COLOR LAYER

black

Method, Laboratories, Case Studies: A Contextual Braid.

R.J. Mackay

R.W. Oldford

Department of Statistics and Actuarial Science
University of Waterloo

+   +

Good sense is the most evenly shared thing in the world, for each of us thinks he is so well endowed with it that even those who are hardest to please in all other respects are not in the habit of wanting more than they have.

It is unlikely that everyone is mistaken in this.

It indicates rather that the capacity to judge correctly and to distinguish the true from the false, which is properly what one calls common sense or reason, is naturally equal in all men, and consequently that the diversity of our opinions ...[springs]... from our conducting our thoughts along different lines and not examining the same things. ...those who go forward only very slowly can progress much further if they always keep to the right path, than those who run and wander off it.

René Descartes ... 1637

The one sample problem

Source: Do robust estimators work with *real* data?

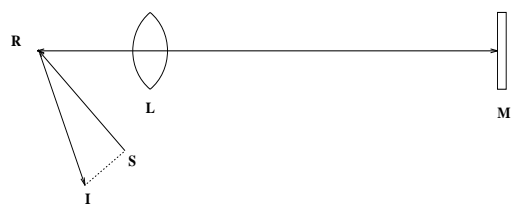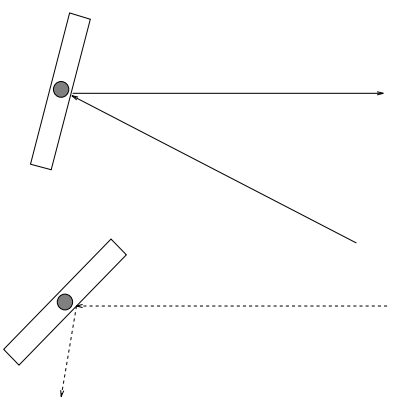Stephen M. Stigler, *Annals of Statistics* Volume 5, 1977, pp. 1055-1098.
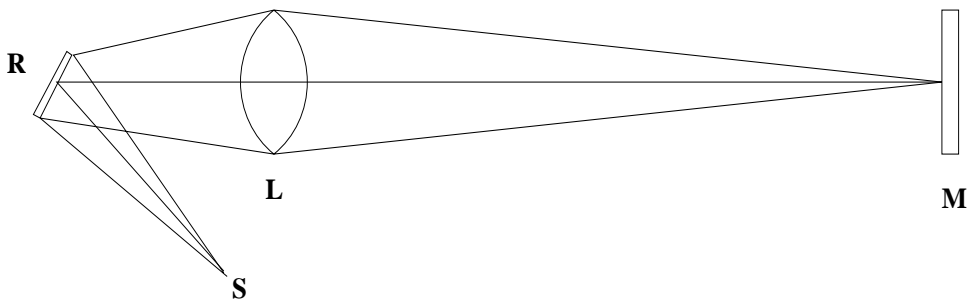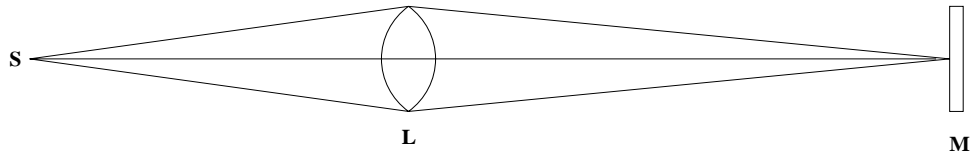
Case study: Speed of Light

to L andM
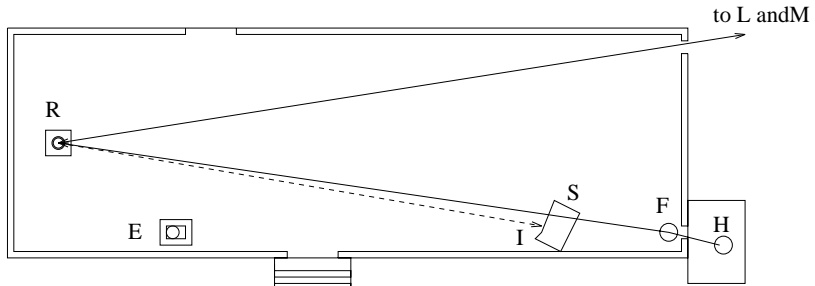
S: Slit Source   H: Heliostat
R: Rotating Mirror   F: Mirror for focusing light
I: Displaced Image   E: Electric tuning fork

Speed of Light

Material
- Light source
- Colour of light
- Transmission medium
- Fixed Mirror
- Rotating Mirror
- Lens material

Measurement
- Image displacement
- Rotation speed
- Calibrations
- Fixed to Rotating Distance |RM|
- Radius |SR|

Machine
- Heliostat
- Rotating Mirror
- Fixed Mirror
- Micrometer
- Lens
- Tuning fork
- Pump
- Electric tuning fork
- Steel measuring tape

Environment
- Temperature
- Particulant in air
- Time of day
- Humidity
- Date
- Air pressure
- Air turbulence

Person
- Eyesight
- Dexterity
- Concentration
- Training
- Judgement
- Condition
- Hearing
- Who?

Method
- Initial placement of pieces
- Fix rotation speed
- Counting sound beats
- Focus on image
- Determine distances
- Average repetitions
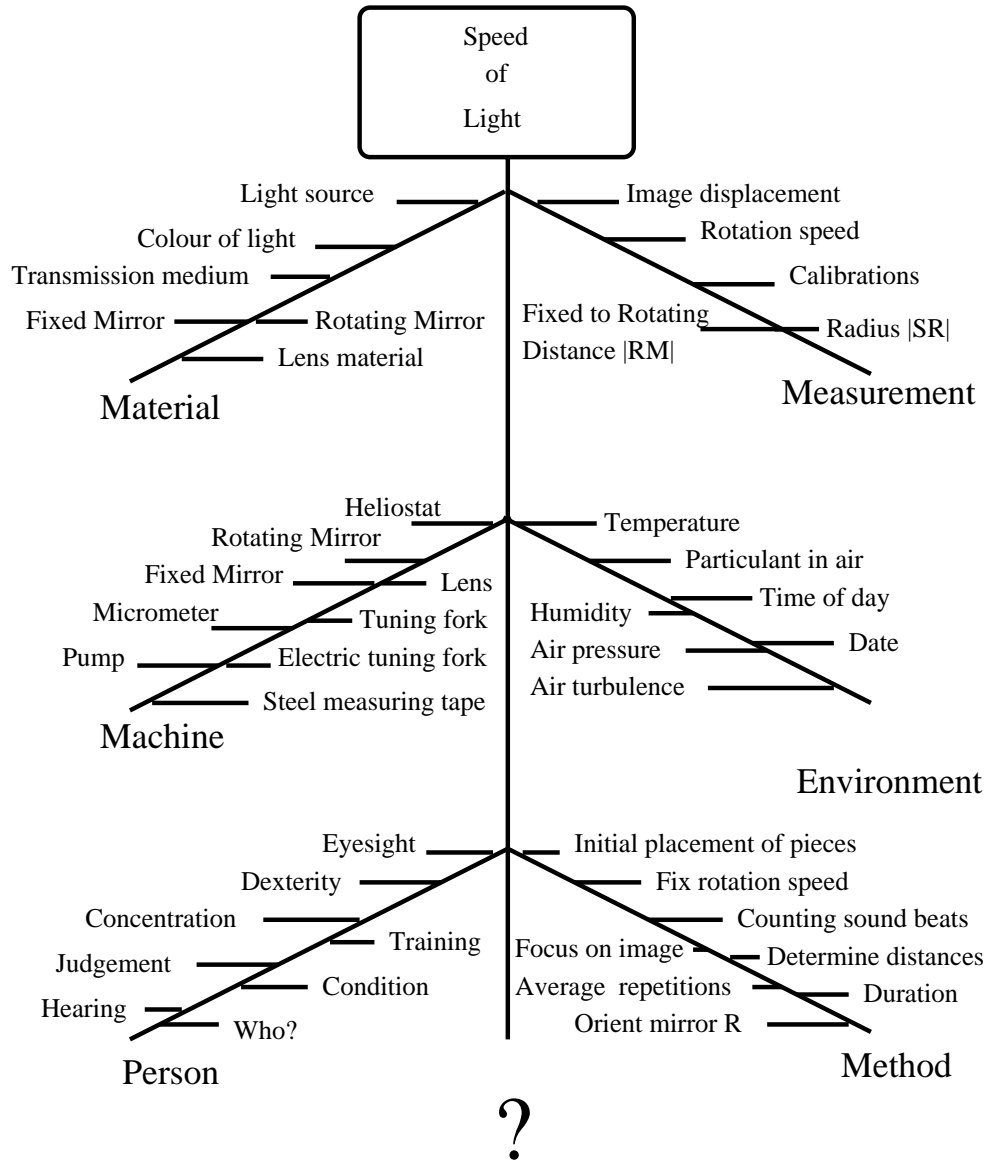- Duration
- Orient mirror R

?

Variates actually measured were:

Speed   -   Encoded speed of light in air.
                  Add 299800 to get km/sec scale.
Beat   -   Number of beats per second between forks.
Cor   -   Correction for temperature
                  to standard fork in beats per second.
Day   -   Day of experiment in progress (June 5 = 1).
Diff   -   Difference between greatest and
                  least values of revolutions.
Qual   -   Quality of the image I.
                  The more distinct it is the higher
                  the quality (3 = good, 1 = poor).
Disp   -   Displacement of image I from slit S
                  in micrometer divisions.
Image   -   Micrometer position of deflected image.
Radius   -   Radius of measurement, in feet.
Revs   -   Number of revolutions per second.
Screw   -   Value of one turn of the screw in millimetres.
Slit   -   Micrometer position of slit.
Tday   -   Time of day observation recorded
                  (AM = 1 hour after sunrise,
                  PM = 1 hour before sunset).
Temp   -   Air temperature in degrees Fahrenheit.
Remarks   -   1. Electric light.
                  2. Frame inclined at various angles.
                  3. Set micrometer and counted oscillations.
                  4. Oscillations of image of revolving mirror.
                  Probably PM.
                  5. Readings taken by Lieut. Nazro.
                  6. Readings taken by Mr. Clason.
                  7. Mirror inverted.
                  8. Mirror erect.

Analysis

$$Y_i = \mu + R_i \qquad i = 1, \ldots, 100 \ .$$

$$
\begin{aligned}
Y_i &= \text{measurement of the speed of light} \\
\mu &= E(Y_i) \\
R_i &= \text{captures the variability in the process} \\
&\quad \text{from all sources in the C \& E diagram}
\end{aligned}
$$

with $E(R_i) = 0$ and $SD(R_i) = \sigma$.

A 95% confidence interval for c:

$$299928.59 \leq c \leq 299960 \ \ .$$

Today's (1986) value $c = 299792.458$ km/s.

Testing H:$c = 299792.458$ km/s. yields

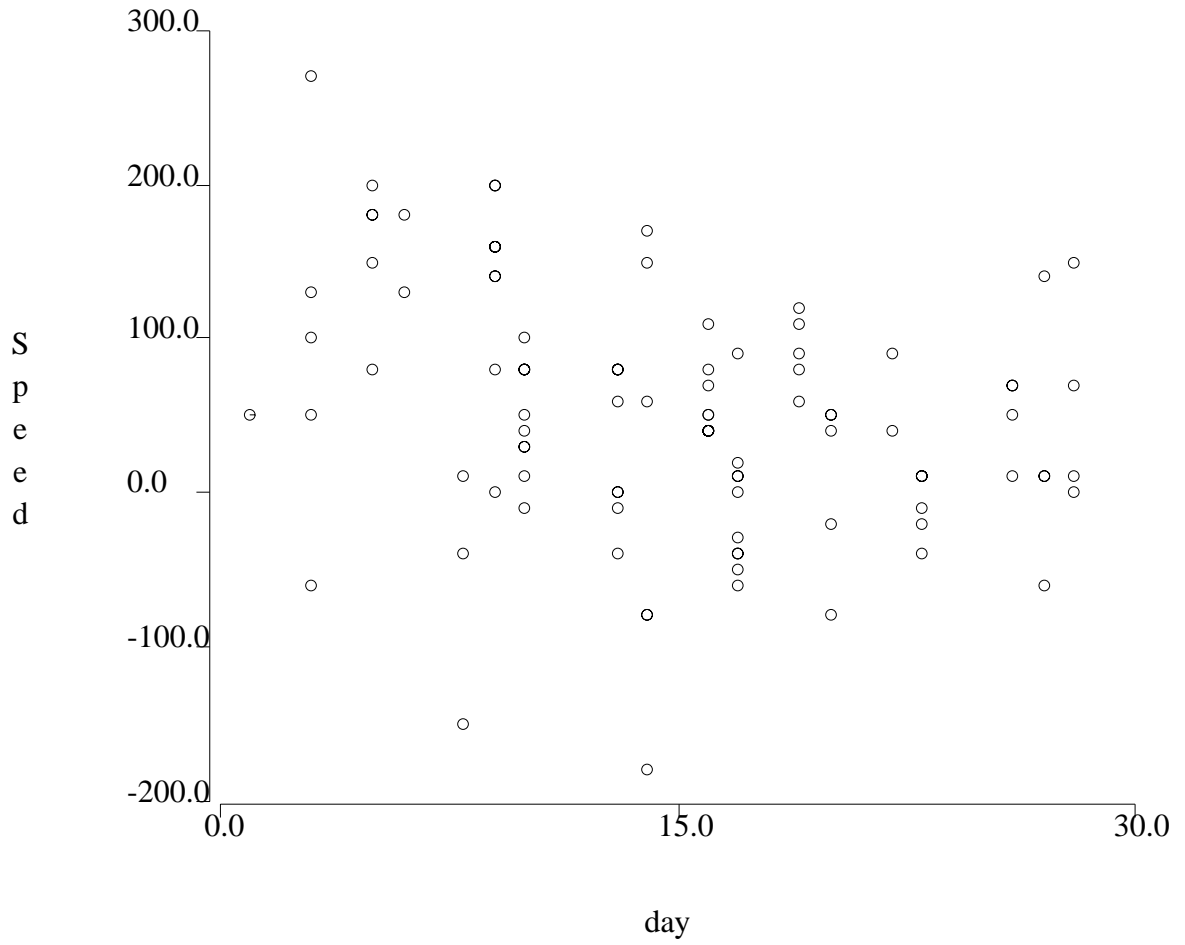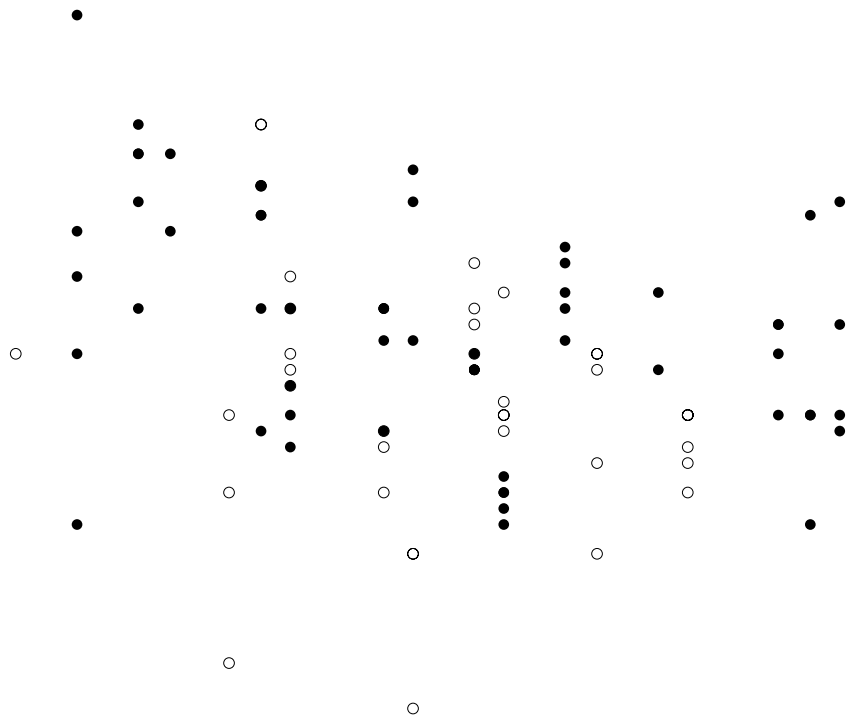$$SL = P(|t_{99}| \geq 19.20) \approx 10^{-35} \ .$$

+   +

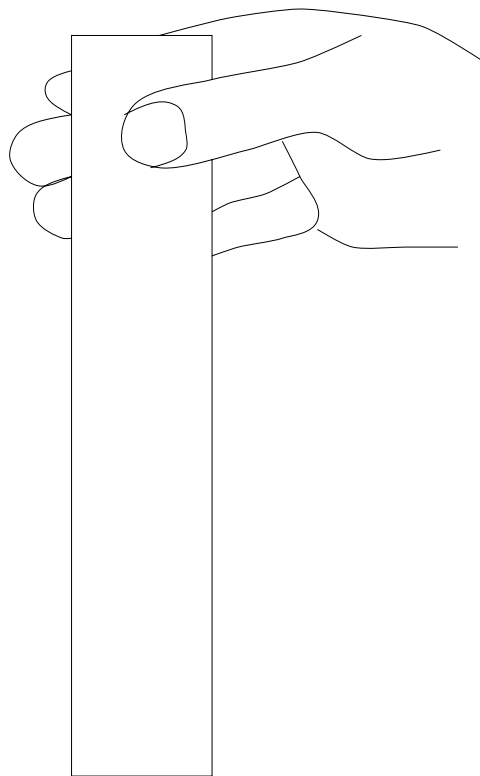Michelson's 1878 determinations of the speed of light

+   9

Laboratory: Reaction time.
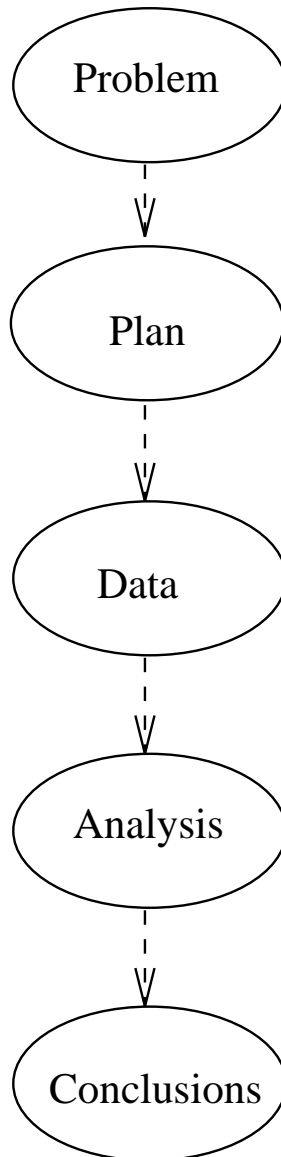
Compare highlight versus lowlight conditions

Method

```
       ┌───────────┐
       │  Problem  │
       └───────────┘
             │
             ▼
        ┌─────────┐
        │  Plan   │
        └─────────┘
             │
             ▼
        ┌─────────┐
        │  Data   │
        └─────────┘
             │
             ▼
       ┌───────────┐
       │ Analysis  │
       └───────────┘
             │
             ▼
     ┌───────────────┐
     │  Conclusions  │
     └───────────────┘
```

Understanding the Problem.

- Target Population or Process.

    – what are the units?

- Identify all variates.

    – Response variate

    – Explanatory variates

    – Cause and Effect Diagram (with ranges)

- Population/Process attributes of interest.

- Problem Aspect(s)

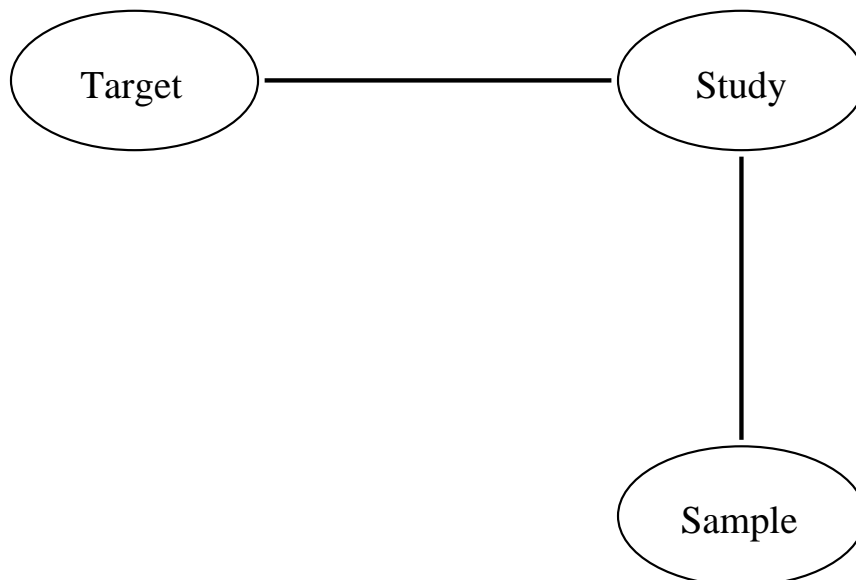   – Descriptive, Predictive, Causative

Developing a Plan.

- Study Population or Process.

- Sampling procedure

- Measurement procedure.

- Protocol.

Target —————— Study

Study | Sample

Data.

- Collect and record the data according to plan.

- Record departures from the plan.

- Error checking and data editing procedures.

- Data storage and accessibility.

Analysis.

- Graphical and tabular methods.

- Numerical methods.

- Keep it simple.

- Criticism.

Conclusions.

- Address the problem statement.

- Limitations of present study.

- Recommendations.

Matters orthogonal.

- Rôle of models.

- Establishing causal relations.

- Multiple studies.

Empirical problem solving.

- Teach method first and always.

- Language is critical.

- Complete context *always* given.

- Incomplete PPDAC given.

- Iterate.

Conclusions.

- Strategy not details.

- It works!

- It's hard.

- Care.

Balance

Men who are given to defining too much inevitably run themselves into confusion on the vague concepts of common sense.

Charles Sanders Peirce ... *circa* 1906

…those who go forward only very slowly can progress much further if they always keep to the right path, than those who run and wander off it.

René Descartes ... 1637

COLOR LAYER

blue

This is the root file for the SSC Banff talk on teaching.