DICOM Softcopy Presentation State Storage and Print Presentation LUT

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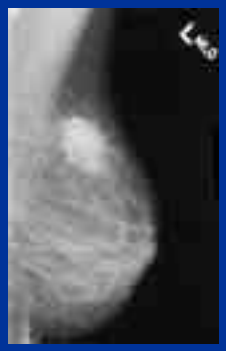
Quintiles Intelligent Imaging

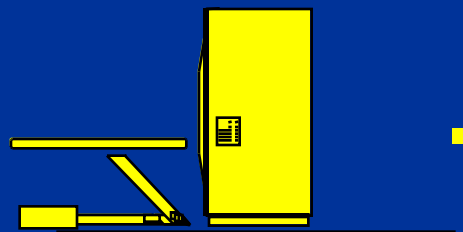
Clear Vision for the Healthcare Industry

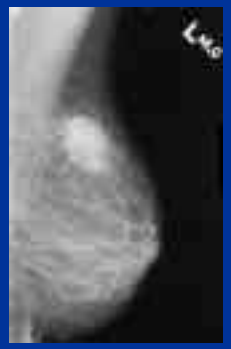
Outline

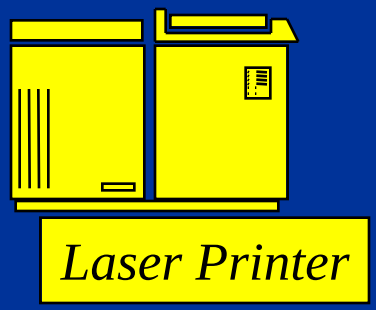
- Inconsistent appearance of images
- Grayscale Standard Display Function
- Print Presentation LUT
- Other Softcopy Presentation features

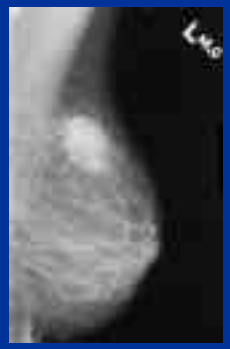
Distributed Image Consistency



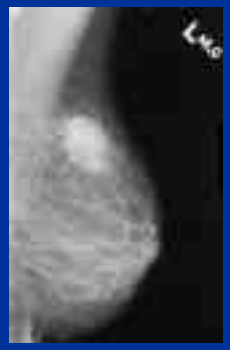








Identical perceived contrast



Problems of Inconsistency

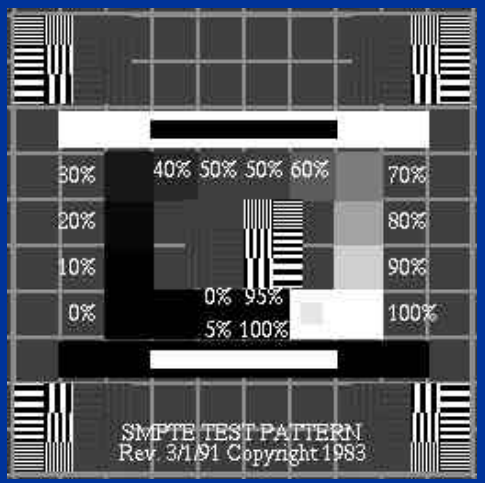
mass visible

mass invisible

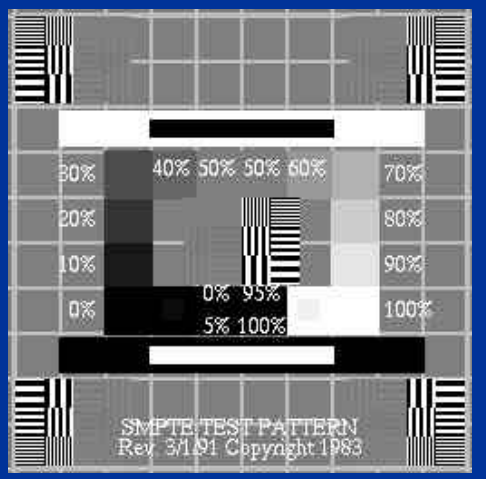
- VOI chosen on one display device
- Rendered on another with different display
- Mass expected to be seen is no longer seen

Problems of Inconsistency

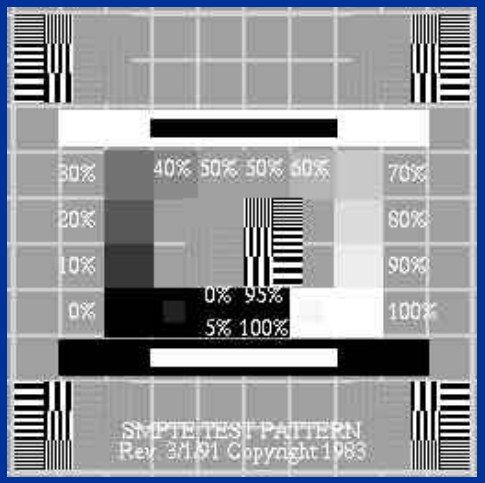
0.5



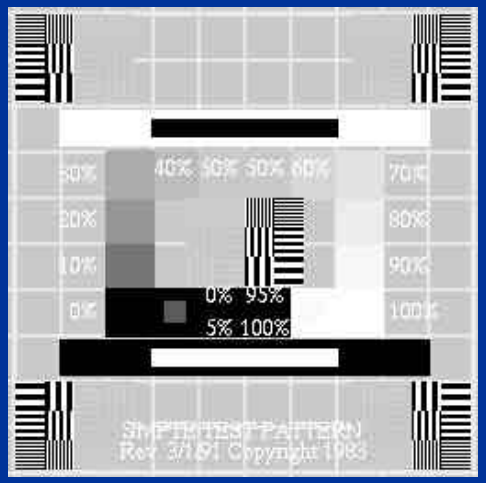
1.0



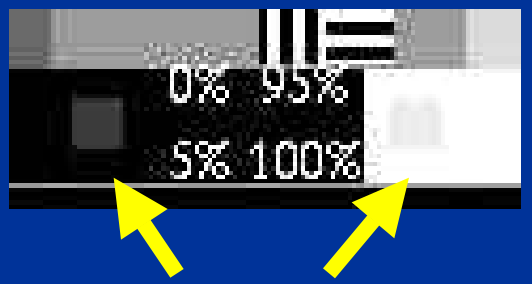
1.5



3.0

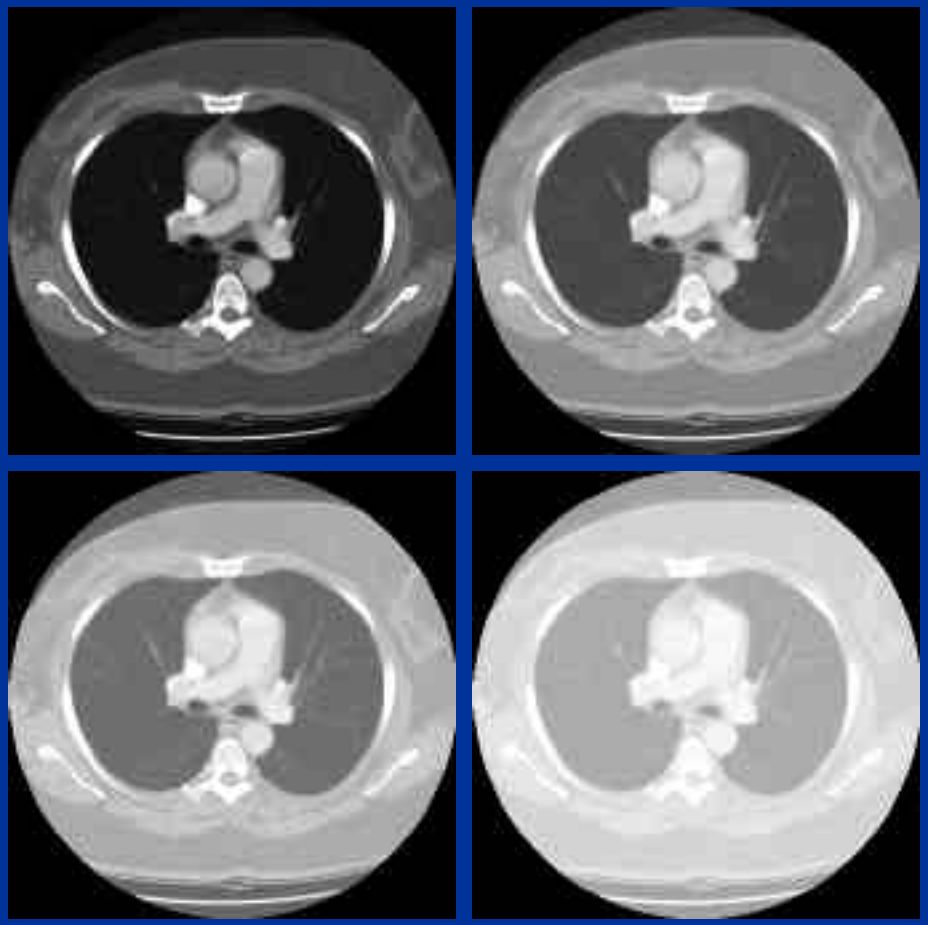


- Not all display levels are perceivable on all devices



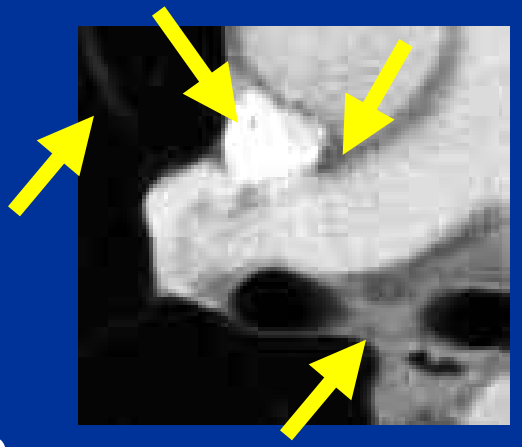
Problems of Inconsistency

0.5



1.0

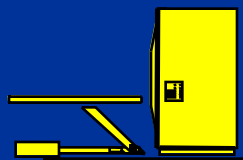
•Not all display levels are perceivable on all devices



1.5

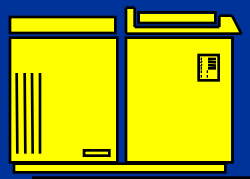
3.0

Problems of Inconsistency



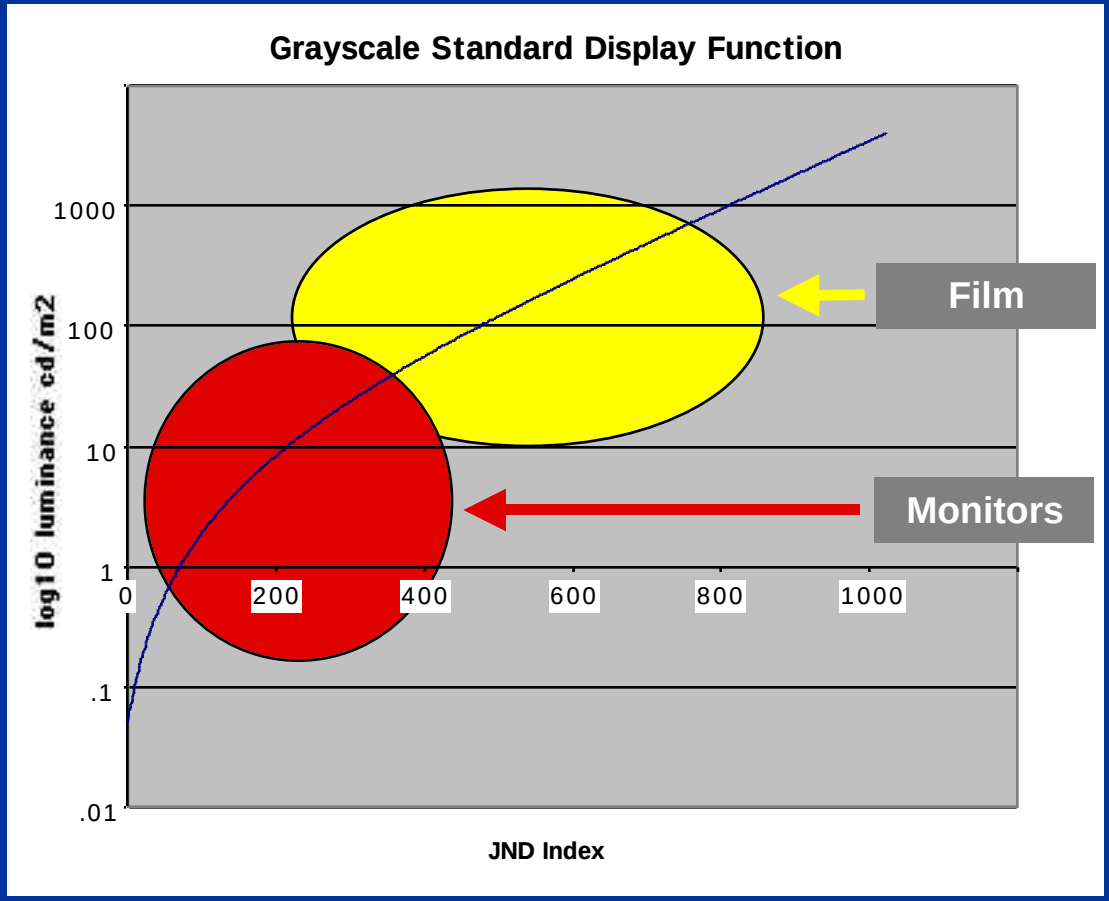
Digital Modality

- Printed images don't look like displayed images



Laser Printer

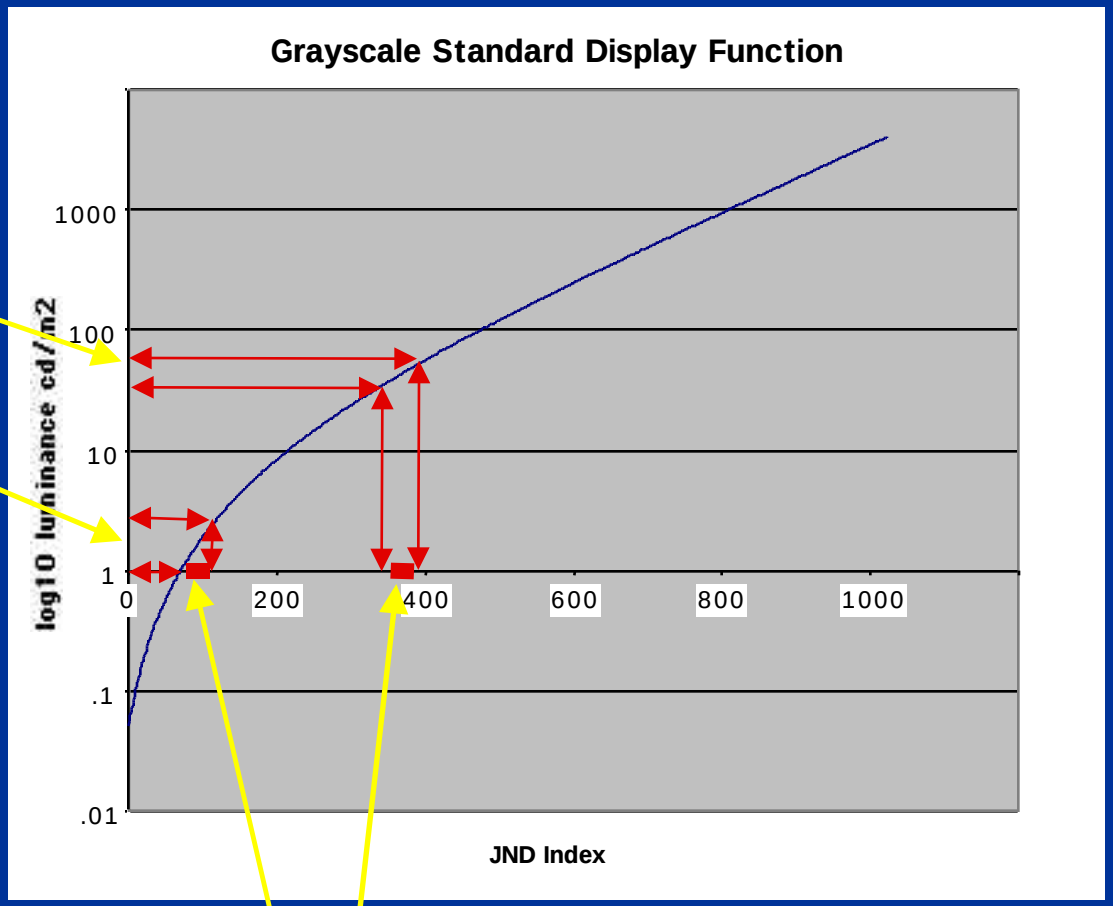
Standard Display Function



Perceptual Linearization

- JND index is “perceptually linearized”:
  - same change in input is perceived by the human observer as the same change in contrast
- Is only a means to achieve device independence
- Does not magically produce a “better” image

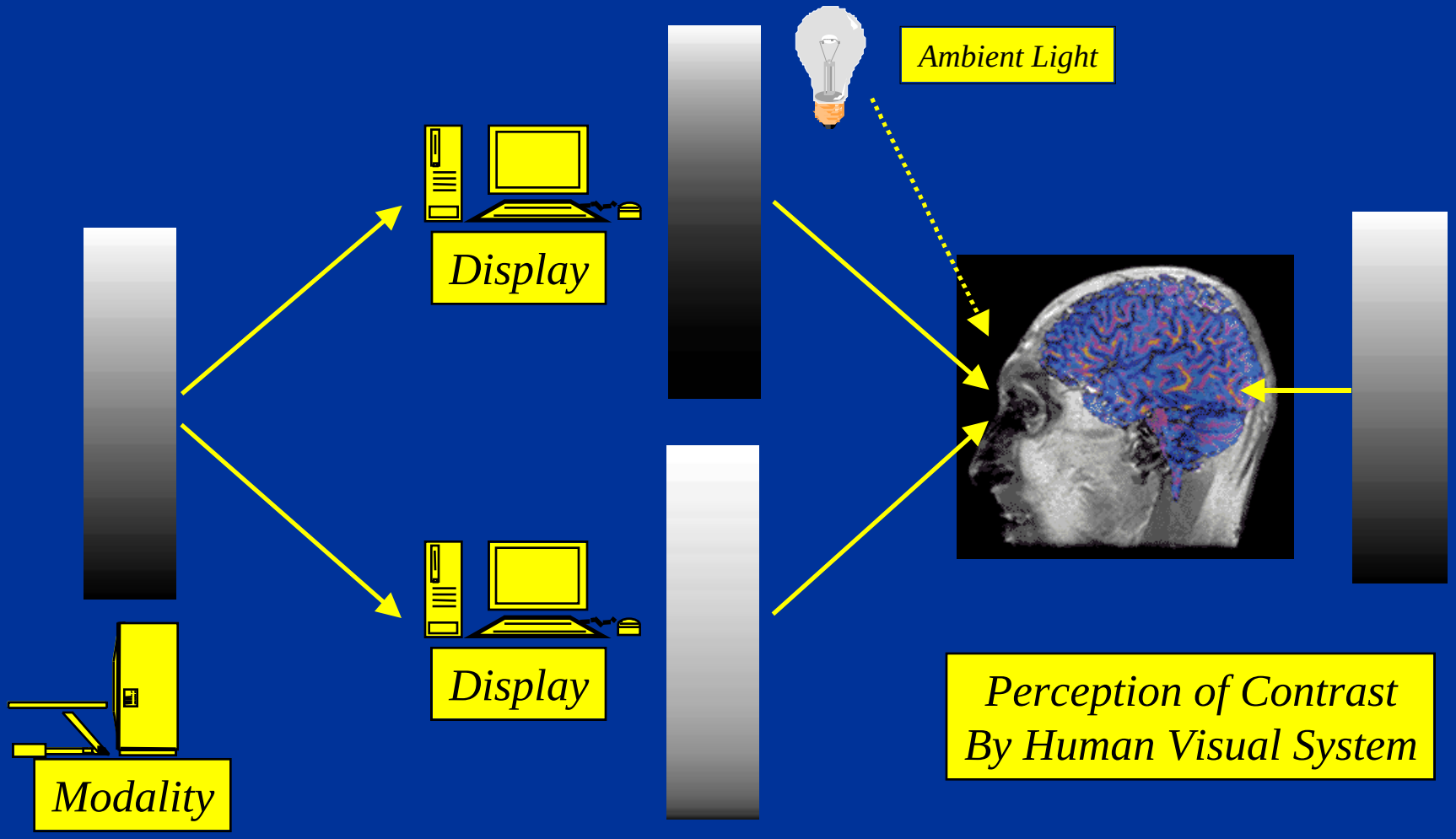
Perceptual Linearization



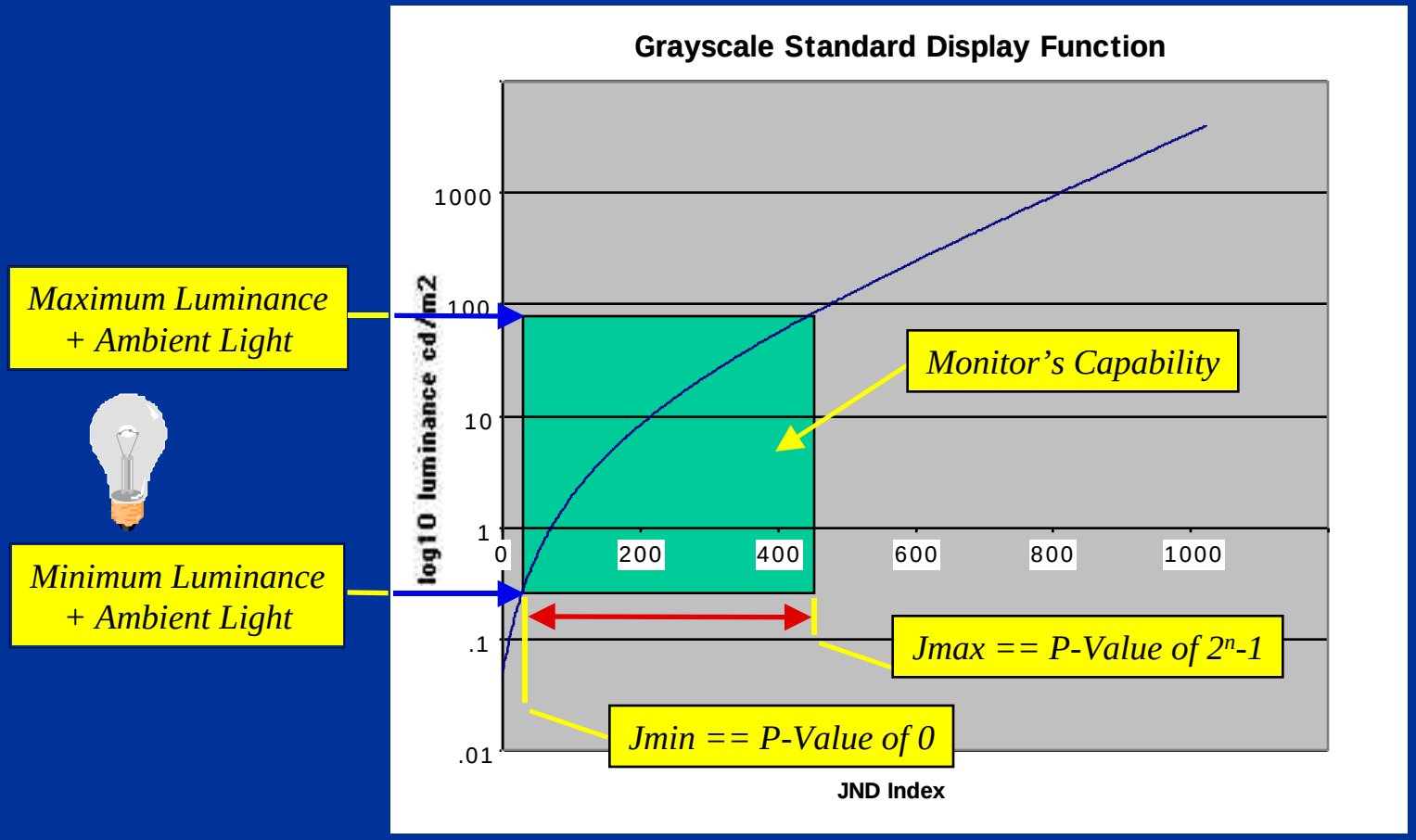
Despite different change in absolute luminance

Same number of Just Noticeable Difference == Same perceived contrast

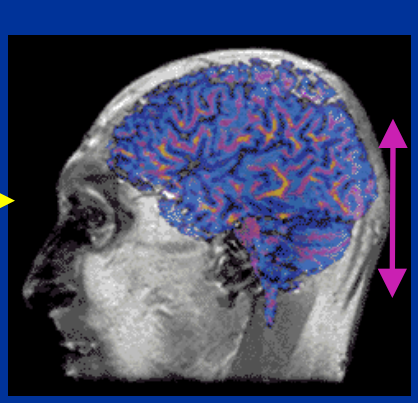
Perceptual Linearization

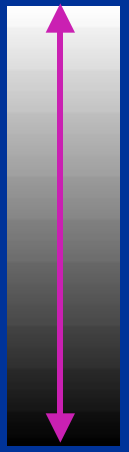


Standard Display Function

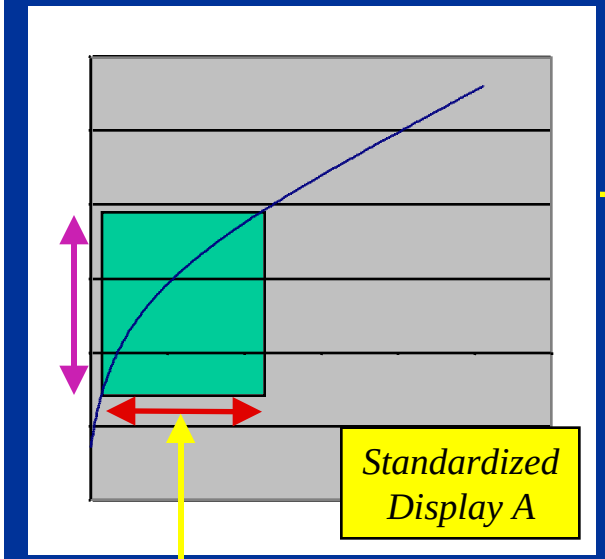


Device Independent Contrast



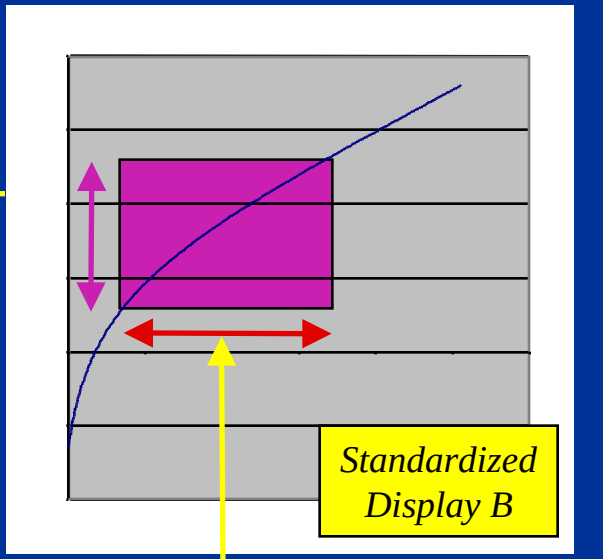


Standard Display Function

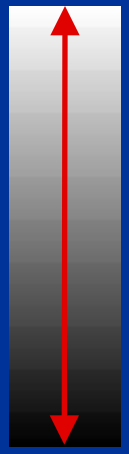


Standardized Display A

Standard Display Function



Standardized Display B



P-Values: 0 to 2^n-1

So what ?

- Images can be made to appear not only similar, but ***the way they were intended to appear***, if images and VOI are targeted to a P-value output space, and printers and displays are ***calibrated*** and ***standardized***

Grayscale DICOM Services

- New image objects are in P-Values
  - e.g. DX in Sup 32
- Softcopy Presentation State Storage
  - adds P-Values to older objects
- Print Presentation LUT
  - adds P-Values to Basic Print

Print Presentation LUT

Print Presentation LUT

- Extends Basic Print
  - negotiated as additional SOP Class
- Pre-formatted pixels sent to printer
  - are defined in P-Values
  - no longer undefined or vendor specific
- Viewing conditions for printed film
  - define transformation to optical density

Existing Basic Print

- Pixel values are sent to printer
- Printer applies a vendor specific LUT transforming value into optical density
- Choice of LUT vendor specific
  - tuned at site during installation
  - modality specific
  - no standard way to select LUT (Configuration Information string)

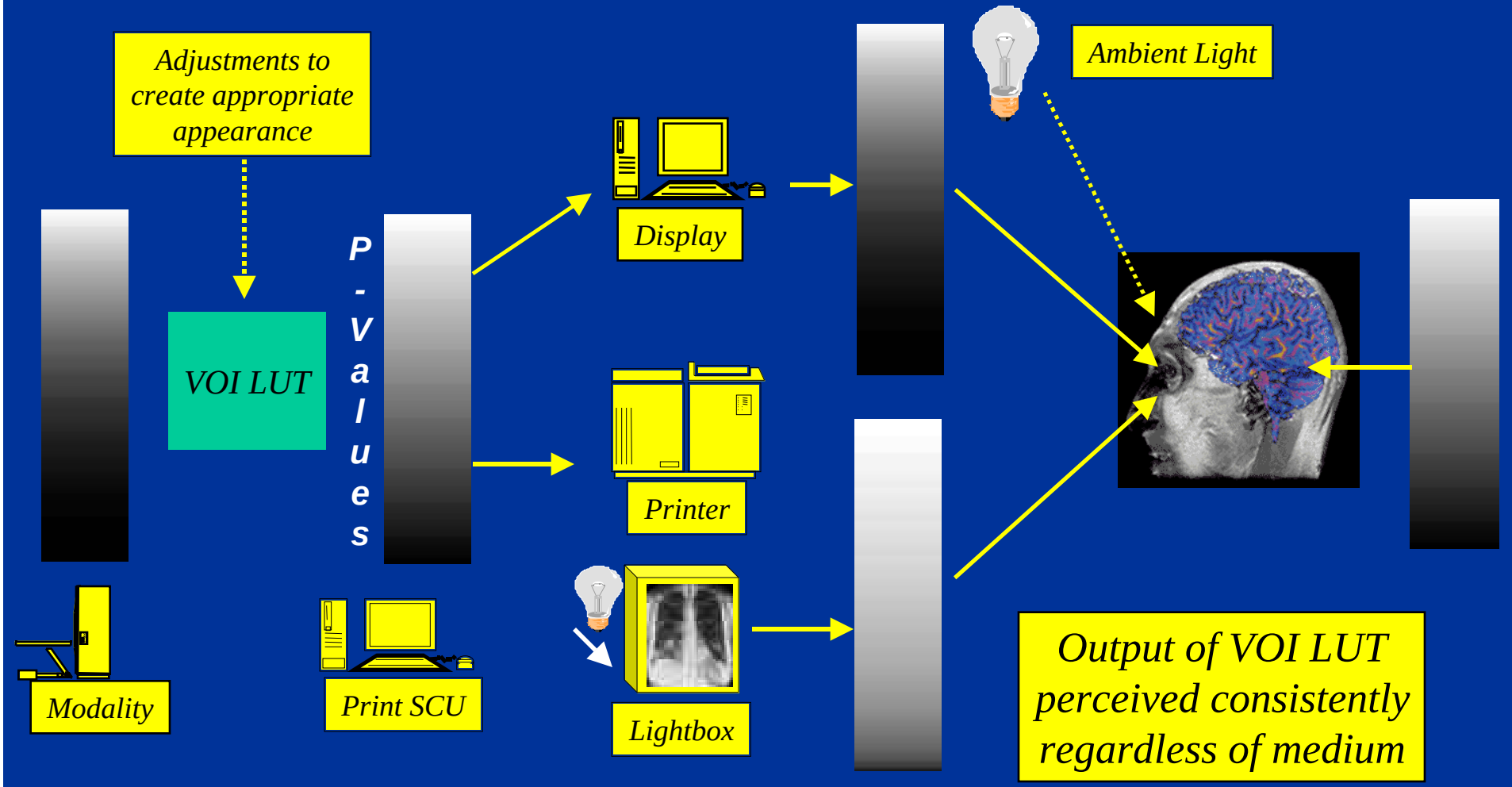
Print Presentation LUT

- Pixel values are in P-Value space
- Mapping of P-Values to luminance assumes print displayed in specified viewing conditions
- Specify (or use defaults for):
  - Reflected Ambient Light
  - Illumination

Print Presentation LUT

- Printer now a consistent slave to SCU
  - renders pixels as requested
  - doesn't "tweak" pixels to site preferences
- SCU now responsible for
  - contrast transformations (VOI LUT) for
    - subject matter, user's preference, etc.
- Consistency between display and print !

Consistent Print and Display



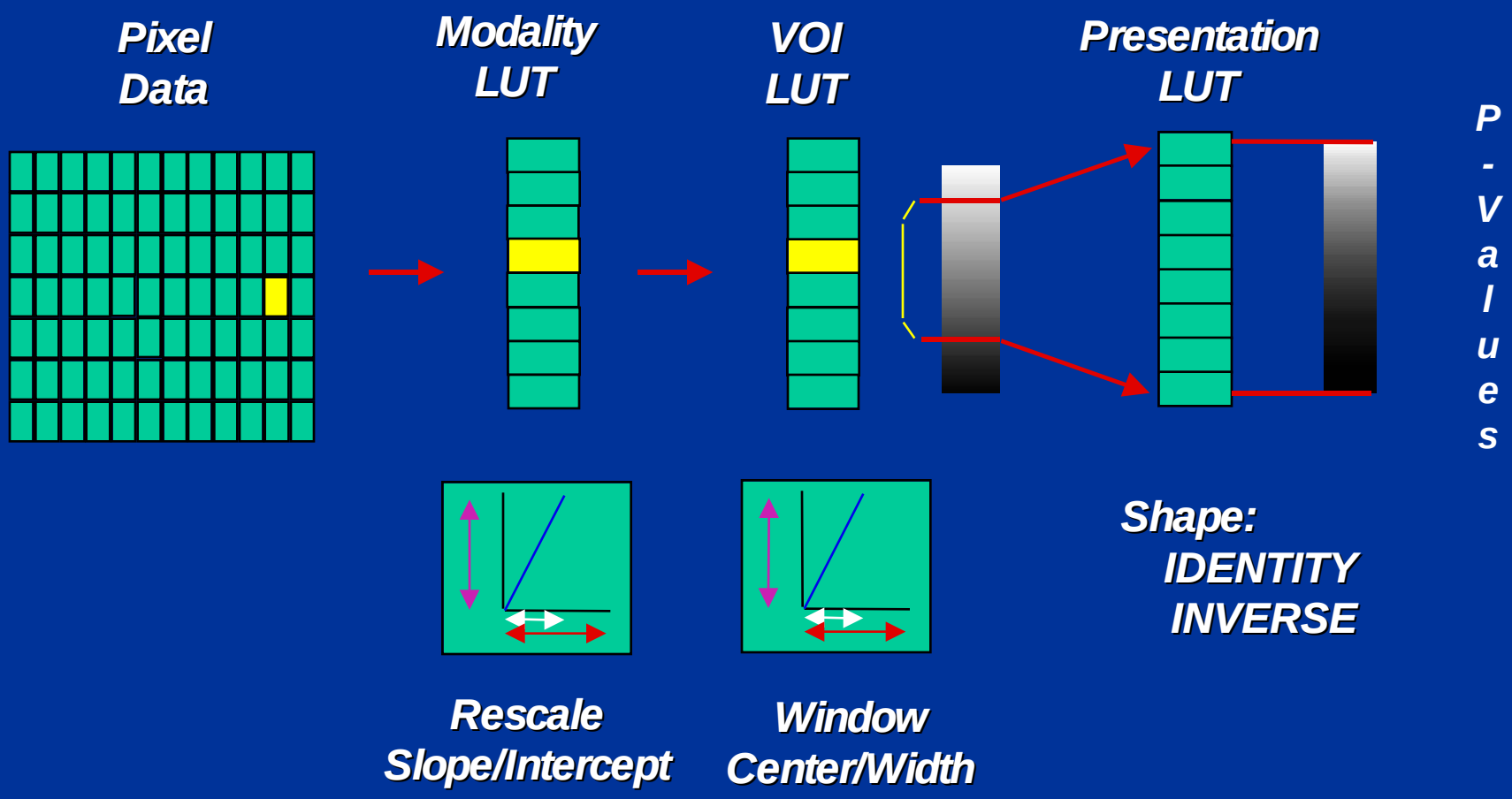
Grayscale Softcopy Presentation State Storage

Softcopy Presentation

- Grayscale Standard Display Function
- Precisely defined gray-scale pipeline
- Is a separate object from image
- May be more than one per image
- Vector graphic annotations
- Spatial transformations

model is to "save state" of image display

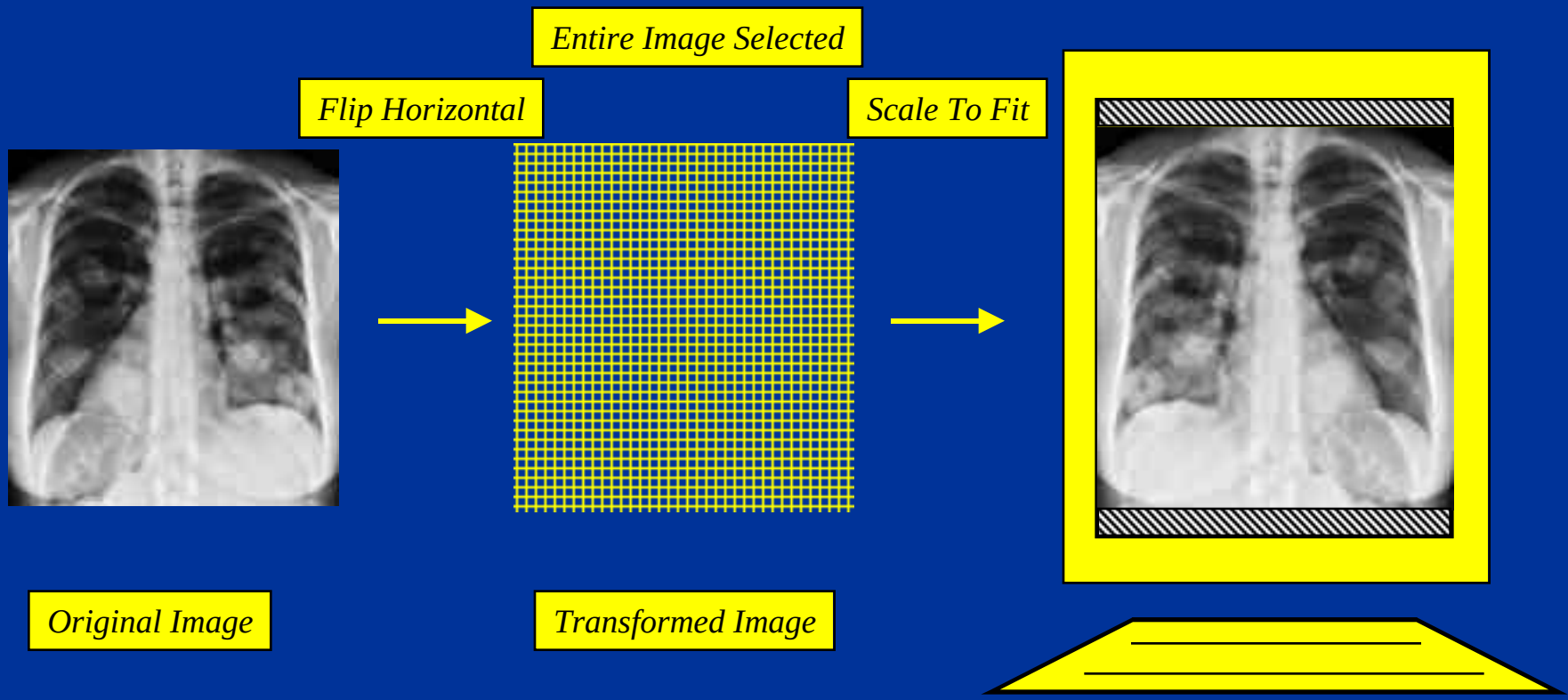
Grayscale Pipeline



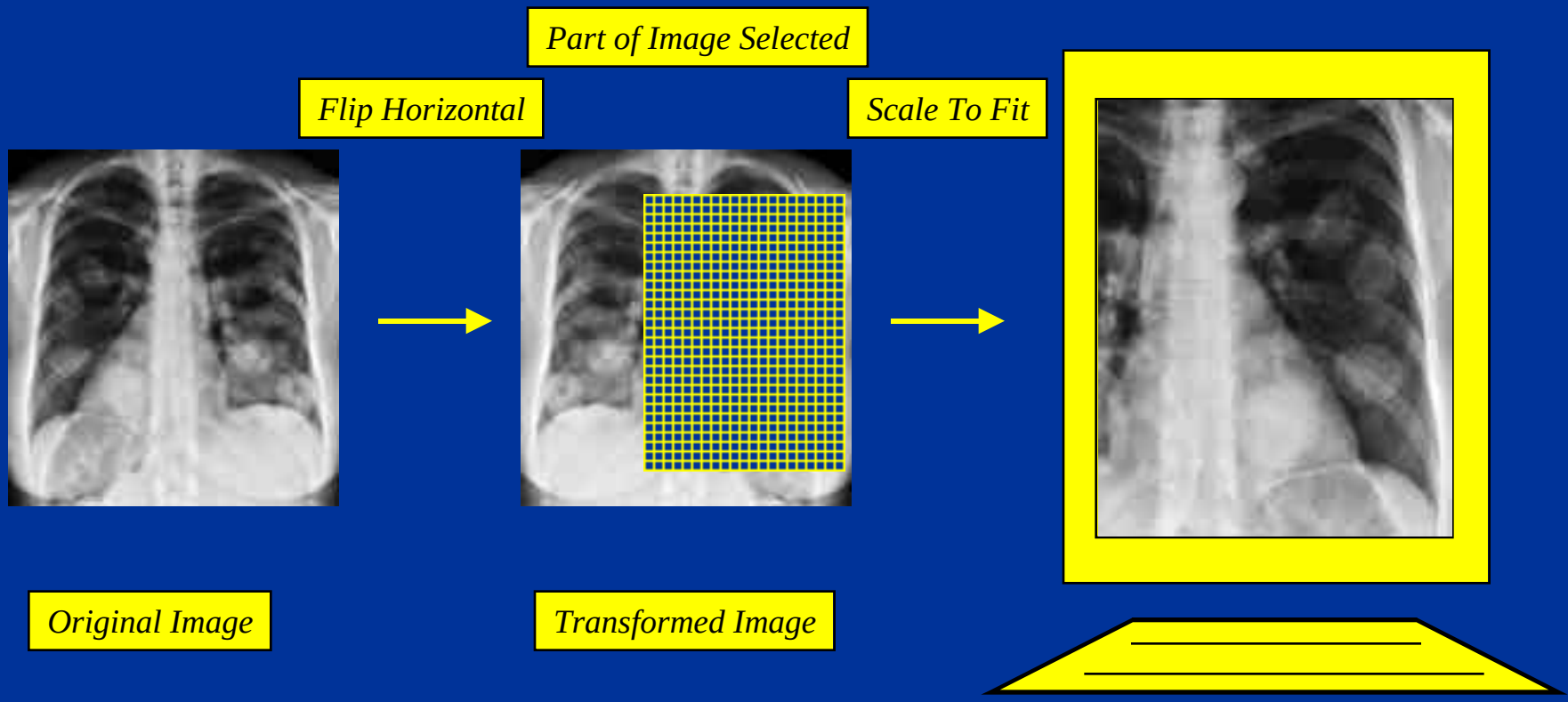
Spatial Transformations

- Displayed area selection
  - select area to be displayed
  - scale to fit
  - true size
  - magnify
- Rotate (90 degree increments)
- Horizontal flip

Spatial Transformations



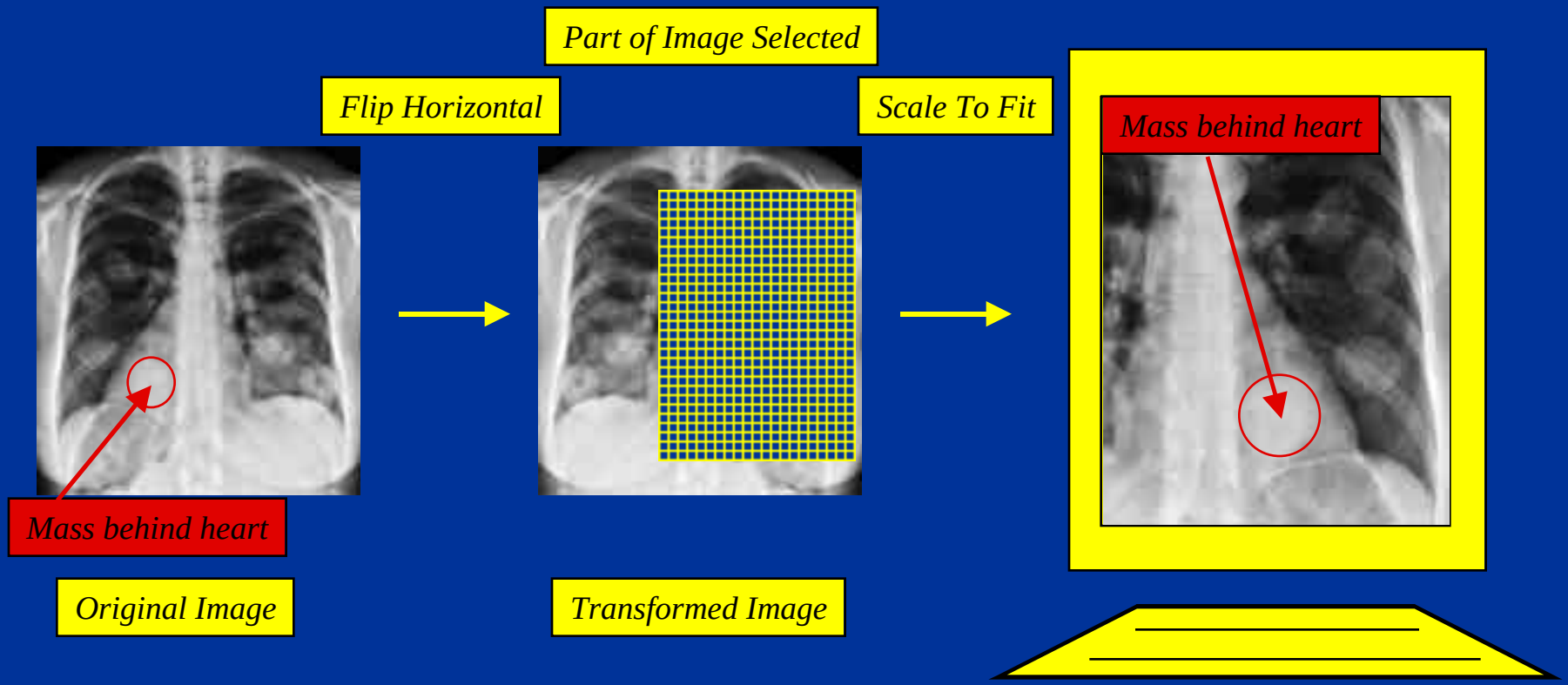
Spatial Transformations



Vector Graphic Annotations

- Graphic objects
  - points, lines, circles, polygons …
  - filled or unfilled
- Text
  - free-standing or attached to anchor point
  - specified by string rather than bit-map
- Image or displayed area relative

Transformation & Annotation



In this example,
- text annotation is specified by image relative visible anchor point
- the circle is a separate image relative graphic annotation

Conclusions (1)

- Consistent appearance on printers and monitors can be achieved using:
  - Grayscale Standard Display Function
  - Print Presentation LUT
  - Softcopy Presentation State Storage
  - Images with P-Value output space (DX)

Conclusions (2)

- Softcopy Presentation State also adds
  - separation of contrast transformation definition from images
  - spatial transformation
  - vector graphic and text annotation

interchangeable saved appearance