

December 5<sup>th</sup>, 2023

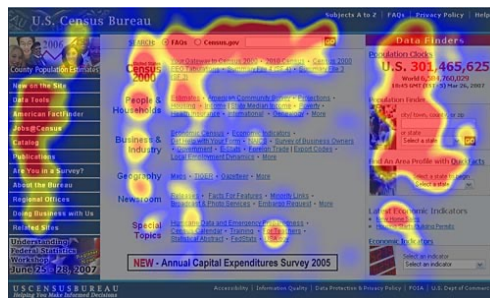
## LECTURE 3 PATTERNS, PERCEPTION

## Usability - Cognetics



Q: What is the current population size of the US ?

## Average heat-map eye-tracking



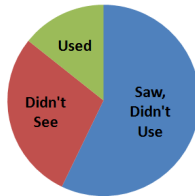
## Specific user categories



- A, D Search dominant (57% of users)
- B Navigation dominant
- C Tool dominant

## Distraction from focus ...

- 14% looked at right position
- Majority did not find correct answer.
- Distraction, some parts of the URL looked like an add.
- Can further analyze the users
- !! Simple Usability Question
- Look at direction of each/exploration
- Importance of Locus of Attention



Understanding the human in interactions

## PATTERNS, PERCEPTION

## Contents

- Perception
- Reasoning
- Gestalt
- Senses, Vision
- Vision, Color, Perception, Depth
- Auditory
- Haptics
- Perception and Interaction

## What do you read ...

TAE CAT

- Information processing to Meaningful items from Context
- Prior Knowledge helps processing ambiguous information
- Not: "tae cht", But: "the cat"

## Learning strategies

- Behaviorism
  - Measurement of outcome of learning process
  - Not considering the mental process
  - Behavior modified by reinforcement responses
- Gestalt
  - Past experience affects individual perception
  - Stimuli grouped in own perception patterns
  - Processes leave a trace in the brain (encoding)
  - Group information to make it more meaningful

## PERCEPTION

## Perception – what is it ...

- Webster (definitions)
  - the way you notice or understand something using one of your **senses**
  - awareness of the elements of environment through physical [sensation](#)
  - how sensory information is organized and interpreted
- 2 Elements
  - Physical sensing of a signal
  - Cognitive concience interpretation of a signal

## Sensation

- Webster (definition):
  - a mental process resulting from the immediate external stimulation of a [sense](#) organ often as distinguished from a conscious awareness of the [sensory](#) process

# GESTALT

13

## Overview Gestalt

- Gestalt = Pattern/Form/Shape
- Gestalt helps ordering a scene (signal)
  - Pragnanz
  - Proximity
  - Similarity
  - Closure (different from previous use of term)
  - Good continuation
  - Symmetry
  - Common fate
  - Familiarity
- Gestalt is a bottom-up approach (stimulus-perception)
- Principles are being used in Symbol design
  - Icons
  - Easterby, 1970

14

## Gestalt & Senses

- Gestalt = Pattern/Form/Shape
- Helps in understanding how the brain “sees” a pattern
- Visual pattern
- Audible pattern
- Haptic pattern
- From simple patterns a complete pattern is interpreted
- The pattern may be incomplete

15

## Image - Pattern

- Figure
  - That what is the important subject
  - Foreground
- Ground
  - That what is the environment of the subject
  - Background
- We actively separate **Figure** from **Ground**
  - Selecting what is important

16

## Pragnanz

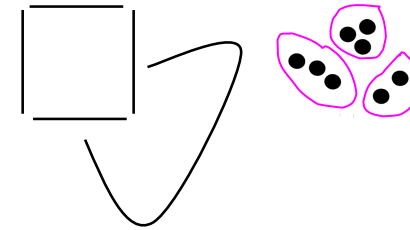
- Patterns are seen as simply as possible



17

## Proximity

- Nearby objects tend to be grouped together  
So there is a focus on how close objects to each other



18

## Similarity

- Similar items tend to be grouped together  
So this is triggered by similarity of objects
- Tendency to group elements of same **shape** or **color** as belonging together



19

## Closure

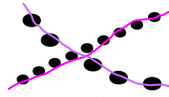
- Nearly closed contours tend to be closed
- Missing parts are filled in ...



20

## Continuity

- Neighbors are grouped when they can be connected
- Simplifying a stimulus



## Constructivists ~ Ecologists

We are active in our perception:

- Constructivists approach for vision
  - Perception involves intervention of representation and memory
  - Actively embellish (process) and elaborate retinal images (stimuli)
  - Related to Gestalt (1935): interpretation result from having innate laws of organization
- Ecological approach for vision
  - Active exploration of objects in environment (Gibson)
  - Use of 5 senses
  - Notion of affordances; easy/difficult to interact with object

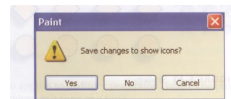
## USING GESTALT

## Gestalt in Design: Pragnanz

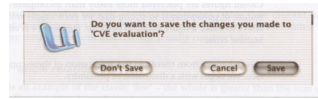
- Prominent role of the figure with respect to figure-ground
- Logo makers use this effect.
- See examples of 3 logos.
- Figure and ground can not be observed at the same time.
- Interpretation!!!



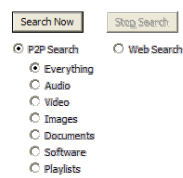
## Using Gestalt in GUI: proximity



Not used, not useful

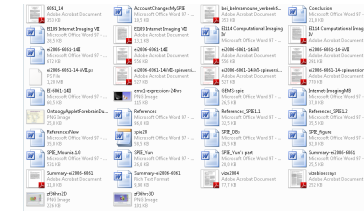
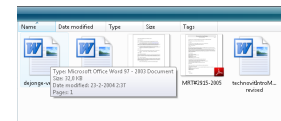


Used, clear



Used, clear

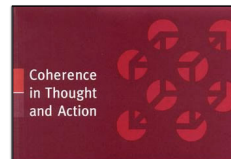
## Using Gestalt in GUI: Similarity



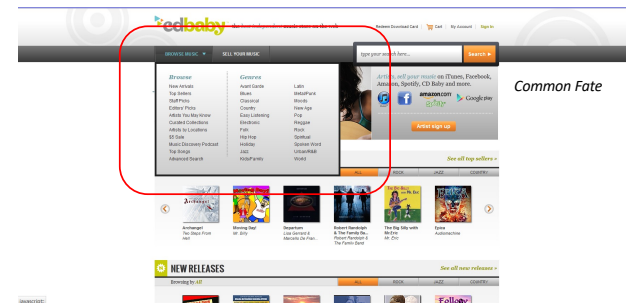
Organization of files in a folder (GUI).

## Gestalt in Design: Closure

- We see more than actually is presented.
- We produce a closure to known artifacts



## Website Design - Gestalt



## InfoViz - Gestalt



29

## SENSES - VISION



HCI & IV 2023, IIV

30

30

## Crux of Human Vision

Facts:

- We like to see “whole” rather than “part”
- There is prior knowledge (LTM)
- There is interpretation ~ cognition
- Gestalt uses the fact that the sum is more than the separate parts

These facts are unconsciously used in GUI design and Information Visualization

Be aware of this!

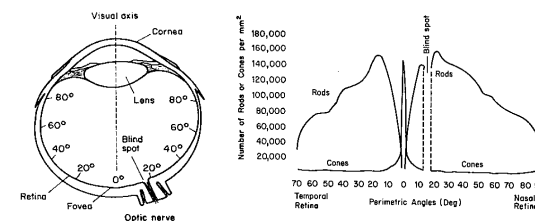


HCI & IV 2023, IIV

31

31

## Human Vision - Visual System



Distribution of Rods and Cones in the Human Retina



HCI & IV 2023, IIV

32

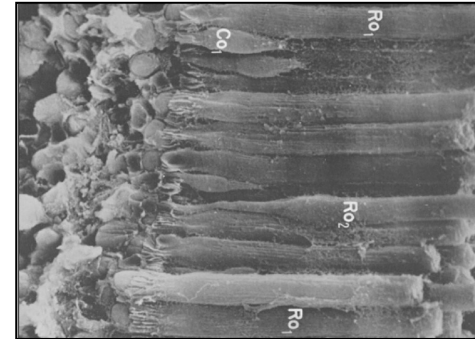
32



## Photo-sensors: the Retina

- From eye to retina to visual cortex: **electrical pulses**
- Cones
  - 6-7 \*10<sup>6</sup> per eye
  - One cone-cell connected to one nerve
  - **Photopic** vision (bright-light vision)
- Rods
  - 75-150 \*10<sup>6</sup> per eye
  - Several rods connected to one nerve
  - **Scotopic** vision (dim-light vision)
- Distribution of sensors is important for vision
- Distribution is radial symmetric around Fovea

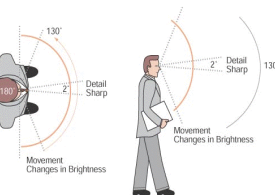
## Cones and Rods



## Visual Field

### Visual Field:

- (a) Sharp vision
- (b) Un-sharp vision
- (c) Only movement seen



### Retinal Image:

- Reflected in fovea area
- Eye muscles help project in fovea area



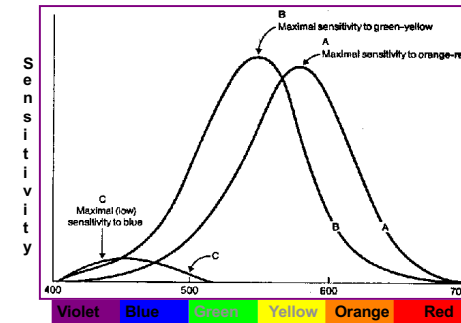
## VISION, COLOR

## Color Perception in Human

- Fovea *centralis*
  - Very detailed colour vision
  - 1 degree of visual field
- Colour sensitivity of 3 types of cones
  - A - mostly red,
  - B - mostly green,
  - C - mostly blue
- Eye most sensitive to green/yellow
- Eye least sensitive to blue

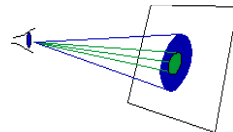
## Cone Sensitivity to Light

- 3 Types of Cones & Light of equal Intensity



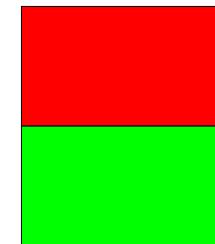
## Color Perception in Human

- Complex perceptual system
  - Cone response e.g.
    - 17:44:39 is blue,
    - 61:39:0 is yellow,
    - 50:45:5 is white
- Defective colour vision
  - 8% males, 0.5% females
  - Red/green blindness is most common



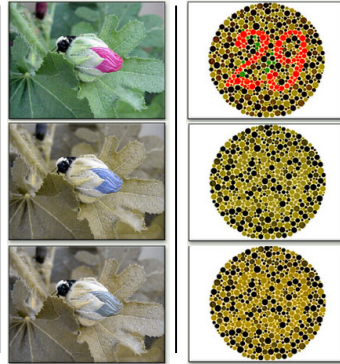
## Color Impairment, Red ~ Green

- X-chromosome related
- Males (XY)
- Female (XX)
- Deficiency more common in males
- 5-8% males
- 0.5% females



## Color Blind

- Normal
- Protans
  - (red weak)
- Deutans
  - (green weak)



41

## Elements of Color Perception

- There are **3** elements to color perception
- **Hue**, perception to a color name, i.e. a spectral definition
- **Saturation**, intensity of a color, with a reference to black and white
- **Lightness** – (value), reflection of a color from a surface with reference to nearby surfaces
- This is part of a color model on perception, more on this in the color lecture

42

## VISION, PERCEPTION

43

## Perceptual Processing of Vision

- Vision consists of sub-systems
- Framework for perceptual vision
  - 2- 3 stages
  - Helps understanding perception
- Stage 1
- Stage 2
- Stage 3



44

## Stage 1 – pre-attentive processing

- Framework for perception
  - Stage 1, Pre-attentive vision
    - There is no focus attention required
    - Resolves in 200-250 msec
    - Basic features in environment, Saliency (remarkable)
    - Bottom-up processing
      - *perception built from sensory input*
  - Pre-attentive vision
    - Parallel low-level vision system
    - Target detection, Boundary detection, Counting

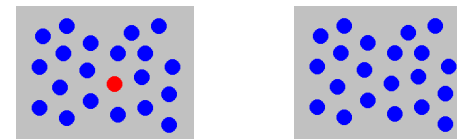
## Stage 2 – attribute attention

- Framework for perception
  - Stage 2, Attribute vision
    - There is focus attention required
    - Segment visual scene (color, texture, motion etc.)
    - Top-down processing:
      - *Perception built from available knowledge/thoughts*
  - Attribute vision
    - Slow serial processing
    - Working Memory – Long Term Memory
    - Focus on arbitrary aspects of symbols

## Stage 3 – active processing

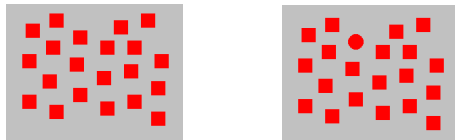
- Framework for perception
  - Stage 3, Active vision
    - There is focus attention required
    - Reduce to few objects in Visual Working Memory
    - Top-down processing
  - Active vision
    - Slow serial processing
    - Working Memory – Long Term Memory
    - VISUAL THINKING, making inferences i.e. Visual queries

## Is there a red circle present (1)



- Hue based
- Rapid – pre-attentive vision
- Surrounding objects: “distractors”

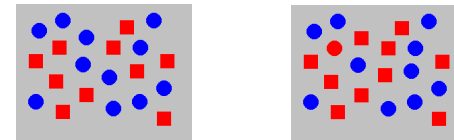
## Is there a red circle present (2)



- Shape based
- Rapid – pre-attentive vision
- Surrounding objects: “distractors”

49

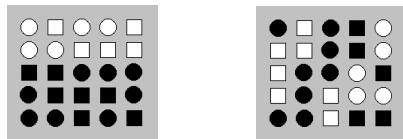
## Is there a red circle present (2)



- Conjunction of features – Hue and Shape
- Can not be completed though pre-attentive vision
- Sequential search – typical stage 2, 3

50

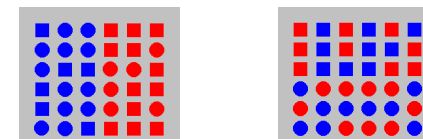
## Boundary in complex scene (1)



- Conjunction of features – Fill and Shape
- Left: Preattentive vision      Right: not preattentive vision
- Sequential search – typical stage 2, 3

51

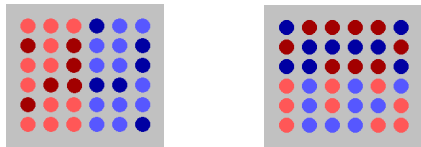
## Boundary in complex scene (2)



- Conjunction of features – Hue and Shape
- Left: Preattentive vision      Right: not preattentive vision (mixing)
- Sequential search – typical stage 2, 3

52

### Boundary in complex scene (3)



- Conjunction of features – Hue and Brightness
- Left: not Preattentive      Right: preattentive (Interference)
- Sequential search – typical stage 2, 3

53

### VISION, DEPTH

54

### Depth Vision

- Stereoscopy, binocular vision
- Accommodation,
- Motion parallax,
- Occlusion,
- Texture,
- Familiarity,
- Laws of perspective
- Shadow casts
- *lens focuses at different depths*
- *distant objects are slower*
- *close occludes distant*
- *distant objects blurry texture*
- *size and shape of objects*

55

### Depth Cues

- Humans use eight (8) depth cues
- Depth cues are used by the brain to estimate the relative distance of the objects in every scene we look at.
- Depth cues are very useful in visualization and can be used effectively in InfoVis.

Some examples...

56

## Focus



Wood anemone, by Håkan Dahlström (flickr.com)

## Perspective



Tay Rail Bridge, by Colin Broug (sxc.hu)

## Occlusion



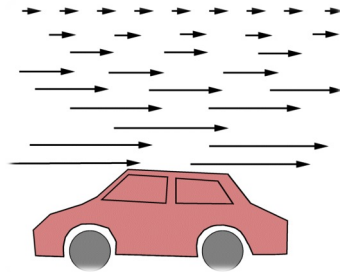
Diamond Ring, By Mucahid Zengin (flickr.com)

## Color Intensity & Contrast



Highland view, by Colin Broug (sxc.hu)

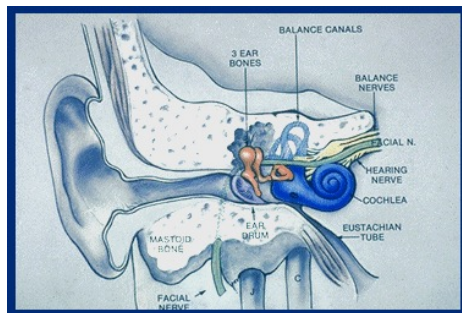
## Motion Parallax



Differential motion parallax from infovis.net

## SENSES, ACOUSTIC

## Human Audio – Hearing System



Ear detects sound, Brain interprets sound

## Hearing & Auditory perception

- Hearing: processing of air pressure variation
  - Density
  - Wave patterns
- Audition: extraction of meaning in a pattern
  - Understanding a sound
- Principles of Gestalt apply
  - Sonic Gestalt



proximity



similarity

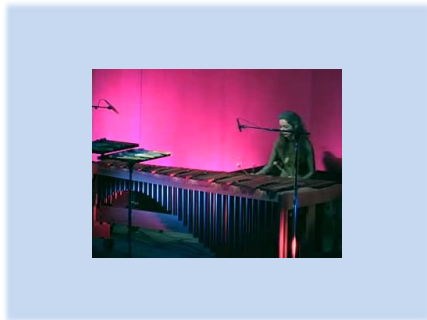


## Sound Perception in Human

- Sound is measured
  - by pitch (frequency, Hz)
  - and loudness (decibels, dB)
- Most people detect sound in the ranges  $[20-20 \cdot 10^3]$  Hz
- Loudness in  $[20-70]$  dB constitutes comfortable hearing
- Features:
  - Sound is transient,
    - once it is stopped, it does not persist
  - Sound is pervasive
    - we do not have to face it in order to hear it
  - Sound triggers “locus of attention”

## Examples of Sound

- Loud rock band 160 dB
- Shouting 100 dB
- Conversation 50 dB
- Whisper 20 dB
- Hearing impaired
  - Middle ear deafness (age & gender)
  - Inner ear deafness



*"Hearing is a form of touch.  
I hear it through the body, by opening myself up.  
Sometimes it almost hits you in the face."  
- Evelyn Glennie*



## SENSES, HAPTICS

## Haptic System

Haptic system is defined as [Gibson]:

- The sensibility of the individual to the world adjacent to her/his body by use of his body.

Haptic perception:

- Links to body movement
- Active exploration.

## Human Touch – Haptic System

- Ubiquitous in the body
  - **Somatosensory** perception of patterns on skin surface
    - edges,
    - curvature,
    - texture
  - **Proprioception** of position and information.
- Hands are often used for haptics
  - Haptic I/O devices
- Explore other areas

## Key concepts in haptics (1)

- *Proprioceptive* - Relating to sensory information about the state of the body (including cutaneous, kinaesthetic and vestibular sensations).
- *Vestibular* - Pertaining to the perception of head position, acceleration and de-acceleration.
- *Kinaesthetic* - The feeling of motion. Relating to sensations originating in muscles, tendons and joints.

## Key concepts in haptics (2)

- *Cutaneous* - Pertaining to the skin itself or the skin as a sense organ. Includes sensation of pressure, temperature and pain.
- *Tactile* - Pertaining to the cutaneous sense but more specifically the sensation of pressure rather than temperature or pain.
- *Force feedback* - Relating to the mechanical production of information sensed by the human kinaesthetic system.

## Directions in Haptics

- Haptic system: bi-directional (in-output)
- Understand touch
- What does one feel/touch
  - Real subject
  - Virtual subject
  - Decouple sense and force
- Internet Interface
- Gaming experience

## Example

- Adding touch to the iPhone 6s
- More force, more (other) options
- Augments the interaction repertoire
- Haptics is a 2-way interaction
  - Apply force
  - Expect feedback of the force ...
- Success?
  - Is Meaning and Action Coupled?
  - Advertised as Multi-Touch



## PERCEPTION & INTERACTION

## Design for Interaction

- There are principles of perception that apply to each of the senses
- Ignoring principles of perception can create dysfunctional information displays
- Knowledge of principles of perception helps to design effective information displays
- Knowledge of *Locus of Attention* and *Attention Variation* are important to interaction design and information display

## Review #3



- Introduction to reasoning
- Principles of Reasoning
- Principles of Gestalt
- Principles of Human Vision/Hearing/Touch
  - (Perceptual) Color
  - Vision sub-systems
  - Haptic sub-system
- Discussed in generic design context (not yet)
  - Color
  - Visual density and balance
  - Text legibility
- Discussed in InfoVis/design context (not yet)
  - Visualisation
  - Visual coding