King Saud University

College of Engineering

IE – 341: "Human Factors Engineering"

Spring – 2024 (2nd Sem. 1445H)

Visual Displays of Dynamic Information (Chapter 5) – part 2: Qualitative Visual Displays

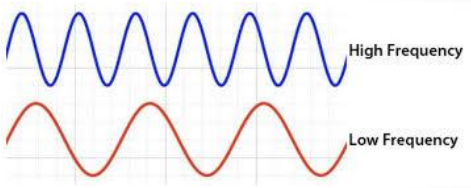
Prepared by: Ahmed M. El-Sherbeeny, PhD

Lesson Overview

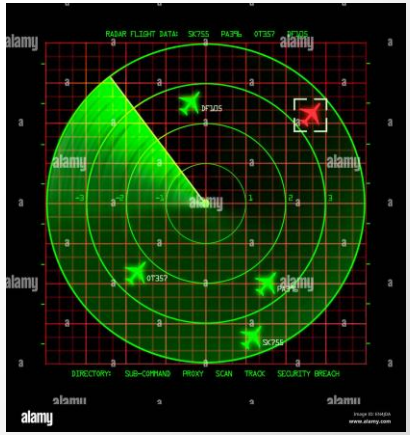
- Uses of Dynamic Information
- Quantitative Visual Displays (part 1)
- Qualitative Visual Displays (part 2)

Uses of Dynamic Information

- Dynamic information: i.e. changing info; e.g:
  - natural phenomena (e.g. temperature, pressure)
  - vehicle speed
  - traffic lights
  - frequency, intensity of sounds, etc.



- Dynamic displays:
  - displays used to display dynamic information
  - types of dynamic displays, type of info. presented:
    - **Quantitative**: precise numeric value of some variable (e.g. "pressure is 80 psi")
    - **Qualitative**: approximate value/rate of change/change in direction (e.g. "pressure is increasing")
    - **Status**/check: determines if readings are normal (e.g. "pressure is normal")
    - **Representational**: situation awareness; e.g. radar display predicts where plane will be in 5 or 10 minutes

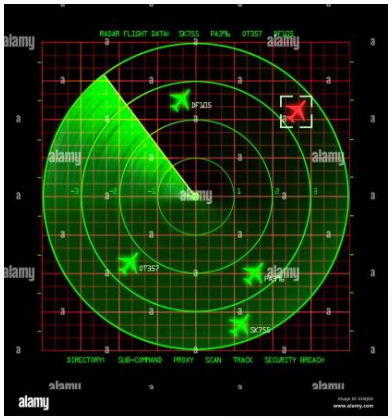


Qualitative Visual Displays

Qualitative Visual Displays

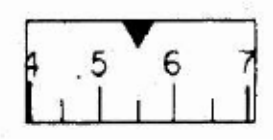
- Objective of displays used for qualitative info:
  - approximate value of continuously changing variable
    - e.g. pressure, temperature, speed, etc.
  - rate of change/change in direction of variable

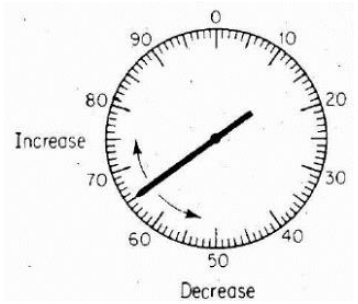
- **Quantitative** basis for **Qualitative** Reading
  1. determining **status**/condition of variable in terms of specific predetermined range(s)
     - e.g. gauge of engine: cold, normal, or hot
  2. maintain a desirable **range** of approximate values
     - e.g. speed range between 50-55 mph (80-88 km/h)
  3. observing **trends**/rates of change
     - e.g. airplane ascending or descending; or N, S, E, W



Cont. Qualitative Visual Displays

- Cont. **Quant.** Basis of **Qualitative** Reading
  - note, scales best applicable for quantitative task are not necessarily best applicable for qualitative task, and vice versa (below)
  - can you analyze table below (experiment: *Elkin, 1959*)?





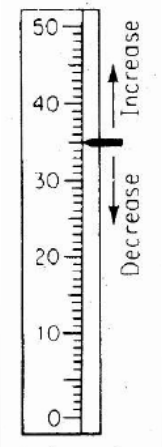


TABLE 5-1
TIMES FOR QUALITATIVE AND QUANTITATIVE READINGS WITH THREE TYPES OF SCALES

	Average reading time, s	
Type of scale	**Qualitative**	**Quantitative**
Open-window	115	102
Circular	107	113
Vertical	101	118

Cont. Qualitative Visual Displays

Design of Qualitative Scales

- Values: sliced into limited number of ranges
- Coding for ranges/readings on qualitative scales:
  1. **color** codes for ranges (right)
  2. **shape** coding for specific ranges of values
     - advise: take advantage of natural compatible associations people have between coding features and intended meanings

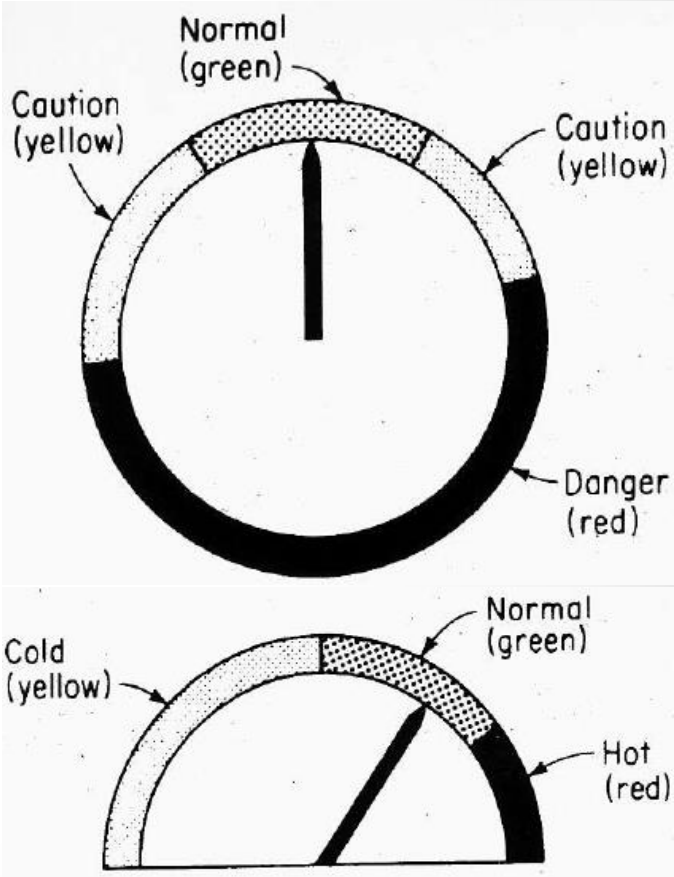


FIGURE 5-10
Illustration of color coding of sections of instruments that are to be read qualitatively.

Cont. Qualitative Visual Displays

Cont. Design of Qualitative Scales

2. Cont. **Shape** coding
   - experiment conducted (*Sabeh, 1958*):
     - purpose: determine best association between shapes and meaning of different military plane readings
     - 140 subjects
     - 7 shapes vs. 7 meanings
     - %ge correct responses shown in ( )

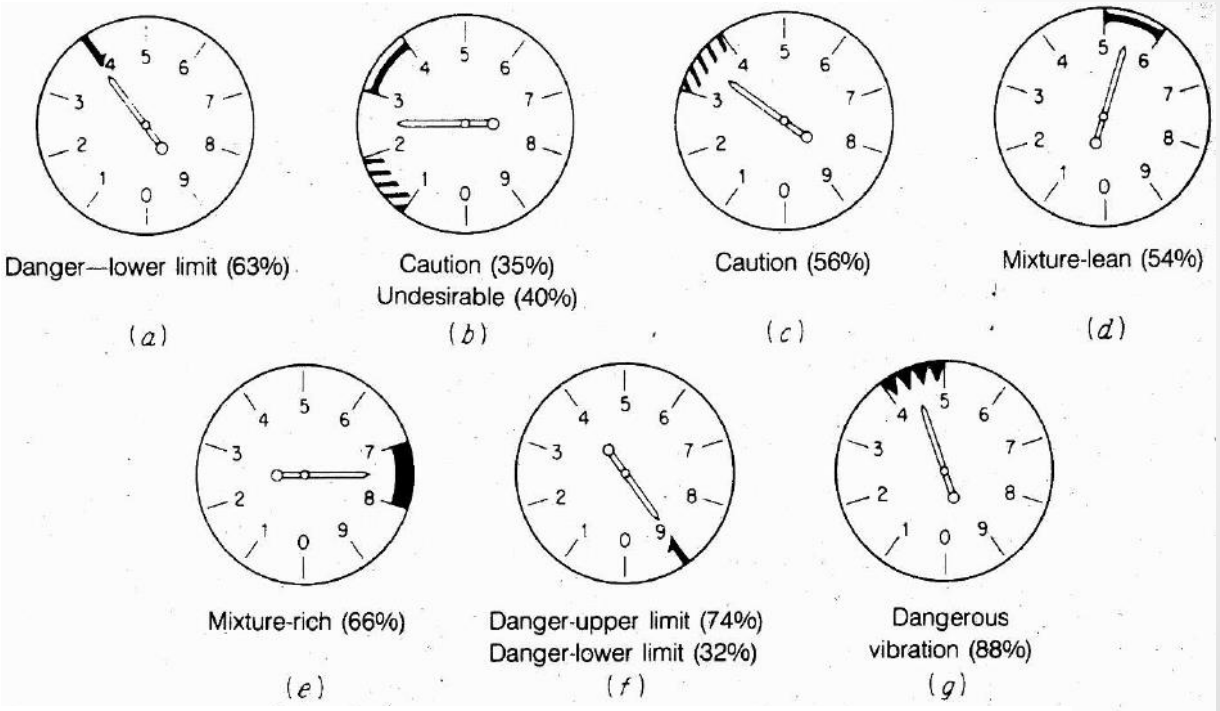


FIGURE 5-11
Association of coded zone markings with the intended meanings of specific scale values of military aircraft instruments. The numbers in parentheses are the percentages of individuals (out of 140) who reported significant associations with the meanings listed. *(Adapted from Sabeh, Jorve, and Vanderplas, 1958.)*

Cont. Qualitative Visual Displays

Cont. Design of Qualitative Scales

- Use of strictly Quantitative displays:
  - involves identifying quantitative value, and
  - involves assigning value read to one of possible ranges of values that represent the categories

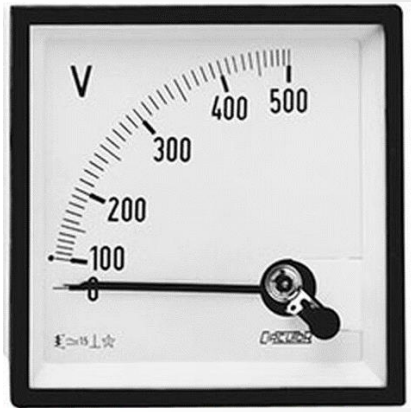
- Use of strictly Qualitative displays
  - directly conveys meaning of display indicator

- Use of Quantitative + Qualitative displays
  - indicate trend, direction, rate of change (i.e. qualitative)
  - indicate also: quantitative reading (if values included)
  - examples:
    - last slide
    - car speed gauge
      (numbers + indication at 120 km/h)
    - other examples?

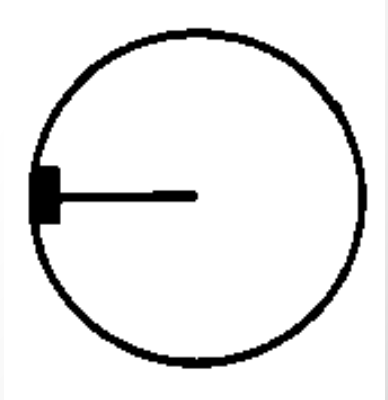
Cont. Qualitative Visual Displays

Check Reading

- instrument that checks if reading is normal
- this is achieved using quantitative scale
- normal condition is represented by an exact or very narrow values (not range)
  - e.g. to determine if voltage is ~110V or ~220V



- requires caution to display normal reading clearly
- research suggests normal reading should be aligned (for circular scales) at:
  - 9 o'clock position (see right)
  - 12 o'clock position (also acceptable)



Cont. Qualitative Visual Displays

Cont. Check Reading

- when several check reading devices used ⇒ deviant device should stand out (see below)
- "gestalt": human tendency to perceive complex configuration as complete entity
  - ⇒ odd entity becomes immediately clear
  - e.g. below: lines between dials adds to "gestalt"
  - lower configuration also acceptable (less clear)

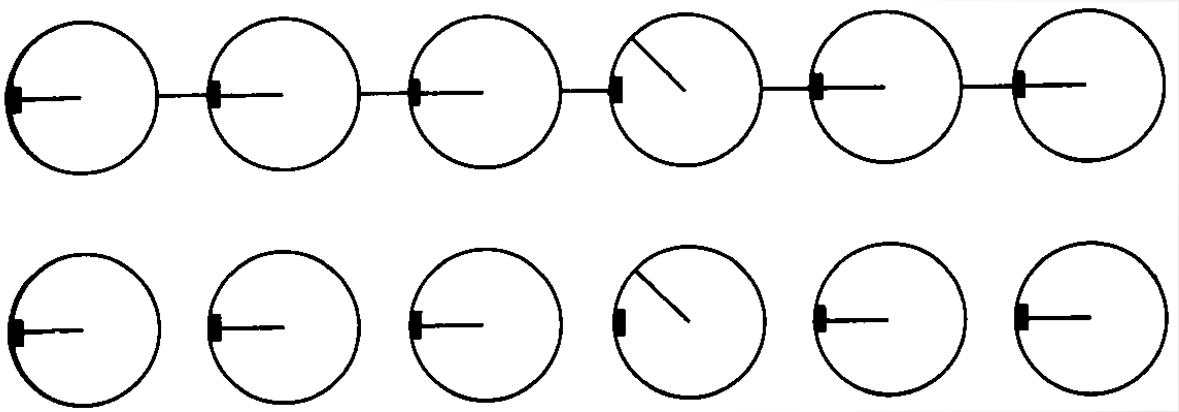
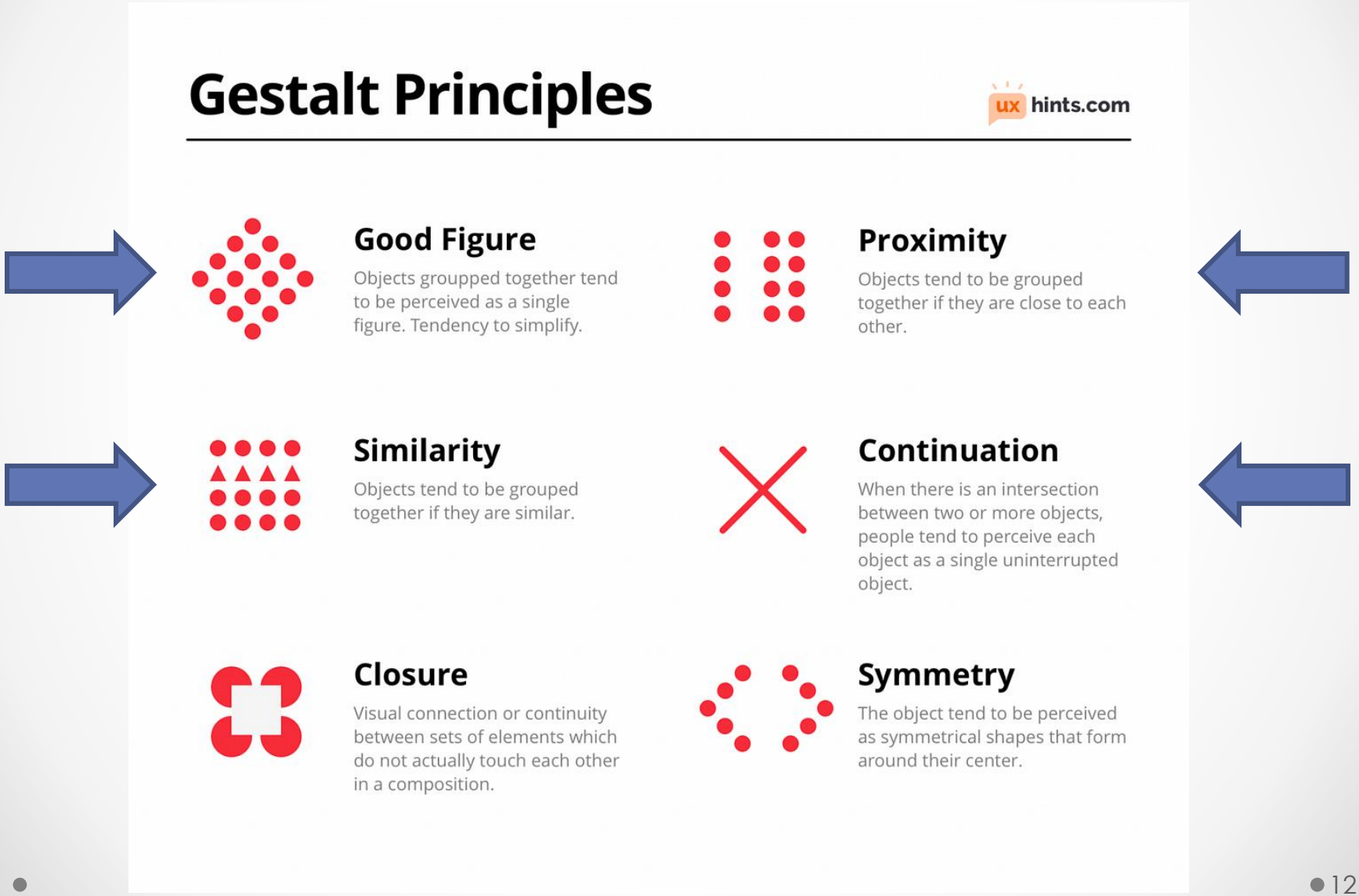


FIGURE 5-12
A panel of dials used for check reading. When all the "normal" readings are aligned at the 9 o'clock (or 12 o'clock) position, any deviant reading can be perceived at a glance. In some instances an extended line is shown between the dials, as illustrated in the top row; this can aid in making the deviant dial more distinct.

Cont. Qualitative Visual Displays

Cont. Check Reading



Cont. Qualitative Visual Displays

Status Indicators

- Qualitative info. can indicate status of system
  - e.g. check reading: normal or abnormal
  - e.g. automobile thermometer: cold/normal/hot

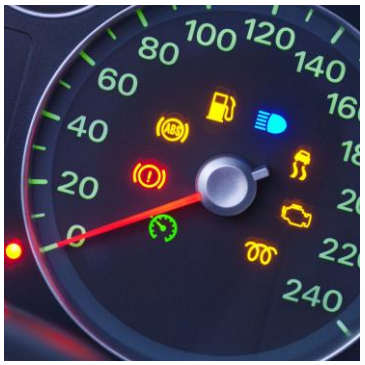
- status indicators: show –only– *separate, discrete* conditions (compare to check reading)
  - e.g. on/off
  - e.g. traffic lights: stop/caution/go

- Note, scales that show only check reading can be converted to status indicators
- Common uses:
  - light indicators (varying color, position)
    - e.g. traffic lights:
      red (top), yellow (middle), green (bot.)
  - also used with stove controls (on/off)

Cont. Qualitative Visual Displays

Signal and Warning Lights

- Flashing/steady state lights used for:
  - warning (e.g. highways)
  - identification (e.g. aircrafts at night)
  - navigation aids, beacons
  - attracting attention (e.g. on instrument panel)



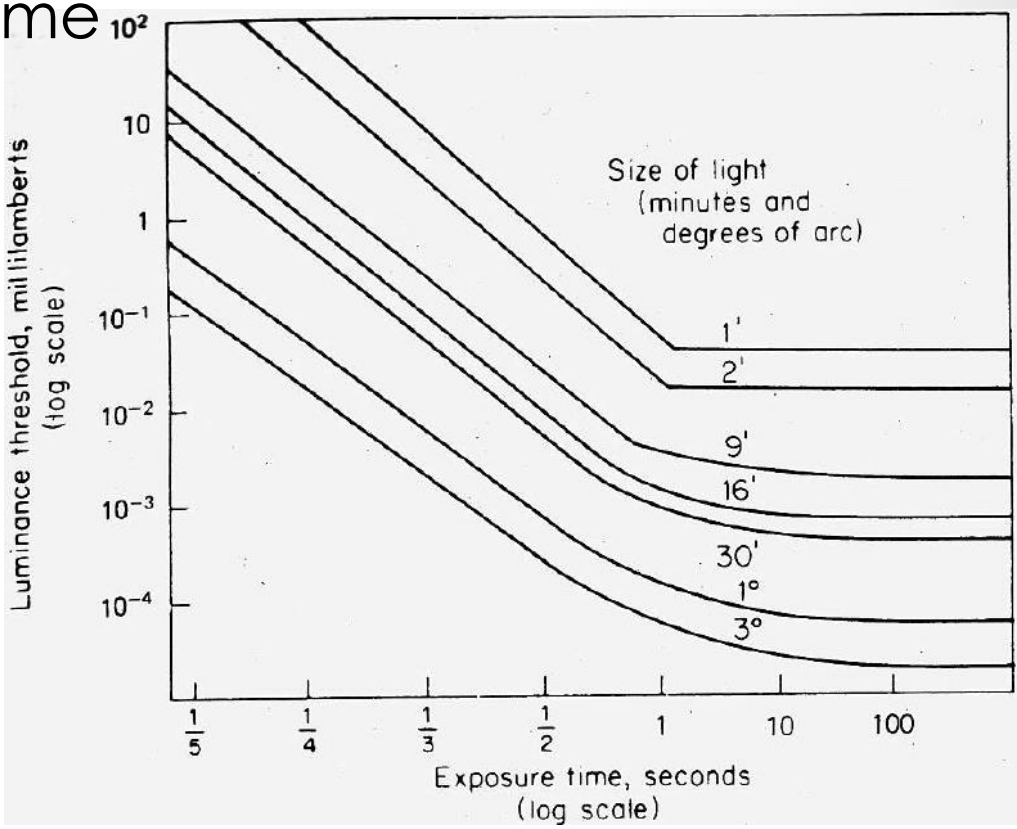
- Factors affecting detectability of lights:
  1. size, luminance, and exposure time
  2. color of lights
  3. flash rate of lights

Cont. Qualitative Visual Displays

Cont. Signal and Warning Lights

1. Size, Luminance, and Exposure Time

- Detecting flashing light depends on combin[on]: size, luminance, exposure time
  - as size of light ↑ and/or as exposure time ↑ ⇒ luminance required to just detect light ↓
  - "just detect": can be detected 50% of the time (i.e. **luminance threshold**)
  - for operational use:
    - luminance should be at least double these to be detected 99% of the time



FIGURE

Minimum sizes of lights (in minutes and degrees of arc) that can be detected 50 percent of the time under varying combinations of exposure time and luminance. *(Source: Adapted from Teichner and Krebs, 1972.)*

Cont. Qualitative Visual Displays

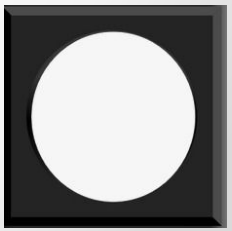
Cont. Signal and Warning Lights

2. Color of Lights

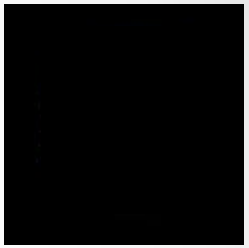
- background color + ambient illumination ⇒
  - influence ability of people to detect and respond to lights of different colors

- With good signal brightness contrast + dark background:
  - color has minimal importance in attracting attention

- With low signal-to-background brightness contrast:
  - red signal is recommended,
  - followed by green, yellow, and white



Cont. Qualitative Visual Displays



Cont. Signal and Warning Lights

3. Flash Rate of Lights

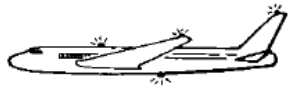
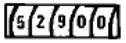
- flash rate should be « 30 times/sec
- ≥ 30 ⇒ light appears steady ⇒ "flicker-fusion"
- recommended to attract attention:
  - flash rates of about 3-10 per second (4 is best)
  - duration of at least 0.05 s
  - lights should subtend at least 1° of visual angle

- recommended for highways and flyways, use:
  - 60-120 flashes per minute (i.e. 1-2 flashes per second)

- varying flashing lights
  - mostly: single/fixed flashing light used
  - some applications: lights with different flash rates
    - e.g. tail lights showing rate of deceleration: car brakes
    - keep in mind: humans can differentiate -maximum of- **three** different flash rates clearly (*remember: JND ?*)

Summary

GENERAL GUIDE TO VISUAL DISPLAY SELECTION

To display	Select	Because	Example
Go, no go, start, stop, on, off	Light	Normally easy to tell if it is on or off.	
Identification	Light	Easy to see (may be coded by spacing, color, location, or flashing rate; may also have label for panel applications).	
Warning or caution	Light	Attracts attention and can be seen at great distance if bright enough (may flash intermittently to increase conspicuity).	
Verbal instruction (operating sequence)	Enunciator light	Simple "action instruction" reduces time required for decision making.	
Exact quantity	Digital counter	Only one number can be seen, thus reducing chance of reading error.	
Approximate quantity	Moving pointer against fixed scale	General position of pointer gives rapid clue to the quantity plus relative rate of change.	
Set-in quantity	Moving pointer against fixed scale	Natural relationship between control and display motions.	

References

- ***Human Factors in Engineering and Design***. Mark S. Sanders, Ernest J. McCormick. 7th Ed. McGraw: New York, 1993. ISBN: 0-07-112826-3.