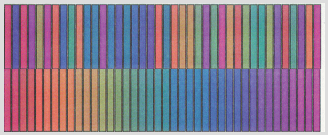
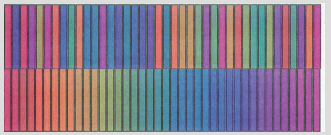


3.0 Goals and Introduction

Goals of this chapter:

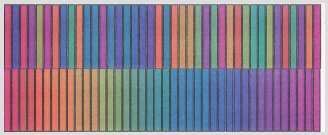
- Increase awareness of the importance to know abilities, disabilities and goals of user
- show methods by which such knowledge can be applied in the visualization process
- evaluate success



3.1 What we need to know

- What characteristics **enable** / **disable** the user to interpret a picture in a **correct** / **desired** way?
  - we need to know about human visual perception
  - we distinguish between general / individual characteristics

- How can a developer / visualizer **make sure** that an image is correctly interpreted?
  - take stock of abilities, characteristics
  - test / evaluate



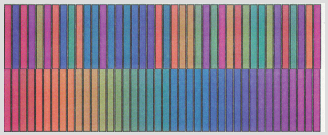
3.1.1 What characteristics **enable** / **disable** the user?

1) How does human visual perception work? Explain by:

- biological / psychophysical / cognitive facts
- perception theories

2) Distinguish between general and individual characteristics, e.g.

- „color blindness“ (individual) vs. Illusions (general) or insensitivity to short wavelenghts (general)



3.1.2 How can a developer / visualizer make sure that an image is correctly interpreted?

1) Take stock of

- abilities, disabilites
- visualization aims, desires, habits
- education, culture

2) Test / evaluate

- „special tasks“
- „thinking aloud“
- statistical analysis

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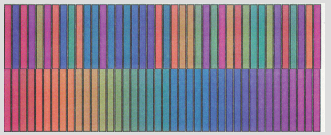
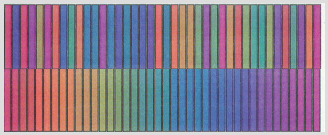
Computer Graphics, Visualization and Image Processing
Prof. Dr. Gitta Domik



3.2 Human Visual System

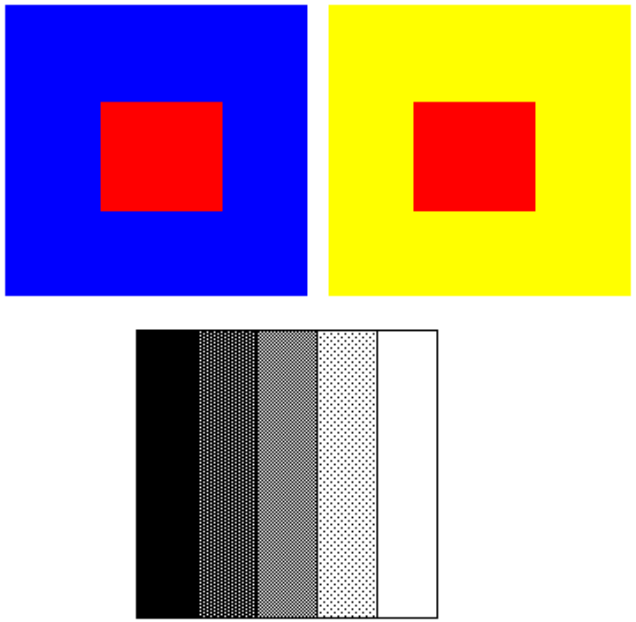
It is important to know about

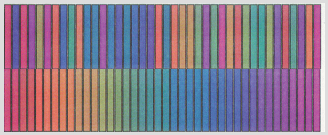
- Biological, psychological, and cognitive aspects of the visual system
- Visual perception and computer-generated images
- Theories of visual perception
- Human memory system
- Visual context – how it aids in the interpretation of images



3.2.1 Human Visual System – General Background

- biological issues
  - eye, neurons
  - effective sensory stimuli
- psychophysical issues
  - e.g. hue, saturation, brightness
- visual phenomena
  - e.g. simultaneous contrast, Machband effect [SEK85]





Individual abilities –color blindness

User Modeling for Adaptive Visualization Systems, G.O. Domik and B. Gutkauf, pp. 217-223.

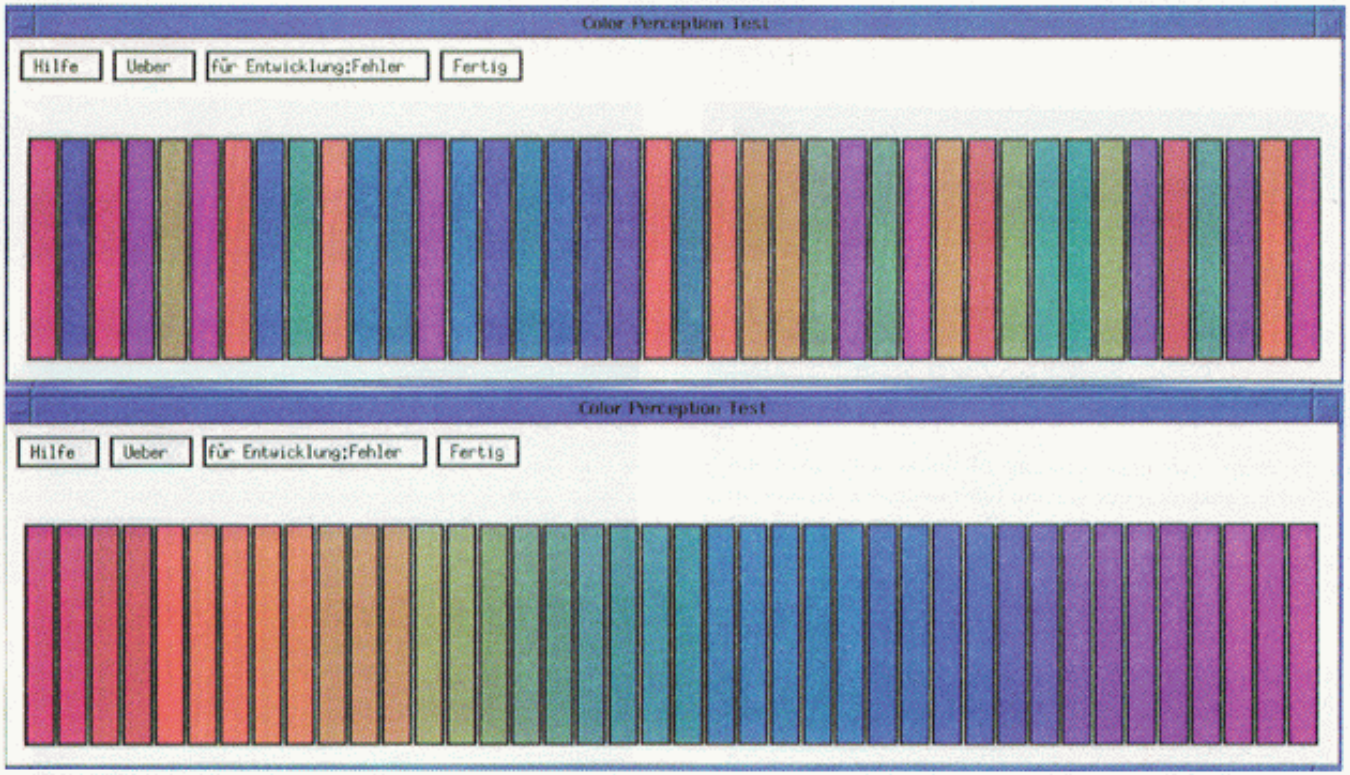
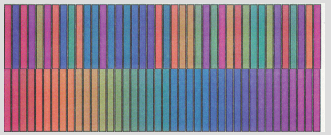


Figure 2: (upper row) Arrangements of color chips at start of color perception test. (lower row) Correct result after rearranging chips.

[DOM94]



Individual abilities – Fine motor skills

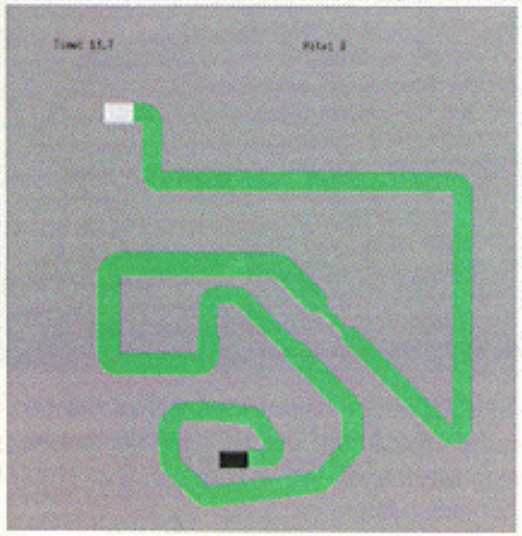
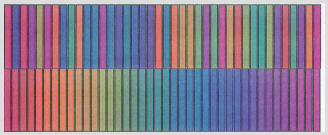


Figure 7: Fine motor coordination test. User traces green path from white rectangle to black rectangle. Errors (leaving green path) are counted and speed is measured.

[DOM94]



Individual abilities – ranking of color

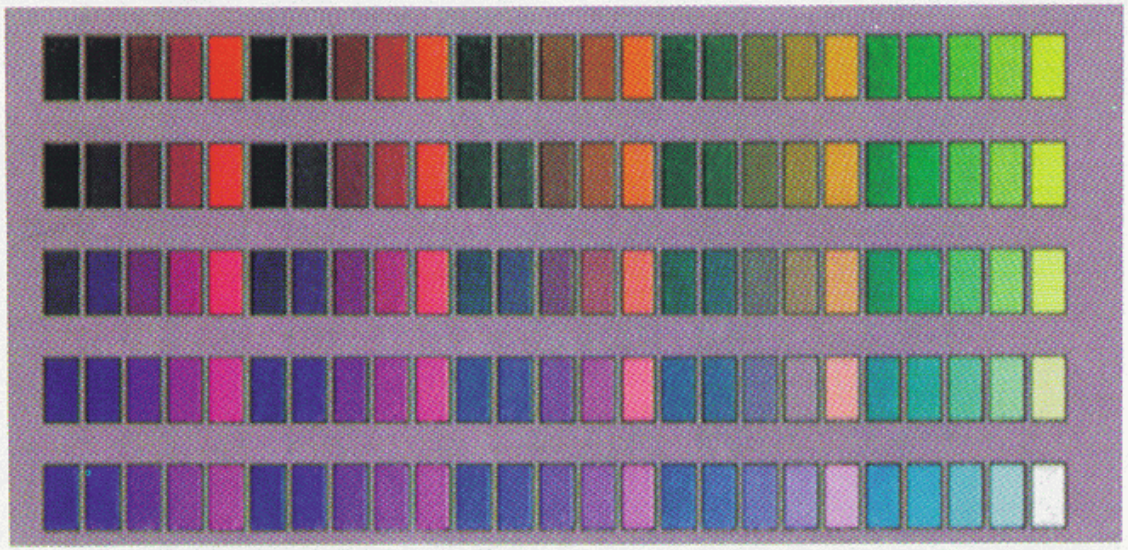
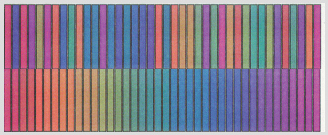


Figure 4: Color gamut for color ranking test.

[DOM94]



Human Visual System – color memory

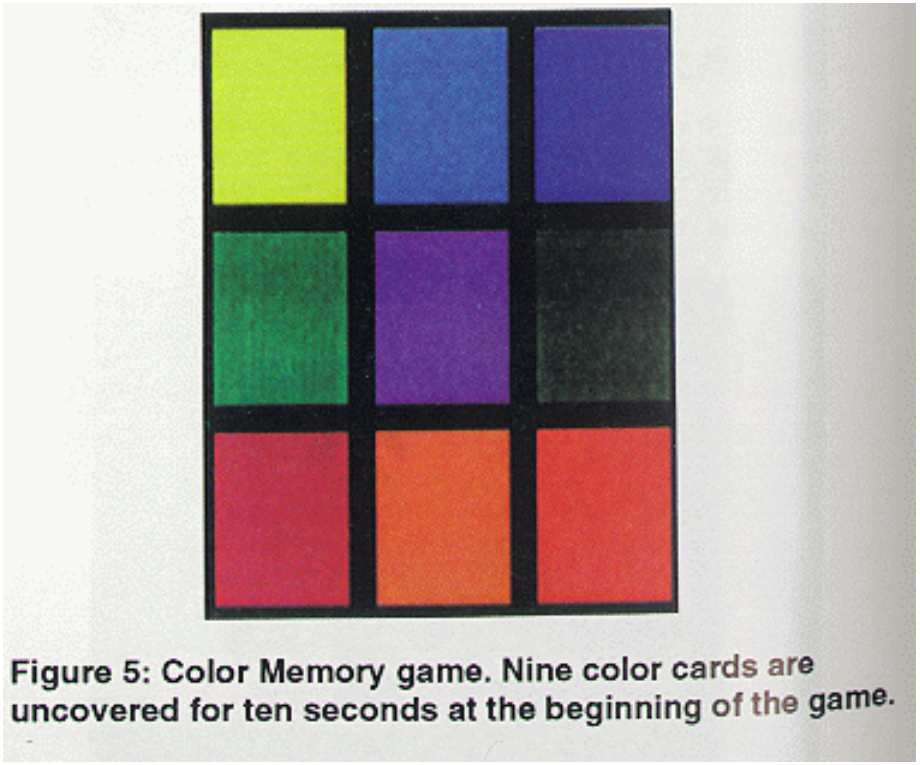
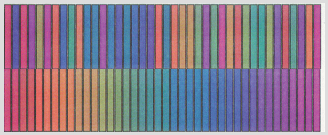


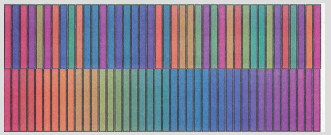
Figure 5: Color Memory game. Nine color cards are uncovered for ten seconds at the beginning of the game.

[DOM94]



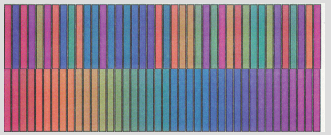
3.2.2 Theories of visual perception

- Gestalt laws
  - E.g. similarity, closeness, continuation
- Integration of images across time



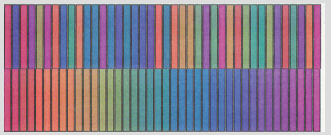
3.2.3 Human memory system [SHN97]

- Short-term memory capacity
  - "The magical number seven - plus or minus two" (G. Miller, 1956)
  - recognize seven "chunks" of information
  - hold for 15 to 30 seconds
  - forget or move to long-term memory
- Short-term memory in conjunction with working memory
  - short term memory: process perceptual input
  - working memory: generate and implement solutions
  - disruptions, anxiety cause loss of information



3.2.4 Contribution of senses other than vision

- e.g. sound, force-feedback, smelling, etc.



3.3 Visual Perception and Computer-Generated Images

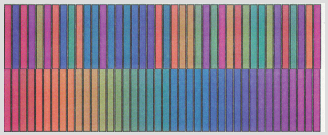
Visualizations / Pictures

- Entirety of graphical objects and their visual attributes as result of visualization process

Visual attributes

- Mode („flavor“) of presentation chosen, e.g. color, size, orientation
- Clever choice of visual attributes is paramount to visualization process
- Redundancy of visual attributes enhances interpretability

[BER67], [TUF83], [KEL93]

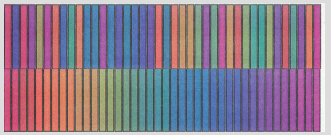


3.3.1 Interpretation of visual attributes

- Innate reaction to visual attributes
  - natural to interpret, usually simple
  - example: increasing brightness gives impression of increasing numerical values
  - preconscious/preattentive interpretation

- Acquired reaction to visual attributes
  - acquired through education, usually more complex
  - example: color ranking, street/travel signs, isolines, isosurfaces

- Illusory visual attributes
  - well documented illusions (not nec. well understood)
  - example: illusory triangle, color contrast, Machband effect, etc.

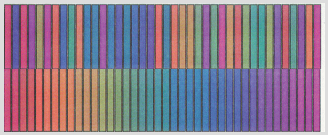


3.3.2 Visual attributes discussed in depth

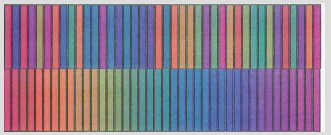
Color

- psychophysical process
  - physics: relates to wavelengths, spectral distribution and amount of light entering eye
  - psychology: perceived sensation with no linear relation to physics
- no complete theory (three types of cones: S,M,L; opponent theory)
- variety of color spaces: geometric descriptions of color gamut
- perceptual dimensions of color: hue, saturation, intensity
  - may be varied independently or in connection to each other
  - hue: “colors” of rainbow (relates to wavelength)
  - saturation: “paleness” of color is lack of saturation (relates to spectral distribution)
  - intensity: light/dark colors (relates to amount of light entering eye) - brightness

Hue

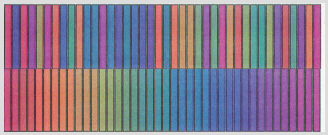


- effective use for nominal data types and ordinal data types (color scale!)
- hints
  - small blue objects: disadvantage for short-wavelengths cones
  - blue (cool colors): farther away, cooler, lower or negative values
  - red (warm colors): nearer, warmer, higher and positive values; danger
  - shape of object displayed with rainbow scale may not be readily apparent
  - hues may change appearance on different backgrounds
  - “color-blindness”
  - ranking of hues not inherent
  - discontinuous color scales



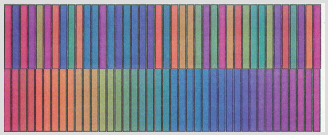
Saturation

- effective use of saturation for ordinal data types
- careful when interpreting saturation and brightness independently
- 2-dimensional color scales for effectiveness

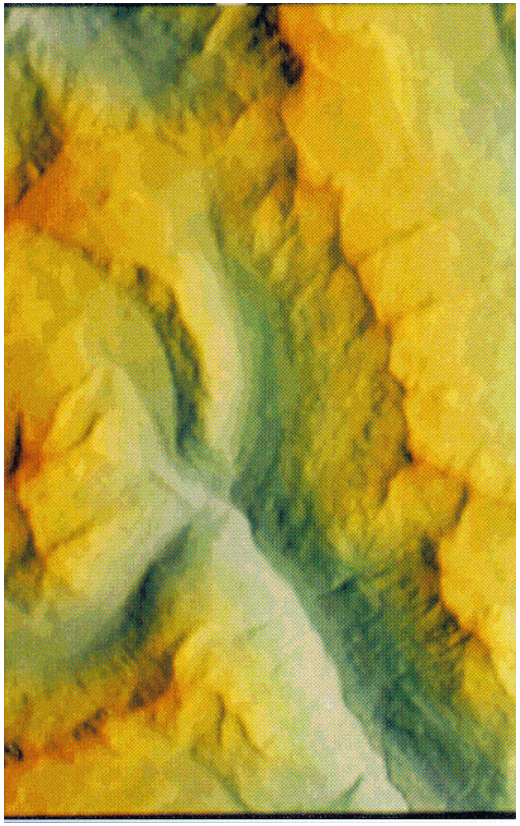


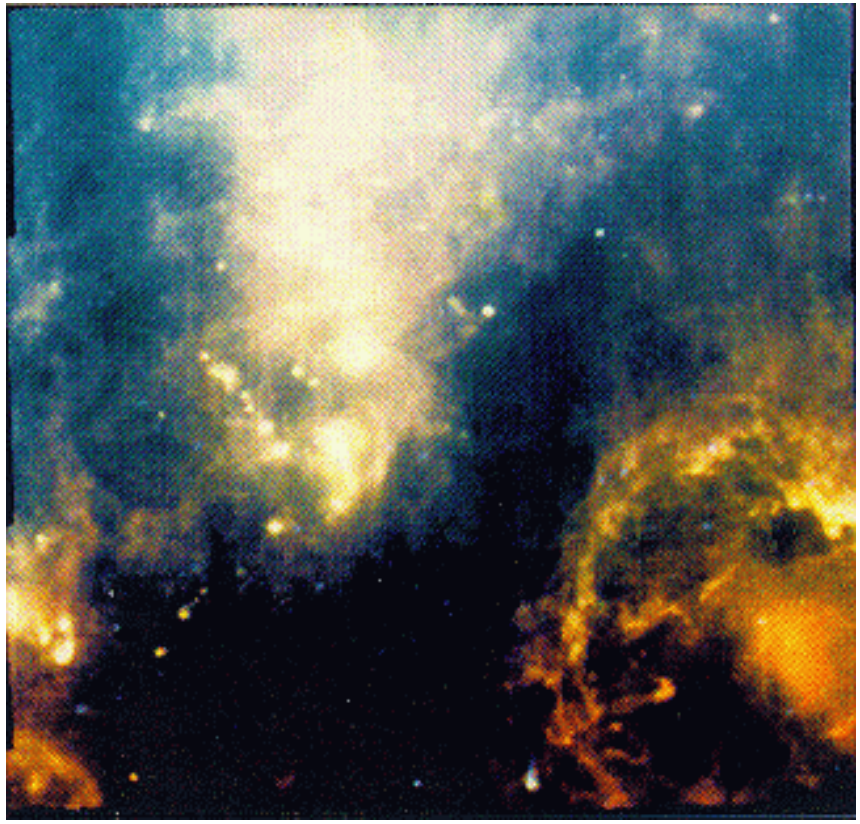
Brightness

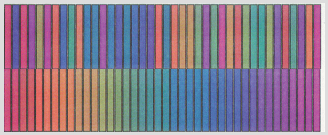
- effective use of brightness for ordinal (and quantitative) data types
- hints
  - bright objects on dark background look bigger than dark objects on bright background
  - fading brightness gives impression of distance/depth
  - absolute brightness not perceived linearly
  - change of brightness not perceived linearly (Machband)
  - brightness contrast influences perception of brightness
- 2-dimensional color scales for effectiveness



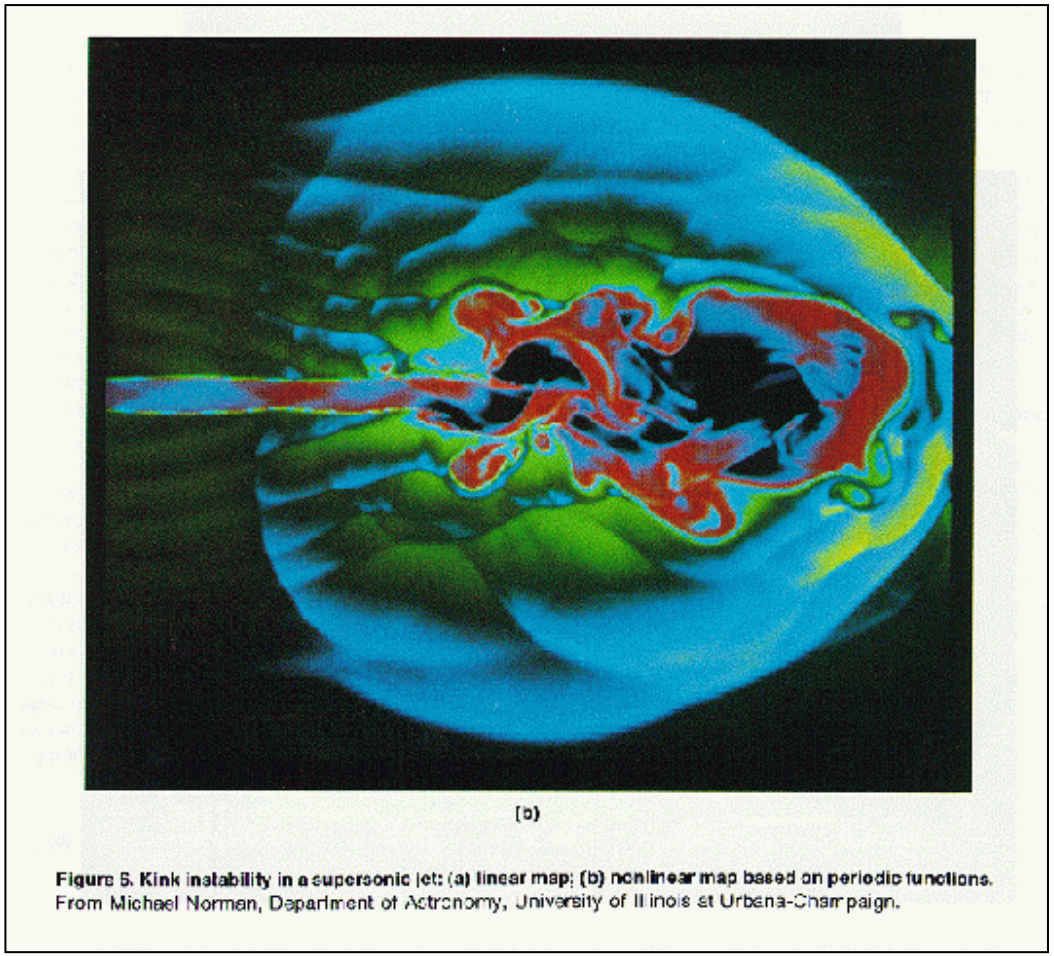
Example IHS + RGB





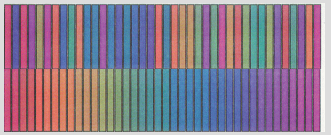


Example: Color Tables



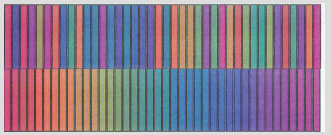
(b)

Figure 5. Kink instability in a supersonic jet: (a) linear map; (b) nonlinear map based on periodic functions. From Michael Norman, Department of Astronomy, University of Illinois at Urbana-Champaign.



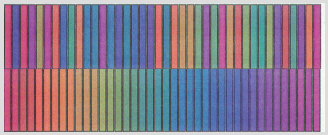
Texture

- effective use for nominal data types
- hints
  - careful with overlapping textures
  - textures may give rise to other impressions, e.g. density
- include legend



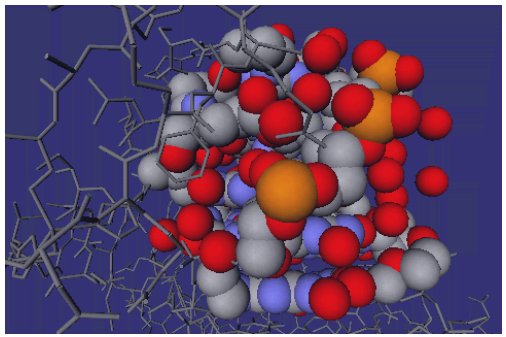
Orientation

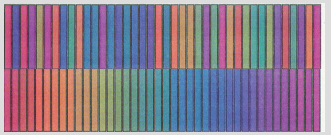
- hints
  - familiarity of shape often connected to orientation
  - symmetry around vertical axis preferred
- use various orientations to assure correct view of objects



Depth Attributes

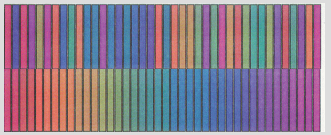
- Use depth attributes to enhance the perception of 3-d structures
  - **fading brightness** to show increasing depth
  - **perspective geometry** to show increasing depth
  - **occlusion** to distinguish back/front
  - **transparency/translucency** to distinguish back/front
  - change of brightness (**shading**) to simulate surfaces
  - **rotation**/"rocking" to enhance 3-d perception
  - **stereo effect**: anaglyph, shutter glasses, VR
- Example: complex molecules





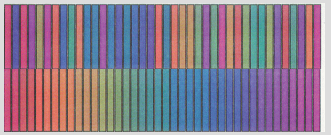
Motion

- Frame update rate to perceive motion
  - at least 10 frames/sec [BRY94]
- Examples
  - animation
  - flicker two or more images to depict differences, similarities



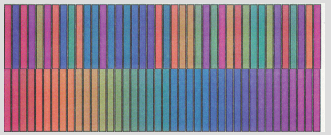
3.3.3 Visual context / Necessary aids for the interpretation

- Adhere to the conventional meaning of colors
- Annotations aid the interpretation of visual attributes
- Examples of annotations
  - in textual form: labels, titles, legends
  - color/brightness scales
  - distance scales (scale bars) to relate world and screen coordinates
  - orientation signs, e.g. North arrow
  - animation annotation: time/spectral indicator



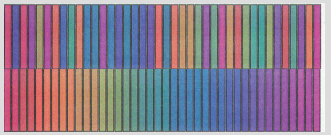
3.4 Visualization Goals / Visualization Tasks / Interpretation Aims

- = focus of a user on a particular domain of interest during interpretation of image
- application dependent visualization goals
- application independent classification of visualization goals



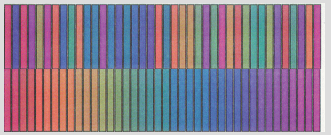
3.4.1 Examples of Visualization Goals

- Scientific visualization, e.g.
  - identify objects, compare values, distinguish objects, categorize objects
- Software visualization, e.g.
  - focus on text/ or data structures/ or performance/ or algorithm
- Information visualization, e.g.
  - focus on detail with overall view, view relations



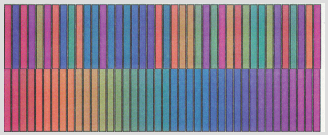
3.4.2 Task analysis [SHN97]

- determine task before determining representations
- tasks often determined informally or implicitly
- high-level tasks / middle-level tasks / atomic actions
- advantage: one representation can serve one high-level task



3.4 Evaluation of progress

- establish a goal that can be assessed
- start evaluation at early stages
  - change is still easy
- determine progress towards that goal
  - choose appropriate procedure, e.g. thinking aloud

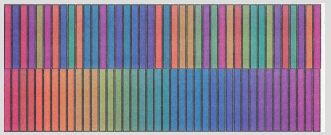


3.5 User

User

- What characteristics **enable** / **disable** the user to interpret a picture in a **correct** / **desired** way?
  - general / individual characteristics
  - how does visual perception work?

- How can a developer / visualizer **make sure** that an image is correctly interpreted?
  - take stock of abilities, characteristics
  - test / evaluate



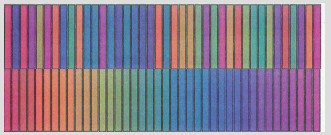
What characteristics **enable** / **disable** the user?

1) General / **individual characteristics**, e.g.

- „color blindness“
- fine motor skills
- mental rotation
- color memory
- ranking of color
- illusions
- insensitivity to short wavelenghts

2) How does visual perception work? Explain by:

- Perception theories
- biological / psychophysical / cognitive facts



How can a developer / visualizer make sure that an image is correctly interpreted?

1) Take stock of

- abilities, disabilites
- visualization aims, desires, habits
- education, culture

2) Test / evaluate

- „special tasks“
- „thinking aloud“
- statistical analysis