Exploration of structural and kinetic components of physical information

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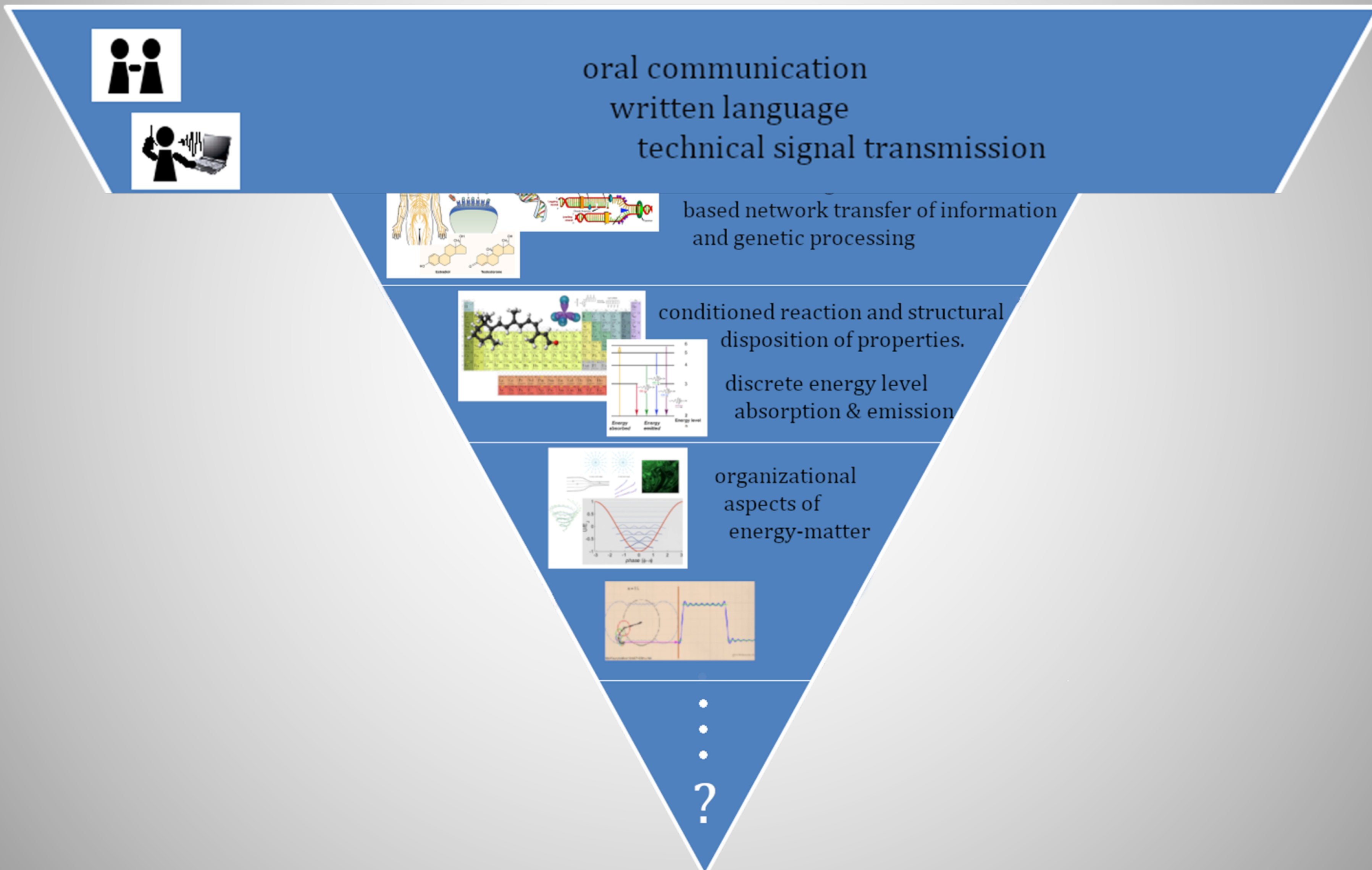
Evolution of Information Processing Systems
Vienna Austria

Where is information involved?



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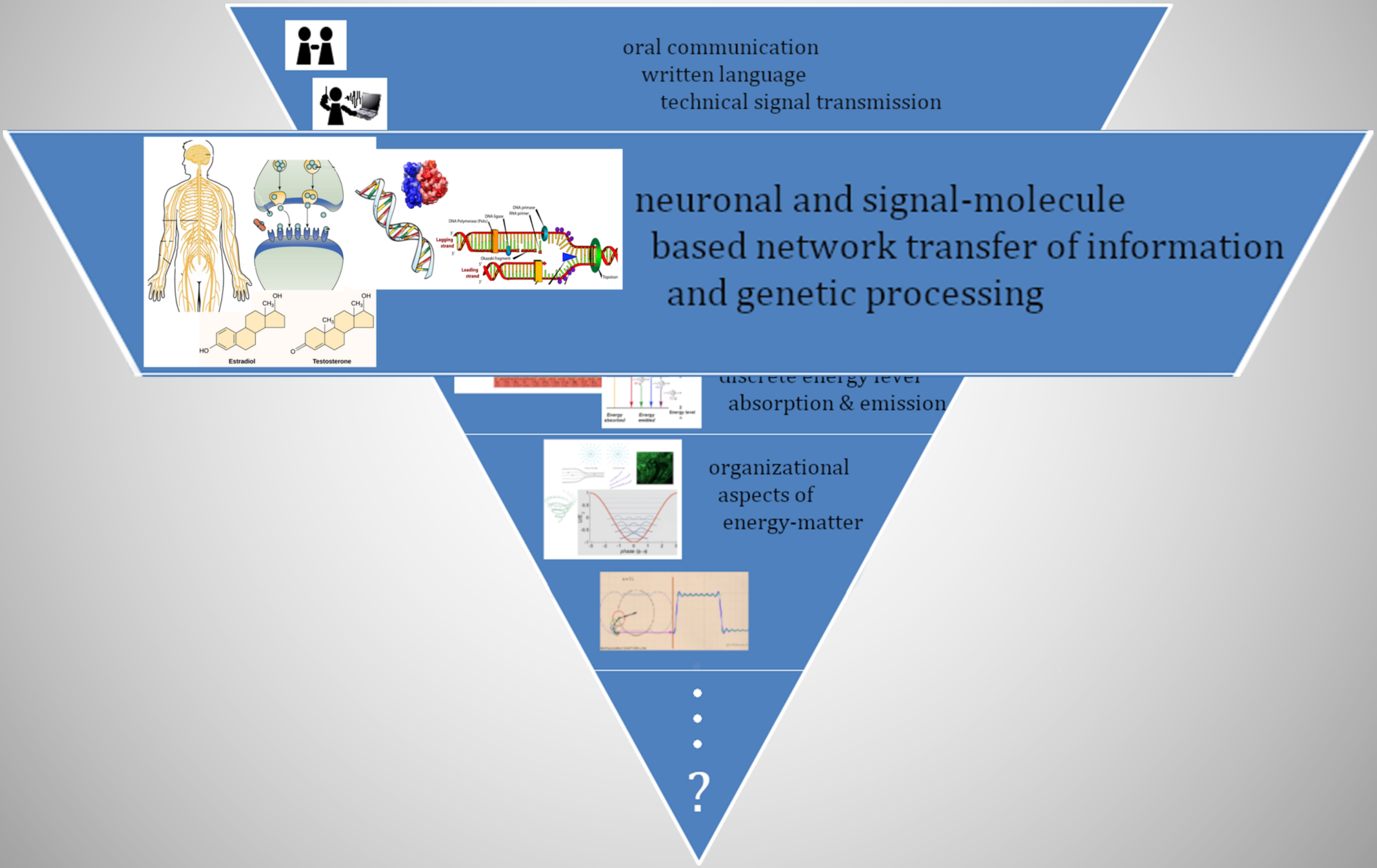
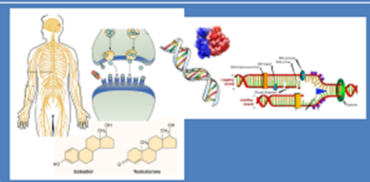
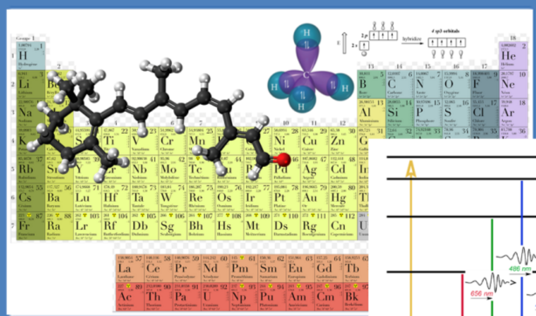


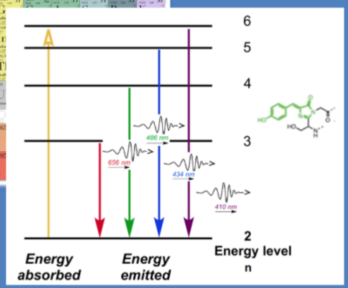
Where is information involved?


oral communication
written language
technical signal transmission



neuronal and signal-molecule based network transfer of information and genetic processing





conditioned reaction and structural disposition of properties.

discrete energy level absorption & emission

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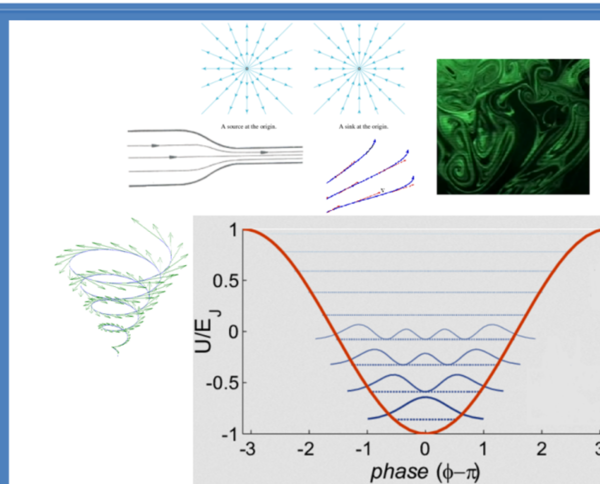

organizational
aspects of
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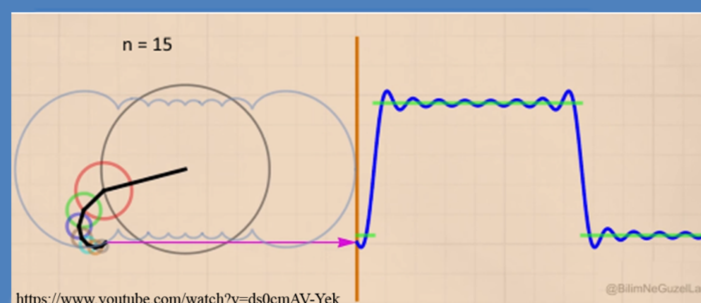

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"What we mean by information — the elementary unit of information — is a difference which makes a difference, and it is ***able to make a difference*** *because the neural pathways along which it travels and is continually transformed are themselves provided with energy. The pathways are ready to be triggered. We may even say that the question is already implicit in them."*

Gregory Bateson, Ecology of mind, p. 459, Chapter "Form, Substance and Difference".

What I want to explore based on Bateson´s idea of information:

- How does a difference arise in physical structures? What *is* a physical difference?
- How can a difference be made in physical structures? What *makes* a physical difference?

Contributions considering physical aspects of information:

*Karpatschof: Information is the quality of a certain signal in relation to a certain release mechanism.

*Burgin: The measure of information I for a system R is some measure of changes caused by I in R.

*Losee: Information may be understood as the value attached or instantiated to a characteristic or variable returned by a function or produced by a process.

*v. Weizsäcker: Information measures the form.

*Jablonka: A source becomes an informational input when an interpreting receiver can react to the form of the source in a functional manner.

*Hofkirchner: Information is the super-concept which incorporates all its different manifestations regardless of the nature of the network of relations in which they appear.

*Brier: Information is a kind of formal cause working through pattern-fitting.

*Fisher: Information qualifies the ability to know using a system of measurement.

*Levitin: The amount of information obtained by the physical system S is equal to its entropy defect.

*Stonier: Information is the capacity to organize a system or to maintain it in an organized state.

Difference

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Making a difference

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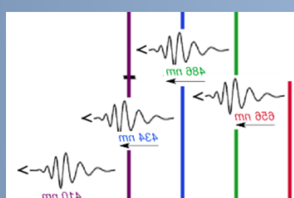
Information

Conditions probabilities

Has a store

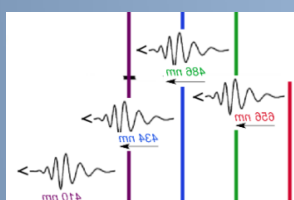


Signals addressing senses and sensitivities

Information

Conditions probabilities

Has a store



Senses and sensitivities adressed by changes acting as signals

It is possible to differentiate between two different physical basic mechanisms producing perceivable differences:

Signals travelling media	*Receivers/Senders of signals*
Signals represented and transported by many independent oscillators	*Senses and sensitivity grounded in networks of interacting entities*
Motions producing a perceivable disturbance of the medium in which they are traveling	*Differences which give objects different properties which again can be perceived*
Differences in trajectories (linear or cyclic). ⇄	Differences in structure and configuration

My proposal is to call the physical information

• Represented in structured motion, carried by a medium*, capable of transmitting energy into a material structure and thereby affecting its configuration structure

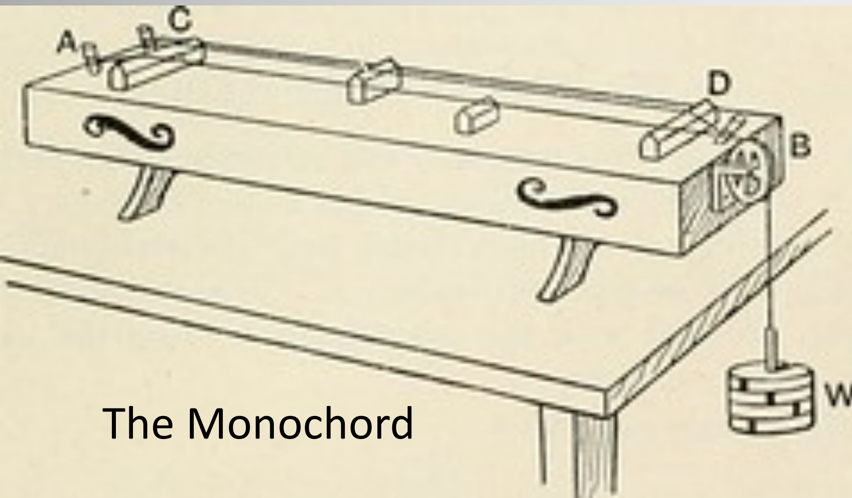
Kinetic Information

• Represented in a structure with configuration, carried by interacting non-identical elements, sensitive to structured motion of certain pacing and threshold-exceeding force and thereby capable of absorbing and emitting kinetic information

Structural Information

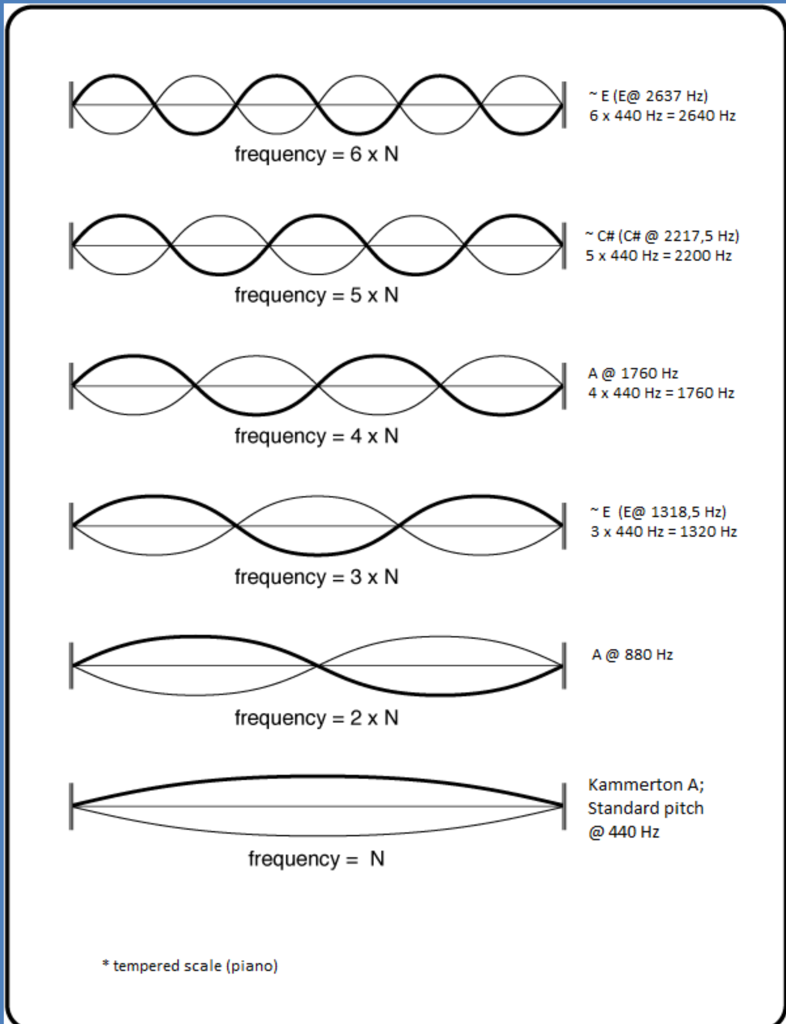
*medium: Aggregate of independent oscillators which are no receivers of the signal they carry.
Differentiation between Kinetic and Structural Information first proposed by Stonier (see references slide at the end of the presentation)

To demonstrate the applicability of kinetic information and structural information,
An example of a musical instrument is given.



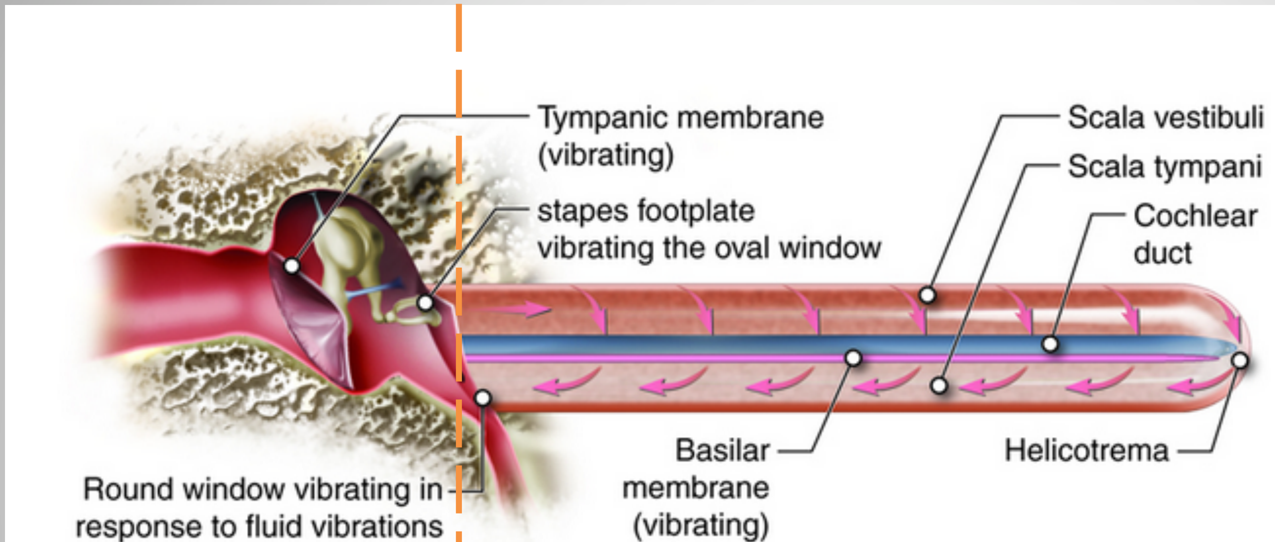
The Monochord

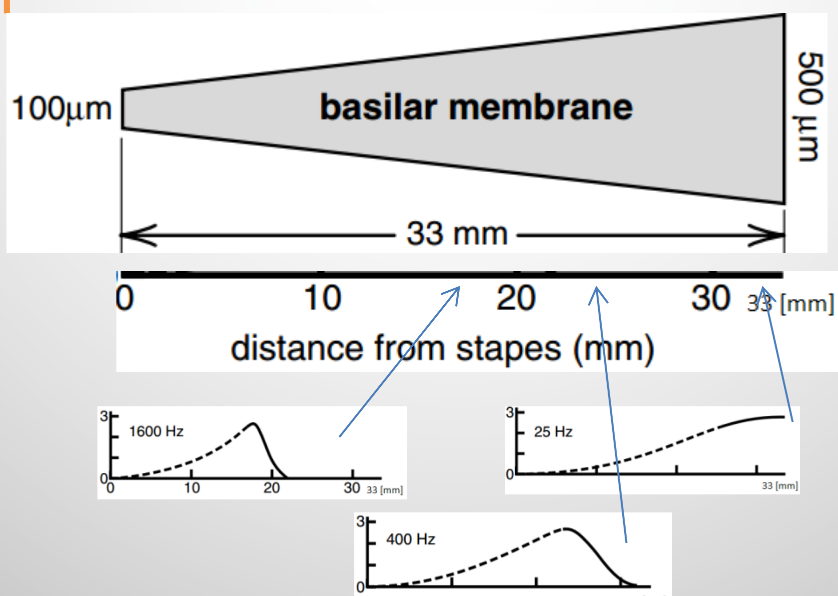
https://archive.org/stream/textbookofphysic00duncuoft/textbookofphysic00duncuoft#page/733/mode/1up



Kinetic Information

Kinetic Information → Uncoiled Cochlea:

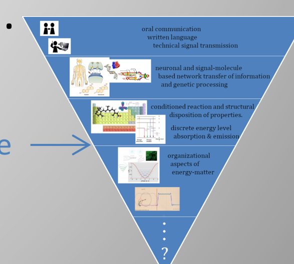




For our focus on physical Information processing, we look on the structure in the human ear which is doing the initial analysis of acoustic signals; mechanically

(Of course the initial analysis is then improved and sharpened by a data analysis network of neurons).

We are here →



Images adapted from:

- https://courses.lumenlearning.com/nemcc-ap/chapter/special-senses-hearing-audition-and-balance/ (http://creativecommons.org/licenses/by/3.0/us/).
- ***Green,*** **An Introduction to Hearing,** ***John Wiley & Sons***
- **Principles of Neural Science** ***Edited by E. R. Kandel and J. H. Schwartz, Elsevier/North-Holland***

What is so special about wave-form motion?

• Changes of second-order differential equations (motion inside a potential field;
In the monochord example: expanding a stretchable string which has a structurally given restoring force)
are guided by a basic physical principle, the **Principle of Stationary Action (PSA)**.

A principle of equal importance as the Second Law of Thermodynamics for distribution functions

• Most resonators are linear or nearly linear.
So they enhance fundamental sinusoidal waves and their harmonics (i.e. integer multiples and divisors)

• A single frequency *sine wave* passing though a *linear* (i.e. free of feedback, hysteresis, etc.) dispersive medium will *remain* as a single frequency sine wave, whereas a triangular or square wave (composite waves according to Fourier Theorem) will be distorted. Many physical processes are frequency dependent, and tend to sort out *sine* wave components

⟹ **Conditioned probabilities and a store !**

Kinetic and Structural Information are generally different basic mechanisms for **conditioning probabilities** and **storing dispositions** for perceivable differences:

Physically realistic trajectories are solutions to **second-order differential equations**:

•A differential equation has to satisfy certain geometrical invariance properties (which are consequences of the homogeneity of space, isotropy…) which impose **rather strong restrictions on** its **form**.

•The **wave equation** is the simplest equation among all which satisfy those invariance properties.

•Many natural phenomena exhibit oscillatory behavior which brings to bear one or more frequencies. A second order system is the lowest order which can reproduce oscillatory behavior.

•For **motion along linear trajectories**, **making action stationary** in Lagrangian equations [(Ekin- Epot) over given time] again confirms the importance of 2nd order equations.

Differences in trajectories (linear or cyclic) ⇄ Differences in structure and configuration

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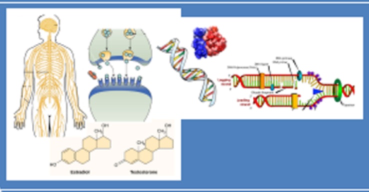

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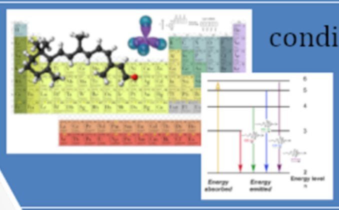

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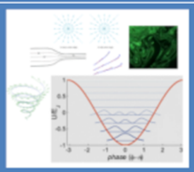

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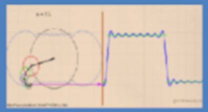

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Thank you for your attention!

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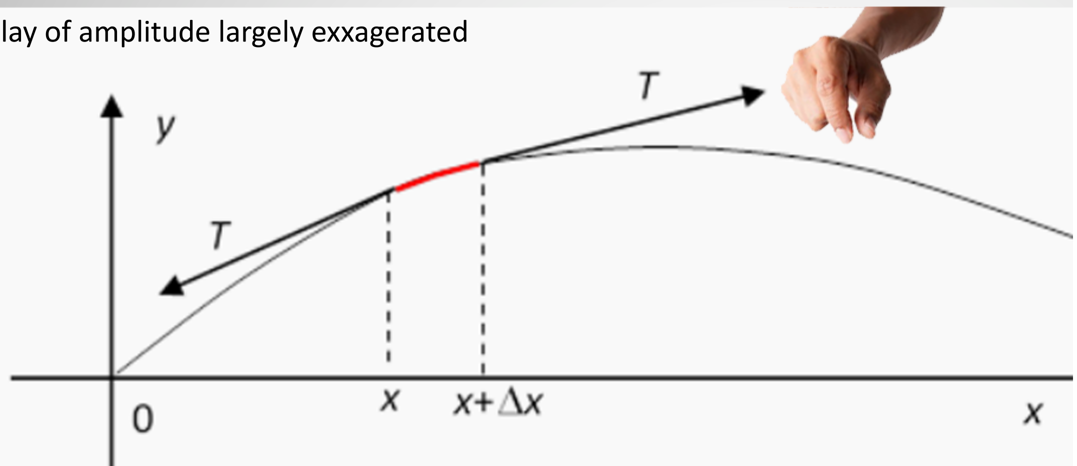
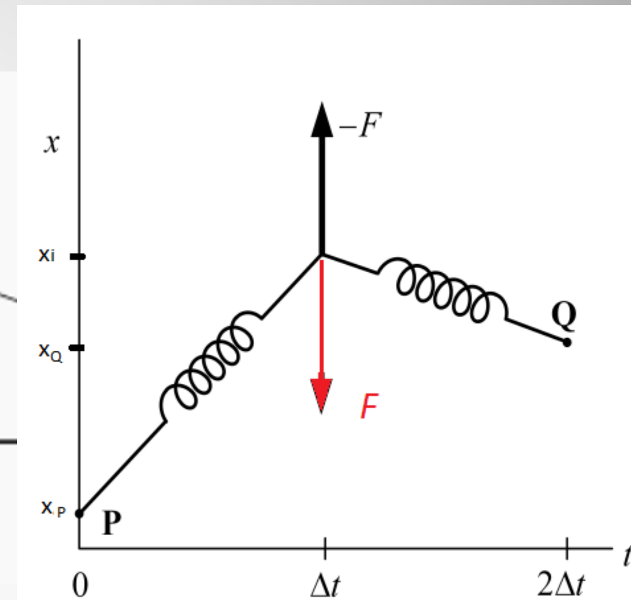
What is so special about wave-form motion?

*Display of amplitude largely exxagerated



Segment x to x+Δx of plucked string plotted versus distance (x,y)



Segment of length x plotted versus time. Tension modelled as fixed ends P, Q with fictitious springs of identical $k = m/(\Delta t)^2$

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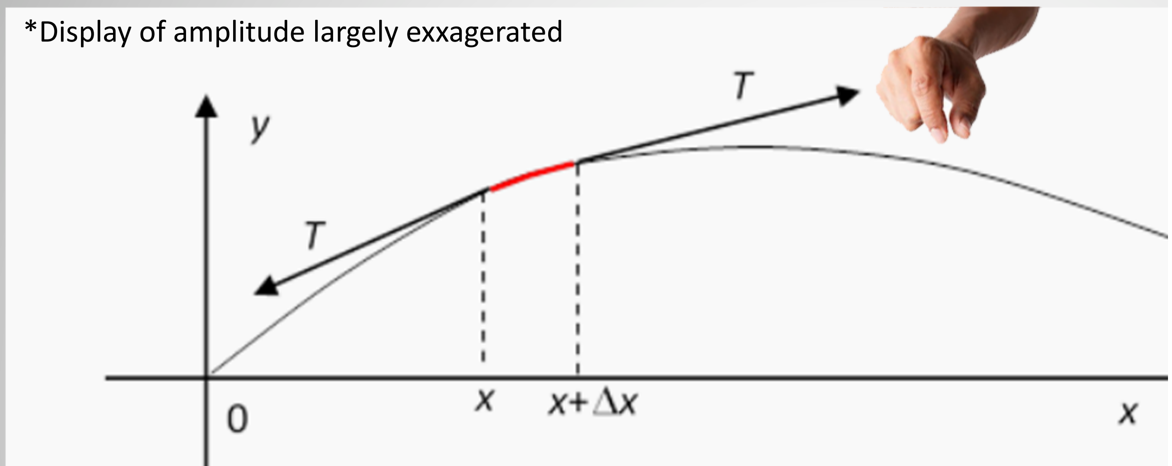

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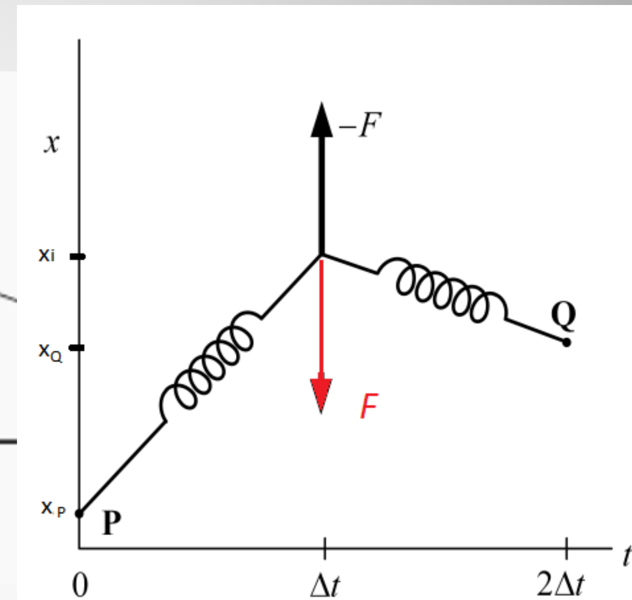

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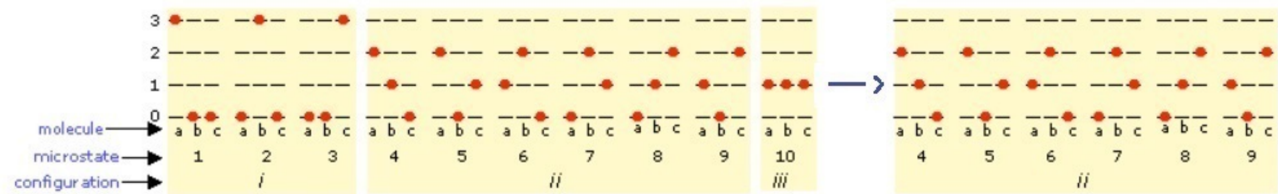
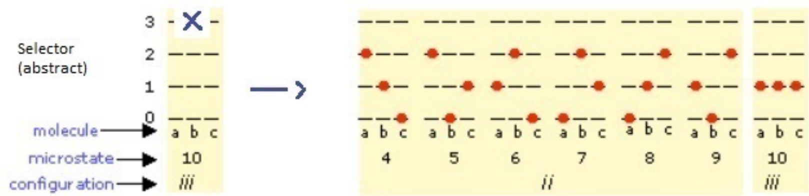


The higher the entropy, the more bits are required on average to code the event.

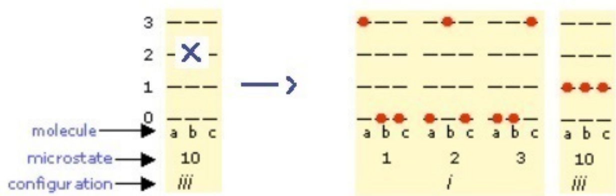
without constraint: configuration ii, 60%



configurations ii and iii

86% ii, 14% iii

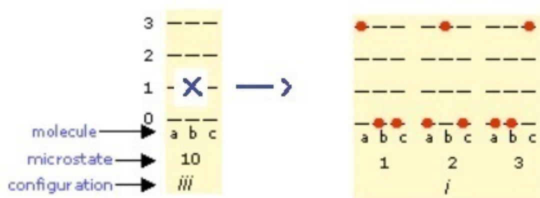
Reduces probability for most common configuration



configurations i and iii

75% i, 25% iii

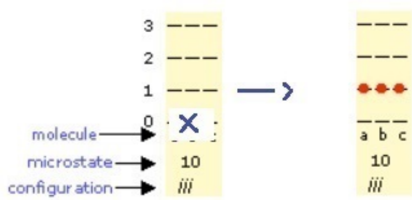
Generates probability for rare configs



configuration i

100% i

Select one of the rare configurations



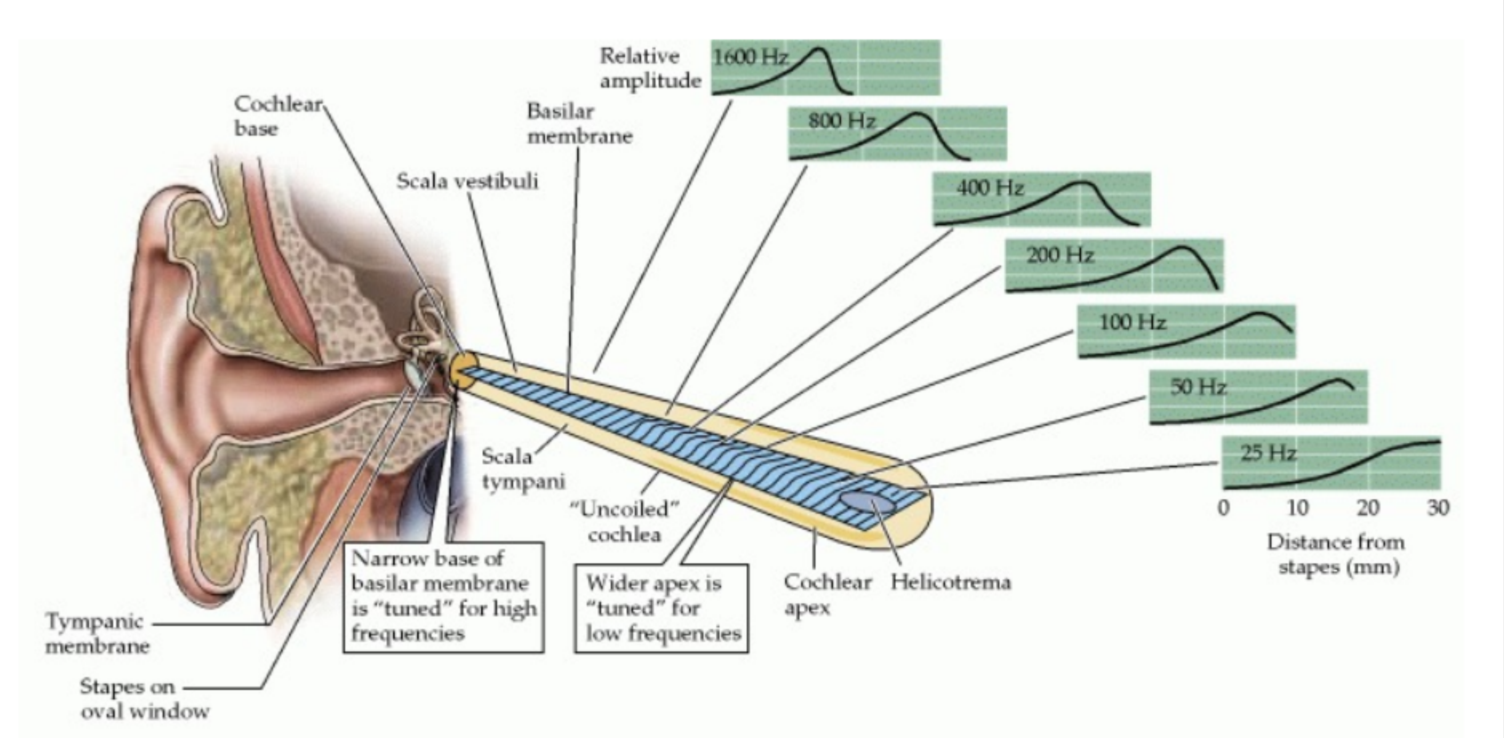
configuration iii

100% iii

"configurations in group iii seem "ordered" and configurations in group ii seem "disordered." So to put this in historic perspective, an "ordered" state is one with very little variability, possibly just a handful of microstates possible. In contrast, a "disordered" state is one with a multitude of possibilities (thousands upon thousands of microstates) - so much so that no apparent patterns are present and we perceive "disorder." It is best to avoid the order/disorder arguments though. Order and disorder are value judgments that we humans impose on arrangements based on our perception. Entropy is a quantifiable measure of the dispersion of energy and our personal perceptions have no place here (https://ch301.cm.utexas.edu/section2.php?target=thermo/second-law/microstates-boltzmann.html)."

We must think of energy dispersal and energy becomes more dispersed when more microstates are available.

Conservative Systems´ Evolution	*Selective Environment*			
	Physics Environment (PE)	*Physico-Chemical Environment (PCE)*	*Biological Environment (BE)*	*Intentional Environment (IE)*
Drive for transformation processes/ Selection Regime	2nd Law of Thermodynamics and Principle of Least Action for movements; Reduction of E_{pot} in resting position	Delocalization of charges and energy; Minimization of Gibbs free energy	Darwinian Fitness & Evolvability	Leading a good life that makes sense; Making things easy but not too easy
Impossible event which marks transition to subsequent selection regime	Reproduction of configuration structure; Autocatalysis	Autopoiesis; Search for Gradients	Teleology	Breaking physical law; ?



the ear is designed in such a way that it separates the complex incoming sound wave into its component frequencies. The information your brain receives is not what the shape of the complex sound wave is, but how much of each component wave is present (https://physics2000.com/PDF/Text/Ch_16_FOURIER_ANALYSIS,_NORMAL_MODES_AND_SOUND.pdf).

„Nun könnten die ubiquitären Vokale der menschlichen Sprache mit ihren harmonischen Spektren das "Trainingsmaterial" darstellen, mit denen das Gehirn des heranwachsenden Kindes dazu konditioniert wird, die akustische Gestalt eines Spektrums mit vielen Teiltönen in das einfache mentale Objekt eines Einzeltons zu transformieren. Liegt also hierin der Schlüssel zum Verständnis des harmonischen Hörens und damit der tonalen Hierarchien?“

ÜBERLEGUNGEN ZU EINER NEUEN THEORIE DER HARMONIE
GEORG HAJDU