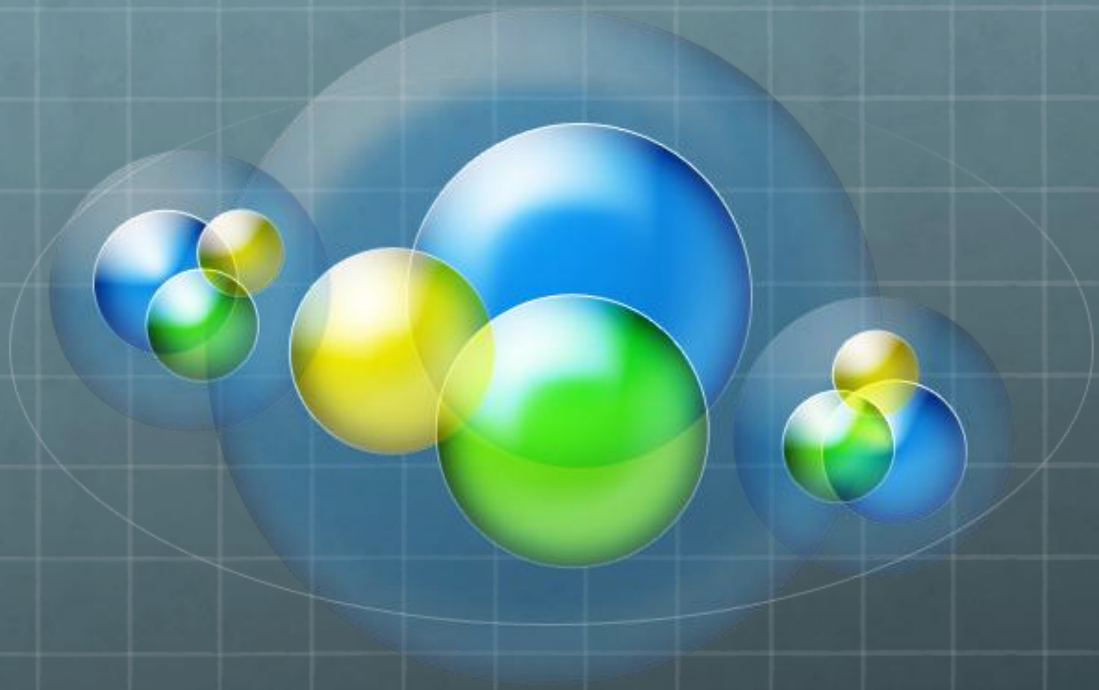

UNDERSTANDING THE WORLD THROUGH A GENERAL THEORY OF OBSERVATION

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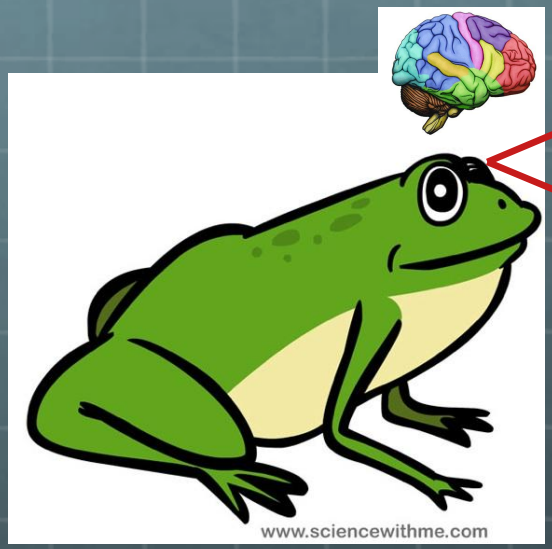
The problem

How did the human physiological and psychophysical performance limitations affect the classical physical measurement systems, and what is the observer theory behind them?

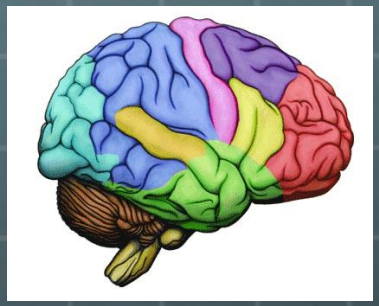
The Amazing Story of Measurement
(Lufkin Rule company, 1949)

The grounding question:
Should modern-day physics be interested in the general theory of observation?

Physicist frog with a human brain: "What the frog's eye tells the human brain?"



Derivative eyes
- sees only moving objects
- nonlinear retina



What kind of world physics would the brain construct from the derivative signals?

Lettvin, Maturana, McCoullogh & Pitts (1968) "What the frog's eye tells the frog's brain?"

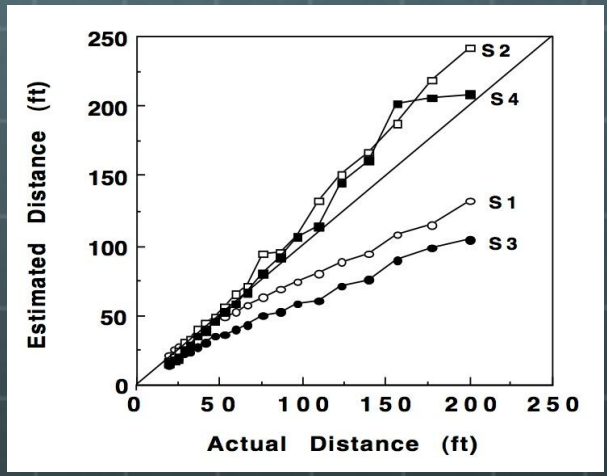
"The response is not affected if the lighting changes or if the background (say a picture of grass and flowers) is moving, and is not there if only the background, moving or still, is in the field. Could one better describe a system for detecting an accessible bug?"

Human errors in absolute and difference perception

dS/S roughly:

Length 2%
Weight 2%

Objective distance estimation



NASA Ames Research Center

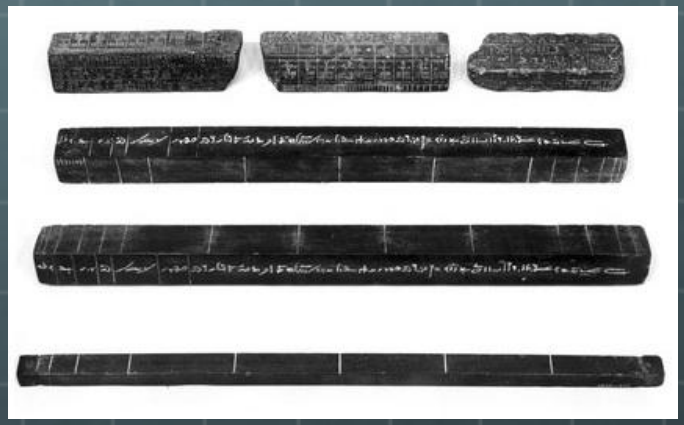
25% - 30% error

-> Measurement systems were originally designed e.g. so that that they minimized the psychophysical magnitude estimation errors and relied on the low dS/S values, especially in vision.

What has guided the construction of measurement systems?

Measurement of length

The Royal Cubit (Egypt appr 2700 B.C): 523 to 529 mm (forearm length)



http://www.ssplprints.com/image/94051/egyptian-cubit-rods-2600-bc-1st-century-ad

4600 years later in Finland

From my grandfather's father, Evijärvi

Arm, palm, finger –based measures

What has guided the construction of measurement systems?

Measurement of time

Sun clocks were used as early as 3500 BC in Egypt, then water clocks. at around 1500 BC, also in China:

"A series of containers that leak water into each other, regulated by precision holes, valves and other machinery. "

cf. Needham, Joseph et al.(1959) *Science and Civilization in China.*

Waterclock: time calculations
600-500 BC (Babylon)

Form Yuan Dynasty
(1271-1368 China)

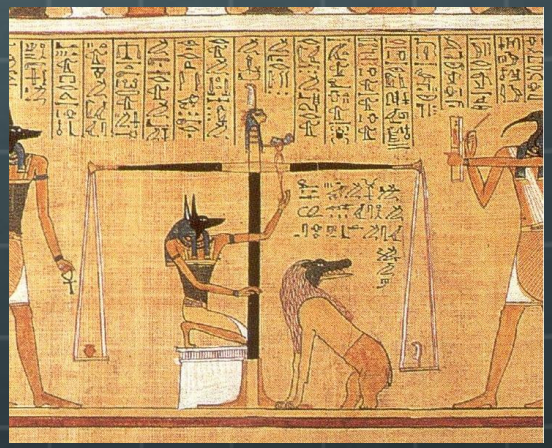
Human drivers in the construction of measurement systems

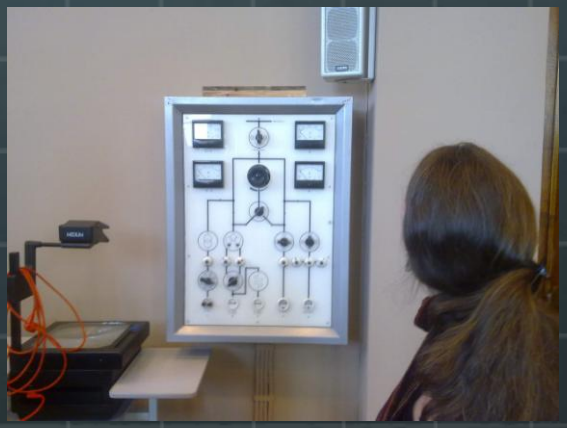
Everyday sensory (visual) performance beliefs

Cost/benefit analysis of methods and procedures

Construction elements for a practical world view – length, time, mass

Religion and philosophy





Ways of compensating for sensory deficiencies in measurements

1. *Sensory amplification* within a sensory domain (vision):
- measurement sticks, pointers, counters, mediums,

2. *Perceptual transformation* from one sensory domain to another
- Chinese volume 'sound standards'
- listening to neural spikes
- cloud chambers
- magnetic and electronic recording systems

3. *Multi-modal combination* of sensory domain information
- Newton in measuring the speed of sound
- Hipparcos satellite/relative 3D imaging

Accuracy

Newton and the speed of sound: vision and audition in synchrony

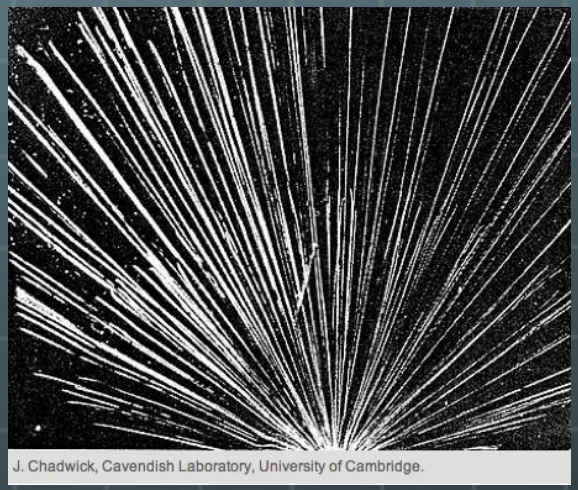
Wikimedia Commons

Newton made a 15% error in estimating the speed of sound by using a pendulum and timing the echo sound with the pendulum's position

Visualization

“Seeing” particles

Alpha particles
(e.g. helium nucleus)

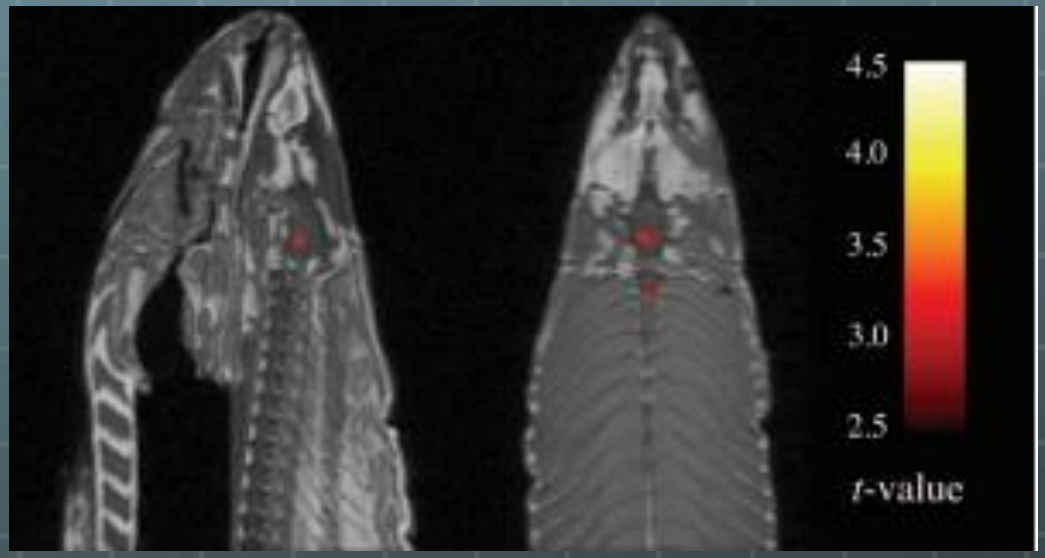


http://www.nuffieldfoundation.org/practical-physics/display-cloud-chamber-photographs

Simulated collision,
“The God particle”)

Higgs boson cannot be directly observed , but is inferred from other observations and standard model predictions.

“Seeing” the brain



Visualizing activities: centers in the dead fish (salmon) brain!
http://prefrontal.org/files/posters/Bennett-Salmon-2009.jpg

“ … demonstrates the dangers of not correcting for chance properly.” (Bennett et al., 2009)

Sense-based world view: vision as the critical sense

Vision as the dominant ‘trusted sense’

Basic physical measures relied on visually verifiable aspects of the human body parts (length) and celestial objects (time) as standards.

Measurement system (length, time) were constructed to minimize visual observation errors.

Mathematical tools were then built on these standards.

Human sensory constraints are implicit in the mathematical formulation of physics problems.

Sense-based world view: lack of observation theory

Observation theory behind these solutions has remained ill-defined or it has not existed at all. It is also lacking from modern physics.

It is not known how the implicit observation theory has affected modern physical theories.

When paradoxes occur in physical theories, consideration of observation theory can become relevant (?)

Building blocks of a general theory of observation

1. An observer is any system that interacts with the environment.

2. An observation is a change in the relationship between the observer and the environment. The relationship can only be defined by a reference system that is external to the observer.

3. All observers suffer from the capacity limitation of the "sensory channels" that interact with the environment.

4. Capacity limitation introduces an inverse problem:
in a natural world, it is not possible to compute the complete state/space of the source without additional information.

5. Observation theory and the theory of the observer determine the means by which optimum approximate information can be collected from the source states and their state space (cf. Bennett & Hoffman, 1989)

6. Observation theory makes it possible to describe what type of knowledge the observer can collect and how it is constrained.

Thank you