources

- Focal (Attentive) processing
  - certain objects selected for further processing
  - requires attentional resources (working memory)
  - fine level of detail (local)

Visual Search

- Serial search: sequential scanning of stimuli needed to detect target (attentive processes)
  - search time increases as # of display elements increases (positive time-numerosity slope)

- Parallel search: target “pops-out” of multi-element display without scanning (pre-attentive processes)
  - search time is constant as # of display elements increases (zero time-numerosity slope)

- Expectancy Effect: search where we expect targets to occur, e.g., football quarterbacks, radiologists

- Availability Effect: search where it is easiest and most obvious (can overcome expectancy)
  - inexperienced drivers may not check mirrors because they are not obvious

Helping Visual Search

- Saliency: some types of stimuli tend to draw our attention → processed preattentively
  - motion or flickering
  - bright, colorful (high contrast)
  - large size (global)

- Ranked speed
  1. Shapes
  2. Size
  3. Color
  4. Alpha characters → %, >, <, ?
  5. Characters → vary by character (A is faster)
Find the Red Letter; Find the ‘A’, Find the triangle

Clarity
► Every element in an interface should have a reason for being there → make it clear, too
► Less is more (economy of visual element)
► Consider overall and local density
  ▪ Overall: how much information is on the screen
  ▪ Local: how tightly packed the information is
► How? White space
  ▪ Leads the eye (pre-attentive processing, figure-ground)
  ▪ Provides symmetry and balance through its use
  ▪ Strengthens impact of message
  ▪ Allows eye to rest between elements of activity
  ▪ Used to promote simplicity, elegance, class, refinement

Which is cleaner & clearer? This?

Consistency
► Helps visual search (expectancy effect)
► Likeness in behavior and appearance between similar tasks/operations/situations/terminology
► Within screen and across screens
► Conceptual consistency is about ensuring the mappings are consistent, that the conceptual model remains clear.
  ▪ Internal: within the system
  ▪ External: in relation to other relevant things
► Physical consistency is ensuring consistent behaviours and consistent use of colours, names, layout and so on.
Consistency

Alignment

- Cultural influence
  - West: top left, going right, then down; others might not be the same
- Allows eye to parse display more easily
- How? Grids
  - (Hidden) horizontal and vertical lines to help align interface elements
  - Align related things
  - Group items logically
  - Aesthetically more pleasing

Grids for user interfaces

- Areas of the screen that automatically add emphasis to any material, graphic, or text placed there
- Tend to minimize whatever is located there
- Ideal for navigational devices such as button bars, pull down menus, or status information

Grids for user interfaces

- Neutral impact on whatever is located there
- Good for summation text or summary graphics
- Minor elements may be overwhelmed
- Tend to add minimal impact to any graphics or text located there

Inverse Pyramid Writing

- Most important info
  - Title
  - Short Intro
  - Summaries
  - Overviews
  - Teasers
- Less important info
  - Background Information
  - Supporting Details
  - Long Quotes

Most important info

Title

Short Intro

Summaries

Overviews

Teasers
Web Screen Grids

1. Inverted 7 Grid
2. L-shaped Grid
3. Double-track Grid
4. Open Grid
5. Invisible Grid
6. Visible Grid
7. Horizontal Grid
8. Vertical Grid

1. L-shaped Grid
- vertical navigation on the left side
- additional navigation on the bottom (less than optimal, don’t use for primary navigation)
- ideal for more text heavy sites

2. Inverted 7 Grid
- horizontal panel dominates the top
- vertical navigation on the left, open to the right (left-hand navigation scheme most dominant, 30% use)
- ideal grid for heavy use of images

3. Double-track Grid
- vertical navigation or secondary info on the left and right
- used for extensive navigation
- crowds the main information in one column

4. Open Grid
- navigation at the top (tab navigation - 30% use, links across top of page 18%)
- no set structure, open page
- cleanest and easiest to use
- used for sites with minimal navigation

5. Invisible Grid
- single-image screen - splash page
- page before the home page
- ideal grid for more artistic sites
- combine with other grid for main page

6. Visible Grid
- a highly visible grid with organized columns
- grid is preserved through every page of the site
- used in e-commerce site to present collections

7. Horizontal Grid
- all elements are aligned left to right and separated with ample white space
- creates a sense of openness from one side to the other
- difficult for large images

8. Vertical Grid
- popular with three-dimensional sites (navigation, advertising, other elements)
- enables clear distinctions in the grid
- not ideal for text-heavy sites, used for short bits of info

Text

- Use appropriate character size (e.g. older persons ≥12pt)
- Plain white text font type is harder to see
- **BOLD is more visible** but tiring so use with caution
- The best for readability/salience trade-off is the Title Case, not ALL CAPITALS nor all small characters
- Sans Serif (Arial, Tahoma) is easier to read on screen than Serif (Times New Romans, Baskerville)
- wide kernerh (horizontal space between letters) is easier to read than narrow kerning
- Also take into consideration ‘leading’ (the distance between 2 baselines)
Images
► Images are the most enduring form of written communication, whether phonetic or ideographic.
► Images have been found to be:
  - Recognized faster and more accurately than text
  - Learned faster
  - Demand less from human memory
► To make effective images, we need to:
  - Know how they work
  - Understand how users perceive, recognize, remember, and use

Icons
► Icon: a (simplified) picture on a screen that represents a specific file, directory, window, option, or program.
► Designed with a purpose, functional, and predictable
► From Apple’s website on designing icons:
  - Perspective and shadows are the most important components
  - Use universal imagery that people will easily recognize
  - Simplicity - use a single object that captures the icon’s action, start from basic shapes
  - Use color judiciously
  - Use icon genres to help communicate what users can do with an application before they open it

Icon Recognition
► Users must first recognize what the image is
► Recognition of images is quicker and more reliable if icons are:
  - Specific & concrete
  - Representations of real-world objects
  - Vivid and clearly depicted
  - Conceptually distinct one from another
► But unless very familiar, might be affected by users’ cultural background

Icon Decoding
► The user must learn the icon’s new meaning
  - What the picture represents
► Sometimes can be ambiguous. Tip: use
  - analogous image to underlying concept
  - a typical example of concept
► Mouse-over is always a good idea

ISO 9186: Testing graphical symbol
► When adapted for icon testing:
  1. Comprehensibility judgment test
     - Give the function and several symbols, one of which has an opposite meaning
     - 1 = Correct understanding is certain (≥80% population)
     - 2 = Correct understanding is very probable (66-80%)
     - 3 = Correct understanding is probable (50-65%)
     - 4 = The meaning understood is opposite of intention
  2. Comprehension test
     - Give one symbol at a time
     - What do you think the symbol mean?

Icon Location
► Users must be able to quickly and accurately locate the icon
► Speed and accurate location of a visual object depends on if:
  - The user has pre-established knowledge of the icon
  - The icon is distinct from all other objects in its shape and color
Icon Activation

► Users must know how to use the icon
   1. **How it is activated**: by single or double click, only mousing over (annoying), etc. through design
   2. **Appearance** of activation: color change, becoming non-underlined, application launch, progress indicators, etc.
   3. Activation **result**: sent to a new page, open a file, open a new window, etc.

**KEY**: Be consistent in icon activation throughout interface (metaphor) and between applications

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Icon Families

► A grouping of similarly-styled icons
► Although each icon in an icon family should be distinct, a consistent **style** should be present in each
► If you are creating a family or grouping of icons, do not design any icon in isolation