Quantitative Visual Displays

Objective --

(1) fixed scale with moving pointer
(2) moving scale with fixed pointer
(3) digital display

Basic Design of Quantitative Displays

(1) fixed scale with moving pointer
(2) moving scale with fixed pointer
(3) digital display

Comparisons of Different Designs

Digital Displays are superior to Analog Displays when:

(1) precise numeric value is required
(2) the values presented remain long enough to read

Analog Displays are useful when:

(1) the values are subject to frequent or continual change
(2) it is important to observe the direction or rate of change of the values presented

Factors to Consider in the Selection of Analog Displays

(1) in general, a pointer moving against a fixed scale is preferred
(2) if numerical increase is typically related to some other natural interpretation, it is easier to interpret a straight-line or thermometer scale with a moving pointer

Quantitative Visual Displays

(3) Normally, do not mix types of pointer-scale indicators when they are used for related functions
(4) If manual control over the moving element is expected, there is less ambiguity between the direction of motion of the control and the display if the control moves the pointer rather than the scale
(5) If slight, variable movements or changes in quantity are important to the observer, these will be more apparent if a moving pointer is used

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Visual Displays of Dynamic Information

### Basic Features of Quantitative Displays

- **Scale Range** -- the numerical difference between the highest and lowest values on the scale
- **Numbered interval** -- the numerical difference between adjacent numbers on the scale
- **Graduation interval** -- the numerical difference between the smallest scale markers
- **Scale unit** -- smallest unit to which the scale is to be read

### Specific Features of Conventional Quantitative Display

1. **Numeric Progressions of Scales**
2. **Length of Scale Unit**
3. **Design of Scale Markers**
4. **Scale Markers and Interpolation**
5. **Design of Pointers**
6. **Combining Scale Features**
7. **Scale Size and Viewing Distance** -- Normally 28 inches

### Specific Features of Electronic Quantitative Displays

Design of Altimeters

triggered by the numerous instances which aircraft accidents had been attributed to misreading of an earlier altimeter model.

many studies on the “best” -- integrated display -- figure 5-7

### Object Displays

Compatibility of Proximity Principle

Information about several variables is used for decision making

Tasks requiring mental integration of information will benefit from close display proximity

Tasks requiring focus of attention on individual displays will be harmed by proximity

Emergent Features

combining dimensions into a perceptual object

### Object Displays or Configural Displays

such displays are polygonal in shape, the number of sides determined by values of multiple variables
Visuals Displays of Dynamic Information

Quantitative Visual Displays
Guidelines:
1. The choice of the type of display must be predicted on a thorough understanding of the nature of the task.
2. Object displays should be considered when integration of information is required.
3. The design of object displays may prove to be as much of a creative process as a systematic science.
4. The display configuration should be tested with subjects representative of the ultimate users under task conditions likely to be experienced in the real world.

Qualitative Visual Displays

In using these displays, the user is primarily interested in the approximate value of some continuously changeable variable, or in its trend, or rate of change.

Quantitative Basis for Qualitative Reading
1. For determining the status or condition of the variable in terms of each of a limited number of predetermined ranges.
2. For maintaining some desirable range of approximate values.
3. For observing trends, rates of change.

Design of Qualitative Scales

Average reading time, s

<table>
<thead>
<tr>
<th>Type of Scales</th>
<th>Qualitative</th>
<th>Quantitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-window</td>
<td>115</td>
<td>102</td>
</tr>
<tr>
<td>Circular</td>
<td>107</td>
<td>113</td>
</tr>
<tr>
<td>Vertical</td>
<td>101</td>
<td>118</td>
</tr>
</tbody>
</table>

Check Reading

-- the use of instrument to ascertain whether the reading is normal.
-- If several check readings are used together in panels, their configuration should be such that any deviant reading stands out from the others.

Status Indicators

-- Sometimes qualitative information indicates the status of a system or a component.
-- Most common used status indicators are lights, such as traffic lights.

Signal and Warning Lights

Various Purposes:
indicators of warning, identification of aircraft at night, navigation aids and beacons to attract attention.

Detectability of Signal and Warning Lights
Size, Luminance, and Exposure Time
Color of Lights
Flash Rate of Lights
3-10 per Second

Recommendations Regarding Signal and Warning Lights
1. When should they be used?
   To warn of an actual or a potential dangerous condition.
2. How many warning lights?
   Ordinarily only one.
3. Steady state or flashing?
   When representing an occasional emergency or new conditions.
   When representing a continuous, ongoing condition.
Signal and Warning Lights

(4) Flash Rate: 3-10 per second
(5) Warning-light intensity: the light should be at least twice as bright as the immediate background
(6) Location: the warning light should be within 30 degrees of the operator’s normal line of sight
(7) Color: warning lights are normally red
(8) Size: warning lights should subtend at least 1 degree of visual angle

Reprensentational Displays

Most of these displays that depict changeable conditions consist of elements that tend to change positions or configuration superimposed on a background

Zones of Interest -- situational awareness
Multiple zones of interest in situations

AirCraft Bank Angle Displays

Moving Aircraft
Moving Horizon

Principles of Aircraft-Position Displays

(1) Principle of pictorial realism
(2) Principle of integration
(3) Principle of compatible motion
(4) Principle of pursuit presentation

Humans naturally use visual cues to perceive their motion through the environment
These cues of direct perception (optical invariants) represent properties of light rays that reach the eye, and have an unchanging relationship to the location and heading of the observer

Representational Displays – Optical Invariants

1. Compression
Change in compression of a textured surface signals a change in altitude and viewing orientation

2. Splay
Parallel receding lines, providing depth cue of linear perspective, will signal a change in altitude given by the angle between them

3. Optical flow
Velocity of points traveling across the display surface (and therefore, the retina) as we move through the world

4. Global optical flow
Rate of flow of optical texture past the observer as determined by both the observer’s velocity over ground and by the height above the ground

Heads-Up Displays (HUD’s)

HUD -- a display in which information is superimposed on the outside world via a windscreen or helmet visor
HUD’s use
Collimated images that are optically focused at infinity