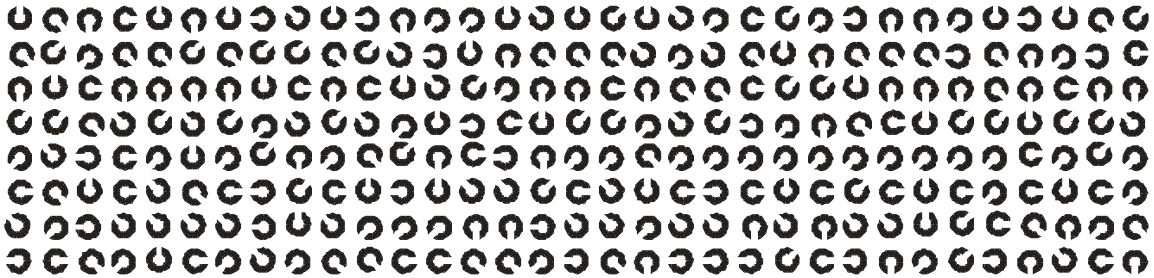
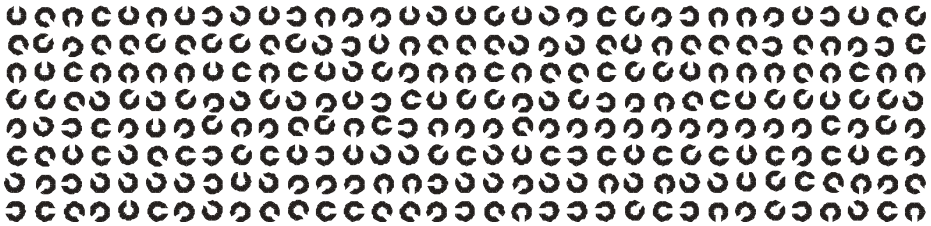
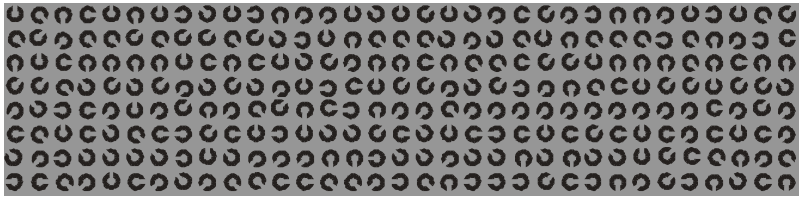
Visual Performance





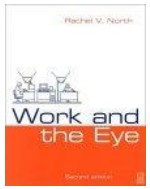


Outline

- **Introduction**
- **Task Visibility**
  - **Others from Cognitive Neuroscience, Optometry, etc.**
- **Visual Performance**
  - **Weston experiment**
  - **CIE model**
- **Discussion**
  - **Supplementary reading and learning**
  - **Free activity no. 2**

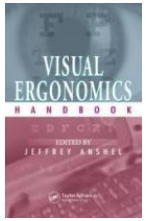
Bibliography & Links

- **Basic:**



- **NORTH, R.V.: *Work and the Eye*, 2nd ed., Oxford: Butterworth-Heinemann, 2001.**

- **CIE – International Commission on Illumination. Divisions no. 2, 3 and 5.**



- **ANSHEL, J.: *Visual Ergonomics Handbook*. Boca Raton: CRC Press, 2005.**

- **Papers from Optometry and Vision Science, Ergonomics, etc.**

Introduction

- **Ability for doing the most of visual tasks depends on many variables, both visual and not**

- **Main factors related to visual performance in work:**
  - **Visual capability of each user (Lesson 1)**
  - **Task visibility (Lesson 2)**
  - **Psycho-sociologic factors (out our scope)**
    - **Motivation, general health, comprehension, stress, etc.**

coordination adaptation

- **What and how is measured visual performance?**
  - **Lesson 2**

Task Visibility

- **The relationship of external factors doing easy the performance of the visual task**
  - **If visibility V ↑ ⇒ visual performance (VP) ↑**

- **Factor list:**
  - **Size 5s**
  - **Viewing distance: d**
  - **Illuminance level: E (lx) or L (cd/m^2)**
    - **Glare index: G**
  - **Lighting contrast: C**
  - **Color: L*a*b*C*h***
  - **Time available for looking at the task: t**
  - **Movement: v**
  - **Environmental conditions: temperature, humidity, etc.**

Is V = f(5s, d, E, C, t, v, …)
a well-defined equation or model? NO

Task Visibility

- **Easy example using visual function at threshold level:**
  - **Reduce task visibility till a threshold value and link after the reduced quantity with a visibility measure**
  - **Effect of veiling luminance on contrast**

$$V = \frac{C}{C_{threshold}}$$

$$C = \left| \frac{L_{TEST} - L_{BACKGROUND}}{L_{BACKGROUND}} \right|$$

$$iF \; \exists \, L_{VEILING} = \frac{\rho_{DISPLAY} \cdot E_{INFLUX}}{\pi} > 0$$

$$\Rightarrow L'_{BACKGROUND} = L_{BACKGROUND} + L_{VEILING}$$

$$\Rightarrow L'_{TEST} = L_{TEST} + L_{VEILING}$$

$$\Rightarrow C' = \left| \frac{L'_{TEST} - L'_{BACKGROUND}}{L'_{BACKGROUND}} \right| = \left| \frac{L_{TEST} - L_{BACKGROUND}}{L_{BACKGROUND} + L_{VEILING}} \right| < C$$

$$\Rightarrow V' < V$$

- **Numerical simulation.**
- **Current technology applications? Mobile displays?**

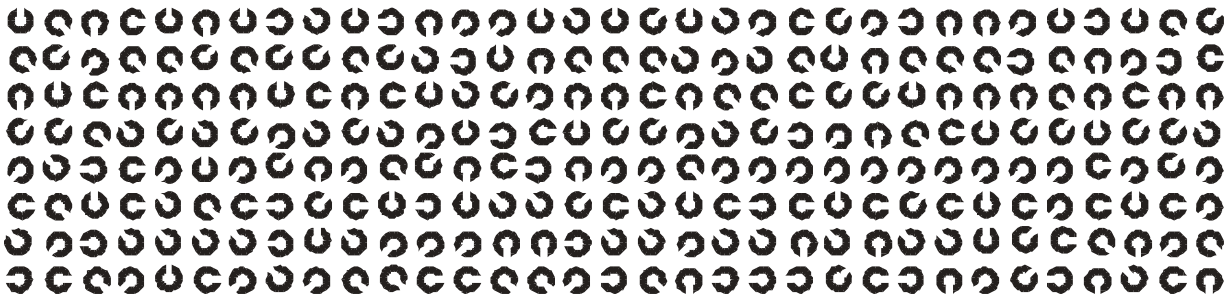
Visual Performance

- What and how is measured?
- It depends on task and visual functions involved
  - Performance speed
  - Accuracy of task → no. errors (efficiency)
- Visual Performance VP ∝ {speed, accuracy}
- How task visibility factors influence on visual performance?
  - Strategy: fix all variables except one
    - Illuminance level is the easiest option
    - And then combine one by one

Visual Performance

- **Weston experiment (1945, UK)**

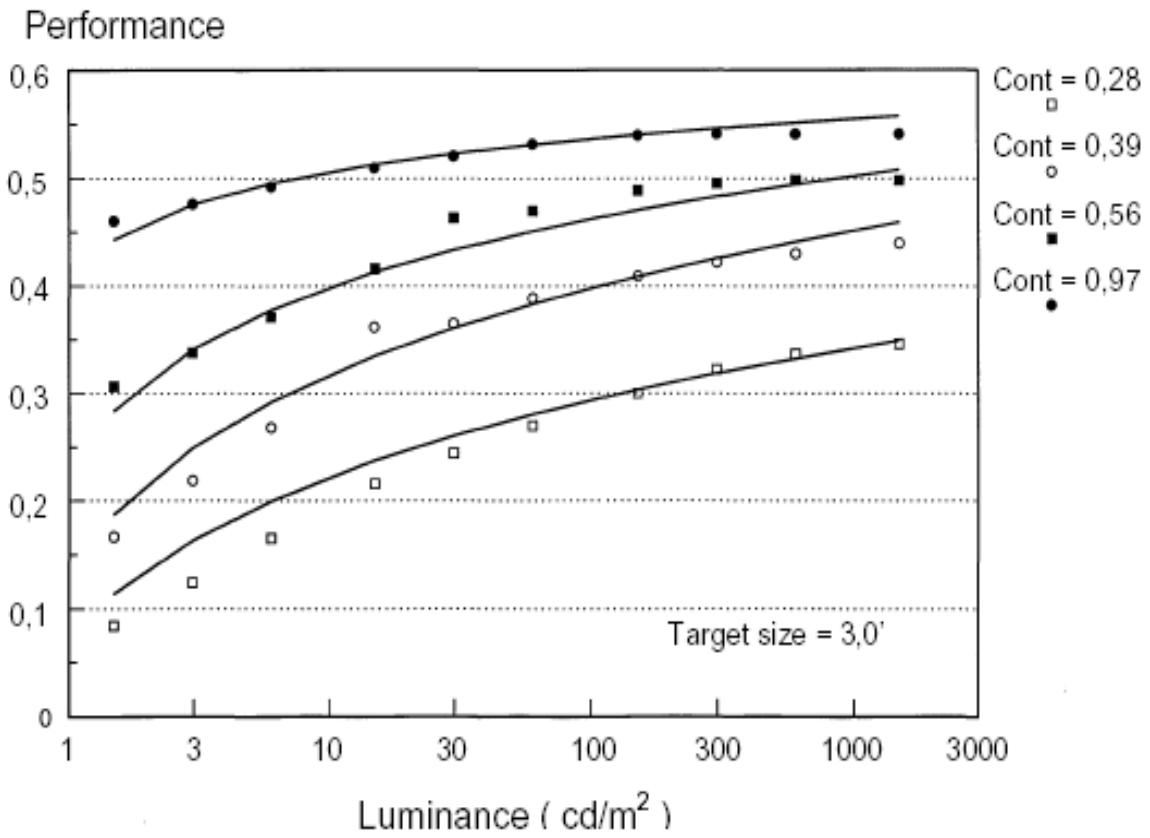
- **Aim: evaluate the lighting effects in a visual search task at automatic rate**
  - **Instruction:**
    - **Mark at minimum possible time Landolt rings with specific orientation**



    - **Task was done varying illuminance level (E), contrast (C) and size (5s) of optotypes**

Visual Performance

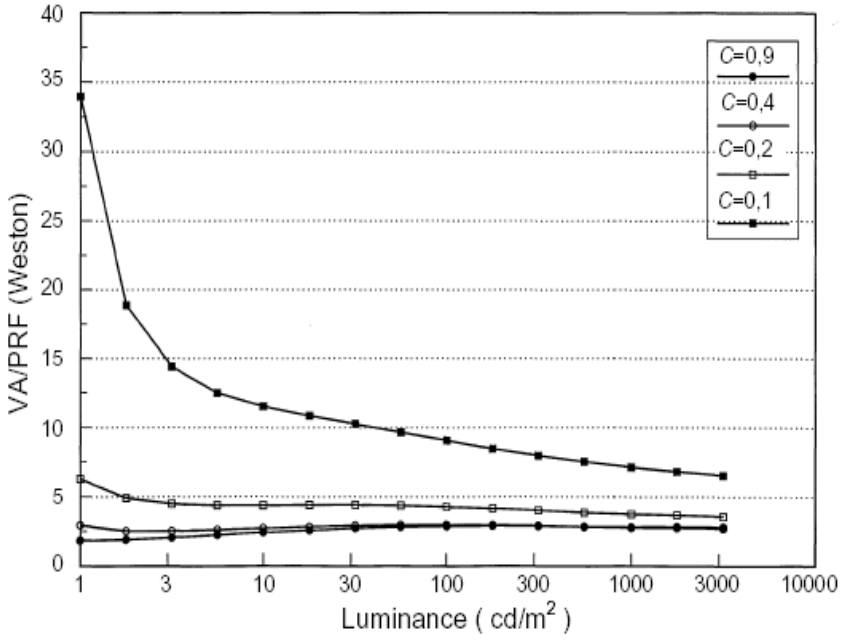
- **Results from Weston experiment:**
  - **VP vs. L (cd/m²)**
    - **C free**
    - **5s fixed**



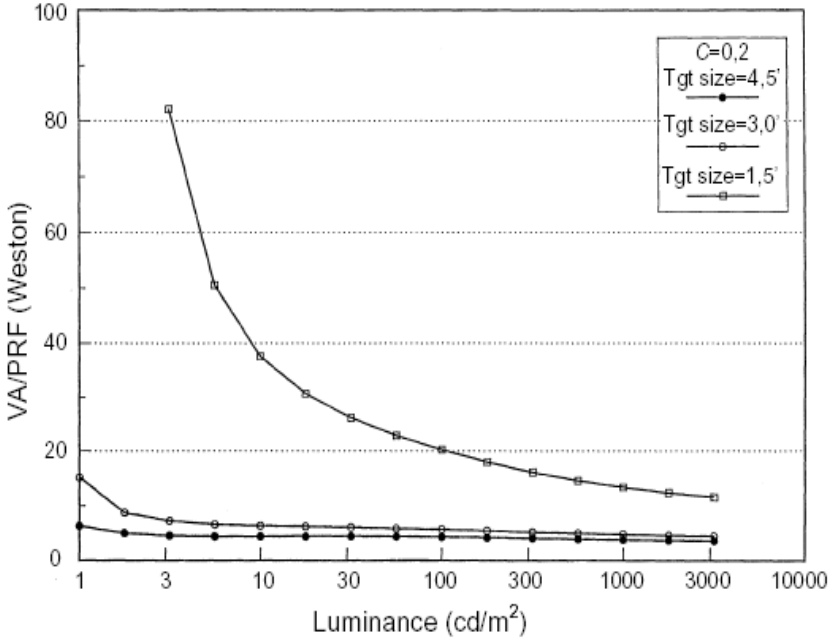
Visual Performance

- **Results from Weston experiment: VA vs. VP**

VA / VP vs. L (C free, 5s fixed)



VA / VP vs. L (5s free, C fixed)



Visual Performance

- **Analysis and conclusion from Weston experiment:**
  - **If E ↑ ⇒ VP ↑ , but if ∃ G ⇒ VP ↓**
  - **VP maximum and different for some configurations (5s, C)**
    - **If 5s ↓ and C ↓ ⇒ VP maximum if si E ↑**
  - **It is more efficient to have VP ↑ to increase 5s ↑ y C ↑ than E ↑**

- **Conclusions:**
  - **Greater difficult visual task, greater profitable illuminance level**
    - **Checklist of visual job analysis**
    - **International standard for recommended illuminance levels for all visual tasks**

Visual Performance

- **Checklist of visual job analysis:**

Checklist of Visual Job Analysis

1. Job description (including qualifications relative to type of training and skills) with standard code number.
2. Distance or distances (distance for acuity and/or near acuity) in inches or feet from eyes of worker to point of operation, fixed or changing.
3. Motion of work (distance and near muscle balance): slow or rapid rotation, vertical or horizontal, fixed or intermittent.
4. Size of central working area, depth perception factors (stereopsis).
5. Type of visual attention required: fixed or changing, casual or concentrated, detailed or gross (or listed as perfect, average or defective permissible; or as class A, B, or C).
6. Colors to be perceived and discriminated.
7. Foot candles of illumination at workpoint, as well as in surrounding area. Direction of light (note any harmful shadows). Reflected or direct glares (to be eliminated if possible). Brightness ratios (avoid sharp contrasts).
8. Color of light source and work area (functional painting, etc.).
9. Type of working surface: glossy or non-glossy, slightly or grossly uneven. Angle of working surface. Position of work in relation to normal level of eyes, viz., does worker have to look down, ahead, or upward (determine whether bifocals are permissible or a handicap).
10. Eye hazards: flying objects, particles of dusts, fumes, splashing chemicals, or molten metal; airborne matter; radiation, etc.
11. Type of eye protection required.

Visual Performance

- **Recommended illuminance levels (general format):**

Orientation and simple visual tasks. Visual performance is largely unimportant. These tasks are found in public spaces where reading and visual inspection are only occasionally performed. Higher levels are recommended for tasks where visual performance is occasionally important.

A	Public spaces	30 lx (3 fc)
B	Simple orientation for short visits	50 lx (5 fc)
C	Working spaces where simple visual tasks are performed	100 lx (10 fc)

Common visual tasks. Visual performance is important. These tasks are found in commercial, industrial and residential applications. Recommended illuminance levels differ because of the characteristics of the visual task being illuminated. Higher levels are recommended for visual tasks with critical elements of low contrast or small size.

D	Performance of visual tasks of high contrast and large size	300 lx (30 fc)
E	Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lx (50 fc)
F	Performance of visual tasks of low contrast and small size	1000 lx (100 fc)

Special visual tasks. Visual performance is of critical importance. These tasks are very specialized, including those with very small or very low contrast critical elements. Recommended illuminance levels should be achieved with supplementary task lighting. Higher recommended levels are often achieved by moving the light source closer to the task.

G	Performance of visual tasks near threshold	3000 to 10,000 lx (300 to 1000 fc)

* Expected accuracy in illuminance calculations are given in Chapter 9, Lighting Calculations. To account for both uncertainty in photometric measurements and uncertainty in space reflections, measured illuminances should be with ± 10% of the recommended value. It should be noted, however, that the final illuminance may deviate from these recommended values due to other lighting design criteria.

Visual Performance

- **CIE modelling (CIE 145:2002) of Weston data:**
  - **VP = Accuracy * Speed**
  - **High contrast (C > 0.35) and visual sizes $\alpha \geq 1.5$ min**

$$VP = 1.728\, AV_{rel}(N) \cdot \left[0.5384\,(\alpha - 1.499)^{X} \cdot (\log L_{fondo} + 0.09196)^{Y} \cdot (C - 0.2534)^{Z}\right]$$

$$X = 0.1194 \cdot (\log L_{fondo} + 1.923)^{0.08403} \cdot (C + 1.516)^{-0.6549}$$

$$Y = 0.8135 \cdot (\alpha - 1.182)^{-0.7831} \cdot (C + 1.054)^{-3.062}$$

$$Z = 0.5745 \cdot (\log L_{fondo} + 0.2669)^{-0.3902} \cdot (\alpha - 0.8302)^{-0.7637}$$

  - **Low contrast (C < 0.35) and visual sizes $\alpha \geq 1.5$ min**

$$VP = 1.728\, AV_{rel}(N) \cdot \left[0.6577\,(\alpha - 1.4999)^{X} \cdot (\log L_{fondo} + 0.035)^{Y} \cdot (C - 0.08521)^{Z}\right]$$

$$X = 0.082 \cdot (\log L_{fondo} + 0.11339)^{-0.6378755} \cdot (C + 0.02243)^{-0.23}$$

$$Y = 0.1452 \cdot (\alpha - 0.00041)^{-0.18451} \cdot (C - 0.099)^{0.1168}$$

$$Z = 1.291 \cdot (\log L_{fondo} + 0.264)^{-0.38675} \cdot (\alpha - 0.218)^{0.523}$$

Supplementary reading and learning

- **CIE 145:2002: “The correlation of models for vision and visual performance” .**
  - **Read this table**
  - **Evaluate its usability**
  - **Why it is interesting?**
  - **Applicability level??**

Target size = 3,0′ Age = 65

Target contrast	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9
Performance levels	Required luminance level cd / m^2								
0,01	1,5	AC	AC	AC	AC	AC	AC	AC	AC
0,1	224	1,8	AC	AC	AC	AC	AC	AC	AC
0,15	NA	4,1	1,4	AC	AC	AC	AC	AC	AC
0,2	NA	11,2	2,3	1,1	AC	AC	AC	AC	AC
0,25	NA	42	4,4	1,6	1,0	AC	AC	AC	AC
0,3	NA	234	10	2,3	1,3	AC	AC	AC	AC
0,35	NA	NA	30	4,1	1,9	1,2	AC	AC	AC
0,4	NA	NA	129	8,3	3,2	1,7	1,2	AC	AC
0,42	NA	NA	257	12,0	4,1	2,0	1,3	AC	AC
0,44	NA	NA	562	17,8	5,5	2,5	1,6	1,1	
0,46	NA	NA	NA	28	7,8	3,3	1,8	1,2	
0,48	NA	NA	NA	44	11,2	4,4	2,3	1,5	1,0
0,5	NA	NA	NA	76	17,4	6,3	3,0	1,7	1,2
0,52	NA	NA	NA	135	28	9,6	4,1	2,1	1,3
0,54	NA	NA	NA	257	49	15,5	6,0	3,0	1,6
0,56	NA	NA	NA	525	93	27	10	4,3	2,1
0,58	NA	NA	NA	NA	191	51	17,8	6,8	3,2
0,6	NA	NA	NA	NA	427	112	35	12,6	4,9
0,62	NA	NA	NA	NA	NA	275	79	27	9,6
0,64	NA	NA	NA	NA	NA	776	224	68	22
0,66	NA	NA	NA	NA	NA	NA	776	224	65
0,68	NA	NA	NA	NA	NA	NA	NA	NA	288
0,7	NA	NA	NA	NA	NA	NA	NA	NA	NA
0,9	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA - Required Performance Level is Not Achievable with these characteristics
AC - Required Performance Level is Achievable at all luminances from 1 to 1000 cd/m^2

Free activity nº 2

- **Relative Weight: 0 %**
- **Delivery process by Virt. Campus discussion: optional**
- **Individual Task:**
  - **How visual performance could be measured in some occupations or sport activities?**
    - **Example: test exam, basketball, F1, etc**
  - **Propose one, but different from the rest of examples provided for other students. Justify it.**