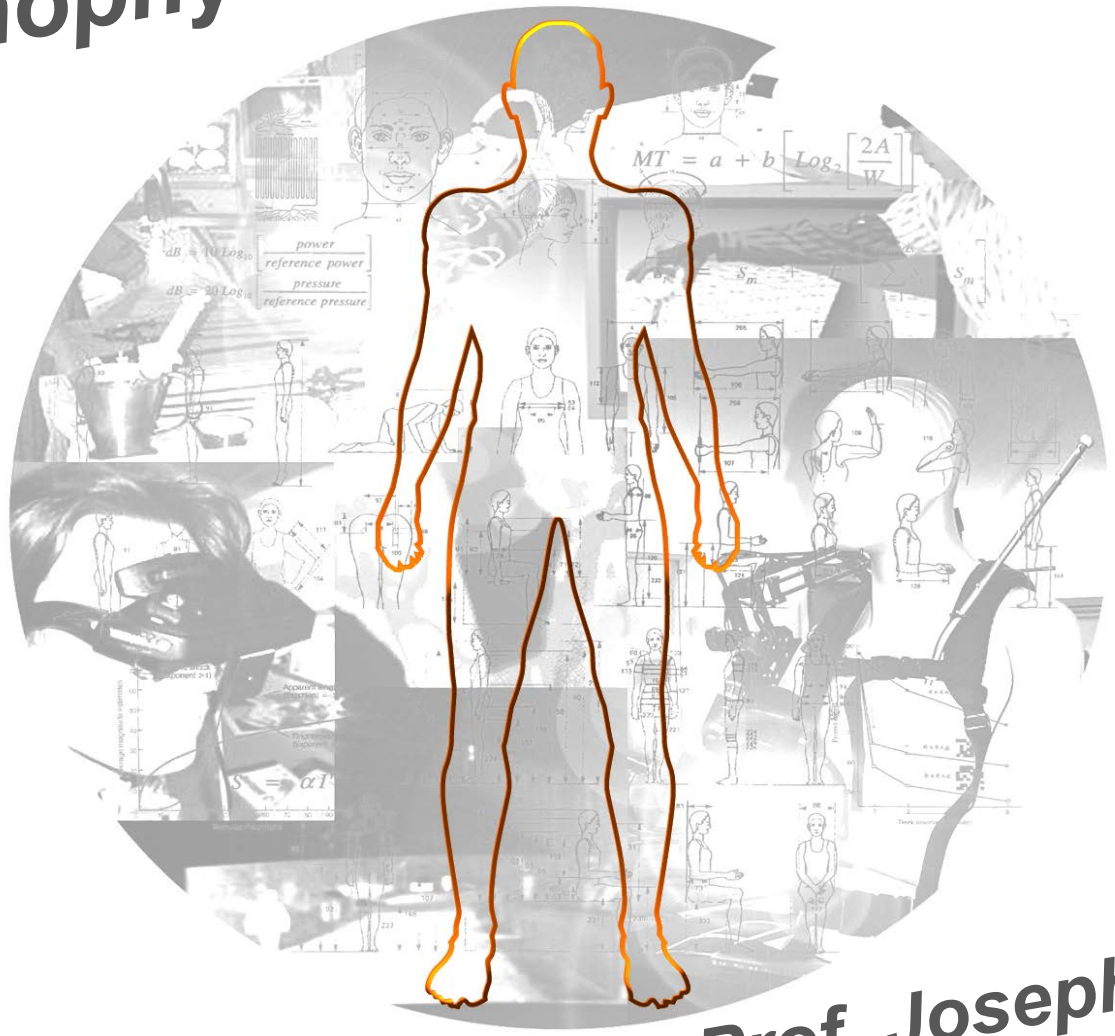
# Psychophysics




Prof. Joseph Giacomin

***Sensation*** **is the conscious experience associated with an environmental stimulus. It is the acquisition of raw information by the body's sense organs**

***Perception*** **is the conscious experience of things and of the relationships between things. It is a more processed form of sensory information which already contains some simplifications and intentionality.**


***Cognition*** **is the process of focussing attention, connecting, incorporating, reasoning, knowing, learning and remembering.**

# Psychophysics

**Psychophysics is the study of the functional relationships between the physical properties of stimuli and the human psychological responses to them.**

# Perception Threshold

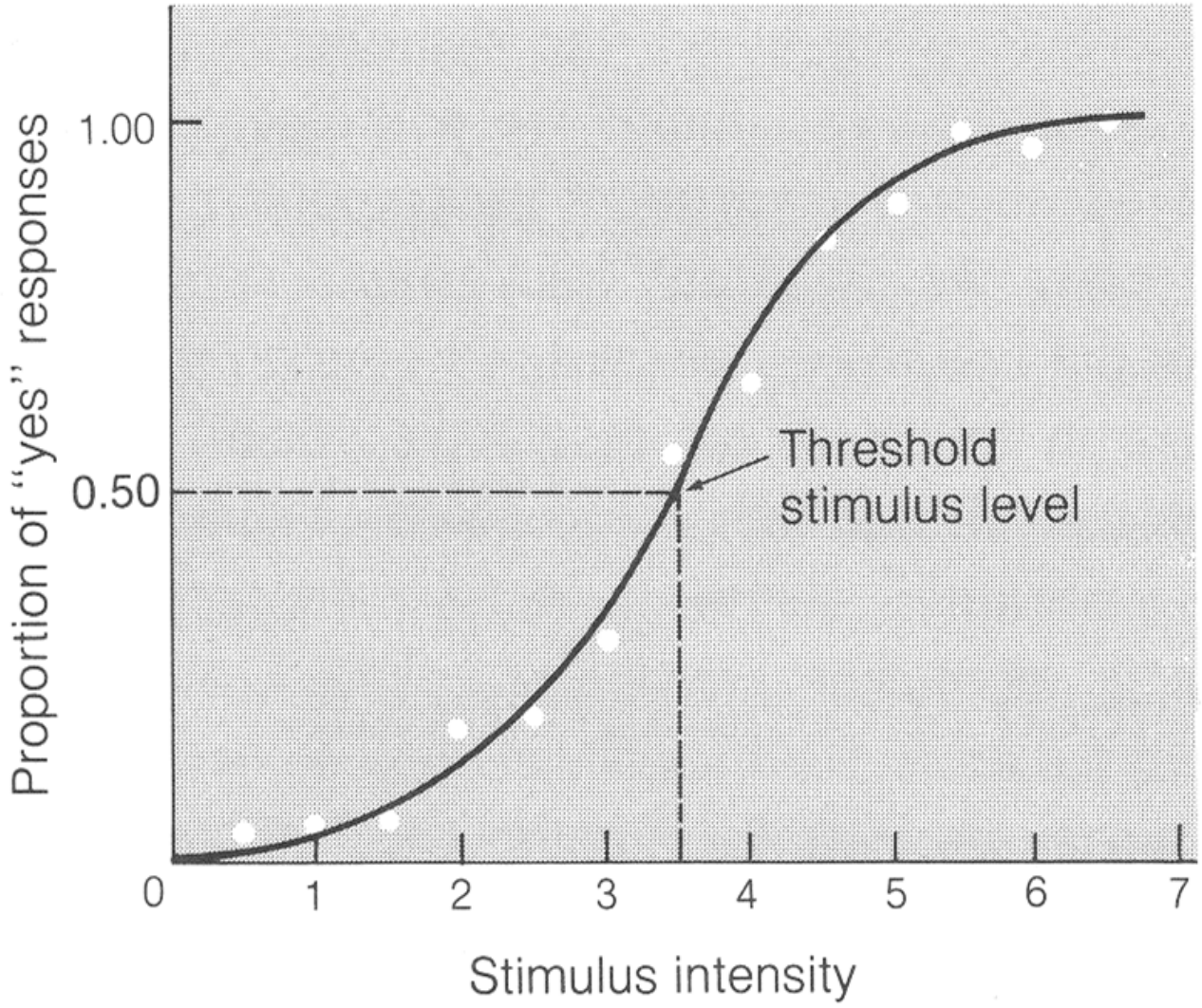
**The *perception threshold* is defined as the minimum quantity of energy required for a person to detect a stimulus.**

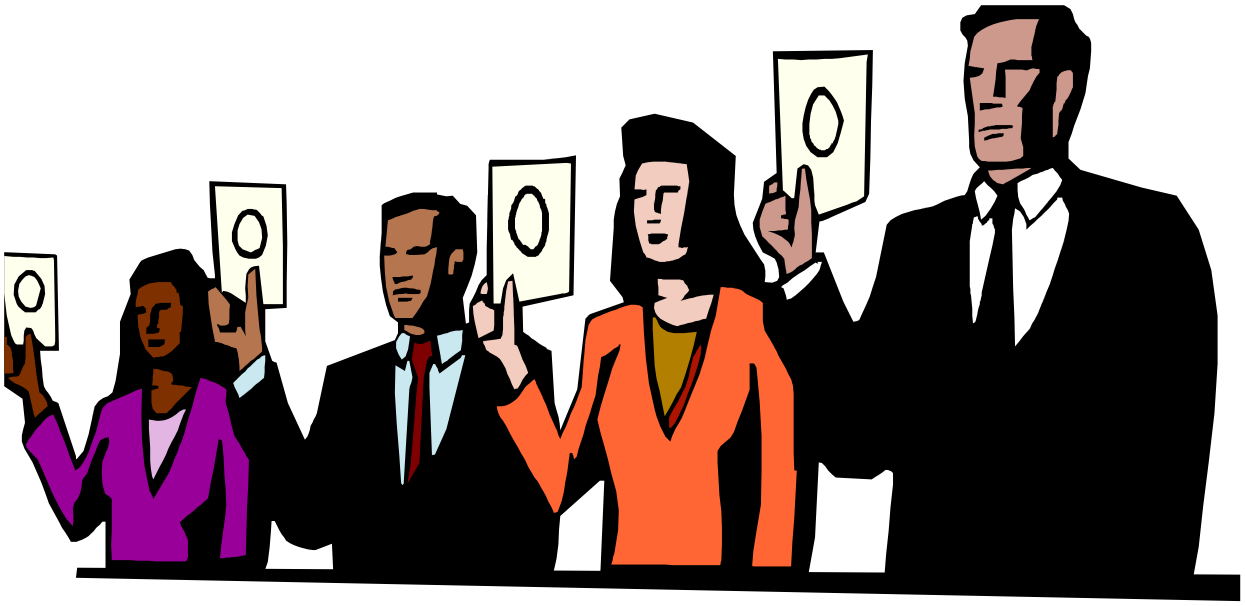
**In 1860 Fechner defined a threshold stimulus as one that “lifted the sensation or sensory difference over the threshold of consciousness”.**

# Perception Threshold

**As with other human properties, threshold values vary from person to person.**

**The standard definition of a perception threshold is the statistical value of the physical intensity for which 50% of the population will detect the presence of the stimulus.**





# Perception Threshold

**There is great variability in perception threshold between different people.**

**Studies of response to vibrational stimuli have shown for example that the perception threshold for the most sensitive person in a group can be as much as 5 times lower than that of the least sensitive person.**

**The threshold values in the literature are the result of averaging across many people, and this should be kept in mind when using the figures.**


# Perceptual Moment

**In 1955 Stroud suggested that physiological time is not a continuous dimension, but rather consists of discrete bits called *perceptual moments*.**

**Perceptual moments have been measured for many tasks and have been found to range from 25 to 100 milliseconds.**


# Perceptual Moment

**Two stimuli presented within 100 msec of each other will not be distinguishable as separate events.**

**Efron demonstrated the phenomena in a series of experiments in 1967 in which either 10 msec of red light was followed by 10 msec of green light, or 10 msec of green light was followed by 10 msec of red light. In both cases the colour was perceived to be one only, yellow.**

# Reaction Time

**An important characteristic of human perception is the reaction time, defined as the time between the onset of a stimulus and the beginning of an overt response.**

***Simple reaction time*** **involves cases where a key, button or other object is pressed immediately upon detecting the stimulus.**

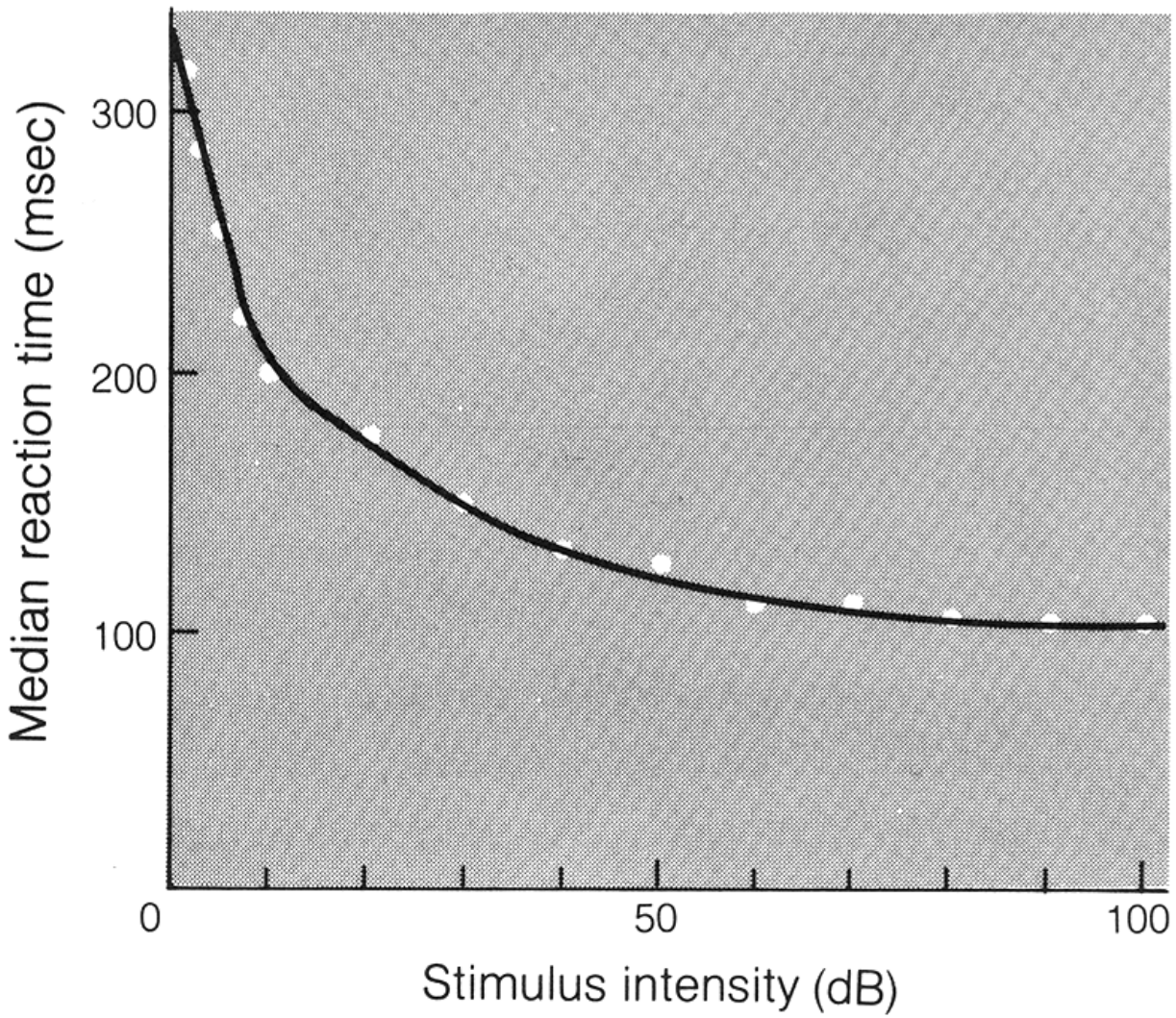
***Choice reaction time*** **involves cases where the subject makes a choice between one of several keys or buttons, after having identified the type of stimulus used (for example one button for each possible colour).**

# Simple Reaction Time

***Simple reaction time*** **becomes longer as the stimulus intensity is lowered.**

**The reaction time becomes particularly long when the stimulus is close to threshold.**

**The reaction time does not continue to improve with increasing stimulus intensity because there is a critical level which guarantees immediate identification.**



# Choice Reaction Time

***Choice reaction time*** **increases with increasing number of items to choose from.**

**The nervous system requires more time to deal with more information.**

**This can be seen in the 1885 data from a study by Friedrick Merkel.**

| Number of Alternatives | Reaction Time (msec) |
|---|---|
| 1 | 187 |
| 2 | 316 |
| 3 | 364 |
| 4 | 434 |
| 5 | 487 |
| 6 | 534 |
| 7 | 570 |
| 8 | 603 |
| 9 | 619 |
| 10 | 632 |

# Hick’s Law

**Studies performed in the 1950s demonstrated that choice reaction time depends not just on the number of choices, but also on the amount of information contained in the stimulus (the complexity of the stimulus).**

**Hick’s law states that choice reaction time is a linear function of the amount of information in the stimuli.**

# Just Noticeable Difference

**The just noticeable difference (jnd) is the smallest difference in stimulus intensity that a person can sense between two stimuli of the same type.**

# Weber's Law

**In 1834 Ernst Heinrich Weber asked participants to hold a weight in each hand, and to state which weight was heaviest.**

**By testing many weights Weber found that the jnd was not a fixed quantity, but was instead proportional to the stimulus. This characteristic of human perception holds for all forms of stimulus and is called Weber's Law.**

$$\Delta I = k\, I$$

**where $\Delta$I is the jnd, I is the stimulus intensity and k is a constant which depends on the type of stimulus.**

| Stimuli | Weber Fraction $k = \frac{\Delta I}{I}$ |
|---|---|
| brightness | 0.079 |
| loudness | 0.048 |
| finger span | 0.022 |
| heaviness | 0.020 |
| line length | 0.029 |
| taste | 0.083 |
| electric shock | 0.013 |
| 60 hz vibration at fingertip | 0.036 |
| 125 hz vibration at fingertip | 0.046 |
| 250 hz vibration at fingertip | 0.046 |

# Weber's Law

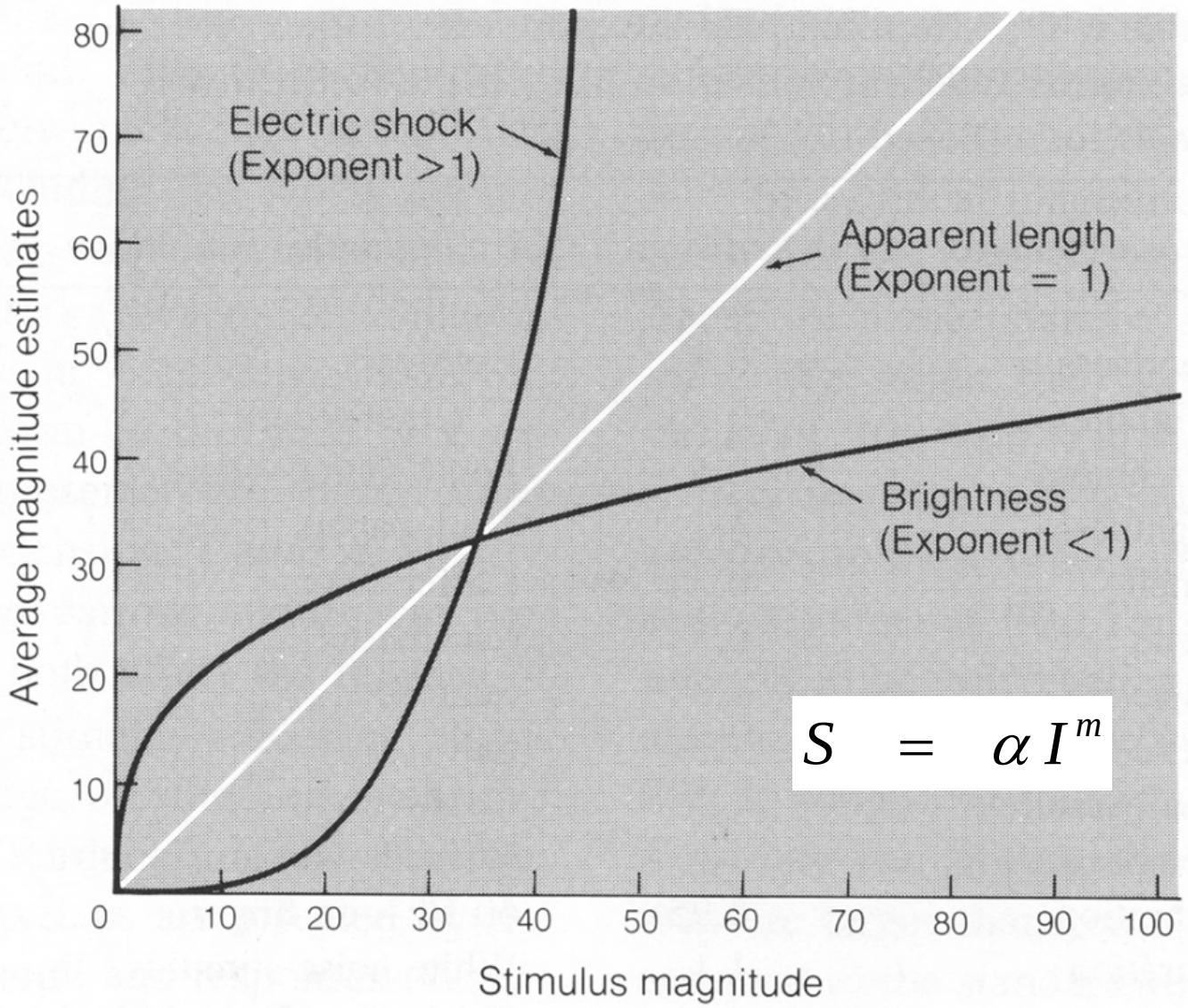
**The constant of proportionality k is called the Weber Fraction. It is a measure of the sensitivity of human perception to the type of stimulus. The lower the value of k, the greater the capacity to discriminate differences.**

# Stevens' Law

**In the 1950s many direct estimation tests were performed by S.S. Stevens and his team using a simple rating scale. The results lead to the now famous power law**

$$S = \alpha I^m$$

**where S is the perceived subjective intensity, I is the physical intensity of the stimulus, $\alpha$ is a constant which depends only on the measurement units used and m is an exponent which changes depending on the type of stimulus.**




# Stevens' Law

**The exponent value m defines the character of the human subjective response.**

# Stevens' Law

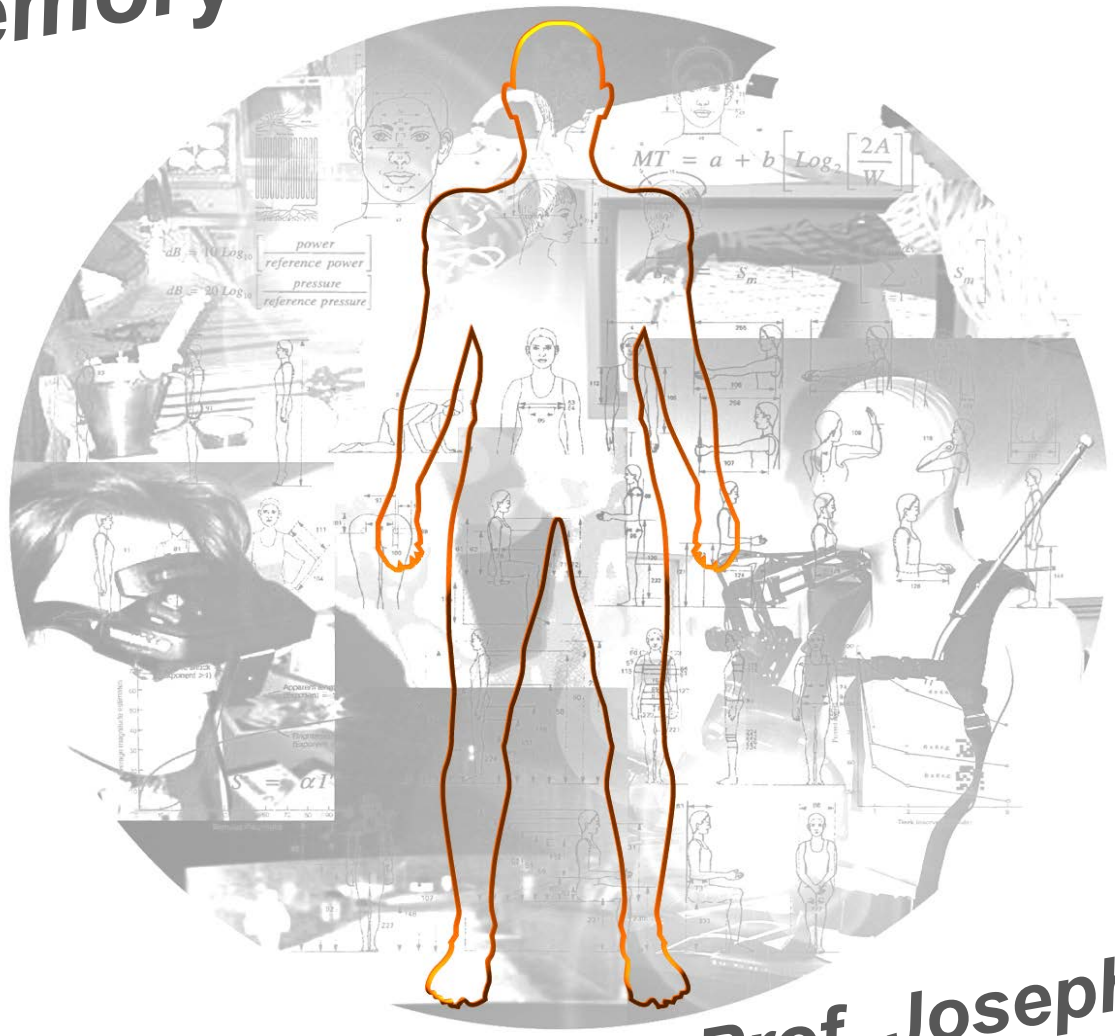
| Stimuli | Exponent | Stimulus Conditions |
|---|---|---|
| loudness | 0.6 | both ears |
| brightness | 0.33 | 5 ° target - dark |
| brightness | 0.5 | point source - dark |
| lightness | 1.2 | gray papers |
| smell | 0.55 | coffee odour |
| taste | 0.8 | saccharine |
| taste | 1.3 | sucrose |
| taste | 1.3 | salt |
| temperature | 1.0 | cold - on arm |
| temperature | 1.6 | warmth - on arm |
| vibration | 0.95 | 60 hz - on finger |
| duration | 1.1 | white noise stimulus |
| finger span | 1.3 | thickness of wood blocks |
| pressure on palm | 1.1 | static force on skin |
| heaviness | 1.45 | lifted weights |
| force of handgrip | 1.7 | precision hand dynamometer |
| electric shock | 3.5 | 60 hz - through fingers |

# Design Classic:
# Three Colour Traffic Light

In 1868 the first traffic lights were installed outside the Houses of Parliament in London. Designed by railway engineer J. P. Knight and constructed by the railway signal engineers of Saxby & Farmer, the classic three colour design has continued on to the present day.

Traffic lights combine the minimum number of choices with various mechanisms for ensuring that the light intensity is greater than that of the local surroundings.

# Memory

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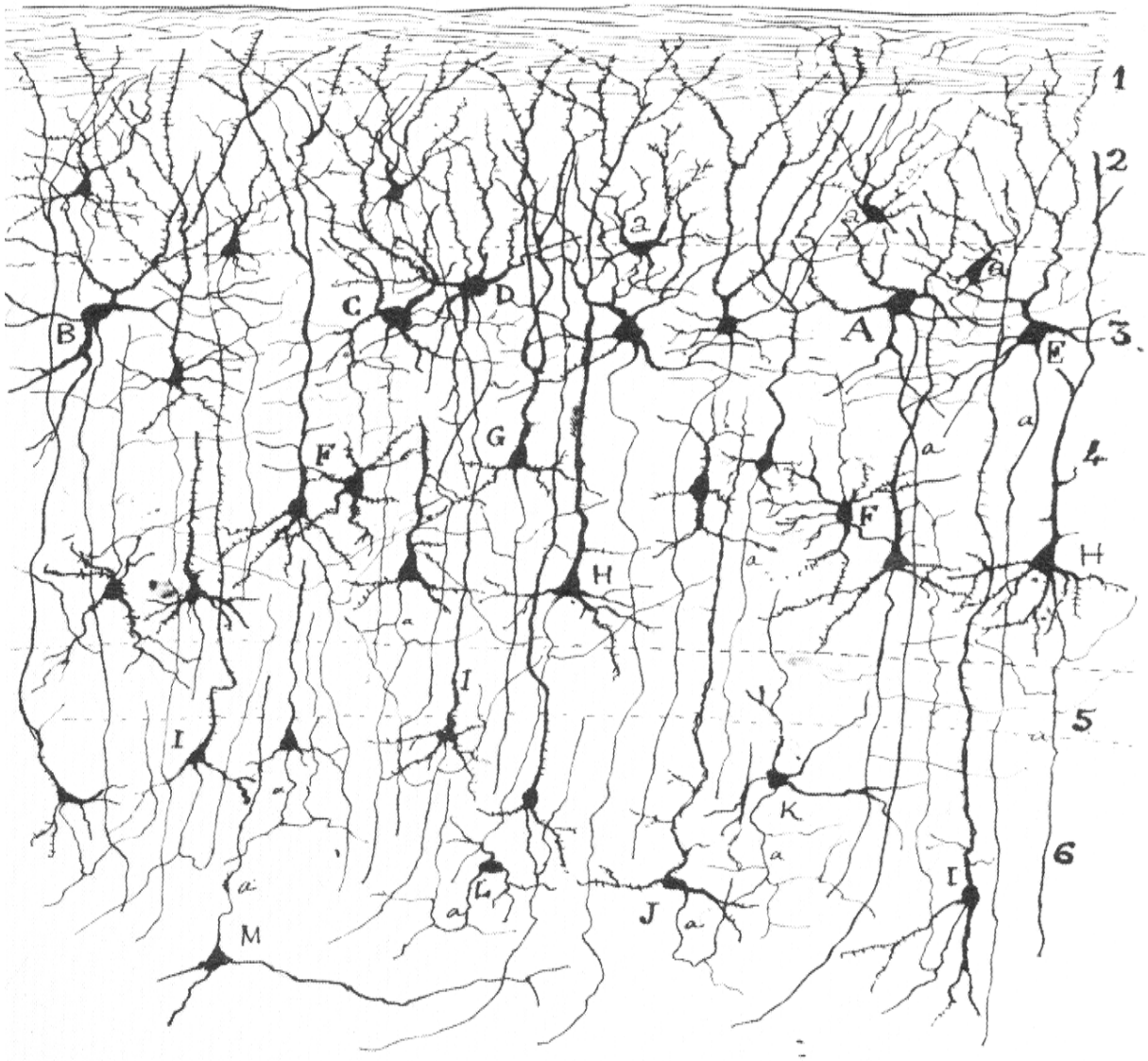



***Human memory*** **is a series of systems which store and retrieve information.**

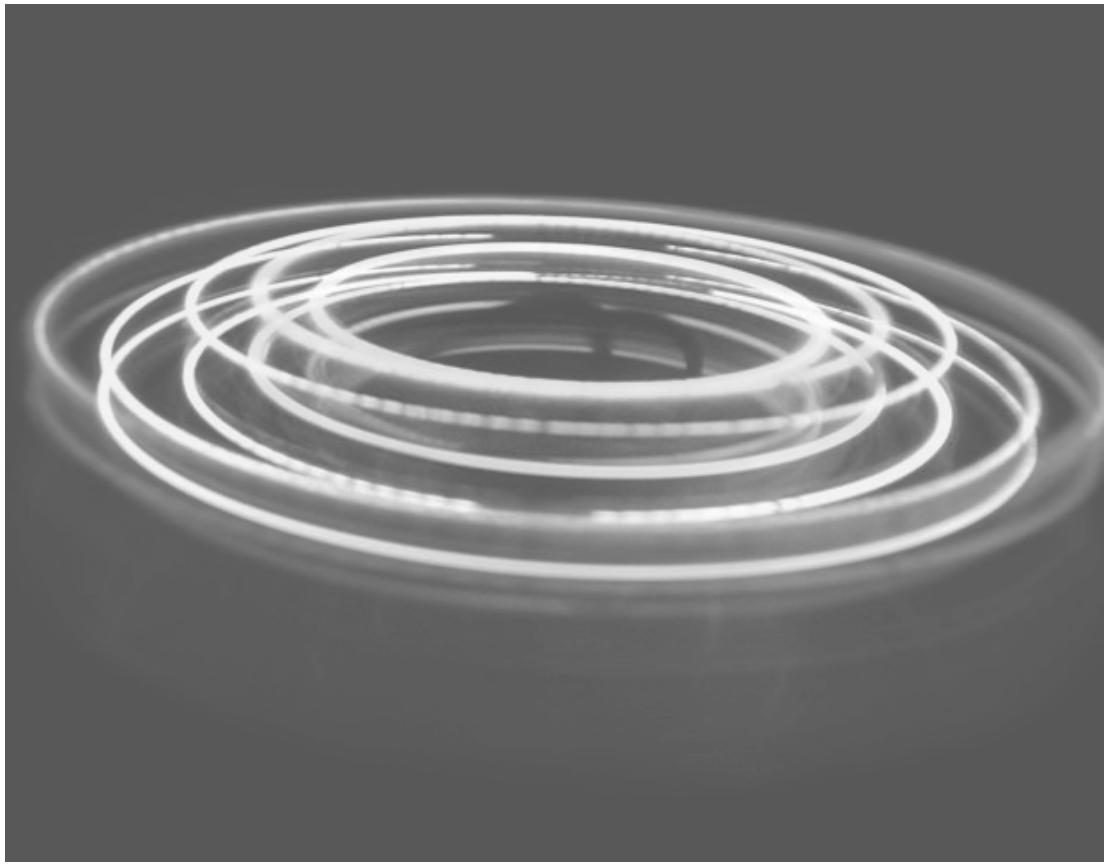
**They range in storage duration from fractions of a second to a whole lifetime.**

**They range in storage capacity from tiny buffers to vast areas of long term memory.**

# Iconic Memory

**In 1740 the German physicist and mathematician Johann Andreas Segner measured the duration of visual persistence by attaching a glowing coal to a cartwheel and rotating the wheel at increasing speed until an unbroken circle of light was perceived.**

**Segner calculated that the glowing coal needed to make a complete circle in under 100ms in order to achieve this effect, and that this was the time duration of visual memory.**



# Echoic Memory

**In 1963 Guttman and Julesz measured the duration of echoic memory by exposing participants to sections of random noise which varied in length from 50 msec to 1 second.**

**The sections of random noise were concatenated in various ways, and were then played to the participants continuously.**

**During the test the participants were asked to detect any rhythmic periodicities which occurred due to repetition of the identical segments.**

**Participants noted repeated segments of up to 250 msec in length, which suggested that echoic memory can hold up to 250 msec of auditory data.**

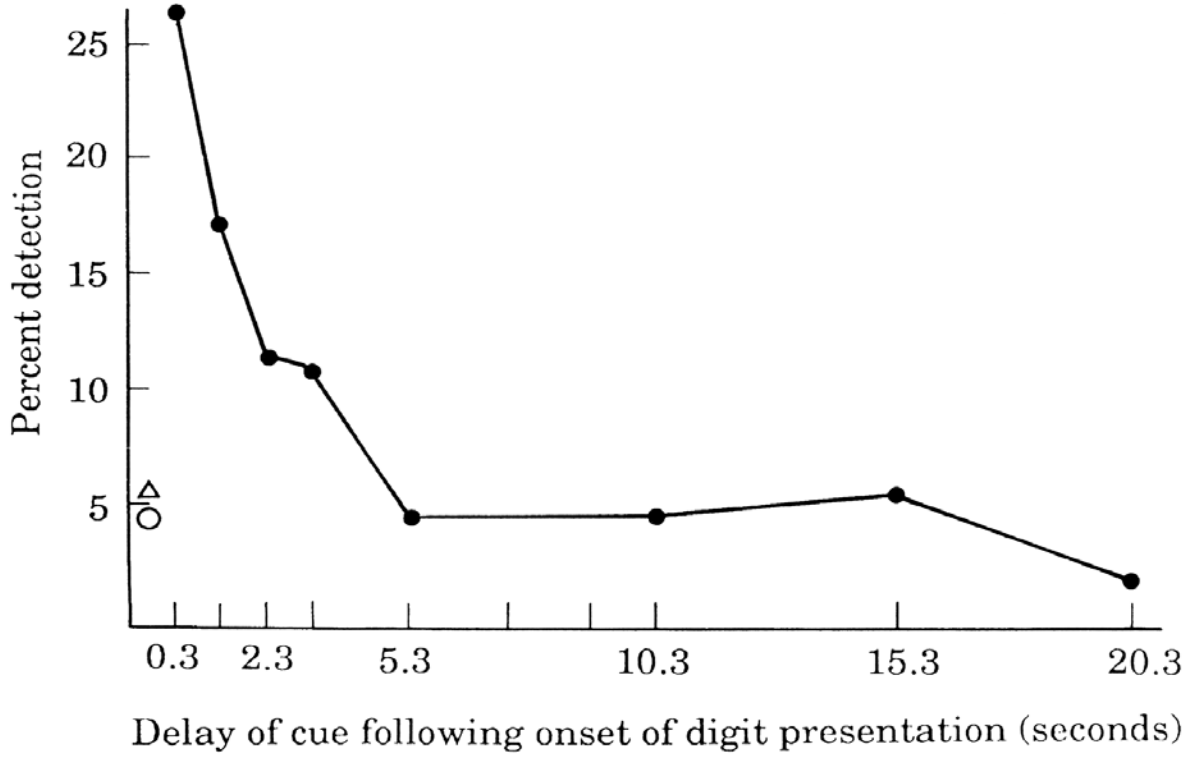
# Iconic and Echoic Memory

**By maintaining a stimulus for a fixed amount of time the iconic and echoic memories maintain a persistence which ensures that the nervous system has enough time to process the information.**

# Short Term Memory

**Studies with letters and patterns have shown the existence of a second and more durable form of memory, *short term memory*.**

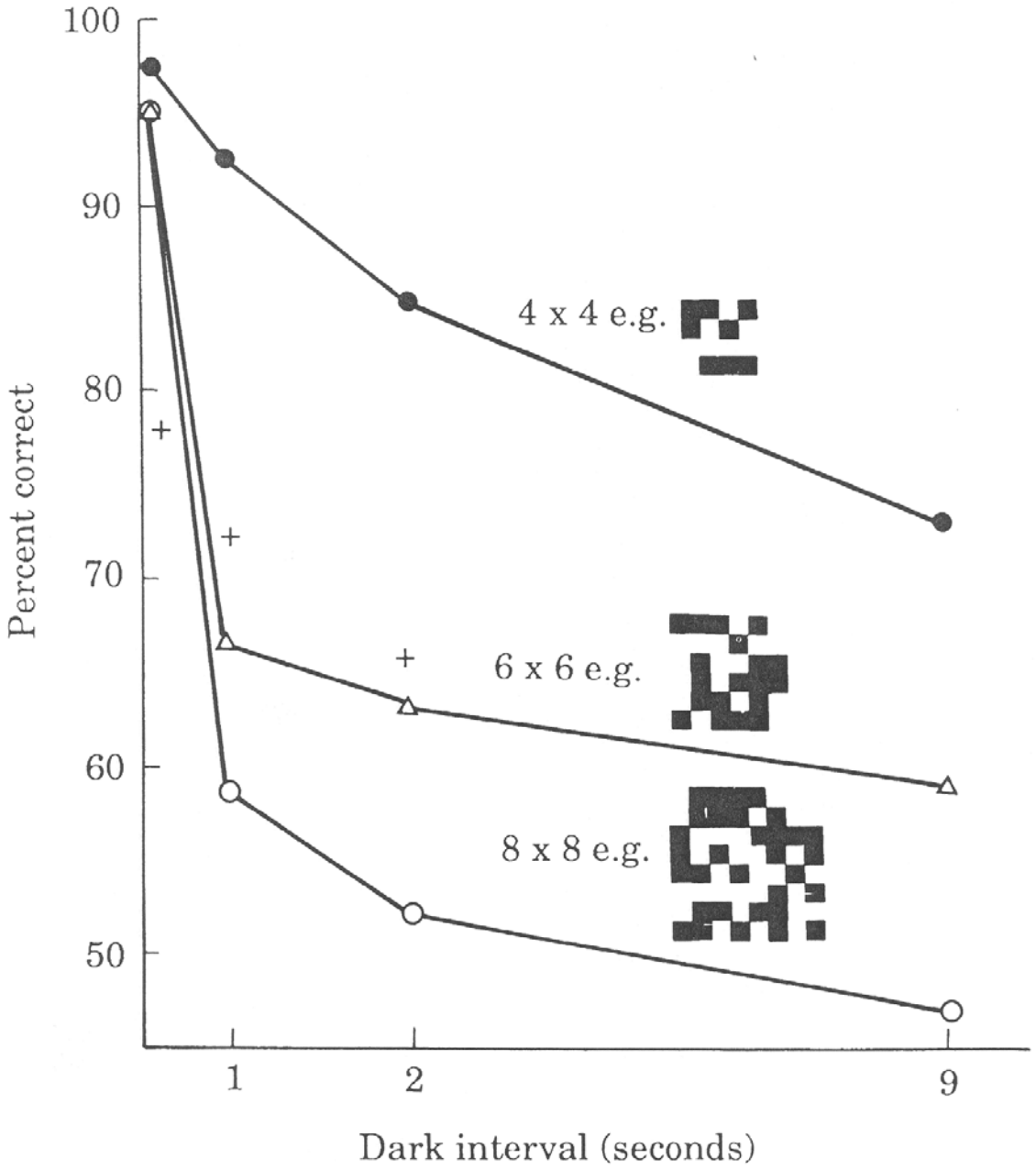
**It has an average time duration of somewhere between 2 and 20 seconds.**




# Short Term Memory

**In 1970 Glucksberg and Cowan asked people to continuously repeat a stream of prose which was presented to one ear, while ignoring text presented to the other which contained embedded numbers. The process was occasionally stopped, and the participant asked to indicate the number.**

**The probability of correctly reporting the number was found to be a function of the time delay between presentation and request to repeat. Short term auditory memory decays rapidly with most items being lost after roughly 5 seconds.**




# Short Term Memory

**Studies of memory retrieval accuracy which used random visual patterns showed that performance deteriorates as a function of both the stimulus complexity and the interval of time which passes before recall.**

# Short Term Memory

**Studies have shown that the human ability to recall information from short term memory drops dramatically when the complexity of the stimulus is more than 7 ± 2 chunks of information.**

# Long Term Memory

**Memory of visual and other stimuli can last for periods far in excess of the few seconds of short term memory.**

**In a 1965 study by Nickerson 600 pictures of various scenes and events were shown to a group of subjects, and recognition was later tested by mixing the original images with new items and asking to categorise each picture as “new” or “old”.**

**Recognition after one day was 92% and after a year was still as high as 63%.**

# Long Term Memory

**A 1983 study by Rubin and Kontis showed how people form a schema (model) in their memory of how a United States coin should look, rather than memorise all the details of each coin.**

**Upon recall each individual tended to reconstruct a coin using a reference model.**





Actual





Modal

# Recognition is Easy but Recall is Hard

**Recognition occurs when the current perceptual stimulus activates the same set of neural pathways as a previous stimulus. Recognition is easy because the pathways have already been adjusted to “hold” the stimulus the first time around, and are thus now prepared to re-activate.**

**Recall, instead, occurs when the associative cortex attempts to activate the perceptual pathways in the absence of the complete external stimulus. Recall is hard because the reactivation starts from a smaller set of neural pathways, which come from other areas of the brain.**

## Recognition is Easy but Recall is Hard

## What car is it ?

## But what did it look like in 1965 ?

# Design Classic: Wikipedia

Wikipedia was launched in January 2001 by Jimmy Wales and Larry Sanger.  It is a free, collaboratively edited and multilingual Internet encyclopaedia supported by the non-profit Wikimedia Foundation. It contains more than 23 million articles, and in 2011 received an estimated 2.7 billion monthly pageviews from the United States alone.

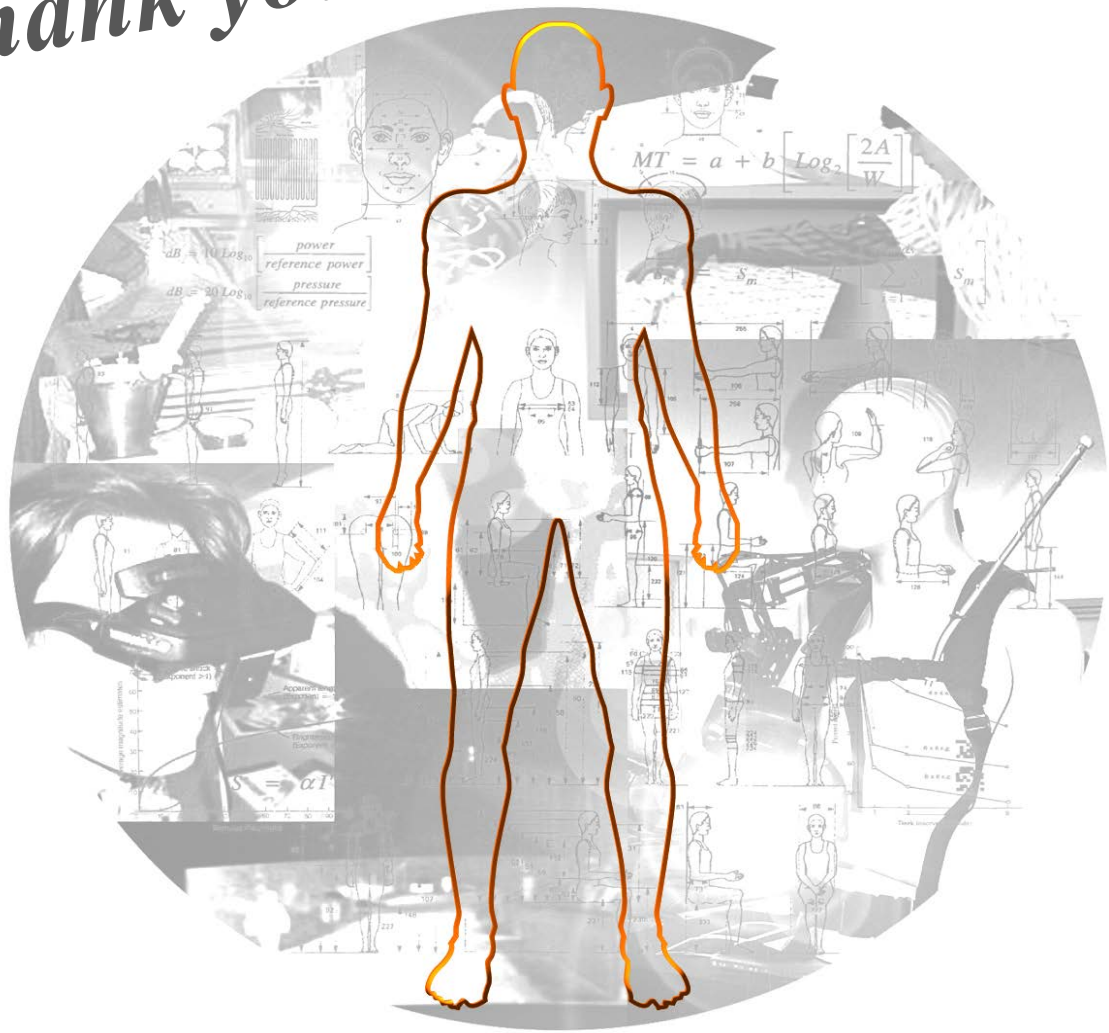
It's departure from the expert-driven style of traditional encyclopaedias, and the presence of a large amount of non-academic content, have lead to extensive media attention and critical analysis.

Wikipedia can be viewed as a modern form of memory aid, as opposed to a digital update of the traditional encyclopaedia.

WIKIPEDIA

*The Free Encyclopedia*

# *Thank you.*


$MT = a + b \left[ Log_2 \left[ \frac{2A}{W} \right] \right]$
$dB = 10 Log_{10} \frac{power}{reference\ power}$
$dB = 20 Log_{10} \frac{pressure}{reference\ pressure}$