LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN
INSTITUTE FOR MEDICAL PSYCHOLOGY AND HUMAN SCIENCE CENTER

Trust as basis for the concept of causality
A biological speculation

Ernst Pöppel
Ludwig-Maximilians-University
Munich, Germany

ernst.poeppel@med.uni-muenchen.de

Theodosius Dobzhansky:

"Nothing in biology
makes sense except
in the light of **evolution**."

Nothing in evolution makes

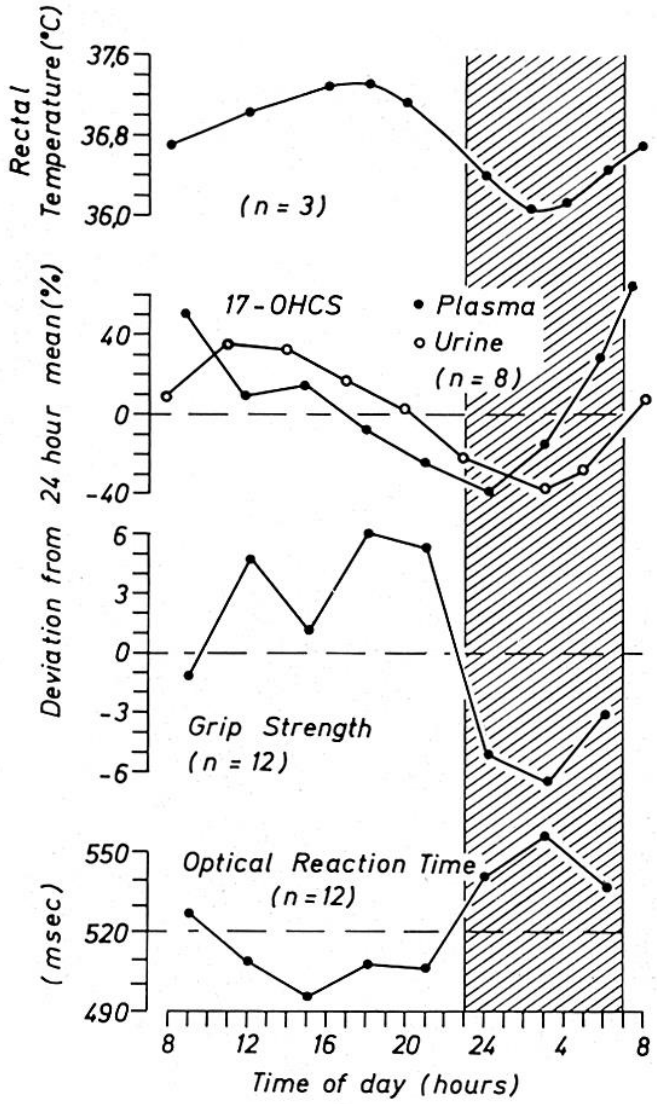
sense except in the light of

trust.

Trust in the future

The disaster to give a talk in

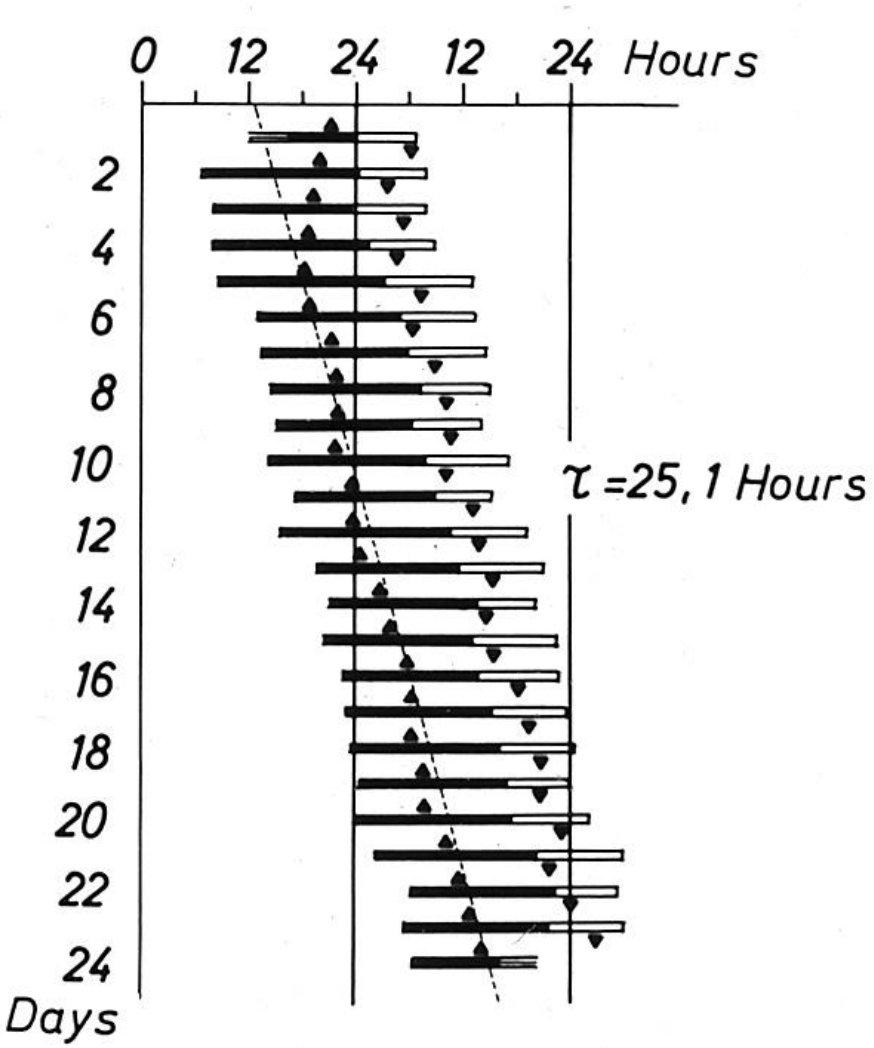
early afternoon.



The question of identity

The phase map changes continuously throughout the day. The same constellation of psychological and physiological functions is seen only every 24 hours.

The question arises why we experience personal identity, our “self”, throughout a day, although we are changing all the TIME?



"Free-running" period of the circadian oscillator indicating the endogenous control of this "body clock".

See the transient phase relationship between the sleep-wakefulness cycle and the maxima and minima of body temperature.

Mother Nature trusts

that there will be a next day.

David Hume, 1711-1776

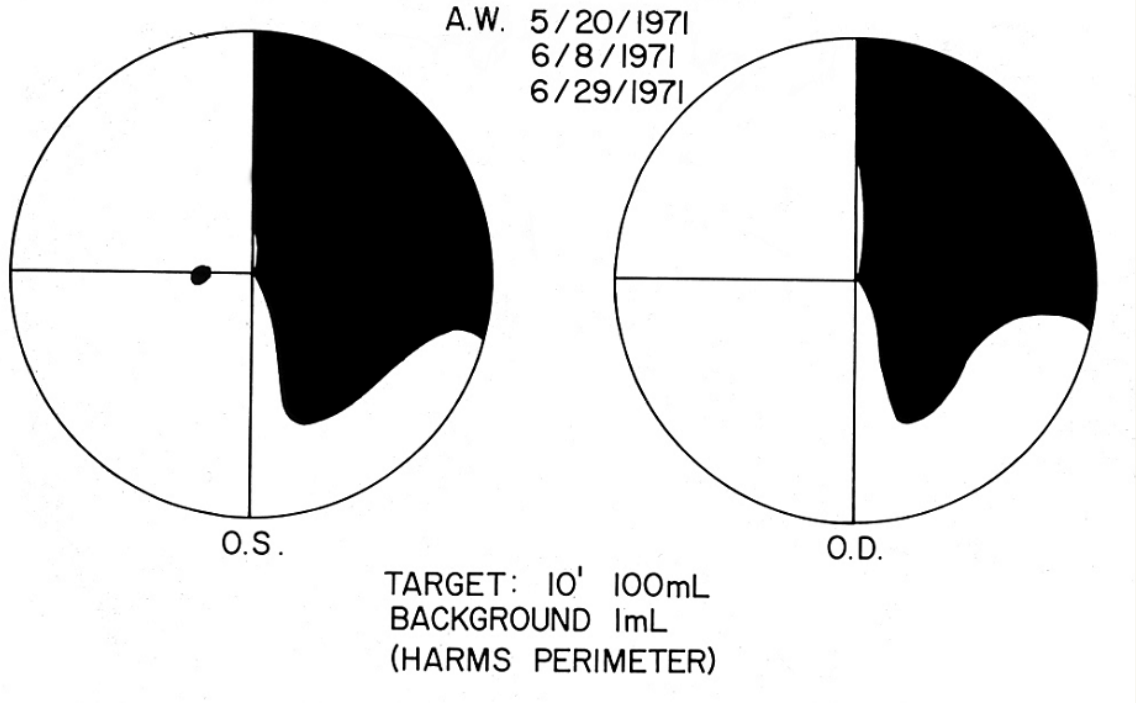
"An Enquiry Concerning Human Understanding", 1748/58

All conclusions are based on habits.

The relation of cause and effect are not discovered by reason, but by experience.

Necessary distinction
between **explicit** and **implicit** knowledge

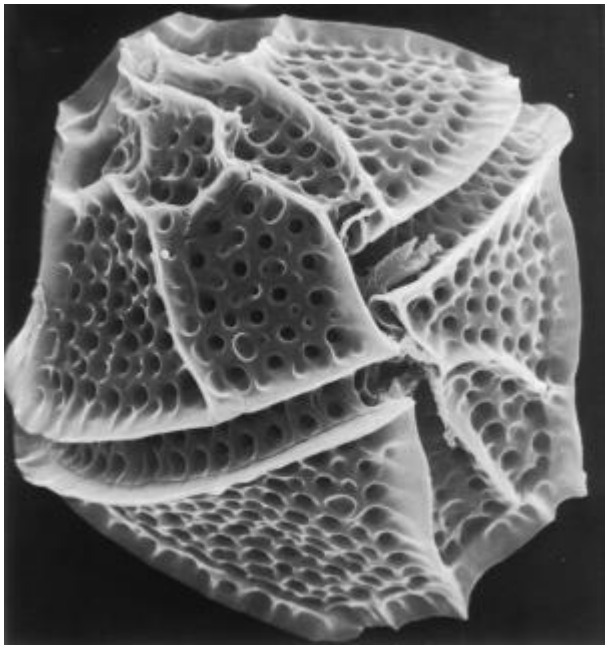
Example: “Blindsight”



Trust in implicit knowledge.
It is not “irrational”.

Unicellular organisms may not have a biological machinery
to “experience” **trust**,
but they function “as if”.
DNA as “frozen time” let them “believe”
that there will be a next day,
that there can be better conditions,
that homeostasis (allostasis) can be reached.

Unicellar Organisms as a Model



Gonyaulax Polyedra

percepts (categories)
relations (spatial, temporal)
comparison (time window)
evaluation
choice, decision
action (anticipation)

re-afference principle

Gonyaulax shows a circadian rhythm by emitting light at specific phases during 24 hours

What makes humans different in “cognitive processing”?

Nothing in principle!

Just a little more:

An external point of view
The invention of beliefs

Epistemological position:

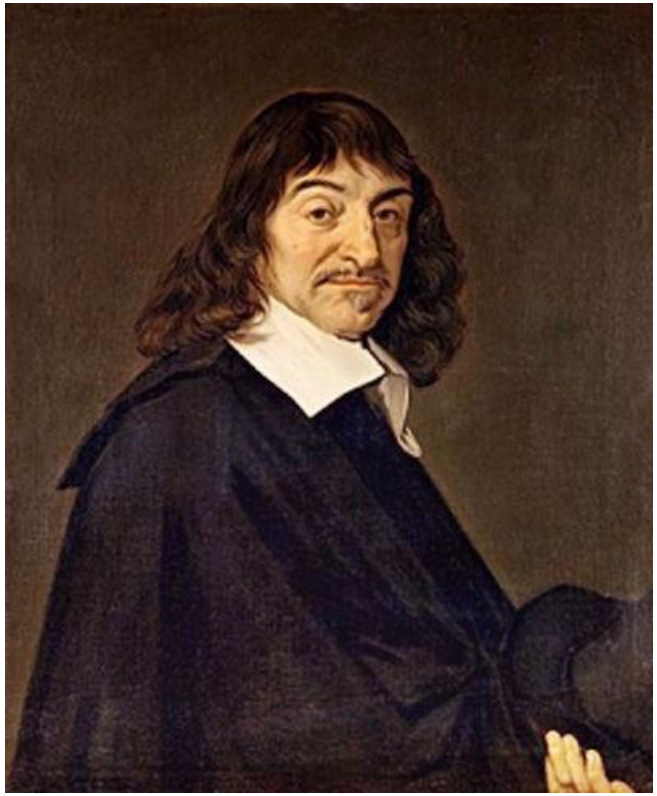
Pragmatic monism

Brain and mind are **not** different “substances”.

All psychological phenomena (percepts, memories, emotions) are based on neural processes.

Every function can be lost.
Thus, the loss of a function is the proof of its existence.
Therefore: pragmatic monism

Example:
Motion blindness (loss of causality)



René Descartes

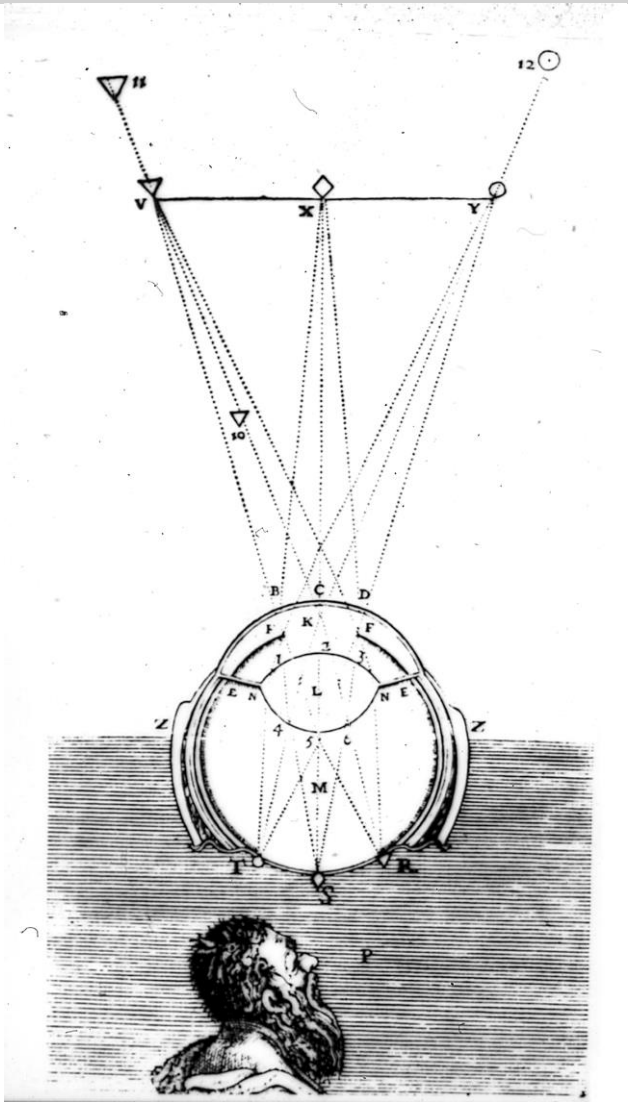
Discours de la Méthode (conceived 1618/19)

Epistemological position: Dualism

Four rules of thinking,

expressing the rationalistic attitude:
All problems can be solved.

1) clear mind, no prejudices, no haste
2) decomposing a problem into parts
3) going from simple to complex
4) considering all aspects



A picture from **René Descartes**

A simple question:

If we look in a mirror,
left and right are reversed,
but not up and down.

Why?

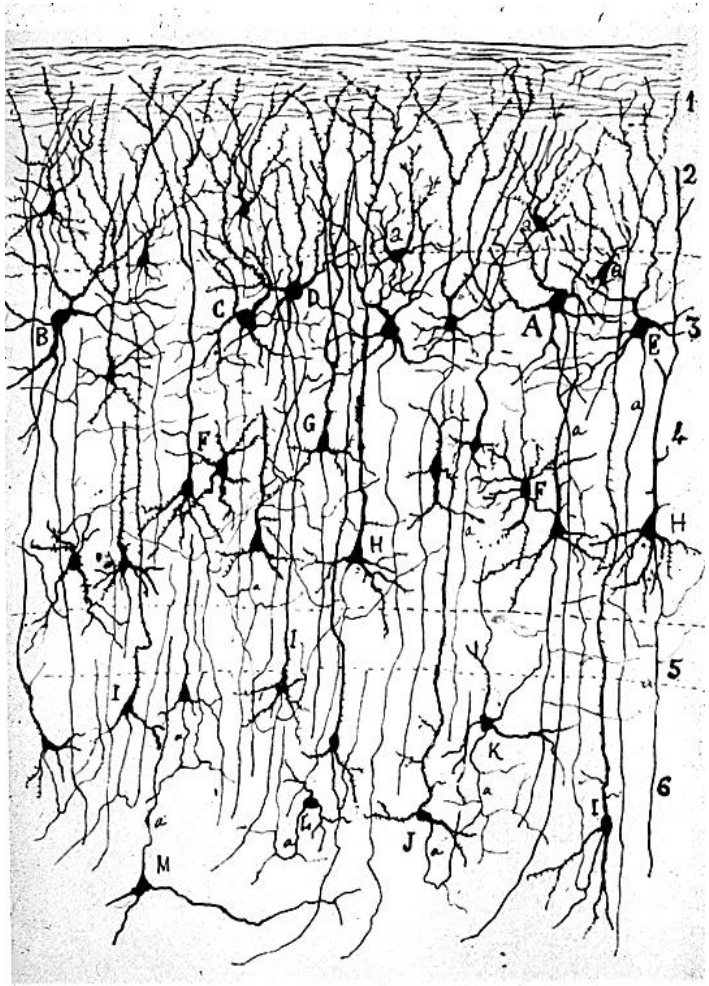
(I do not know the answer.)

Francis Bacon
Novum Organum (1620)

Induction
as a scientific method

Four errors,
we scientists can make
(and everybody else)

1) because we are human
2) because we are individuals
3) because we use language
4) because we have “theories”, prejuduces



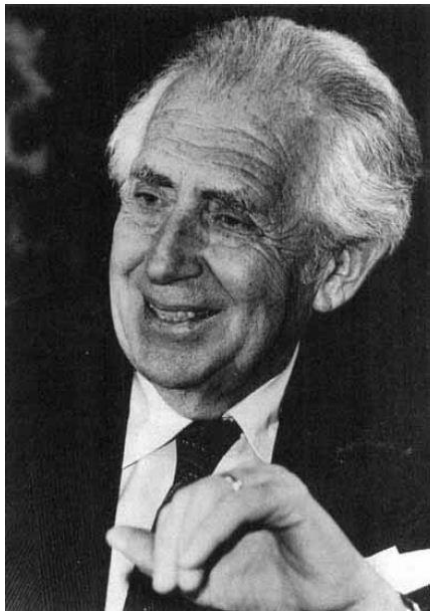
GOLGI-STAINED NERVE TISSUE from the visual cortex of a rat was sketched by Cajal in 1888. The numbers along the right-hand margin identify cellular layers; the capital letters label individual neurons. One of Cajal's most important contributions to neurobiology was to establish the neuron as a discrete, well-defined cell rather than as part of a continuous network.

Perhaps the most challenging question in Cognitive Science is the "identity question".

How is unity in the mind possible, if the brain consists of more than 100 billion discrete elements (neurons) as **Ramón y Cajal** has shown?

How becomes
an object an object,
a face a face
a thought a thought,
a feeling a feeling,
a memory a memory,
a melody a melody
being always

ONE.



Janos Szentágothai

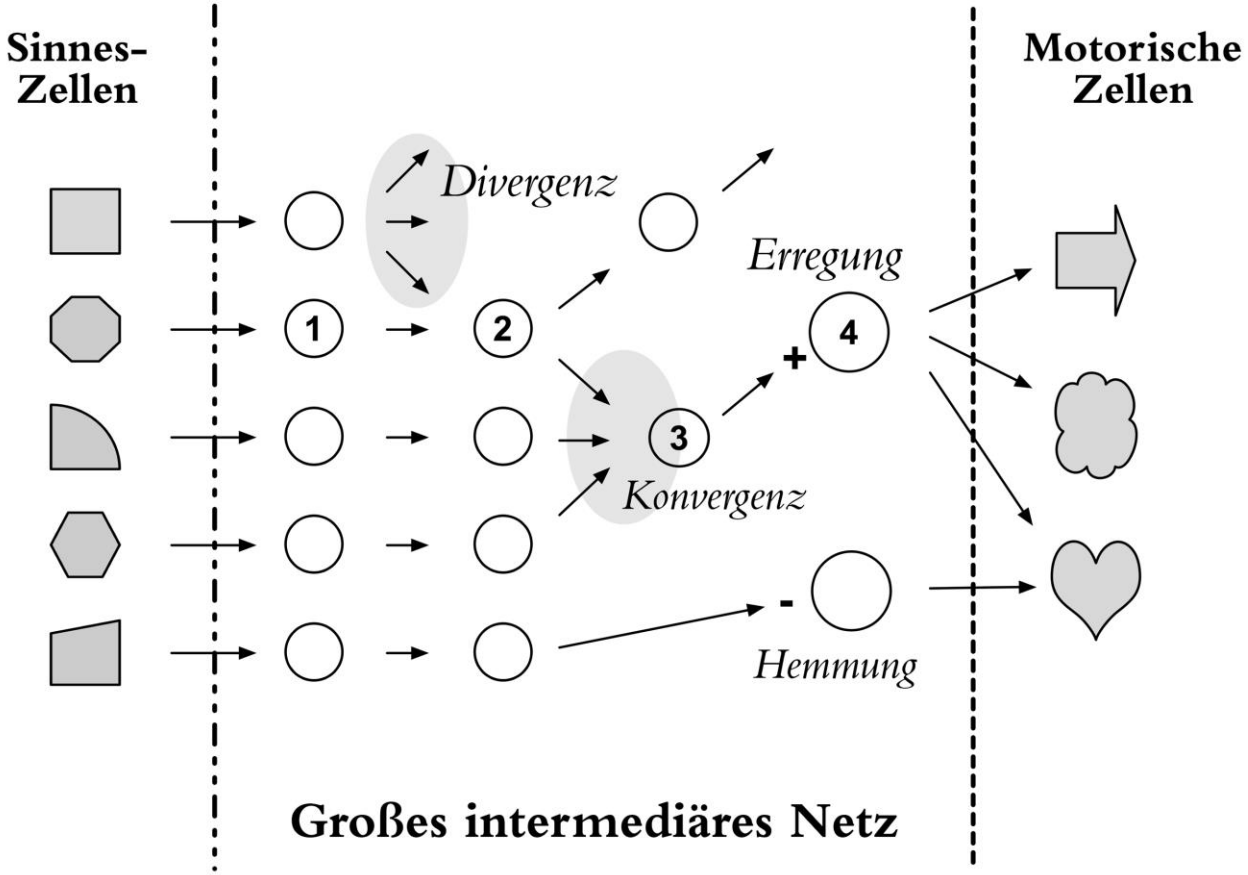
What he once said to me:
When one believes in God,
it is easier to die.

A belief

Walle Nauta

What he said at lectures at MIT:
The maximal distance of any neuron to any other neuron is 4 intermediate neurons.

A belief?



Principal Structure and Function of Brains

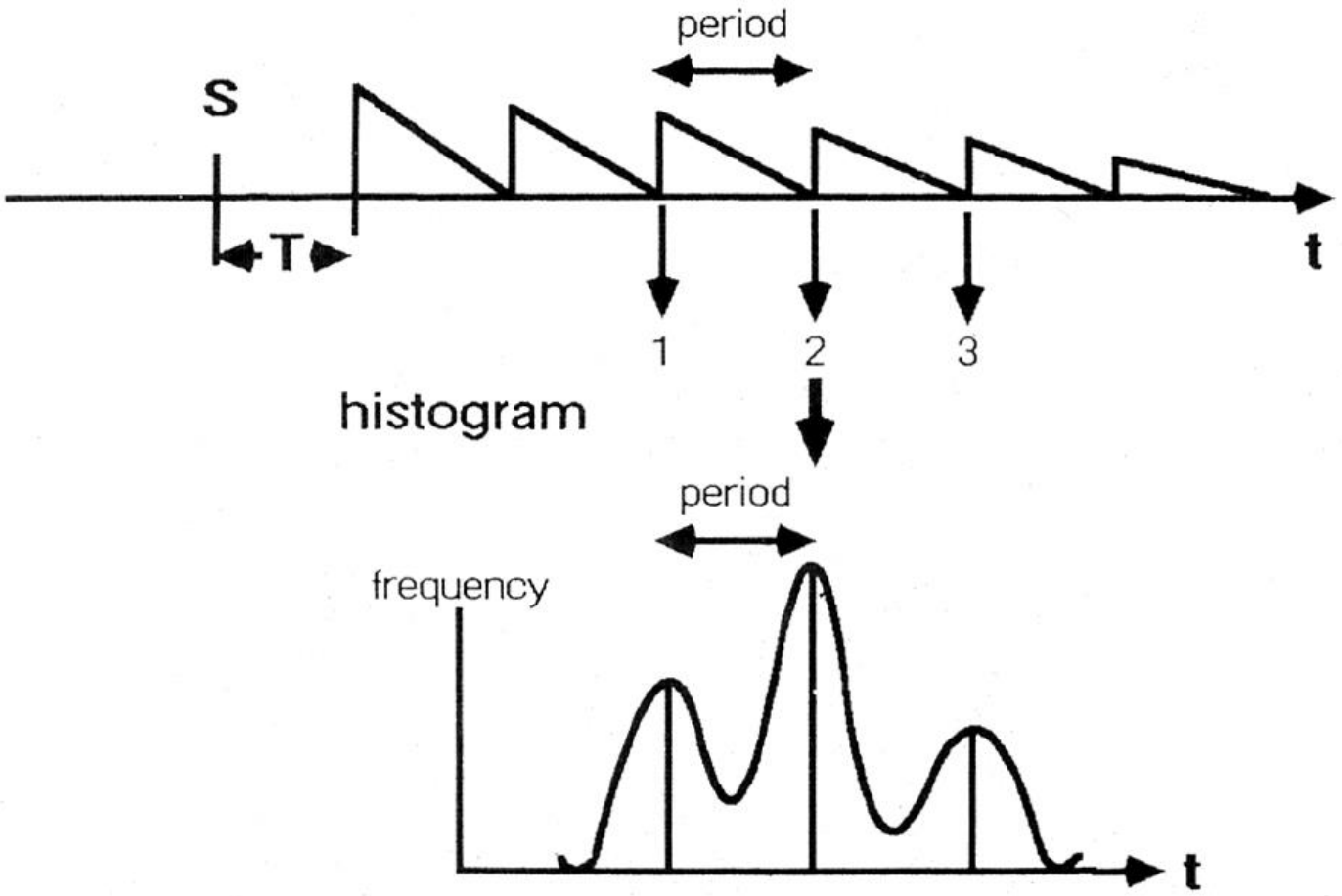
Three Types of Neurons:
Receptors, Motor Neurons,
Great Intermediate Net

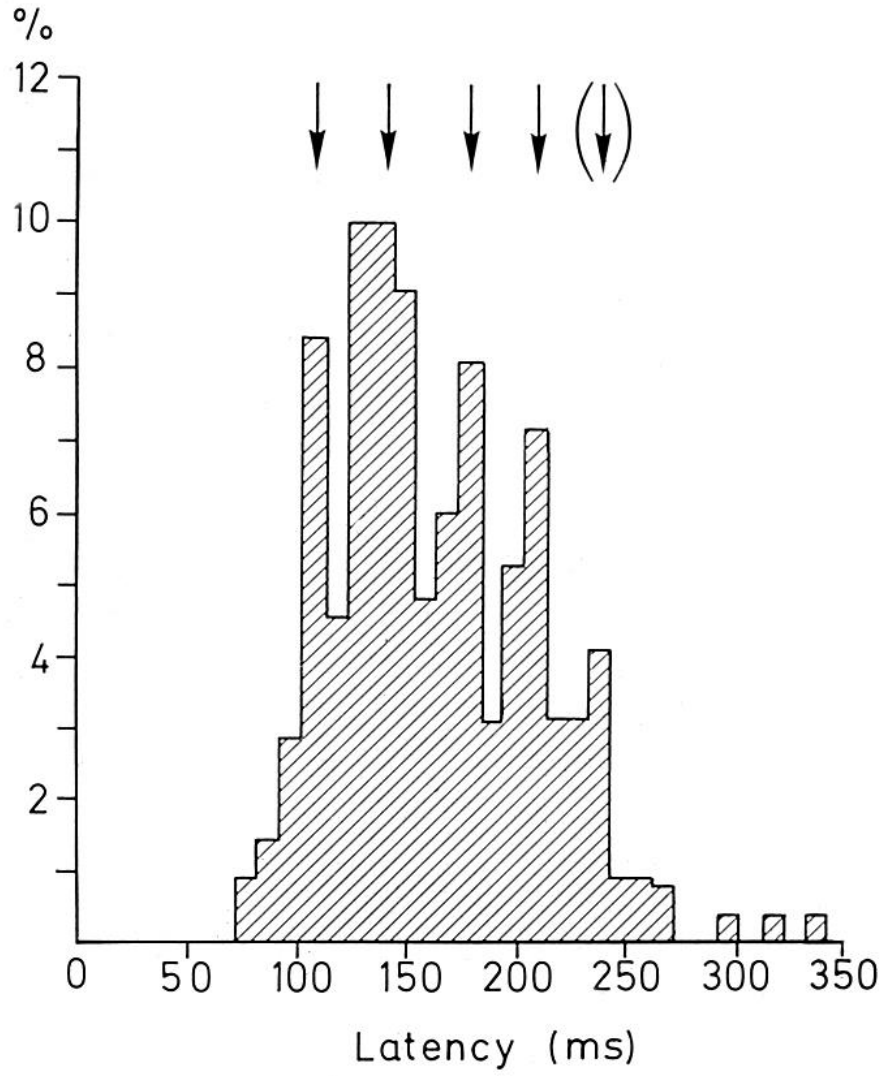
Three Aspects concerning the Great Intermediate Net:

Architecture
Synaptic Contacts
Functional Distance

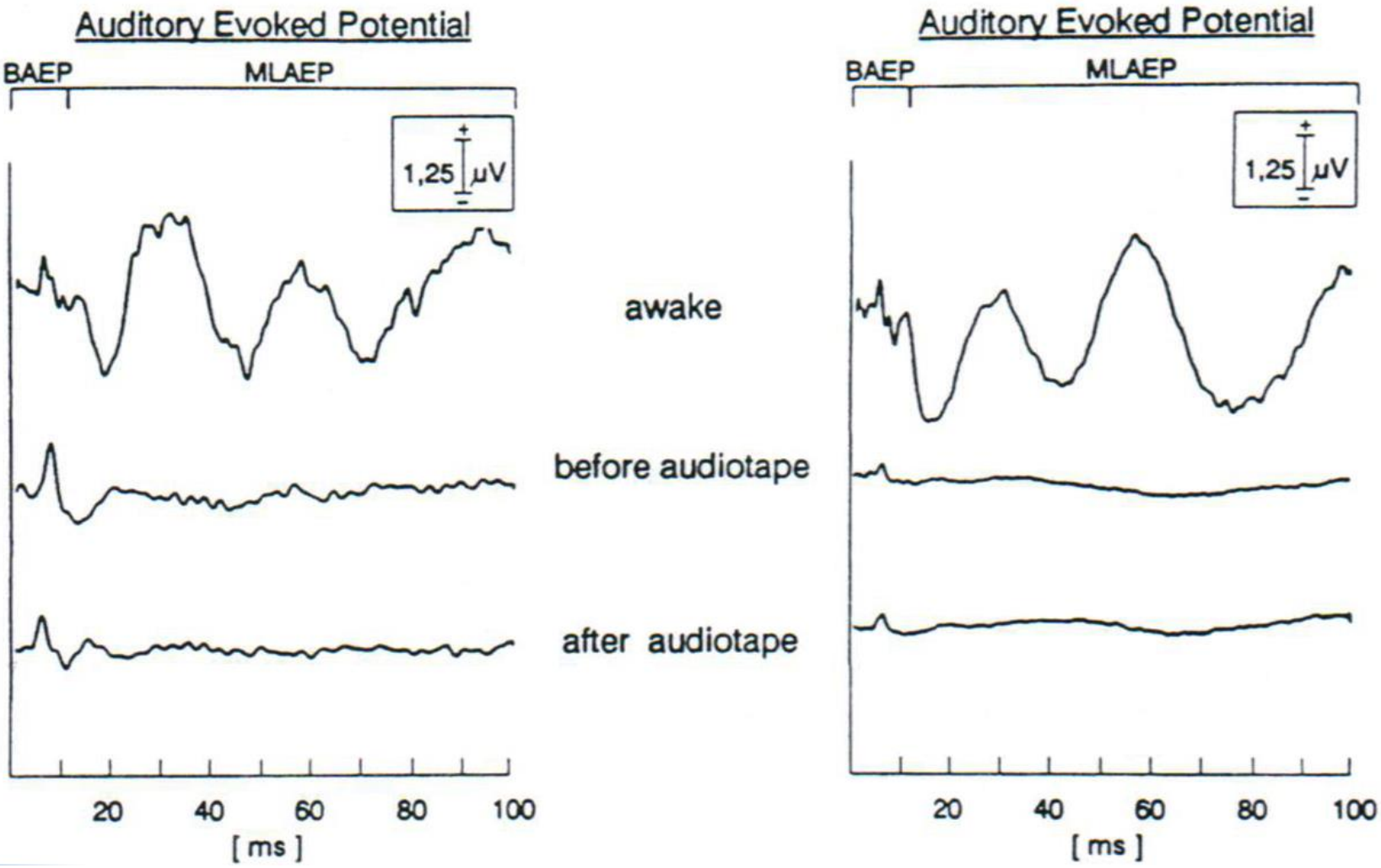
Consequences:
Interdependence of all Psychological Functions

Stimulus–dependent neuronal oscillation



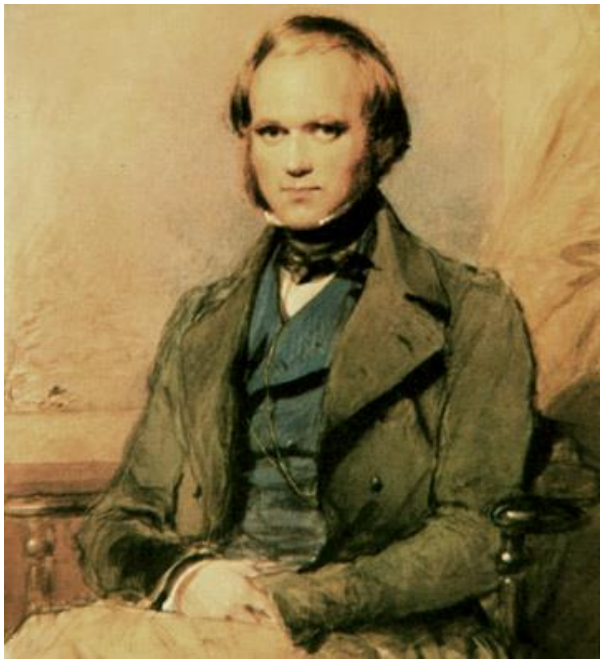


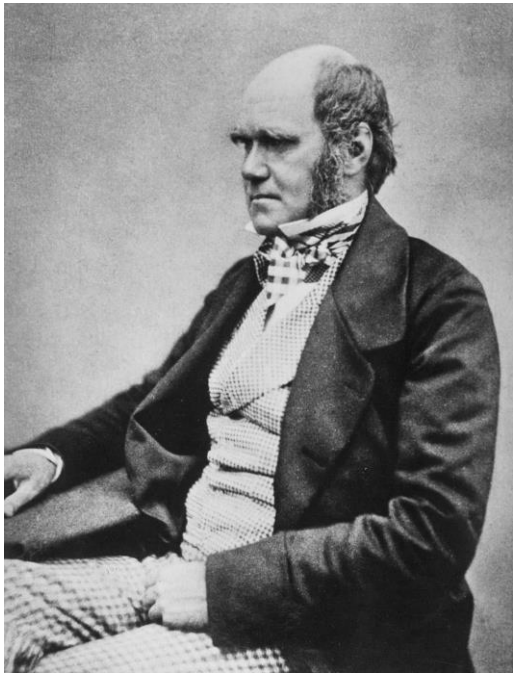
Multimodal distribution
of the latency of
pursuit eye movements
described by Nikos Logothetis in
his doctoral thesis.

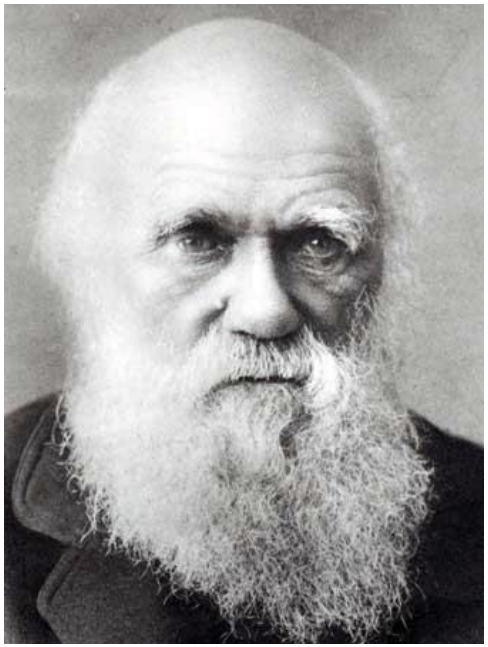

Auditory Evoked Potential
BAEP
MLAEP
1,25 µV
awake
before audiotape
after audiotape
20
40
60
80
100
[ms]
Auditory Evoked Potential
BAEP
MLAEP
1,25 µV
20
40
60
80
100
[ms]

Examples for a TIME WINDOW of 30 - 40 (20 - 60) ms

Simple and Choice Reaction Time
Latency for Pursuit and Saccadic Eye Movements
Temporal Order Threshold in 3 Sensory Modalities
Auditory Evoked Midlatency Potential
Temporal Tolerance in Stereopsis
Temporal Masking for Colour Percepts
Temporal Reversal of Spontaneous Speech
Single Cell Activities in Sensory Pathways
Anticipatory Control of Movements
„Key-Touching“ Time of Ballistic Movements
Temporal Tolerance in Sensorimotor Synchronization
Eccentricity Effect of Inhibition of Return
Sequential Scanning in Working Memory
Subjective Experience of a „Time Point“ (Ernst Mach)







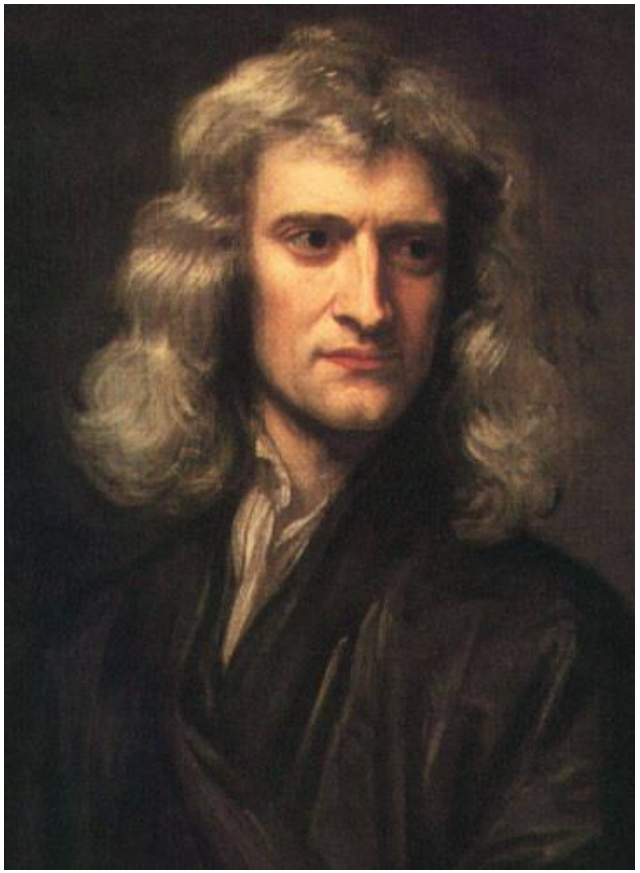
"Darwinian" Statement
according to the principle of **induction** by Francis Bacon,
an example of scientific **complexity reduction**

In temporal order judgments, reaction time, movement control, memory scanning, on the level of single cell activities and evoked potentials, discrete temporal processing in the same time domain of some tens of milliseconds is observed.

"Time" is processed in discrete steps, not continuously.

All observations together indicate a robust temporal machinery,
a time window of some tens of milliseconds
that create the building blocks of temporal perception and
"states of being conscious" (STOBCON).

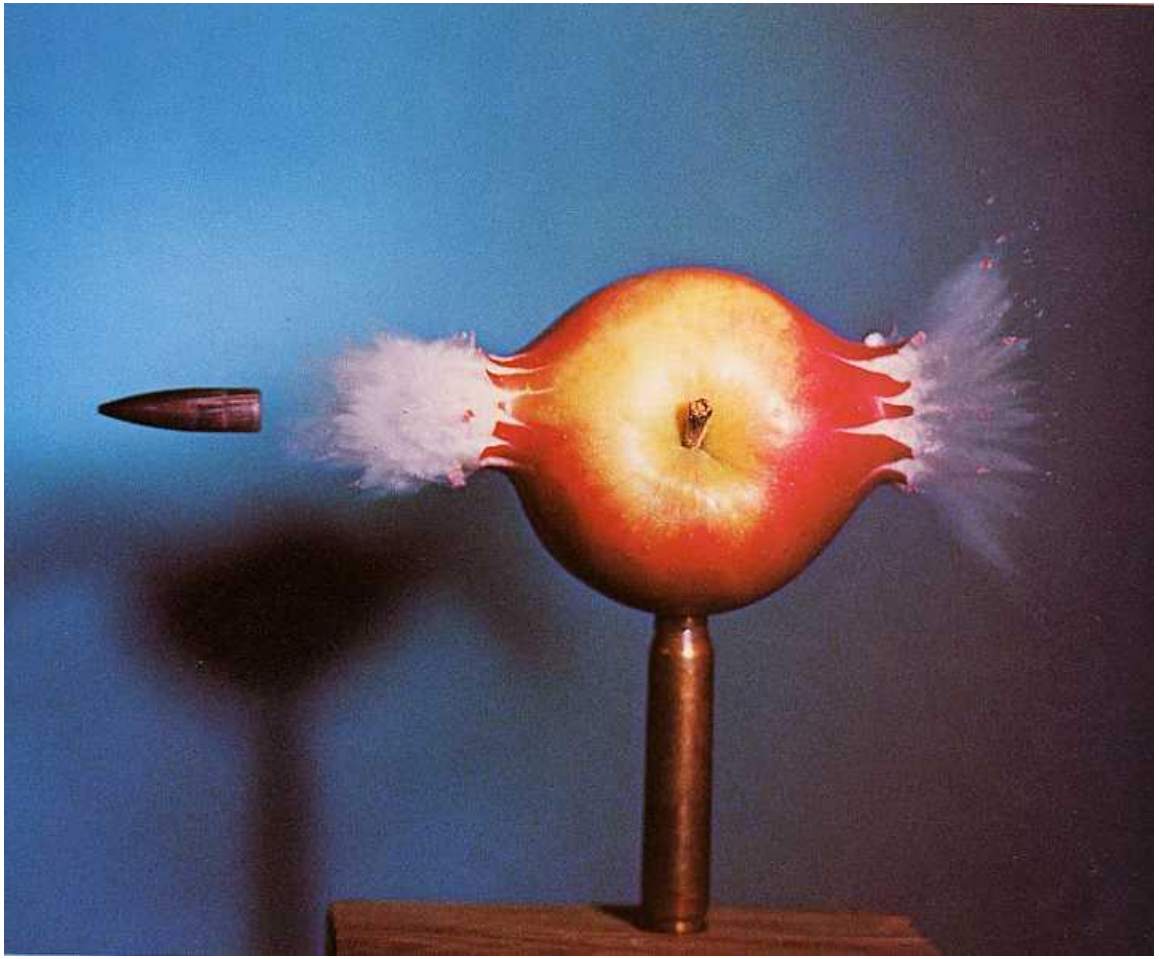
Isaac Newton
(Principia Mathematica Philosophiae Universalis)



"Absolute, true and mathematical time, by itself and from its own nature flows equably without relation to anything external".

But does subjective TIME, does TIME in the brain, actually flow "equably", as it is implied in classical physics (and also in Einstein's theories of relativity) ?

No: TIME in the brain "jump ahead"
in discrete steps.
Otherwise no complexity reduction

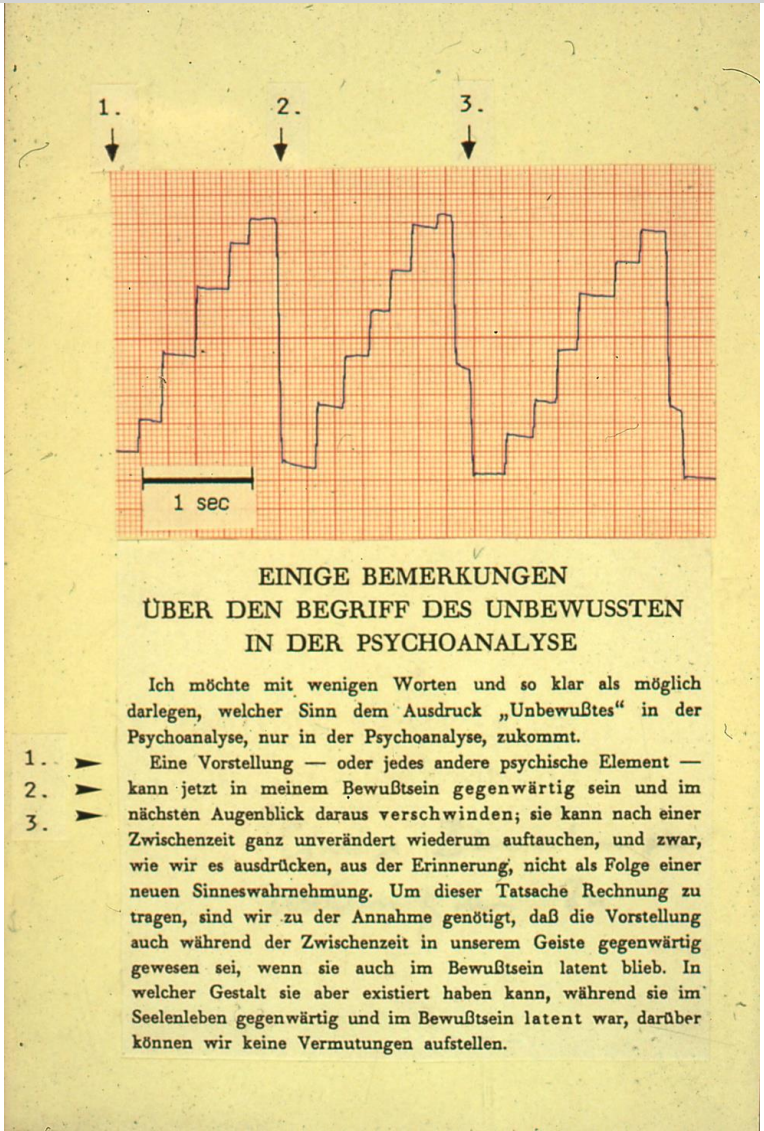


H. Edgerton

A much shorter "moment" or "time window" would allow to see the bullet.

Reading:

Illusion of temporal continuity



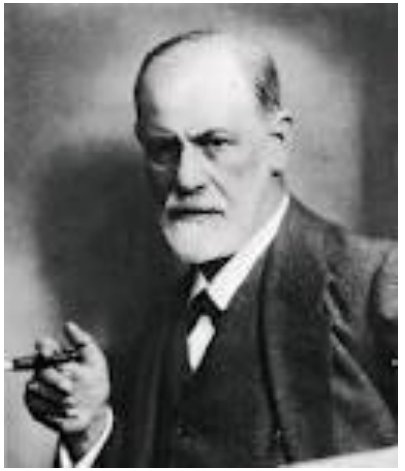
EINIGE BEMERKUNGEN
ÜBER DEN BEGRIFF DES UNBEWUSSTEN
IN DER PSYCHOANALYSE

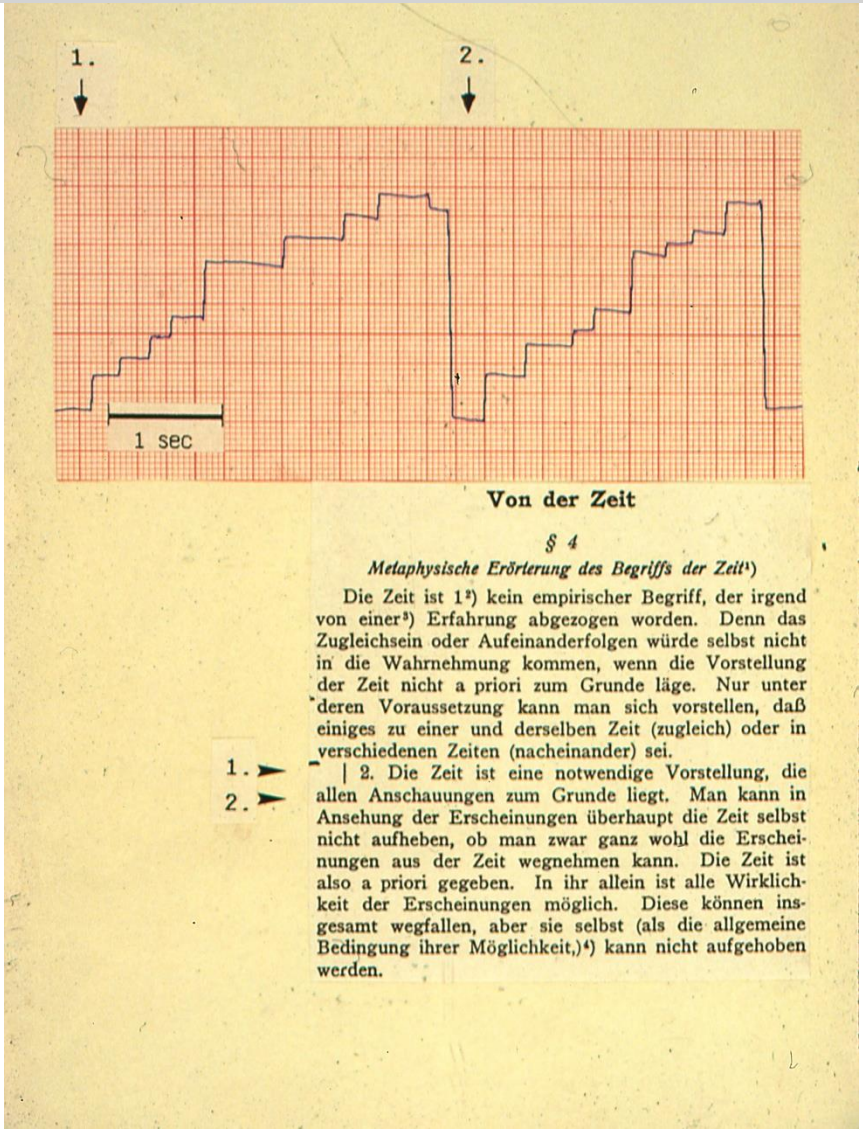
Ich möchte mit wenigen Worten und so klar als möglich darlegen, welcher Sinn dem Ausdruck „Unbewußtes" in der Psychoanalyse, nur in der Psychoanalyse, zukommt.

1. ► 2. ► 3. ► Eine Vorstellung — oder jedes andere psychische Element — kann jetzt in meinem Bewußtsein gegenwärtig sein und im nächsten Augenblick daraus verschwinden; sie kann nach einer Zwischenzeit ganz unverändert wiederum auftauchen, und zwar, wie wir es ausdrücken, aus der Erinnerung, nicht als Folge einer neuen Sinneswahrnehmung. Um dieser Tatsache Rechnung zu tragen, sind wir zu der Annahme genötigt, daß die Vorstellung auch während der Zwischenzeit in unserem Geiste gegenwärtig gewesen sei, wenn sie auch im Bewußtsein latent blieb. In welcher Gestalt sie aber existiert haben kann, während sie im Seelenleben gegenwärtig und im Bewußtsein latent war, darüber können wir keine Vermutungen aufstellen.

Saccadic eye movements when reading a text on the **present** by

Sigmund Freud, 1856-1939





Von der Zeit

§ 4

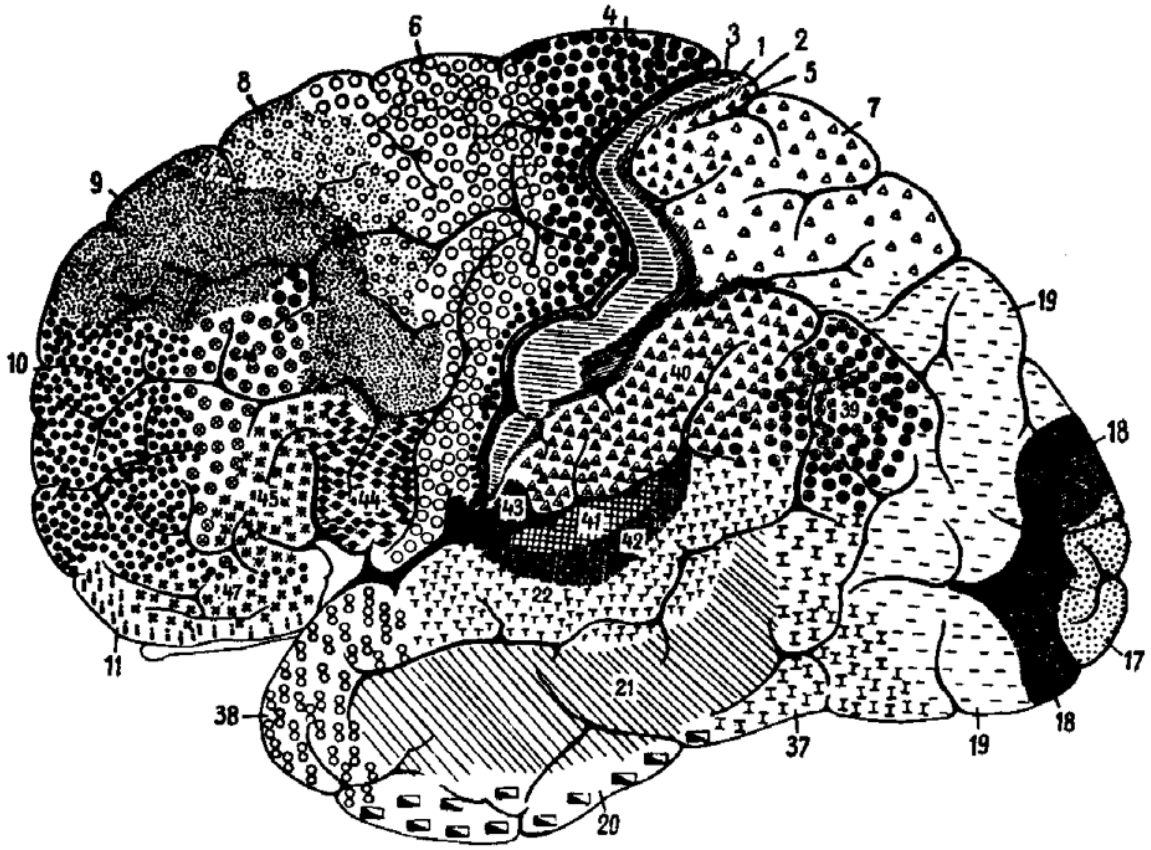
Metaphysische Erörterung des Begriffs der Zeit[1])

Die Zeit ist 1[2]) kein empirischer Begriff, der irgend von einer[3]) Erfahrung abgezogen worden. Denn das Zugleichsein oder Aufeinanderfolgen würde selbst nicht in die Wahrnehmung kommen, wenn die Vorstellung der Zeit nicht a priori zum Grunde läge. Nur unter deren Voraussetzung kann man sich vorstellen, daß einiges zu einer und derselben Zeit (zugleich) oder in verschiedenen Zeiten (nacheinander) sei.

1. ➤ | 2. Die Zeit ist eine notwendige Vorstellung, die
2. ➤ allen Anschauungen zum Grunde liegt. Man kann in Ansehung der Erscheinungen überhaupt die Zeit selbst nicht aufheben, ob man zwar ganz wohl die Erscheinungen aus der Zeit wegnehmen kann. Die Zeit ist also a priori gegeben. In ihr allein ist alle Wirklichkeit der Erscheinungen möglich. Diese können insgesamt wegfallen, aber sie selbst (als die allgemeine Bedingung ihrer Möglichkeit,)[4]) kann nicht aufgehoben werden.

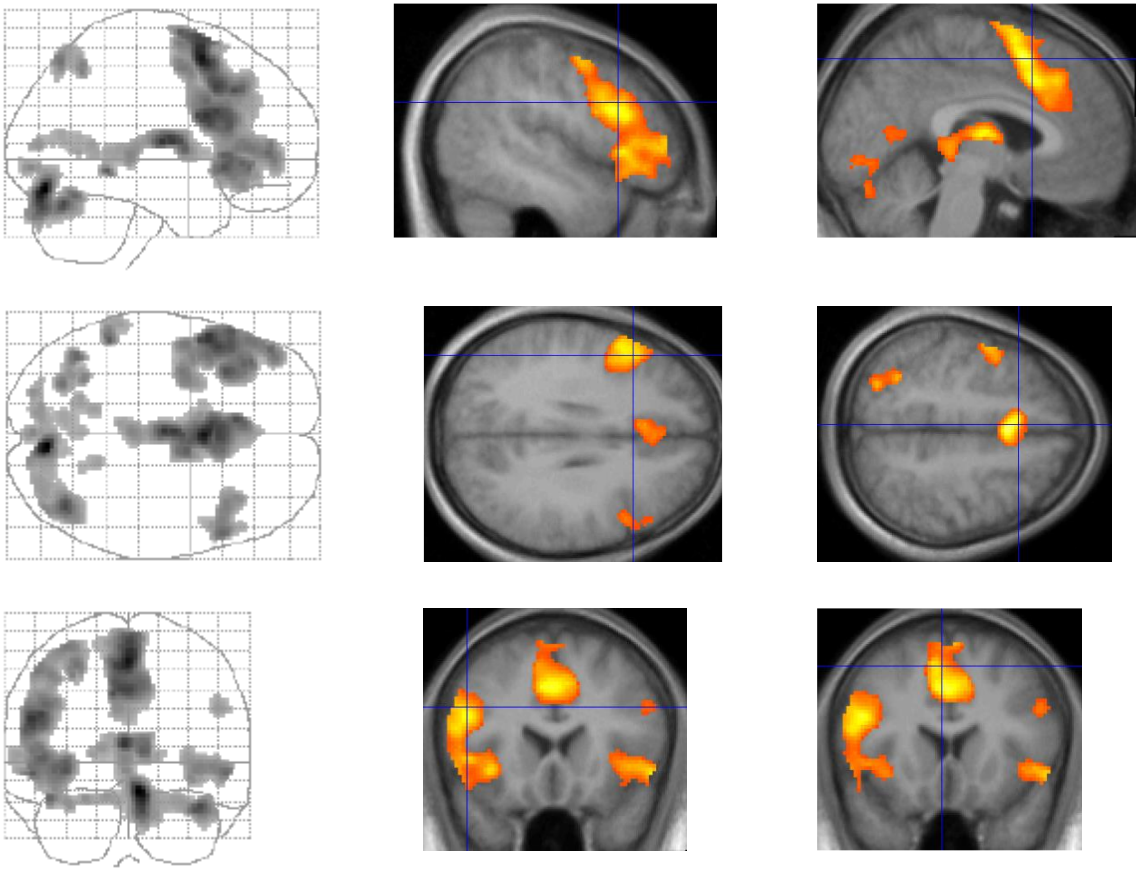
Saccadic eye movements when reading a text on TIME by Immanuel Kant, 1724-1804 “Critique of Pure Reason”

Note that the text of Kant being more difficult then the text of Freud requires more eye movements.



K. Brodmann

Brain Activations during Decisions



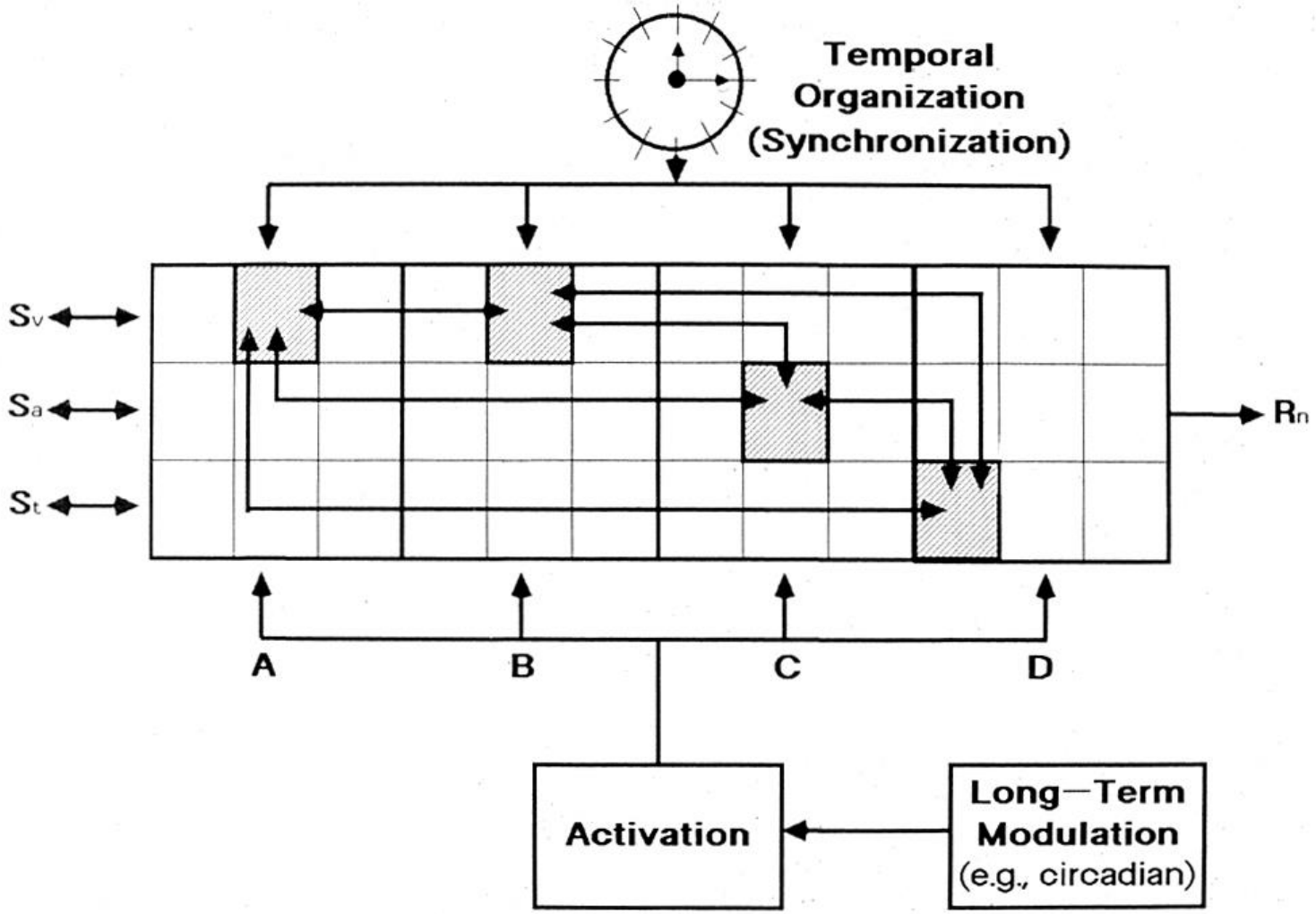
Taxonomy of functions (rudimentary)

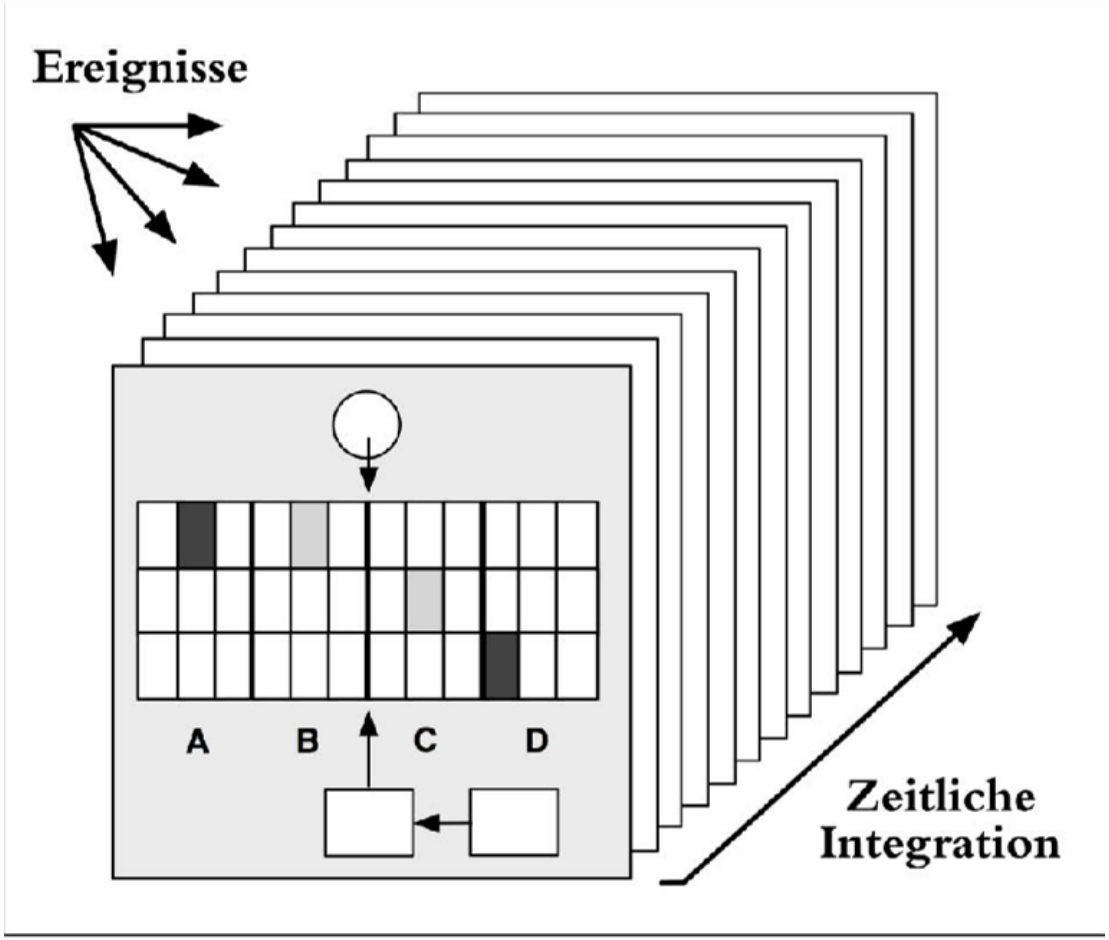
Distinction between

Content Functions: “What”
Perceptions, Memories, Emotions, Volitions

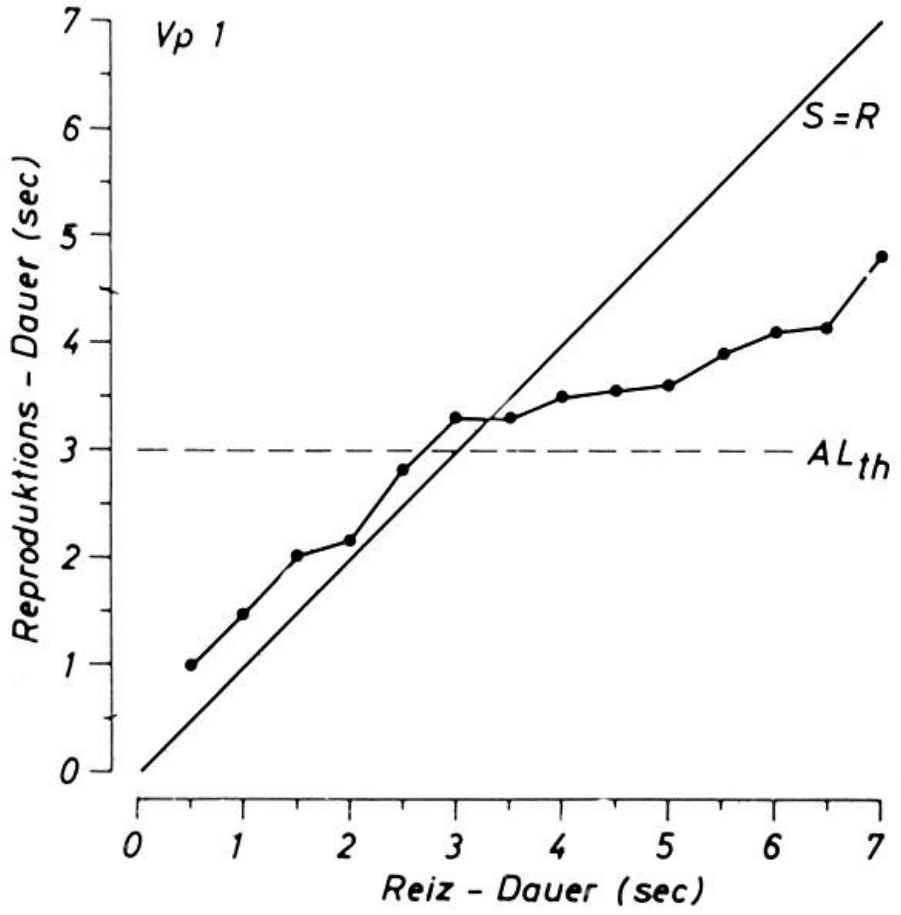
and

Logistical Functions: “How”
Time windows, presemantically implemented
Activation (Power Supply)
Attentional Control



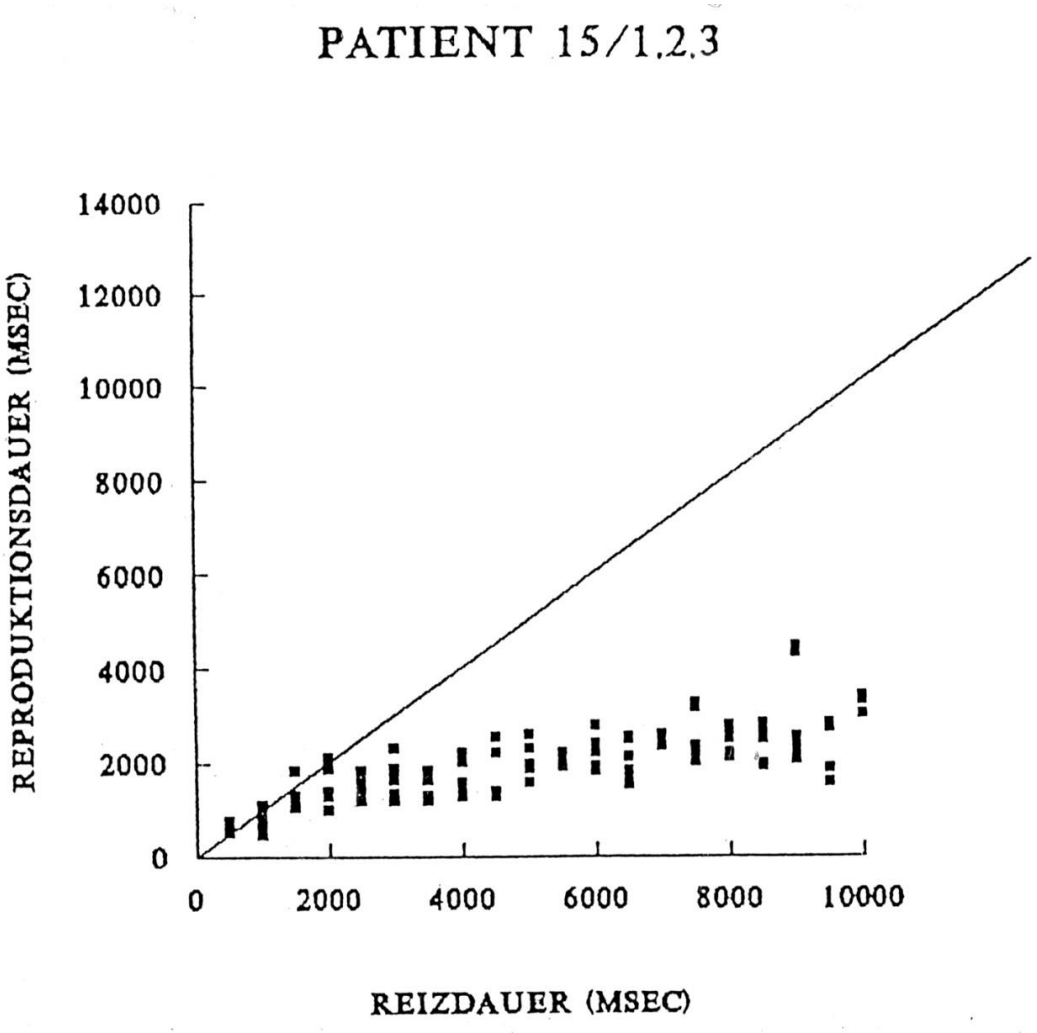


Creation of "identity" by temporal integration

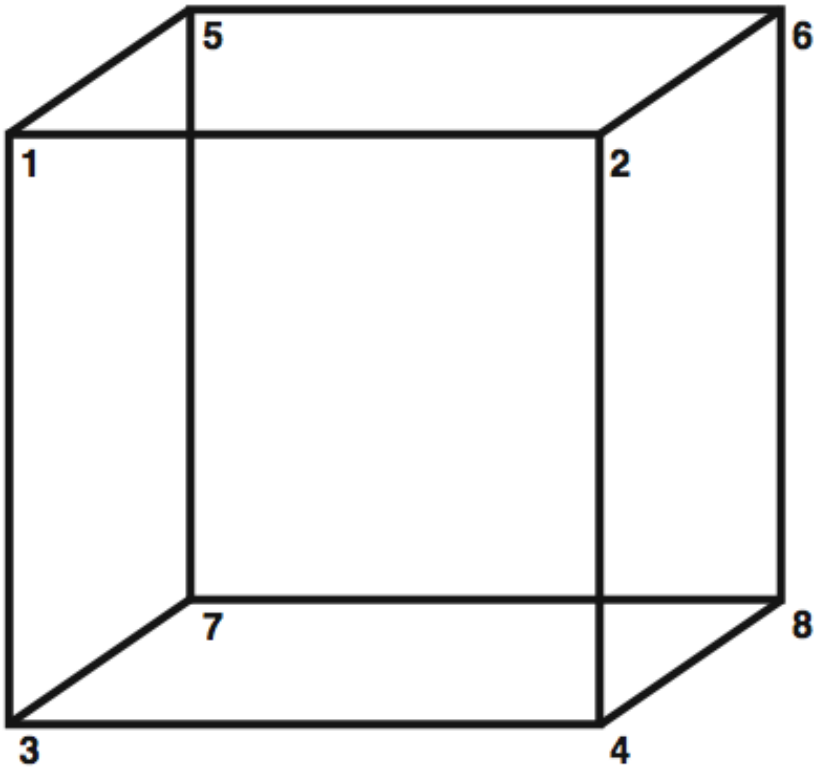


Reproduction of auditory stimuli lasting between 0.5 and 7 seconds, presented in random order.

Note the change of "gain function" at approximately 3 seconds.



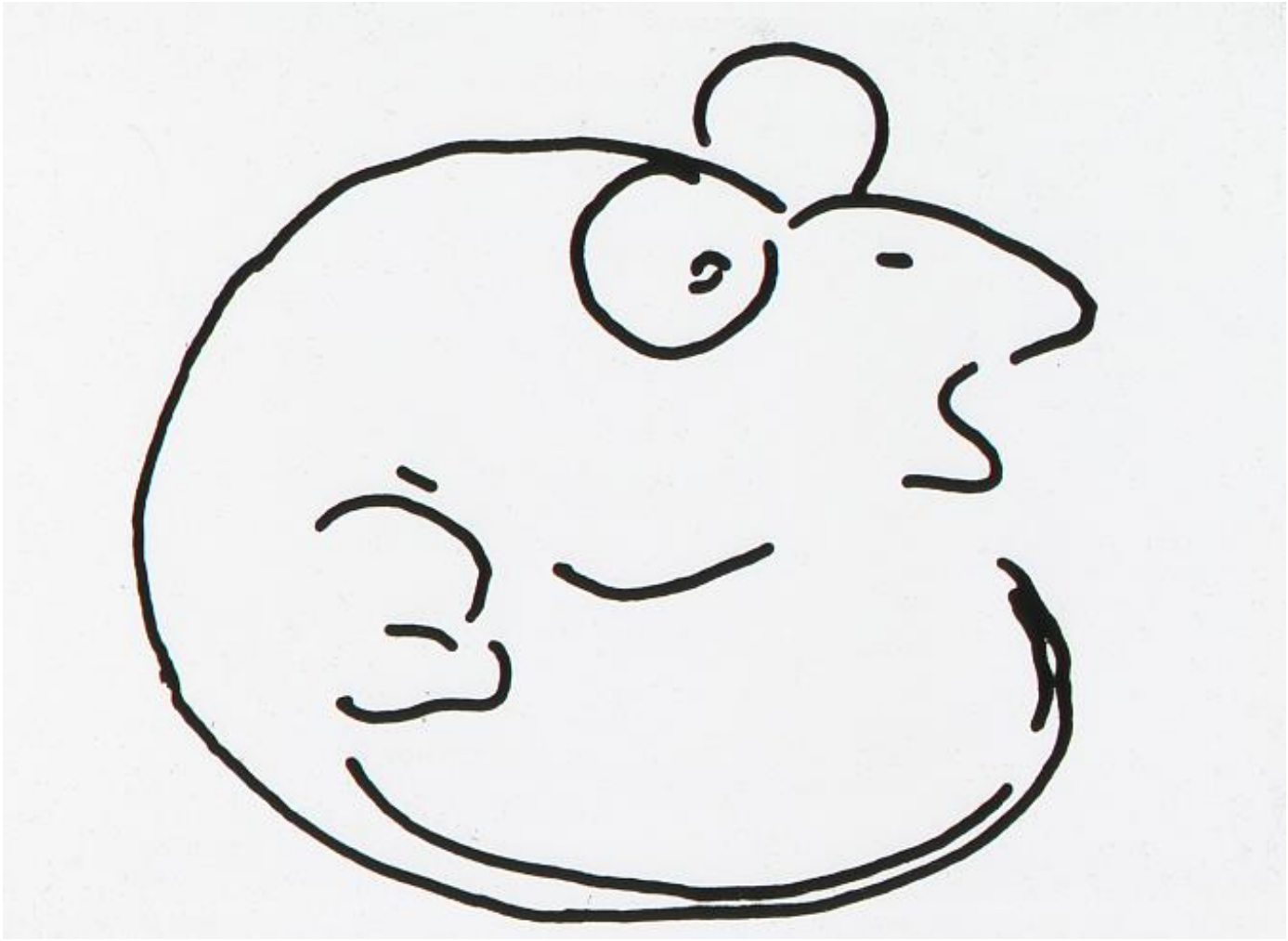
Patients with "formal thought disorder" and children with autism often reproduce intervals close to 3 sec, independent of their objective duration.



"Necker-cube" to be seen
in two different perspectives

Experiment:
Switch back and forth as fast
as possible !

Try to see only one
perspective !



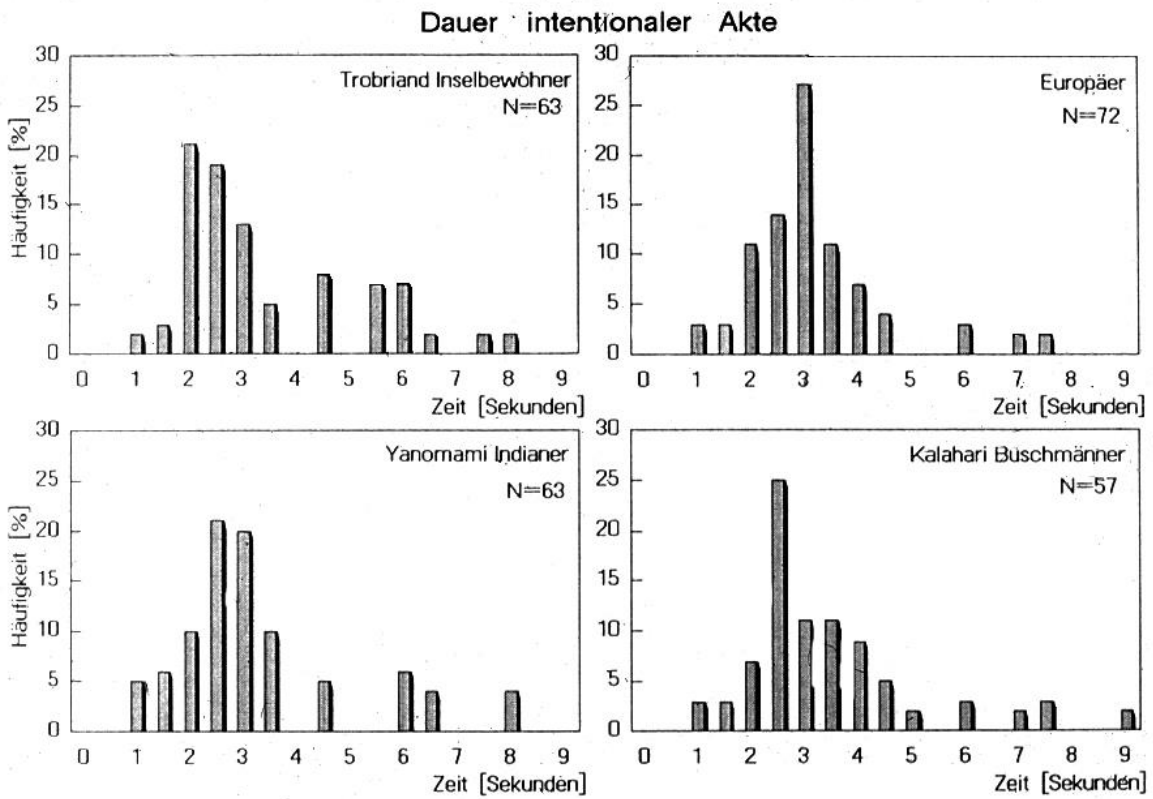
Auditory Ambiguous “figures”:

Ku Ba Ku Ba Ku Ba

Kuba
Baku

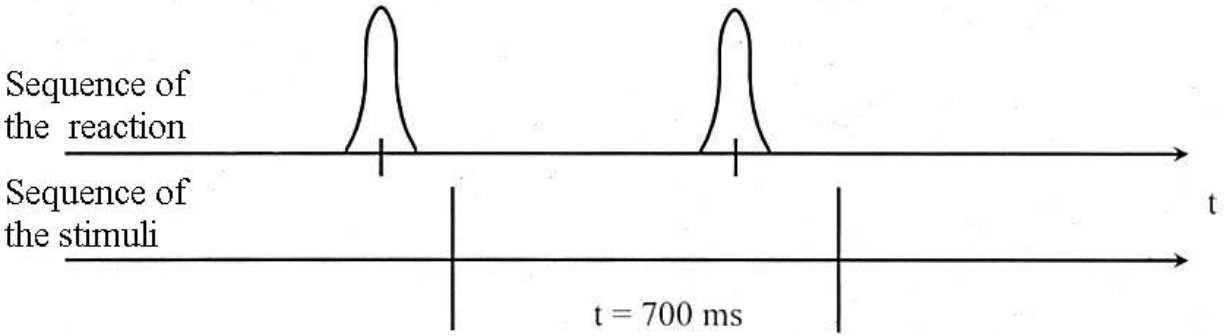
So Ma So Ma So Ma

Soma
Maso

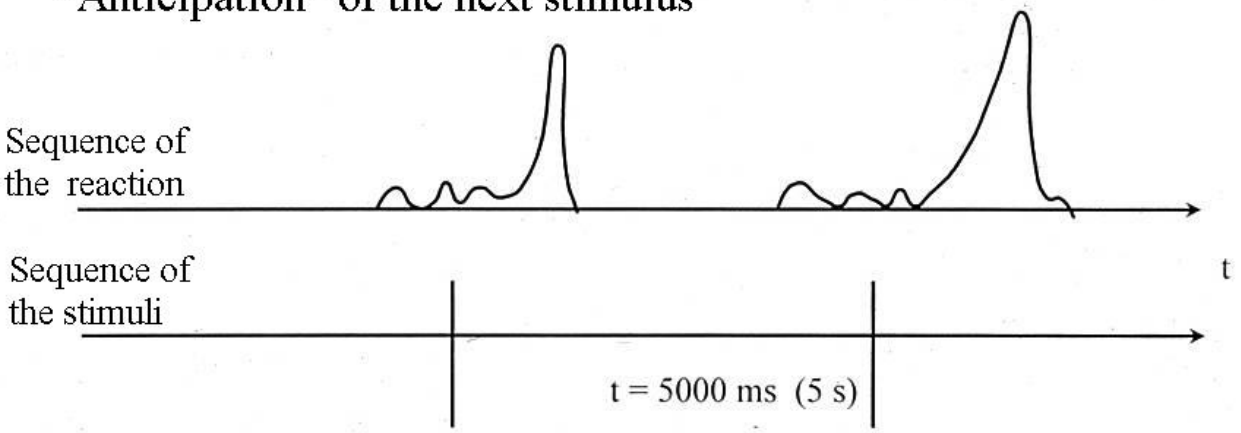


Independent of culture, the duration of intentional movements is often close to 3 sec. This is also observed in “higher mammals” other than humans.

Sensorimotor synchronization at different intervals

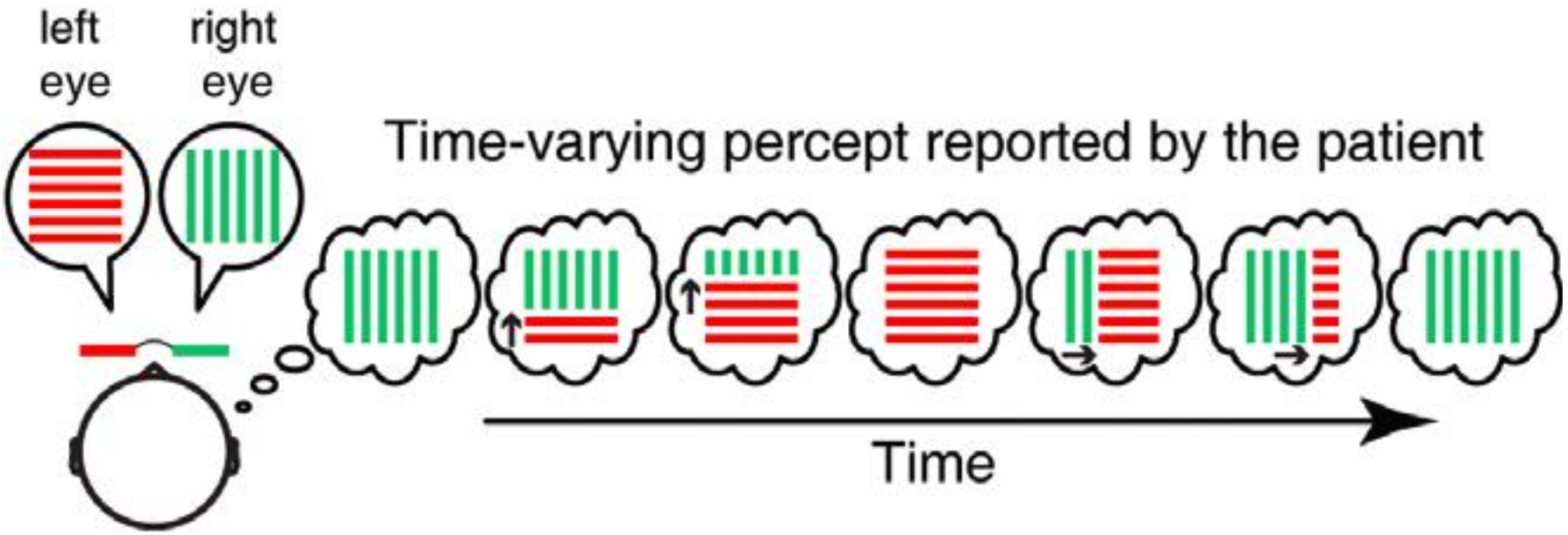


"Anticipation" of the next stimulus



No "Anticipation" of the next stimulus

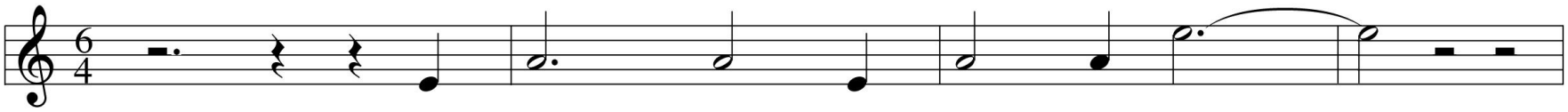
(J. Mates, E. Pöppel)



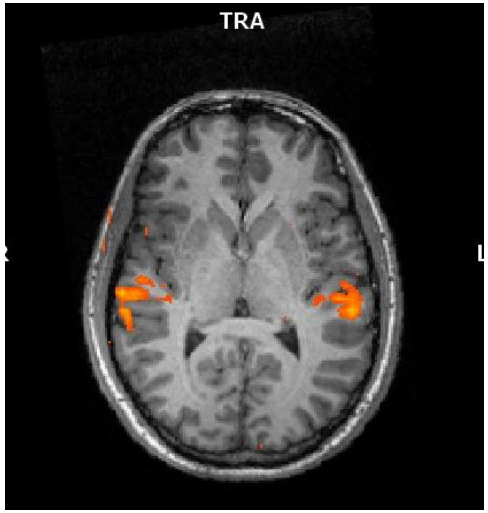
The prolongation of the “moment” or a “time window” allows to experience perceptual alterations in binocular rivalry.
(Data taken from patient H.H. with tunnel vision)

Richard Wagner, 1813-1883

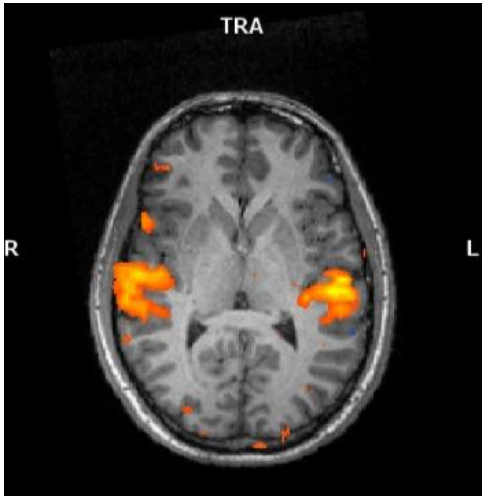
"One has understood a piece of music, if one has understood its tempo"



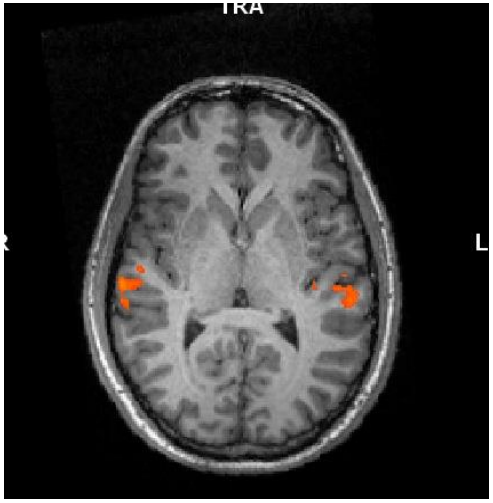
Richard Wagner - Beginning of the Flying Dutchman



too slow



"3-second" tempo



too fast

William Shakespeare, 1564-1616

Shall I compare thee to a summer's day?
1 2 3 4 5 6 7 8 9 10

Shall I compare thee to a Summer's day?

Thou art more lovely and more temperate:

Rough winds do shake the darling buds of May,

And Summer's lease hath all too short a date:

...

…So long as men can breathe, or eyes can see,

So long lives this, and this gives life to thee.

(Note the last two lines: They represent "frozen" TIME)

Johann Wolfgang Goethe, 1749-1832

Ihr naht euch wieder, schwankende Gestalten,
Die früh sich einst dem trüben Blick gezeigt.
Versuch ich wohl, euch diesmal festzuhalten?
Fühl ich mein Herz noch jenem Wahn geneigt?
Ihr drängt euch zu! Nun gut, so mögt ihr walten,
Wie ihr aus Dunst und Nebel um mich steigt.

(Memories represent “frozen” TIME)

Federico Lorca, 1898-1936

No te conoce el toro ni la higuera,

ni caballos ni hormigas de tu casa.

No te conoce el niño ni la tarde

Porque te has muerto para siempre

...

...

No te conoce nadie. No. Pero yo te canto.

Yo canto para luego tu perfil y tu gracia.

(Note the last two lines: They represent “frozen” TIME)

Paul Verlaine, 1844-1896

Il pleure dans mon coeur

Comme il pleut sur la ville,

Quelle est cette langueur

Qui pénètre mon coeur?

...

…C’ est bien la pire peine

De ne savoir pourquoi

Sans amour et sans haine

Mon coeur a tant de peine.

A poetic description of a state of depression. One automatically speaks slower with less words in one line.

Friedrich Schiller, 1759-1805

Auch das Schöne muß sterben! Das Menschen und Götter bezwinget,

Nicht die eherne Brust rührt es des stygischen Zeus.

Einmal nur erweichte die Liebe den Schattenbeherrscher,

Und an der Schwelle noch, streng, rief er zurück sein Geschenk.

……

Siehe! Da weinen die Götter, es weinen die Göttinnen alle,

Dass das Schöne vergeht, dass das Vollkommene stirbt.

Auch ein Klaglied zu sein im Mund der Geliebten, ist herrlich,

Denn das Gemeine geht klanglos zum Orkus hinab.

Overcoming the limits of our personal TIME in ART – (and SCIENCE?)

Examples of a „Time Window“ of 2 to 3 Seconds

Intentional Acts
Binocular Rivalry
Time-Order Error
Cortical Sensitivity
Temporal Reproduction
Sensorimotor Synchronization
Accentuation of Successive Stimuli
Segmentation of Spontaneous Speech
Ambiguous Phoneme Sequences
Ambiguous Visual Figures
Duration of Verses in Poetry
Duration of Musical Motifs
Decision Processes
Attentional Control

"Darwinian" Statement

In temporal mechanisms of perception, speech,
movement control, working memory, decision processes,
cultural artifacts (poetry, music, images),
on the level of neuronal activity,
discontinuous temporal processing
in **one** time domain
of 2 to 3 seconds is indicated.

Taking all empirical evidence together
a robust temporal machinery is suggested
that underlies the creation of a "subjective present",
of states of being conscious (STOBCON).

TIME (temporal processing) allows, thus, an
operational definition of CONSCIOUSNESS.

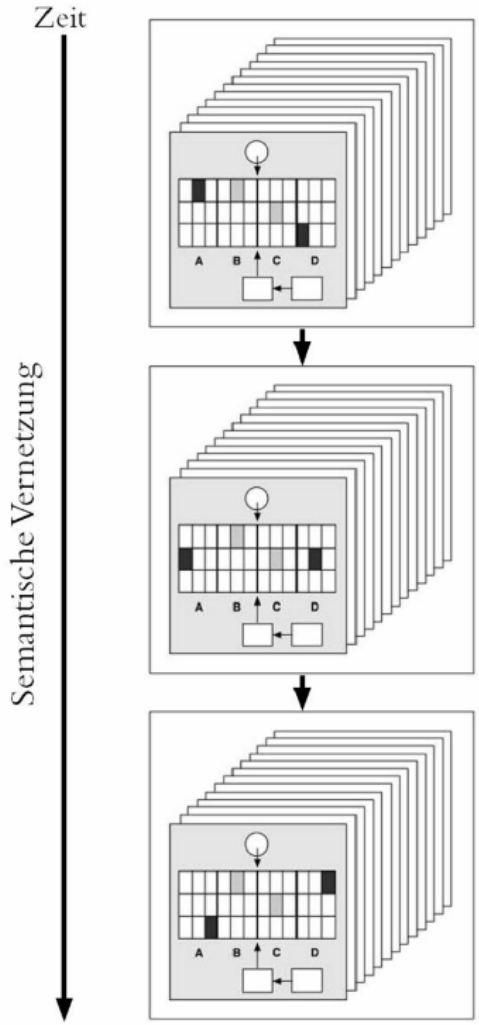
Functional reason of a 3 second time window

Creation and maintenance of perceptual and conceptual **identity** for some time, but not forever

Reduction of mental workload by presemantic **temporal chunking**

Allowing veridical **comparisons** overcoming the problem of the time order error

Creating a common time window for **social interactions** and empathic relations



A paradoxical situation:

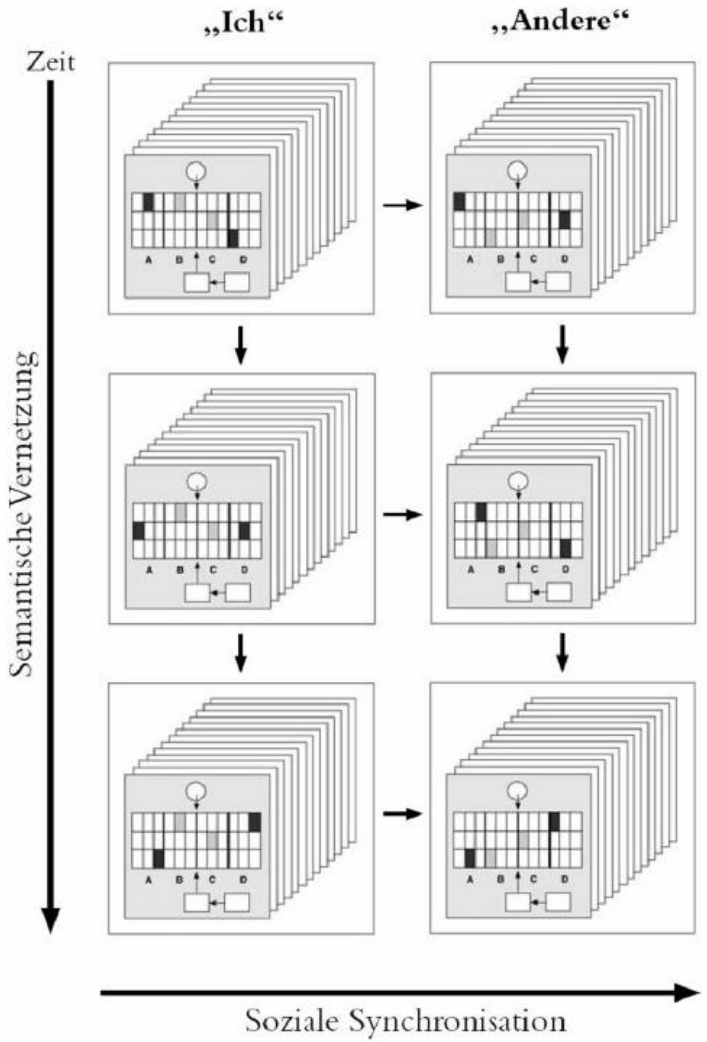
On the level of some tens of milliseconds and approximately two to three seconds “time” is processed in discrete steps.

Where does the impression of a continuous time come from?

This impression (or implicit conclusion) is due to the semantic connection of what is represented within the 3-second-windows.

Thus, “continuity of time” is an illusion, although a necessary illusion.

(Temporal continuity may break down as in some patients with schizophrenia or Korsakow psychosis; thus, the breakdown indicates that there must be under “normal circumstances” an active neural mechanism to create subjective temporal continuity.)



Communication is synchronisation using for instance the 3-second-window.

But who is "I" ?

Some final observations from episodic memory,
time traveling to one's own past:

I am present in my own pictures.

"I" am, because I am my own "Doppelgänger".

Because I am present in my own pictures in episodic memory,

the images in my mind cannot represent physical reality.

These images represent “personal reality” (Wirklichkeit),
and are continuously adjusted
to create continuity of individual **identity**.

Complementarity as generative principle to be recommended as a thought pattern to overcome the human disease of "monocausalitis"

Content (What)	AND	Logistics (How)
Identity of Mental Content	AND	Dynamics (Change of Content)
Evolutionary Heritage	AND	Environmental Imprinting
Explicit Knowledge	AND	Implicit Knowledge
Induction (Francis Bacon)	AND	Deduction (Parmenides)
Internal Point of View	AND	External Pont of View
Elements (Local)	AND	Gestalt (Gobal)
Top-Down	AND	Bottom-Up
Time Windows	AND	Temporal continuity
„I"	AND	My Doppelgänger
„Reality" (Wirklichkeit)	AND	Reality