

December 6th, 2023

LECTURE 5 COLOUR MODELS, COLOUR CODING, TEXT, VISUAL SEARCH, GLYPHS



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You and Human Centered Interaction!

- Learned major principles: expert mode
- Assess an interactive computer/visualization task
 - Usability, recognize its usability
 - Cognetics, assess Focus, Attention, Cognitive Load
 - Affordance, are affordances well communicated
 - Visibility, assess feedback and reachability
 - Screen Layout, principles of Gestalt, Perceptics
 - Logics, reasoning
 - Mental Model & Metaphor



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From lecture 4

MENTAL MODELS & METAPHORS



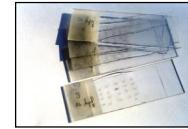
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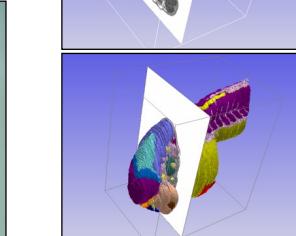
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Example from the Workbench



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Functional ~ Structural Mental Model

- Physical sectioning of an object
- Reconstructing the sections to 3D object
- **Metaphor:** section is represented by image:
 - Image has a thickness
 - All domains in that image have same thickness
 - Builds up a model of the object
- Mental Model:
 - How does the biologist look at this model
 - How does the CS look at this model



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Metaphor Example (1)

- King Harald Blåtand was a legendary 10th century Viking king who unified Scandinavian countries (N + DK):
 - succeeded people talk to each other
 - taken up by ICT industry as metaphor for wireless technology uniting technology, communication and consumer electronics.
- Blåtand = *Blue tooth*



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Metaphor Example (2)

- Harald Blåtand (HB) continued policy of his father
- King of Denmark, then Norway
- Brought Christianity
- Tall man with a dark skin
- Old Danish
 - Blå = dark skinned
 - Tan = great man
 - tooth hygiene not known
- Left stones with Old Norge Runes



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Mismatched Metaphor



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Colour

- Colour, Definition
- Colour, Model
- Colour & Design
- Colour Expectancy, Schema
- Colour, Screen & Text



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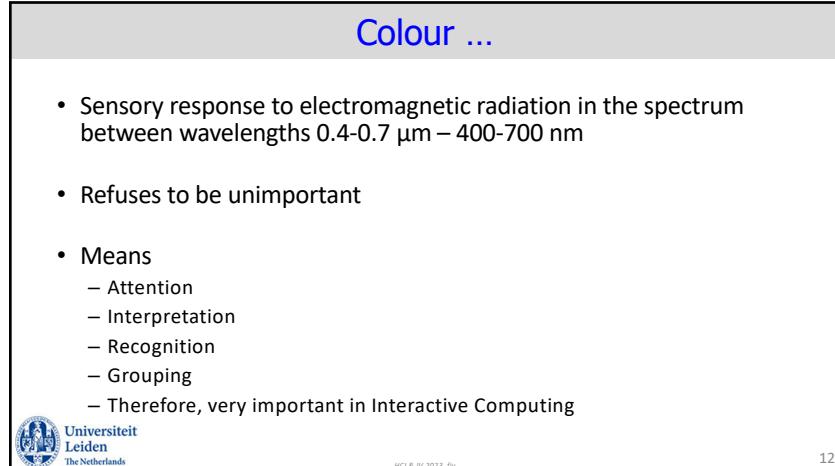
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FUNDAMENTALS OF COLOUR FOR INTERACTION (1)



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COLOUR MODELS



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3 Colour Models

- Red, Green, Blue Model: RGB
 - Additive Colour model
 - Defining Colour on a screen
- Hue, Saturation and Lightness Model: HSL
 - Perceptive Colour model
 - Defining Colour on a screen
- Cyan, Magenta, Yellow, K (Black): CMYK
 - Subtractive Colour model
 - Defining Colour on a printer



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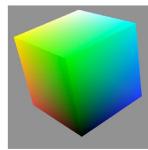
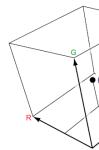
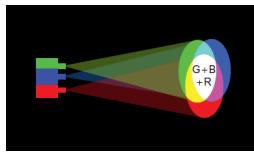
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RGB Model

- $Color \equiv r \cdot R + g \cdot G + b \cdot B$
i.e the perceptual match of its constituents



- Mixing, ratios of r,g and b gives another Colour
- Visualized in the Colour-Cube; additive vectors
- Normalized r,g,b



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Elements of Colour Perception

- There are 3 elements to Colour perception
- **Hue**, perception to a Colour name, i.e. a spectral definition
- **Saturation**, intensity of a Colour, with a reference to black and white
- **Lightness** – (value), reflection of a Colour from a surface with reference to nearby surfaces



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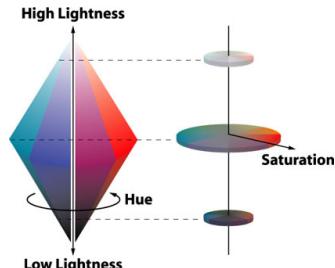
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Hue, Saturation, Lightness

- Three perceptual attributes of Colour can be visualized as a solid (HSL)
- aka HSV
- Relation to artist:
 - Hue = Tint
 - Saturation = Shade
 - Lightness = Tone (or Value)

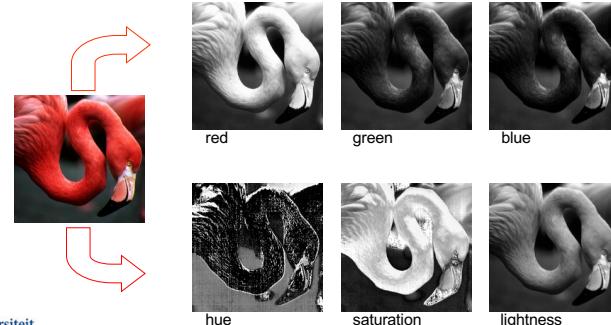


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Example RGB vs. HSL



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Hue

- Hue is the perceptual attribute associated with elementary Colour names.
- Colour deficits have diminished ability to discriminate Colours on the basis of hue
- Hue: how far from the pure “spectral” Colour (λ)
- Hue = Tint



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Saturation

- Saturation is the degree of Colour intensity associated with a Colour's perceptual difference from a white, black or gray of equal lightness.
- Colour deficits have difficulty discriminating between Colours on the basis of saturation.
- Saturation = Shade



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Lightness (aka Value)

- Lightness corresponds to the amount of light that appears to be reflected from a surface in relation to nearby surfaces.
- Lightness is important as an attribute to make contrast more effective.
- Colour deficits have a reduced ability to discriminate Colour on the basis of lightness.
- Lightness (Value) = Tone



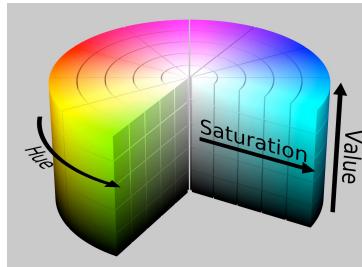
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HSL Model

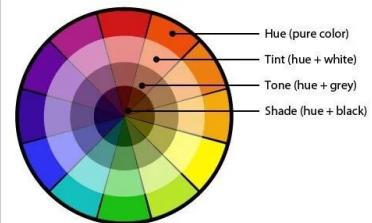
- Hue, Saturation, Lightness: cylinder visualization.



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Colour Constancy (1)

- Experience Coloured surfaces, not Coloured light
- This has to do with light quantity and light scattering
- *Color constancy* refers to our ability to perceive colors as relatively constant over varying illuminations
 - i.e. light sources
 - i.e. scatters
- Characterized by 3 components
- Brain helps to understand colour.



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Colour Constancy (2)

- *Luminance*:
 - Measured amount of light from region of space. Physics, measured in candela's; what gets into the eye
- *Brightness*:
 - Perceived amount of light from a source. Psychology, perceived luminance; how we experience the colour
- *Lightness*:
 - Perceived reflectance of a surface, i.e. white (light) vs. black (dark)



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COLOUR & DESIGN FOR INTERACTION (2)



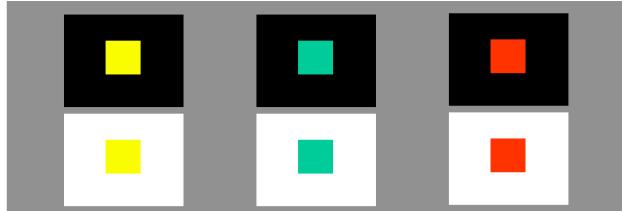
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Background, Apparent Brightness & Size



- Colours look brighter and larger against black
- Colours look darker and smaller against white



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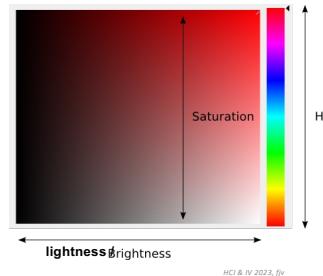
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Colour ...

- Colour is the visual perceptual property corresponding in humans to the categories called red, yellow, blue and others.
- Components of Colour: hue, saturation, lightness; R G & B



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Hue Choice



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Optimizing Lightness

Optimizing: Light + Dark Colour Hue



Lightness (Tone): corresponds to the amount of light that appears to be reflected from a surface in relation to nearby surfaces.



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Colour on Computer Screens

- Aesthetic appeal
- Can improve human efficiency
 - e.g. searching for "targets", such as characters, words or graphical shapes
 - Easier to find and distinguish
- Can provide (useful) redundant coding
 - e.g. Standard background colour for main menu
 - = Support colour
- Can easily be misused
- Monochrome display helps design for Colour Impairment



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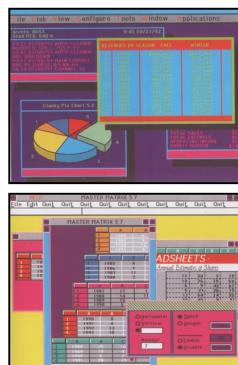
Colour Pollution

Dangers

- Easy to overdo Colour.
- Screaming Colours
- Wrong combinations
- **Complicates Gestalt**

Principles

- Colour scheme
- Support Colour
- Functional use
- Known meaning



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Alert on Colour Design ...

Avoid these colour pairings (in direct combinations)

- red on blue vibrate ➔ **Red**
- yellow on purple pale at junctions ➔ **Yellow**
- red on green or yellow on blue shadows ➔ **Red**
- green on blue after-image ➔ **Green**



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COLOUR & DESIGN FOR INTERACTION (3)



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Colour Expectation(s)

Actions/User	RED	GREEN	ORANGE	BLUE	BLACK	WHITE
Driver	Stop	Go	Caution	-	-	-
Investment	Loss	-	-	-	Gain	-
Chemical engineer	Hot	-	-	Cold	-	-
Operator	Ready	-	-	-	-	-
	Danger	Safe	-	-	-	-
Cartographer	-	Vegetation	Dry - Sand	Water	-	-
Student	Fail	OK	Alert	-	-	-
Western Culture	Alert	-	-	-	Mourn	Peace
Asian Culture	Happy	-	-	-	-	Mourn

- The list can be made very long
- Colour expectation differs
- Colour should not be used statically
- Be aware of expectations



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Colour Association in Design

Association used in design	
Blue	Security, Trust Worthy, Stability, Loyalty, Wisdom, Confidence, Trust, Friendliness, Preservation, Courage, Science.
Green	Wealth, Money, Calming, Trees, Ambition, Endurance, Healing, Calm, Generosity, Natural, Completion, and Protection
Red	Energy, Power, Vigor, Leadership, Courage, Passion, Activity, Joy
Yellow	Optimism, Childish, Freshness, Law, Education, Arrogance
Pink	Romantic, Feminine, Love, Beauty
Orange	Cheerful, Passion, Pleasure, Enthusiasm, Fascination, Creativity, Fun
Black	Powerful, Mysterious, Elegance, Sophistication, Functionality



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Design: Colour Scheme

- Colour Scheme supports
 - Branding
 - Recognisability
 - Expectation and Association
- Types of Schemes (eg with Adobe-Kuler, Adobe-Color Wheel)
 - Complementary
 - Monochromatic
 - Analogous
 - Trias
 - Custom (e.g. inspired by scene)



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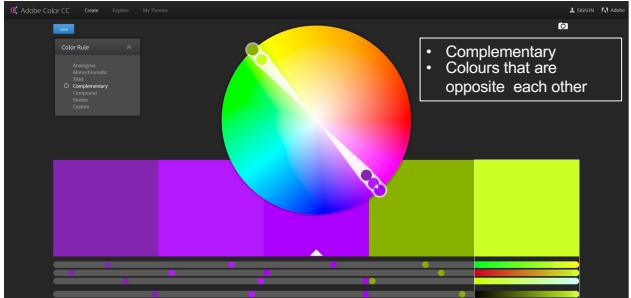
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Complementary Colour Scheme

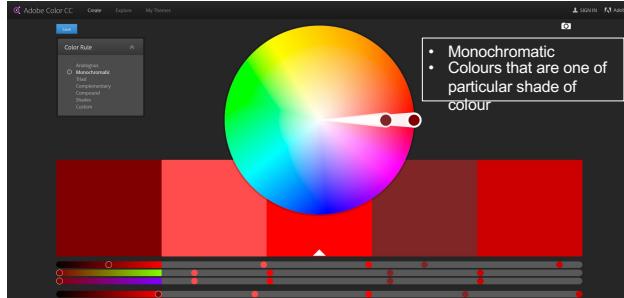


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Monochromatic Colour Scheme

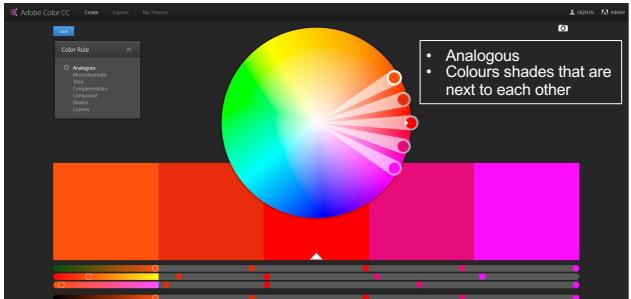


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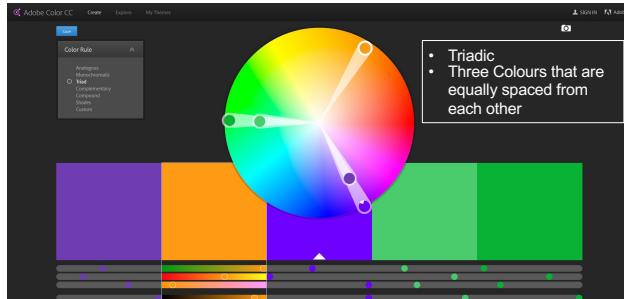
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Analogous Colour Scheme



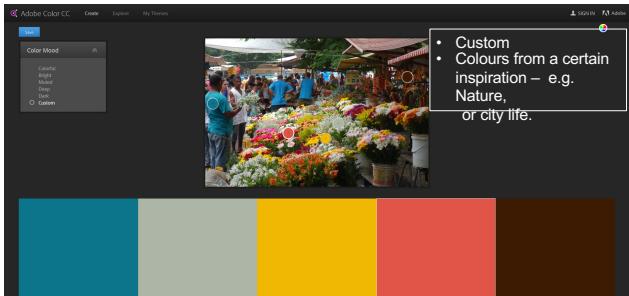
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Triad Colour Scheme



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Custom Colour Schema



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Guidelines: Colour on Screens

- **Do not use too many colours**
 - No more than 4 or 5 colours at one time i.e. on an uncluttered, highly structured display
- **Use Colour coding to support users' task**
 - Identify similar instances
 - Exceptional instances e.g. warnings
 - Common coding scheme
 - Green normal or OK
 - Orange caution
 - Red problem
 - However, no universal interpretations of colour
 - **Bright Colours emphasise data**
 - Less bright Colours de-emphasise data



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Guidelines: Colour

- Colour coding scheme must be relevant + known to user
 - Enables selective attention
 - User will notice differences and similarities of colour, regardless of whether they have task-related meaning.
 - Irrelevant colour increases search time
 - Colour refuses to be irrelevant
- Use **Colour coding** in a consistent way
- Give user control of Colour coding
- Design for monochrome displays (test)
 - Add colour later to enhance



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Value of Colour in Screens/InfoVis

- Search
- Screen segmentation (Gestalt)
- Relates separated fields
- Categorise e.g. **Info-Vis**
 - Actual and projected figures
 - More or less recent data
 - Caption or data field
 - User or computer provided data
 - Status - correct or error, normal or urgent



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Content

- Information Visualization
- Text
- Color coding
- Visual support, Visual search
- Design, Interaction design
- PACT
- Guidelines, Principles & Golden Rules



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Mantra's and Tasks

INFOVIS BASICS



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Mantra of Infovis

InfoVis:

1. Overview first,
2. Zoom and Filter,
3. then details on demand

Attention

- Orienting
 - Searching
 - Filtering
- (Expecting, mapping user model)

- Overview produces mental model of information
- Visual Search/Query: Zoom, Filter, Details
- Visual Color Coding, Dashboards
- Data Visualization, InfoGraphic(s)



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Information Visualization

- Compact graphical presentation
 - User Interface for a large data collection ($>10^6$ points)
 - Or a subset of a large data collection
- Allows users to:
 - Discover
 - Decide
 - Explain
- Basis:
 - Patterns, trends
 - Groups/Individual items



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Task Information Visualization

- Overview
 - present entire collection
- Zoom
 - zoom to specific parts of interest
- Filter
 - filter out uninteresting items
- Details on demand
 - Select specific group/item and present details
- Relate
 - Relationships among items
- History
 - History of actions for progressive refinement, i.e: undo, replay.
- Extract
 - Extraction of sub-collections through queries.

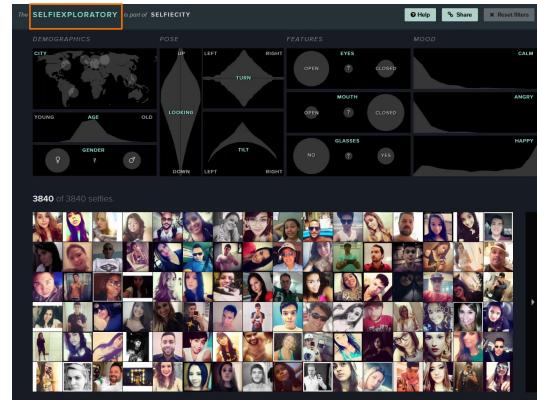


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Example Mantra InfoVis



Overview first,
Zoom and Filter,
Details on demand

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Some important aspects of using text in interactive applications

TEXT & LEGIBILITY



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Visual Representations & Aspects

- Visual density and balance
- Text legibility
- Visualisation
- Visual coding



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Visual Density and Balance

- Measure of amount of 'White Space' in relation to the amount of text.
 - Relation with Information content
 - How to present Information
 - Helps structure the Information load



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Visual Density and Balance



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Text Density

Rules (Guideline):

- On paper: density of 70-80% common
 - On screen: 15 - 20% recommended



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Text Legibility (1)

Choice of upper and /or lower case

- Longer text passages are easier to read when presented using standard capitalization rules rather than using all capital letters.
 - READING IN ALL CAPITAL LETTERS CAN TAKE LONGER BECAUSE WORDS LOSE THEIR CHARACTERISTIC SHAPES. ALL WORDS BECOME RECTANGULAR.



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Text Legibility (2)

- Follow all rules for grammar / punctuation
- Long line lengths can be difficult to read
- Abbreviations must be familiar to users
- Preference for Sans-Serif
- Some font styles might look decorative but they are not necessarily legible.



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Text Coding (Visual) I

- Intensity (brightness)
- Shape e.g. box frame
- Color and/or Shading
- Underlining
- Character size and *font style*



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Text Coding (Visual) II

- Blinking
- Reverse Video
- Greying-out
 - Relevance / Availability
- Movement e.g. use of
 - M-icons
 - Kineicons
 - Gesticons
- Sound and/or synthesized speech
- Change Locus of Attention



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Principles, Guidelines

COLOUR & DESIGN FOR INTERACTION (3)



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Visualisation: Accessibility Aid

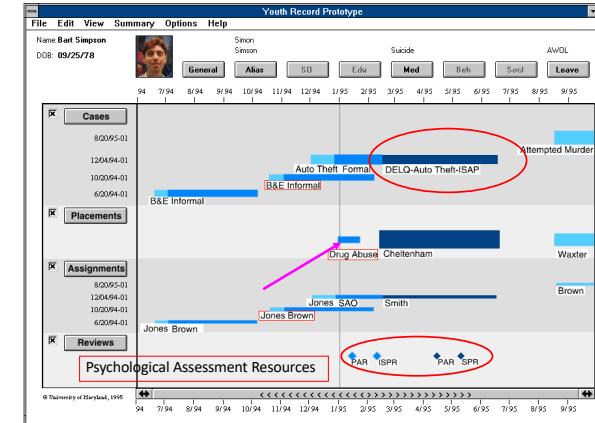
DWJN/IC03 ISYS - INFORMATION SYSTEM FOR YOUTH SERVICES 10/27/94 15:04
 INQCASE CASE DETAIL INQUIRY W0003

YOUTH NUMBER: 000123456 CASE NO: 09/14/93 - 01
 NAME: FIRST XXXXXX MID XXXXXXXX LST XXXXX SWF
 DOB: XX/XX/XX VERIFIED (Y/N): N RACE: X SEX: X COUNTY: 24
 ----- CASE -----
 RECEIVED: DATE 09/14/93 SOURCE POLC REASON DELQ OFFICE 71610
 INTAKE DECISION: DATE 09/14/93 CODE CCAI AGENCY REF TO
 INTAKE REASON:
 APPEALED: / / APPEAL DISP CODE: / / APPEAL DISP DATE: / /
 LEGAL COUNSEL: JUDGE/MASTER:
 COURT FINDING: DISP DATE: / / DISP CODE:
 TERM/COND: WARN
 TERMINATION: FIXED / / ACTRUL 09/19/93 LAST UPDT: 010/07/93 TEXT: N
 CONSENT GIVEN (Y/N): START DATE: / / EXPIRT DATE: / / -----
 ALLEGED OFFENSE: OL DATE 09/14/93 CODE ENWY CTY 16 POL CAPLNT NO: 93045011
 DESC/OFF ERN AWAY FROM HOME UPON RELEASE FROM CSC ARREST DATE: 09/14/93
 LOCATION STREETS ON OXON HILL M.D. ZIP 20745 0000 OTW INV (Y/N) X
 POLICE ID 1777 POLICE NAME NICODEMUS
 ADJUDIC OFFENSE: 00 CODE PETI DISP CODE DATE / /
 NEXT REQUEST: INQCASE NEXT KEY:
 PC900004 NO MORE DATA

(<http://www.cs.umd.edu/projects/hcil/>)

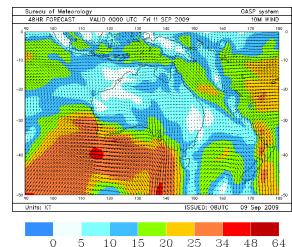
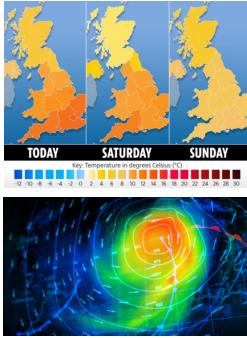


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Colour Coding: Meaningful LUT



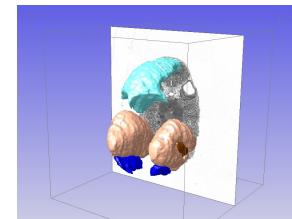
- BTW- what is a LUT?
- Heatmap-like LUT are well understood
- For Infoviz, LUT ~ Colour schema



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Colour in 3D Graphics

- Meaning of Colours: colour schema – LUT
- Depth & Depth perception
- Supports Perspective
- Light source(s): directed, ambient



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VISUAL SUPPORT



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Support for Visual Search

A visual search is a mental pattern

Aim: find patterns in the information display
Colour can support segmenting the display

- **Symbol**

- Graphical object that represents an entity
- Can be iconic, otherwise data point



- **Glyph**

- Graphical object that represents an entity and conveys one or more numerical attributes of the entity
- Rapidly found, understood, supports visual query/search



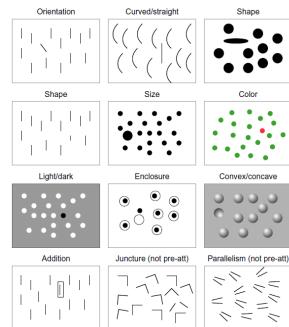
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Perceptual Properties – *Pre-attentive*

- Luminance
- Brightness
- Colour (Hue)
- Texture
- Shape
- Motion
- Convex/Concave



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Pre-attentive & distractors

- Find a target among other symbols
- What can we process with pre-attentive vision
- Time to search
 - Distractors present?
 - Colour differences? = hue
 - Strength of pre-attentive effect
 - Distinctiveness and Expectation
- Use asymmetries
 - Adding marks



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Symbols-Glyphs: London Tube Map



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Integral ~ Separable Dimensions (i)

- Integral display dimensions:
 - Two (+) attributes of a visual object are perceived holistically
 - e.g. rectangle: shape, width, height
- Separable display dimensions (analytical processing)
 - Viewer makes separate judgements about each graphical dimension of a visual object
 - e.g. ball diameter, ball colour
- Use colour expectation
- Important to Glyph design
(from Colin Ware, *Information Visualization*)



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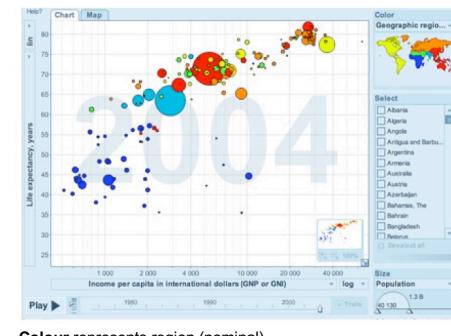
Integral ~ Separable Dimensions (ii)

- Theory from Garner (1974),
 - used for Glyph design
- Consistency of colour coding and perception
- Can an attribute be perceived independent
 - Colour
 - Shape
 - Size
- Classification of an information display
- Holistic response → integral glyph
- Analytic response → separable glyph



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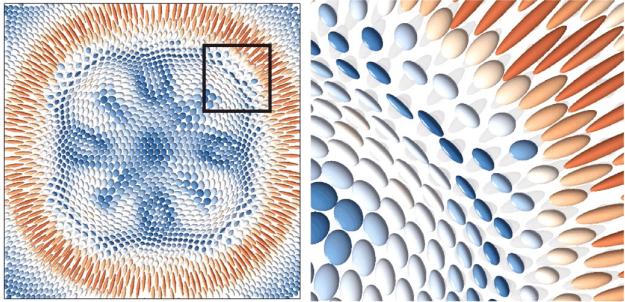
Glyphs and Display Dimension



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Glyphs help understand Visualization



Flow surfaces – showing different displacements,
each Glyph represents a set of properties in a “flow field”
Obermaier & Joy, UCSD.

{Colour, Size, Shape & Direction}



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Integral vs. Separable

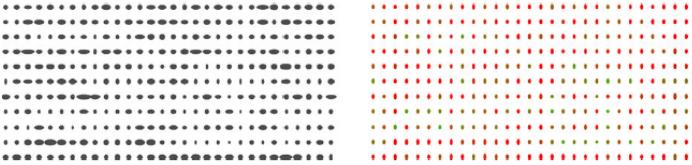


Figure 5.21 Height and weight data from 400 elderly Dutch people is displayed. On the left, height squared is mapped to the height of each ellipse and the weight is mapped to the width. On the right, weight is mapped to color and the width is held constant (red is more, green is less).

Holistic: combination of dimensions
Dimensions perceived as whole

From *Information Visualization*, Colin Ware, 2013



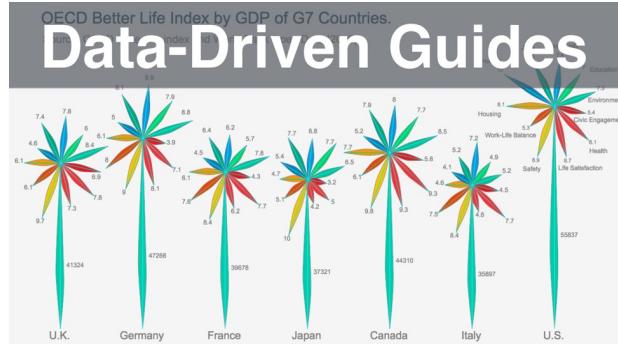
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Analytic: separation of dimensions
Dimensions processed independently

HCI & IV 2022, fv

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Glyph - Colour



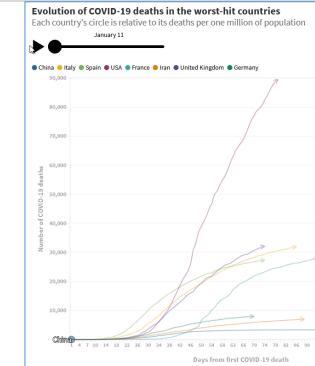
OECD Better Life Index by GDP of G7 Countries.



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Glyph - Dynamics



Colour: Nominal
Size: Ratio

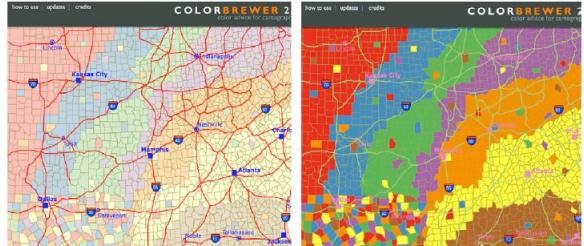
From Euronews, may 2020



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High-lighting with Colour



Made using: <http://ColorBrewer2.org>

Low vs High saturation
Area coding vs symbol and linear features.
Lack of efficient contrast (right)



Review #5b

- Mantra of Information Visualization
- Text and Legibility
- Visual Coding
- Visual Search
- Glyphs & Symbols
- Separable dimensions
- Highlighting



Example from HCI&IV

